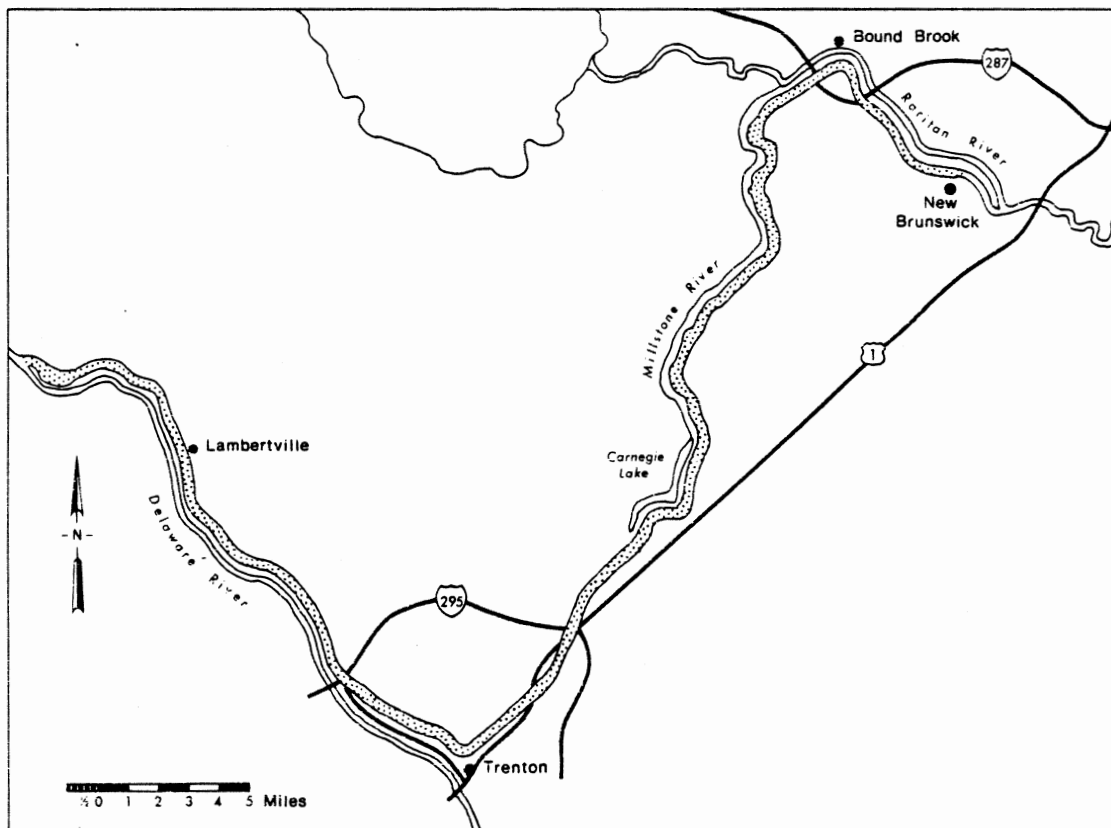


STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES
WATER SUPPLY FACILITIES

DREDGING THE
DELAWARE AND RARITAN CANAL
PROGRAM PLAN
AND
PROGRAMMATIC ENVIRONMENTAL ASSESSMENT
REPORT

INVESTIGATION BY
COLLEGE OF ENGINEERING
COOK COLLEGE
RUTGERS UNIVERSITY
1980-81



AUGUST 1981



A REPORT
ON THE
DREDGING OF THE DELAWARE AND RARITAN CANAL

A PROGRAM PLAN AND A PROGRAMMATIC
ENVIRONMENTAL IMPACT ASSESSMENT

Prepared for
Water Supply Facilities Element
Division of Water Resources
New Jersey Department of Environmental Protection

by

Rutgers, The State University
College of Engineering
Cook College

31 August 1981

EXECUTIVE SUMMARY

The Problem

The sixty-mile long Delaware and Raritan Canal serves as an inter-basin water transfer system. It begins at the Delaware River, midway between Frenchtown and Lambertville, New Jersey, parallels the Delaware River to Trenton, then turns northeastward paralleling the Assunpink and then the Millstone River through Princeton to Bound Brook, and then travels southeastward along the Raritan River to New Brunswick, its terminus. This waterway was built originally as a barge canal commencing operations in 1834; the last barge made its journey in 1933. In 1934, the State of New Jersey acquired the Canal and has been using it since as an interbasin transfer system with secondary recreational benefits. The right of New Jersey to take water from the Delaware River was established by a 1954 United States Supreme Court Decree and reaffirmed by the 1961 Delaware River Basin Compact. The decree allocates 100 million gallons per day (MGD) with an infrequent permitted peak of 120 MGD. It currently supplies water to about 600,000 people.

The State of New Jersey has designated the Water Supply Facilities Element of the Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) as the managing operator of the Delaware and Raritan Canal Water Supply System. Untreated water is sold from the Canal to some 22 customers.

The Canal has not escaped the ravages of time. Floods breach its banks; sediment and weeds choke the channel; and structures deteriorate. The Canal receives washoff from rural lands and urban areas as it passes through four counties and numerous communities. By 1980, the Canal would not have the hydraulic capacity to deliver the contracted amounts of water at all times of the year. This is the major concern of the Water Supply Facilities Element (WSFE) and the reason for the study undertaken by the Bureau of Engineering Research (BER) of Rutgers University.

Objectives of the Study

The objectives of this study are to (1) develop a plan for the dredging and spoils disposal and (2) prepare a programmatic environmental assessment of the effects of the dredging and spoils disposal. There is no intent to provide the detailed engineering specifications for dredging, dewatering, transport or disposal methods. Nor is it the intent to provide detailed environmental assessments of the several sections of the Canal. These will be the responsibility of the consultants engaged for each segment. However, it is the objective of this study to provide the necessary information for program planning and to develop a plan for programmatic assessments for each section. These objectives will guide the Water Supply Facilities Element and also the individual consultants.

The Canal is more than a conduit for raw water; it is also a cultural heritage portraying some of the history of the region. Also, it has been and will continue to be a recreational resource. The responsibility for the preservation of the Canal and the usage for recreation was assigned to the Delaware and Raritan Canal Commission by an Act of the Legislature of New Jersey in 1974.

The Approach

In previous studies, estimates of the locations and magnitude of the sediment deposits and their effect on hydraulic capacity were made. It was realized that with sediment removals the hydraulic capacity of the Canal would be at least 100 MGD. Furthermore, sediment removal would not only restore the Canal to its original design but would increase its attractiveness and usefulness as a recreational area.

The sediment in the Canal have absorbed some chemical or biological species which will determine the manner of final sediment disposal. To estimate the significance of the adsorbed species, samples of sediment were taken from 34 sites for analyses. The analyses made were selected to identify organic and inorganic chemical types of possible concern in the sediments and in the interstitial waters. From a few sites, samples were tested for evidence of fecal contamination. Also, samples from a few sites near an industrial area were tested for asbestos. Engineering properties related to slope stability and particle size distribution were determined on each of the samples.

The processes of dredging will include use of hydraulic dredges, pipelines, cranes, front end loaders, belt loaders, bulldozers, trucks and the like. These machines will be in and around the Canal. Locations for entry and exit have been identified as have possible sites for dewatering the spoil. Possible routes for transport of the soil to location of final disposal have been indicated.

If the Canal is to be drained, in sections, to permit sediment removal in the dry, alternative sources of water must be provided. For most of the Canal customers such alternatives have been identified and one plan for providing the water has been suggested.

The Findings

With few exceptions the sediments can be disposed of either by spreading on land--the thickness of the layers are somewhat limited--or in landfills. For these few exceptions landfilling will be required. Because the sampling density for this study was low, 34 samples in 60 miles, the individual consultants will need to do more intensive sampling and analyses for each segment of the Canal.

The engineering property analyses identified most of the sediments to be silty-clay. These will drain and dry fairly well and offer no particular problems in handling or disposal.

Environmental Assessment

Dredging of the Canal is necessary; however, it will be disruptive of the environment. The very process of dredging, transportation of dredge spoils, dewatering and disposal of spoils will all have an impact on the environment. These impacts will include: releases of sediments to the water column, damages to vegetation and to Canal structures, disruption of recreation, disturbance or damage to cultural resources, noise, odors, spills, erosion, leachate movement

and possible dispersion of pollutants to the surface waters and the air. Each of these considerations was addressed.

The possible alternatives considered in the assessment were:

- (1) dredging vs. no dredging
- (2) hydraulic dredging vs. dry dredging
- (3) sediment disposal sites
- (4) routes of transport
- (5) replacing the Canal with a pipeline

For each segment of the Canal to be dredged, the design consultant will make an assessment of the specific effects of the proposed dredging. He will consider each of the various environmental aspects listed above and will follow the procedures established in this study.

ACKNOWLEDGMENTS

The Rutgers University Project Study Team and the Water Supply Facilities Element personnel wish to acknowledge and express appreciation to the persons who attended the public meetings on April 25, 1980 and January 29, 1981. Further appreciation is expressed to the Advisory Committee which met with the Rutgers and Water Supply Facilities Element groups on May 29, July 23, September 24, November 9, December 13, 1980 and January 21, March 25, May 14, June 24 and July 30, 1981. The Committee members devoted numerous hours and provided many suggestions for conduct of the study and preparation of the reports.

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CHAPTER 1.0 INTRODUCTION - THE PROBLEM

1.1 Introduction

The sixty-mile long Delaware and Raritan Canal serves as an inter-basin water transfer system. It begins at the Delaware River, midway between Frenchtown and Lambertville, New Jersey, parallels the Delaware River to Trenton, then turns northeastward paralleling the Assunpink and then the Millstone River through Princeton to Bound Brook, and then travels southeastward along the Raritan River to New Brunswick, its terminus. This waterway was built originally as a barge canal commencing operations in 1834; the last barge made its journey in 1933. In 1934, the State of New Jersey acquired the Canal and has been using it since as an interbasin transfer system with secondary recreational benefits. The right of New Jersey to take water from the Delaware River was established by a 1954 United States Supreme Court Decree and reaffirmed by the 1961 Delaware River Basin Compact. The decree allocates 100 million gallons per day (MGD) with an infrequent permitted peak of 120 MGD. It currently supplies water to about 600,000 people.

The State of New Jersey has designated the Water Supply Facilities Element of the Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) as the managing operator of the Delaware and Raritan Canal Water Supply System. Untreated water is sold from the Canal to some 22 customers. The listing and location of these purchasers and the contracted amounts of water are given in Table 1.1 of Ref. 1.1.

The Canal has not escaped the ravages of time. Floods breach its banks; sediment and weeds choke the channel; and structures deteriorate. The Canal receives washoff from rural lands and urban areas as it passes

through four counties and numerous communities. The Canal does not have the hydraulic capacity to deliver the contracted amounts of water at all times of the year. This is the major concern of the Water Supply Facilities Element (WSFE) and the reason for this study.

1.2 Previous Studies

In early 1977, the State of New Jersey, through the WSFE requested Rutgers-The State University to undertake a study of certain aspects of the Canal. The objectives of the study were to: estimate the hydraulic capacity of the Canal under normal, low, and high (flood) flow conditions; estimate the stability and integrity of its structures; conduct a limited evaluation of water quality; and, describe the institutional relationships between the WSFE, the operator of the Canal, and the many agencies having responsibility for other aspects of the Canal.

From that study, described in the DELAWARE AND RARITAN CANAL HYDROLOGIC, HYDRAULIC, STRUCTURAL, WATER QUALITY AND INSTITUTIONAL REPORT (Ref. 1.1), it was realized that the Canal does not now have the hydraulic capacity to transport the 100 MGD. The constrictions are the collected sediment deposits and, in some locations and seasons, the attendant rooted vegetation. The rooted vegetation appears to become progressively a problem.

To illustrate the extent of this problem, the hydraulic capacity of the Canal had been reduced by the summer of 1980 to some 35 MGD. The west side of the twin conduits - "Trenton Tubes" - under U.S. Highway 1 in Trenton has considerable sediment: up to half full, in some sections. Also, there was considerable weed growth in the Canal both upstream and downstream of the Trenton Tubes. Because of the high hydraulic friction losses due to those weed growths, attempts to increase flow through the Trenton Tubes (by opening the Lambertville Lock) raised the water surface elevation upstream of the

Trenton Tubes high enough to cause leakage through the embankments in the Trenton area. Weed cutting in the Canal downstream of the Trenton Tubes did increase flow capacities. However, because of equipment and budget limitations, the weed cutting program was curtailed and the flow capacity equivalent to that in the winter months of 1979-80 and 1980-81 was not attained.

It should be noted that the profiles of the Canal bottom, as shown on Figs. 2.4A-2.4M, of Ref. 1.1 are of the centerline of the Canal and do not indicate the extent of the problem of sediments. The sediments and the weed growths are greatest along the sides of the Canal channel. Some several hundred cross-sections of the Canal were taken to provide information for hydraulic computations and also to estimate sediment volumes. Subsequently, many other cross-sections have been taken by the survey crews of the WSFE.

In addition to the work reported in Ref. 1.1, the Rutgers Study Group is completing a report by an AGREEMENT between Rutgers University and the State of New Jersey entitled, DELAWARE AND RARITAN CANAL WATER QUALITY ANALYSIS AND ASSESSMENT (Ref. 1.2). The objectives of that study are directed toward water quality.

Another study, completed in January 1981, was of the chemical characteristics of the sediment in the West Trenton Tube. The preliminary report of that study is entitled EVALUATION OF THE WATER AND SEDIMENT IN THE WEST TUBE OF THE TRENTON CULVERT OF THE DELAWARE AND RARITAN CANAL (Ref. 1.3).

The Mercer County 208 Water Quality Planning Program also under contract with the New Jersey Department of Environmental Protection, is conducting studies of the quality of the storm runoff entering the West Trenton Tubes through the MERCER COUNTY STORMWATER TOXICS MANAGEMENT PROGRAM (REF. 1.4).

The Legislature of the State of New Jersey established the Delaware and Raritan Canal Commission to plan and protect the Delaware and Raritan Canal Park. In the Delaware and Raritan Canal Park Law, the State directed the Commission to establish a zone for review of private and public projects that might adversely affect the park. To provide guidance in its reviews, the Commission has prepared RULES AND REGULATIONS FOR THE REVIEW ZONE OF THE DELAWARE AND RARITAN CANAL STATE PARK (Ref. 1.5). The rules and regulations are directed primarily to storm drainage and water quality, visual impact and noise. The Commission has also prepared a DELAWARE AND RARITAN CANAL STATE PARK DESIGN GUIDE (Ref. 1.6). This design guide outlines principles which are the basis for all site planning and design decisions for the Canal Park. Another report of the Commission is listed as Ref. 1.7.

1.3 Present Study

Following the studies reported in Ref. 1.1, the State of New Jersey, through its Water Supply Facilities Element of the Division of Water Resources of the New Jersey Department of Environmental Protection requested Rutgers-The State University, to continue its studies of the Canal with emphasis on sediment removal. The AGREEMENT between the State and Rutgers entitled, "DEVELOPMENT OF PROCEDURES FOR PROGRAM PLAN AND ENVIRONMENTAL IMPACT ASSESSMENT REPORT became effective on January 22, 1980. The objectives of the study were to: (1) develop a plan for the dredging and spoils disposal, and (2) prepare a programmatic environmental impact assessment of the effects of the dredging and spoils disposal. A revised Scope of Work is included as Appendix 1.1 of this report.

The State project officers for this study are Messrs. Michael J. Galley, Donald J. Kroeck, and Ibrahim Shaikh. The Rutgers study team is Dr. Marvin L. Granstrom as Project Coordinator, Drs. Robert C. Ahlert and Joel Wiesenfeld from the College of Engineering, and Drs. William Goldfarb, Joseph V. Hunter and Harry L. Motto from Cook College. In addition, students from the two colleges participated.

To provide guidance to the Water Supply Facilities Element and the Rutgers Study Group and to make public the proposed program for dredging, a Public Meeting was held on April 29, 1980, at Trenton State College. At that meeting an Advisory Committee was formed; this Committee has met with the Water Supply Facilities Element personnel and the Rutgers Study Group on May 29, July 23, September 24, November 9, December 13, 1980; January 21, March 25, May 14, June 24 and July 30, 1981. An Advisory Committee has been most helpful with guidance, suggestions, and encouragement. A second Public Meeting was held on January 29, 1981 in Princeton Township Municipal Hall and a tentative schedule for public hearings on the PROGRAM PLAN AND PROGRAMMATIC ENVIRONMENTAL ASSESSMENT has been established for December 8, 9 and 11, 1981 in the Lambertville, Trenton and New Brunswick Areas.

1.3.1 Project Definition

The dredging process consists of removal of the sediment from the Canal channel and transporting it to acceptable disposal sites.

During the dredging processes the Canal must continue to transport water, or alternative sources of water for the Canal customers must be provided. The dredging could be in the wet (i.e. hydraulic dredging) or, if sections of the Canal were drained, the dredging could be in the dry and dewatering of the spoil would not be necessary. Slurries could be transported by pipeline and the dewatered spoil by truck or railroad car.

These processes have an impact on the environment and assessments are necessary. Such assessments include consideration of: sediment suspension;

noise; Canal bank, structural and roadway damages; impingement on cultural resources, the chief of which is the Canal itself, and property included on both the State and National Register of Historic Places; stability of spoil banks; effects of spoil on land and waters; and disruption of Canal recreational uses and aquatic life. Furthermore, the assessment includes inter-institutional relationships, required permits and, in general, coordination of activities with involved and concerned agencies and members of the public. Environmental assessment necessitates public participation in planning and review. The participation included public hearings and at the first meeting an advisory committee to the study team at Rutgers and the State officers was established.

1.3.2 Procedure

The Canal is in need of many improvements. The tentative plan of the Water Supply Facilities Element proposes that the channel dredging program be conducted over a period of several years. The proposed sequence is:

- 1) U.S. Route 1 Canal Conduit (Trenton Tubes)
- 2) Washington Crossing to Rose Street, Trenton
- 3) Prallsville to Stockton, Lambertville Lock to Washington Crossing
- 4) Mulberry Street to Kingston Lock
- 5) Kingston Lock to Ten Mile Lock
- 6) Ten Mile Lock to Five Mile Lock
- 7) Inlet to Prallsville Lock.

It is seen that the Canal will be dredged in sections. The proposed order is subject to revision and the schedule will depend on availability of monies.

The objectives of this Study are limited. There is no intent to provide the detailed engineering specifications for dredging, dewatering, transport or disposal methods. Nor is it the intent to provide detailed environmental

assessments of the several sections of the Canal. These will be the responsibility of the consultants engaged for each segment. However, it is the objective of this study to provide the necessary information for program planning and to develop a plan for programmatic assessments for each section. These objectives will guide the Water Supply Facilities Element and also the individual consultants.

To these ends the Study Group, in concert with the State officers and with the advice of the Advisory Committee and from comments at public hearings, has:

- 1) Conducted field and office surveys to: locate critical sediment locations; access points for equipment; locate dewatering sites; locate transport pathways and disposal sites.
- 2) Established sites for sediment samples and conducted analyses of the sediments to determine: their engineering soil characteristics, chemical constituents, and fecal coliform content.
- 3) Interpreted the data gathered to estimate suitability of spoil disposal by land spreading, land filling, and ocean dumping.
- 4) Provided preliminary designs for stream and storm sewer diversions.
- 5) Prepared a Programmatic Environmental Assessment including consideration of: disruption of recreational activities and of aquatic life, legal requirements; rules and regulations; guidelines; permit requirements, vegetation, noise, odors, spillages, erosion; and cultural resources; physical and chemical characteristics of the dredging processes on the water column and the disposal on land, in landfills or ocean dumping.
- 6) Considered alternatives are proposed for each of the several methods.

The details of this study are given in the following Chapters: Chapter 2, Procedures and Data obtained; Chapter 3, Analyses and Interpretation; Chapter 4, Sediment Reduction and Removal; and Chapter 5, Programmatic Environmental Assessment.

REFERENCES

- 1.1 State of New Jersey, Department of Environmental Protection, Division of Water Resources, Water Supply Facilities Element, DELAWARE AND RARITAN CANAL HYDROLOGIC, HYDRAULIC, STRUCTURAL, WATER QUALITY AND INSTITUTIONAL REPORT. June 1980. Investigation by Rutgers University. 1977-80.
- 1.2 State of New Jersey, Department of Environmental Protection, Division of Water Resources, Office of Planning and Standards, DELAWARE AND RARITAN CANAL WATER QUALITY ANALYSIS AND ASSESSMENT. 1981. Investigation by Rutgers University. 1979-81 - in preparation.
- 1.3 State of New Jersey, Department of Environmental Protection, Division of Water Resources, Water Supply Facilities Element. EVALUATION OF THE WATER AND SEDIMENT IN THE WEST TUBE OF THE TRENTON CULVERT OF THE DELAWARE AND RARITAN CANAL. Investigation by Rutgers University. January 1981.
- 1.4 State of New Jersey, Department of Environmental Protection, Division of Water Resources, Office of Planning and Standards and Mercer County Planning Division, 208 Water Quality Planning Program, MERCER COUNTY STORMWATER TOXICS MANAGEMENT PROGRAM. DELAWARE AND RARITAN CANAL CONDUIT SPECIAL STUDY. September 1980; January 30, 1981; March 5, 1981.
- 1.5 Delaware and Raritan Canal Commission. RULES AND REGULATIONS FOR THE REVIEW ZONE OF THE DELAWARE AND RARITAN CANAL STATE PARK. 1979.
- 1.6 Delaware and Raritan Canal Commission. DELAWARE AND RARITAN CANAL STATE PARK DESIGN GUIDE. December 1980.
- 1.7 Delaware and Raritan Canal Commission. DELAWARE AND RARITAN CANAL STATE PARK MASTER PLAN. 1977

APPENDIX 1.1

SCOPE OF WORK

1.0 INTRODUCTION

The objectives of this AGREEMENT are: (1) to develop a plan for the dredging of the Canal and disposal of the spoils, and (2) to prepare a programmatic environmental impact assessment of the effects of the planned dredging and spoils disposal. These would provide guidance to the Bureau of Water Facility Operations* in its programs of capital expenditures, operation and maintenance. Also, for individual dredging activities, the plan and assessment would provide to the consultant much basic data and a format for specific plan development and environmental impact assessments.

Sediment accumulation in certain segments of the Canal has reduced its hydraulic capacity. There are some efforts to limit erosion in areas tributary to the Canal; however, there are limits to the effectiveness of these efforts; so, there is, and will continue to be, need for clean-out of the sediment accumulation. The sediment contains soil particles and also inorganic and organic debris, as separate particulates and as absorbed matter on the soil particles. In addition, dissolved matter may exist in the quiescent interstitial waters of the sediments. Disturbance of the sediments may release soil particles, absorbed and dissolved matter into the water column. The solids of the dredge spoils will be similarly constituted.

Dredging will involve equipment at the site and over the route to disposal. Noise, spillage, air pollution, and, general nuisances may result. Other problems of spoils disposal will include erosion, permanency of retention dikes, rates of decomposition, and dissolution.

Along and within the Canal are sites of historical and archaeological interest. Law, both codified and common, requires care to protect and preserve these sites. The processes discussed above will be conducted with due cognizance of these requirements.

Conduct of the processes described above impinges upon and is the legitimate and required concern of many institutions and agencies. Studies of and along the Canal of several types--including those at RU, the NJDEP, the Delaware and Raritan Canal Commission, and others--are underway. Information concerning permits, agreements, support, advice, and coordination of activities will be considered and sought.

Thus, to meet the many needs, including increased hydraulic capacity, environmental concerns, protection of historical sites, and interinstitutional coordination, a careful study will be needed. The conduct of the study and research under this AGREEMENT is described below.

2.0 PROCEDURES

The procedure for the conduct of the studies under this AGREEMENT are contained in this section.

* As of July 1, 1979, the Water Supply Facilities Element (WSFE)

3.1 Dredging Processes

Following identification of the segments of the Canal that need dredging, selection of the several processes which may be used will be considered for typical sites. The process considerations will include: (1) machine selection, (2) placement of machines, (3) loading for transport, (4) dewatering systems, (5) disruption of sediments, and (6) return of excess water to the Canal. These considerations will be based on: (1) amount of sediment to be dredged; (2) particle size distribution of soils; (3) engineering properties of the dredge spoils such as slope stability, water content, permeability, dewatering rate, erodibility, and compaction rate; (4) rate of settling of disturbed sediments; and (5) chemical and/or biological characteristics of the sediment and dredge spoils.

3.2 Dredge Spoils Transportation

The dredge spoils must be transported to dewatering sites and hence to sites for final disposal. Depending upon the dredging machines, the initial transport may be by pipeline, channel, barge, or truck. Subsequent to dewatering, the final transport may be by barge or truck. Depending upon the dredging machine used and the sites for dewatering and final disposal, the means for transport will be limited. In addition to transport, the program plan will include route selection, effects of noise, air pollution, on-road and off-road damages, and haulage regulations (DOT).

3.3 Dredge Spoils Disposal

The dredge spoils disposal will probably be limited to landfill, in diked retention basins, or to spreading on land used for crops or woodlands. The selection of the type of disposal will be determined by the availability of the disposal sites. The availability, in turn, is dependent upon the dredge spoils itself, and also upon the soils and geohydrology of the sites. Consideration will be given to the leaching potential; leachate effects on ground and surface waters; erosion potential; and suitability for crops and/or woodlands including consideration of particle-size distribution, soil chemical composition, nutrients, metals, and organic matter.

The environmental assessment guidelines will suggest that cognizance be taken of the possible effect of dredge spoil disposal on the indigenous flora and fauna, particularly rare or endangered species.

3.4 Environmental Impacts

The impacts of alternative methods for the several processes-dredging, transportation and disposal on the environment and also on historical structures-will be assessed. Mitigative procedures for reduction of such impacts will be suggested.

3.0 INSTITUTIONAL RELATIONSHIPS AND RESPONSIBILITIES

The Study will be conducted under the direction of the Water Supply Facilities Element, Division of Water Resources, NJDEP. Dredging activities, the transport of dredge spoils, and the final disposal impinge upon numerous institutions and agencies which may have defined or general responsibilities relative to these

actions. Included among, but not necessarily limited to, these institutions and agencies are the following: (1) NJDEP Bureaus of Programs: Environmental, Carcinogenic, and Toxic Substances; Potable Water; Water Supply Facilities Element, Areawide Planning Management--Delaware and Raritan Basins; and Flood Plain Management; (2) U.S. Environmental Protection Agency; (3) U.S. Army Corps of Engineers; (4) U.S. Coast Guard; (5) U.S. Geological Survey; (6) U.S. and N.J. Departments of Transportation; (7) Delaware and Raritan Canal Commission; (8) several local and county planning agencies; and (9) the water customers of the Canal.

The responsibilities of these agencies and the institutional relationships relative to the dredging operations will be identified.

4.0 ALTERNATIVES AND IMPACTS OF ALTERNATIVES

The alternative to dredging, i.e. no dredging, will be considered with respect to the continuing and worsening limit of hydraulic capacity of the Canal and the environmental impacts of dredging. Alternative methods of dredging, transport, and final disposal will be considered.

The viable alternatives will be compared with respect to costs and to environmental impacts. The latter will include noise, spillages, damages to structures, existing and proposed recreational uses, roads and traffic, floodplain interference, access to private lands, water quantity, and water quality.

CHAPTER 2.0 PROCEDURES AND DATA OBTAINED

2.1 Field Surveys

The entire Canal was traversed several times by different persons of the Rutgers Study Team during the course of this Study for the reasons discussed below.

Preliminary estimates of sediment volumes to be removed are shown on Table 2.1. Recent (Summer 1981) estimates of sediment volumes made by the WSFE are considerably greater than those shown on Table 2.1. From Prallsville Lock to Kingston, Table 2.1 shows the sediment volume to be about 342,000 cu.yds. - the WSFE estimates are 705,600 cu.yds. Detailed evaluations of the significance of the sediments on the hydraulic capacities are reported in Chapter 6 of Ref. 1.1. These evaluations were used by the Water Supply Facilities Element to select the sequence of the dredging program.

On-site observations of the flow constrictions due to sediment deposits were made by walking along the Canal and also by probing, particularly at sites where the sediments were sampled. Along much of the Canal the banks were being filled in, weeds were growing well into the shallow waters and trapping more sediment, which in turn promoted more weeds, etc. A narrow channel in the center of the Canal is transporting the water. Dredging is necessary to remove hydraulic constrictions, discourage weed growth, remove polluted sediments, and to increase the flow of Delaware River waters in the Canal.

2.1.1 Location of Sediment Deposits

The sediments in the Canal come from the Delaware River and some 130 separate areas totaling 82.71 sq.mi. of land which are drained to the Canal. In addition, there are numerous small areas totaling 7.3 sq.mi. which drain into the Canal by direct overland flow. During flood conditions some culverts under the Canal may be inadequate, resulting in spillage into the Canal. The hydraulic capacity of the Canal is being continually limited by these sediment deposits

and if these inflows are not diverted the situation will become worse.

The hydraulic significance and volumes of these sediments were determined by the Rutgers study of the Canal hydraulics (Ref. 1.1). The procedure used was to estimate the hydraulic capacity of segments of the Canal under present conditions and to repeat the analyses with the Canal considered dredged to a design profile and cross-sections. The differences in hydraulic capacities were used to identify the effects of the sediments.

2.1.2 Access Points for Equipment

Field surveys were made to locate access points for dredging and transport equipment. Three procedures for removing the sediment were considered:

- 1) Wet condition: flow maintained in the Canal,
- 2) Dry condition: the Canal drained and the water permitted to drain from the sediment, and
- 3) Partial drained condition: the Canal partially drained to increase the proportion of solids in the dredged spoil. Also, this would permit the contractor to see the boulders, stumps, drums, etc., and to remove them before dredging commences.

For the wet and partially drained conditions, the following types of equipment were considered: compact portable floating dredges, such as the "Mud-Cat" (with necessary accessories); associated wide-body truck-trailers to transport the dredges; mobile cranes for lifting the dredges into and out of the water; lengths of pipe to convey the spoil to dewatering sites or to transportation vehicles; barges; cable-actuated excavators, equipped with clamshell or dragline; trucks; and tankers.

For the dry condition, the following types of equipment were considered: bulldozers; front-end loaders, cable-actuated excavators equipped with shovel, backhoe, clamshell or dragline; trucks and truck-trailers; and belt-loaders.

In general, the field survey indicated that large "off-highway" equipment was impractical but that small or moderate-sized equipment could be used. The factors which were considered in determining the access locations for the

various kinds of equipment are:

- 1) proximity to paved roads and highways for transportation of equipment;
- 2) locations and capacity of bridges over the Canal;
- 3) adequate clearances;
- 4) spacing of trees and shrubs;
- 5) road and roadbeds alongside the Canal;
- 6) location of Canal structures;
- 7) possibility of permanent construction to enhance the public's access to Canal - see Appendix 2.1;
- 8) minimum damage to the surroundings of the Canal;*
- 9) avoidance of inhabited areas, if possible.

Based on these considerations, access points for equipment were located as shown on Fig. 2.1.

2.1.3 Location of Possible Dewatering Sites

If sections of the Canal are drained and the sediment allowed to dry (dry condition), further dewatering will probably not be necessary. Table 2.12 showing the Engineering Soil Characteristics indicates that most of the spoil samples have fair to poor drainage characteristics. Thus, if allowed to dry, the spoil would not contain free moisture and could be handled by bulldozer or front-end loader, loaded onto a truck and transported directly to the disposal area. The time required for a given deposit to dry to a level for handling by bulldozer is dependent on the particle size distribution, water content,

* During these surveys and studies it was not intended to consider cultural resources. These will be considered in the Environmental Assessment for each segment of the Canal to be dredged. For a general statement, see Chapter 4.

and inadvertent or adventitious flows introduced to the Canal. While no exact time can be determined, the probability is that it would take one to two weeks, barring heavy rainfalls.

If, on the other hand, sections of the Canal are not drained (wet condition), or only partially drained and a hydraulic dredge used, the solid content of the spoil may be only 10 to 20 percent. Free moisture will probably be present and dewatering will therefore be necessary. Thus, as part of the field survey, possible dewatering sites located in proximity to the Canal were scouted. Depending on the location, some of the dewatering sites could also serve as the final disposal site. The dewatering sites require a containment area and a means of removing the free water. Natural bowls are not available and artificial lagoons to allow water to drain out of the spoil would be necessary. The lagoons could be built by encircling the dewatering site with an earthen embankment. Diversion of upland flow to the lagoon area would be necessary. To minimize erosion of the dewatering sites the lagoon could be constructed with drainage ditches at 10-20 foot intervals; an impervious liner covered with 6-12 inches of sand could be installed. The bottom would slope to the drainage ditches which themselves would be sloped to drain back to the Canal. Also, adjustable spillways would allow supernatant water to flow off the surface of the spoil and back into the Canal. If it is not possible to drain to the Canal the water would have to be drained into a nearby water body. The Division's Water Quality Management Element should be consulted about possible needs for permits for discharge of the water to the Canal or other waterways - see Chapter 5.

The dewatered spoil may then remain in place if the dewatering site is suitable for permanent disposal, or be loaded into the trucks for disposal onto land, into landfills or embankments. The lagoon drain and diversion system would minimize ponding and its attendant mosquito breeding potential.

Possible dewatering sites were located with respect to nearness to the Canal, potential for supernatant water to drain back to the Canal, and accessibility to earth-moving equipment and trucks. These are shown on Fig. 2.2.

In areas where dewatering sites are not available, it will be necessary to pump the spoil into tank trucks for delivery to suitable sites.

Hydraulic dredging when the Canal is partially drained may produce a relatively high solids content of about 20%. In this case, the wet spoils could be pumped into tankers for delivery to the final disposal sites.

2.2 Field Sampling and Analysis

To formulate reasonable recommendations for dredging methods and spoil disposal, knowledge of both the physical and chemical characteristics of the Canal sediments is necessary. In July 1980, samples were taken from about 25 sites spaced throughout the Canal's length. In March and April 1981 there was some resampling and, in addition, more locations were added to raise the total to 34. Locations and descriptions of the sampling sites appear on Fig. 2.3 and Table 2.3, respectively. Additional chemical tests were performed and a more complete data base was established.

Efforts were made to obtain representative samples of the Canal sediments. However, the density of sampling was not adequate to describe the sediment quality along the entire stretch of the Canal. Samples were taken at 34 sites in the 60-mile length; entire stretches of several miles were not included. A more comprehensive sampling and analyses program will be necessary for each segment of the Canal to be dredged.

2.2.1 Sampling Sites

Two factors were considered in the selection of the location of sampling sites: large sediment volume segments of the Canal, and areas of possibly or

probably contaminated sediments. Sediment depths are noted at each sampling site.

2.2.2 Method of Sampling

Core samples were taken at each sampling site from a boat using a 2-inch diameter, 18-foot long PVC pipe with a one-way flap valve on the end of the sampler. The pipe was thrust by hand as far as possible into the sediment (to sediment depths of up to 8 feet) with the flap valve open allowing sediment to enter into the tube. When the pipe was withdrawn, the valve closed to trap the sediment inside the tube. The pipe was positioned over a bucket (stainless steel) in the boat, the flap valve was detached, and the sediment was allowed to flow into the bucket. This was repeated at several points across the Canal at each site. When all cores at one site were collected, the resulting sample was well mixed and partitioned for shipment to the various laboratories for analyses.

2.2.3 Sample Treatment

The manner of dividing the samples into portions for the various analyses is shown on Table 2.4.

2.2.4 Analyses

Analyses of the sediments were made of some engineering properties and some chemical characteristics. The engineering properties tests were conducted on dried samples. For the chemical characteristics, the samples were divided into several portions for analyses of wet solids, dried solids, centrifuged solids, centrate, gravity-settled interstitial waters. Not all analyses were performed for all of the constituents on all of the fractions

of samples. The fractions selected for each analysis are shown on Table 2.5.

Fecal coliforms were enumerated for several of the gravity-settled interstitial waters and special samples were taken near South Bound Brook for asbestos counting.

2.2.4.1 Chemical Characteristics

The results of the chemical analyses are shown on Tables 2.6-2.11. The Appendices to Chapter 2 contain 2.1 Asbestos data from Princeton Testing Lab, 2.2 Fecal coliform data from N.J. Testing Lab, and 2.3 the USEPA EP extraction procedure.

2.2.4.2 Engineering Soil Characteristics

Analyses to determine their engineering properties were performed on the dried sediment from 33 sampling sites.* The samples from each location were drained, dried at room temperature, crushed and sieved.

The measurements included:

- 1) determination of the specific gravity of the sediment particles;
- 2) determination of the liquid limit (LL) and the plastic limit (PL);
- 3) calculation of the plasticity index (LL-PL);
- 4) determination of the particle-size-distribution by sieving for sizes larger than 270 mesh screen (0.053 mm diameter) and using the hydrometer method for smaller particles.

Each sample was then classified in accordance with the Unified Soil Classification System, described, and its drainage characteristics deduced. The results of these tests are shown on Table 2.12. Curves showing the particle-size-distribution of each sample are presented in Appendix 2.4.

* Insufficient sample at Site D-15 for testing

The Canal's sediments are classified as silt with a large fraction of fine sand and some clay. Most of the sediment has fair to poor drainage characteristics. This will permit reasonably easy dewatering of the spoil, be it in the Canal or in a dewatering lagoon. The sediment's specific gravity of about 2.5 indicates quartz origin plus organic matter. The liquid limit and plasticity index values indicate that silt-sized particles predominate in the sediment. As shown on the particle sized distribution curves (Appendix 2.4) the sediments vary from sand to clay silt.

2.3 Location of Possible Disposal Sites

The amount of sediment to be dredged and disposed of is considerable. From Table 2.1 it is seen that the estimated volume is 850,000 cu.yds. The spoils may be spread on land, put into a landfill, or disposed of at sea. The selection of the sites will depend upon quality of the sediment and availability of disposal sites.

2.3.1 Landfill

The N.J. Department of Environmental Protection, Solid Waste Administration has the responsibility for licensing and supervising landfills in the State of New Jersey (Ref. 2.4). The list of operating commercial sanitary landfills registered to accept dredge spoils is given on Table 2.13. As discussed in Chapter 3, landfilling may be required for some of the spoils because sediment chemical characteristics may preclude land spreading.

2.3.2 Land-Spreading

Dredged sediment can be spread on farms, parks, golf courses, etc., unless it is chemically or physically unsuited. Much of the sediment is from erosion

of farm land and return there may be desirable. A discussion of land spreading is included in Chapter 3.

2.3.3 Ocean Dumping

One of the options considered for spoil disposal is ocean dumping. Authorization from the New York District of the U.S. Army Corps of Engineers is required for dumping spoils into the ocean.

In order to obtain authorization to dispose of the dredged spoil in the Atlantic Ocean at the Interim Mud Dump, located six nautical miles east of Sandy Hook, NJ, the Corps requires the submission of the following: (as outlined in a letter received by one of the principal investigators)

- "1. Updated information regarding the need for dredging, including volume and area to be dredged, extent of shoaling, interruption or changes in standard operations resulting from the shoaling, any available documentation showing problems resulting from the shoaling, etc.
2. Updated justification and documentation concerning the applicant's study of alternate methods and means of disposing the dredged material, as well as the reasons for having rejected these alternatives and why the ocean dumping is required. No material may be ocean dumped unless there is a demonstrated need to do so. Specific disposal sites which have been considered, environmental considerations, local offices approached for assistance, and economic factors that make the locations, other than ocean disposal, economically unfeasible should be addressed.

3. Two copies of the results of testing as explained in the enclosed manual entitled "Guidance for Performing Tests on Dredged Material to be Disposed of in 'Ocean Waters'."
4. Appropriate laboratory certification of compliance with New York District guidance.
5. Two copies of a 8 1/2" x 11" map showing the area to be dredged and the specific location of the sampling sites as well as the date of the sampling.
6. Dimensions of the dump vessel (length, width and volume of hopper), type of dump vessel (split hull or pocket) and a general description of the dumping operation including vessel speed while dumping and duration of dump. . . . "

The tests required under item 3 involve a minimum of three samples. Each sample is divided into three parts, a liquid phase, a particulate phase, and a solid phase. The liquid phase is subjected to chemical analysis and a 96 hour bioassay, the particulate phase to a 96 hour bioassay and the solid phase to a ten day bioassay and a bioaccumulation potential.

The spoils would have to be transported in trucks and tankers to piers which could accommodate the dump scows. The closest location of existing piers in the Raritan River is downstream of the New Jersey Turnpike Bridge in Edison, NJ. On the Delaware River the location is downstream of Trenton.

According to the Corps of Engineers requirements, ocean dumping may be permitted only if there is a demonstrated need to do so and where other methods are economically unfeasible.

Based on the need to rehandle the spoil and the large haul distances, the costs of ocean dumping may well be excessive. Ocean dumping, then, is an alternative only if the material is suitable and no other spoil site can be obtained .

2.4 Transporting Dredged Material

The dredge spoil must be transported to dewatering sites or sites for final disposal. Depending upon the dredging condition (wet, dry, or partially drained) and the equipment used, the transport of the spoil may be by pipeline, barge, railroad hopper-car, truck, or tanker. The choice of equipment may be further limited by the location of the dewatering and disposal sites and the selection of the routes to be used. These are discussed below.

2.4.1 Conveyance

Although the Delaware and Raritan Canal is close to and parallels the Delaware, Millstone, and the Raritan Rivers, these bodies of water are too shallow to support a barge (except possibly downstream of Trenton); the use of a barge or scow is not feasible. Railroad hopper-cars can also be ruled out since the rails have been removed from the railroad beds paralleling the Canal above Trenton. It is, however, conceivable that rails could be reinstalled. The only feasible transport conveyances remain pipelines for dredging in the wet condition, trucks for dredging in the dry condition, or pipelines and tankers for dredging in the partially drained condition.

If a hydraulic dredge such as the "Mud Cat" is used, spoil can be deposited as much as 2000 to 3000 feet away using lightweight eight-inch diameter plastic pipe. Distances up to 2 miles are attainable by using a booster pump. Longer distances might be possible, depending on the static head and friction head requirements.

For dredging in the dry and for hauling material from a dewatering site to one of final disposal, highway trucks or truck-trailers appear to be the only feasible transport. These vehicles can carry 20 tons and more, depending on the number of axles. Truck bodies should be tight and covered to prevent spillage during the haul.

2.4.2 Routes to Dewatering and Disposal Sites

With the exception of pipelines, which can be routed within the confines of the Canal, transport of the spoil will be by tanker or truck routed through the excellent network of roads and highways adjacent to the Canal.

Railroad beds parallel the Canal from Raven Rock to Trenton and in some locations downstream of Trenton. These roadbeds can be used as haul roads or rails could be reinstalled. Empty trucks would enter at the upper end of a reach, move to the loading area, be loaded and exit at the lower end of a reach, moving onto the highways to the location of final disposal. The railroad roadbed is generally in excellent condition; however, certain lengths might have to be rebuilt or reconstructed. A bike trail may be built on segments of this roadbed - Washington Crossing to Trenton Battle Monument. If there is to be rebuilding, a bike trail and possibly other recreational uses and haul road uses should be considered together. Some of the railroad bridges, such as the bridge over the Lockatong, will have to be checked for strength and rebuilt if necessary.

Route 29 parallels the Canal from Raven Rock to Trenton and will be used as the primary road to haul the spoil. In some areas the road is so close to the Canal that it is possible, with proper traffic control, to dredge or to load onto trucks stationed on the highway.

In the City of Trenton, there are many streets that cross over the Canal. These will be the primary haul roads. It will probably be necessary to limit the size of the trucks to be used in this area. Use of conveyor belts may be necessary.

With the exception of a few locations, the Canal downstream of Trenton is paralleled by good paved secondary roads such as Canal Road in the vicinity of Bound Brook. These are the roads for access and transport to the dewatering or disposal sites.

Some limitations on road use, i.e. 7-9 a.m. and 4-6 p.m. may be necessary.

2.5 Dry Dredging - Maintaining the Water Supply

If dredging is to be done in the dry, provision must be made to insure an adequate supply of raw water to the water purveyors having sales contracts with the WSFE. Table 1.1 of Ref. 1.1 lists these customers. Table 1.3 of the same reference indicates alternative water supply sources for these customers.

The State Water Supply Facilities Element is proposing to pump Raritan River water into the Canal at the confluence of the Raritan and Millstone Rivers near the Elizabethtown Water Company intake. Water from the Raritan River, augmented by releases from the Spruce Run-Round Valley Reservoirs, would be pumped into the Canal at this location to supply the New Brunswick Water Department and the Middlesex Water Company. Water could also be pumped to the upstream side of Ten Mile Lock in order to supply the North Brunswick Water Department. If, in addition, pumps are installed to raise water from the downstream side to the upstream side of the locks at Griggstown and at Kingston, the Stony Brook plant of the Elizabethtown Water Company (Princeton Water Company) could be supplied with water. An alternate scheme would use water from the Millstone River or Lake Carnegie to feed the Stony Brook plant. Damming the Canal downstream of Duck Pond Run for use as a reservoir would be still another alternative.

2.5.1 Sequential Cofferdamming Plan

A comprehensive plan can be developed to sequentially dry up reaches of the Canal while maintaining service to the major water purveyors. A typical plan could be as follows:

Construct a cofferdam in the Canal upstream of the Diamond Shamrock intake (mile 27.3) and feed the Canal downstream of the cofferdam by the Raritan River pumping system described above. Place a cofferdam at the Canal intake. This will dry up 27 miles at the head end of the Canal. Inflows from the Lockatong and Wickecheoke Creeks will have to be controlled. A recommendation for permanent diversion at each location to bypass these flows is stated elsewhere in this report (Section 4.1.2). If these diversions are not available, temporary cofferdams and pumping facilities will be required for the period of time required to dredge to the Lambertville Locks.

All of the customers in this reach with the exception of the Thikol Corporation, the Trenton Country Club, the Mercer County Park Commission (Belle Mountain) and the Lambertville Water Company will be supplied with water. These four customers can operate without Canal water for a considerable period of time.

With the cofferdams in place, dredge the Canal from the intake to the Lambertville Locks, a distance of about 8 miles. Remove the intake cofferdam and close the gates at the Lambertville Locks. Water will then spill back to the Delaware River at Lambertville and still keep the lower section dry.

Dredge the next section from Lambertville to Washington Crossing, a distance of about 6.5 miles. Place a cofferdam in the Canal just downstream of the spillway (mile 13.64) at the Washington Crossing Bridge and waste the water to the Delaware River through the adjacent creek. Dredge the next section to the Diamond Shamrock Intake, a distance of about 13.5 miles.

Next, build a cofferdam just upstream of the Stony Brook Water Treatment Plant intake (mile 30.9). Remove the cofferdam at the Washington Crossing Bridge and waste the water to the Shipetaukin Creek at the

cofferdam upstream of the Diamond Shamrock intake. Provide a temporary hookup to the Diamond Shamrock plant. In this reach, the Mercer County Park Commission and Vacarro Brothers will not be served with Canal water. They can operate for a time without Canal water. Dredge between the two cofferdams (a distance of about 3.5 miles).

Next, move the cofferdam from upstream to downstream of the Stony Brook plant. Remove the cofferdam at the Diamond Shamrock intake and remove the pumping equipment that pumps Raritan River water upstream of the Griggstown and Kingston Locks. This would dry up the Canal from the Stony Brook plant to the Griggstown Lock. The Springdale Golf Club, Princeton University and the Princeton Nurseries will not be supplied with Canal water. The Springdale Golf Club and the Princeton Nurseries use Canal water for irrigation purposes and would not be affected if dredging were done at a time other than the summer time. Princeton University uses Canal water for fire standby and for cooling at the Forrestal Laboratories. Other sources would have to be made available for the University. Dredge this reach, a distance of about 8 miles.

Next, construct a cofferdam just upstream of the North Brunswick Water Department intake. Remove the Stony Brook cofferdam and waste the Canal water at the Griggstown Lock. Dredge between the Griggstown Lock and the North Brunswick cofferdam, a distance of about 3 miles.

Finally, move the cofferdam at the North Brunswick plant downstream of the intake and stop pumping Raritan River water above Ten Mile Lock. This will dry up the reach between the North Brunswick plant and Ten Mile Lock. Dredge this section a distance of about 6.5 miles.

Dredging of the Canal down stream of Ten Mile Lock in the dry condition appears to be extremely difficult. Alternate sources of water for

the Middlesex Water Company and the New Brunswick Water Department would have to be provided. Both water purveyors have interconnections with other systems.* If these could be strengthened and dredging scheduled during periods of low water demand then dredging this last reach in the dry condition might be possible.

The sequences described above could be altered to dredge sections in any order of priority. Cofferdams can be eliminated at locations where existing locks have adequate flow shutoff arrangements.

2.6 Cultural Resources

Certain data on cultural resources are necessary before an environmental assessment can be made (see Chapter 4.0). Cultural resources include prehistoric and historic period archeological sites, historic structures and historic districts, and possibly sites of particular aesthetic importance. The cultural resources data obtained for this study are presented on Figures 2.4 and 2.5. The information was provided by Mr. Jonathan Gell of the Review and Compliance Section, Office of Cultural and Environmental Services, New Jersey Department of Environmental Protection. It includes State and National Register properties through 1979, resources discovered or identified in the course of professional surveys for environmental impact reports, information from the Hunterdon County Historic Sites Survey, and from the Middlesex County Historic Sites Survey, 1979.

Other data was obtained from THE STATE AND NATIONAL REGISTERS OF HISTORIC PLACES (Ref. 2.7) 1979 and from eight strip maps as part of the DELAWARE AND

* The Middlesex Water Company well system and its connections to the Elizabethtown Water Company are not adequate at this time. New Brunswick could overdraft the Lawrence Brook Reservoir system and draw some water from the Elizabethtown Water Company. These alternate arrangements would have to be thoroughly investigated.

RARITAN CANAL STATE PARK MASTER PLAN (Ref. 1.7) 1977. It should be noted that the Delaware and Raritan Canal is listed on the Historic Register.

The data shown on Figs. 2.4 and 2.5 are illustrative only and for general guidance and does not profess to show all sensitive cultural resources that might be impacted by the dredging program.

A list of Canal Artifacts prepared for the Canal Commission by historic preservation architects is given in Appendix 2.5.

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TABLE 2.1
 PRELIMINARY ESTIMATES OF
 SEDIMENT DEPOSITIONS ALONG THE CANAL

	PERCENT OF CANAL LENGTH AT INDICATED SEDIMENT DEPOSITION IN 10 ³ cu. yds./mi.					ESTIMATED SEDIMENT cu. yds.	
	0-5	5-10	10-20	20-40	over 40	per mile	Total
Inlet Section, -0.77 to 0.0	1.3	-	98.7	-	-	14,800	11,400
Inlet to Prallsville Lock, 0.0 to 2.93	17.4	14.0	41.3	24.9	2.4	16,250	47,600
Prallsville Lock to Lambertville Lock, 2.93-7.19	0.2	12.7	68.1	19.0	-	17,000	71,900
Lambertville Lock to Upstream of Trenton Culvert, 7.19-22.06	13.5	40.8	45.0	0.3	0.4	10,400	155,000
Trenton Culvert, 22.06-23.2							East channel: 433 yd ³ West channel: 5310 yd ³ - 5,743
Downstream of Trenton Culvert to Kingston Lock, 23.2-35.19	50.8	21.5	10.7	17.0	-	9,600	115,000
Kingston Lock to Griggstown Lock, 35.19-39.49	12.3	20.2	4.4	37.5	25.6	25,000	108,600
Griggstown Lock to Ten Mile Lock, 39.49-49.09	0.73	0.21	58.2	35.8	5.1	22,000	209,250
Ten Mile Lock to South Bound Brook Lock, 49.09-51.46	-	0.8	45.6	53.6	-	23,000	54,450
South Bound Brook Lock to Five Mile Lock, 51.46-53.18	0.6	1.7	15.0	22.7	60.0	36,000	62,300
Five Mile Lock to end 53.18-end							negligible 841,243
							Say 850,000

Note: Sediment deposition rates were computed based on the differences between existing and design cross sectional areas of the Canal, except the Trenton Culvert in which estimations were based on sediment depths measured by Walker Diving Contractors, Inc.

Table 2.2

DESCRIPTION OF SAMPLING SITES WHERE
SEDIMENT SAMPLES WERE DRAWN

<u>Site No.</u>	<u>Milepost</u>	
D-1	- .70	Canal Inlet - shallow area ~50 ft. from Delaware River. Sediment: 2 ft.-3 ft. sandy sample taken.
D-2	.00	Just upstream of Raven Rock Lock ~200 ft. upstream of lock → 1.5 ft. sediment (large buildup within 5 ft. of lock). Sediment: 1.5 ft.-4 ft.
D-3	2.90	Between Wickecheoke Creek and Prallsville Lock. Sediment: <1 ft.
D-4	3.40	Stockton Bridge - no sediment in main channel - sample taken 50 ft. downstream of bridge near bank. Sediment: 0 ft.-5 ft.
D-5	5.05	100 yds. downstream of mining site and railroad bridge on Route 29 - little sediment in main channel, samples taken 8 ft. from bank. Sediment: ~3 ft.
D-6	6.00	~1 mile past site D-5, 25 ft.-100 ft. downstream of a railroad bridge. Sediment: 5 ft.-6 ft.
D-7	6.64	Lambertville - next to a bridge ~1/4 mile upstream of bridge to New Hope, PA. Sediment: ~1 ft.
D-8	7.10	At southern end of Lambertville - last turnoff of Route 29 in Lambertville. Sediment: 1 ft.-5 ft.
D-9	10.05	On Route 29 across from road to Belle Mt. Ski Area. No sediment in main channel. Sediment: 0 ft.-3 ft.
D-10	12.45	Titusville Bridge - no sediment right at bridge - sample taken ~100 yds. upstream. Sediment: 0 ft.-1 ft.
D-11	15.00	1/2 mile upstream of Jacobs Creek Rd. off Route 29. Sediment: 0 ft.-1 ft.
D-12	18.10	Lower Ferry Rd. (West Trenton) 50 ft. upstream of gaging station. Sediment: 1 ft.-2 ft.

<u>Site No.</u>	<u>Milepost</u>	
D-13	19.05	Trenton-Sullivan Way Aqueduct-3/4 mile downstream of Lower Ferry Road. Sediment: 0 ft.-6 ft.
D-14	21.15	Trenton; 2 bridges past Prospect St. (West Hanover St.). Sediment: 0 ft.-4 ft.
D-15	22.05	Inlet to Trenton Culvert (little sediment could be collected right at inlet). Sediment: 0 in.-6 in. (right at inlet)
D-16	23.21	Mulberry St. Trenton - Outlet of culvert. Sample taken -100 ft. downstream, little sediment right at culvert exit. Sediment: 0 ft.-5 ft.
D-17	26.49	East Trenton - At Mercer Co. 546 Bridge over the Canal. Sediment: 0 ft.-4 ft.
D-18	28.80	Port Mercer-Provincetown Rd. 200 yds. north of Quakerbridge Rd. Bridge. Sediment: 0 ft.-5 ft., ave. depth 1.5 ft.
D-19	32.96	At Millstone River Aqueduct - Sample taken 100 ft. downstream of aqueduct. Sediment: 2 ft.-3 ft.
D-20	35.18	Kingston Lock (just upstream of lock (~200 ft.)) Sediment: 4 ft.+
D-21	37.12	Washington Road Bridge over the Canal. Sample taken 50 ft.-100 ft. downstream of bridge. Sediment: 3 ft.-4 ft.
D-22	40.17	Griggstown Bridge - Sample taken 30 ft.-50 ft. downstream of bridge. Sediment: 1 ft.-2 ft.
D-23	43.45	Canal Road, 1/4 mile upstream of Blackwell Mills. Sediment: 1 ft.-2-1/2 ft.
D-24	43.69	Blackwell Mills Bridge over Canal. Sample taken 1000 ft. upstream of bridge. Sediment: 1 ft.-2-1/2 ft.
D-25	45.70	Industrial site in East Millstone. Sample taken right at concrete wall of plant. Sediment sparse but a localized area of 4 ft. of sediment. Sediment: 0 ft.-4 ft., ave. depth: 6 in.
D-26	45.79	East Millstone-Amwell Road Bridge. Sample taken within 100 ft. of bridge. Sediment: 2 ft.-3 ft.

<u>Site No.</u>	<u>Milepost</u>	
D-27	47.92	Weston Causeway Bridge - No sediment right at bridge - sample taken upstream. Sediment: <1 ft.
D-28	49.10	Downstream of 10 mile lock - sample taken within 50 yds. of lock. Sediment: 1 ft.-2-1/2 ft.
D-29	50.6	100 yds. upstream of Route 287 bridge. Little sediment throughout channel. Sample taken near fallen log. Sediment: <1 ft.
D-30	51.45	Upstream of South Bound Brook Lock. All samples taken within 200 ft. of lock. Sediment: 1-1/2 ft.-2 ft.
D-31	51.51	South Bound Brook - just downstream of lock - sample taken within 100 ft. of lock. Sediment: 1 ft.-3 ft.
D-32	51.81	Industrial Site in South Bound Brook. Sample taken ~100 ft. upstream of railroad bridge over Canal. Sediment: 3 ft.-5 ft.
D-33	51.90	South Bound Brook - downstream of railroad bridge. Sediment: 0 ft.-2 ft.
D-34	53.15	100 ft. upstream of 5 Mile Lock. Sediment buildup between a concrete culvert and 5 Mile Lock. Sediment: 2 ft.-3 ft.

TABLE 2.3
TREATMENT OF SAMPLES

<u>Sample Fraction</u>	<u>Procedures for Treating Samples Before Analysis</u>
Wet Solids	(1) Drain off interstitial water
Dry Solids	(1) Drain off interstitial water (2) Dry at room temperature (3) Crush, sieve
Centrifuged Solids	(1) Centrifuge at 2000 rpm for 20 min. (2) Decant centrate
Unfiltered Centrate	(1) Centrifuge at 2000 rpm for 20 min. (2) Decant centrate
Filtered Centrate	(1) Filter unfiltered centrate using Whatman 42 filter paper
Interstitial Water	(1) Drain off and collect interstitial water
Gravity Settled Interstitial Water	(1) Drain off and collect interstitial water (2) Let settle for up to 3 days (3) Carefully decant and collect upper portion of sample

TABLE 2.4

TESTS - RELATIONSHIPS. SAMPLE FRACTION.

Analyses	Table	Sediment Fraction(s) Tested	Reference	Lab	Comments
Asbestos	2.7b	Dry Solids	Electron Microscope	RCE	Sample taken of pile along the Canal in South Bound Brook
	2.11b	Gravity settled interstitial water	LM (see Appendix)	PT	
Chromatographable Oils	2.7c	Dry solids	State #300.1 (Modified)	RES	
Chemical Oxygen Demand(COD)	2.7a	Dry Solids	SM (Standard Methods)	RCE	Samples soaked for 24 hours in distilled water
	2.9b	Unfiltered Centrate	SM	RCE	
EP Extraction Procedure (metals)	2.6b	Wet Solids	Federal Register May 19, 1980	RSC	
Fecal Coliform	2.11a	Gravity settled	(see Appendix)	NJL	
Total Metals	2.8	Centrifuged Solids	Perchloric Acid Extraction, SM	RSC	
	2.10	Filtered Centrate	SM	RSC	
<u>Nutrients</u> Total Phosphorus	2.7a	Centrifuged Solids	Perchloric Acid Extraction, SM	RSC	
Total Kjeldahl Nitrogen	2.7a	Dry Solids	SM	RCE	
Oil and Grease	2.7a	Dry Solids	Gravimetric method	RCE	
Pesticides and PCBs	2.6a	Wet Solids		RES	

TABLE 2.4
(continued)

Analyses	Table	Sediment Fraction(s) Tested	Reference	Lab	Comments
<u>Solids Analysis</u> Total Residue Dried at 103-105 C	2.9b	Unfiltered Centrate	SM		RCE
Total Fixed Residue at 550 C	2.9b	Unfiltered Centrate	SM		RCE
Total Volatile Residue at 550 C	2.9b	Unfiltered Centrate	SM		RCE
Engineering Properties	2.12	Dry Solids			RCE

Abbreviations:

SM	Standard Methods for Examination of Water and Wastewater
LM	Light Microscope
RCE	Rutgers College of Engineering
RES	Rutgers Environmental Science
RSC	Rutgers Soils and Crops
PT	Princeton Testing Labs Inc.
NJL	New Jersey Laboratories Inc.

TABLE 2.5a

ANALYSES ON WET SOLIDSOrganochlorine Pesticides, Polychlorinated Biphenyls and Herbicide Fraction
(milligram/kilogram)

<u>Compound</u>	<u>Sample from Site</u>					
	D-2	D-4	D-6	D-8	D-11	D-13
Aroclor 1016	ND	ND	ND	ND	ND	ND
Aroclor 1242	↓	↓	↓	↓	↓	↓
Aroclor 1248	0.43	↓	0.46	0.43	0.40	↓
Aroclor 1254	ND	↓	ND	ND	ND	↓
α BHC	↓	↓	↓	↓	↓	↓
γ BHC (Lindane)	↓	↓	↓	↓	↓	↓
β BHC	0.13	↓	↓	↓	0.15	0.61
heptachlor	ND	↓	↓	↓	ND	ND
aldrin	↓	↓	↓	↓	↓	↓
heptachlor epoxide	↓	↓	↓	↓	↓	↓

ND - Not Detected

TABLE 2.5a
(continued)

ANALYSES ON WET SOLIDS

Organochlorine Pesticides, Polychlorinated Biphenyls and Herbicide Fraction
(milligram/kilogram)

<u>Compound</u>	<u>Sample from Site</u>					
	D-16	D-17	D-18	D-20	D-21	D-25
Aroclor 1016	ND	ND	ND	ND	ND	ND
Aroclor 1242	↓	↓	↓	↓	↓	↓
Aroclor 1248	6.8	↓	↓	↓	↓	↓
Aroclor 1254	ND	↓	↓	↓	↓	↓
α BHC	↓	↓	↓	↓	↓	↓
γ BHC (Lindane)	↓	↓	↓	↓	↓	↓
β BHC	2.8	0.73	0.081	0.26	0.058	↓
heptachlor	ND	ND	ND	ND	ND	↓
aldrin	↓	↓	↓	↓	↓	↓
heptachlor epoxide	↓	↓	↓	↓	↓	↓

ND - Not Detected

TABLE 2.5a
(continued)

ANALYSES ON WET SOLIDS

Organochlorine Pesticides, Polychlorinated Biphenyls and Herbicide Fraction
(milligram/kilogram)

<u>Compound</u>	<u>Sample from Site</u>		
	D-28	D-32	D-33
Aroclor 1016	ND	ND	ND
Aroclor 1242	↓	↓	↓
Aroclor 1248			
Aroclor 1254			
α BHC			
γ BHC (Lindane)	↓	↓	↓
β BHC	0.23	0.85	0.80
heptachlor	ND	ND	ND
aldrin	↓	↓	↓
heptachlor epoxide	↓	↓	↓

ND - Not Detected

TABLE 2.5a
(continued)ANALYSES ON WET SOLIDSOrganochlorine Pesticides, Polychlorinated Biphenyls and Herbicide Fraction
(milligram/kilogram)

<u>Compound</u>	<u>Sample from Site</u>					
	D-2	D-4	D-6	D-8	D-11	D-13
γ chlordane	ND	ND	ND	ND	ND	ND
p,p' - DDE	0.033	↓	0.021	↓	↓	0.054
dieldrin	ND	↓	ND	↓	↓	ND
endrin	↓	↓	↓	↓	↓	↓
o,p' - DDT	↓	↓	↓	↓	↓	↓
p,p' - DDD	0.021	↓	0.021	↓	↓	↓
p,p' - DDT	ND	↓	ND	↓	↓	↓
mirex	↓	↓	↓	↓	↓	↓
methoxychlor	↓	↓	↓	↓	↓	↓
toxaphene	↓	↓	↓	↓	↓	↓

ND - Not detected

TABLE 2.5a
(continued)

ANALYSES OF WET SOLIDS

Organochlorine Pesticides, Polychlorinated Biphenyls and Herbicide Fraction
(milligram/kilogram)

<u>Compound</u>	<u>Sample from Site</u>					
	D-16	D-17	D-18	D-20	D-21	D-25
γ chlordane	ND	0.026	0.059	0.010	0.010	0.024
p,p' - DDE	↓	0.069	0.034	0.020	0.037	0.067
dieldrin	↓	ND	ND	ND	ND	ND
endrin	↓	↓	↓	↓	↓	↓
o,p' - DDT	↓	↓	↓	↓	↓	↓
p,p' - DDD	↓	↓	↓	0.049	↓	0.045
p,p' - DDT	↓	↓	↓	ND	↓	ND
mirex	↓	↓	↓	↓	↓	0.10
methoxychlor	↓	↓	↓	↓	↓	ND
toxaphene	↓	↓	↓	↓	↓	↓

ND - Not detected

TABLE 2.5a
(continued)ANALYSES OF WET SOLIDSOrganochlorine Pesticides, Polychlorinated Biphenyls and Herbicide Fraction
(milligram/kilogram)

<u>Compound</u>	<u>Sample from Site</u>		
	D-28	D-32	D-33
γ chlordane	0.028	ND	ND
p,p' - DDE	0.030	0.19	0.026
dieldrin	ND	ND	ND
endrin	↓	↓	↓
o,p' - DDT	↓	↓	↓
p,p' - DDD	0.047	0.028	↓
p,p' - DDT	ND	ND	↓
mirex	↓	↓	↓
methoxychlor	↓	↓	↓
toxaphene	↓	↓	↓

ND - Not detected

TABLE 2.5b
EP TOXICITY ANALYSES ON WET SOLIDS
Heavy Metals
(milligram/liter)

Element	Sample										
	D-1	D-2	D-4	D-5	D-6	D-7	D-8	D-9	D-10	D-11	D-12
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cr	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Cu	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Mn	3.2	3.2	.27	2.6	.93	1.2	1.6	.64	.35	.25	3.4
Ni	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9
Pb	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	ND
Zn	1.5	.38	.09	.38	1.06	1.06	.68	.09	.22	.35	2.4

TABLE 2.5b
(continued)

EP TOXICITY ANALYSES ON WET SOLIDS

Heavy Metals
(milligram/liter)

<u>Element</u>	<u>Sample</u>										
	D-13	D-14	D-16	D-17	D-18	D-19	D-20	D-21	D-22	D-23	D-24
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cr	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Cu	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Mn	1.4	1.4	1.2	1.5	.52	.56	1.8	.35	1.1	1.5	1.2
Ni	↓	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pb	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Zn	.19	.86	1.5	1.4	.08	.08	.72	.05	.15	.05	.1

TABLE 2.5b
(continued)

EP TOXICITY ANALYSES ON WET SOLIDS

Heavy Metals
(milligram/liter)

<u>Element</u>	<u>Sample</u>									
	D-25	D-26	D-27	D-28	D-29	D-30	D-31	D-32	D-33	D-34
Cd	ND	ND	ND	ND	ND	ND	ND	2.8	ND	ND
Cr	↓	↓	↓	↓	↓	↓	↓	ND	↓	↓
Cu	↓	↓	↓	↓	↓	↓	↓	.09	↓	↓
Mn	2.7	1.1	1.6	.51	.96	2.2	2.2	4.6	3.0	2.6
Ni	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pb	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Zn	1.4	.8	.4	.06	.08	.54	.61	.85	3.1	.31

TABLE 2.6a
ANALYSES ON DRIED SOLIDS
Oil and Grease, Chemical Oxygen Demand (COD),
Total Organic Carbon (TOC), Total Nitrogen, Total Phosphorus
(milligrams/gram)

<u>Test</u>	<u>Sample</u>										
	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	D-9	D-10	D-11
Oil and Grease	3.25	2.30	1.62	2.52	3.18	2.89	3.01	3.11	1.89	3.61	3.51
COD* <#270	106.5	70.0	76.9	79.7	139.1	57.8	51.2	101.2	59.8	95.1	79.5
COD** #270<x<#10	78.3	74.5	91.4	164.8	190.1	155.7	126.6	175.3	164.7	162.9	140.5
TOC	29	22	16	19	16	11	15	29	9	16	15
Total Nitrogen	-	-	-	11.7	-	-	-	9.88	-	-	-
Total Phosphorous	-	-	-	-	-	-	-	.974	-	-	-

* Passes #270 sieve

** Passes #10 and retained on #270 sieves

TABLE 2.6a
(continued)

ANALYSES ON DRIED SOLIDS

Oil and Grease, Chemical Oxygen Demand (COD),
Total Organic Carbon (TOC), Total Nitrogen, Total Phosphorus
(milligrams/gram)

<u>Test</u>	<u>Sample</u>										
	D-12	D-13	D-14	D-15	D-16	D-17	D-18	D-19	D-20	D-21	D-22
Oil and Grease	3.60	2.08	11.23	14.90	22.48	6.22	1.96	2.12	2.72	5.50	4.66
COD* <#270	68.7	104.5	92.0	136.6	125.6	172.7	90.3	38.7	60.4	23.8	70.5
COD** #270 <x< #10	115.9	165.1	232.4	218.3	230.1	113.5	103.3	72.8	94.5	37.9	97.6
TOC	14	23	27	31	34	30	34	12	25	7	28
Total Nitrogen	-	11.9	-	-	6.80	9.32	-	-	8.64	6.94	-
Total Phosphorous	-	1.03	-	-	-	1.27	-	.798	-	-	-

* Passes #270 sieve

** Passes #10 and retained on #270 sieves

TABLE 2.6
(Continued)ANALYSES ON DRIED SOLIDS

Oil and Grease, Chemical Oxygen Demand (COD),
Total Organic Carbon (TOC), Total Nitrogen, Total Phosphorous
(milligrams/gram)

<u>Test</u>	<u>Sample</u>											
	D-23	D-24	D-25	D-26	D-27	D-28	D-29	D-30	D-31	D-32	D-33	D-34
Oil and Grease	4.17	4.76	9.31	5.44	5.32	12.52	3.02	5.27	8.74	5.55	12.89	4.70
COD* <#270	76.6	90.8	172.6	87.5	43.0	71.5	106.8	69.0	137.3	90.7	139.8	52.1
COD** #270<x<#10	99.4	121.3	141.9	134.7	83.6	26.2	235.6	143.7	139.6	120.9	140.7	93.0
TOC	28	22	41	30	12	33	7	14	34	41	36	17
Total Nitrogen	-	-	10.4	-	-	7.89	-	-	8.06	-	7.59	-
Total Phosphorous	-	-	1.46	-	-	-	-	-	1.08	1.18	1.07	-

Chromatographable Oils
(milligram/kilogram)

	<u>Sample</u>							
	D-8	D-16	D-17	D-21	D-25	D-28	D-32	D-33
Chromatographable Oils	148	19800	1140	403	232	295	16000	2820

* Passes #270 sieve

TABLE 2.7
ANALYSES ON CENTRIFUGED SOLIDS
Heavy Metals
(milligrams/kilogram)

Element	<u>Sample</u>										
	D-1	D-2	D-4	D-5	D-6	D-7	D-8	D-9	D-10	D-11	D-12
Cd	1.8	9.8	2.4	3.4	8.5	7.4	9.9	ND	5.1	4.4	2.8
Cr	20.0	22.6	20.0	22.6	27.5	22.6	36.3	22.6	27.5	37.4	24.8
Cu	29.8	55.6	34.5	90.8	89.1	70.4	81.4	38.1	89.1	83.3	80.3
Mn	544	979	368	710	429	406	385	338	454	435	421
Ni	30.2	42.6	26.9	48.1	48.1	42.9	22.6	33.6	55.6	55.0	52.8
Pb	55	116	62.2	176	124	157	226	158	165	164	140
Zn	341	770	297	786	1155	803	175	264	946	792	720

TABLE 2.7
(continued)

ANALYSES ON CENTRIFUGED SOLIDS

Heavy Metals
(milligrams/kilogram)

<u>Element</u>	<u>Sample</u>										
	D-13	D-14	D-16	D-17	D-18	D-19	D-20	D-21	D-22	D-23	D-24
Cd	3.3	4.4	4.7	5.5	2.2	0.8	3.3	1.1	2.5	1.9	1.9
Cr	39.0	30.8	42.4	48.1	45.4	23.6	43.4	78.6	47.3	51.2	66.6
Cu	57.8	105.1	126.5	75.4	50.6	34.5	73.7	162.3	101.2	72.0	82.0
Mn	313	466	355	325	202	434	459	654	550	605	583
Ni	ND	42.6	52.8	13.8	ND	31.6	47.3	42.9	48.1	46.2	53.9
Pb	234	292	1430	503	165	82	276	198	141	129	151
Zn	103	710	1045	179	363	126	412	226	286	270	308

TABLE 2.7
(continued)

ANALYSES ON CENTRIFUGED SOLIDS

Heavy Metals
(milligrams/kilogram)

<u>Element</u>	<u>Sample</u>									
	D-25	D-26	D-27	D-28	D-29	D-30	D-31	D-32	D-33	D-34
Cd	5.0	3.6	1.6	1.4	0.8	1.9	2.8	5.5	3.3	3.8
Cr	45.4	66.6	39.0	113.8	19.8	78.7	60.5	91.9	57.8	27.5
Cu	85.3	67.1	59.4	62.1	39.9	71.5	36.9	57.8	81.4	54.8
Mn	399	498	517	610	520	529	384	770	402	605
Ni	19.3	39.C	48.1	39.0	42.9	48.1	51.7	118	33.0	47.3
Pb	462	280	142	128	96.3	176	180	154	256	148
Zn	261	2420	358	280	132	313	44.6	70.4	125	324

TABLE 2.8a
ANALYSES ON UNFILTERED CENTRATE

Trihalomethane Formation Potential (Chlorination)
 (microgram/liter)

	Sample				
	D-18	D-20	D-21	D-25	D-24
dibromomethane	ND	ND	ND	ND	ND
dichlorobromomethane	1.06		.38	.72	2.18
1,1,2 trichloroethane	ND		ND	ND	ND
dibromochloromethane					.22
1,1,2,2, tetrachloroethylene + 1,2 dibromoethane					.78
bromoform					ND
1,1,2,2, tetrachloroethane					
diiodomethane					
m-dichlorobenzene					
p-dichlorobenzene					
o-dichlorobenzene					
1,2,4 trichlorobenzene					

TABLE 2.8a
(continued)

ANALYSES ON UNFILTERED CENTRATE

Trihalomethane Formation Potential (Chlorination)
(microgram/liter)

	<u>Sample</u>				
	D-18	D-20	D-21	D-25	D-24
fluoroform	ND	ND	ND	ND	ND
methyl chloride	↓	↓	↓	↓	↓
vinyl chloride	↓	↓	↓	↓	↓
methyl bromide	↓	↓	↓	↓	↓
dichloroethylene (gem)	↓	↓	↓	↓	↓
methylene chloride	↓	↓	↓	↓	↓
t-dichloroethylene	↓	↓	↓	↓	↓
chloroform	12.4	3.92	5.74	26.1	16.3
1,1,1 trichloroethane	ND	ND	ND	ND	ND
1,2 dichloroethane	↓	↓	↓	↓	↓
carbontetrachloride	.46	.10	.98	.82	.80
1,1,2 trichloroethylene	ND	ND	ND	ND	2.52

TABLE 2.8b

ANALYSES ON UNFILTERED CENTRATE

Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Total Residue at 103-105C (TR)
Total Volatile Solids (TVS), Total Fixed Solids at 550C (TFS)
 (milligrams/liter)

<u>Test</u>	<u>Sample</u>										
	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	D-9	D-10	D-11
COD	61.0	184.3	137.8	166.7	168.2	86.2	250.0	199.2	205.5	296.2	172.4
TOC	30.0	77.1	43.0	46.7	51.2	31.5	75.6		61.0	102.2	56.7
TR	-	-	249	-	-	-	868	893	-	-	-
TVS	-	-	67.4	-	-	-	200	222	-	-	-
TFS	-	-	182	-	-	-	668	671	-	-	-
<u>Test</u>	<u>Sample</u>										
	D-12	D-13	D-14	D-15	D-16	D-17	D-18	D-19	D-20	D-21	D-22
COD	231.1	356.2	235.7	196.1	484.6	99.4	380.2	141.3	152.2	432.0	46.9
TOC	74.0		54.8	50.7	-			57.3	86.6	101.7	10.4
TR	-	1410	-	-	-	588	1820	1350	-	-	260
TVS	-	315	-	-	-	113	350	250	-	-	70
TFS	-	1095	-	-	-	475	1470	1100	-	-	190

TABLE 2.8b
(continued)

ANALYSES ON UNFILTERED CENTRATE

Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Total Residue at 103-105C (TR),
Total Volatile Solids (TVS), Total Fixed Solids at 550C (TFS)
(milligrams/liter)

<u>Test</u>	<u>Sample</u>											
	D-23	D-24	D-25	D-26	D-27	D-28	D-29	D-30	D-31	D-32	D-33	D-34
COD	122.5	301.2	78.9	99.5	346.5	543.5	590.0	216.5	71.0	137.7	102.6	564.8
TOC	69.2	58.9		25.4	97.5	71.6	-	64.9				81.7
TR	580	1730	490	-	-	254	5800	1020	380	317	574	-
TVS	130	330	100	-	-	50	880	260	85	107	122	-
TFS	450	1400	390	-	-	204	4920	760	295	210	452	-

TABLE 2.9
ANALYSES ON FILTERED CENTRATE
Heavy Metals
(milligram/liter)

<u>Element</u>	<u>Sample</u>										
	D-1	D-2	D-4	D-5	D-6	D-7	D-8	D-9	D-10	D-11	D-12
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cr	-	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Cu	.03	.04	.07	.08	.09	.08	↓	.08	.08	.08	.10
Mn	3.5	1.0	.18	.45	.29	.43	4.5	.53	.70	.51	.41
Ni	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pb	-	0.1	.13	.13	.08	.08	↓	.17	.08	.10	.19
Zn	.02	.03	.27	.34	.28	.18	.28	.25	.22	.21	.36

TABLE 2.9
(continued)

ANALYSES ON FILTERED CENTRATE

Heavy Metals
(milligram/liter)

Element	Sample										
	D-13	D-14	D-16	D-17	D-18	D-19	D-20	D-21	D-22	D-23	D-24
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cr	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Cu	↓	.04	.03	↓	↓	.02	.03	.02	.03	.05	.05
Mn	6.9	.63	.23	4.9	1.4	.08	1.07	.91	4.4	2.85	1.15
Ni	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pb	↓	.06	.13	↓	↓	.06	↓	↓	↓	↓	.06
Zn	.43	.12	.07	.27	.06	.06	.03	.04	.22	.17	.17

TABLE 2.9
(continued)

ANALYSES ON FILTERED CENTRATE

Heavy Metals
(milligram/liter)

<u>Element</u>	<u>Sample</u>									
	D-25	D-26	D-27	D-28	D-29	D-30	D-31	D-32	D-33	D-34
Cd	ND	-	ND	ND	ND	ND	ND	ND	ND	ND
Cr	↓	-	↓	↓	↓	↓	↓	↓	↓	↓
Cu	↓	-	↓	↓	↓	↓	↓	↓	↓	↓
Mn	5.5	.02	1.65	1.37	.90	.40	4.8	↓	5.9	.64
Ni	ND	-	ND	ND	ND	ND	ND	↓	ND	ND
Pb	↓	-	↓	.04	↓	↓	↓	↓	↓	↓
Zn	.53	.06	.06	.02	.03	.03	.08	↓	↓	.03

TABLE 2.10

ANALYSES ON INTERSTITIAL WATER

Fecal Coliforms

(Reported As Most Probable Number (MPN) In 100 ml.)

	<u>Sample</u>								
	D-2	D-4	D-8	D-16	D-18	D-20	D-21	D-25	D-32
MPN per 100 ml.	1,100	ND	45	ND	ND	20	ND	ND	ND

Asbestos

(Number of Fibers Greater than 5 Microns/Liter)

	<u>Sample</u>				
	D-30	D-31	D-32	D-33	D-34
Fibers/Liter	210,000	340,000	1,440,000	2,374,000	210,000

TABLE 2.11
ENGINEERING SOIL CHARACTERISTICS

<u>Site No.</u>	<u>Unified Soil Classification System</u>	<u>Specific Gravity</u>	<u>Liquid Limit(%)</u>	<u>Plasticity Index(%)</u>	<u>Soil Description</u>	<u>Drainage Characteristics</u>
D-1	SP	2.56	-	-	Poorly graded sand with little silt	Excellent
D-2	SM	2.53	36.4	-	Silty sand	Fair to poor
D-3	MH	2.52	53.5	11.0	Sandy silt	Fair to poor
D-4	ML/OL	2.52	49.0	13.8	Sandy silt with fine sand and small amounts of clay	Fair to poor
D-5	MH	2.50	55.0	12.9	Sandy silt	Fair to poor
D-6	ML	2.55	48.8	13.8	Silt	Fair to poor
D-7	ML	2.65	48.5	9.3	Sandy silt	Fair to poor
D-8	OH	-	-	-	Clayey silt with some fine sand	Poor
D-9	ML	2.56	48.4	7.9	Sandy silt with some clay	Fair to poor
D-10	OH	2.45	53.5	11.4	Clayey silt with some fine sand	Poor
D-11	ML/OL	2.58	48.5	9.8	Sandy silt with fine sand and some clay	Fair to poor
D-12	OL	2.55	48.2	9.8	Sandy silt with organic silt clay	Poor
D-13	OH	-	-	-	Clayey silt with fine sand	Poor
D-14	SM	2.53	37.4	-	Silty sand	Fair to poor
D-15	-	-	-	-	-	-
D-16	MH	2.46	52.0	14.1	Sandy silt	Fair to poor

TABLE 2.11 (continued)
ENGINEERING SOIL CHARACTERISTICS

<u>Site No.</u>	<u>Unified Soil Classification System</u>	<u>Specific Gravity</u>	<u>Liquid Limit(%)</u>	<u>Plasticity Index(%)</u>	<u>Soil Description</u>	<u>Drainage Characteristics</u>
D-17	SC	-	-	-	Clayey-silty sand	Poor
D-18	SM	-	-	-	Silty-clayey sand	Fair to poor
D-19	SM	2.61	62.6	27.6	Silty-clayey sand	Fair to poor
D-20	SC	2.55	53.8	12.7	Clayey-sand	Poor
D-21	MH	2.62	53.8	11.8	Sandy-silt	Fair to poor
D-22	ML	2.58	48.7	13.2	Sandy-silt	Fair to poor
D-23	OH	2.55	63.0	17.5	Silt	Poor
D-24	OH	2.56	62.4	21.5	Silty clay with some fine sand	Poor
D-25	SM	-	-	-	Clayey-silty sand	Fair to poor
D-26	OH	2.58	62.4	17.3	Clayey-silt	Poor
D-27	OH	2.65	63.2	28.4	Clayey-silt	Poor
D-28	ML	2.56	45.0	8.8	Silty-sand	Fair to poor
D-29	OH	2.53	53.5	9.4	Clayey-silt	Poor
D-30	OH	2.47	62.5	20.5	Clayey-silt with some fine sand	Poor
D-31	SM	-	-	-	Silty-sand with clay	Fair to poor
D-32	SM	-	-	-	Silty-sand with clay	Fair to poor
D-33	OH	-	-	-	Sandy-clayey silt	Poor
D-34	SM	2.60	36.4	-	Silty sand	Fair to poor

TABLE 2.12

CURRENTLY OPERATING COMMERCIAL SANITARY LANDFILLS
REGISTERED FOR INDUSTRIAL WASTE (I.D. #27) 4/1/79
WHICH HAVE WATER MONITORING FACILITIES

ATLANTIC COUNTY		MIDDLESEX COUNTY	
0112B	Hamilton Twp. S.L.F.	1204A*	Edgeboro Disposal Inc.
0113A	Hammonton City S.L.F.	1205A*	Edison Twp. S.L.F.
0117A	Mullica Twp. S.L.F.	1221B*	South Brunswick Twp.
BURLINGTON COUNTY		MONMOUTH COUNTY	
0304A	Parklands Reclamation	1309B	Shrewsbury Disposal S.L.F.
0308C*	Sanitary Landfill Inc.	1319B*	Waste Disposal Inc. S.L.F.
0315B*	Florence Land Recontouring		
0323A*	Landfill & Development S.L.F.		
0333A*	Big Hill S.L.F.		
CAMDEN COUNTY		MORRIS COUNTY	
		1407A*	Combe S.L.F. (Chester Site)
		1427A*	Combe S.L.F. (Mt. Olive Site)
0415C*	Amadei S.L.F.		
0427A	Pennsauken Twp. S.L.F.		
0436A	Winslow Twp. S.L.F.		
CUMBERLAND COUNTY		OCEAN COUNTY	
		1506B*	Brick Twp. S.L.F.
		1511A*	Jackson Twp. S.L.F.
		1514A	Lakewood Twp. S.L.F.
		1520A*	Southern Ocean L.F.
0601A*	Bridgeton City S.L.F.		
0602A	Commercial Twp. S.L.F.		
GLOUCESTER COUNTY		WARREN COUNTY	
		2105A	High Point Sanitation S.L.F.
0802B*	Kinsley's S.L.F.		
0811A	Monroe Twp. S.L.F.		

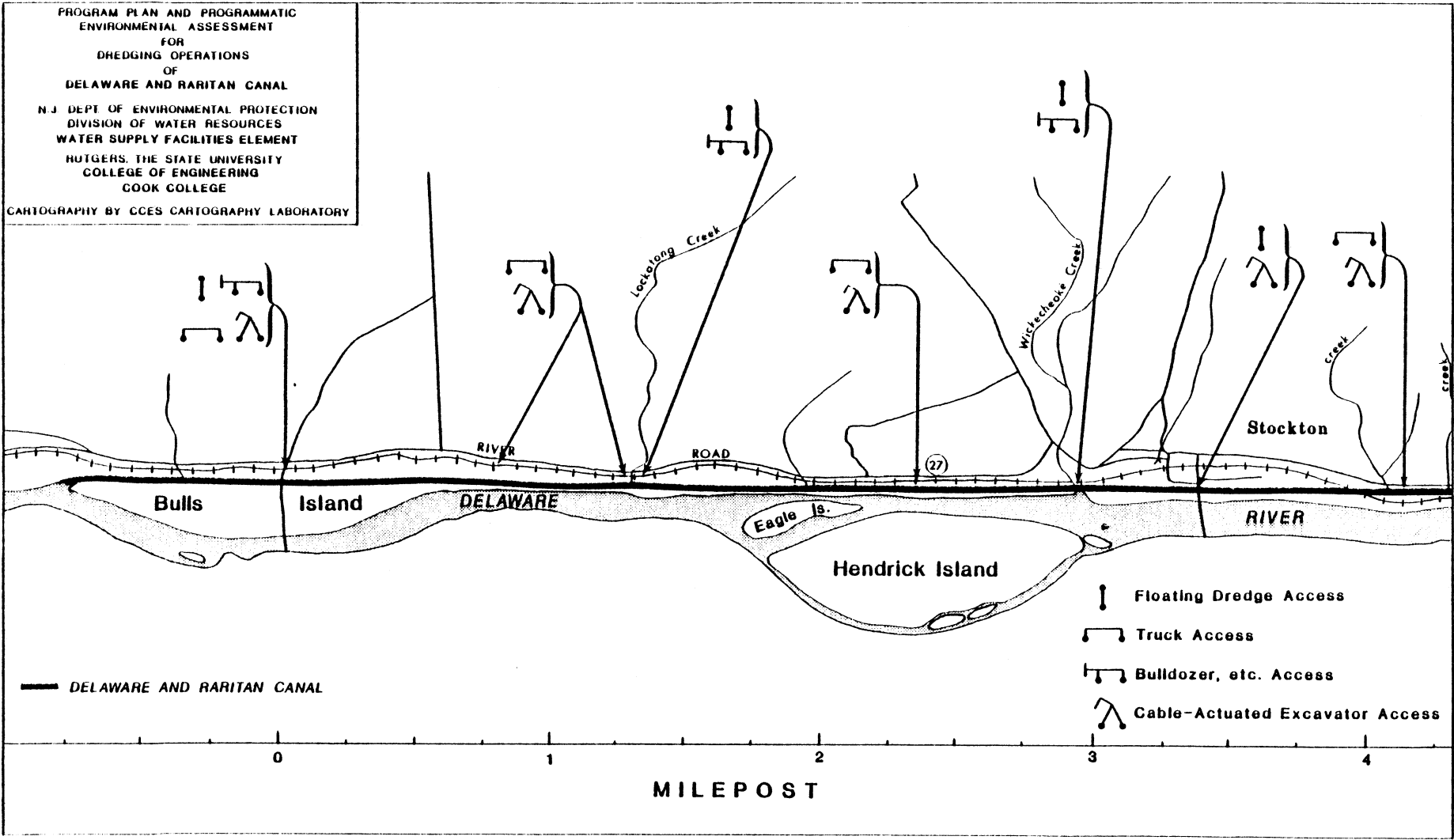
* Licensed by the Public Utilities Commission to accept wastes for disposal on a commercial basis.

List supplied by Solid Wastes Administration of NJDEP.

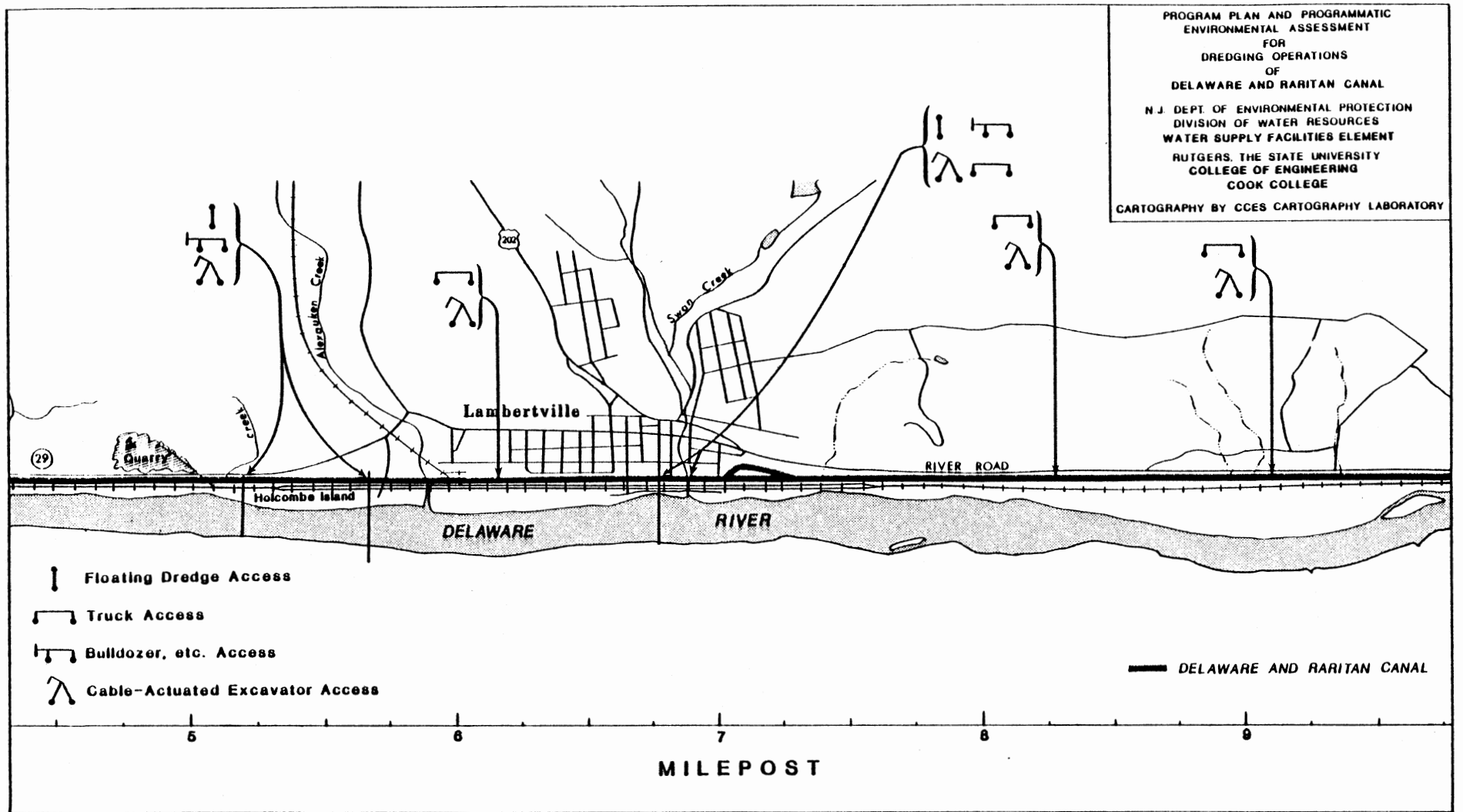
CHAPTER 2
LIST OF FIGURES

Figure No.

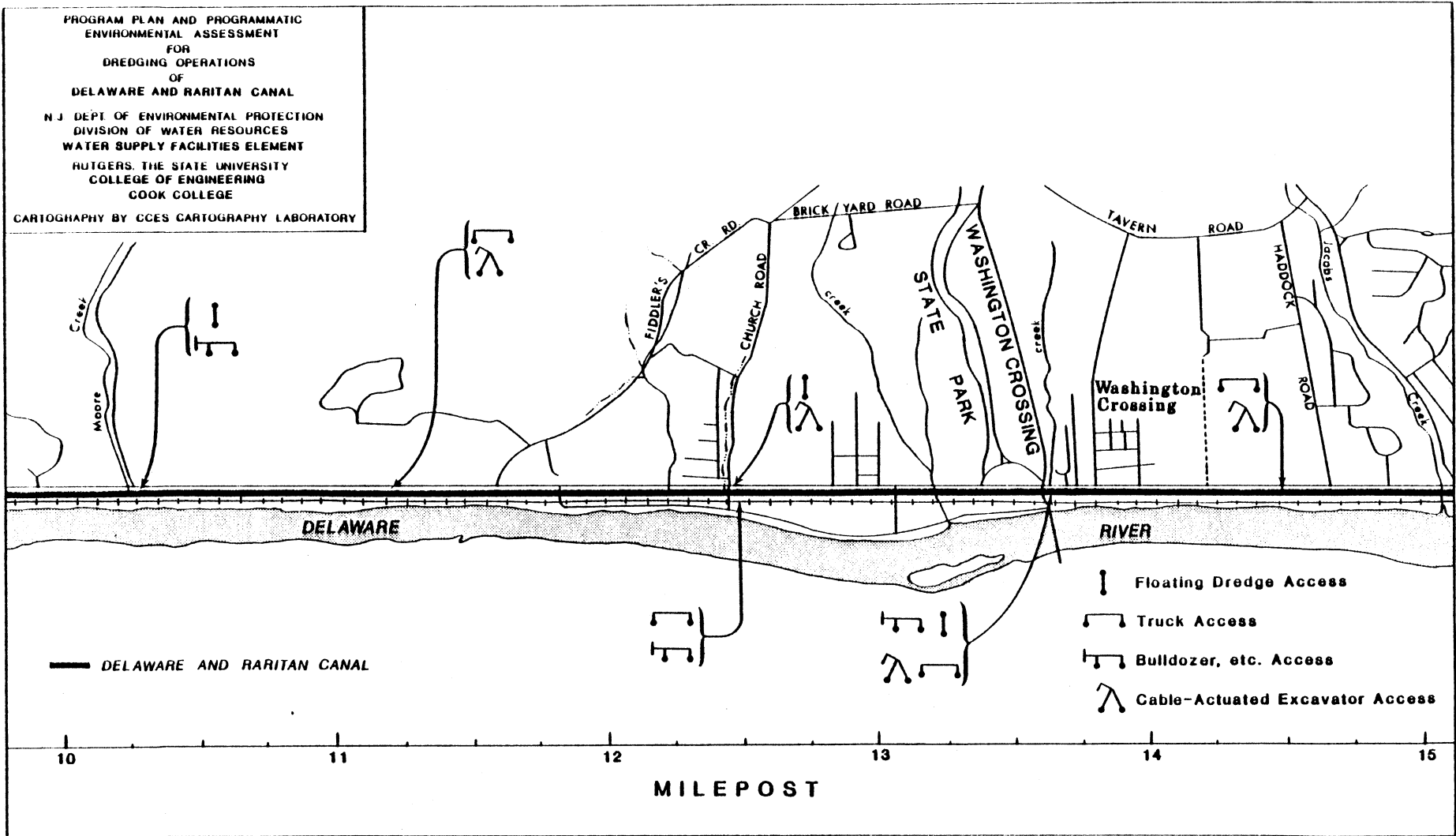
- | | |
|-----|--|
| 2.1 | ACCESS POINTS FOR EQUIPMENT |
| 2.2 | LOCATION OF POSSIBLE DEWATERING SITES |
| 2.3 | LOCATION OF SEDIMENT SAMPLING SITES AND CULTURAL RESOURCES |
| 2.4 | LOCATION OF CULTURAL RESOURCES - STRIP MAPS |
| 2.5 | LOCATION OF CULTURAL RESOURCES - AREA MAPS |



ACCESS POINTS FOR EQUIPMENT
Figure 2.1

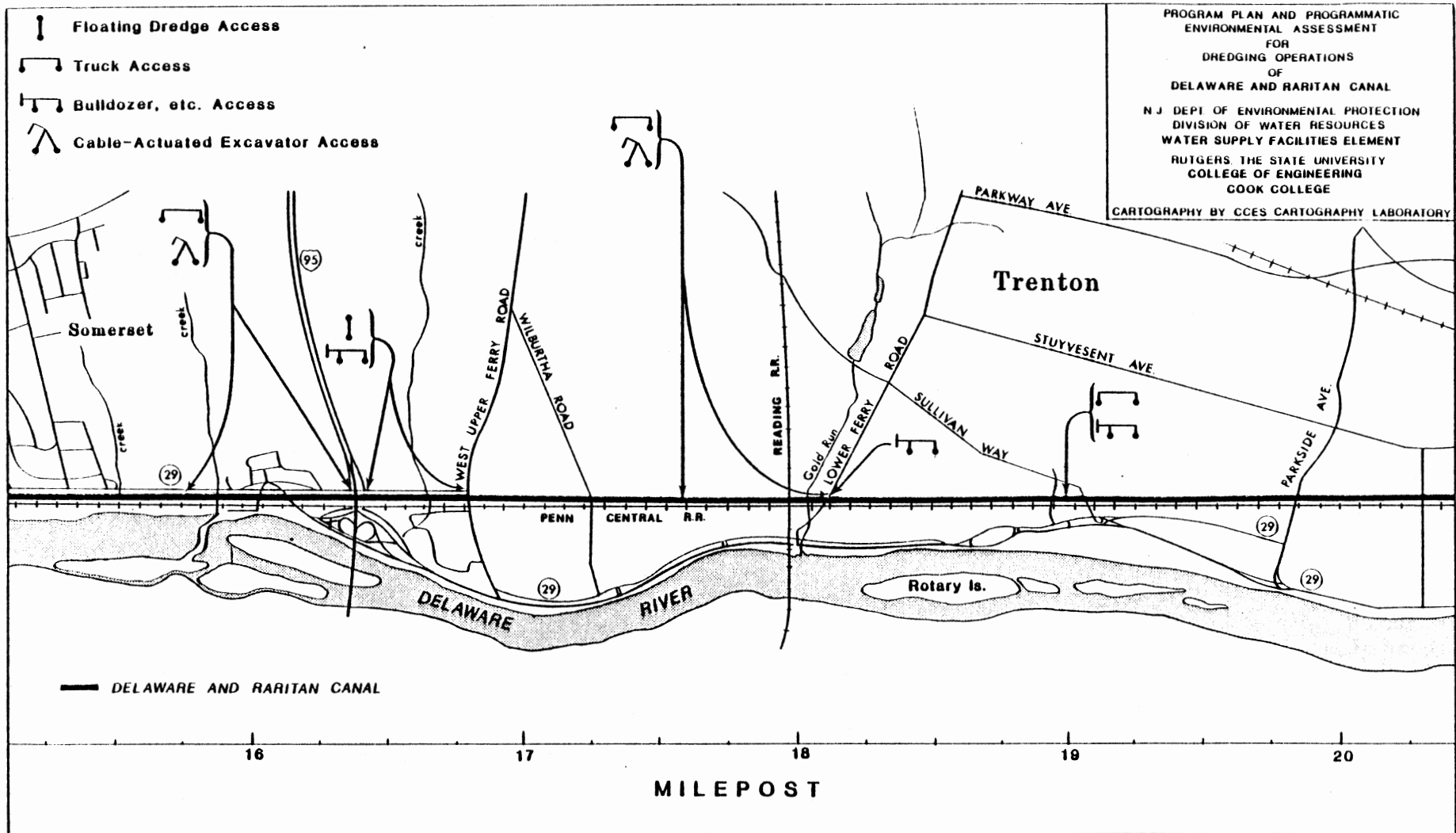


ACCESS POINTS FOR EQUIPMENT
Figure 2.1 (continued)



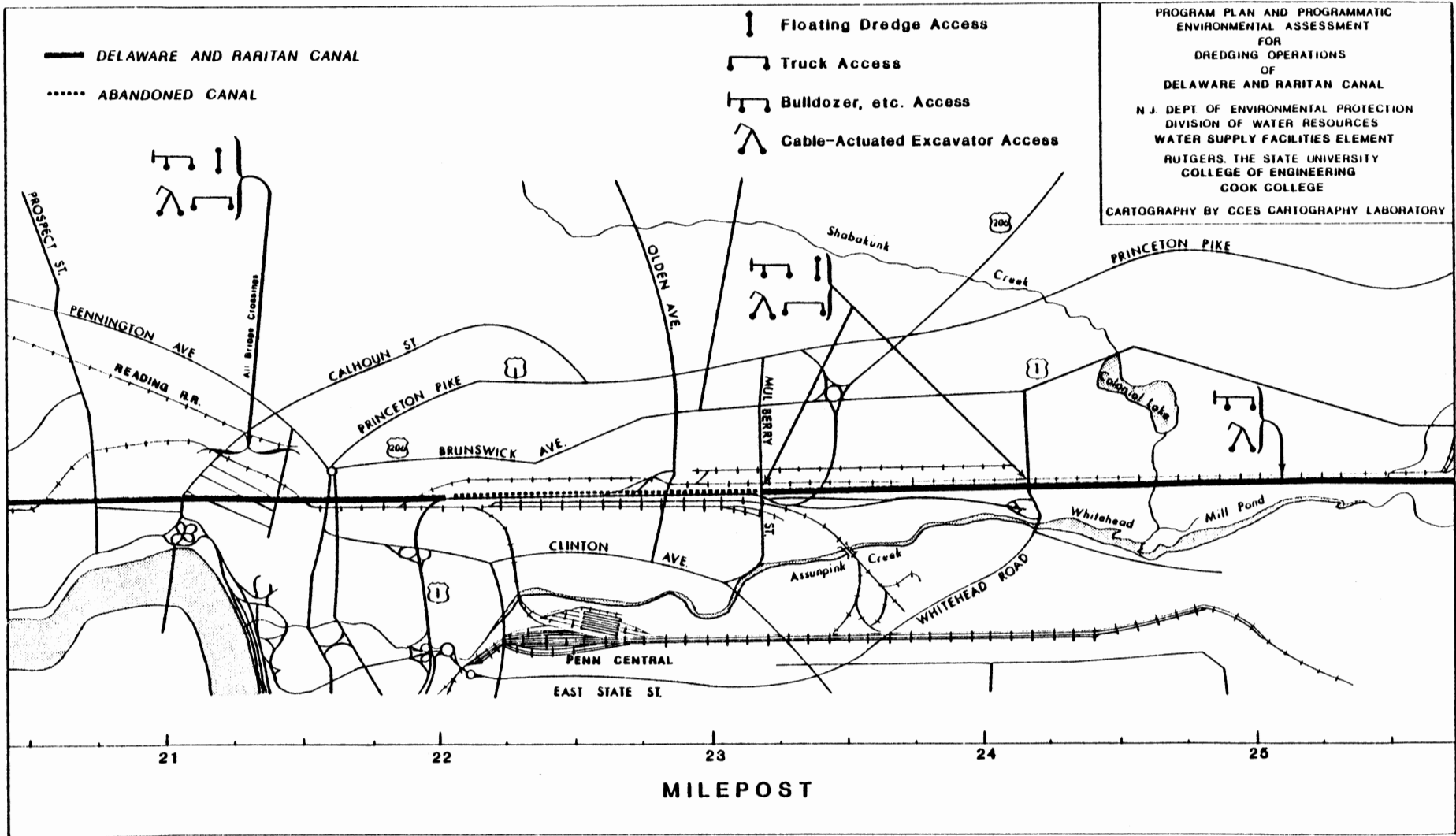
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Figure 2.1 (continued)



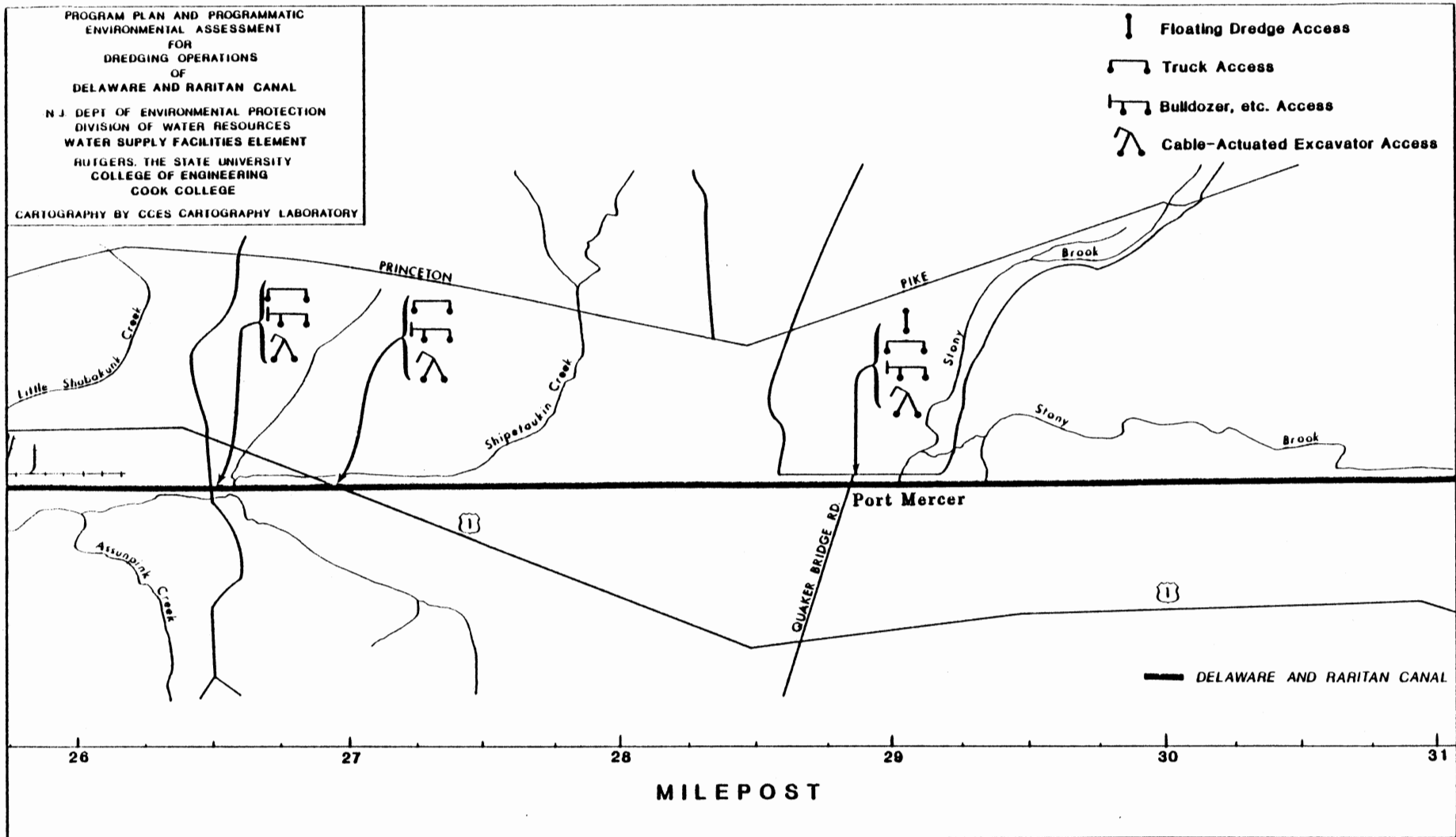
ACCESS POINTS FOR EQUIPMENT

Figure 2.1 (continued)



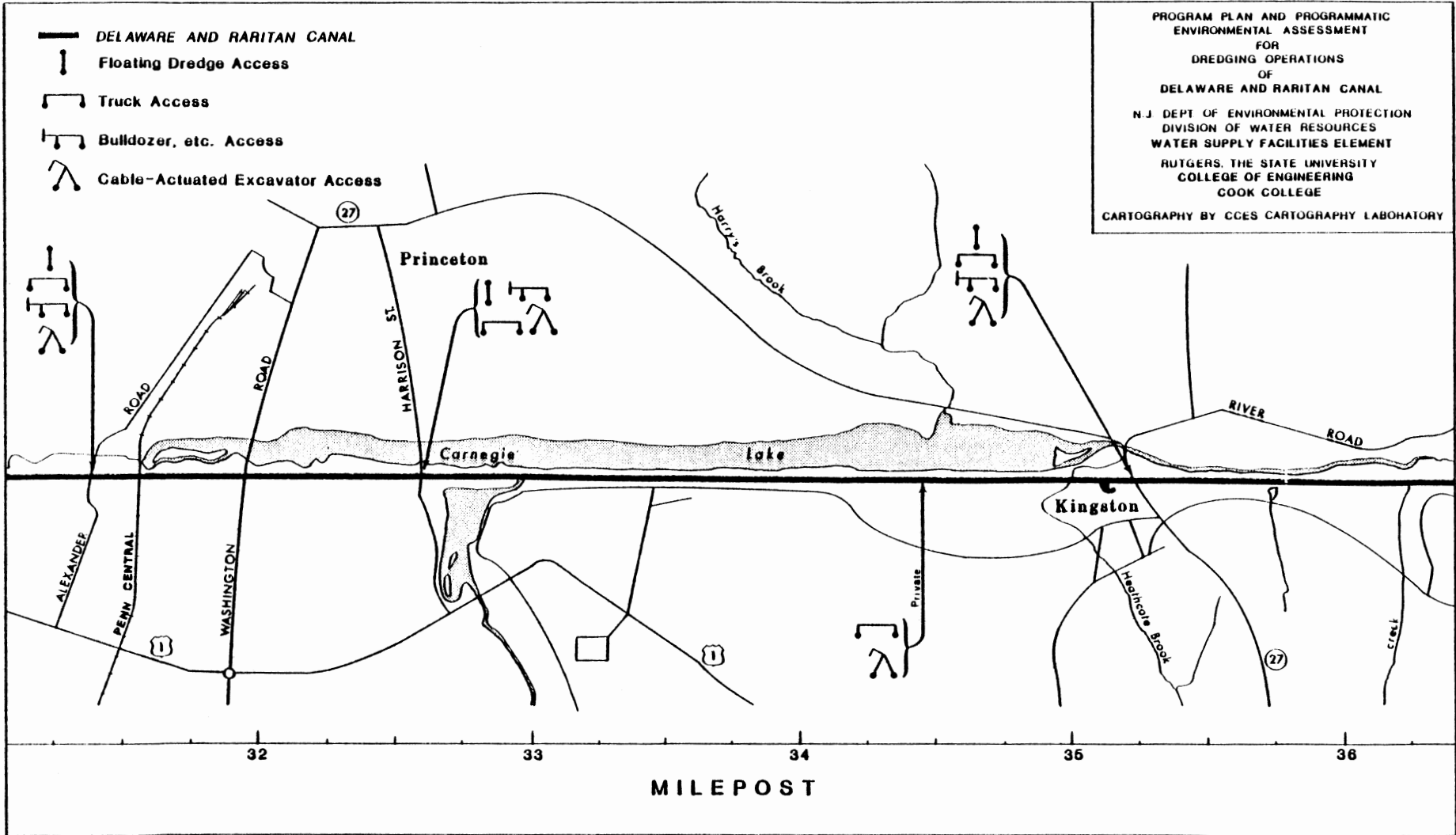
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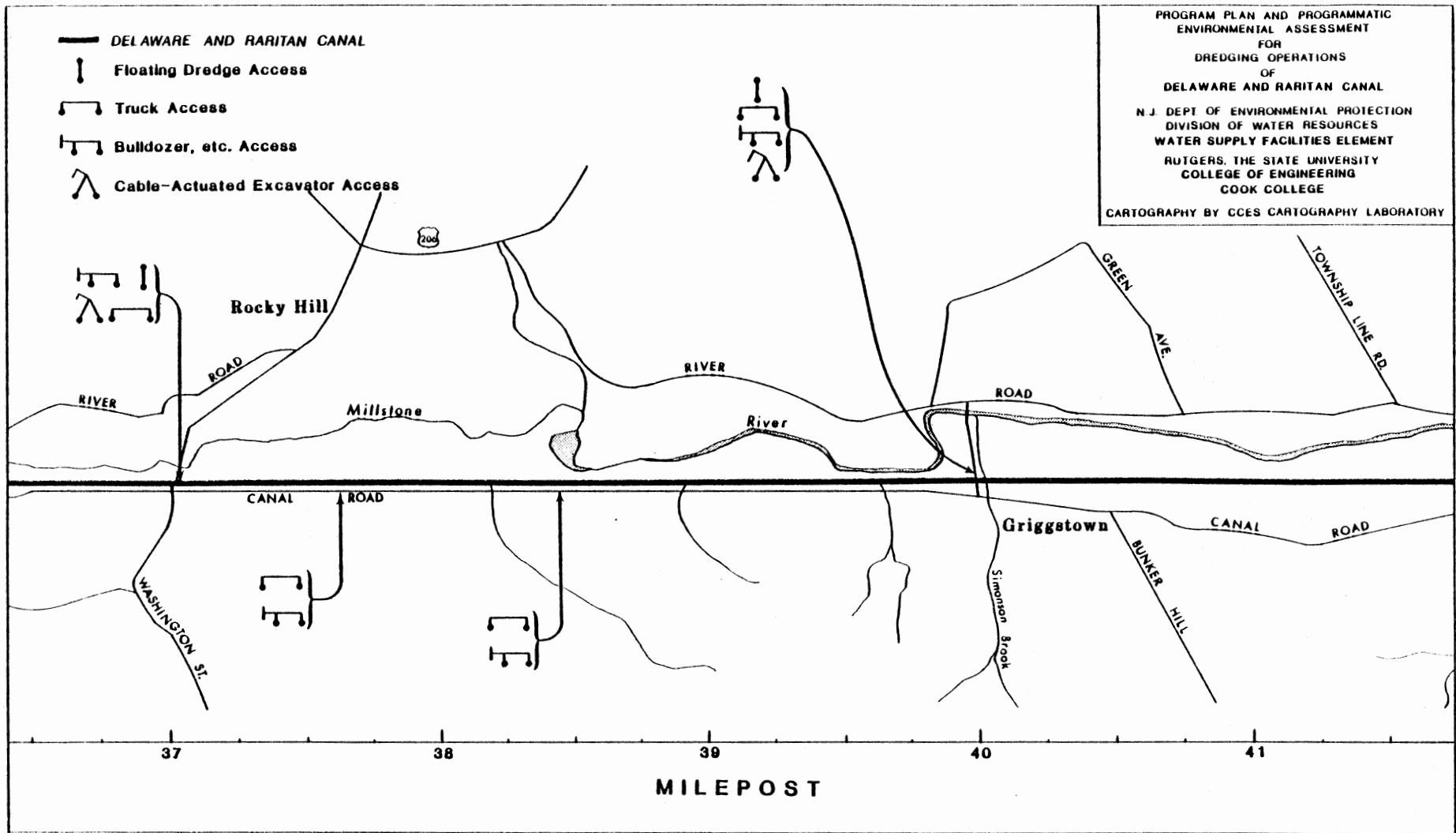
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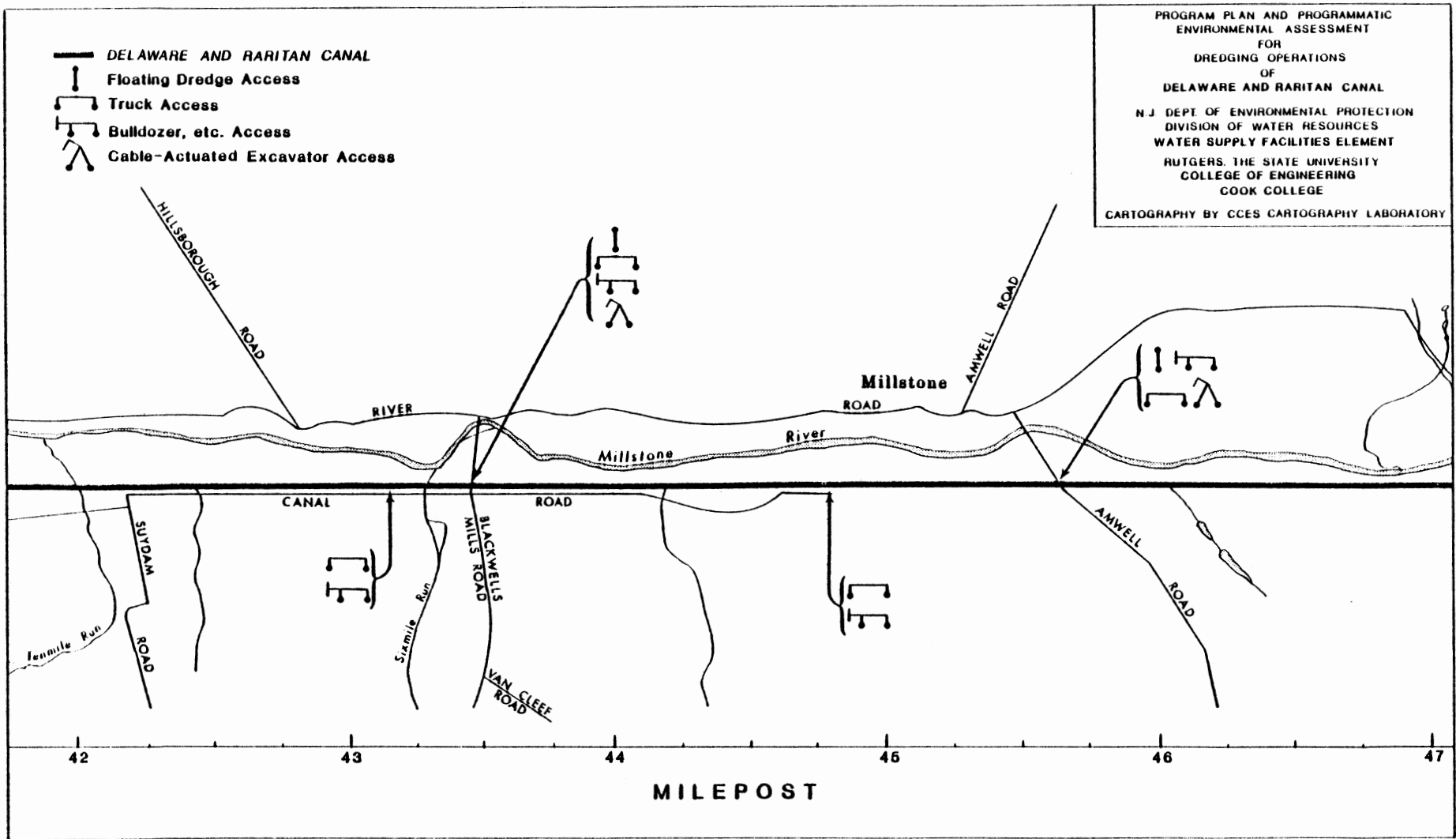


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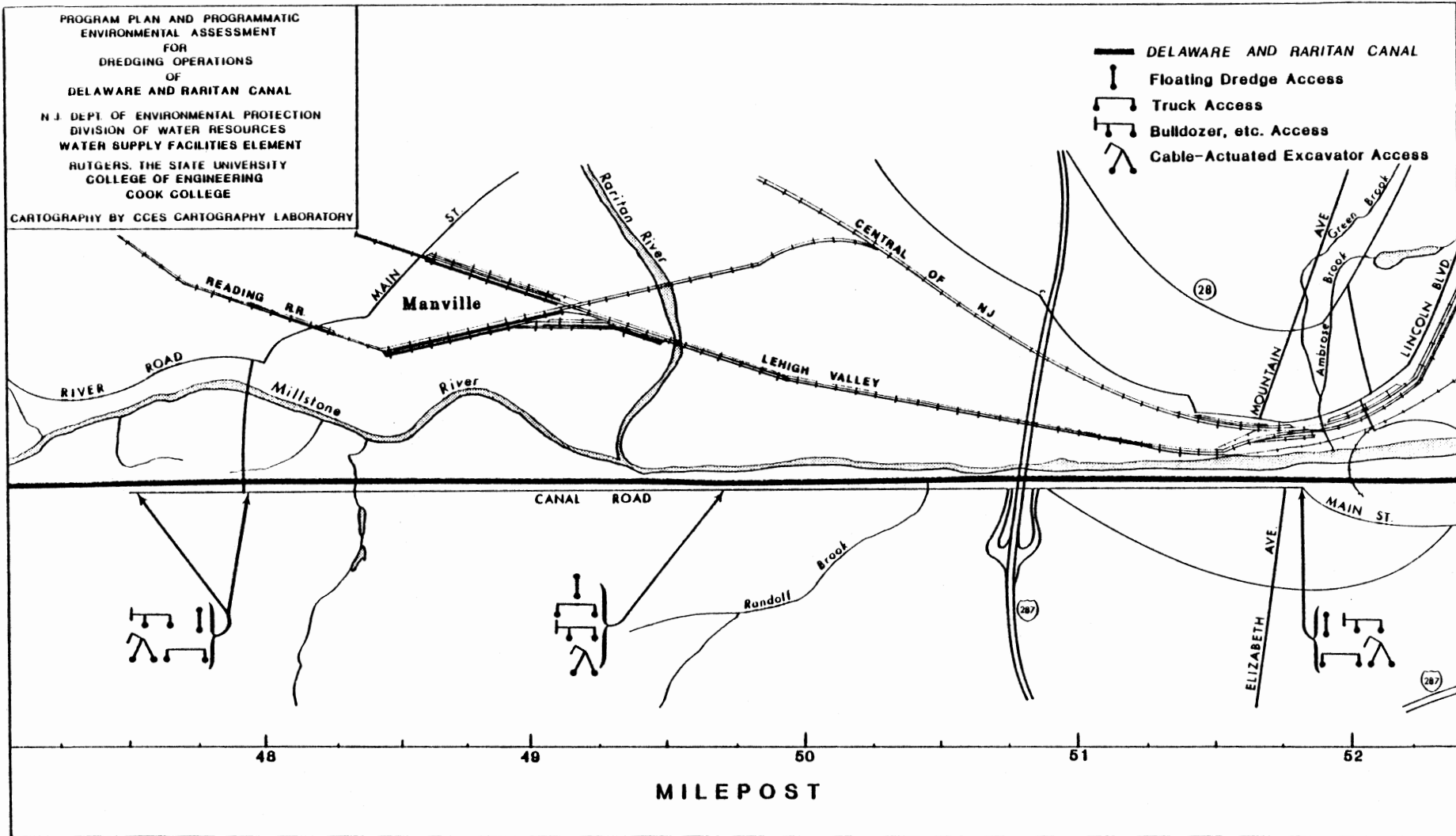
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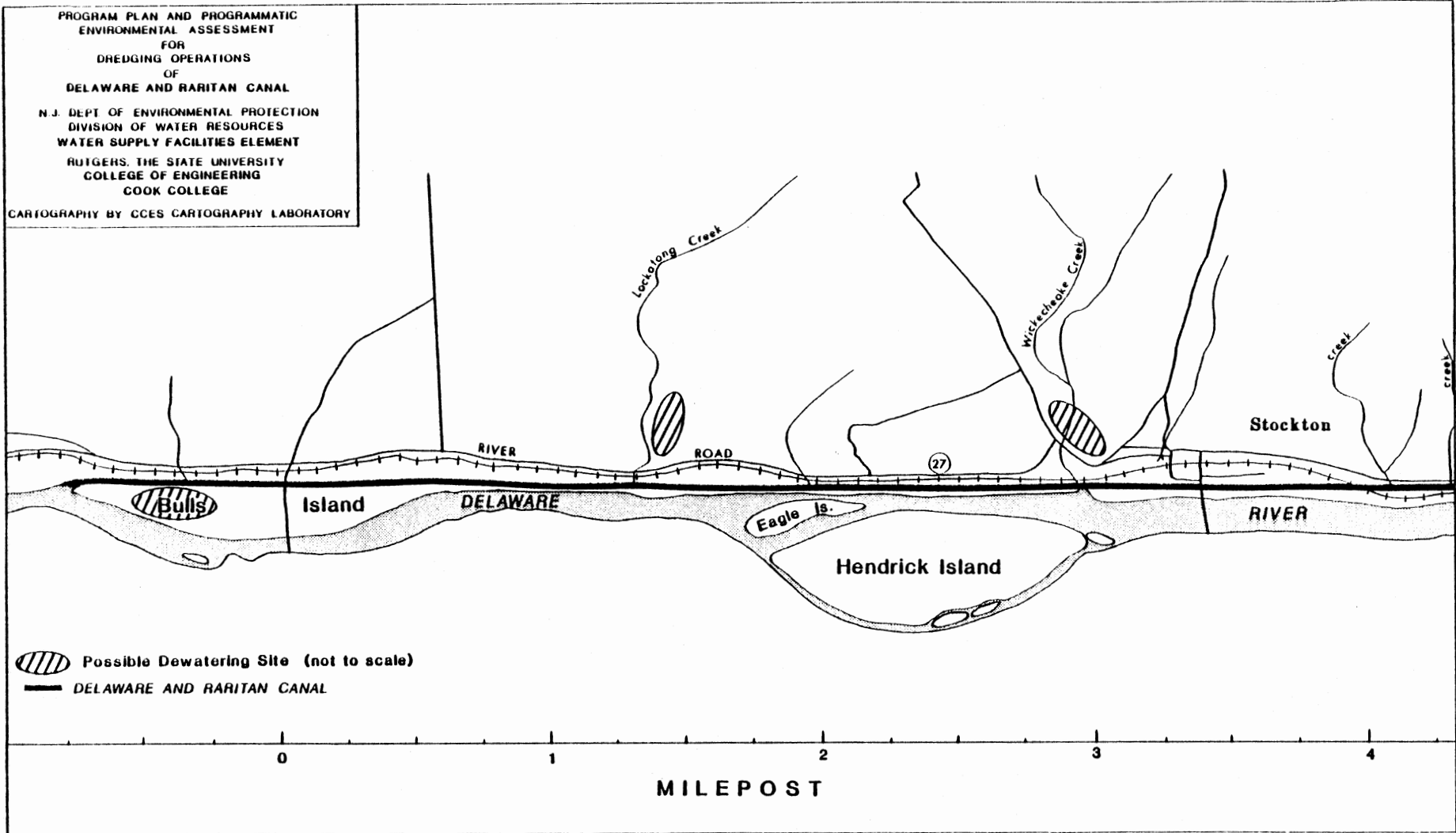


ACCESS POINTS FOR EQUIPMENT
 Figure 2.1 (continued)



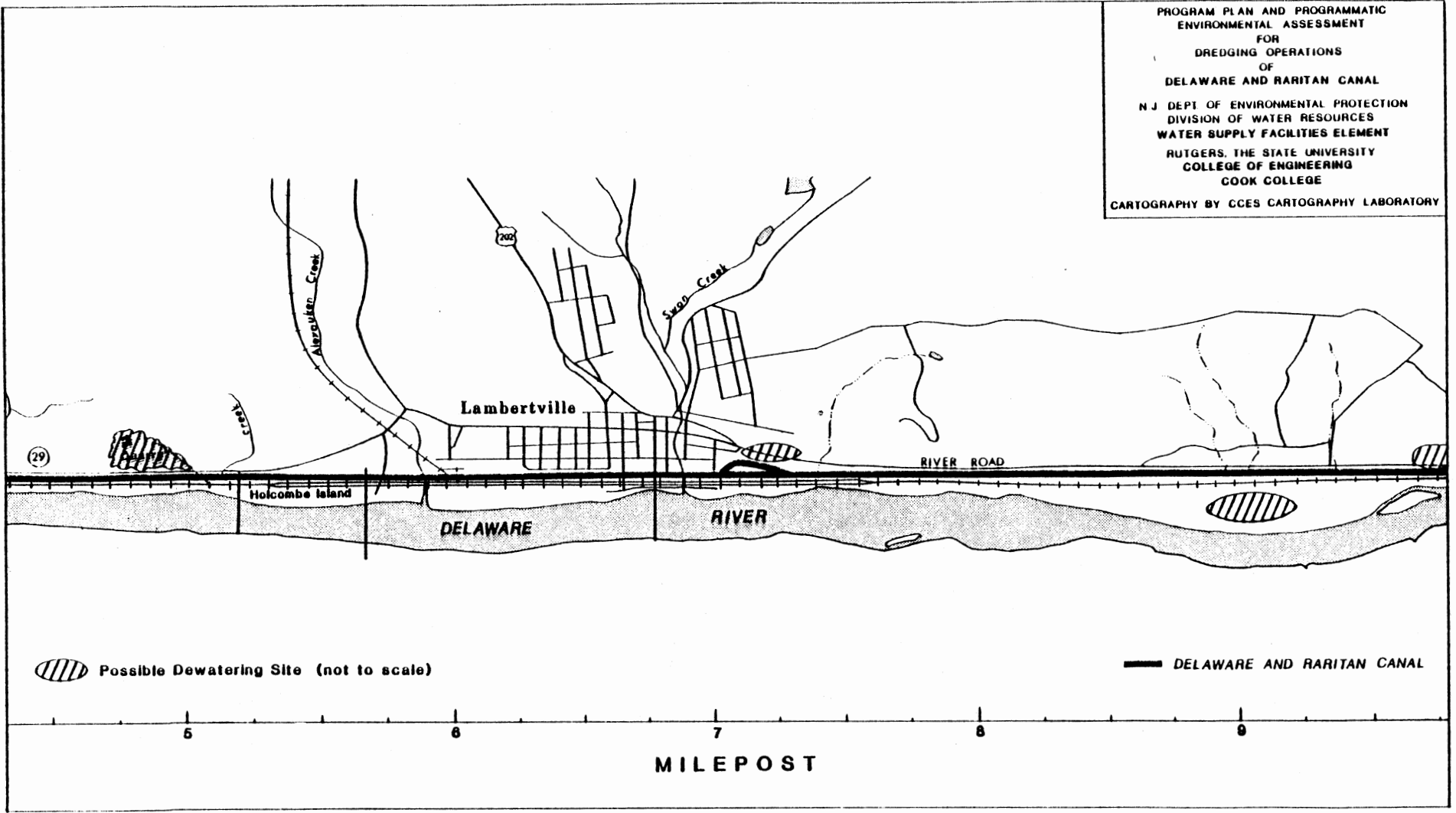
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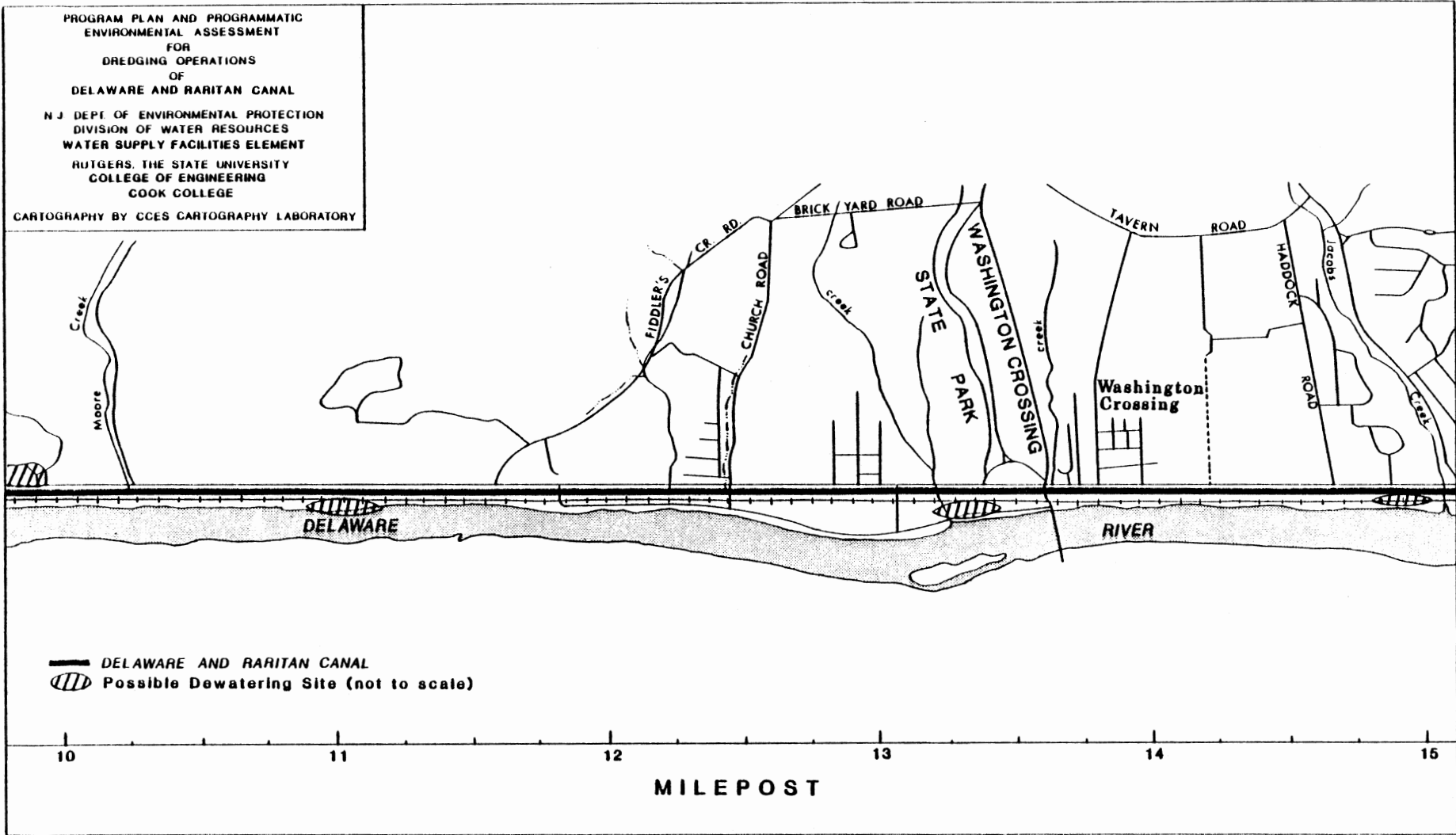


POSSIBLE DEWATERING SITES

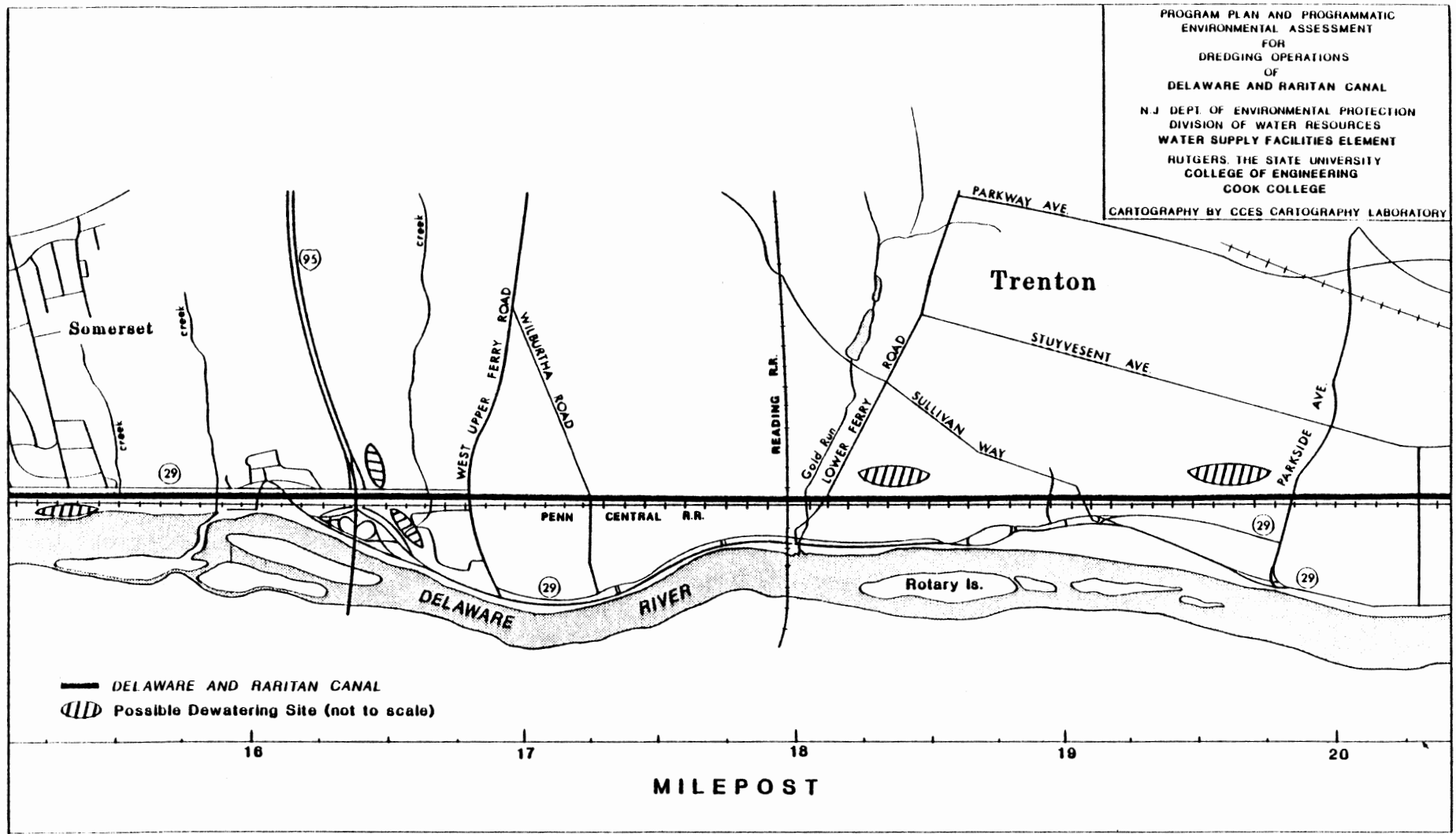
Figure 2.2



POSSIBLE DEWATERING SITES
Figure 2.2 (continued)

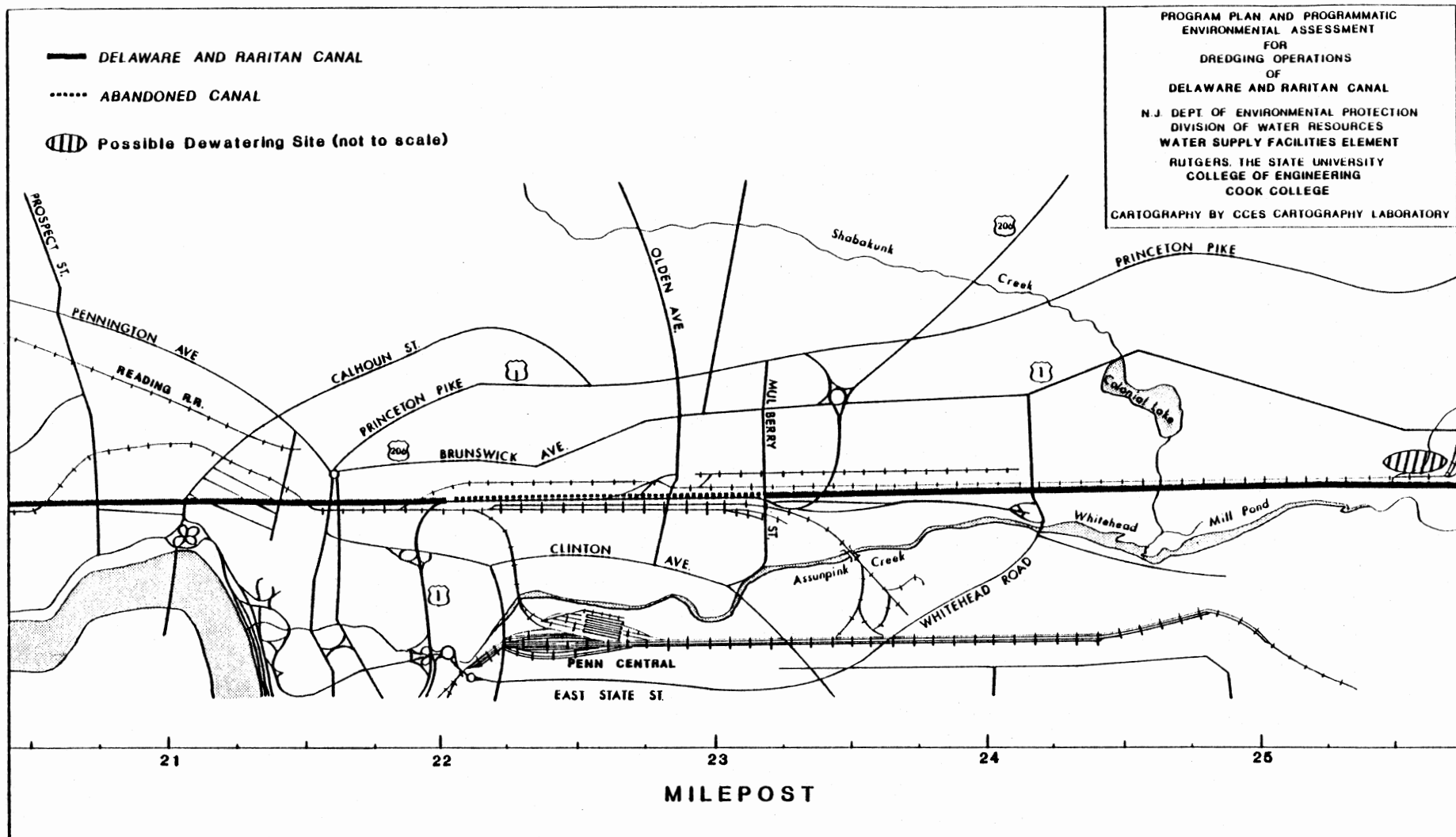


POSSIBLE DEWATERING SITES
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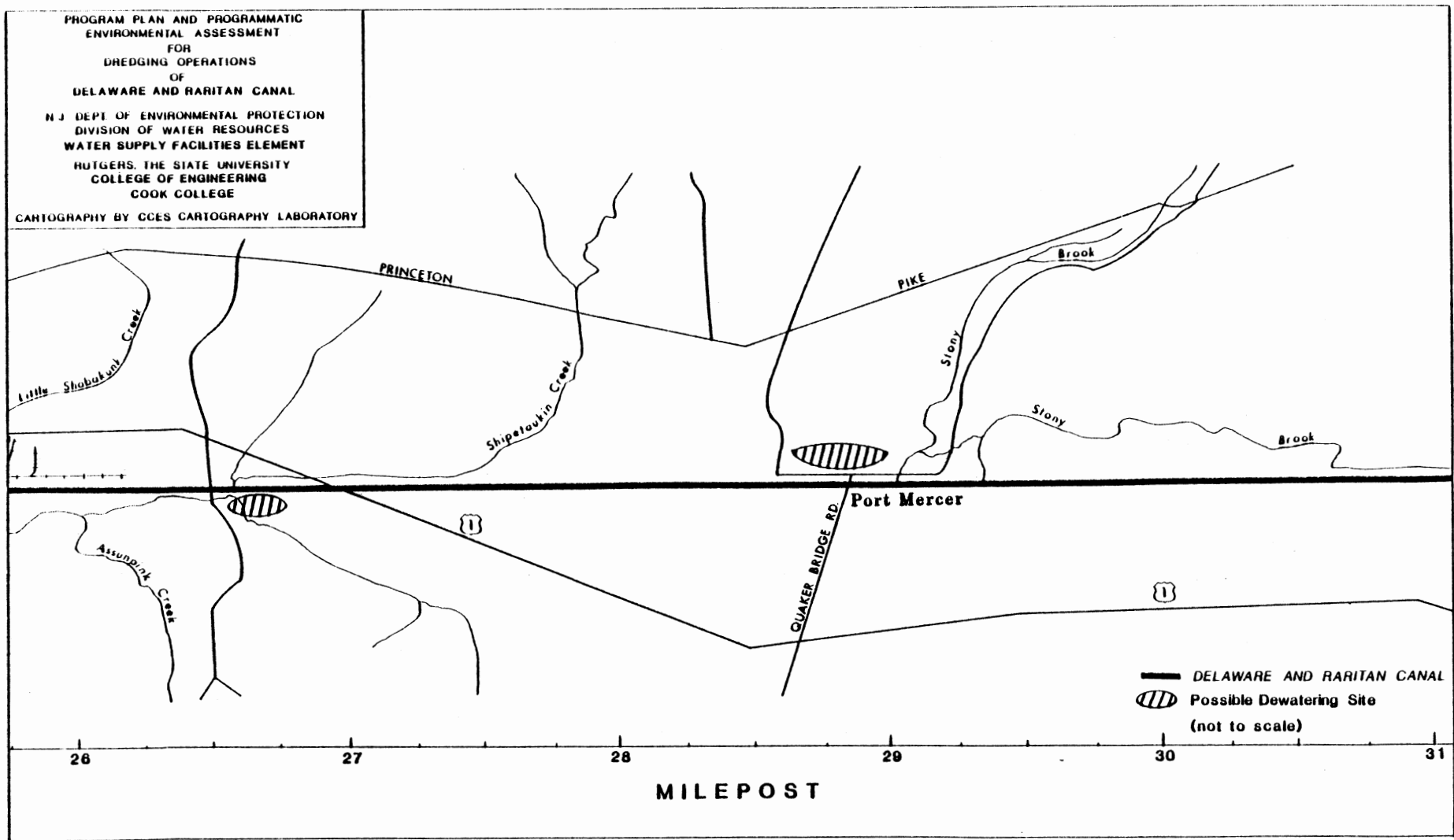


PROGRAM PLAN AND PROGRAMMATIC ENVIRONMENTAL ASSESSMENT FOR DREDGING OPERATIONS OF DELAWARE AND RARITAN CANAL
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DIVISION OF WATER RESOURCES
WATER SUPPLY FACILITIES ELEMENT
RUTGERS, THE STATE UNIVERSITY
COLLEGE OF ENGINEERING
COOK COLLEGE
CARTOGRAPHY BY CCES CARTOGRAPHY LABORATORY

POSSIBLE DEWATERING SITES
Figure 2.2 (continued)

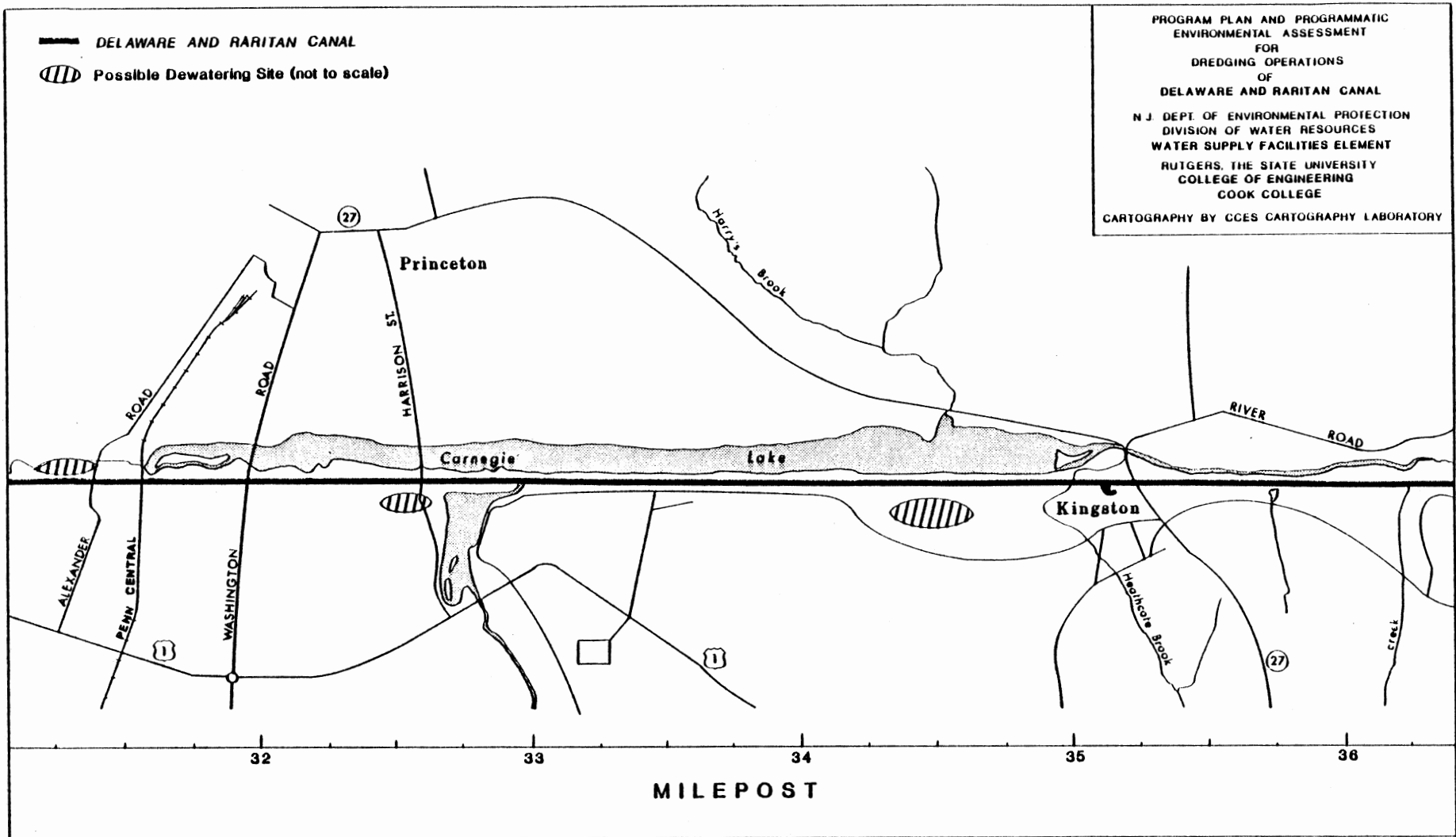


POSSIBLE DEWATERING SITES
FIGURE 2.2 (continued)



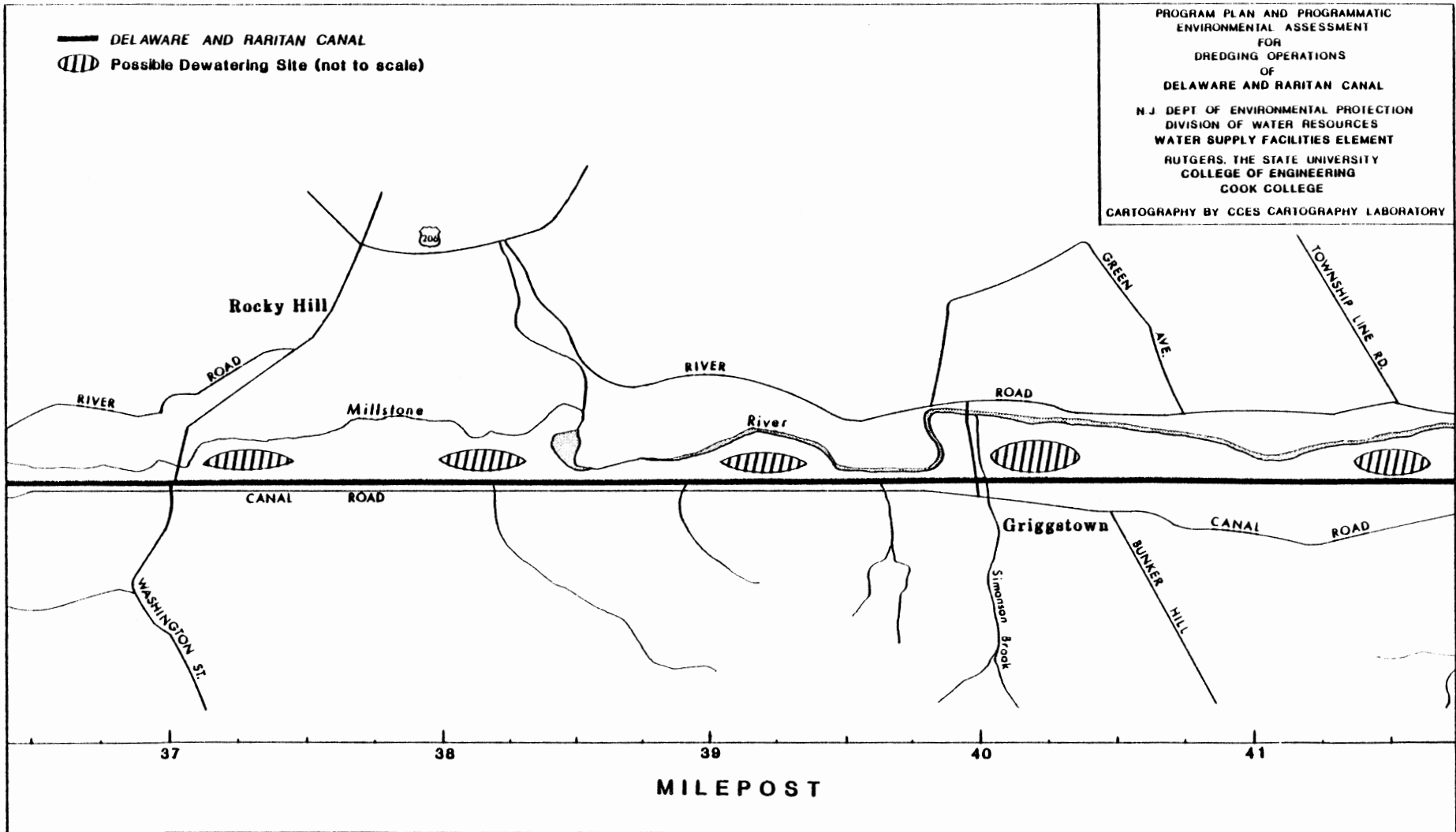
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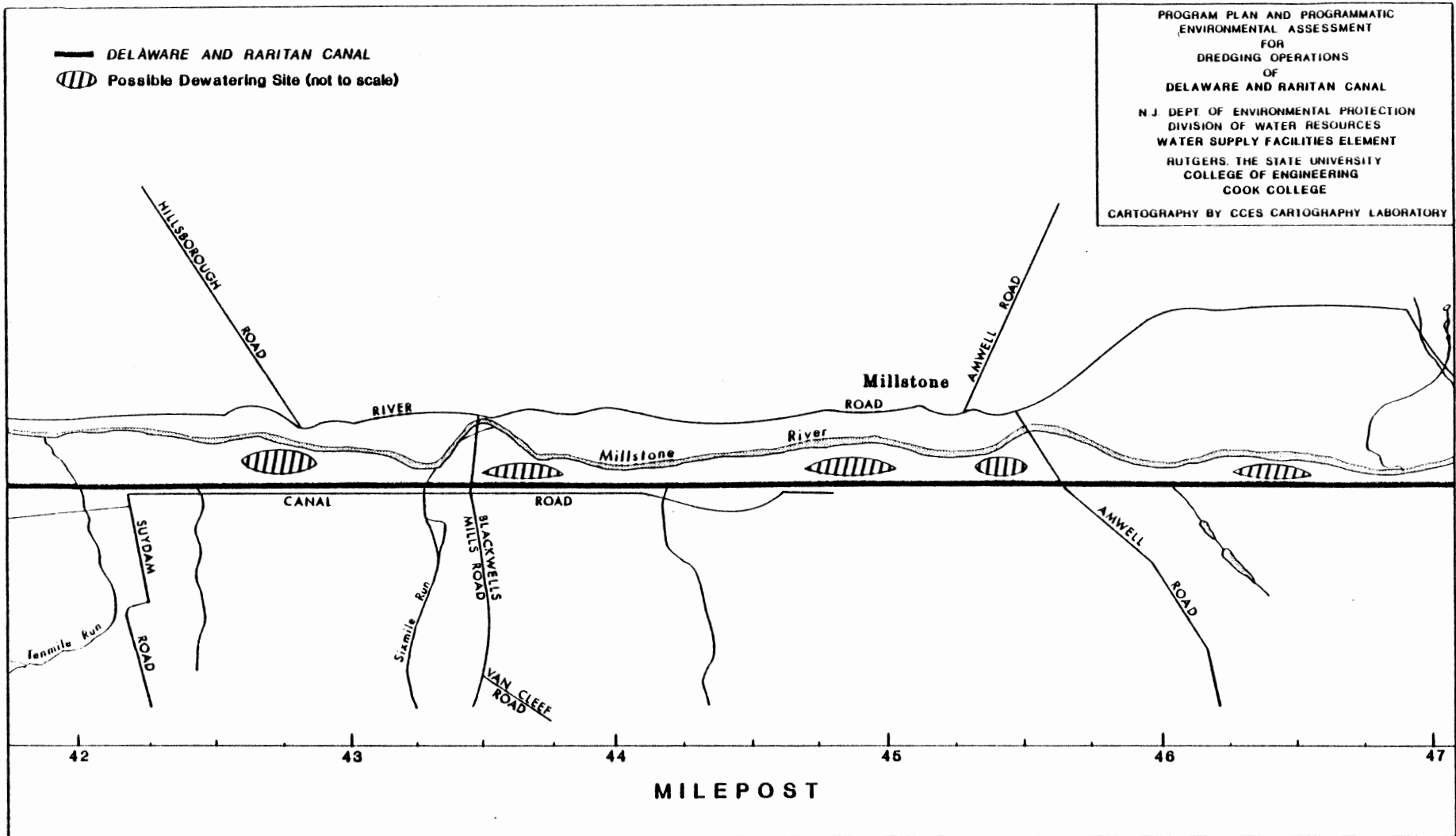
POSSIBLE DEWATERING SITES

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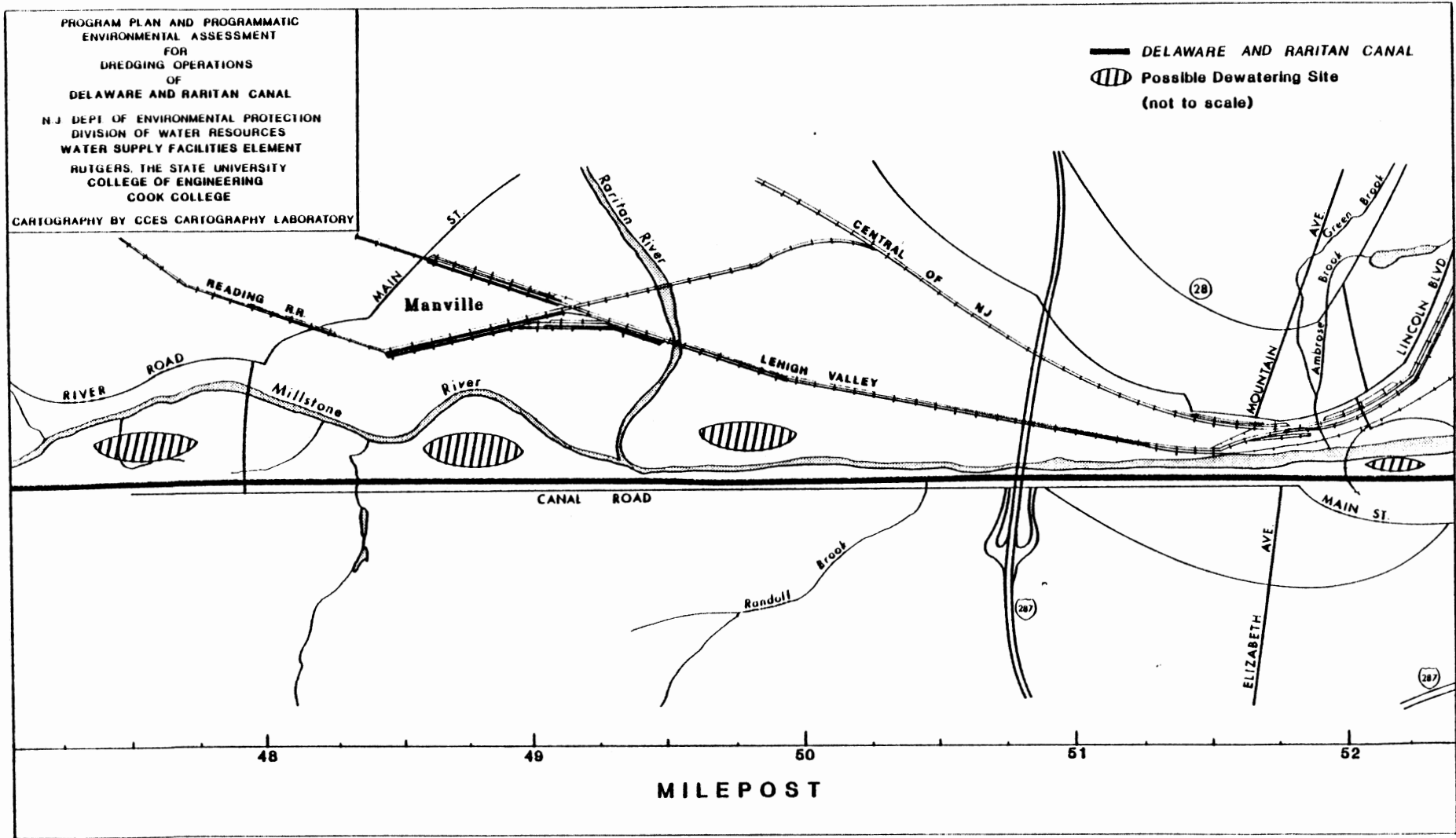


POSSIBLE DEWATERING SITES

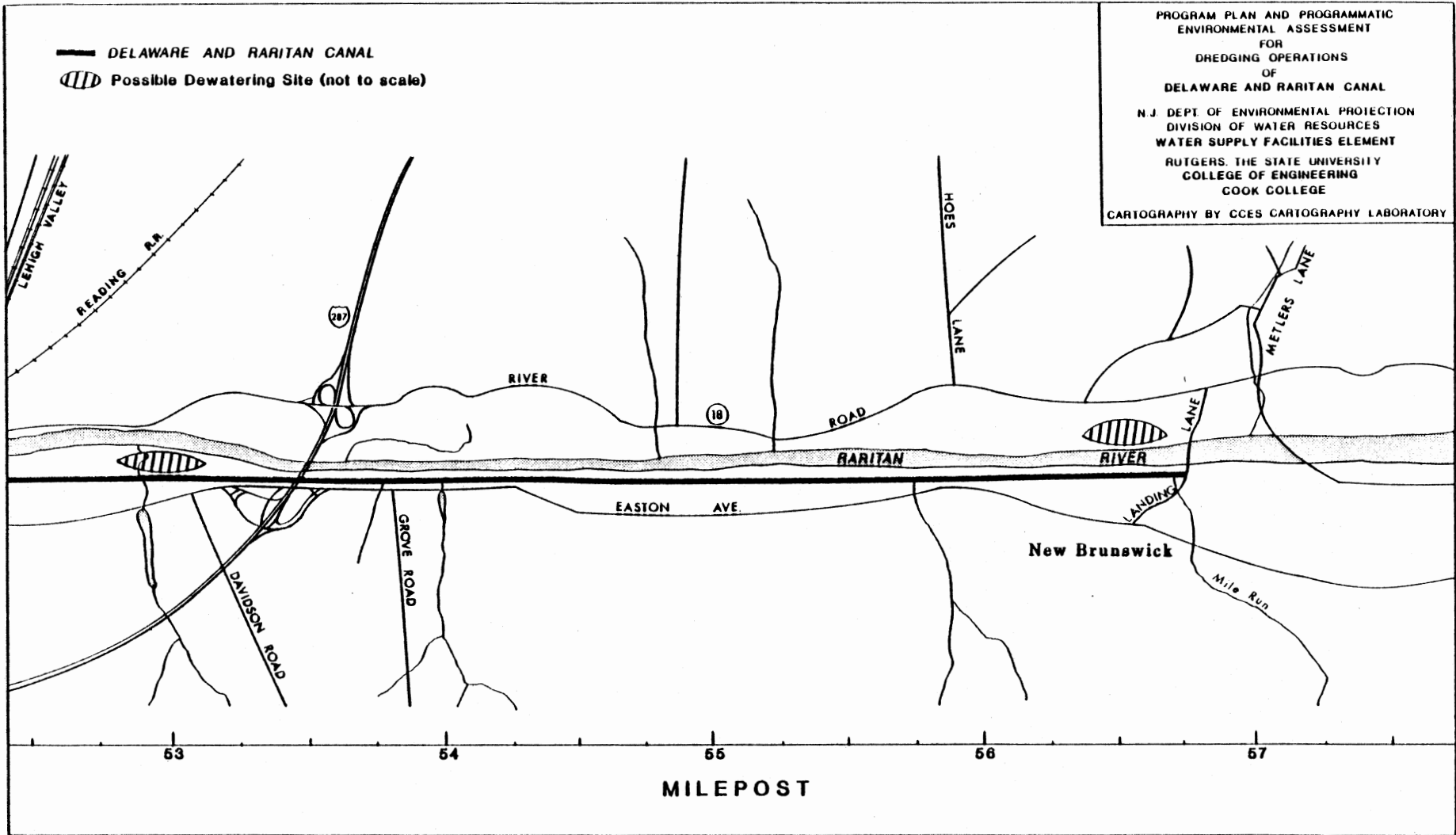
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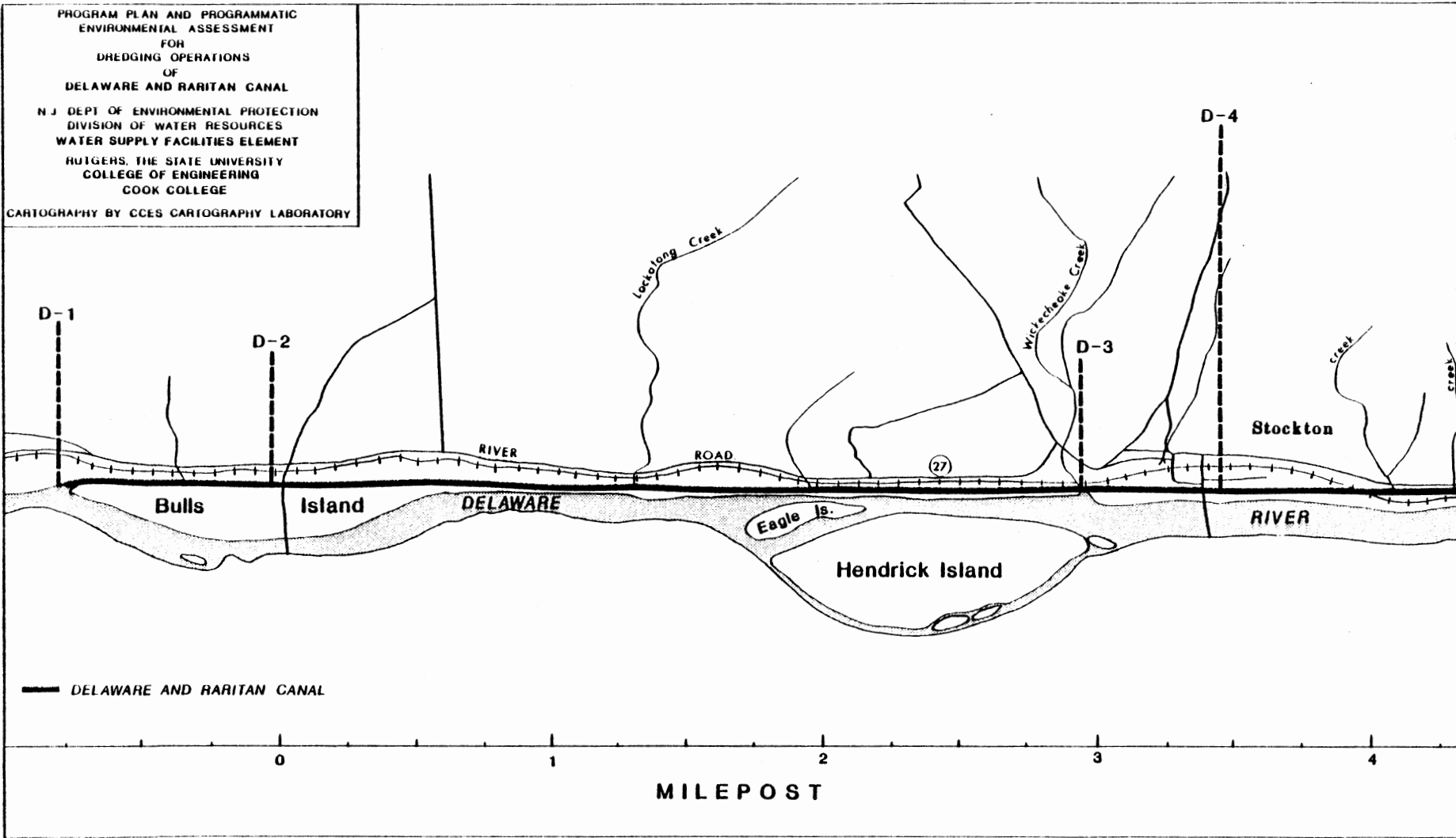
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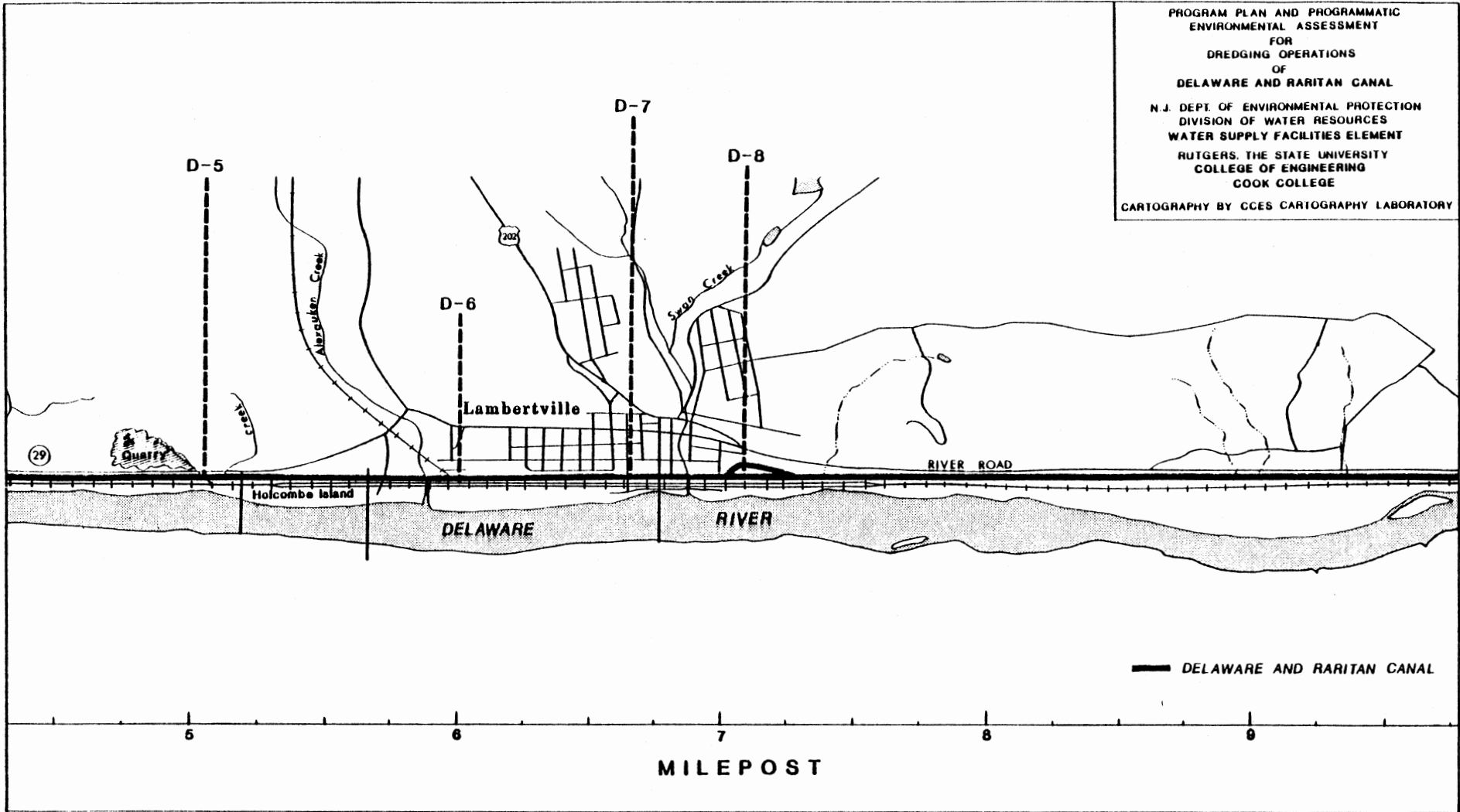
POSSIBLE DEWATERING SITES
Figure 2.2 (continued)



POSSIBLE DEWATERING SITES
 Figure 2.2 (continued)



LOCATION OF SEDIMENT SAMPLING SITES
Figure 2.3



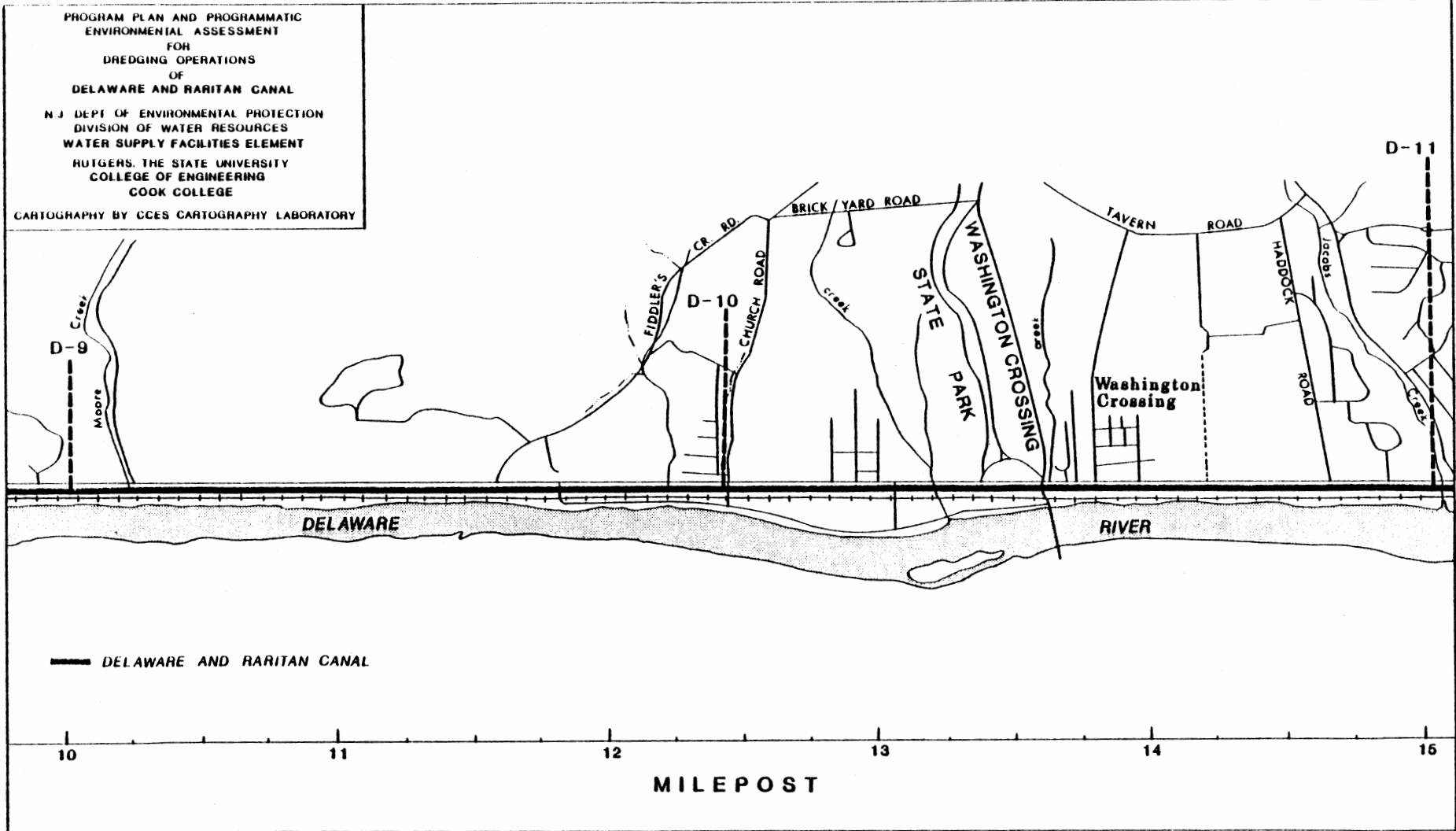
PROGRAM PLAN AND PROGRAMMATIC ENVIRONMENTAL ASSESSMENT FOR DREDGING OPERATIONS OF DELAWARE AND RARITAN CANAL

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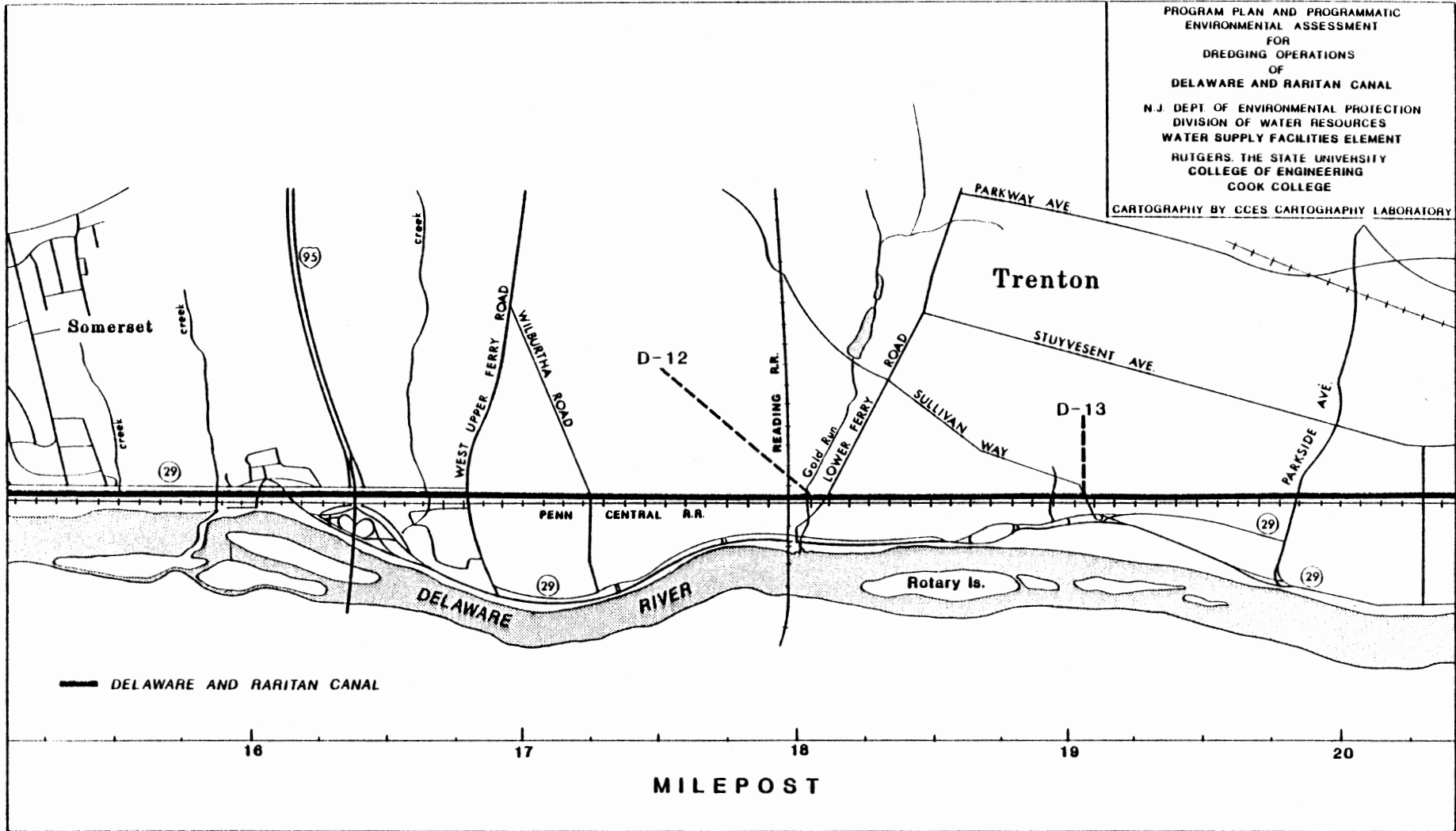
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LOCATION OF SEDIMENT SAMPLING SITES

Figure 2.3 (continued)

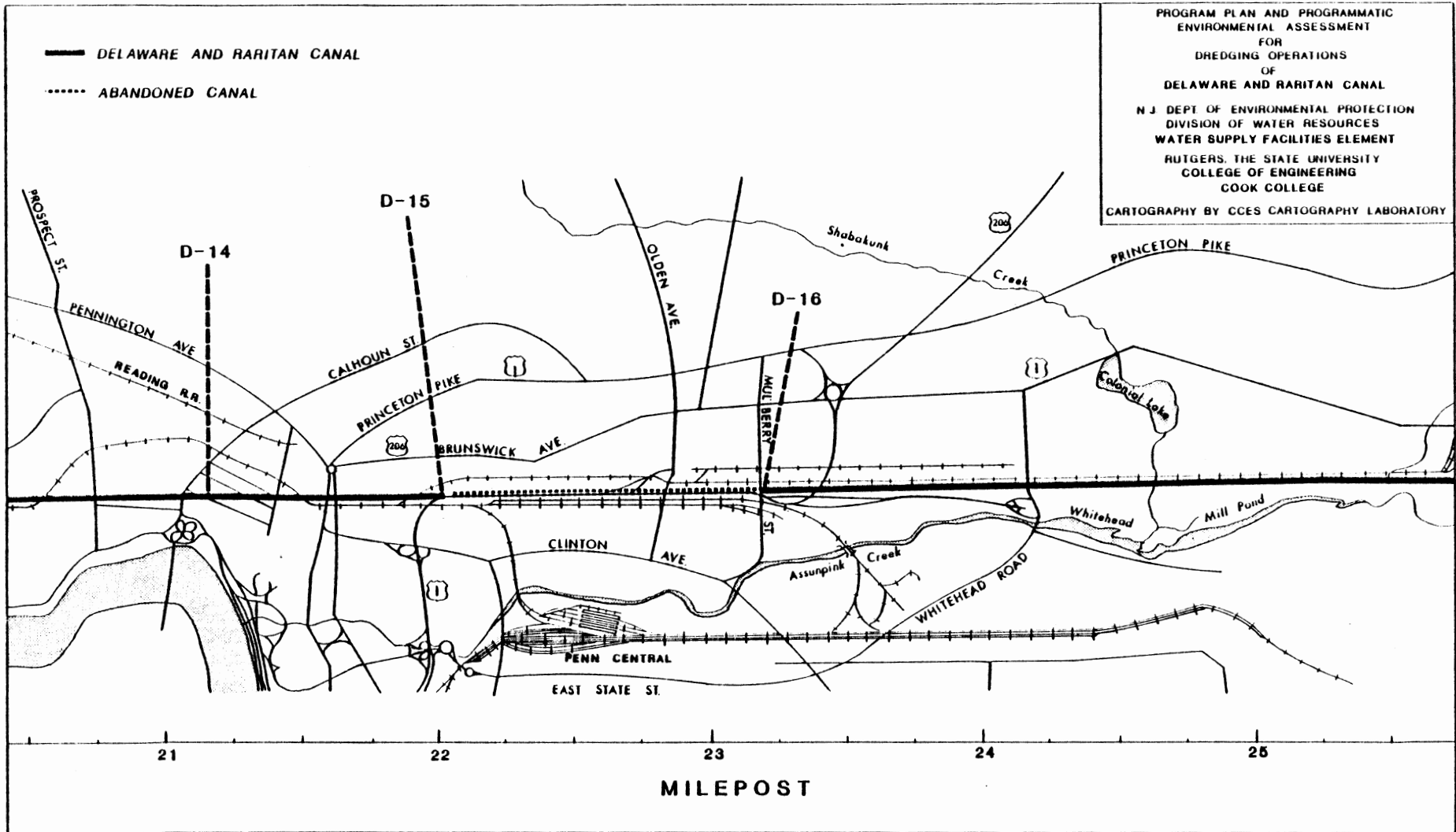


LOCATION OF SEDIMENT SAMPLING SITES
Figure 2.3 (continued)



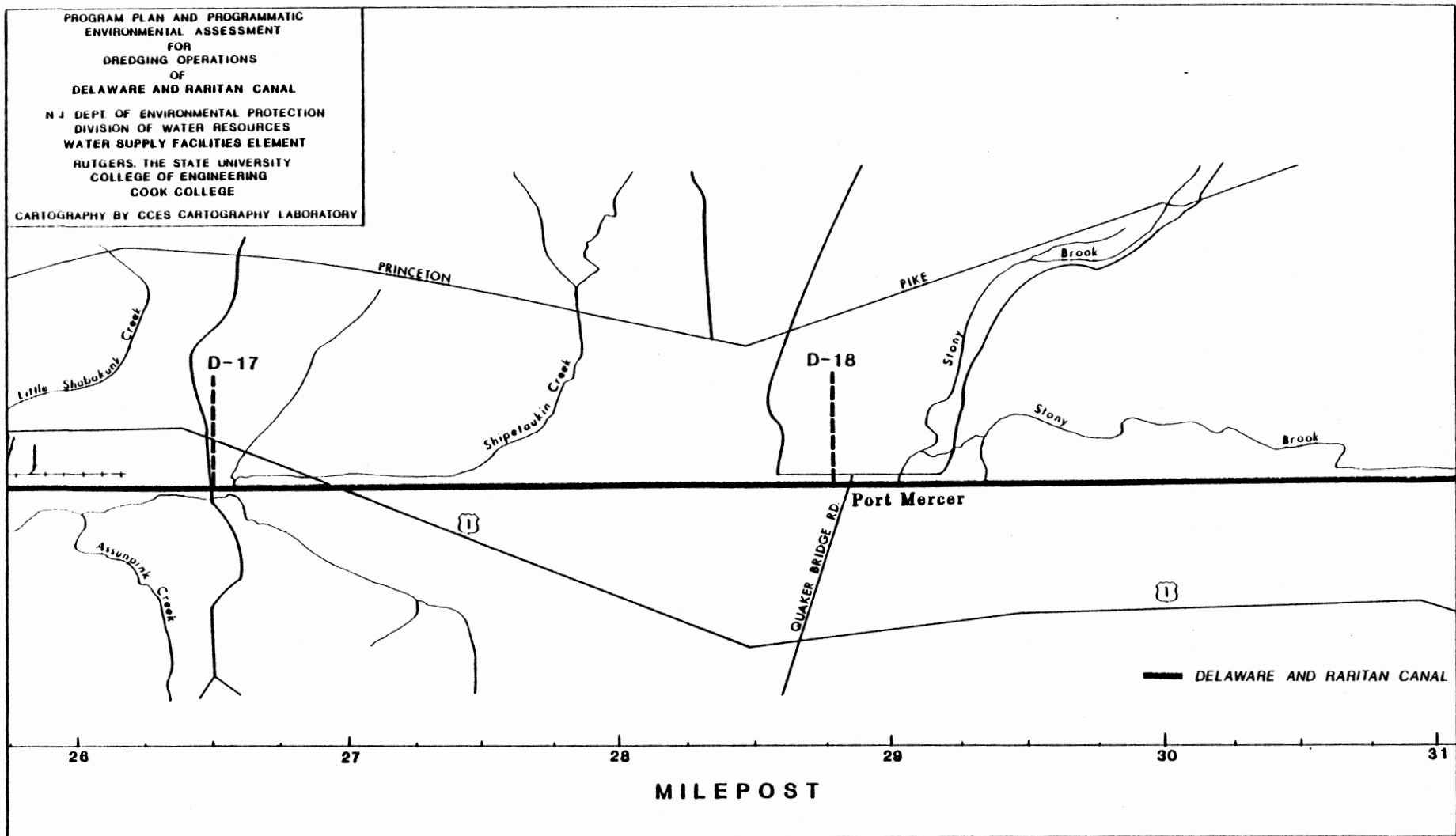
LOCATION OF SEDIMENT SAMPLING SITES

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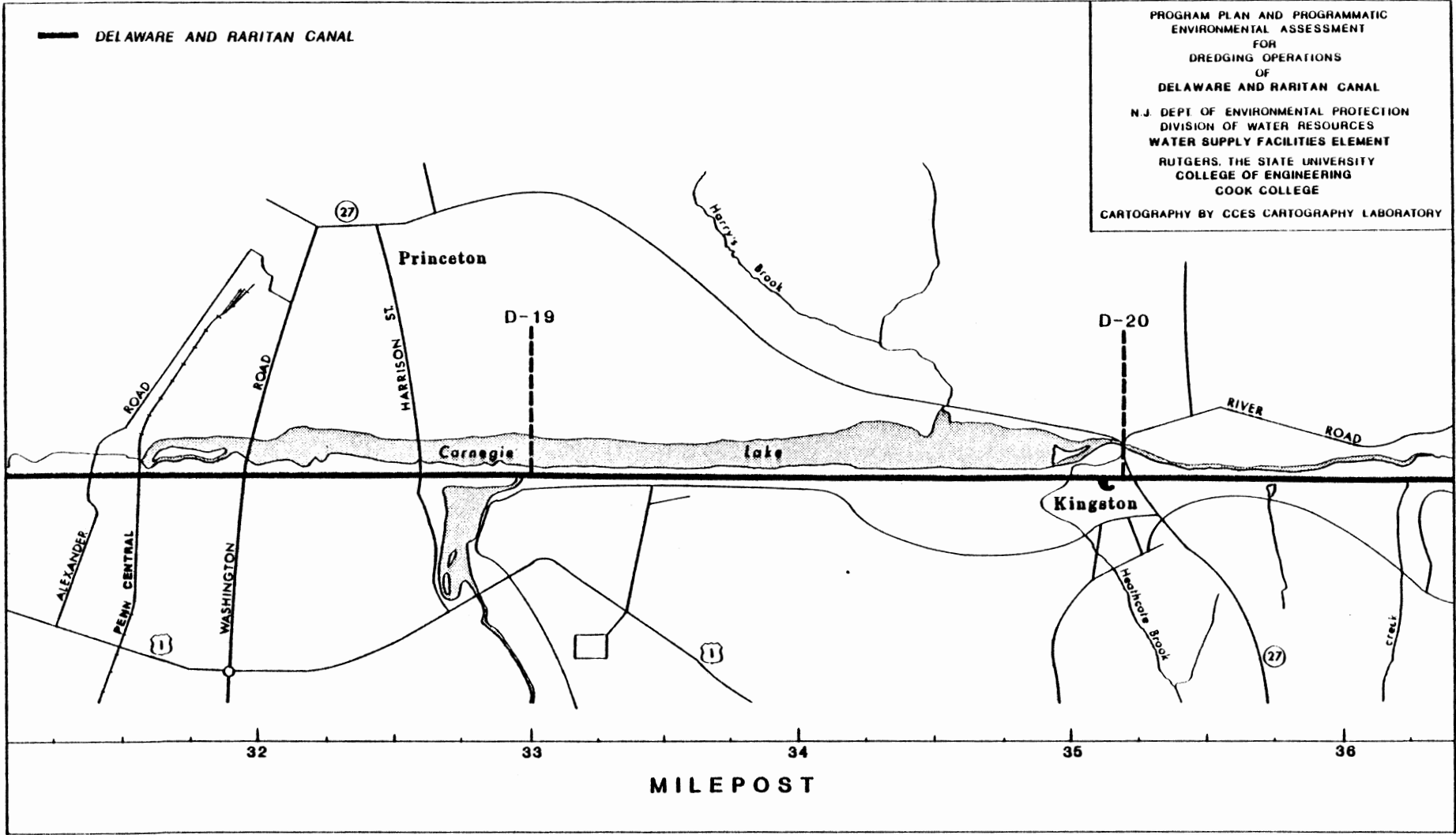


LOCATION OF SEDIMENT SAMPLING SITES

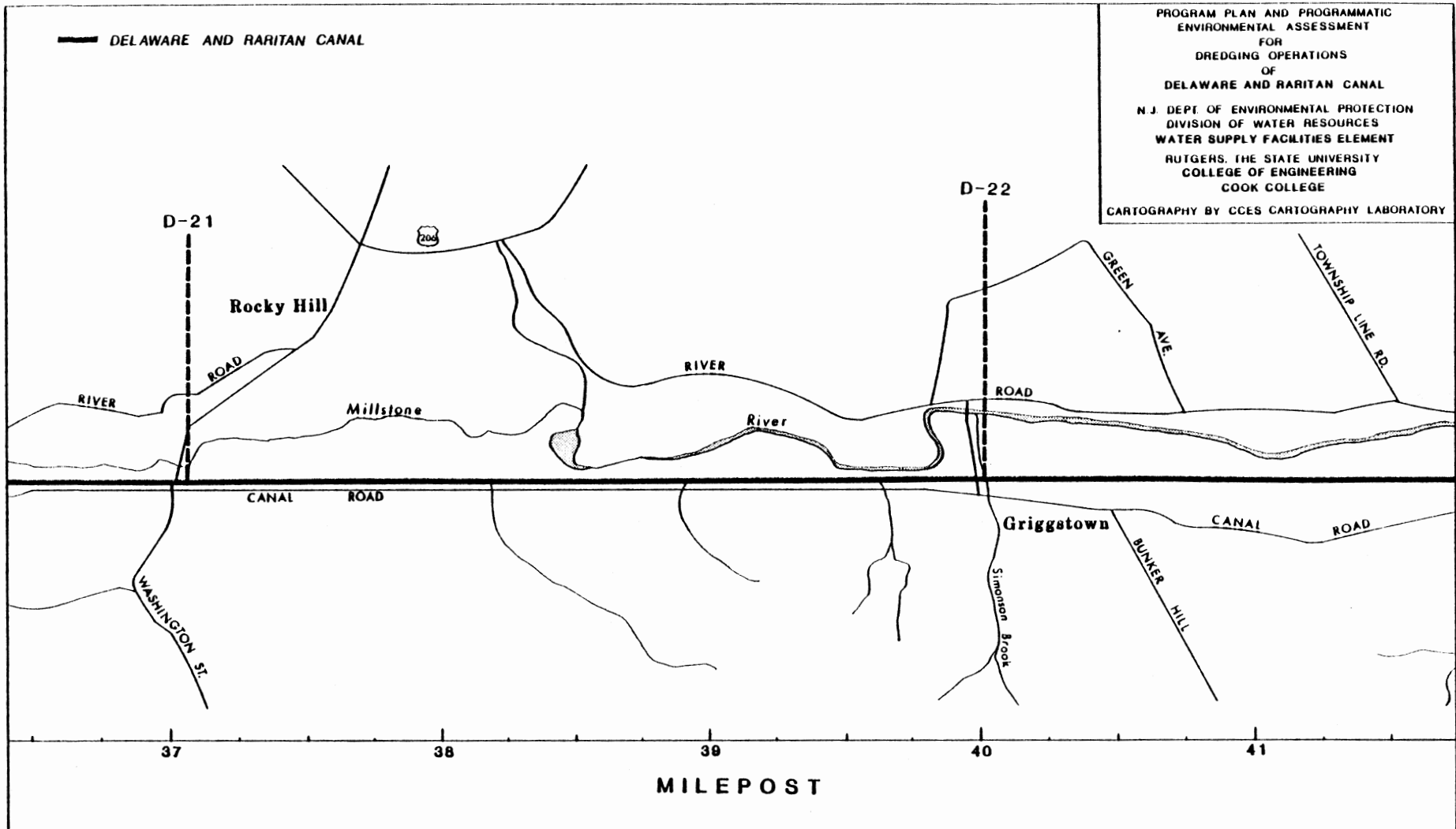
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LOCATION OF SEDIMENT SAMPLING SITES
Figure 2.3 (continued)

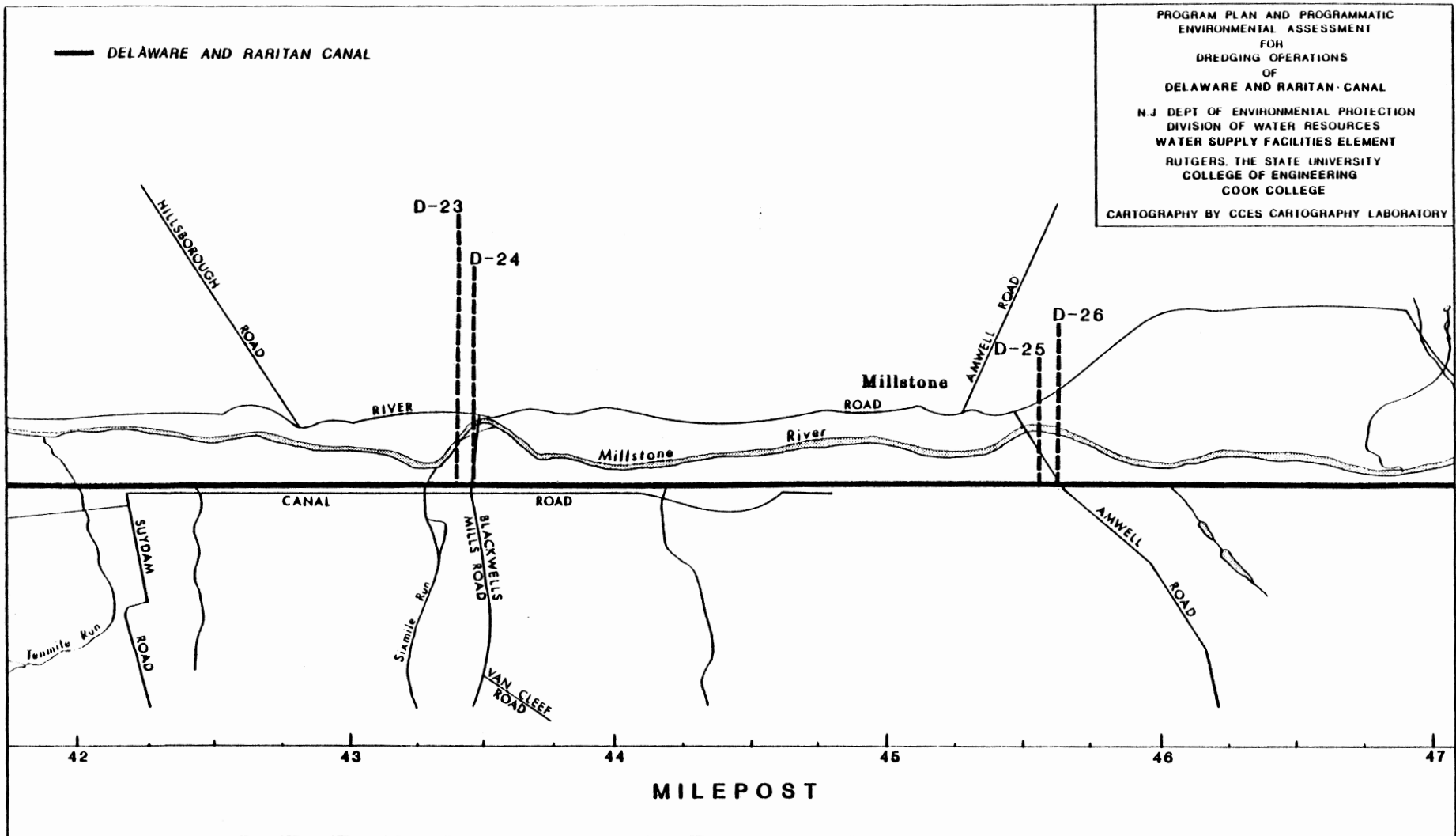


LOCATION OF SEDIMENT SAMPLING SITES
Figure 2.3 (continued)



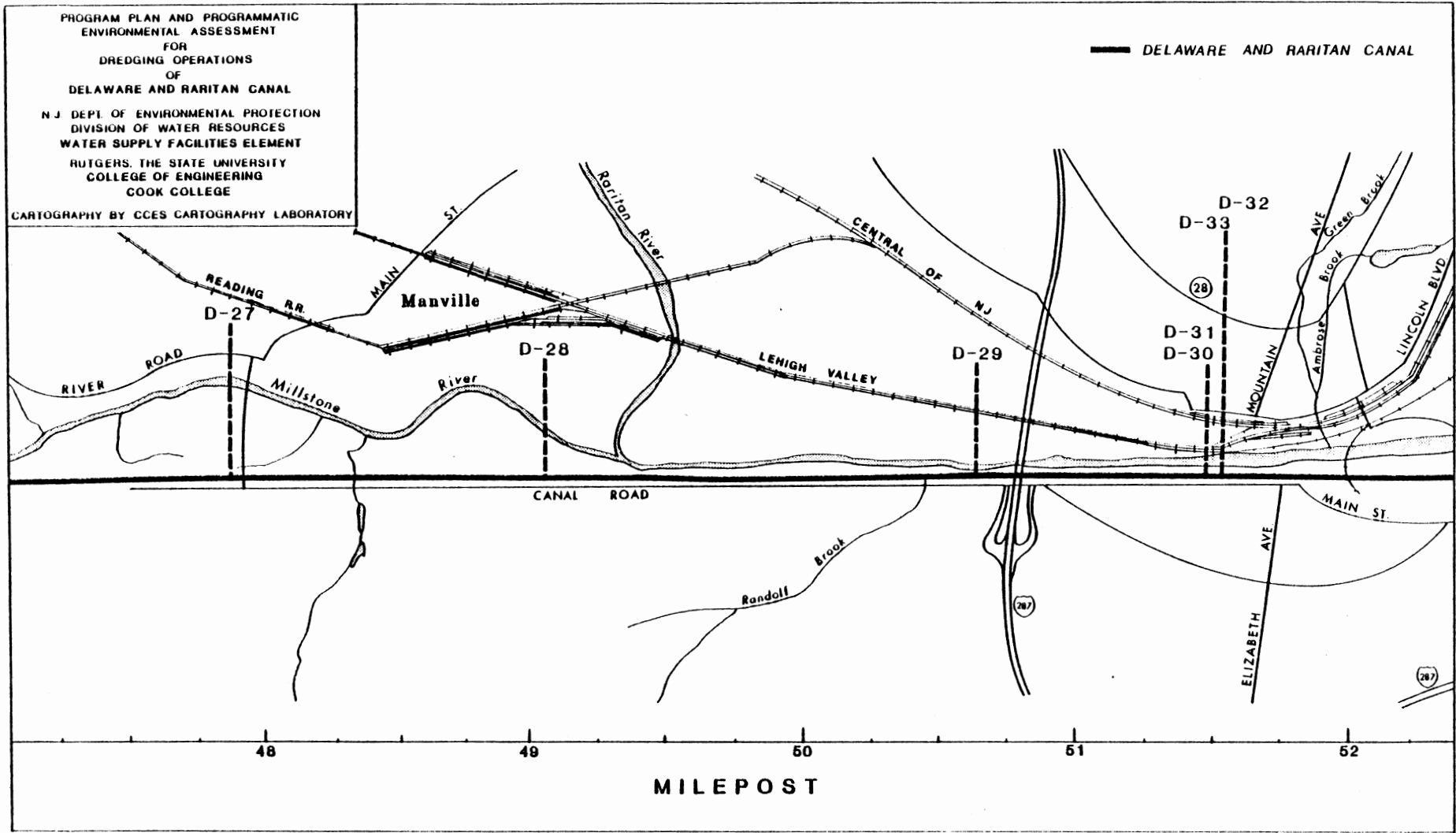
LOCATION OF SEDIMENT SAMPLING SITES

Figure 2.3 (continued)



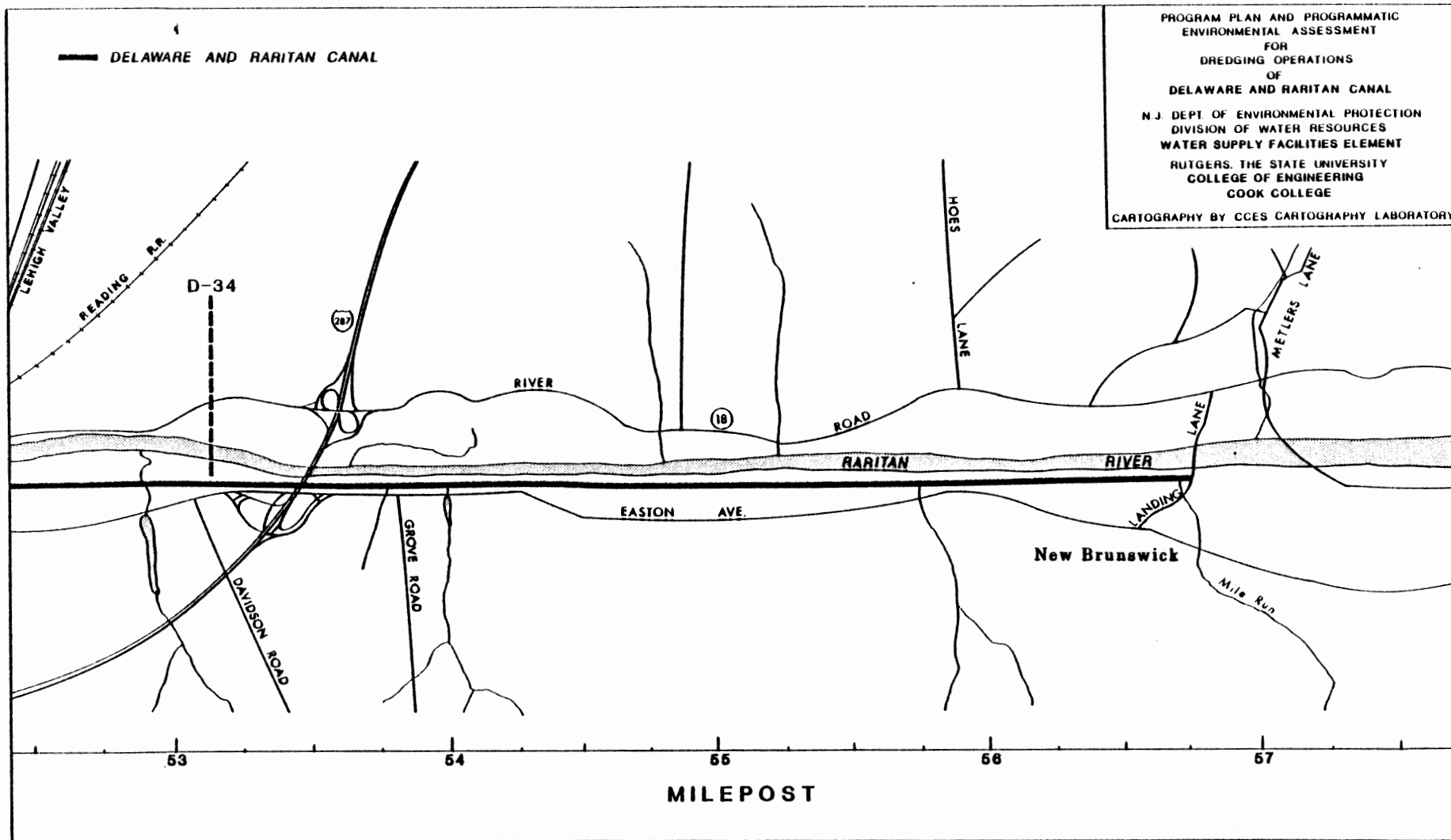
LOCATION OF SEDIMENT SAMPLING SITES

Figure 2.3 (continued)



LOCATION OF SEDIMENT SAMPLING SITES

Figure 2.3 (continued)

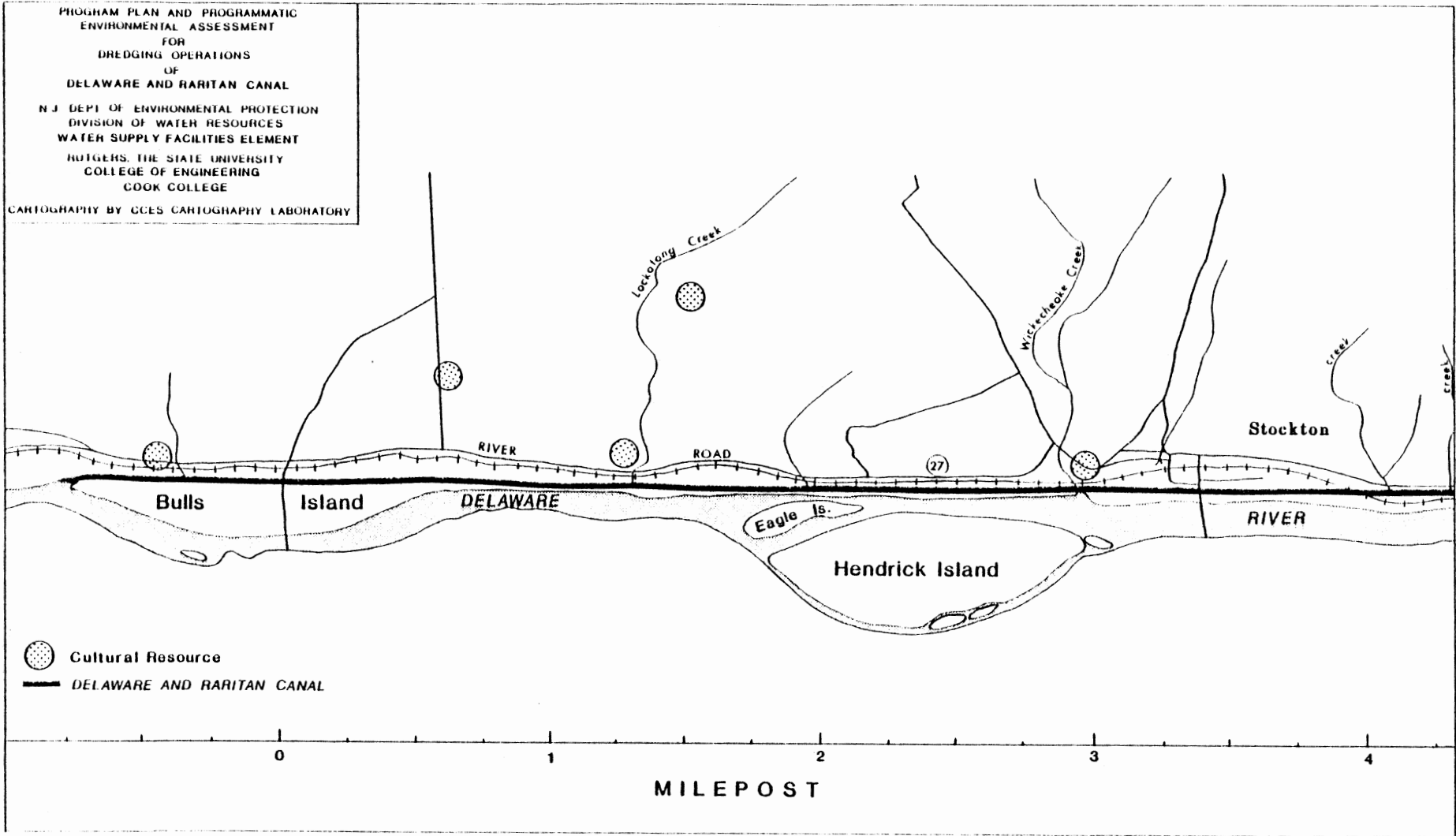


LOCATION OF SEDIMENT SAMPLING SITES

Figure 2.3 (continued)

EXPLANATION FOR FIGURE 2.4

Cultural Resources shown here are prehistoric and historic period archeological sites, structures and districts that have been given recognition and protection by inclusion in the New Jersey by the National Register of Historic Places; or have been determined eligible for the Keeper of National Register, or considered so in the opinion of the New Jersey Historic Preservation Officer (Commissioner of NJDEP); or that have been discovered or identified in the course of professional surveys for environmental impact reports and county architectural studies. This information is for general guidance only and no conclusions should be drawn or plans based on it.



LOCATION OF CULTURAL RESOURCES

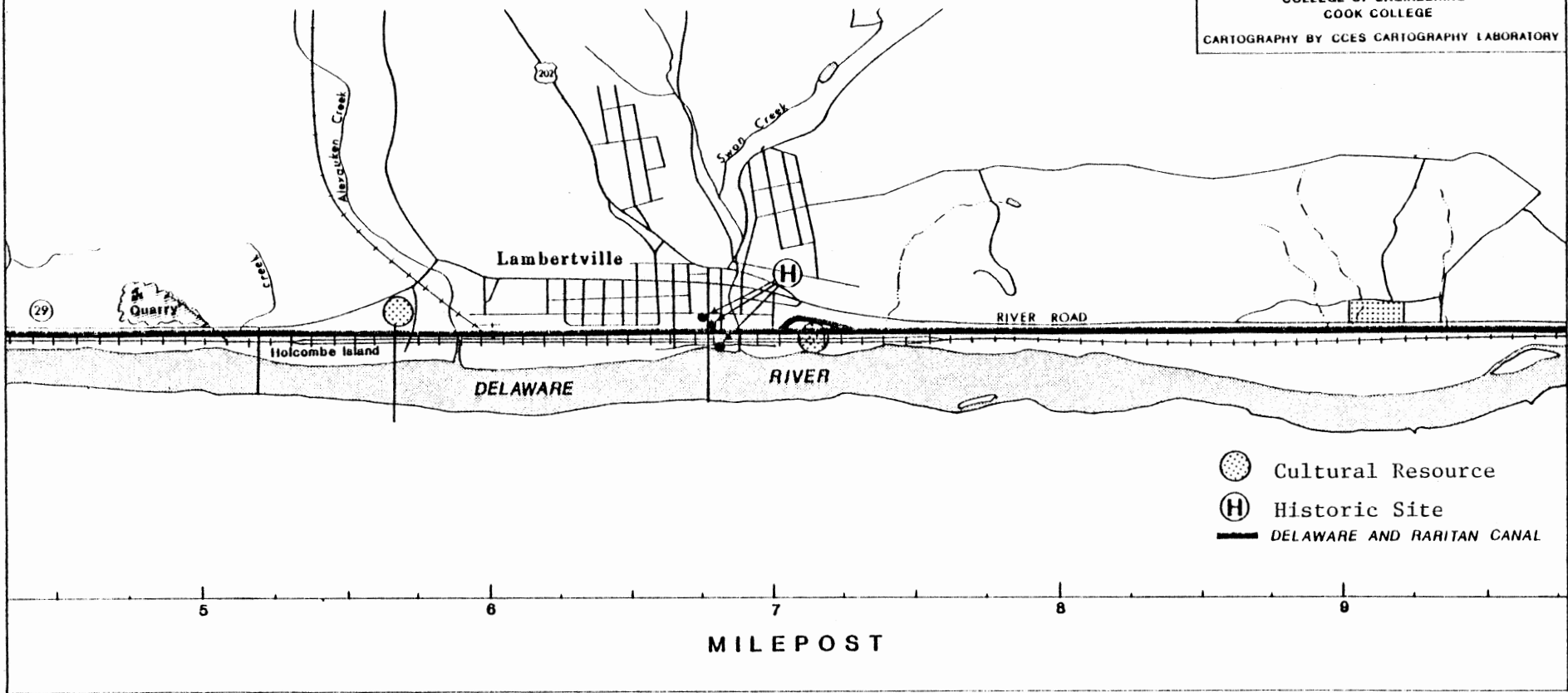
Figure 2.4

PROGRAM PLAN AND PROGRAMMATIC ENVIRONMENTAL ASSESSMENT FOR DREDGING OPERATIONS OF DELAWARE AND RARITAN CANAL

N J DEPT OF ENVIRONMENTAL PROTECTION
 DIVISION OF WATER RESOURCES
 WATER SUPPLY FACILITIES ELEMENT

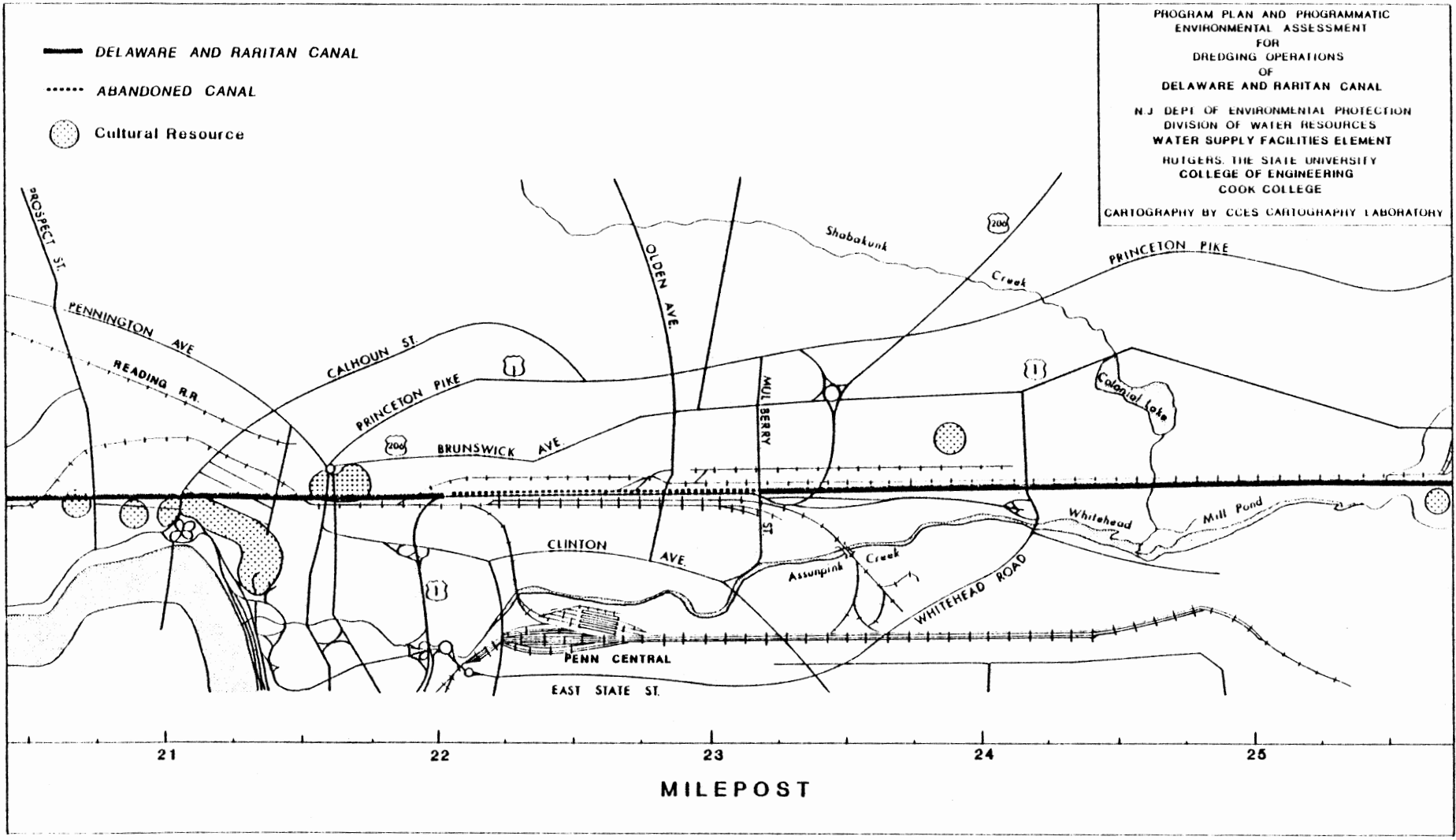
RUTGERS, THE STATE UNIVERSITY
 COLLEGE OF ENGINEERING
 COOK COLLEGE

CARTOGRAPHY BY CCES CARTOGRAPHY LABORATORY

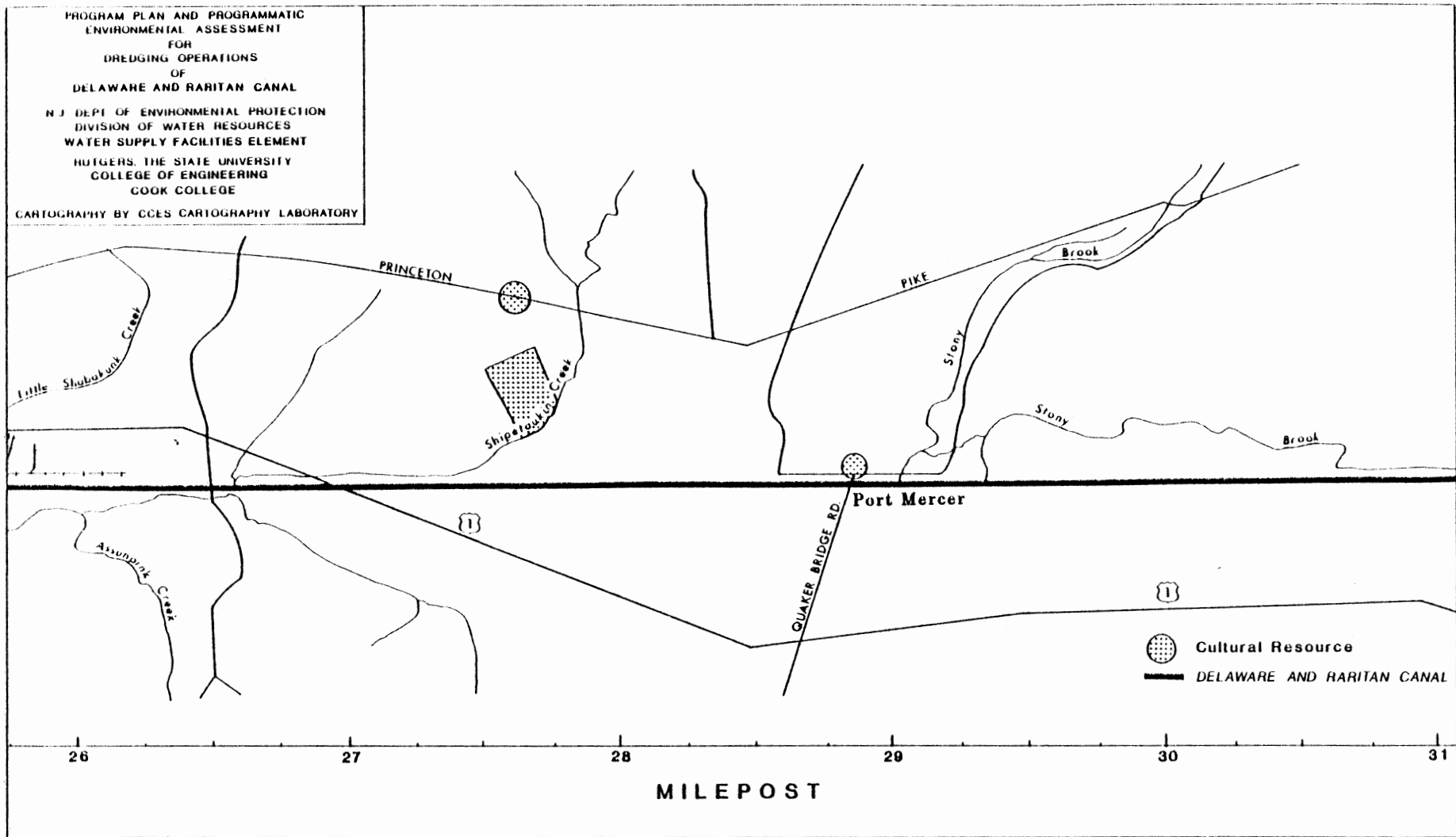


- Cultural Resource
- Ⓜ Historic Site
- DELAWARE AND RARITAN CANAL

LOCATION OF CULTURAL RESOURCES
 Figure 2.4 (continued)

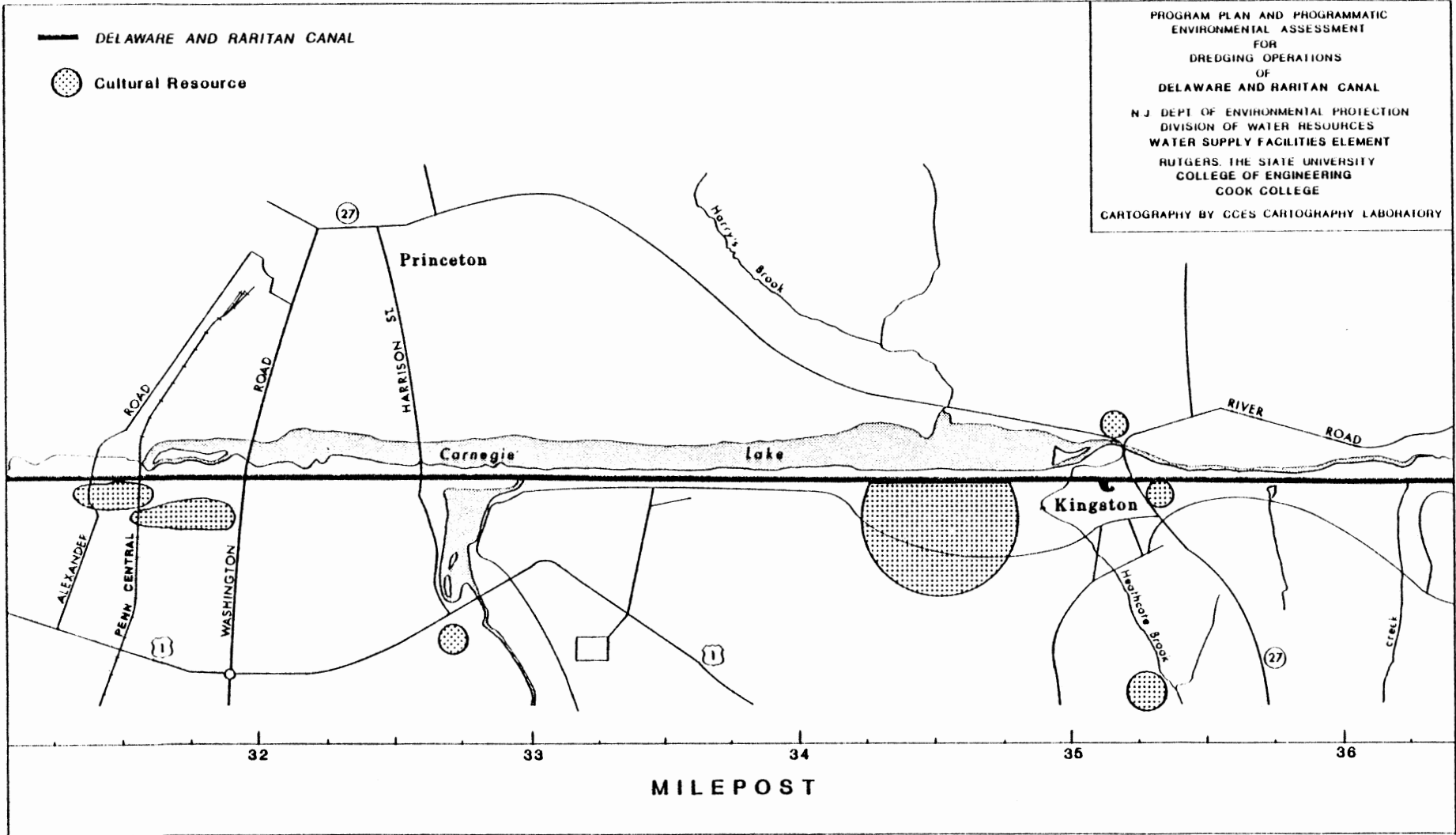


LOCATION OF CULTURAL RESOURCES
 Figure 2.4 (continued)



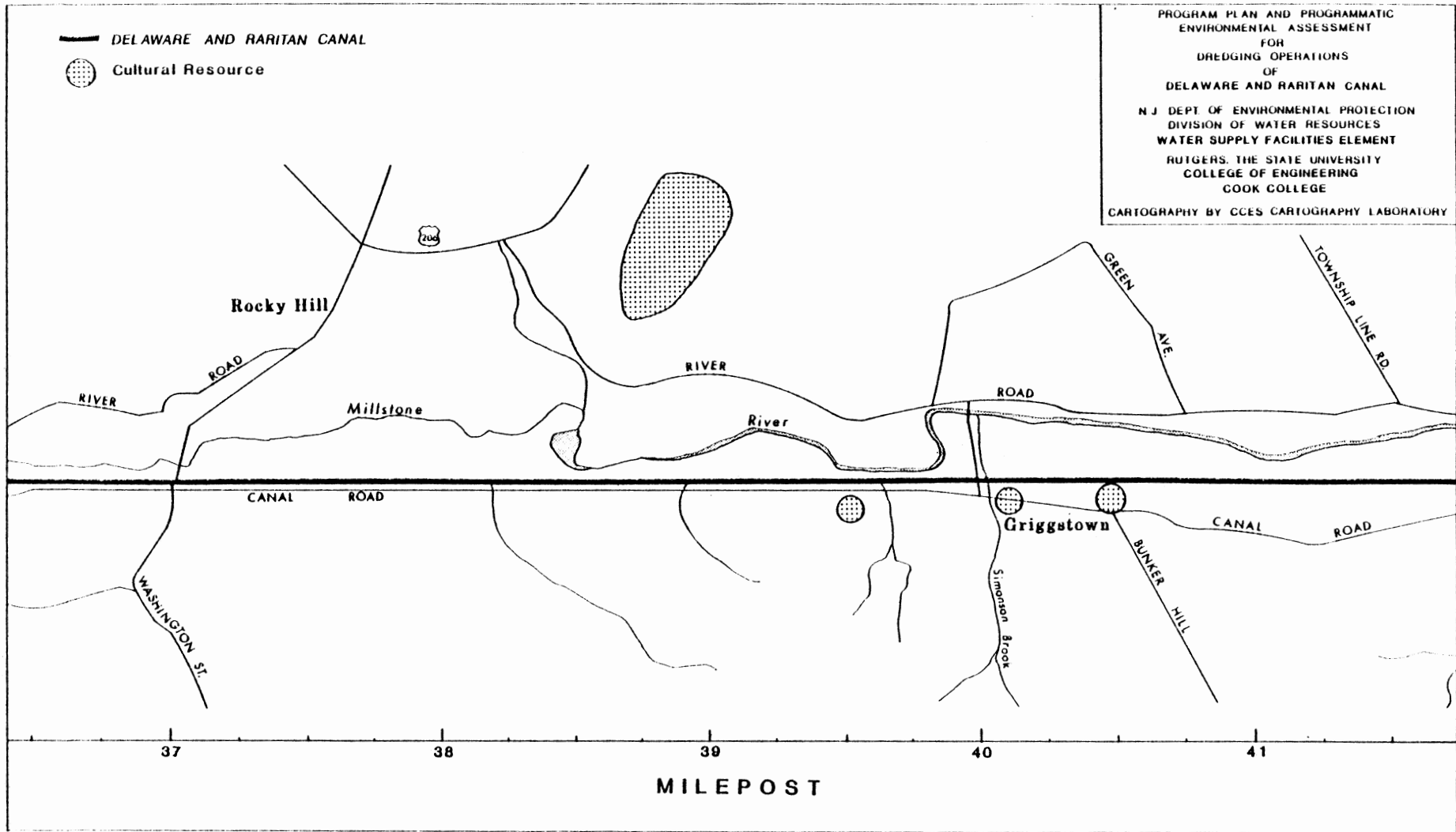
LOCATION OF CULTURAL RESOURCES

Figure 2.4 (continued)



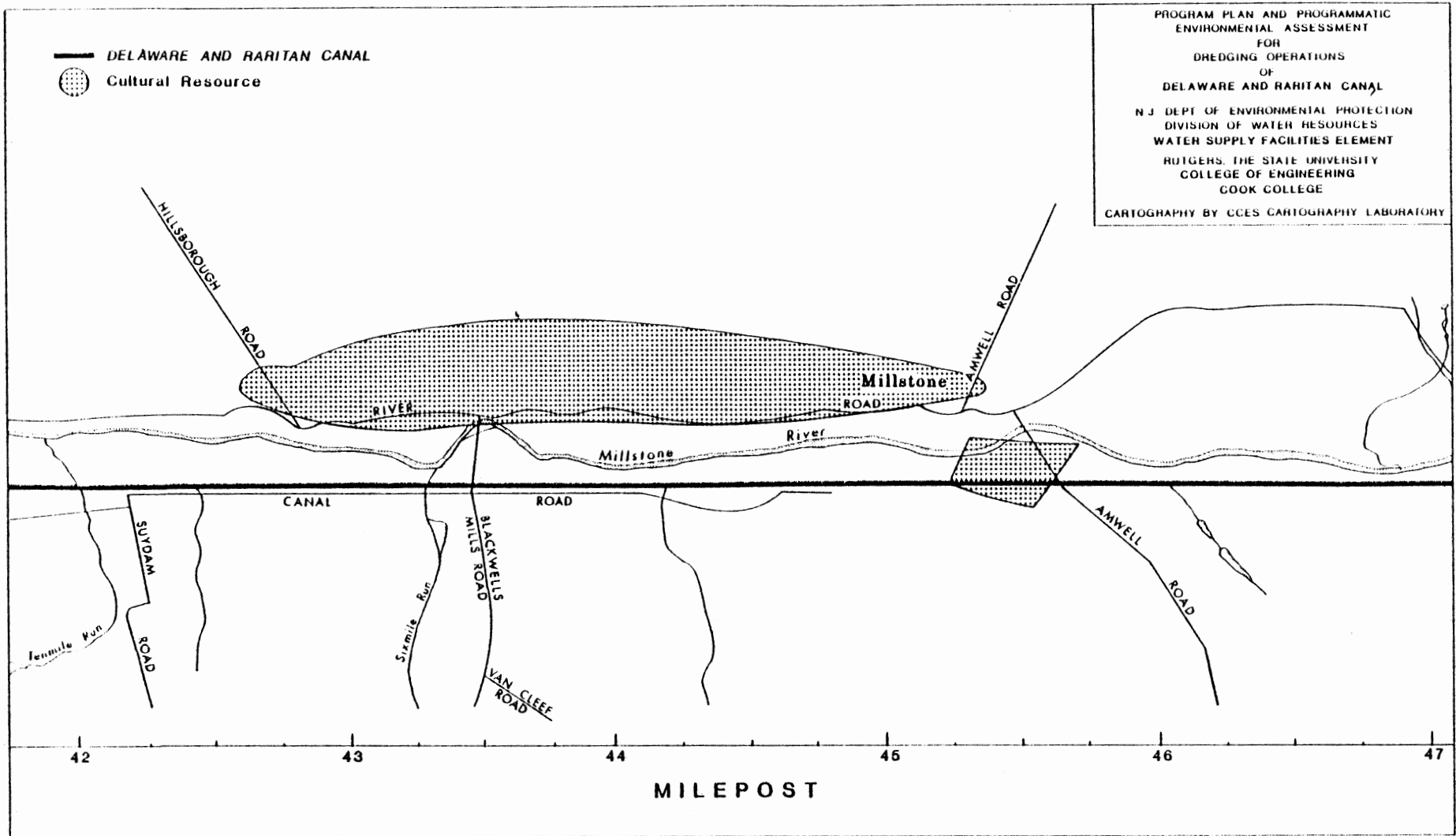
LOCATION OF CULTURAL RESOURCES

Figure 2.4 (continued)



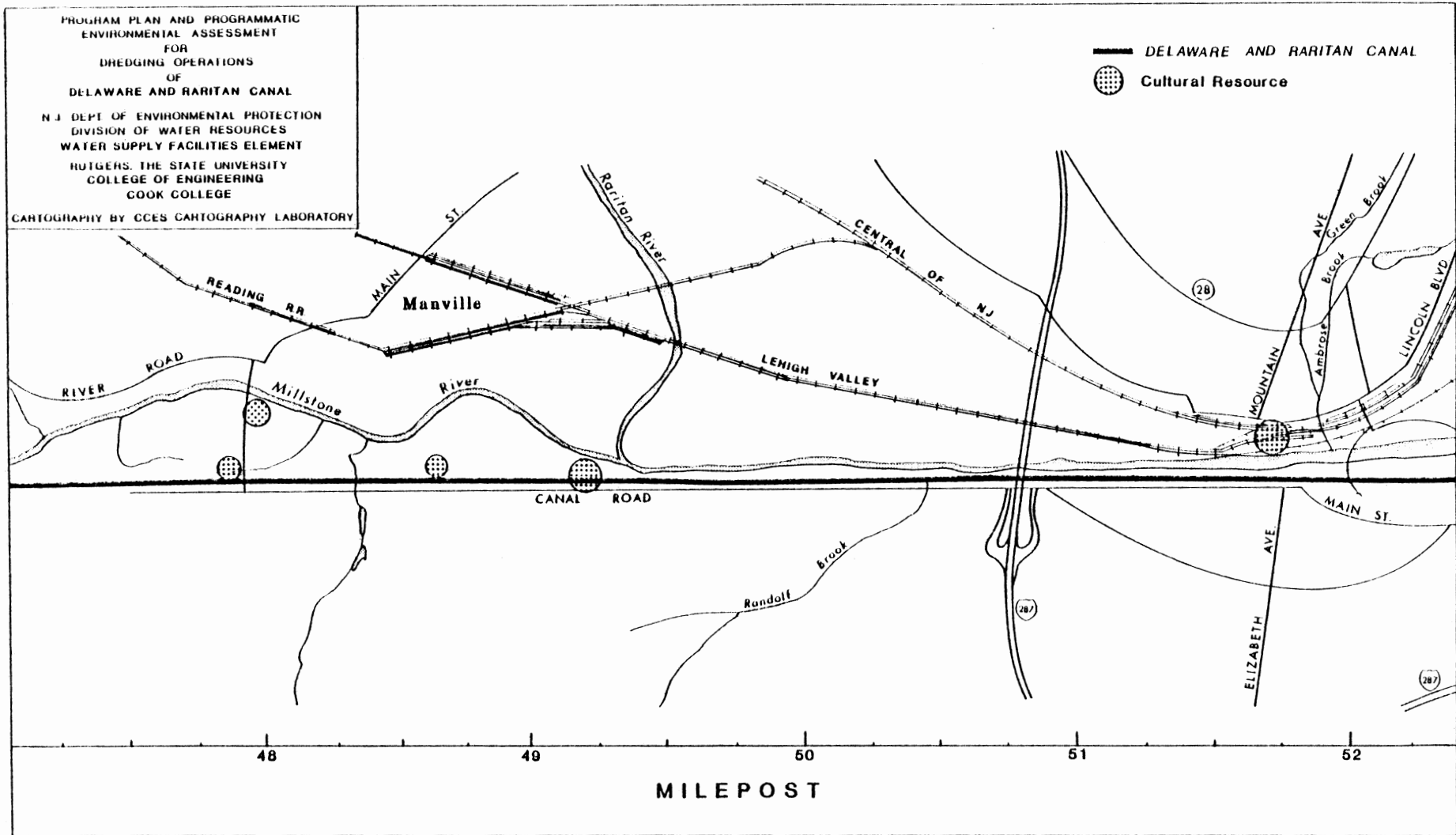
LOCATION OF CULTURAL RESOURCES

Figure 2.4 (continued)



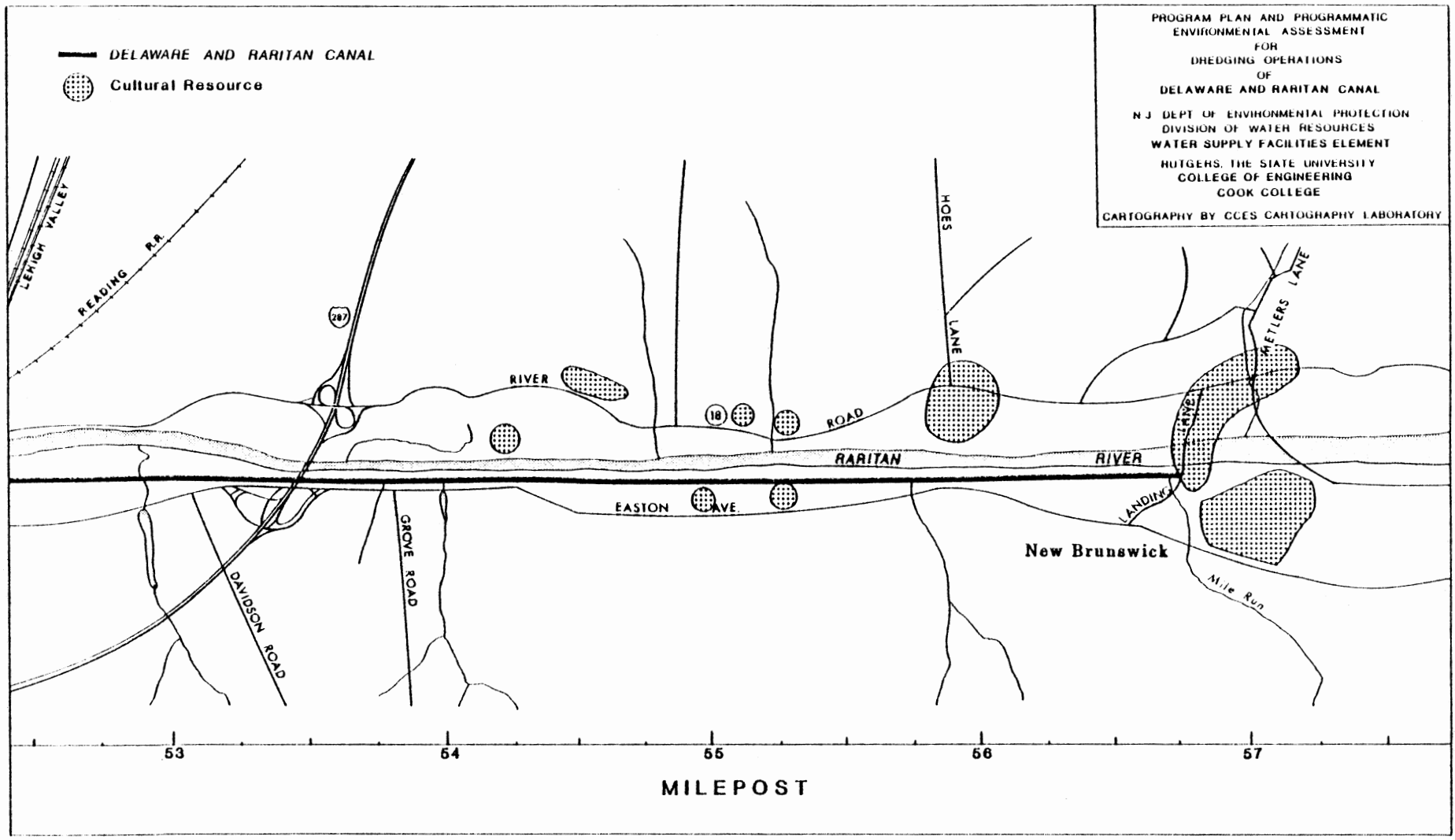
LOCATION OF CULTURAL RESOURCES

Figure 2.4 (continued)



LOCATION OF CULTURAL RESOURCES

Figure 2.4 (continued)



LOCATION OF CULTURAL RESOURCES

Figure 2.4 (continued)

CHAPTER 2

APPENDICES

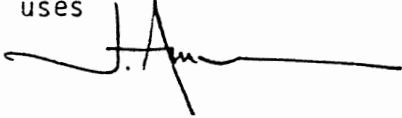
- 2.1 POTENTIAL CONVERSION OF ACCESS SITES FOR
DREDGING OPERATION TO RECREATIONAL USES
(Delaware and Raritan Canal Commission)
- 2.2 ASBESTOS IN WATER SAMPLES
(Princeton Testing Laboratory)
- 2.3 FECAL COLIFORMS
(New Jersey Laboratories)
- 2.4 EP TOXICITY TEST PROCEDURE
(U.S. Environmental Protection Agency)
- 2.5 PARTICLE SIZE DISTRIBUTIONS
- 2.6 CANAL ARTIFACTS

Delaware and Raritan Canal Commission

MEMORANDUM

To: Dr. Joel Wiesenfeld, College of Engineering, Rutgers

Subject: Potential conversion of access sites for dredging operation
to recreational uses

From: James C. Amon 

Date: 3 August 1981

We agreed that we should look closely at the possibility of using the dredging access sites for recreational purposes after the conclusion of the dredging. Further decisions will have to be made when the details for the dredging procedures are worked out, but I would like to make some comments now that can serve as guidelines.

First, the Canal State Park Law of 1974 instructs the Commission to locate those portions of the Canal Park that are "...designated wilderness areas to be kept as undeveloped, limited-access areas restricted to canoeing and hiking." (C13:13A-13b) The MASTER PLAN locates three such areas: first, from the Raven Rock lock to Smith's Mill; second, from the U.S. Route 1 crossing to Province Line Road; third, from the Griggstown Causeway to the North Brunswick Water Filtration Plant. In these places, access or clearing for the dredging operation should be minimized and any damage should be repaired with new landscape material.

The primary use of dredging access sites would be for parking yards that will provide recreation access to the Canal Park. Where this conversion is anticipated, several points should be kept in mind. First, the Commission has a policy of advocating many small parking yards rather than a few large ones. Parking should not be for more than twenty or twenty-five cars. Second, several parts of the DESIGN GUIDE should be referred to for guidance, particularly the chapters on parking and landscaping.

Getting to particulars at last, the following sites marked as potential access points for the dredging program look like they might be good for conversion to recreational access points.

1. Bridge Street in Stockton
2. Two sites downstream of Lambertville are shown -- one might be good for recreation purposes.
3. Church Road in Titusville
4. Upper Ferry Road
5. Lower Ferry Road
6. Mulberry Road
7. Whitehead Road
8. Baker's Basin Road
9. Quakerbridge Road

princeton testing laboratory

March 24, 1981

TO: Rutgers University
Bureau of Engineering Research
PO Box 909
Brett & Bowser Roads
Piscataway, NJ 08854

ATT: Dr. R.C. Ahlert

Job Number: 16270

Authorization: PO# 799476

Analysis Requested: Asbestos in Water Samples (3)

Analytical Method: Due to the high level of suspended material in all three samples, 10 cc of each sample was diluted with 100 cc of previously filtered deionized water. All three samples plus a 100 cc filtered deionized water were passed through a Metrical GN 6 filter (0.8 micron pore size) utilizing glass millipore filtration equipment. All four filters were dried in a vacuum dessicator, and then mounted and analysed as outlined in NIOSH Method P & CAM 239 (Asbestos Fibers in Air)

Results:

<u>Sample #</u>	<u>Fibers > 5 Micron/Liter</u>
D-31	340,000
D-32	1,440,000
D-33	2,374,000

Very truly yours,

Gene Dennison, PhD, CIH
Technical Director

GD: smb

2-102

princeton testing laboratory

May 21, 1981

TO: Rutgers University
Bureau of Engineering Research
PO Box 909
Brett & Bowser Roads
Piscataway, NJ 08854

ATT: R.C. Ahlert

Job Number: 17066

Authorization: PO# Q512171

Analysis Requested: Asbestos in Water Samples (2)

Procedure Outlined: Ten milliliters of each sample was diluted with filtered deionized water and then passed through a Metrical GN 6 filter (0.8 micron pore size) utilizing glass millipore filtration equipment. A blank filter was prepared by filtering same amount of deionized water. All filters were dried in a vacuum dessicator, and then mounted and analyzed as outlined in NIOSH Method P & CAM 239 (Asbestos Fibers in Air). Fibers longer than 5 microns were counted.

Results:

	Fibers/liter
D-30	210,000
D-34	210,000

Very truly yours,

Gene Dennison, PhD, CIH
Technical Director

GD: smb

cc: John Gorgol

NEW JERSEY LABORATORIES
 222-226 EASTON AVENUE 201 249-0148
 P. O. BOX 748 NEW BRUNSWICK, N. J. 08903

ANALYTICAL TESTING
 SINCE 1939

REPORT ON WATER SAMPLES

Divisions:
 NEW JERSEY DAIRY LABORATORIES
 PHARMETICS LABORATORY

BUREAU OF ENGINEERING RESEARCH
 College of Engineering
 Busch Campus - Room B-210
 P.O. Box 909
 Piscataway, N.J. 08854
 Att: Dr. R.C. Ahlert

DATE 3/12/81 NO. 5748-5756
 COPY
 P.O. No. 799436

IDENTIFICATIONS:

- | | | |
|---------------------|----------------------|----------------------|
| 1. Water sample D-2 | 4. Water Sample D-1C | 7. Water Sample D-21 |
| 2. Water Sample D-4 | 5. Water Sample D-1E | 8. Water Sample D-25 |
| 3. Water Sample D-8 | 6. Water Sample D-20 | 9. Water Sample D-32 |

SAMPLES:

Received on:	Delivered by:	Refrigerated:	Taken by:	On:	Refrigerated:
3/9	Your Agent	No	Your Agent		No
In Glass Container:	Sterilized by:	Thiosulfate Added:	At Site: ppm Chlorine	At Site: pH reading	At Site: Water Temp.
Bag	Your Agent	No			

BACTERIAL DATA:

	TOTAL AGAR PLATE COUNTS		COLIFORMS in Five 10, 1 and 0.1 ml. Tubes			Pertinent Bacterial Standards SATISFIED
	35°C. Incub.	Colonies per ml.: 20°C. Incub.	Presumptive Test: Tubes "POSITIVE"	Confirmed Test: Tubes "POSITIVE"	Equivalency, or "MPN per 100 ml."	
1.	Fecal Coliforms (44.5°C)				MPN = 1,100 per 100 ml	
2.	Fecal Coliforms (44.5°C)				MPN = #20 per 100 ml	
3.	Fecal Coliforms (44.5°C)				MPN = 45 per 100 ml	
4.	Fecal Coliforms (44.5°C)				MPN = #20 per 100 ml	
5.	Fecal Coliforms (44.5°C)				MPN = #20 per 100 ml	
6.	Fecal Coliforms (44.5°C)				MPN = 20 per 100 ml	
7.	Fecal Coliforms (44.5°C)				MPN = #20 per 100 ml	
8.	Fecal Coliforms (44.5°C)				MPN = #20 per 100 ml	
9.	Fecal Coliforms (44.5°C)				MPN = #20 per 100 ml	

= Less Than

Charles F. Molino, Manager

BACTERIAL STANDARDS:

- To be "satisfactory", five 10 ml. (thus 50 ml.) portions of properly representative samples of drinking waters and swimming pool waters must show the complete absence of coliforms, by the codes of both the U. S. Public Health Service and the N. J. State Department of Health.
- Coliforms in waters from natural bathing places are reported as "Most Probable Number in 100 ml." The American Public Health Association classifies bathing areas whose samples show MPN values below 1000 as "suitable" for use; those between 1000 and 2400 as "acceptable, subject to further test"; and those above 2400 as "unsuitable".

NOTES:

- We certify that our analyses of water samples are made in full conformance with the appropriate procedures specified in "Standard Methods for the Examination of Water", and are accurate to within the experimental errors of these techniques.
- We certify that samples of water, taken by our representatives, have been prepared and transported to the laboratory in full conformance with the procedures prescribed in the SMEW manuals.
- We do not certify to the authenticity of samples prepared by other than our own representatives. Such samples' identities are detailed only as reported to us.

Hazardous Waste No.	Substance ¹
U223.....	Toluene diisocyanate
U224.....	Toxaphene
	2,4,5-TP see U233
U225.....	Tribromomethane
U226.....	1,1,1-Trichloroethane
U227.....	1,1,2-Trichloroethane
U228.....	Trichloroethene
	Trichloroethylene see U228
U229.....	Trichlorofluoromethane
U230.....	2,4,5-Trichlorophenol
U231.....	2,4,6-Trichlorophenol
U232.....	2,4,5-Trichlorophenoxyacetic acid
U233.....	2,4,5-Trichlorophenoxypropionic acid alpha, alpha, alpha-Trichlorotoluene see U023
	TRI-CLENE see U228
U234.....	Trinitrobenzene (R,T)
U235.....	Tris(2,3-dibromopropyl) phosphate
U236.....	Trypan blue
U237.....	Uracil mustard
U238.....	Urethane
	Vinyl chloride see U043
	Vinylidene chloride see U078
U239.....	Xylene

¹ The Agency included those trade names of which it was aware; an omission of a trade name does not imply that it is not hazardous. The material is hazardous if it is listed under its generic name.

Appendix I—Representative Sampling Methods

The methods and equipment used for sampling waste materials will vary with the form and consistency of the waste materials to be sampled. Samples collected using the sampling protocols listed below, for sampling waste with properties similar to the indicated materials, will be considered by the Agency to be representative of the waste.

Extremely viscous liquid—ASTM Standard D140-70 Crushed or powdered material—ASTM Standard D348-75 Soil or rock-like material—ASTM Standard D420-69 Soil-like material—ASTM Standard D1452-65 Fly Ash-like material—ASTM Standard D2234-76 [ASTM Standards are available from ASTM, 1916 Race St., Philadelphia, PA 19103]

Containerized liquid wastes—"COLIWASA" described in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods,"¹ U.S. Environmental Protection Agency, Office of Solid Waste, Washington, D.C. 20460. [Copies may be obtained from Solid Waste Information, U.S. Environmental Protection Agency, 28 W. St. Clair St., Cincinnati, Ohio 45268]

Liquid waste in pits, ponds, lagoons, and similar reservoirs.—"Pond Sampler" described in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods."¹

This manual also contains additional information on application of these protocols.

¹ These methods are also described in "Samplers and Sampling Procedures for Hazardous Waste Streams," EPA 600/2-80-018, January 1980.

Appendix II—EP Toxicity Test Procedure

A. Extraction Procedure (EP)

1. A representative sample of the waste to be tested (minimum size 100 grams) should be obtained using the methods specified in Appendix I or any other methods capable of yielding a representative sample within the meaning of Part 260. [For detailed guidance on conducting the various aspects of the EP see "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods," SW-846, U.S. Environmental Protection Agency Office of Solid Waste, Washington, D.C. 20460.]

2. The sample should be separated into its component liquid and solid phases using the method described in "Separation Procedure" below. If the solid residue² obtained using this method totals less than 0.5% of the original weight of the waste, the residue can be discarded and the operator should treat the liquid phase as the extract and proceed immediately to Step 8.

3. The solid material obtained from the Separation Procedure should be evaluated for its particle size. If the solid material has a surface area per gram of material equal to, or greater than, 3.1 cm² or passes through a 9.5 mm (0.375 inch) standard sieve, the operator should proceed to Step 4. If the surface area is smaller or the particle size larger than specified above, the solid material should be prepared for extraction by crushing, cutting or grinding the material so that it passes through a 9.5 mm (0.375 inch) sieve or, if the material is in a single piece, by subjecting the material to the "Structural Integrity Procedure" described below.

4. The solid material obtained in Step 3 should be weighed and placed in an extractor with 16 times its weight of deionized water. Do not allow the material to dry prior to weighing. For purposes of this test, an acceptable extractor is one which will impart sufficient agitation to the mixture to not only prevent stratification of the sample and extraction fluid but also insure that all sample surfaces are continuously

brought into contact with well mixed extraction fluid.

5. After the solid material and deionized water are placed in the extractor, the operator should begin agitation and measure the pH of the solution in the extractor. If the pH is greater than 5.0, the pH of the solution should be decreased to 5.0 ± 0.2 by adding 0.5 N acetic acid. If the pH is equal to or less than 5.0, no acetic acid should be added. The pH of the solution should be monitored, as described below, during the course of the extraction and if the pH rises above 5.2, 0.5N acetic acid should be added to bring the pH down to 5.0 ± 0.2. However, in no event shall the aggregate amount of acid added to the solution exceed 4 ml of acid per gram of solid. The mixture should be agitated for 24 hours and maintained at 20°-40° C (68°-104° F) during this time. It is recommended that the operator monitor and adjust the pH during the course of the extraction with a device such as the Type 45-A pH Controller manufactured by Chemtrix, Inc., Hillsboro, Oregon 97123 or its equivalent, in conjunction with a metering pump and reservoir of 0.5N acetic acid. If such a system is not available, the following manual procedure shall be employed:

(a) A pH meter should be calibrated in accordance with the manufacturer's specifications.

(b) The pH of the solution should be checked and, if necessary, 0.5N acetic acid should be manually added to the extractor until the pH reaches 5.0 ± 0.2. The pH of the solution should be adjusted at 15, 30 and 60 minute intervals, moving to the next longer interval if the pH does not have to be adjusted more than 0.5N pH units.

(c) The adjustment procedure should be continued for at least 6 hours.

(d) If at the end of the 24-hour extraction period, the pH of the solution is not below 5.2 and the maximum amount of acid (4 ml per gram of solids) has not been added, the pH should be adjusted to 5.0 ± 0.2 and the extraction continued for an additional four hours, during which the pH should be adjusted at one hour intervals.

6. At the end of the 24 hour extraction period, deionized water should be added to the extractor in an amount determined by the following equation:

$$V = (20)(W) - 16(W) - A$$

V = ml deionized water to be added
W = weight in grams of solid charged to extractor
A = ml of 0.5N acetic acid added during extraction

7. The material in the extractor should be separated into its component liquid and solid phases as described under "Separation Procedure."

8. The liquids resulting from Steps 2 and 7 should be combined. This

¹ Copies may be obtained from Solid Waste Information, U.S. Environmental Protection Agency, 28 W. St. Clair Street, Cincinnati, Ohio 45268.

² The percent solids is determined by drying the filter pad at 80° C until it reaches constant weight and then calculating the percent solids using the following equation:

$$\frac{(\text{weight of pad} + \text{solid}) - (\text{tare weight of pad})}{\text{initial weight of sample}} \times 100 = \% \text{ solids}$$

combined liquid (or the waste itself if it has less than 1/2 percent solids, as noted in Step 2) is the extract and should be analyzed for the presence of any of the contaminants specified in Table I of § 261.24 using the Analytical Procedures designated below.

Separation Procedure

Equipment: A filter holder, designed for filtration media having a nominal pore size of 0.45 micrometers and capable of applying a 5.3 kg/cm² (75 psi) hydrostatic pressure to the solution being filtered shall be used. For mixtures containing nonabsorptive solids, where separation can be affected without imposing a 5.3 kg/cm² pressure differential, vacuum filters employing a 0.45 micrometers filter media can be used. (For further guidance on filtration equipment or procedures see "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.")

Procedure:³

(i) Following manufacturer's directions, the filter unit should be assembled with a filter bed consisting of a 0.45 micrometer filter membrane. For difficult or slow to filter mixtures a prefilter bed consisting of the following prefilters in increasing pore size (0.65 micrometer membrane, fine glass fiber prefilter, and coarse glass fiber prefilter) can be used.

(ii) The waste should be poured into the filtration unit.

(iii) The reservoir should be slowly pressurized until liquid begins to flow from the filtrate outlet at which point the pressure in the filter should be immediately lowered to 10-15 psig. Filtration should be continued until liquid flow ceases.

(iv) The pressure should be increased stepwise in 10 psi increments to 75 psig and filtration continued until flow ceases or the pressurizing gas begins to exit from the filtrate outlet.

(v) The filter unit should be depressurized, the solid material removed and weighed and then transferred to the extraction apparatus, or, in the case of final filtration prior to analysis, discarded. Do not allow the

³This procedure is intended to result in separation of the "free" liquid portion of the waste from any solid matter having a particle size >0.45µm. If the sample will not filter, various other separation techniques can be used to aid in the filtration. As described above, pressure filtration is employed to speed up the filtration process. This does not alter the nature of the separation. If liquid does not separate during filtration, the waste can be centrifuged. If separation occurs during centrifugation the liquid portion (centrifugate) is filtered through the 0.45µm filter prior to becoming mixed with the liquid portion of the waste obtained from the initial filtration. Any material that will not pass through the filter after centrifugation is considered a solid and is extracted.

material retained on the filter pad to dry prior to weighing.

(vi) The liquid phase should be stored at 4°C for subsequent use in Step 8.

B. Structural Integrity Procedure

Equipment: A Structural Integrity Tester having a 3.18 cm (1.25 in.) diameter hammer weighing 0.33 kg (0.73 lbs.) and having a free fall of 15.24 cm (6 in.) shall be used. This device is available from Associated Design and Manufacturing Company, Alexandria, VA., 22314, as Part No. 125, or it may be fabricated to meet the specifications shown in Figure 1.

Procedure:

1. The sample holder should be filled with the material to be tested. If the sample of waste is a large monolithic block, a portion should be cut from the block having the dimensions of a 3.3 cm (1.3 in.) diameter x 7.1 cm (2.8 in.) cylinder. For a fixated waste, samples may be cast in the form of a 3.3 cm (1.3 in.) diameter x 7.1 cm (2.8 in.) cylinder for purposes of conducting this test. In such cases, the waste may be allowed to cure for 30 days prior to further testing.

2. The sample holder should be placed into the Structural Integrity Tester, then the hammer should be raised to its maximum height and dropped. This should be repeated fifteen times.

3. The material should be removed from the sample holder, weighed, and transferred to the extraction apparatus for extraction.

Analytical Procedures for Analyzing Extract Contaminants

The test methods for analyzing the extract are as follows:

(1) For arsenic, barium, cadmium, chromium, lead, mercury, selenium or silver: "Methods for Analysis of Water and Wastes," Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268 (EPA-600/4-79-020, March 1979),

(2) For Endrin; Lindane; Methoxychlor; Toxaphene; 2,4-D; 2,4,5-TP Silver: in "Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," September 1978, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 42568,

as standardized in "Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods."

For all analyses, the method of standard addition shall be used for the quantification of species concentration.

This method is described in "Test Methods for the Evaluation of Solid Waste." (It is also described in "Methods for Analysis of Water and Wastes.")

BILLING CODE 6560-01-M

GRAIN SIZE DISTRIBUTION

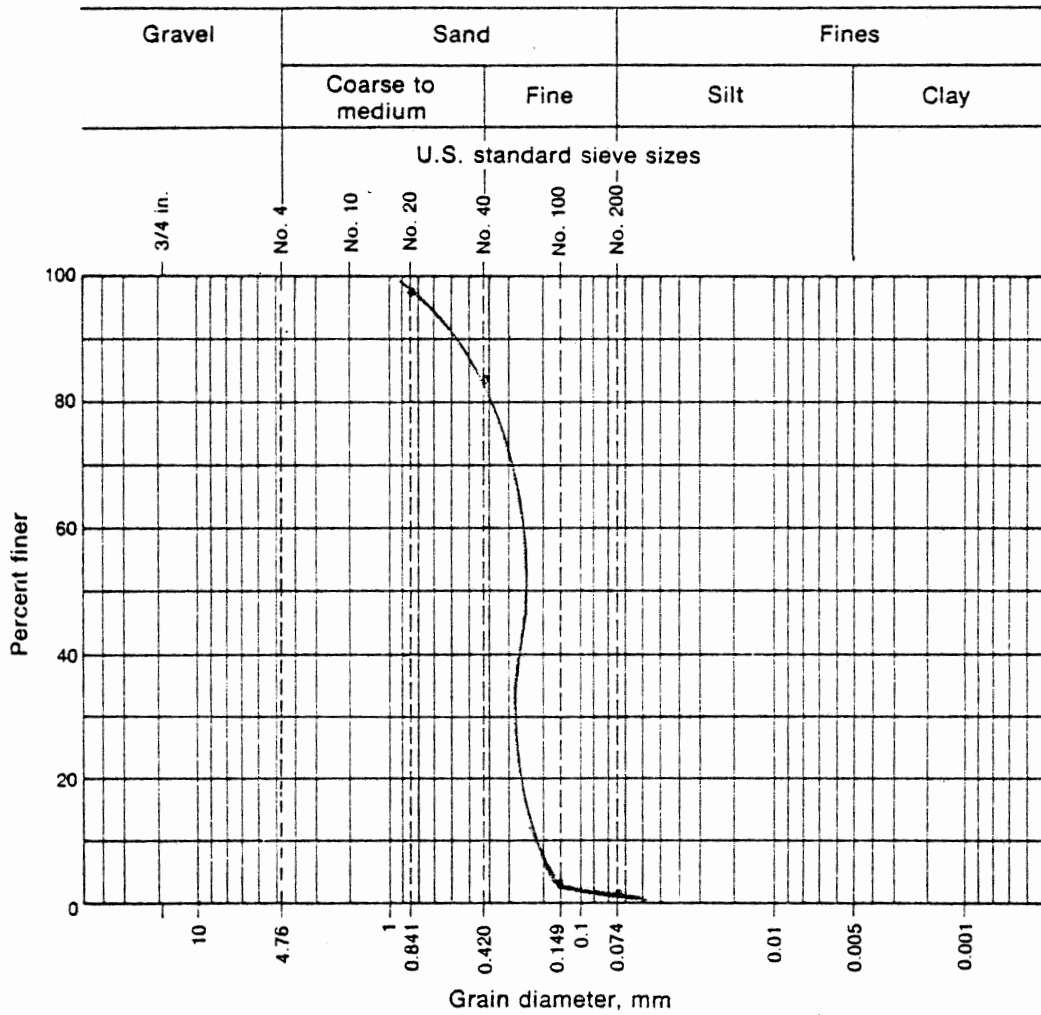
Data Sheet 5

Project D&RC - Dredging Job. No. Site No D-1

Location of Project See Table Z-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description Poorly Graded Sand

Soil classification: SP System Unified

GRAIN SIZE DISTRIBUTION

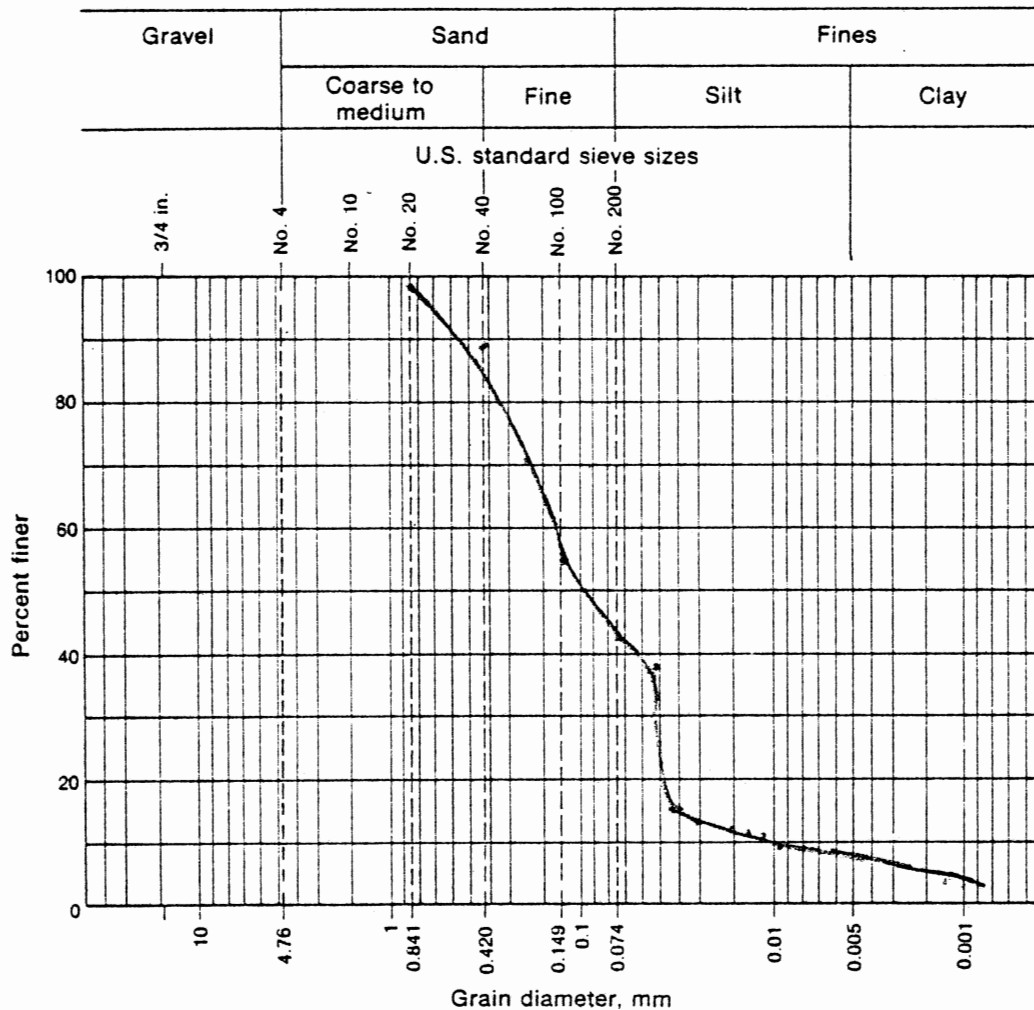
Data Sheet 5

Project D+R C - Dredging Job No. Site No. D-2

Location of Project See Table 2.3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description silty sand

Soil classification: SM System Unified

GRAIN SIZE DISTRIBUTION

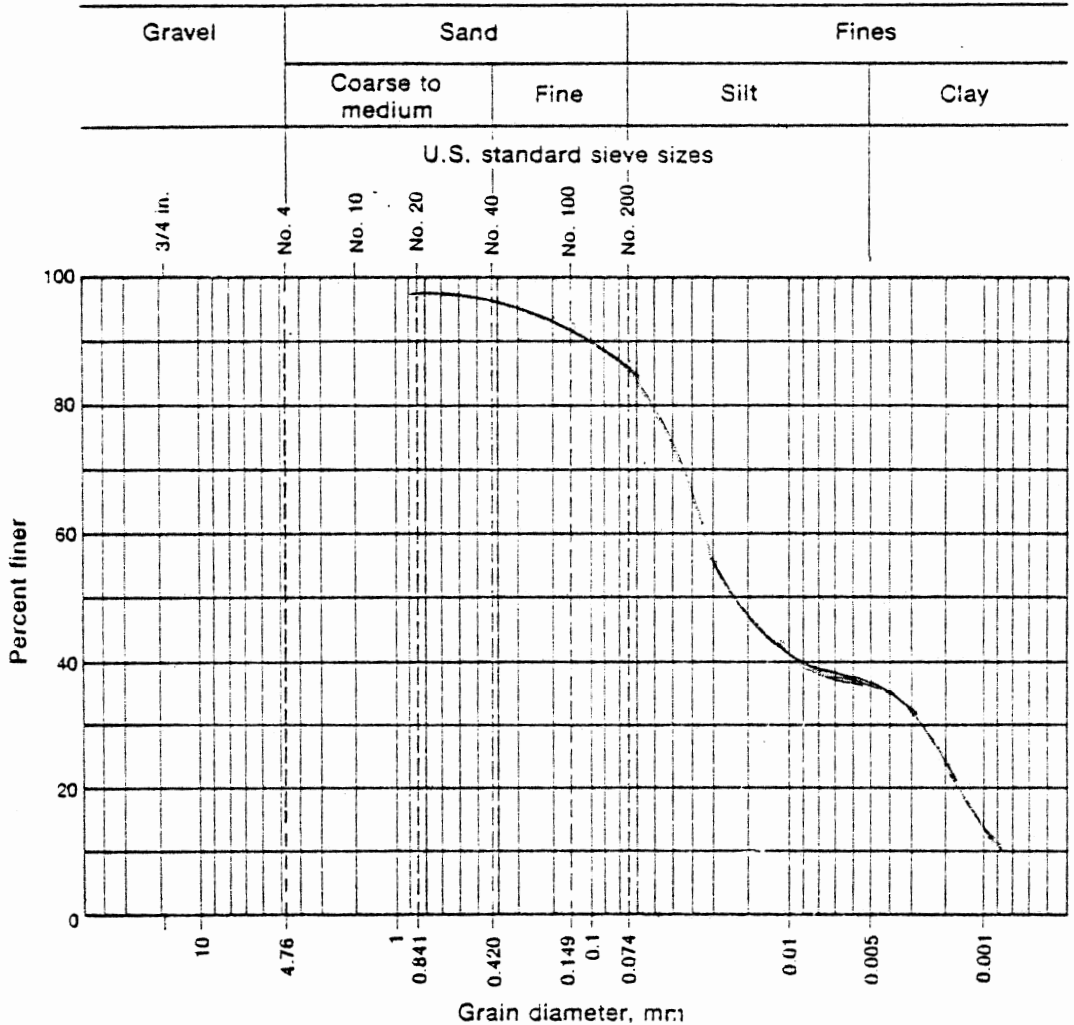
Data Sheet 5

Project D+RC - Dredging Job. No. Site No D-3

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description Sandy silt

Soil classification: MH System Unified

GRAIN SIZE DISTRIBUTION

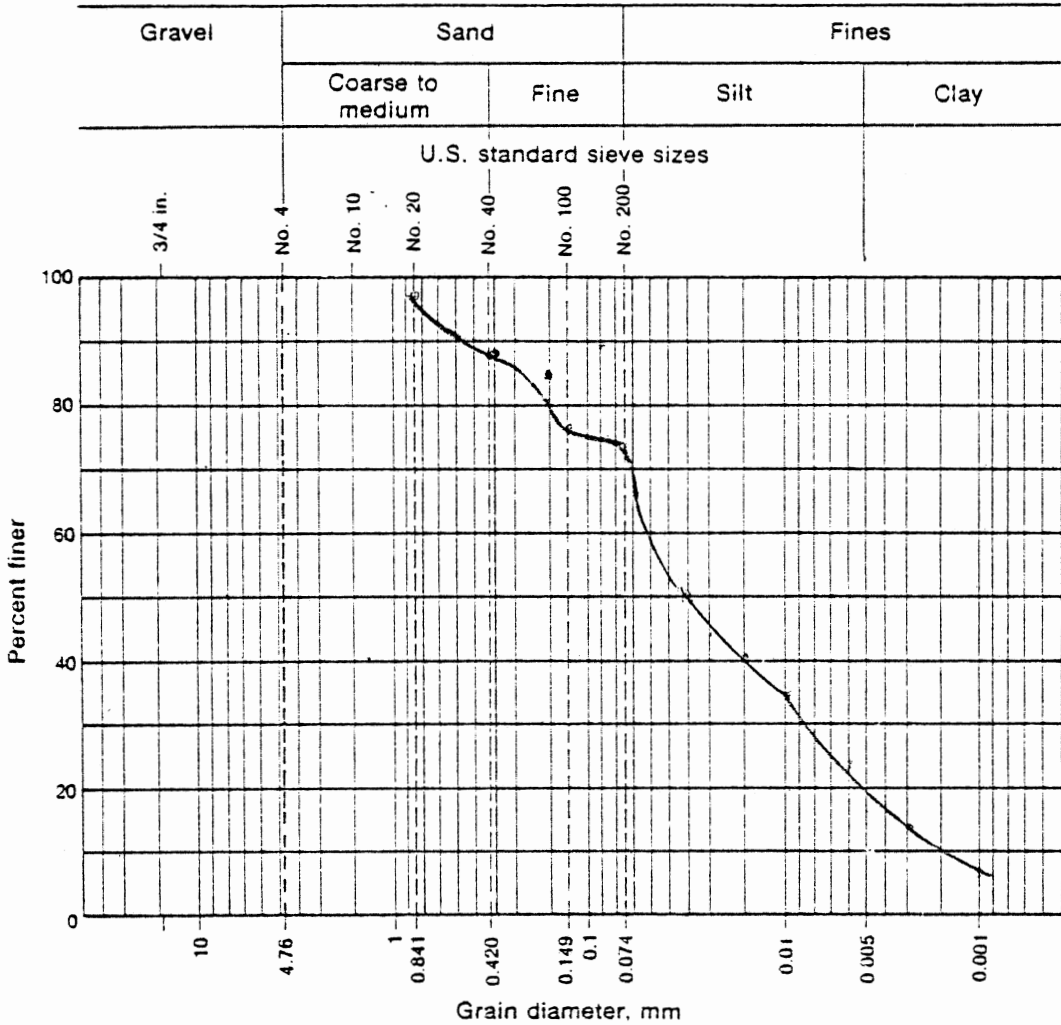
Data Sheet 5

Project D&RC - Dredging Job. No. Site No. D-4

Location of Project See Table Z-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description sandy silt with some clay

Soil classification: ML/OH System Unified

GRAIN SIZE DISTRIBUTION

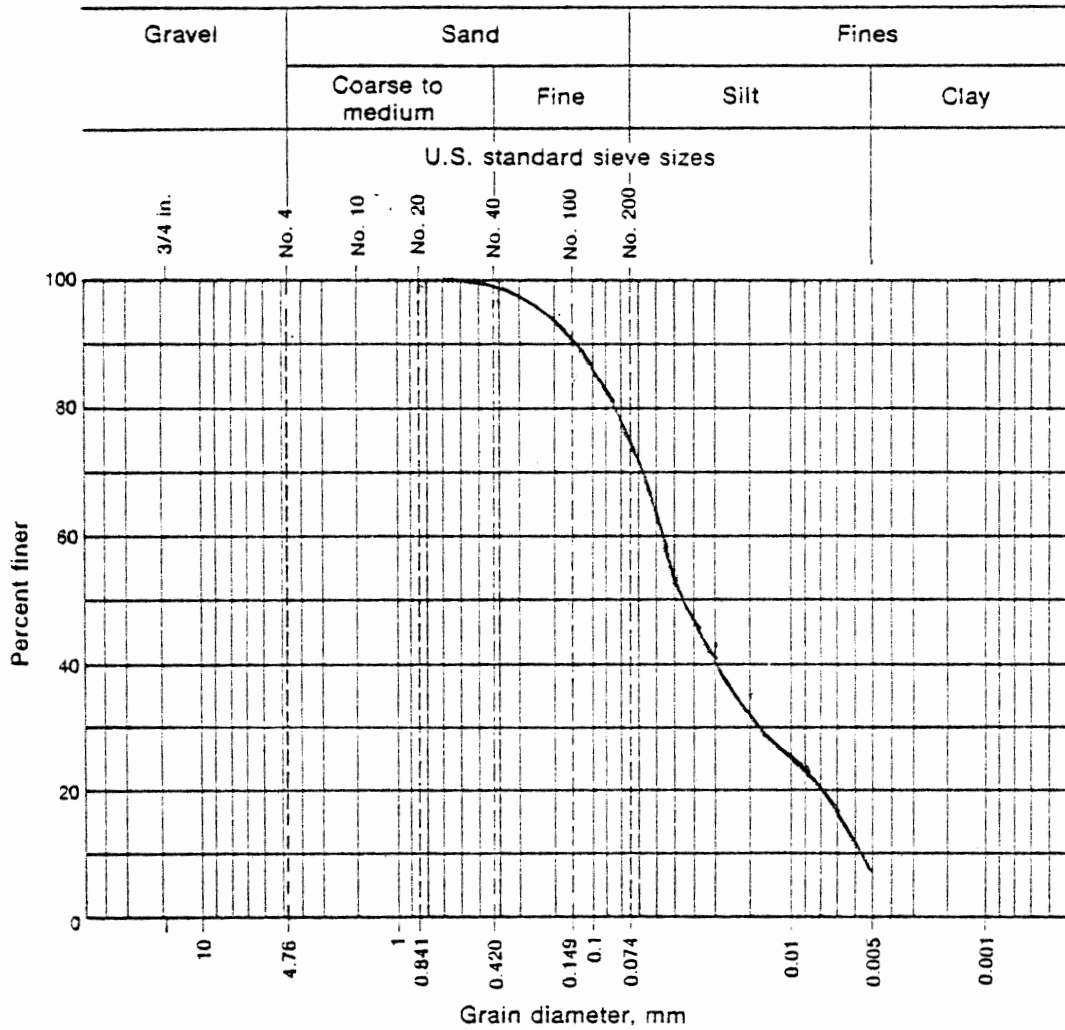
Data Sheet 5

Project D+RC - Dredging Job. No. Site No D-5

Location of Project See Table Z-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



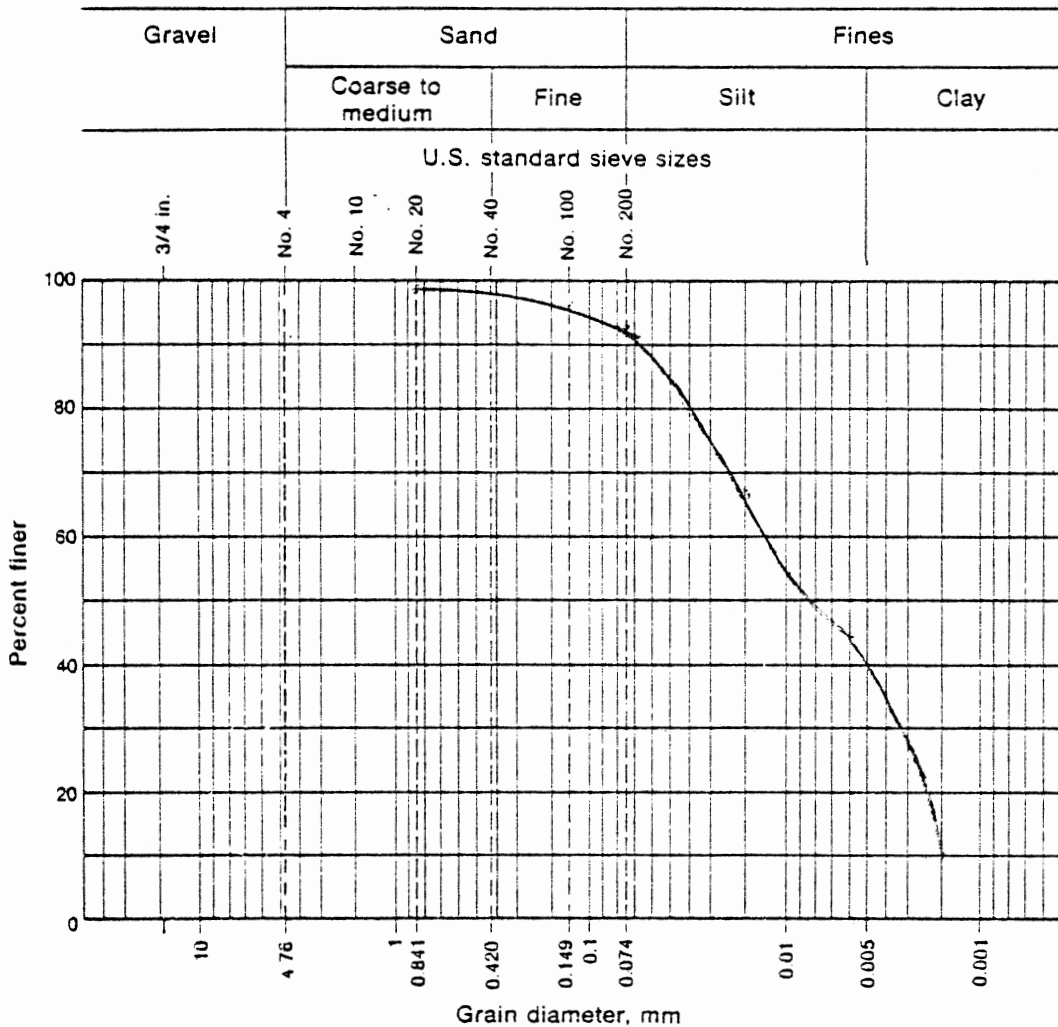
Visual soil description Sandy silt

Soil classification: MH System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D+RC - Dredging Job. No. Site No D-6
 Location of Project See Table 2-3 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



Visual soil description Silt

Soil classification: ML System Unified

GRAIN SIZE DISTRIBUTION

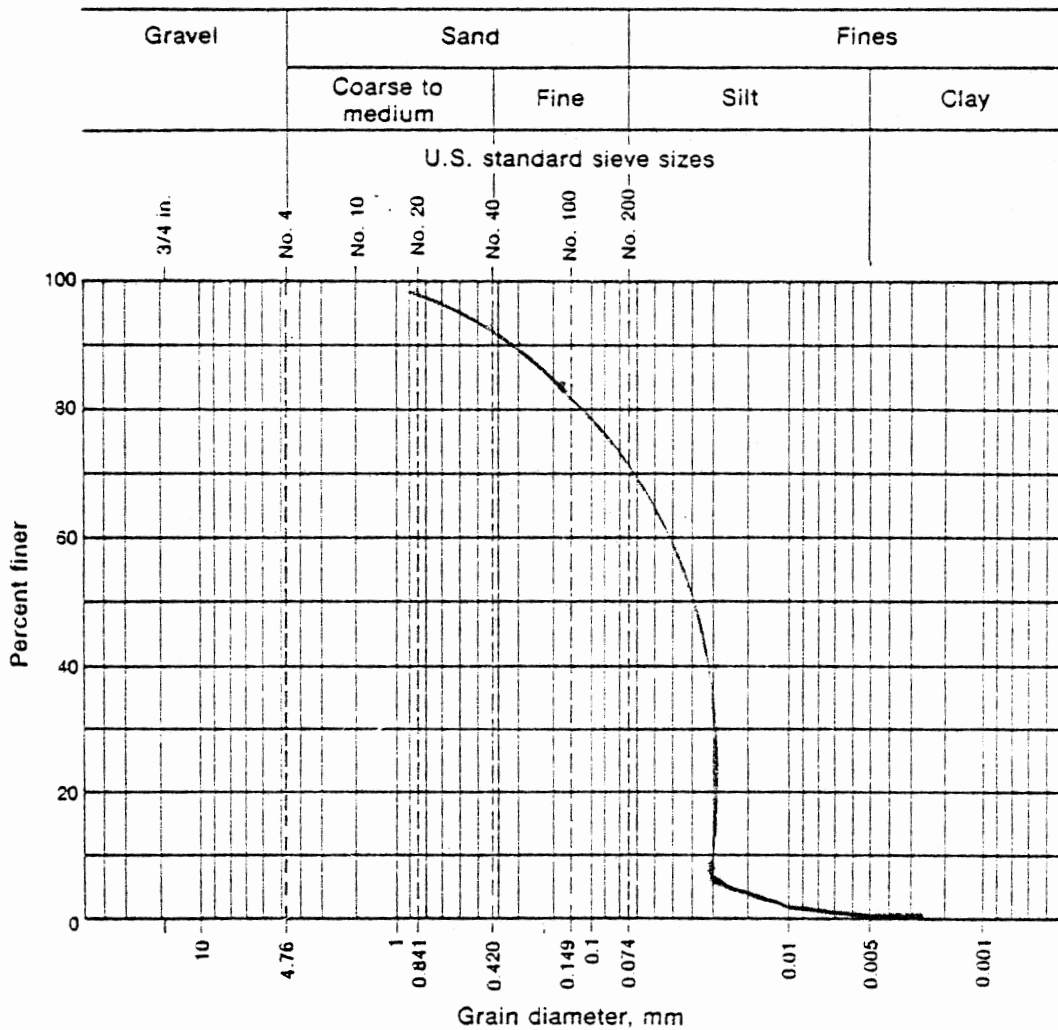
Data Sheet 5

Project D+RC - Dredging Job. No. Site No D-7

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



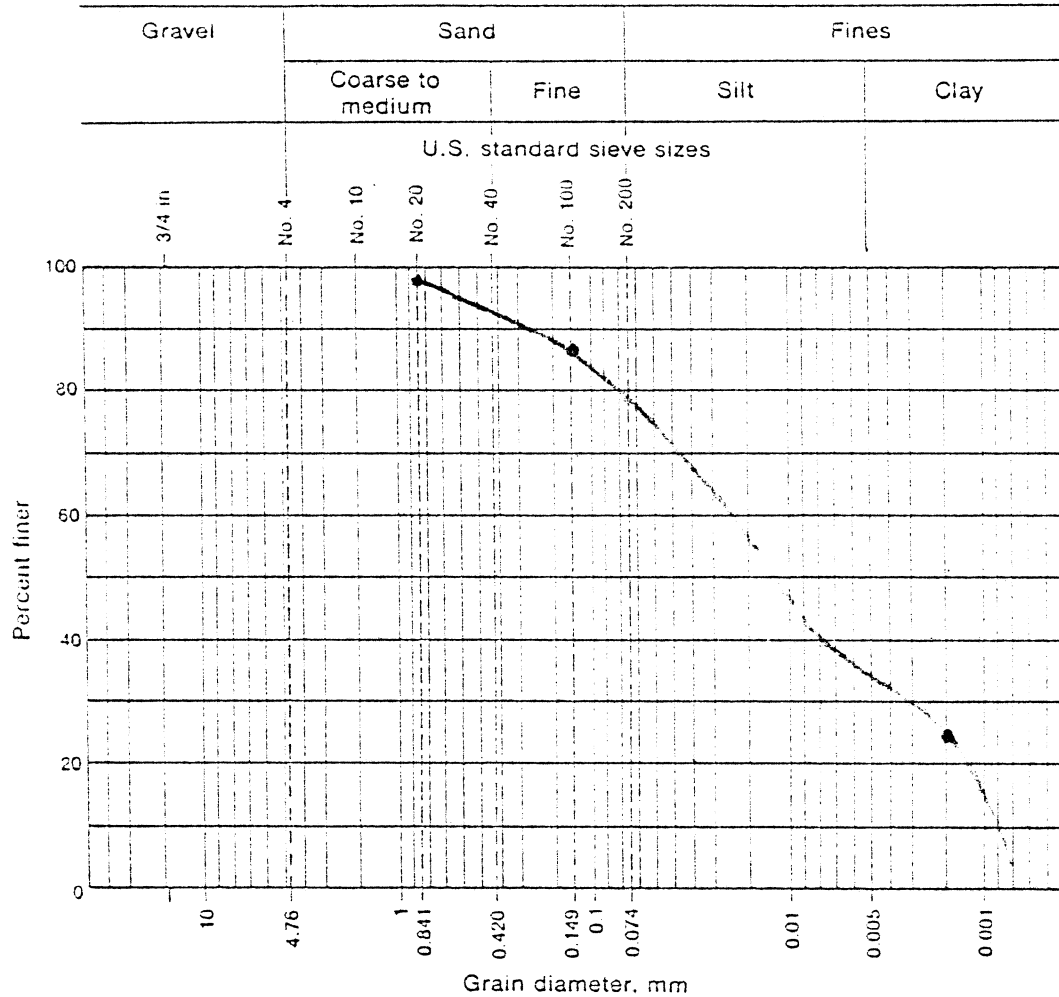
Visual soil description Sandy silt

Soil classification: ML System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D+RC - Dredging Job No. Site No D-8
 Location of Project See Table 2-3 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



Visual soil description clayey silt with some fine sand

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

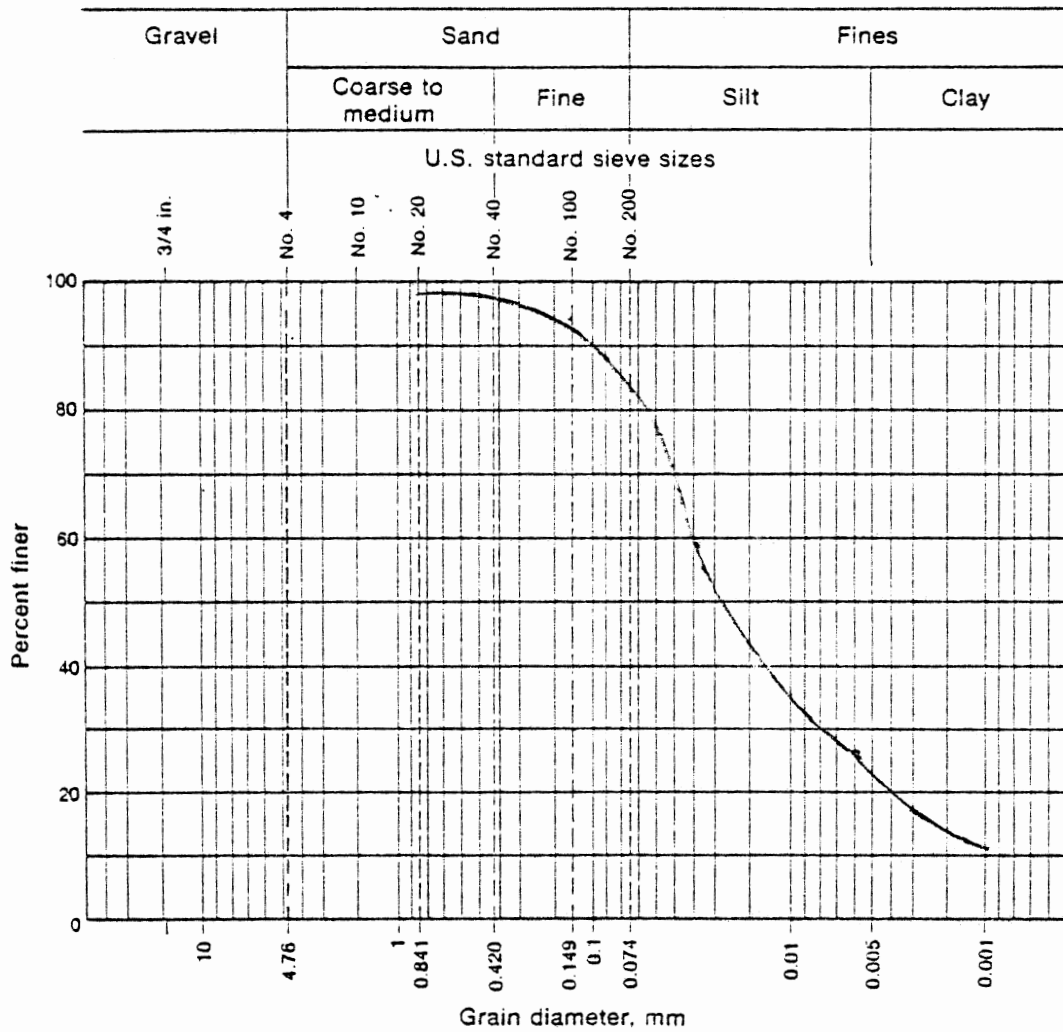
Data Sheet 5

Project D+R.C. - Dredging Job No. Site No. D-9

Location of Project _____ Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description Sandy silt with some clay

Soil classification: ML System Unified

GRAIN SIZE DISTRIBUTION

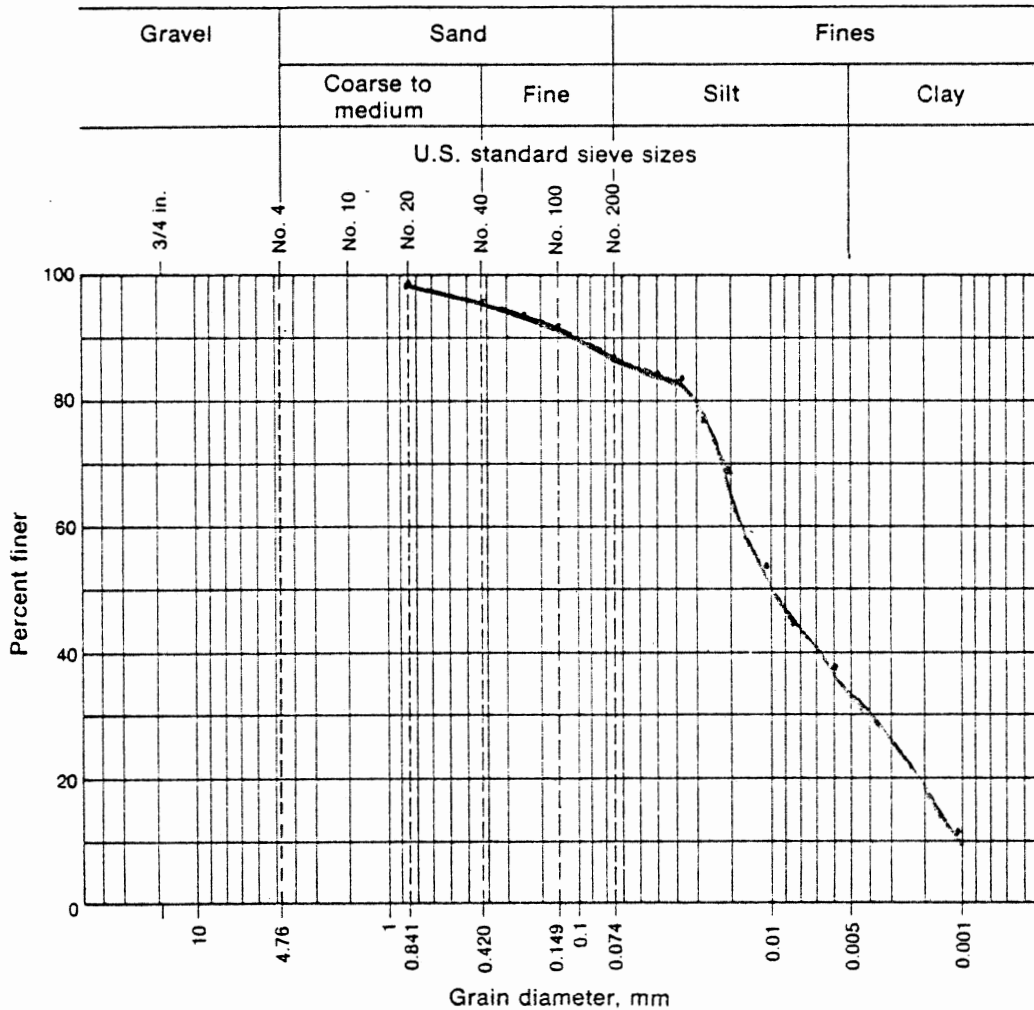
Data Sheet 5

Project D.R.C - Dredging Job No. Site No D-10

Location of Project See table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description clayey organic silt with some fine sand

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

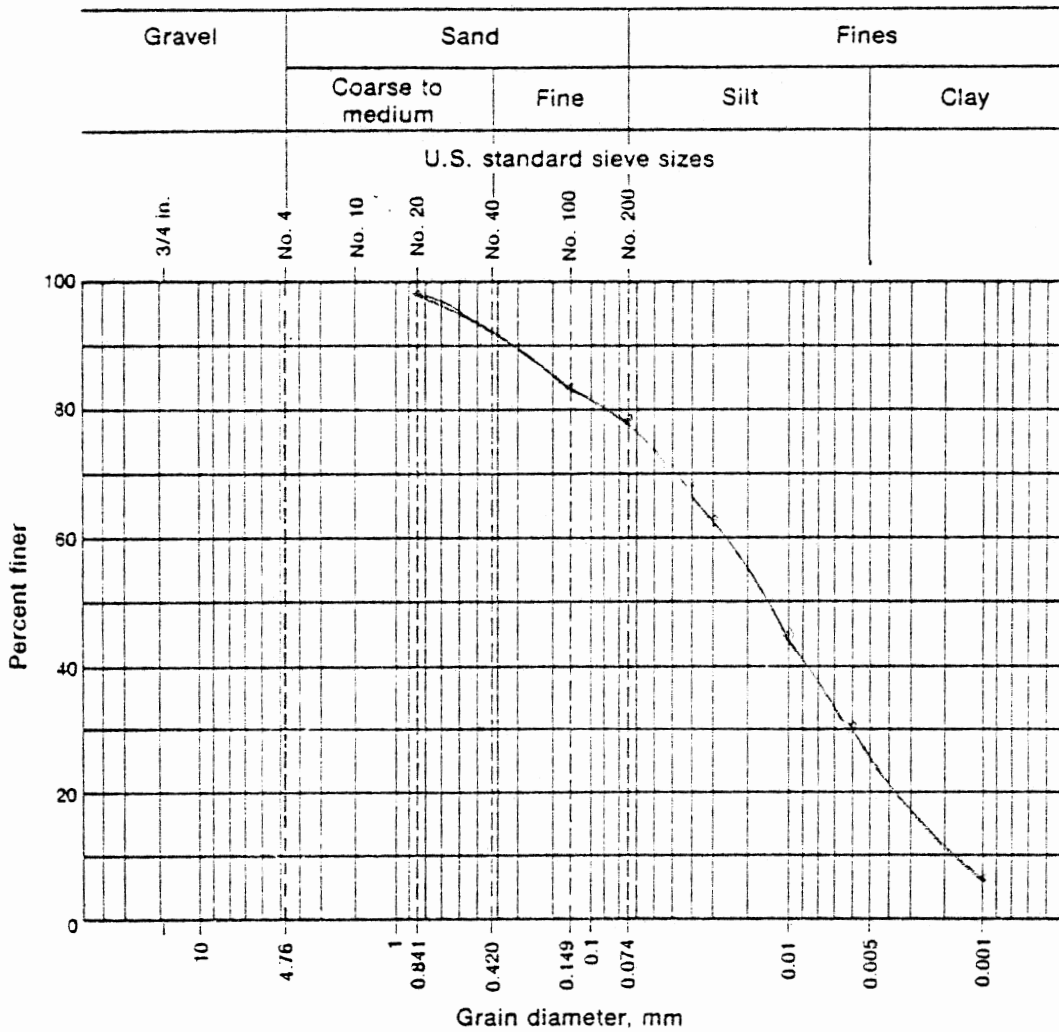
Data Sheet 5

Project D. + R.C. - Dredging Job. No. Site No D-11

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description Sandy silt with fine sand and some clay

Soil classification: ML/OL System Unified

GRAIN SIZE DISTRIBUTION

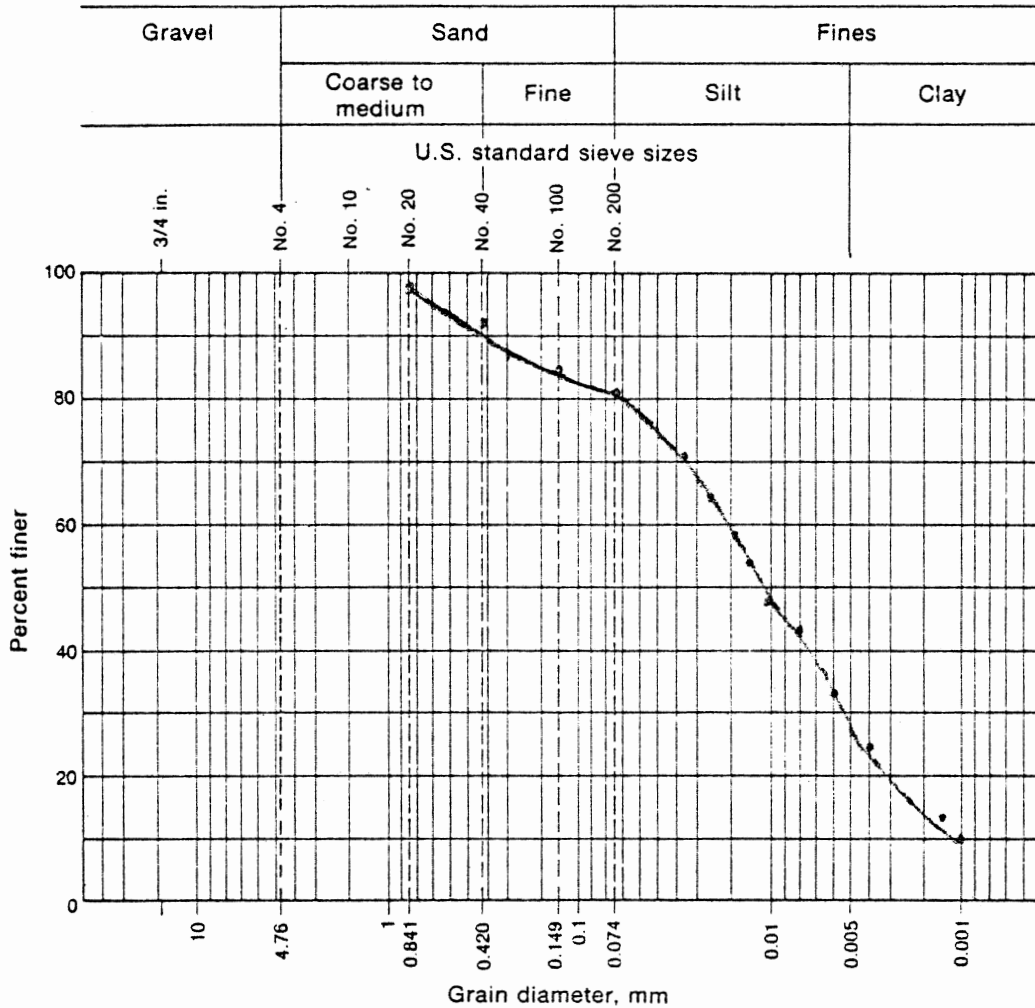
Data Sheet 5

Project D+RC - Dredging Job. No. Site No D-12

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description Sandy silt with organic
silt and clay. oily

Soil classification: OL System Unified

GRAIN SIZE DISTRIBUTION

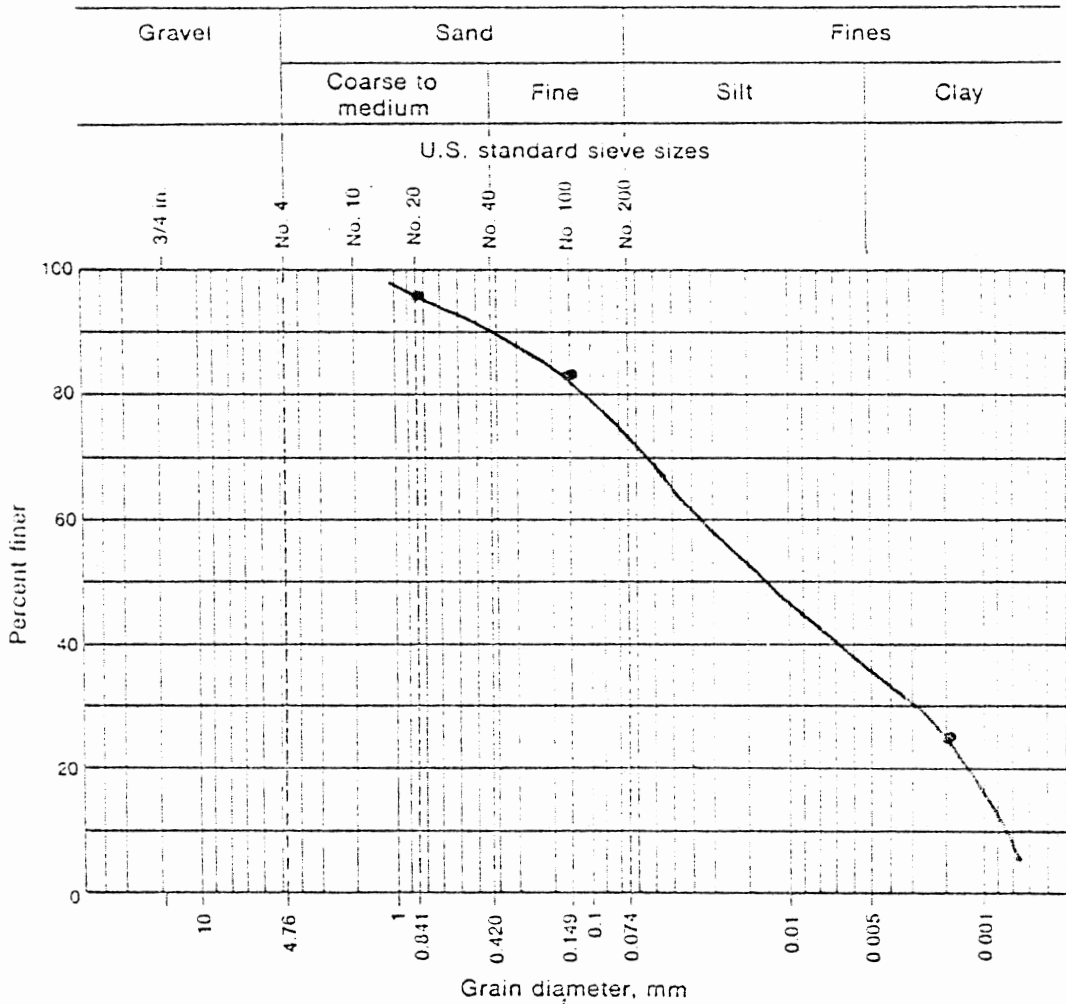
Data Sheet 5

Project D+RC - Dredging Job No. Site No D-13

Location of Project See Table 2.3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description clayey silt with some fine sand.

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

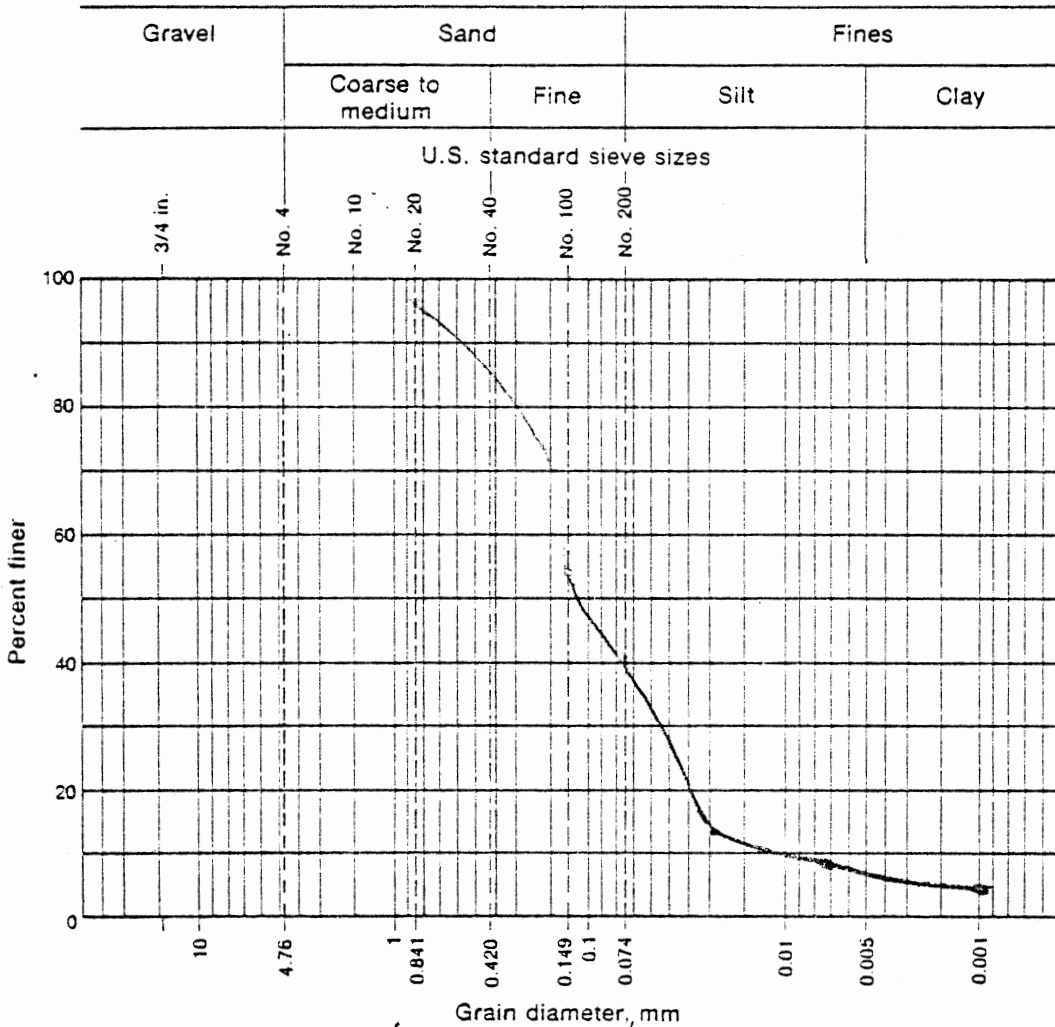
Data Sheet 5

Project D+RC-Dredging Job No. Site No D-14

Location of Project See Table 2.3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description silty sand

Soil classification: SM System Unified

GRAIN SIZE DISTRIBUTION

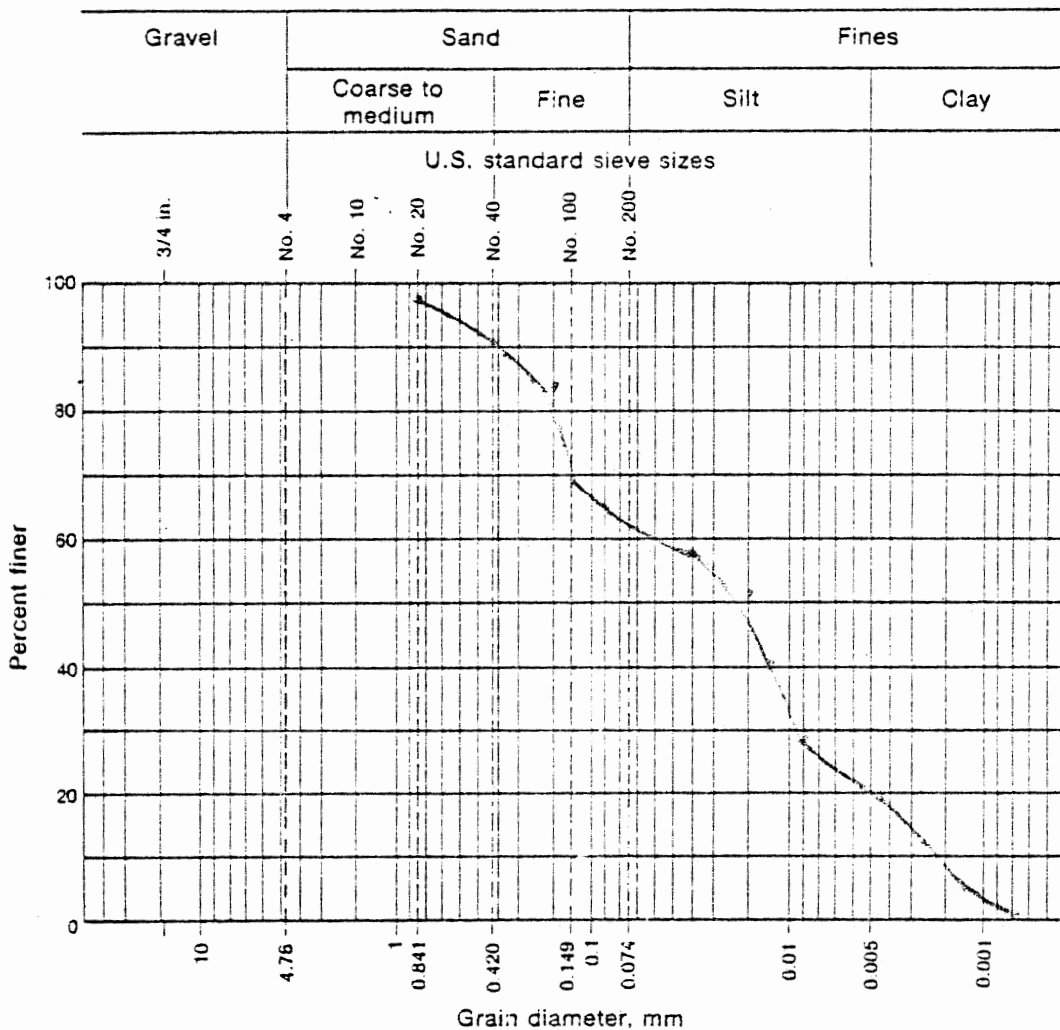
Data Sheet 5

Project D+R C - Dredging Job No. Site No D-16

Location of Project See Table Z-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



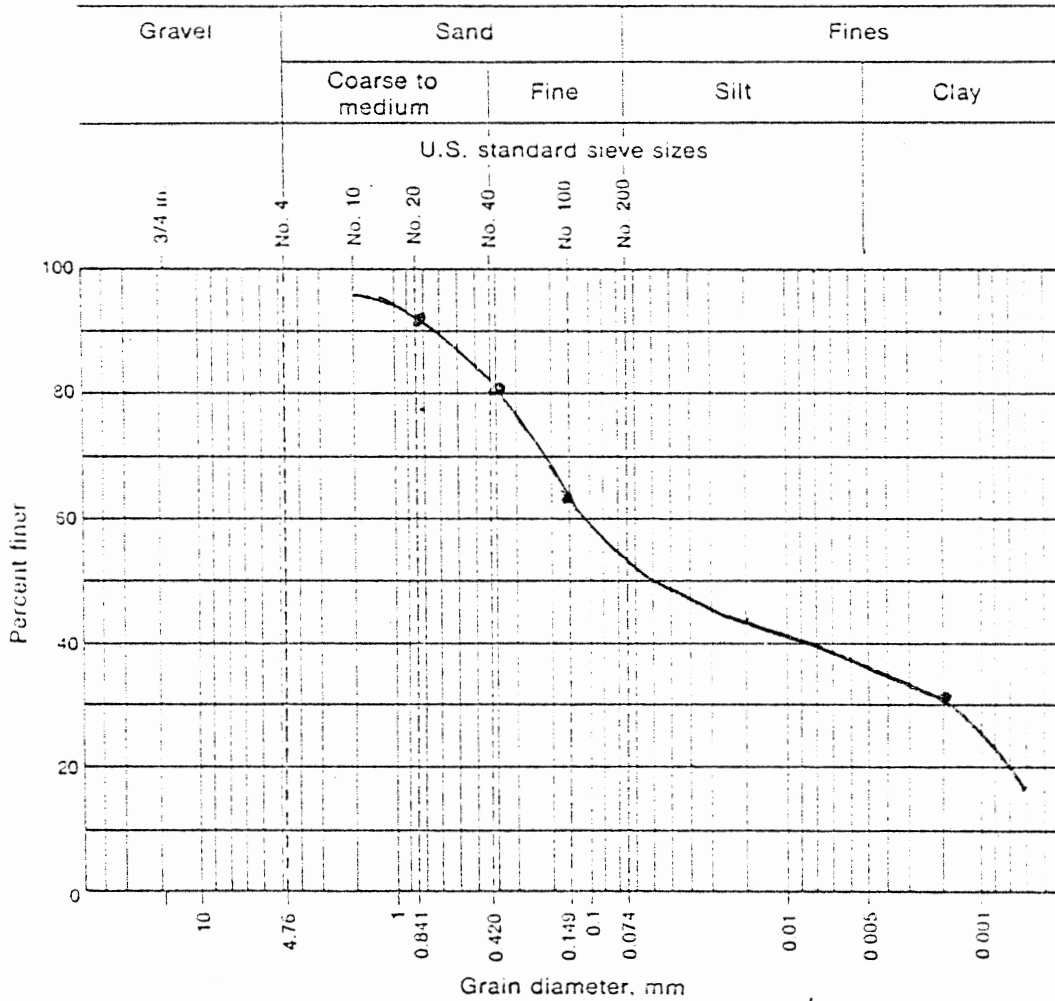
Visual soil description Sandy silt with organic content

Soil classification: MH System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D.F.R.C. - Dredging Job No. Site No D-17
 Location of Project See Table 2-3 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



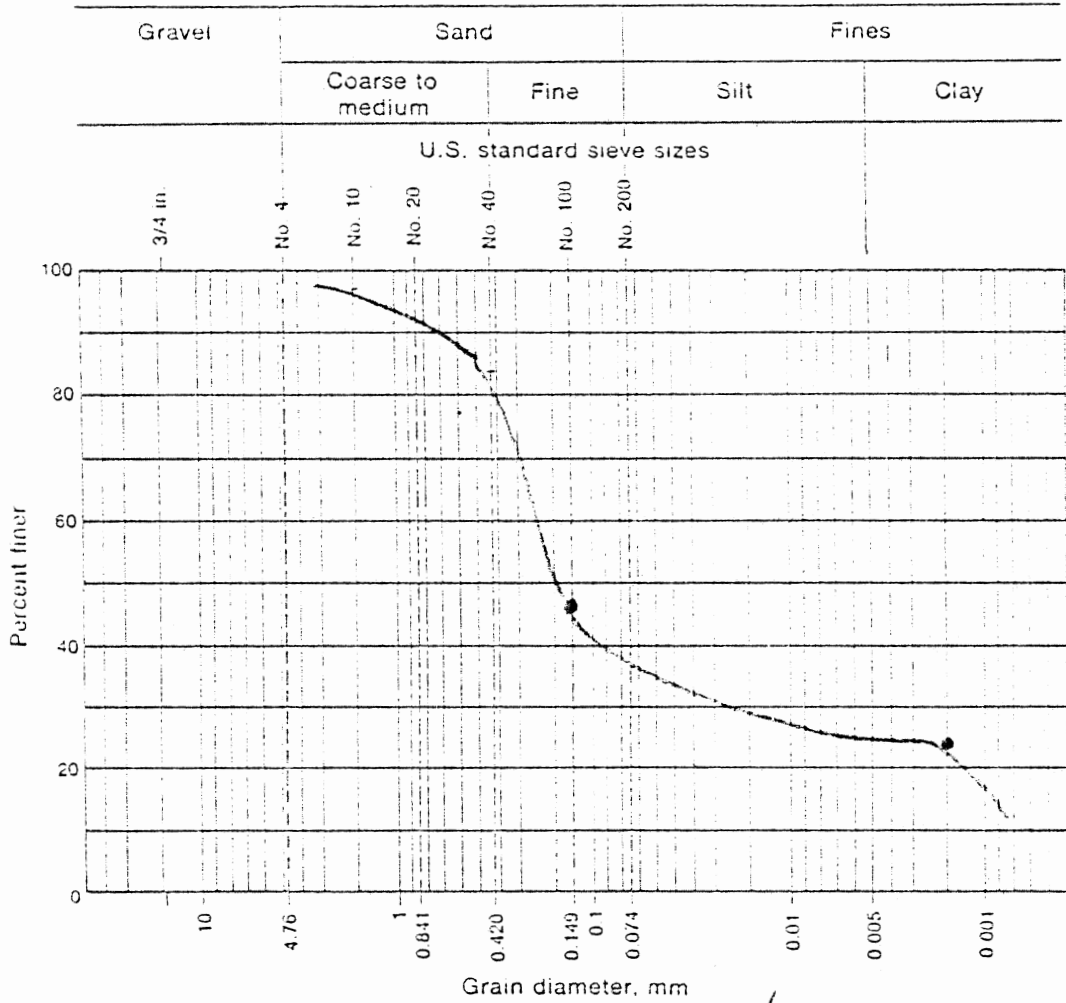
Visual soil description clayey-silty sand

Soil classification: SC System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project DARC-Dredging Job. No. Site No 2-13
 Location of Project See Table 2-3 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



Visual soil description silty-clayey sand

Soil classification: SM System Unified

GRAIN SIZE DISTRIBUTION

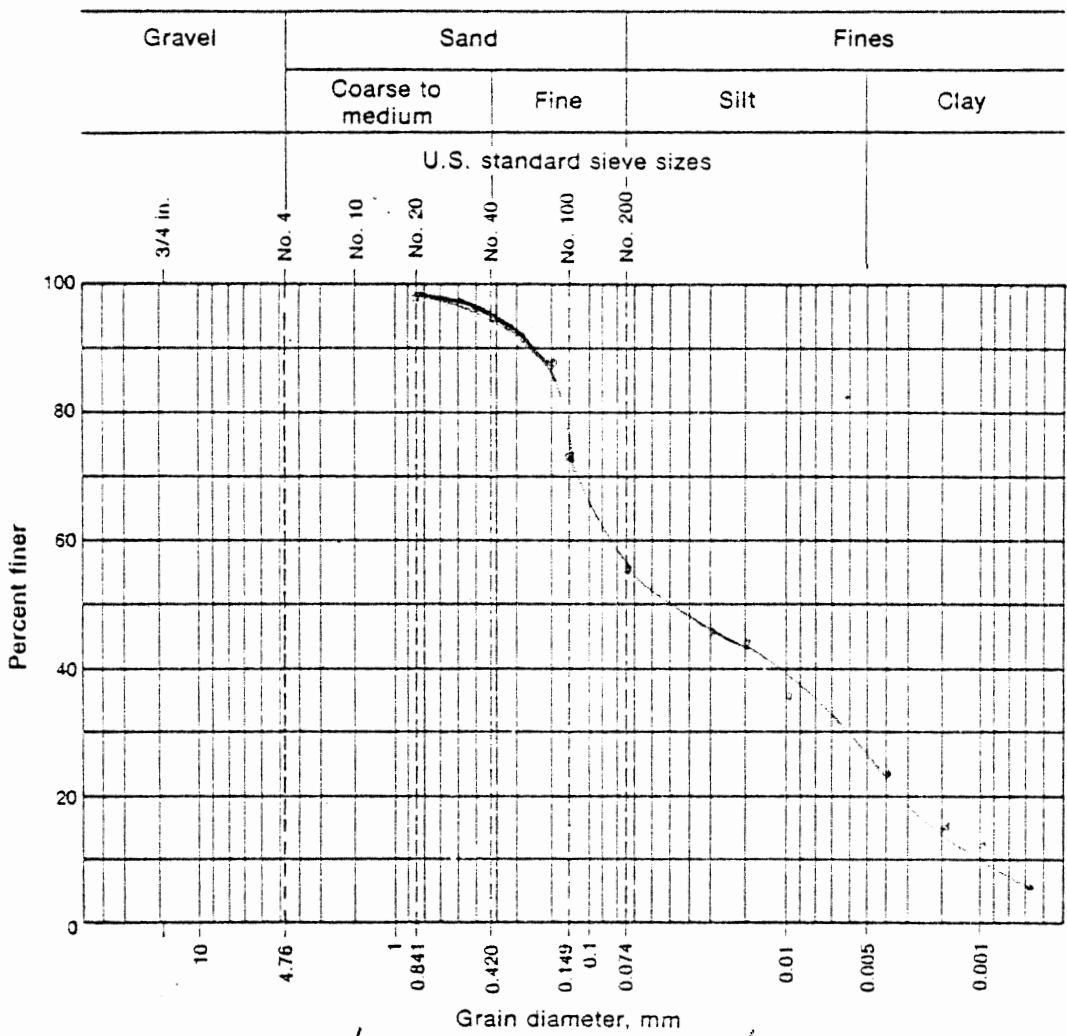
Data Sheet 5

Project D & RC - Dredging Job No. Site No D-19

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description silty-clayey sand

Soil classification: SM System Unified

GRAIN SIZE DISTRIBUTION

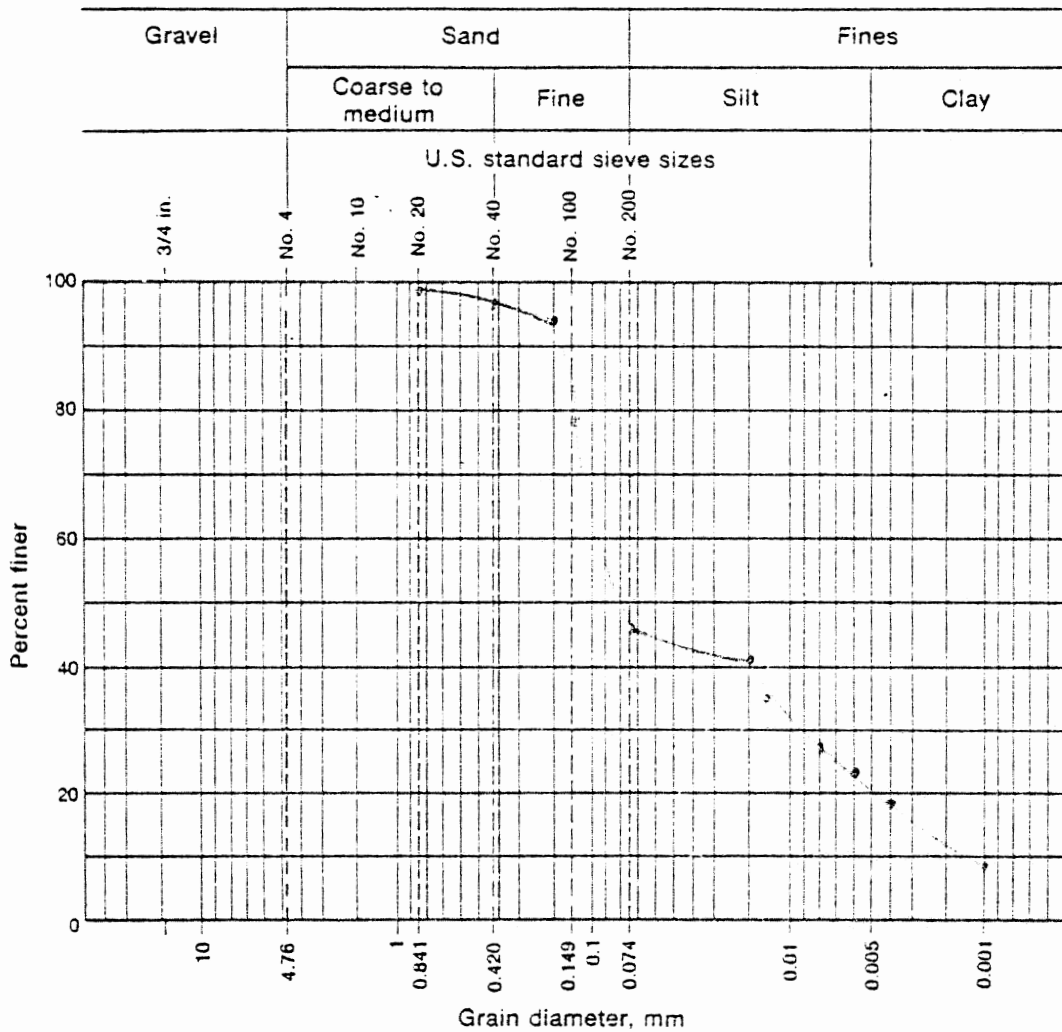
Data Sheet 5

Project D+RC - Dredging Job. No. Site No D-20

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description clayey sand, small amount of silt

Soil classification: SC System Unified

GRAIN SIZE DISTRIBUTION

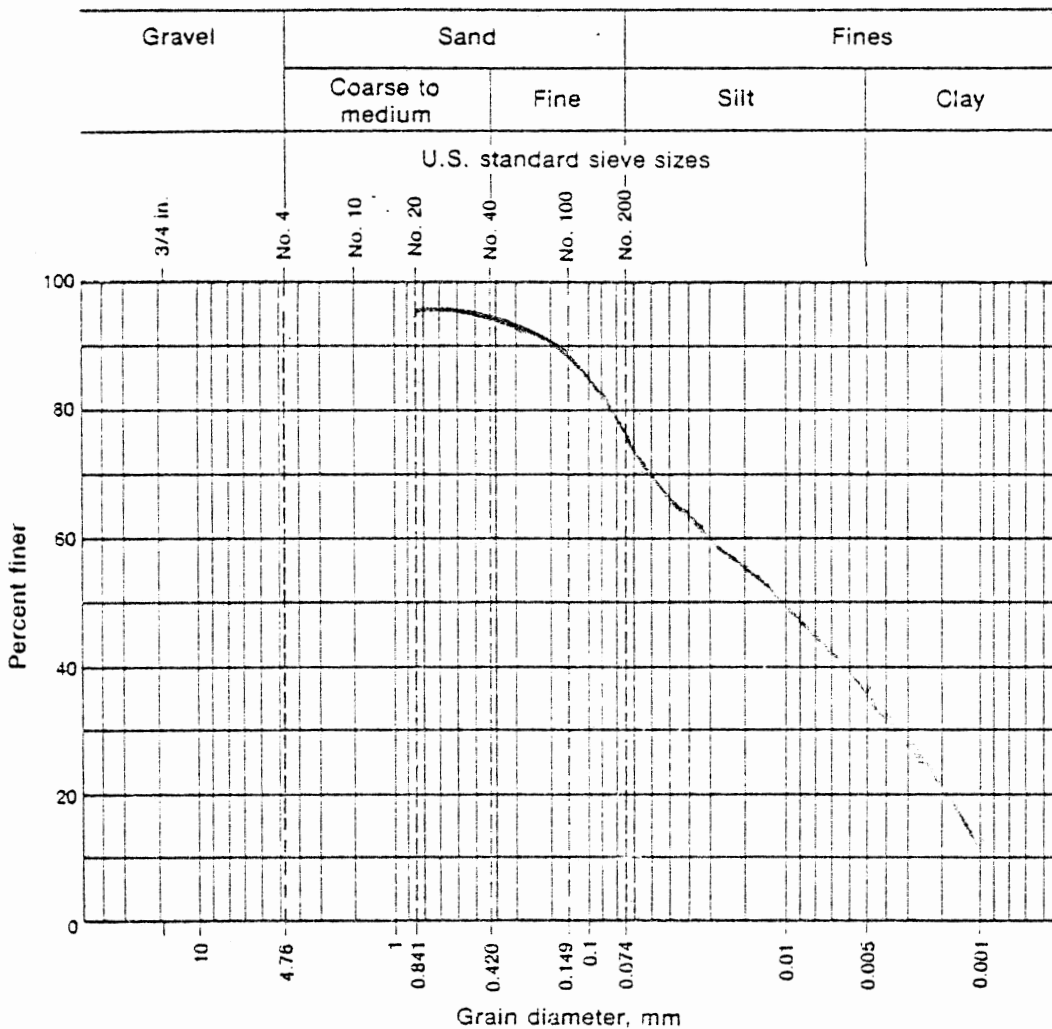
Data Sheet 5

Project D+RC - Dredging Job No. Site No D-21

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description Sandy silt - some oil present

Soil classification: MH System Unified

GRAIN SIZE DISTRIBUTION

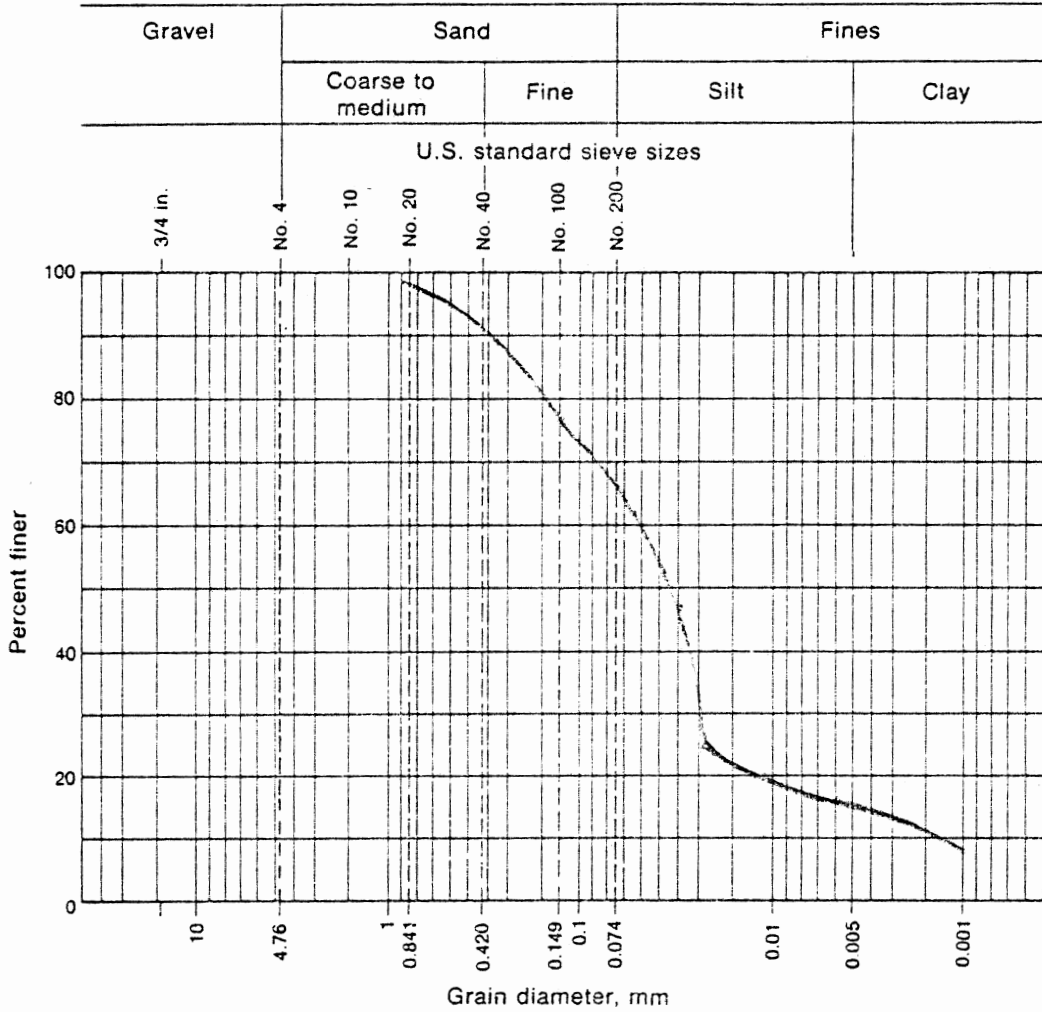
Data Sheet 5

Project D4 RC-Dredging Job No. Site No D-22

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description Sandy-silt

Soil classification: ML System Unified

GRAIN SIZE DISTRIBUTION

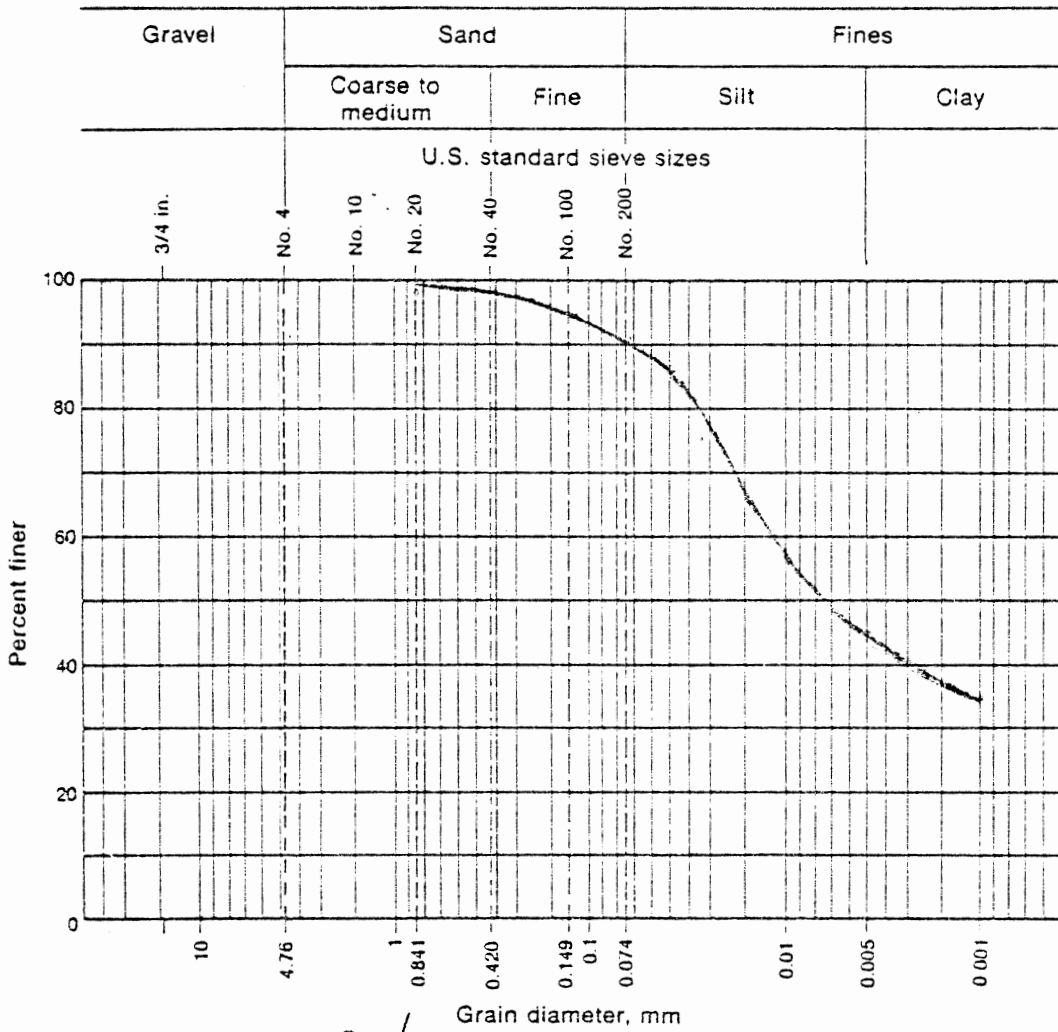
Data Sheet 5

Project D+RC - Dredging Job No. Site No D-23

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By _____ Date of Testing _____



Visual soil description silt

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

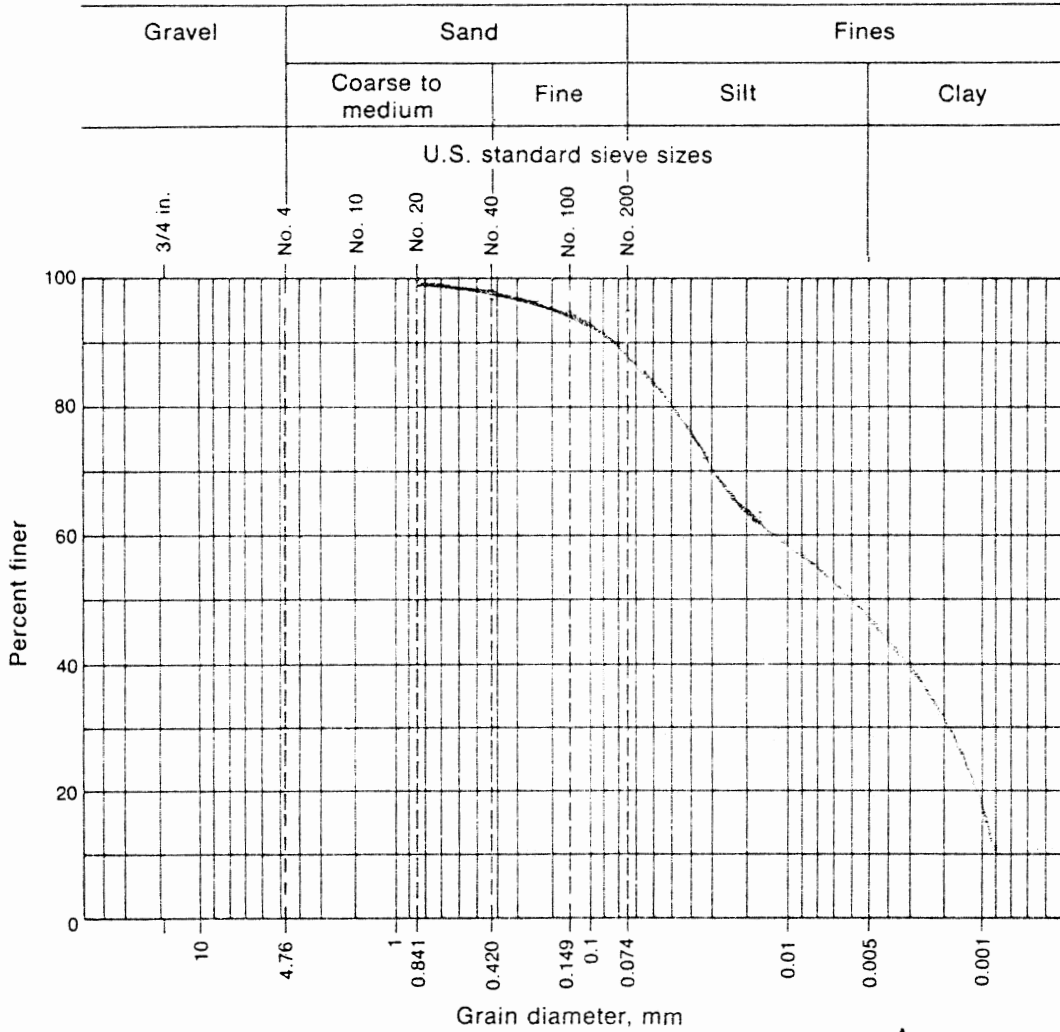
Data Sheet 5

Project D+RC - Dredging Job No. Site No D-24

Location of Project See Table 2.9 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



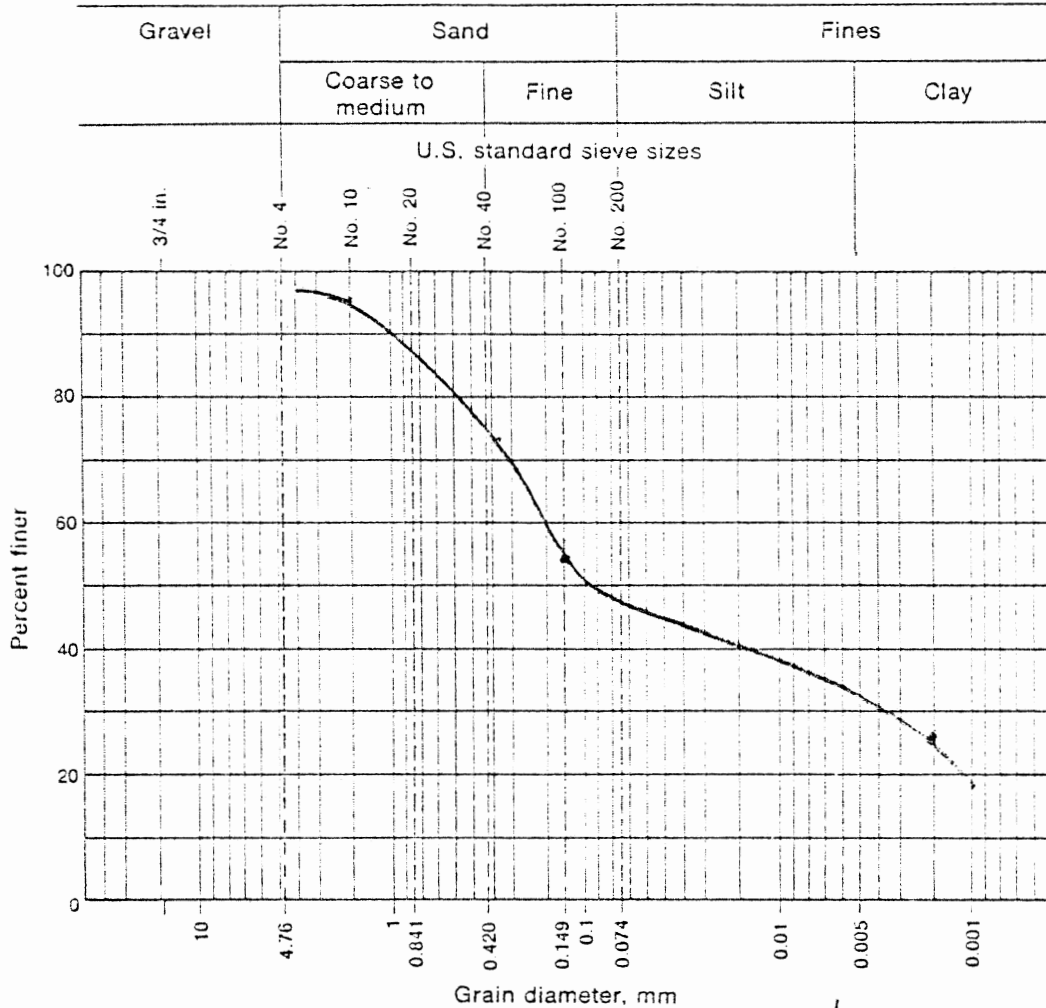
Visual soil description Silty clay with some fine sand
High organic content

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D+RC-Dredging Job No. Site No D-25
 Location of Project See Table 2-3 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



Visual soil description Clayey-silty-sand

Soil classification: SM System Unified

GRAIN SIZE DISTRIBUTION

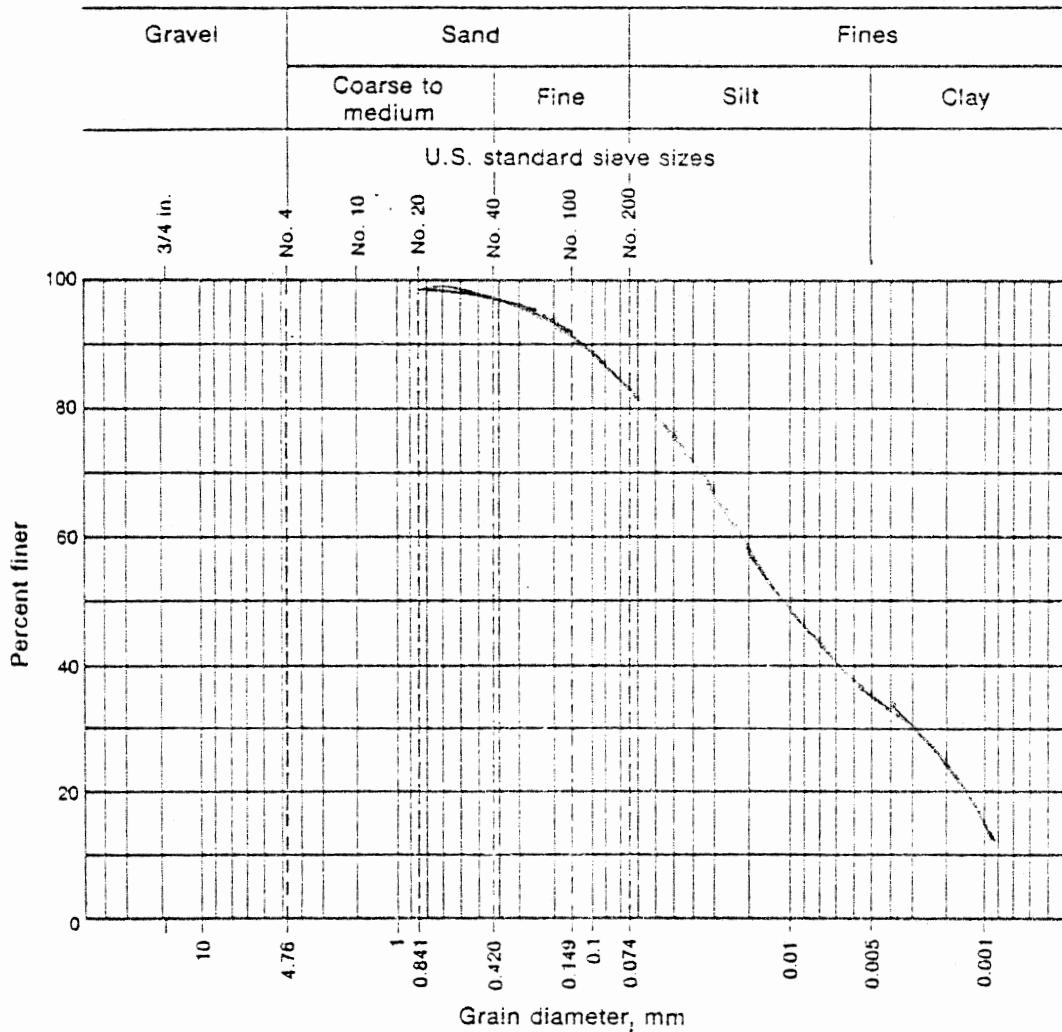
Data Sheet 5

Project D.R.C. - Dredging Job. No. Site No D-26

Location of Project See Table C-230 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description clayey-silt

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

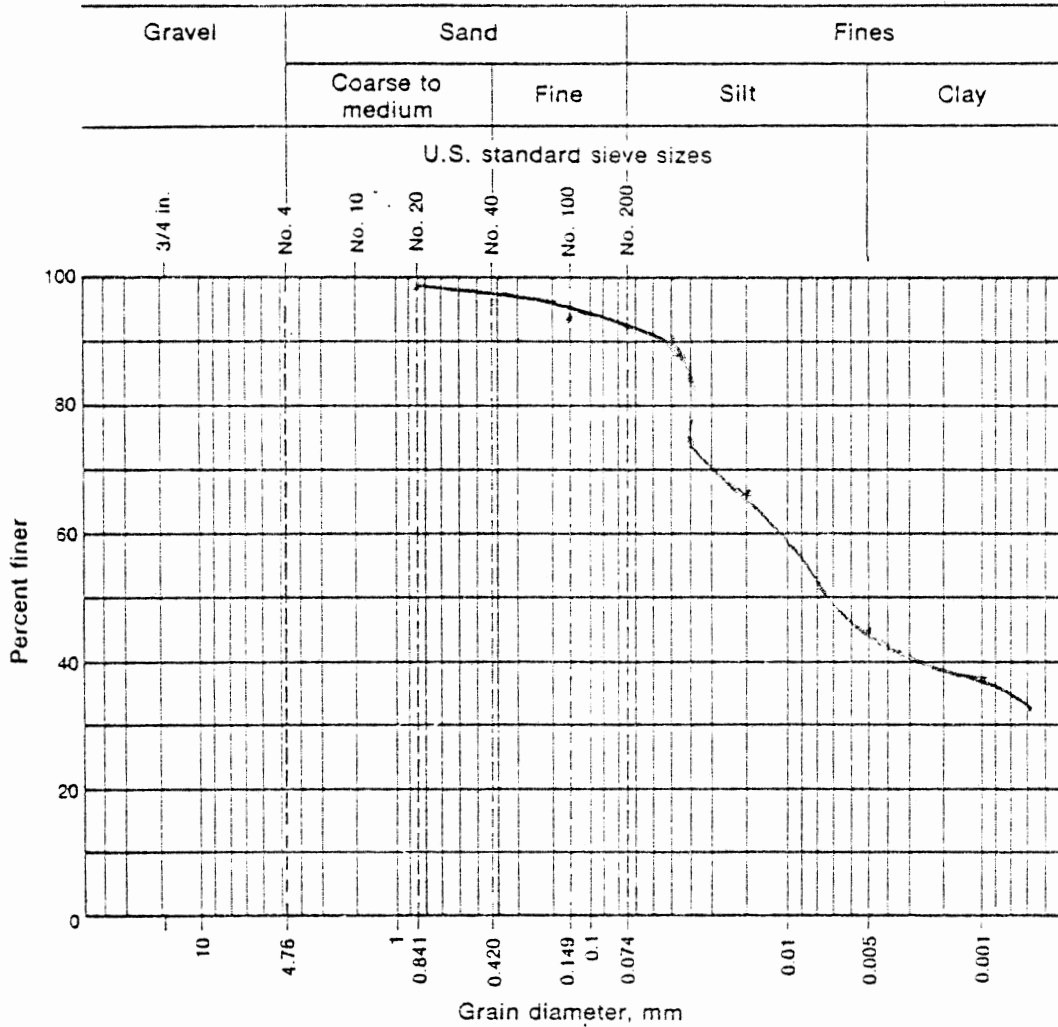
Data Sheet 5

Project D+RC-Dredging Job. No. Site No D-27

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



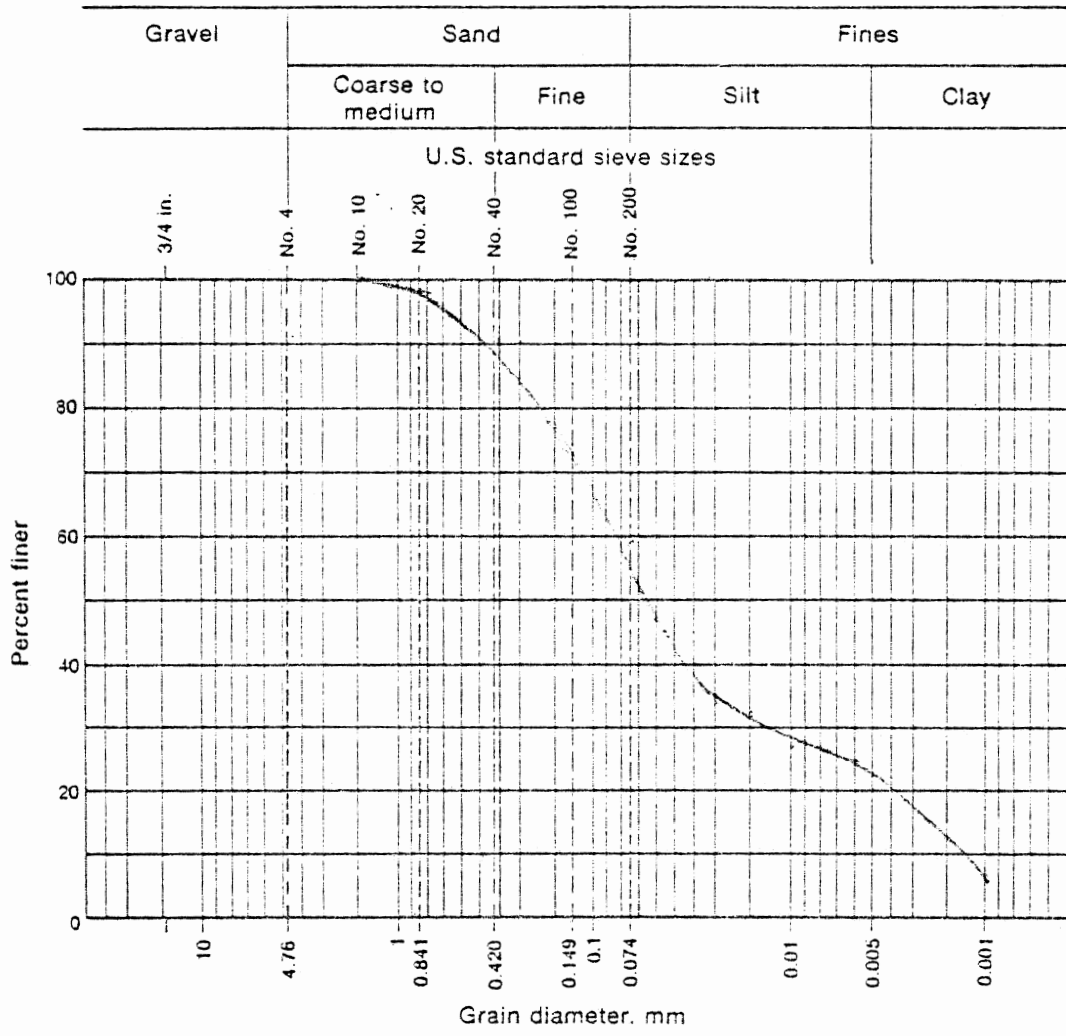
Visual soil description clayey-silt

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D+RC-Dredging Job No. Site No D-23
 Location of Project See Table 2-3 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



Visual soil description Silty-Sand

Soil classification: ML System Unified

GRAIN SIZE DISTRIBUTION

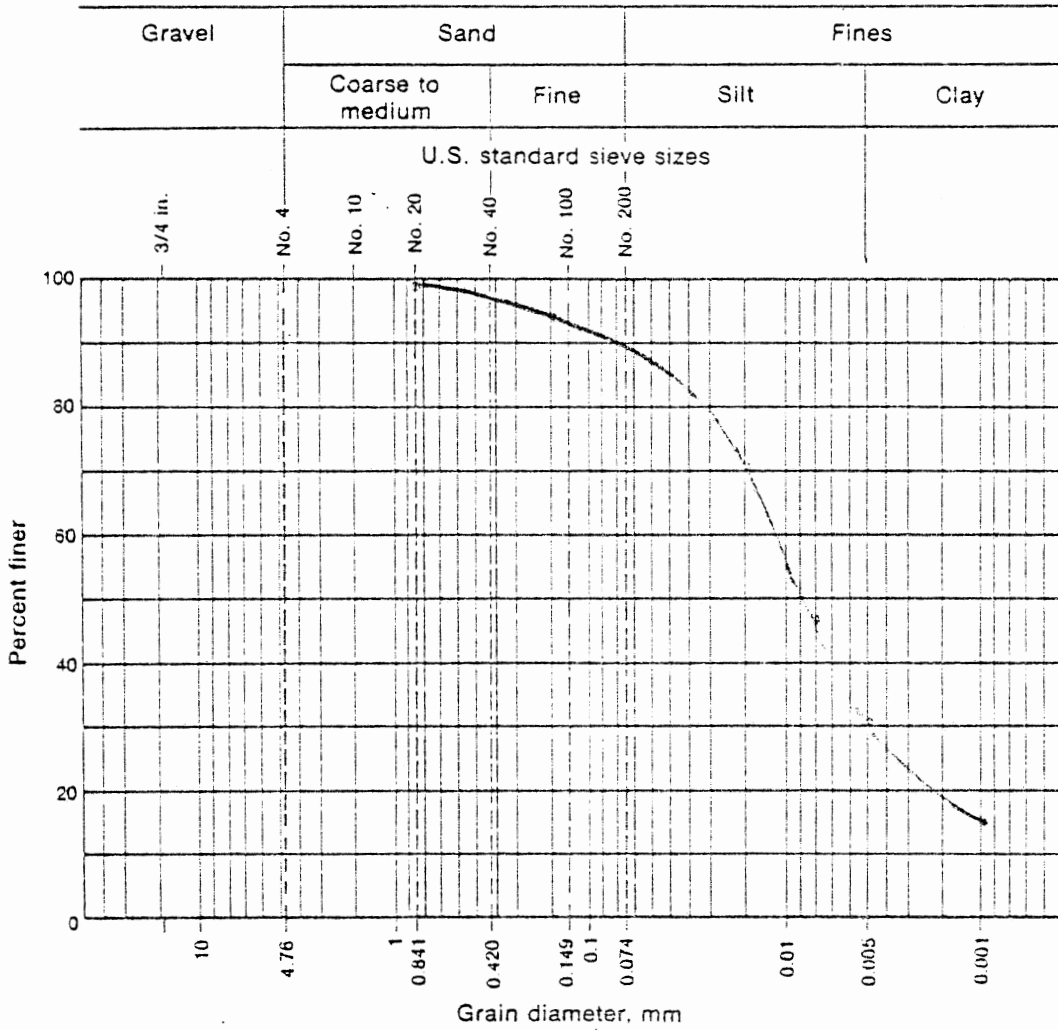
Data Sheet 5

Project D+RC - Dredging Job No. Site No D-29

Location of Project See Table Z-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description clayey-silt

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

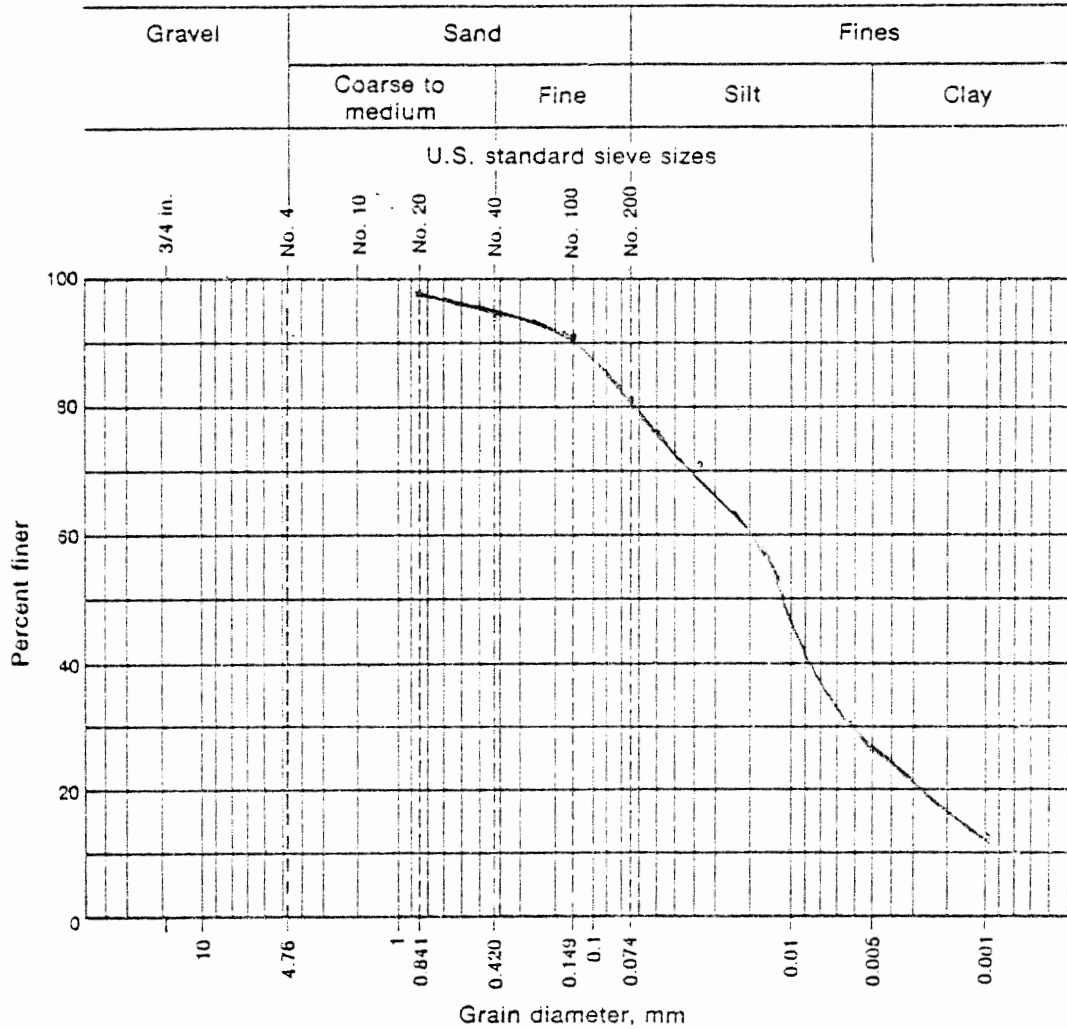
Data Sheet 5

Project D. + RC - Dredging Job. No. Site No D-30

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



Visual soil description clayey-silt with some fine sand

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

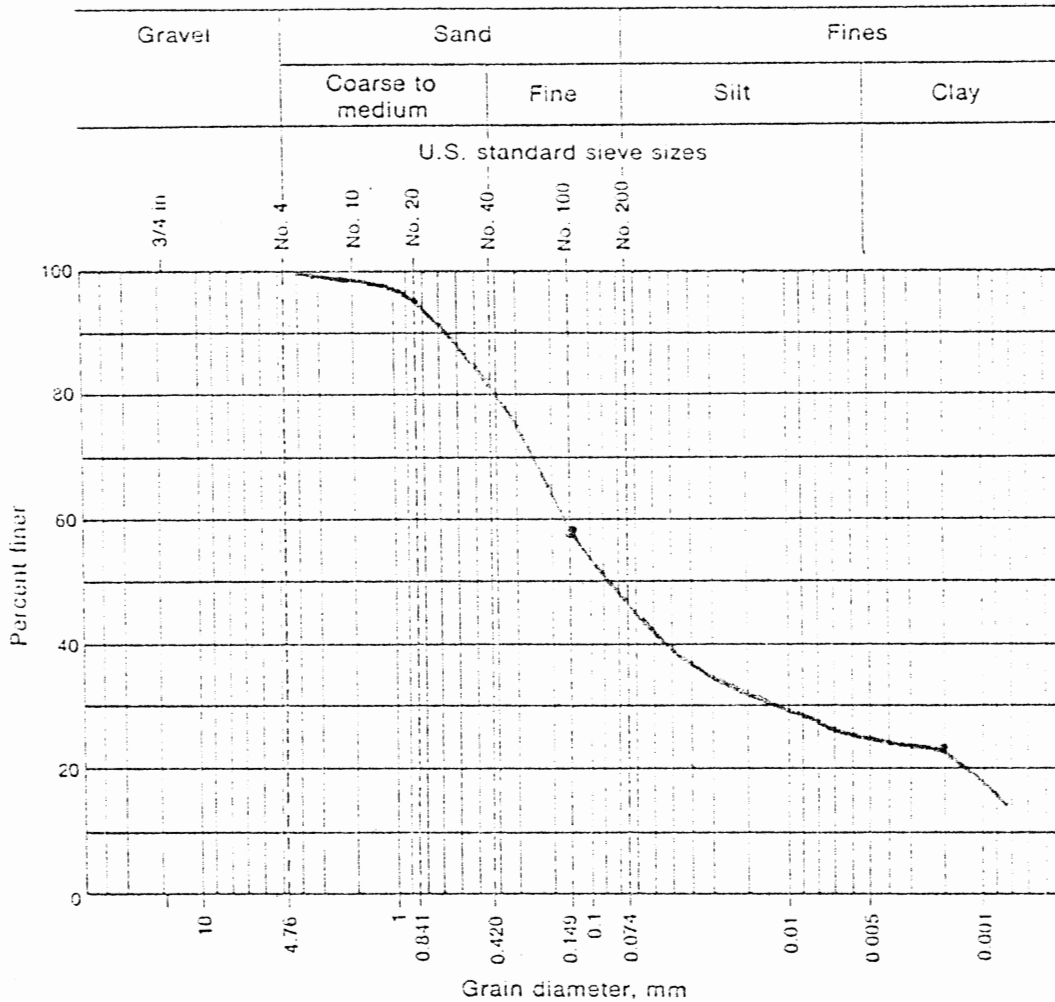
Data Sheet 5

Project D&RC - Dredging Job. No. Site No D-31

Location of Project See Table 2-3 Boring No. _____ Sample No. _____

Description of Soil _____ Depth of Sample _____

Tested By. _____ Date of Testing _____



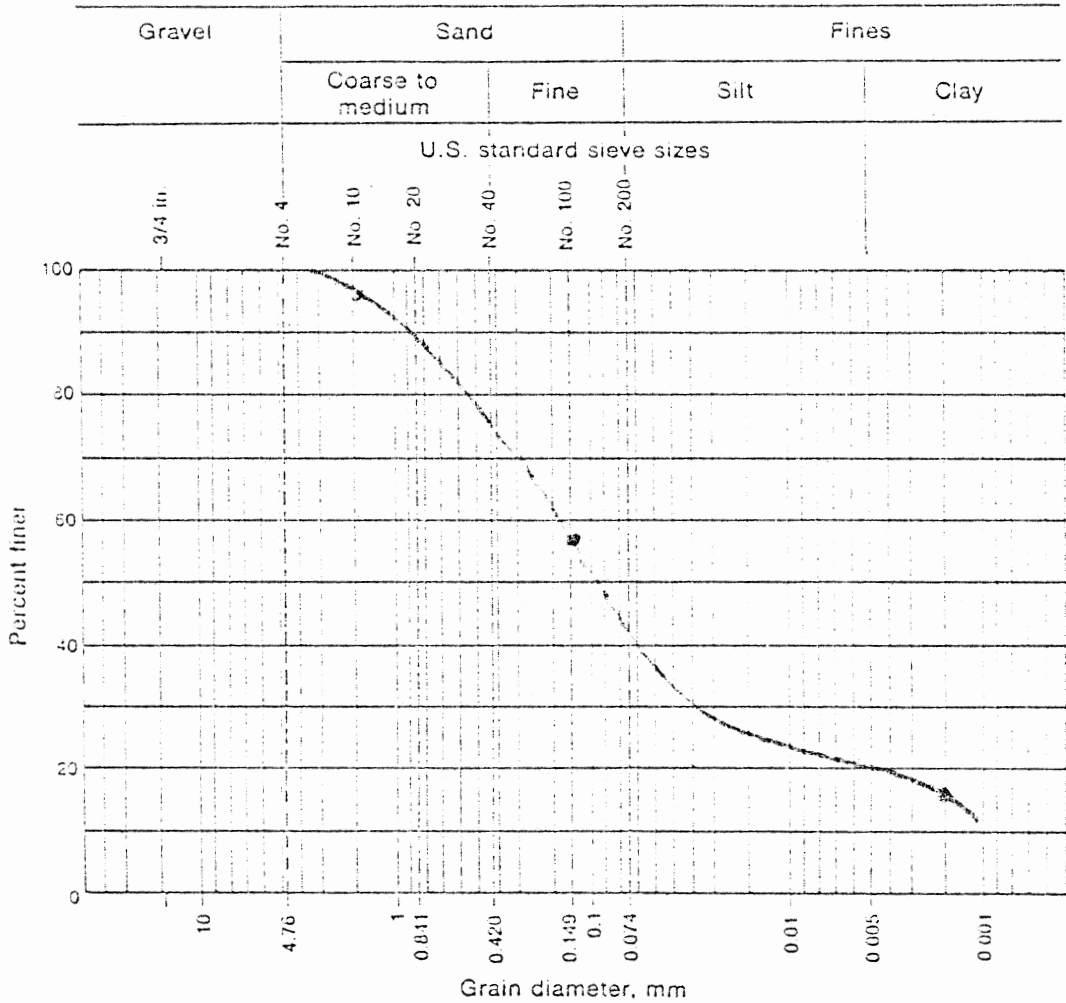
Visual soil description Silty-Sand with clay

Soil classification: SM System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D & R C - Dredging Job No. SIL No D-32
 Location of Project See Tabc 2C Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By: _____ Date of Testing _____



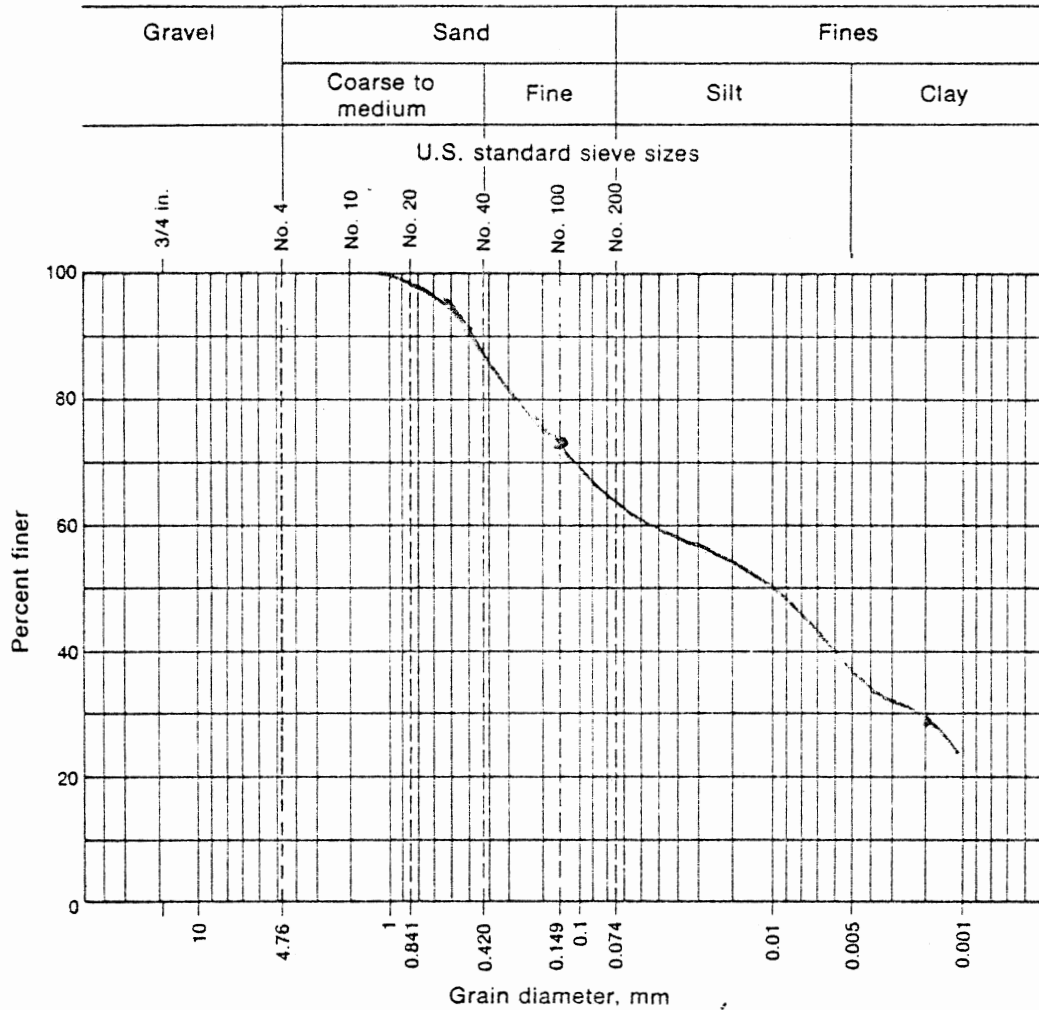
Visual soil description silty-sand with some clay

Soil classification: SM System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D & RC - Dredging Job. No. Site No D-33
 Location of Project See Table 2-30 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



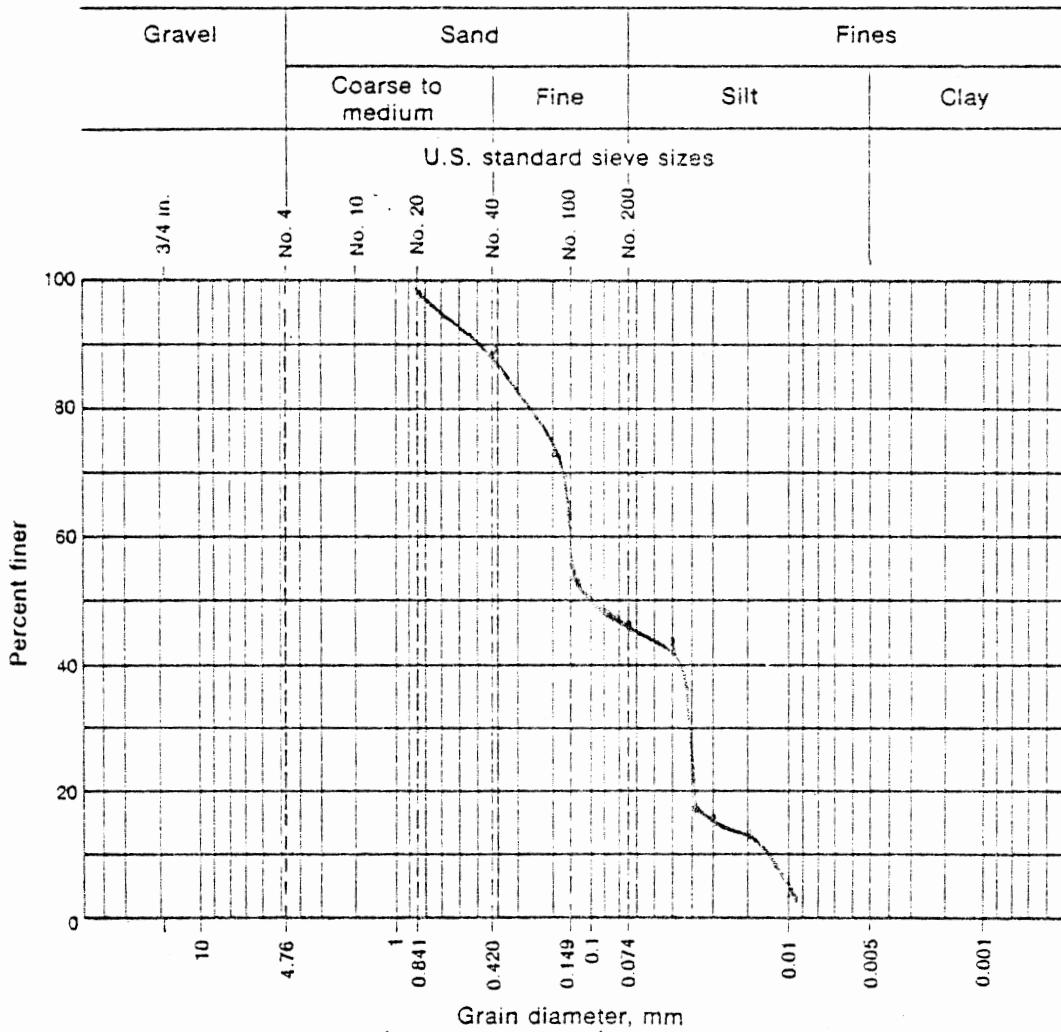
Visual soil description Sandy-clayey silt

Soil classification: OH System Unified

GRAIN SIZE DISTRIBUTION

Data Sheet 5

Project D4EC - Dredging Job No. Site No D-34
 Location of Project See Table 2-3 Boring No. _____ Sample No. _____
 Description of Soil _____ Depth of Sample _____
 Tested By. _____ Date of Testing _____



Visual soil description silty sand

Soil classification: SM System Unified

APPENDIX 2.6

Delaware and Raritan Canal Commission

MEMORANDUM

To: Marvin Granstrom
Subject: Canal artifacts
From: James C. Amon
Date: 13 May 1981

Attached is a list of canal artifacts prepared for the Canal Commission by historic preservation architects.

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
00.00	LOCK	1831-1834	STONE WALLS COVERED WITH CONCRETE IN THE LATE 1930'S. TWO SEGMENTAL ARCHED CULVERTS OF STONE -- CONCRETE FLOODGATE ON UPSTREAM SIDE	CONCRETE WALLS IN GOOD CONDITION ALTHOUGH HAIRLINE CRACKS ARE PRESENT. STONE CULVERT WALLS ARE IN FAIR CONDITION WITH SOME MISSING FACE STONE DOWNSTREAM WALLS ON EAST SIDE OF STABLE; WEST WALL HAS BEEN REMOVED.
00.00	BRIDGE	c1935	STONE ABUTMENTS, STEEL BEAMS WITH WOOD DECK	GOOD
01.30	SPILLWAY	1831-1834	COBBLESTONE SECTION OF TOWPATH -- DEPRESSED ONE FOOT BELOW REST OF TOWPATH	GOOD
01.74	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
02.86	SPILLWAY	c1935	CONCRETE -- CREEK FLOWS INTO AND ACROSS CANAL AND THEN INTO THE DELAWARE RIVER VIA SPILLWAY	GOOD CONDITION ALTHOUGH DOWNSTREAM THERE IS SOME EVIDENCE OF EROSION
		1877	RAILROAD BRIDGE ACROSS CREEK SET ON STONE PIERS WITH STEEL BEAMS AND WOOD TIES -- REPLACED EARLIER WOODEN COVERED BRIDGE WHICH BURNED.	GOOD
02.95	LOCK	1831-1834	STONE WALLS COVERED WITH CONCRETE IN THE LATE 1930'S. CONCRETE WATER CONTROL GATES ACROSS LOCK HAVE STEEL GATES AND MECHANISM. STONE APPROACH WALLS BOTH UP AND DOWNSTREAM OF CANAL. LOCK LENGTHENED TO 220' IN 1852-1853 FROM ORIGINAL 110' LENGTH.	CONCRETE WALLS IN GOOD CONDITION ALTHOUGH HAIRLINE CRACKS ARE PRESENT.
03.38	BRIDGE	20TH CENTURY	CONCRETE	GOOD
03.93	RR BRIDGE	c1935	STONE ABUTMENTS WITH STEEL BEAMS AND WOOD TIES	GOOD -- SOME DETERIORATION IN TIES
04.09	CREEK		CREEK DRAINS INTO CANAL VIA CULVERT AND THEN INTO RIVER VIA STONE ARCHED CULVERT	GOOD
04.31	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
05.04	RR BRIDGE	c1935	STONE FOUNDATION, WOOD TRESTLE WITH STEEL BEAMS AND WOOD TIES	FAIR -- SOME DETERIORATION IN TIES AND WOOD SUPPORTS
05.18	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
05.70	BRIDGE	1978-1979	STONE PIERS, STEEL TRUSS AND CONCRETE DECK	EXCELLENT
05.72	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
05.87	AQUEDUCT	20TH CENTURY	CONCRETE TROUGH CARRIES CANAL OVER CREEK -- REPLACES ORIGINAL STONE ARCHES. SPILLWAY ON EAST SIDE OF AQUEDUCT	GOOD
		c1935	RAILROAD BRIDGE ACROSS CREEK SET ON STONE PIERS WITH STEEL BEAMS AND WOOD TIES ON CONCRETE DECK. REMNANTS OF RAILROAD BRIDGE LOCATED WEST OF CANAL -- STONE PIERS ARE ALL THAT REMAIN	GOOD
06.00	RR BRIDGE	c1935	CONCRETE PIERS WITH STEEL BEAMS AND WOOD TIES	GOOD
06.15	CULVERT	1831-1834	SINGLE STONE ARCH SET WITHIN STONE WALL	GOOD
06.18	SPILLWAY	c1935	CONCRETE	GOOD
06.64	BRIDGE	c1935	CONCRETE	GOOD
06.67	BRIDGE	c1935	CONCRETE	GOOD
06.67.01	BRIDGETENDER'S HOUSE	c1831	SEE SURVEY FORM	
06.87	AQUEDUCT	1831-1834	STONE ARCH OVER CREEK WITH CONCRETE LINER	GOOD -- SOME MINOR DETERIORATION IN STONE WALL; CONCRETE LINER EXHIBITS HAIRLINE CRACKS
	SPILLWAY	c1935	CONCRETE	
06.88	SPILLWAY	c1915	CONCRETE	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
07.19	LOCK	1831-1834	STONE SIDEWALLS AND APPROACH WALLS ARE INTACT. CONCRETE WATER CONTROL GATE WITH STEEL MECHANISM ADDED IN THE LATE 1930'S. LOCK LENGTHENED TO 22' IN 1852-1853 FROM ORIGINAL 110' LENGTH.	GOOD -- SOME MINOR DETERIORATION IN STONE AND MORTAR; WEEDS GROWING BETWEEN STONES; SHOULD BE CLEANED OF ALL VEGETATION.
	LOCK	1847-1848	LOCK BETWEEN CANAL AND DELAWARE RIVER ALLOWED COAL BARGES FROM DELAWARE CANAL IN PENNSYLVANIA TO CROSS RIVER AND CONTINUE ON TO NEW BRUNSWICK AND NEW YORK.	POOR -- GREAT DETERIORATION IN STONE WALLS WITH MANY DISPLACED STONES. PARTIALLY FILLED IN WITH SOIL AND GARBAGE
07.19.01	LOCKTENDER'S HOUSE	c.1847	SEE SURVEY FORM	
07.25	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
07.35	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
08.23	SPILLWAY	c1915	CONCRETE	GOOD
08.42	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
09.24	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
09.53	SPILLWAY	c1915	CONCRETE	GOOD
09.91	RR BRIDGE	1898	WOOD TRESTLE WITH STEEL BEAMS AND WOOD TIES	POOR -- SOME TIES AND RAILS MISSING IN SEVERAL PLACES; WOOD MEMBERS EXHIBIT ROT
10.22	CULVERT	1912	CONCRETE -- SINGLE ARCHED OPENING	GOOD
10.24	RR BRIDGE	c1935	WOOD TRESTLE WITH STEEL BEAMS AND WOOD TIES	POOR -- SOME TIES AND RAILS MISSING IN SEVERAL PLACES; WOOD MEMBERS EXHIBIT ROT
11.21	CULVERT	20TH CENTURY	METAL	
11.59	CULVERT	1831-1834	STONE ARCH WITH METAL LINER; ROUGH STONE WALL WITH SMOOTH STONE VOUS-SOIRS	GOOD -- NO MAJOR CRACKS OR STRUCTURAL FLAWS ARE IN EVIDENCE.

APPENDIX 2.6
(continued)

<u>MILEAGE /</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
11.91	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
12.21	CULVERT	1914	CONCRETE -- SINGLE ARCHED OPENING	GOOD
	BRIDGE	1831-1834	STONE ROAD BRIDGE OVER CREEK; SINGLE ARCH WITH SIDE WALLS; IRON BRACE ABOVE ARCH	GOOD -- SOME DETERIORATION (MINOR) IN STONE AND MORTAR
12.45	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
12.55	SPILLWAY	c1915	CONCRETE	GOOD
13.06	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
13.20	CULVERT	1831-1834	STONE ARCH	GOOD -- SOME MINOR DETERIORATION IN STONE AND MORTAR
13.60	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD
13.64	SPILLWAY	1915	SERIES OF CONCRETE PIERS SET WITHIN CONCRETE WALL	GOOD
15.05	CULVERT	1831-1834	STONE ARCH WITH STONE WALL AND SMOOTH STONE VOUSSOIRS; LARGEST CULVERT ALONG CANAL	GOOD -- NO EVIDENCE OF DETERIORATION
15.56	SPILLWAY	c1915	CONCRETE	GOOD
16.01	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
16.11	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
16.12	BRIDGE	c1970	CONCRETE WITH STEEL BEAMS AND CONCRETE DECK	GOOD
16.38	BRIDGE	c1970	CONCRETE PIERS WITH STEEL BEAM AND CONCRETE DECK	GOOD
16.67	CULVERT	20TH CENTURY	CONCRETE	GOOD
16.79	BRIDGE	c1935	CONCRETE	GOOD
17.25	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
17.25.01	BRIDGETENDER'S HOUSE	c1852	SEE SURVEY FORM	
17.97	RR BRIDGE	c1935	CONCRETE ARCH WITH WOOD TIES	GOOD
18.05	CULVERT	1831-1834	STONE ARCH WITH STONE WALL AND SMOOTH STONE VOUSSOIRS WITH METAL LINER	GOOD
18.09	SPILLWAY	c1915	CONCRETE	GOOD
	FLOODGATE	c1935	CONCRETE PIERS IN MIDDLE OF CANAL	GOOD
18.12	BRIDGE	c1935	CONCRETE PIERS WITH STEEL BEAMS AND CONCRETE DECK	GOOD
18.94	BRIDGE	20TH CENTURY	PEDESTRIAN FOOT BRIDGE; WOOD PLANKS ON TOP OF STEEL CABLES STRUNG ACROSS CANAL	GOOD
19.06	AQUEDUCT	c1935	CONCRETE TROUGH CARRIES CANAL	GOOD
19.52	CULVERT	20TH CENTURY	CONCRETE	GOOD
19.87	AQUEDUCT	c1935	CONCRETE TROUGH SUPPORTED ON CONCRETE COLUMNS AND ARCHES; DONE IN CLASSICAL STYLE	FAIR--SOME DETERIORATION OF CONCRETE WITH WATER SEEPAGE ONTO ROADWAY BELOW
20.30	BRIDGE	c1935		
20.56	RR BRIDGE	c1935	CONCRETE ABUTMENTS WITH STEEL BEAMS AND WOOD TIES	GOOD
20.74	BRIDGE	c1935	CONCRETE	GOOD
20.74.01	BRIDGETENDER'S HOUSE	c1852	SEE SURVEY FORM	
20.82	BRIDGE	c1935	PEDESTRIAN FOOT BRIDGE; CONCRETE	GOOD
20.85	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
21.06	BRIDGE	c1935	CONCRETE	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
21.06.01	BRIDGETENDER'S HOUSE	c1852	SEE SURVEY FORM	
21.16	BRIDGE	c1935	CONCRETE	GOOD
21.16.01	BRIDGETENDER'S HOUSE	c1852	SEE SURVEY FORM	
21.35	BRIDGE	c1935	CONCRETE	GOOD
21.42	BRIDGE	c1935	CONCRETE	GOOD
21.50	RR BRIDGE	c1935	CONCRETE ABUTMENTS WITH STEEL BEAMS	GOOD
21.59	BRIDGE	c1935	CONCRETE	GOOD
21.62	BRIDGE	c1935	CONCRETE	GOOD
21.71	BRIDGE	c1935	CONCRETE	GOOD
21.92	RR BRIDGE	c1935	CONCRETE ABUTMENTS WITH STEEL BEAMS	GOOD
22.05	ENCLOSURE	c1970	CONCRETE	GOOD
NOTE: BETWEEN 22.05 AND 23.20 THE CANAL FLOWS WITHIN A CONCRETE CULVERT ROUTE 1 HIGHWAY LOCATED ABOVE CANAL				
23.20	OUTLET	c1970	CONCRETE	GOOD
24.05	SPILLWAY	c1935	CONCRETE	GOOD
24.18	BRIDGE	c1978	CONCRETE PIERS SET WITHIN CANAL SUPPORT STEEL BEAMS AND CONCRETE DECK	GOOD
24.66	CULVERT	20TH CENTURY	CONCRETE; 4 ARCHES SET WITHIN CONCRETE WALL	GOOD
25.50	CULVERT	20TH CENTURY		
25.86	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
25.86.01	BRIDGETENDER'S HOUSE	1831-1834	SEE SURVEY FORM	
25.95	BASIN	1831-1834	LARGEST BASIN ALONG CANAL; SEPARATED FROM CANAL BY TOWPATH	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
26.48	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
26.52	SPILLWAY	1831-1834	COBBLESTONE SECTION OF TOWPATH; DEPRESSED ONE FOOT BELWO TOWPATH	GOOD
26.57	CULVERT	1831-1834	STONE WALL AND ABUTMENTS; OPENING IS BELOW CREEK WATER LINE	GOOD -- SOME DETERIORATION IN STONE AND MORTAR; SOME DISPLACED STONE ON ABUTHEN
26.93	BRIDGE	c1970	CONCRETE PIERS WITH STEEL BEAMS AND CONCRETE DECK	GOOD
27.20	BRIDGE	c1970	CONCRETE PIERS WITH STEEL BEAMS AND CONCRETE DECK	GOOD
27.30	INTAKE	c1935	CONCRETE PLATFORM WITH STEEL GATE AND MECHANISM; CONCRETE BLOCK BUILDING NEXT TO INTAKE	GOOD
27.97	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
28.93	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD
29.02	BASIN	1831-1834	SEPARATED FROM CANAL BY TOWPATH	
29.34	CULVERT			
31.40	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD
31.45	BASIN	1831-1834	PARTIALLY INFILLED AND SEPARATED FROM CANAL BY TOWPATH	
31.47	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
31.57	RR BRIDGE	19TH CENTURY	STONE ABUTMENTS WITH STEEL BEAMS AND DECK; SWING BRIDGE; ONE OF FOUR REMAINING ALONG CANAL	GOOD
31.96	BRIDGE	c1935	CONCRETE	GOOD
32.59	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
32.96	AQUEDUCT	c1935	CONCRETE TROUGH CARRIES CANAL THROUGH LAKE CARNEGIE. CONCRETE RAILROAD PIERS LOCATED NEXT TO AQUEDUCT; BEAMS AND TIES REMOVED	GOOD
33.20	CULVERT	1831-1834	TWO STONE ARCHES; RQNDOM STONE WALL WITH SMOOTH STONE VOUSOIRS	FAIR -- MOST MORTAR GONE AND SEVERAL STONES IN WALL HAVE BEEN DISPLACED; ARCHES APPEAR TO BE IN GOOD CONDITION
34.99	SPILLWAY	1831-1834	COBBLESTONE SECTION OF TOWPATH; DEPRESSED ONE FOOT BELOW REST OF TOWPATH	GOOD
35.01	CULVERT	1831-1834	STONE ARCHED	
35.10	BASIN	1831-1834	STILL CONNECTED TO CANAL	
	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
35.19	LOCK	1831-1834	STONE WALLS COVERED WITH CONCRETE IN THE LATE 1930'S; CONCRETE WATER CONTROL GATES ACROSS LOCK HAVE STEEL GATES AND MECHANISM. LOCK LENGTHENED TO 220' IN 1852-53 FROM ORIGINAL 110' LENGTH.	GOOD CONDITION WITH SOME HAIRLINE CRACKS IN CONCRETE
35.19.01	LOCKTENDER'S HOUSE	1831-1834	SEE SURVEY FORM	
35.19.02	LOCKTENDER'S STATION	1831-1834	SEE SURVEY FORM	
35.24	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
35.26	BRIDGE	c1970	CONCRETE ADJUTMENT WITH STEEL BEAMS AND CONCRETE DECK.	GOOD
35.76	BASIN	1831-1834	CONNECTED TO CANAL VIA TWO STEEL PIPES UNDER TOWPATH	
36.51	SPILLWAY	1831-1834	COBBLESTONE SECTION OF TOWPATH DEPRESSED ONE FOOT BELOW REST OF TOWPATH	GOOD

APPENDIX 2.6
(continued)

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<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
37.11	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD
38.11	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
38.29	CULVERT			
39.04	CULVERT	c1935	CONCRETE PIPE SET WITHIN STONE WALL	PIPE IN GOOD CONDITION; STONE WALL IN POOR CONDITION WITH MISSING AND DISPLACE STONES.
39.06	SPILLWAY	1831-1834	COBBLESTONE SECTION OF TOWPATH DEPRESSED ONE FOOT BELOW REST OF TOWPATH	GOOD
39.46	CULVERT	c1935	CONCRETE PIPE SET WITHIN STONE WALL	PIPE IN GOOD CONDITION; STONE WALL IN POOR CONDITION WITH MISSING AND DISPLACED STONES.
	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
39.49	LOCK	1831-1834	STONE WALLS COVERED WITH CONCRETE IN THE LATE 1930's. CONCRETE WATER CONTROL GATES ACROSS LOCK HAVE STEEL GATES AND MECHANISM. LOCK LENGTHENED TO 220' IN 1852-53 FROM ORIGINAL 110' LENGTH	GOOD CONDITION WITH SOME HAIRLINE CRACKS IN CONCRETE
39.49.01	LOCKTENDER'S HOUSE	1831-1834	SEE SURVEY FORM	
39.50	BRIDGE	c1935	WOOD WITH WOOD DECK	GOOD
	BRIDGETENDER'S STATION	c1831	SEE SURVEY FORM	
40.16	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD
40.16.02	BRIDGETENDER'S HOUSE	c1831	SEE SURVEY FORM	
40.18	CULVERT	1831-1834	STONE WALL AND ABUTMENTS; OPENING IS BELOW CREEK WATER LINE	GOOD -- SOME DETERIORATION IN STONE AND MORTAR

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
41.11	SPILLWAY	1831-1834	COBLESTONE SECTION OF TOMPATH DEPRESSED ONE FOOT BELOW REST OF TOMPATN	
41.12	CULVERT	1831-1834	STONE WALL AND ABUTMENTS; TWO STONE BUTRESSES; OPENING IS BELOW CREEK WATER LINE	
42.11	CULVERT	1831-1834	STONE WALL AND ABUTMENTS; TWO STONE BUTRESSES; OPENING IS BELOW CREEK WATER LINE	
42.45	INTAKE	c1960	CONCRETE WITH STEEL GATE AND MECHANISM; BUILDING AND FILTRATION PLAN	GOOD
42.60	CULVERT	20TH CENTURY	CONCRETE	GOOD
43.53	CULVERT	1831-1834	STONE WALL WITH THREE STONE ARCHES	
43.	BRIDGETENDER'S STATION	c1831	SEE SURVEY FORM	
43.70	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD
43.70.01	BRIDGETENDER'S HOUSE	c1831	SEE SURVEY FORM	
44.40	CULVERT	1831-1834	STONE WALL WITH ARCHED OPENING	GOOD
44.89	CULVERT	1831-1834	STONE WALL WITH ARCHED OPENING	GOOD
45.78	BASIN	1831-1834	SITLL CONNECTED TO CANAL; PARTIALLY INFILLED	
45.79	BRIDGE	c1935	CONCRETE	GOOD
45.79.01	BRIDGETENDER'S HOUSE	c1831	SEE SURVEY FORM	
46.23	CULVERT	1831-1834	STONE WALL WITH ARCHED OPENING	GOOD
46.57	SPILLWAY	1831-1834	COBLESTONE SECTION OF TOMPATH DEPRESSED ONE FOOT BELOW REST OF TOMPATN	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
46.68	CULVERT	1831-1834	STONE WALL WITH ARCHED OPENING	GOOD
47.93	BRIDGE	c1935	WOOD WITH ASPHALT WOOD DECK	GOOD
47.93.01	BRIDGETENDER'S HOUSE	c1831	SEE SURVEY FORM	
48.31	CULVERT	1831-1834	STONE WALL WITH ARCHED OPENING	GOOD
48.50	BRIDGE	c1935	WOOD WITH ASPHALT COVERED WOOD DECK	GOOD
48.50.01	BRIDGETENDER'S HOUSE	c1831	SEE SURVEY FORM	
49.06	FLOODGATE	c1935	STONE WALL WITH CONCRETE FRAME HOLDING STEEL GATE AND MECHANISM	GOOD
49.09	LOCK	1831-1834	STONE WALLS COVERED WITH CONCRETE IN THE LATE 1930'S. CONCRETE WATER CONTROL GATES ACROSS LOCK HAVE STEEL GATES AND MECHANISM. LOCK LENGTHENED TO 220' IN 1852-53 FROM ORIGINAL 110' LENGTH.	GOOD CONDITION WITH SOME HAIRLINE CRACKS IN CONCRETE
49.09.01	LOCKTENDER'S HOUSE	c1831	SEE SURVEY FORM	
49.23	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
49.36	INTAKE	c1935	CONCRETE PLATFORM WITH STEEL GATE AND MECHANISM; BRICK BUILDING	GOOD
	BRIDGE	c1935	CONCRETE ABUTMENTS WITH STEEL BEAMS AND CONCRETE DECK	GOOD
50.41	CULVERT	20TH CENTURY	CONCRETE WALL WITH STEEL LINER	GOOD
50.53	BRIDGE	c1970	CONCRETE PIERS WITH STEEL BEAMS AND CONCRETE DECK.	GOOD
51.11	SPILLWAY	c1935	CONCRETE	GOOD

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
51.46	LOCK	1831-1834	STONE WALLS PARTIALLY COVERED WITH CONCRETE IN THE LATE 1930'S. CONCRETE WATER CONTROL GATES ACROSS LOCK HAVE STEEL GATES AND MECHANISM. STONE WALLS ARE INTACT DOWNSTREAM OF WATER CONTROL GATES. EVIDENCE OF WOOD LINER VISIBLE ON STONE. LOCK LENGTHENED TO 220' IN 1852-53 FROM ORIGINAL 110' LENGTH.	GOOD--CONCRETE COVERING HAS SOME HAIRLINE CRACKS; STONE SECTION DOWNSTREAM IS IN FAIR CONDITION WITH SOME DETRIORATION IN STONE AND MORTAR; VEGETATION GROWING BETWEEN STONES.
51.62	BRIDGE	19TH CENTURY	CONCRETE ABUTMENTS WITH STEEL BEAMS AND CONCRETE DECK; TURNING BRIDGE; ONE OF FOUR REMAINING	GOOD
51.67	RR BRIDGE	19TH CENTURY	CONCRETE ABUTMENTS WITH STEEL BEAMS AND WOOD TIES; TURNING BRIDGE; ONE OF FOUR REMAINING	GOOD
52.76	CULVERT	1831-1834	STONE WALL WITH TWO STONE ARCHES	GOOD
53.07	FLOODGATE	c1935	CONCRETE WITH STEEL GATE AND MECHANISM	GOOD
53.14	SPELLWAY	1831-1834	COBBLESTONE SECTION OF TOMPATH; DEPRESSED ONE FOOT BELOW REST OF TOMPATH	GOOD
53.18	LOCK	1831-1834	STONE WALLS COVERED WITH CONCRETE IN THE LATE 1930'S. CONCRETE WATER CONTROL GATES ACROSS LOCK HAVE STEEL GATES AND MECHANISM. LOCK LENGTHENED TO 220' IN 1852-53 FROM ORIGINAL 110' LENGTH.	GOOD CONDITION WITH SOME HAIRLINE CRACKS IN CONCRETE
53.18.01	LOCKTENDER'S HOUSE	c1831	SEE SURVEY FORM	
53.25	BRIDGE	c1970	CONCRETE PIERS SET WITHIN CANAL SUPPORT STEEL BEAMS AND CONCRETE DECK	GOOD
53.33	SPELLWAY	1831-1834	COBBLESTONE SECTION OF TOMPATH; DEPRESSED ONE FOOT BELOW REST OF TOMPATH; CONCRETE AND STEEL BULKHEAD	GOOD; SOME CONCRETE PATCHES

APPENDIX 2.6
(continued)

<u>MILEAGE #</u>	<u>ENTITY</u>	<u>DATE</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>
55.72	CULVERT	1967	CONCRETE	GOOD
56.67	CULVERT	1831-1834	STONE WALL WITH TWO ARCHED OPENINGS WITH BRICK LINER AND SMOOTH STONE VOUSSOIRS; BRICK PATCHES	FAIR--STONE VOUSSOIRS HAVE SPAULDED OFF; BRICK PATCHES REPLACE MISSING STONES
56.81	SPILLWAY	1831-1834	COBBLESTONE SECTION OF TOWPATH; DEPRESSED ONE FOOT BELOW REST OF TOWPATH	GOOD WITH A FEW CONCRETE PATCHES
56.84	BRIDGE	19TH CENTURY	CONCRETE ABUTMENTS WITH STEEL BEAMS AND CONCRETE DECK; SWING BRIDGE; ONE OF FOUR REMAINING; SWING BRIDGE LEFT ON CANAL	GOOD
57.06	DRAIN			

CHAPTER 3.0 ANALYSES AND INTERPRETATION OF SPOILS CHARACTERISTICS

3.1 Characteristics of Dredge Spoils

As human experiences have shown need, criteria have been established to protect the public from excess exposure to chemical and biological agents. The Canal sediments do contain some agents which are included in these criteria. The several chemical analyses and the one biological analysis selected for this study were performed on some of the separate fractions of the samples taken.

The significance of the findings is discussed below.

3.1.1 Organochlorine, Polychlorinated Biphenyls (PCB's) and Herbicide Fraction

The results of these analyses performed on the wet-solids fraction are shown in Table 2.6a. The concentrations of the chemicals listed are either not detected (ND) or in low concentration. The PCB, Aroclor 1248, was detected in five of the 15 samples tested; the highest level 6.8 milligrams per kilogram (or parts per million) was found in the sample taken at site D-16 which is 100 feet downstream of the Trenton Tubes. The values for PCB's found in the similar sample-fraction in the Trenton Tubes were 5.8, 10.6 and 2.5 milligram per kilogram. Apparently the contaminated sediments in the Trenton Tubes were washed downstream. The same recommendations for disposal of the sediments in the Trenton Tubes are made for the sediments just downstream, i.e., landfill and cover.

3.1.2 Heavy Metals

Analyses were made for heavy metals in several of the sample fractions, i.e.: EP Toxicity Extract, Table 2.6b; centrifuged solids, Table 2.8; and

filtered centrate, Table 2.10.

3.1.2.1 EP Toxicity Extract

In the May 19, 1980 Federal Register, the U.S. Environmental Protection Agency (USEPA) proposed a procedure for an extraction procedure to be used on solid materials. (Appendix 2.3). The extraction is intended to simulate leaching which would occur on landfills. The solid-sample-fraction of the samples taken for this study were extracted in the manner prescribed and the extracts were analyzed for the content of some of the heavy metals, Table 2-6b. As part of the same document the USEPA proposed acceptable maximum concentration levels (MCL's) of metals and pesticides; these levels are 100 times those MCL's given in the USEPA Primary Drinking Water Standards (PDWS). Of the metals listed in the PDWS only cadmium was detected and in only the sample from Site D-32, an industrial area in South Bound Brook; the level detected in the extract was 2.8 mg/l. The acceptable level of cadmium concentration in the extract is 1 mg/l; therefore the MCL is exceeded by a factor of 2.8.

Leachates from the sediments taken from the vicinity of Site D-32 should be prevented from entering potable water sources.

3.1.2.2 Centrifuged Solids

After centrifuging, a portion of the solids was taken for analyses for heavy metals. The sediments were subjected to a perchloric acid extraction procedure which provides an essentially complete metal removal, Table 2.8. The metals content of the sediments might be of concern in land spreading as discussed below.

3.1.2.3 Unfiltered Centrate

After centrifuging, the centrate (the liquid fraction) was filtered and

analyses were made for the heavy metals content in the filtrate, Table 2.10. This filtrate might be considered as representing the waters draining from the sediment. Of the metals, only lead has concentrations in excess of the PDWS, i.e. 0.05 mg/l; this occurred in 13 of the 34 samples tested with the highest level (0.19 mg/l) in sample D-12 taken in the City of Trenton.

3.1.3 Bacterial Quality

Concern for the bacterial quality of the interstitial waters, i.e., waters drained off from the sediments, suggested analyses for fecal coliforms. Samples were taken in March 1981 and the results are shown on Table 2.11a. The New Jersey Standard (Ref. 3.4) of a maximum of 200 fecal coliforms/100 ml sample (FW-2) was exceeded only in sample D-2. This sample site, just upstream of Raven Rock Lock, is just downstream of the building complex of the ranger station and public campground. It should be noted that the fecal coliform content of the Delaware River at Lumberville, Pa. does, at times, exceed the standard of 200/100 ml (Ref. 3.17).

3.1.4 Asbestos Content

In the vicinity of the industrial area of South Bound Brook, samples of sediment were taken for asbestos content. The analyses were necessarily made of the interstitial waters, the results are shown on Table 2.11b. The USEPA has suggested (Ref. 3.5) that levels which may result in an increase in cancer risk over a lifetime are estimated at 10^{-5} , 10^{-6} , and 10^{-7} . The corresponding criteria are 300,000, 30,000 and 3,000 fibers per liter, respectively. Obviously, asbestos fiber content in the interstitial waters greatly exceeds these levels.

3.1.5 Formation of Chlorinated Compounds

Chlorination is a standard treatment process for potable water. Chlorine

will react with some compounds to form chlorinated hydrocarbons and those of current public health concern are the trihalomethanes, THM's. For this study, the unfiltered centrate from five samples were chlorinated and analyses were made to measure the formation of some 25 different chlorinated hydrocarbons; the results are shown in Table 2-9. The only THM formed was chloroform and its levels ranged from 3.9 to 26.1 micrograms per liter. The PDWS MCL standard is 100 micrograms per liter.

3.1.6 Other Quality Parameters

Other analyses made on some of the sample-fractions included: chemical oxygen demand (COD); total organic carbon, (TOC); oils and greases; total phosphorus; total nitrogen; total residue, (TR); total volatile solids, (TVS); total fixed solids, (TFS); and chromatographic oils. No specific criteria are established for maximum concentration levels of these several water quality parameters. However, judgement of the overall quality of the solid and of the liquid fractions can be made.

3.1.6.1 Dried Solids Fraction

As a check on the "gross parameters" of oils and greases analyses were made on the dry solids for chromatographable oils, Table 2.7c. The oils and grease tests were for the heavier fraction (higher molecular weight) organic matter soluble in hexane, benzene and methanol-chloroform. These solvents were evaporated and the residue is termed "oils and greases." Any volatile (low molecular weight) extract was vaporized along with the solvents. Another procedure, gas chromatography, was used to measure the amount of volatile oils and greases - these are termed chromatographable oils. Therefore, the two tests compliment one another. There is a good correlation between the results shown on Tables 27.a and 27.c, except in a sample from

D-28; the oils and greases there are quite high and the chromatographable oils are low.

3.1.6.2 Unfiltered Centrate Fraction

Analyses were made of the centrate for COD, TOC, TR, TVS, and TFS. No unexpected or significant results were noted.

3.2 Sediment Disposal

3.2.1 Suitability of Dredge Spoils for Land Spreading

According to Section H, APPLICATION OF LAND USE FOR THE PRODUCTION OF FOOD-CHAIN CROPS, the EPA in the development of these criteria addressed four general categories of pollutants: (1) cadmium; (2) pathogens; (3) pesticides and persistent organics; (4) ingestion of toxic organic chemicals and heavy metals (especially PCBs and lead). Of these, the promulgated regulations address only cadmium and PCBs. Cadmium application is limited to 0.5 kilograms/hectare/year to a maximum of 5 kilograms/hectare; corresponding to 0.45 pounds per acre per year and a total of 4.5 pounds per acre. Until 1984 the yearly allowable cadmium application will be 1.5 kilograms/hectare. Similarly, the regulations require (with some exceptions) that if the PCB concentration in solid wastes exceed 10 milligrams/kilogram (ppm) the solid waste must be well mixed with the soil.

Other criteria were established by the NJDEP for disposal of sewage sludge on land used for food-chain crop production (Ref. 3.7). These criteria include: Table II-4 -- Maximum Allowable Cumulative Metals Application on Agricultural Lands; Table II-3 -- Sludge or Compost Heavy Metals Limit for Application Rates given in Section 2-9.2 -- Option B. (The Option B is sewage sludge application rates at 10 tons/acre/year or composted sewage sludge rate at 20 tons/acre/year); Table A-1 -- Median Heavy Metals Level; and Table A-2 --

Organic Compounds Limits. These latter two tables were intended to aid in the devising of a sampling program and are not established limits.

3.2.1.1 Heavy Metals

In this discussion it is assumed that

- 1) The heavy metals in the sediment are no more soluble or active than those in sewage sludge.
- 2) The land application system would involve mixing or incorporating the sediment in six to seven inches of soil weighing about two million pounds per acre.
- 3) The soil would have an initial pH of 6.5 or greater and the soil-sediment mixture will have a pH of 6.2 or greater.
- 4) The soil-rating guidelines for land application established by the Soil Conservation Service (SCS) will be followed (Ref. 3.8). Only soils with slight or moderate limitations will be considered (see Appendix 1).

The values on Table 3.1 indicate the limitation imposed by the cadmium limits (Ref. 3.6).

The values on Table 3.2 indicate the limitation imposed by the maximum lead applications of 100 lbs/acre/year.

Table 3.3 indicates the total tonnages of sediment permissible on cropland based on maximum cumulative additions of lead, zinc, copper, and nickel. A medium-range exchange capacity is assumed, i.e., 5-15 milliequivalent/100 grams of soil (Ref. 3.7 and Table II-4).

As seen on Tables 3.1-3.2 the limitations on land-spreading is in some cases set by the annual permissible cadmium loadings and in other cases by the annual lead loading.

It does not appear that the cumulative totals of other metals are limiting, Table 3.3.

It is reasonable to expect that land-spreading of the dredge spoils would be completed within a year on any given field. Therefore, the limitation on the annual loading should prevail.

Table 3.4 indicates that the normal metal content of New Jersey soils would not be affected significantly if 50 tons/acre of sediment were applied and disced into about 6-7 inch depth of soil.

Table 3.5 was prepared to aid in estimating sediment volumes from tonnage values.

3.2.1.2 Organic Compounds

Little information on toxic organic chemical limitations of sewage sludge or other solid matter is available. The USEPA requirements are primarily directed to the PCBs (Ref. 3.6, 3.9, 3.10). In its May 19, 1980 release (Ref. 3.3) the USEPA regrets its inability to coordinate the PCB requirements promulgated under Toxic Substances Control Act of 1976 (Ref. 3.11) and under the Resource Conservation Act of 1976 (Ref 3.12). The EPA Rules and Regulations of Refs. 3.6, 3.9, 3.10 concerning PCBs are somewhat vague.

The USEPA (1980) lists many organic compounds as "hazardous"; however, it does not establish acceptable or non-acceptable levels (Ref. 3.3). New York State has also proposed guidelines for PCBs in sediments dredged from the Hudson River (Ref. 3.13) -- see Table 3.6.

New Jersey DEP listed on Table A-2 of Ref. 3.7, Organic Compounds Limits in ppm of sewage sludge to be spread on crop land; however, this list is primarily a guide to a sampling program and not upper-limit criteria. On Table 3.7 is presented a brief resume of the several PCB requirements referenced above.

From Table 3.7 it is seen that the PCB content of the sediments (Table 2) requires:

- 1) New York State Standard - be placed in an ordinary dredge spoil site with efforts to minimize loss by grading, etc.
- 2) USEPA Standard - could be placed into soil used for crop production
- 3) NJDEP - only sediments from the vicinity of site D-16 cannot be disposed of as crop land without further consultation with NJDEP.

The other organic compound limits for sewage sludge listed by NJDEP, in Table A-2 of Ref. 3.7 are compared on Table 3.8 to organics found in the sediment -- Table 2.6a.

From Table 3:8 it is seen that the only organic pollutants that may be of concern are PCBs at sample site D-16 and pp'DDE at sample site D-13.

3.2.1.3 Oil and Greases

As shown on Table 2.7A the total oil and grease ranges from about 0.2% to 2.3% on a dried-weight basis. The dried sediment from the highest oil and grease samples would neither sustain combustion nor smoulder in a laboratory experiment. So the sediment is not in the "hazardous" category of "ignitability" as described in Section 261.20 of Ref. 3.3.

Because of the "greasy and sticky" nature of the sediment, in the regions of sample sites D-16 and D-32, land spreading of the drained sediment in thin layers would be physically difficult. The sludge would need to be dried and pulverized. From their experiments, Brown et al. (Ref. 3.14) concluded that both refinery and petrochemical wastes high in crude and refined petroleum products did impede the growth of grass-type plants. They also observed a persistence of this negative effect over a period of some eight plant cycles.

Land spreading of the sediments high in oils and greases would be difficult and the effects on plant growth might be of concern; these would preclude the use of land spreading of sediments from the vicinity of sites D-16 and D-32. The sediments low in oils and greases might well be spread on land in thin layers with relative ease and the effects on plant growth rates would be limited.

3.2.1.4 Asbestos

High levels of asbestos turned up in the sediment samples taken near the industrial area of South Bound Brook (Table 2.11b). Upon drying, the asbestos fibers may become airborne when the sediment dries. It is recommended that the spoils in the vicinity of sampling sites D-30 to D-34 be put into a landfill and be covered promptly. If the dredge spoil were to be left at the dewatering sites until dry, similar precautions for covering (temporary basis) would be necessary.

3.2.2 Conclusion on Land-Spreading

The NJDEP limitation of 0.5 mg/kg of PCBs appears to be some 10 to 20 times as stringent as that of the USEPA or New York State. However, even if that limitation prevails, land-spreading is precluded only for sediments containing greater than 0.5 milligrams per kilogram such as those taken from the vicinity of sampling site D-16, just downstream of the Trenton Tubes. If the NJDEP PCBs limitations were adjusted upwards toward that of the USEPA, land-spreading for all sediments would be possible with a maximum rate of spreading limited only by metal concentrations. The limitations may be established by either the "annual rates" and "maximum cumulative" and also upon degree of mixing of the sediment.

3.2.3 Landfilling of Sediments

The alternative to land spreading is landfilling; that is, the sediment is placed in a pile and covered. Such landfills should be located, constructed, and maintained to minimize losses due to floods and erosion and to control runoff to both surface and ground waters to avoid excessive pollution of those waters.

3.2.3.1 New Jersey Regulations

In New Jersey the Bureau of Solid Waste Management (SWM) has the responsibility of supervising these landfills; their rules and regulations are given in Ref. 3.15. It is presumed that if the sediment is placed onto landfills, the procedures will follow those of the SWM. However, the regulations are not specific on the method of monitoring leachate formation and dispersion either in surface or groundwaters. However, a list of some 29 physical characteristics or chemical species to be analyzed are included.

3.2.3.2 USEPA Regulations

The USEPA, under the mandates of the TSCA and RCRA Acts has promulgated several series of rules and regulations on solid waste management (Refs. 3.3, 3.6, 3.9, 3.10, 3.16). However, since the EP extract procedure of the USEPA (Ref. 3.3) failed to identify any significant amount of any of the materials analyzed for and identified in that publication as hazardous, the specific need for an extensive monitoring program is not clear.

3.2.4 Conclusion of Landfilling of Sediments

Since land spreading of any of the sediments within and immediately downstream of the Trenton Tubes may be precluded by the PCBs limitation given in Ref. 3.7, i.e., 0.5 ppm, landfilling is recommended for all of the sediment to be removed from the Trenton Tubes and immediately downstream.

The construction and operation of the landfill should follow the rules and regulations of the Solid Waste Administration of the NJDEP. The landfill need not be lined with impervious liners; however, monitoring of the surface runoff and ground waters may be a part of the program as recommended by the SWA of the NJDEP for all "new" landfills (Ref. 3.16) and/or the USEPA recommendations given in Ref. 5, Subpart F.

Analyses of the surface runoff and the ground waters should include testing for the 29 items listed in Ref. 3.7. To that list should be added Total Organic Carbon, Total Organic Halogen and pH (Ref. 3.3, Section 265.92). Even though the PCB content of the sediment is well below the level of the USEPA concern (Ref. 3.9 and Ref. 3.10), i.e., 50 ppm, the very high public interest and concern suggests the PCBs should be added to the list for analyses.

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CHAPTER 3.0

LIST OF TABLES

- 3.1 AMOUNT OF SEDIMENT TO MEET CADMIUM STANDARDS
- 3.2 AMOUNT OF SEDIMENT TO MEET MAXIMUM LEAD STANDARDS
- 3.3 AMOUNT OF SEDIMENT WHICH MEETS TOTAL CUMULATIVE METAL ADDITION STANDARDS
- 3.4 COMPARISON OF SEDIMENT TO TOTAL METAL CONTENT OF SOILS
- 3.5 VOLUME OF SEDIMENT IN CUBIC YARDS/ACRE EQUIVALENT TO TONS/ACRE
- 3.6 PROPOSED GUIDELINES, FOR CONTAMINATED HUDSON RIVER SEDIMENTS
- 3.7 COMPARISON OF RULES AND REGULATIONS FOR PCB DISPOSAL
- 3.8 COMPARISON OF NJDEP ORGANIC COMPOUNDS LIMITS ON SEWAGE SLUDGE WITH SEDIMENTS

TABLE 3.1

AMOUNT OF SEDIMENT TO MEET CADMIUM STANDARDS*

Sediment Sample	Cd Content** mg/kg	Tons/Acre Sediment Which Would Provide	
		1.8 lbs Cd/A/yr	4.5 lbs Cd/A/total
D-1	1.8	500	1200
D-2	9.8	92	230
D-4	2.4	370	940
D-5	3.4	260	660
D-6	8.5	110	260
D-7	7.4	120	300
D-8	9.9	91	230
D-9	ND	---	---
D-10	5.1	180	440
D-11	4.4	200	510
D-12	2.8	320	800
D-13	3.3	270	680
D-14	4.4	200	510
D-16	4.7	190	480
D-17	5.5	160	410
D-18	2.2	410	1000
D-19	0.8	1100	2800
D-20	3.3	270	680
D-21	1.1	820	2000
D-22	2.5	360	900
D-23	1.9	470	1200
D-24	1.9	470	1200
D-25	5.0	180	450
D-26	3.6	250	620
D-27	1.6	560	1400
D-28	1.4	640	1600
D-29	0.8	1100	2800
D-30	1.9	470	1200
D-31	2.8	320	800
D-32	5.5	160	410
D-33	3.3	270	680
D-34	3.8	240	590

* Ref. 3.6

** Table 2.8

TABLE 3.2

AMOUNT OF SEDIMENT TO MEET MAXIMUM LEAD STANDARDS*

<u>Sediment Sample</u>	<u>Pb Content** mg/kg</u>	<u>Tons/Acre of Sediment to Provide 100 lbs lead/acre/year</u>
D-1	55	909
D-2	116	431
D-4	62.2	804
D-5	176	284
D-6	124	403
D-7	157	318
D-8	226	221
D-9	158	316
D-10	165	303
D-11	164	305
D-12	140	357
D-13	234	214
D-14	292	171
D-16	1430	35.0
D-17	503	99.4
D-18	165	303
D-19	82	610
D-20	276	181
D-21	198	253
D-22	141	355
D-23	129	388
D-24	151	331
D-25	462	108
D-26	280	179
D-27	142	352
D-28	128	391
D-29	96.3	519
D-30	176	284
D-31	180	278
D-32	154	325
D-33	256	195
D-34	148	338

* Ref. 3.7

** Table 2.8

TABLE 3.3

AMOUNT OF SEDIMENT WHICH MEETS TOTAL CUMULATIVE METAL ADDITION STANDARDS

(Tons of Sediment/Acre)

<u>Metal</u>	<u>Limit*</u> <u>(Lbs/Acre)</u>	<u>Sample</u>											
		<u>D-1</u>	<u>D-2</u>	<u>D-4</u>	<u>D-5</u>	<u>D-6</u>	<u>D-7</u>	<u>D-8</u>	<u>D-9</u>	<u>D-10</u>	<u>D-11</u>	<u>D-12</u>	<u>D-13</u>
Cd	10	2800	510	2100	1500	590	680	510	---	980	1100	1800	1500
Cu	250	4190	2250	3620	1380	1400	1780	1540	3280	1400	1500	1560	2160
Ni	100	1660	1170	1860	1040	1040	1170	2210	1490	899	909	947	---
Pb	1000	9090	4310	8040	2840	4030	3180	2210	3160	3030	3050	3570	2140
Zn	500	733	325	842	318	216	311	1430	947	264	316	347	2430

* Ref. 3.7, Table II-4, Soils with medium exchange capacity, i.e., 5-15 meq/100 g.

TABLE 3.3
(continued)

AMOUNT OF SEDIMENT WHICH MEETS TOTAL CUMULATIVE METAL ADDITION STANDARDS
(Tons of Sediment/Acre)

<u>Metal</u>	<u>Limit*</u> (Lbs/Acre)	<u>Sample</u>										
		<u>D-14</u>	<u>D-16</u>	<u>D-17</u>	<u>D-18</u>	<u>D-19</u>	<u>D-20</u>	<u>D-21</u>	<u>D-22</u>	<u>D-23</u>	<u>D-24</u>	<u>D-25</u>
Cd	10	1100	1100	910	2300	6300	1500	4500	2000	2600	2600	1000
Cu	250	1190	988	1660	2470	3620	1700	770	1240	1740	1520	1470
Ni	100	1170	947	3620	----	1580	1060	1170	1040	1080	928	2590
Pb	1000	1710	350	994	3030	6100	1810	2530	2550	3880	3310	1080
Zn	500	352	239	1400	689	1980	607	1110	874	926	812	958

* Ref. 3.7, Table II-4, Soils with medium exchange capacity, i.e., 5-15 meq/100 g.

TABLE 3.3
(continued)

AMOUNT OF SEDIMENT WHICH MEETS TOTAL CUMULATIVE METAL ADDITION STANDARDS
(Tons of Sediment/Acre)

<u>Metal</u>	<u>Limit*</u> <u>(Lbs/Acre)</u>	<u>Sample</u>								
		<u>D-26</u>	<u>D-27</u>	<u>D-28</u>	<u>D-29</u>	<u>D-30</u>	<u>D-31</u>	<u>D-32</u>	<u>D-33</u>	<u>D-34</u>
Cd	10	1400	3100	3600	6300	2600	1800	910	1500	1300
Cu	250	1860	2100	2010	3130	1750	3390	2160	1540	2280
Ni	100	1280	1040	1280	1170	1040	967	424	1520	1060
Pb	1000	1790	3520	3910	5190	2840	2780	3250	1950	3380
Zn	500	103	698	893	1890	799	5610	3550	2000	772

* Ref. 3.7, Table II-4, Soils with medium exchange capacity, i.e., 5-15 meq/100 g.

TABLE 3.4

COMPARISON OF SEDIMENT TO TOTAL METAL CONTENT OF SOILS AT 50 TONS OF SEDIMENT/ACRE
(lbs of Metal/Acre)

<u>Metal</u>	<u>N.J. SOILS</u>		<u>Sample</u>												
	<u>Ave</u>	<u>Normal Range</u>	<u>D-1</u>	<u>D-2</u>	<u>D-4</u>	<u>D-5</u>	<u>D-6</u>	<u>D-7</u>	<u>D-8</u>	<u>D-9</u>	<u>D-10</u>	<u>D-11</u>	<u>D-12</u>	<u>D-13</u>	
Cd	4	1-6	.18	.98	.24	.34	.85	.74	.99	---	.51	.44	.28	.33	
Cr	30	10-100	2.0	2.3	2.0	2.3	2.8	2.3	3.6	2.3	2.8	3.7	2.5	3.9	
Cu	30	10-100	3.0	5.6	3.5	9.1	8.9	7.0	8.1	3.8	8.9	8.3	8.0	5.8	
Ni	60	4-160	3.0	4.3	2.7	4.8	4.8	4.3	2.3	3.4	5.6	5.5	5.3	---	
Pb	60	10-200	5.5	12	6.2	18	12	16	23	16	17	16	14	23	
Zn	120	40-200	34	77	30	79	120	80	18	26	95	79	72	10	

TABLE 3.4
(continued)

COMPARISON OF SEDIMENT TO TOTAL METAL CONTENT OF SOILS AT 50 TONS OF SEDIMENT/ACRE
(lbs of Metal/Acre)

<u>Metal</u>	<u>N.J. SOILS</u>		<u>Sample</u>									
	<u>Ave</u>	<u>Normal Range</u>	<u>D-14</u>	<u>D-16</u>	<u>D-17</u>	<u>D-18</u>	<u>D-19</u>	<u>D-20</u>	<u>D-21</u>	<u>D-22</u>	<u>D-23</u>	<u>D-24</u>
Cd	4	1-6	.44	.47	.55	.22	.08	.33	.11	.25	.19	.19
Cr	30	10-100	3.1	4.2	4.8	4.5	2.4	4.3	7.9	4.7	5.1	6.7
Cu	30	10-100	11	13	7.5	5.1	3.5	7.4	16	10	7.2	8.2
Ni	60	4-160	4.3	5.3	1.4	---	3.2	4.7	4.3	4.8	4.6	5.4
Pb	60	10-200	29	140	50	17	8.2	28	20	14	13	15
Zn	120	40-200	71	100	18	36	13	41	23	29	27	31

TABLE 3.4
(continued)

COMPARISON OF SEDIMENT TO TOTAL METAL CONTENT OF SOILS AT 50 TONS OF SEDIMENT/ACRE
(lbs of Metal/Acre)

<u>Metal</u>	<u>N.J. SOILS</u>		<u>Sample</u>									
	<u>Ave</u>	<u>Normal Range</u>	<u>D-25</u>	<u>D-26</u>	<u>D-27</u>	<u>D-28</u>	<u>D-29</u>	<u>D-30</u>	<u>D-31</u>	<u>D-32</u>	<u>D-33</u>	<u>D-34</u>
Cd	4	1-6	.50	.36	.16	.14	.08	.19	.28	.55	.33	.38
Cr	30	10-100	4.5	6.7	3.9	11	2.0	7.9	6.1	9.2	5.8	2.8
Cu	30	10-100	8.5	6.7	5.9	6.2	4.0	7.2	3.7	5.8	8.1	5.5
Ni	60	4-160	1.9	3.9	4.8	3.9	4.3	4.8	5.2	12	3.3	4.7
Pb	60	10-200	46	28	14	13	9.6	18	18	15	26	15
Zn	120	40-200	26	240	36	28	13	31	4.5	7.0	13	32

TABLE 3.5

VOLUME OF SEDIMENT IN CUBIC YARDS/ACRE
EQUIVALENT TO TONS/ACRE APPLICATION

<u>Tons/Acre</u>	<u>Bulk Density</u>		
	<u>1.0</u>	<u>1.5</u>	<u>2.0</u>
10	11.9	7.9	6.0
30	35.6	23.7	17.8
50	59.4	39.6	29.7
100	118.8	79.2	59.4
500	584	396	297

TABLE 3.6

PROPOSED GUIDELINES
Re: CONTAMINATED HUDSON RIVER SEDIMENTS*

After evaluating the data and information we have on hand, we would recommend the following guidelines be used regarding upland disposal of PCB contaminated sediments dredged from the Hudson River north of the Tappan Zee Bridge. These guidelines are not in conflict with, but supplement federal and state proposed and existing regulations.

1. Greater than 1,000 ppm: This material should be incinerated. Temporary storage pending availability of acceptable incineration facilities will be considered.
2. Between 50 and 1,000 ppm: This material should be incinerated or disposed of in an approved chemical landfill. The landfill should be constructed in such a way that the material can be removed and further treated if economical technologies for destruction of PCBs at these levels are developed.
3. From 10 to 50 ppm: Material should be put in a restricted spoil disposal site. The site should be located, graded and covered to minimize loss of PCBs from the site. Access to the site should be restricted so that it is not disturbed.
4. From 1 to 10 ppm: Material should be placed in a spoil disposal site located and graded to minimize loss of PCBs from the site.
5. Less than 1 ppm: Unless extremely large quantities of this material are to be dredged, precautions normal to environmentally should uncontaminated dredge spoil disposal are sufficient.

* Approved by PCB Advisory Committee to the NY State Dept. of Environmental Conservation on 1/17/79

TABLE 3.7

COMPARISON OF RULES AND REGULATIONS FOR PCB DISPOSAL

PCB Concentration Ranges
milligrams/kilogram (ppm)

<u>Regulation</u>	<u>0-10</u>	<u>10-50</u>	<u>50-500</u>	<u>50-1000</u>	<u>>1000</u>
N.Y. State (Ref. 3.13)	minimize PCB loss for ordinary spoil site	minimize PCB loss from spoil site		incinerate or chemical landfill	incinerate
USEPA (Ref. 3.6)	plow into soil				
(Refs. 3.9, 3.10)	less than 50 ppm - no regulations		incinerate or chemical landfill		
NJDEP (Ref. 3.7)	0.5 suggested upper limit for land spreading				

TABLE 3.8

COMPARISON OF NJDEP ORGANIC COMPOUNDS
LIMITS ON SEWAGE SLUDGE WITH CANAL SEDIMENTS
(milligrams/kilogram)**

Compound	NJDEP* Limits	D-2	D-4	D-6	D-8	D-11	D-13	D-16	D-17	D-18	D-20	D-21	D-25	D-28	D-32	D-33
Aldrin	0.1	ND														
Chlordane	0.1	ND							.026	.059	.010	.010	.024	.028	ND	
Dieldrin	0.1	ND														
Endrin	0.1	ND														
Heptachlor	0.1	ND														
Heptachlor epoxide	0.1	ND														
DDT-o,p' and p,p'	0.25	ND														
pp' DDE	0.25	0.33	ND	.021	ND	ND	0.54	ND	.069	.034	.020	.037	.067	.030	.19	.026
Mirex	0.25	ND											.10	ND		
Toxaphene	1.0	ND														
PCBs (Aroclor 1248)	0.5	.43	ND	.46	.43	.40	ND	6.8	ND							
Methoxychlor	0.25	ND														
Lindane	0.10	.13	ND													

* Ref. 3.7, Table A-2

** Table 2.6, Test

CHAPTER 4.0 PROCEDURES FOR SEDIMENT REDUCTION AND REMOVALS

4.1 Reducing Sedimentation in the Canal

Cleaning the Canal will be an involved and expensive process. Sediments hinder the flow of water and also may degrade the water. Stopping or at least reducing inflows and sediment deposition is desirable.

A long-term program to remove or, at least, reduce all inflow to the Canal has been recommended by the Rutgers Study Group (Ref. 1.1).

For the near future, a priority for inflow removal or reduction has been tentatively established. These include a jetty at the inlet to the Canal, tributary diversion, specifically the Lockatong and Wickecheoke Creeks; and diversion of storm sewers in Lambertville, Trenton, East Millstone and South Bound Brook.

The statewide erosion control program described by Ref. 3.1 may give some relief; however, the legislation exempts agriculture. Also the Delaware and Raritan-Canal Commission has established certain requirements for detention ponds to store water during floods; these will also trap sediments (Ref. 1.6). Agricultural erosion remains a major problem and little improvement can be expected. Sediment reduction in the Canal from these sources will necessitate diversion of inflows.

4.1.1 Storm Sewer Diversions

The evidence of sediment accumulations and contamination by runoff from the urban areas to the Canal is quite clear (Ref. 1.1, 1.2, 1.3). The most serious, both from the considerations of hydraulics and water quality, is in Trenton. Plans have been made to divert the storm runoff to the Assunpink Creek, a tributary to the Delaware River. Other storm sewer diversions are to be considered--in Lambertville, East Millstone and South Bound Brook.

Downstream of Lambertville the weed growth is prolific; at East Millstone a single 24-inch storm drain has contributed a four to five foot depth of sediment along the west side of the Canal channel. Evidence of contaminated sediments in the South Bound Brook area (Site 32) may be seen in Tables 2.5 - 2.10. For a more detailed discussion of the proposed storm sewer diversions see Ref. 1.2.

4.1.2 Diversions -Inlet, Wickecheoke and Lockatong Creeks*

The Wickecheoke and Lockatong Creeks carry much sediment to the Canal. At low and moderate flows, mixing would be complete and sediment entering the Canal is retained and settles out. In addition, Wickecheoke Creek transports effluent from two permitted "point sources," one municipal and one industrial. High flows in the creeks carry high loads of suspended solids and bed load, derived from erosion.

The peak discharges in cfs in the Lockatong and Wickecheoke Creeks at various flood recurrence intervals are:

<u>Creek</u>	<u>Discharge in cfs</u>			
	<u>Recurrence Interval in Years</u>			
	<u>2</u>	<u>10</u>	<u>50</u>	<u>100</u>
Lockatong	1040	2300	3500	4200
Wickecheoke	1100	2200	3200	4050

The hydraulic capacity of the Canal ranges from about 100 to 150 cfs (Ref. 1.1). Excess waters pass over spillways to the Delaware River. The degree of mixing of the Canal and creek waters under flood conditions is difficult to estimate, however, it is seen that for creek runoff from 2-year to 100-year recurrence intervals about 90 to 98% of the water at the Canal-creek junction is from the creek; and if complete mixing is assumed it is this water which will travel downstream through the Canal.

*For details, see Ref. 1.2.

These storm waters are carrying high suspended sediment loads (Ref. 1.1). In addition, bed load from these creeks also deposits in the Canal.

The detailed hydraulic study required to estimate the degree of mixing of the two creeks will accompany preparation of final engineering design drawings and specifications for new structures that would carry one or both creeks either over or under the Canal.

Sediment and aquatic weeds are a major nuisance in the reach of the Canal downstream of the two creeks. As obstructions have grown, flow has become severely restricted, especially by summer weed growth which may reduce the capacity of the Canal by a factor of two to three (Ref. 1.1). Diversion of creek flows would reduce this problem most of the time and the effect that these by-passed flows would have on the Delaware River water quality would be small. Diversion of Wickecheoke Creek at low and moderate flows would essentially eliminate the dissolved solids impact of the Magnesium Electron, Inc. industrial discharge to the West Branch of Wickecheoke Creek. The impact on the Delaware River would be minimal due to its larger dilution capacity. Under present conditions the greatest part of the high flows from the creeks pass directly into the Delaware River over spillways.

4.1.2.1 Delaware River Inlet Improvement

The reach of the Canal from the inlet to the lock at Raven Rock requires dredging of an estimated 11,400 cu. yds. and removal of snags. Once the channel has been cleaned, measures to control or reduce sedimentation or to mitigate the impact due to sedimentation ought to be instituted. These include:

- 1) No structural improvements and periodic dredging to maintain capacity and appearance.
- 2) Raise the elevation of the dam across the Delaware River immediately below the inlet to the Canal.
- 3) Control sediment deposition at the inlet with a jetty.

Periodic sediment removal is possible. Raising the dam across the Delaware River does not protect the Canal inlet; it would, however, enhance flows into the Canal at extremely low Delaware River flows.

Three types of inlet jetties can be considered, i.e.:

- 1) Rubble
- 2) Double-wall sheet-piling
- 3) Concrete wall

Rubble construction requires a wide base and sloping sides. Local dredging and maintenance would be difficult. Double-wall sheet-piling has vertical sides filled with crushed rock and stone and its width can be designed to accommodate a truck and clamshell. A concrete wall jetty requires double-sheeting for forms; thus, it has no advantage over double wall sheet piling. The latter is preferred.

Sediment from the Delaware River will be deposited at the jetty and must be removed. However, the costs are estimated to be less than for periodic dredging of the inlet unprotected by the jetty.

4.1.2.2 Preliminary Hydraulic Design of Lockatong Creek Diversion

For two-year recurrence interval flood, selected for illustration only, two 200-foot-long rectangular culverts under the Canal, 4 feet x 10 feet will pass the two-year discharge. Or, an aqueduct to carry the Creek above the Canal, consisting of single channel, 2 feet deep and 50 feet wide would be adequate. Either would be an encroachment on the Canal and would probably require a permit - see Chapter 5; however, the aqueduct would detract much more from the appearance of the Canal.

4.1.2.3 Preliminary Hydraulic Design of Wickecheoke Creek Diversion

Similar structural diversions can be provided for the Wickecheoke Creek.

For a two-year recurrence interval flood a culvert 120 feet long with two rectangular cross sections 4 feet x 8 feet would be adequate to pass the flow. Or a 2 feet deep and 50 feet wide aqueduct over the Canal would serve the same purpose.

4.2 Removal of Sediments

Reference is made to Chapter 2.0 for data on sediment volumes, points of access for equipment and routes of conveyance. It must be noted that these volumes are estimates made from a limited amount of measured data. For the dredging of any segment of the Canal the consultant will need to estimate the total volumes to be removed from much more extensive survey data. The indicated access points are those selected by the Rutgers Study Group as convenient and usable. Other considerations may limit the use of these points.

4.2.1 Sediment and Spoil Weight and Volume Relationships

As discussed above in Section 2.5 the dredging process may be by hydraulic means, in the dry, or partially drained. The volumes and weights of materials to be handled will be different as will costs and other considerations.

4.2.1.1 Hydraulic Dredging

The sediments in the bottom of the Canal would be removed as sediment-water slurries. The slurries would be pumped or trucked to dewatering sites from which they would be taken, after dewatering, to disposal sites. Volumes and weights may be estimated as shown on Table 4.1.

4.2.1.2 Partially Drained Sediment Dredging

If the Canal is partially drained to a level in which the "Mud Cat" can still just float it may be possible to operate that dredge with a thick slurry, possibly as much as 20-25% solids. For the thicker slurry the weight-specific gravity-approximate volume relationships illustrated on Table 4.1 will have to be adjusted.

4.2.1.3 Dry Dredging

Possibly segments of the Canal will be drained, allowed to dry and then be excavated by such equipment as bulldozers, pan scrapers, front end loaders, conveyor belts and trucks.

The weight of the material to be handled will be the weight of the sediment in situ less the weight of water removed (Table 4.1).

4.2.2 Volumes of Dredge Spoils and Drain Waters

As shown on Table 2.1, the sediment volumes in the Canal range up to greater than 40,000 cu. yds. per mile. For illustration, a volume of 10,000 cu. yds. per mile is assumed.

As described above, the volumetric increase of the 30% solids sediment to the 15% solid dredge slurry is 2.23-fold. Therefore, the total volume of dredge spoil is 22,300 cu. yds. per mile.

Assuming the dredge pumps the 15% solids slurry at a rate of 100 cu. yds. per hour, and six hours of pumping per day, the total number of pumping days per mile of Canal is $22,300/600 = 37$ days or about eight weeks at a five day week. Assuming a two week draining and drying time, the total volume of the dewatering site should be equal to 10 days of pumping (five days per week); $600 \times 10 = 6,000$ cu. yds. If the slurry is applied at a depth of one yard the

total area requirement would be 6,000 sq. yds. This would be divided into several cells to permit draining and drying of some cells while others are being filled. If the solids content of the dredge slurry is higher, as in the case of the partially drained procedure, the total volumes and area needs would be approximately proportionally reduced.

The volume of water removed during the draining and drying of the 15% solids to the 40% solids spoil is approximately 75% of the total volume applied.

4.2.3 Transport of Dewatered Dredge Spoils

The solids content of the sediment *in situ* is estimated at 30% and the solids content of either the dewatered or the dry excavation dredge spoils is estimated at 40%. The reduction in weight by dewatering is about 25%. As shown above, the weight of the sediment *in situ* is about 2060 lbs. per cu. yd; for 10,000 cu. yds. per mile of Canal, the total weight would be 20.6 million lbs. The weight of the dewatered spoil would be 0.75×20.6 million = 15.45 million pounds or 7,730 tons per miles. If the dump truck net load is 20 tons (approximately 18 cu. yds.), there would be 390 truck loads per mile of Canal with the sediment volume of 10,000 cu. yds. per mile.

TABLE 4.1

SUMMARY OF SEDIMENT, SPOILS AND DRAIN WATER VOLUMES AND WEIGHTS

	<u>Sediment</u>	<u>Slurry</u>	<u>Dewatered or Dry Excavation</u>
assumed percent solids	30	15	40
approximate specific gravity	1.22	1.10	1.33
approximate wt./cu. yd. lbs.	2060	1850	2240
relative total weights	1.0	2.0	0.75
relative volumes	1.0	2.23	0.7 - 0.75
volume removed per mile, cu. yds.	10,000	22,300	7000 - 7500
water removed per mile, tons	7210	17,500	4700
volume of drain water per mile, gallons	-	-	671,000
truck loads per mile at 20 tons per load	515	1030	390

Note: The approximate volumes of sediment per mile are shown in Table 2.1. The volume-weight-number of trucks shown in Table 4.1 are for 10,000 cu. yds. per mile of sediment. Corresponding values for the several segments of the Canal can be readily determined when the actual sediment volumes have been determined.

If the water content of the spoil is different from those assumed, the weight and volumes will be different.

CHAPTER 5.0 PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

The importance of the Delaware and Raritan Canal encompasses more than its function as a source of raw water. The Canal is not just a convenient substitute for a pipe, it is an artifact. As such, it memorializes the age and society that created and used it. The Canal embodies the technology, organizational abilities, and the values of nineteenth century America. The Canal's spillways and locks, the old bridges and culverts, as well as the very structure of the Canal itself, are part of this country's heritage. Through legislation an opportunity has been created to enjoy the Canal, to understand its heritage and its unique position in the growth of the corridor.

In addition to its importance as a water resource and an historic site, the canal offers the citizens of New Jersey a third use. In 1974 the State Legislature passed a law which established the Canal and its adjoining lands as a state park. This law recognized that the Canal has been a place of recreation from its earliest days and requires the state to further enhance this sixty-mile long ribbon of water and vegetation for boaters, hikers, joggers, bicyclists, and fisherman. The law also recognizes the importance of the Canal as a corridor of natural beauty that runs past the doorstep of Central New Jersey.

For each segment of the Canal to be dredged, the design consultant should make an assessment of the specific effects of the proposed dredging. The

design consultant shall include the effects of dredging on the Canal as a vital water resource, a historic site, a recreational resource, and as a corridor in which the natural landscape is to be conserved. None of these aspects of the Canal is incidental to the Canal's importance; each is integral to it. These considerations should not be seen as placing unnecessary restrictions on the dredging program nor as adding unreasonable costs, but simply as part of the total scope of the work.

The proposed dredging final plans and specifications should incorporate solutions cited in the consultant's assessment report, both of which should also be submitted to the New Jersey Department of Environmental Protection Office of Cultural and Environmental Services. It is the intent to provide in this chapter a Programmatic Environmental Assessment which will serve as a guide to the consultant who will write his detailed environmental specifications.

5.1 Legal Requirements

A major federal action which significantly affects the quality of the human environment must be preceded by a federal environmental impact statement under the provisions of the National Environmental Policy Act (42 U.S.C. 4341 et seq.). At the very least, a lead federal agency must prepare and make available a finding of no significant impact if the agency determines not to prepare a statement. Moreover, if any federal action may affect cultural resources listed or eligible for listing on the National Register of Historic Places, the lead agency must comply with the consultation process established by the National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.). Where a federal agency proposes to modify or license the modification of a body of water it must also consult with the United States Fish and Wildlife Service pursuant to the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.).

There will probably be no federal action involved in dredging the Delaware and Raritan Canal. No federal funds will be used for the dredging project. Nor will federal permits be necessary. By letter dated May 6, 1981 (Appendix 5.1b) in response to a letter from NJDEP dated April 1, 1981 (Appendix 5.1a) the Philadelphia District of the U.S. Army Corps of Engineers disclaimed jurisdiction over the portion of the Canal within the Delaware River Basin with respect to Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403), (permits to dredge in navigable waterways). Furthermore, the Philadelphia District of the Corps also disclaimed jurisdiction under Section 404 of the Clean Water Act (33 U.S.C. 1344), (permits for discharges of dredged or fill material into waters), unless dredged spoil were returned to the Canal or dumped into waters or wetlands--results which are not anticipated. Although the Corps' New York District Office has not yet determined its jurisdiction over Canal dredging within the Raritan River Basin, the answer is expected to be the same. In the unlikely event that dredged spoil is disposed of offshore, the Corps will have jurisdiction under Section 103 of the Marine Protection, Research, and Sanctuaries Act (33 U.S.C. 1423 et seq.).

This Assessment has been prepared under the requirements of Executive Order No. 53, entitled "Environmental Assessment," and issued by Governor William T. Cahill on October 5, 1973. The Order requires all departments and agencies of the State to submit to NJDEP a description and identification of the environmental impact of major construction projects, defined "as any construction project with a total cost greater than \$1,000,000 and a construction project of lesser cost which has the potential for substantial adverse environmental impact." A copy of Executive Order No. 53 and its accompanying General Policy Guidelines is included as Appendix 5.2

5.2 Permits

As explained in 4.1, there will most likely be no necessity to obtain federal permits for the dredging project. However, a number of regional and

State permits may be required.

5.2.1 Interstate Permits

5.2.1.1 Delaware River Basin Commission

5.2.1.1.1 Approval of DRBC needed for any governmental project having a substantial effect on the water resources of the Delaware River Basin. (N.J.S.A. 32:11D-21)

5.2.2 State of New Jersey Permits

5.2.2.1 Department of Environmental Protection
Division of Water Resources

The Water Quality Planning Act provides that the Commissioner shall not grant any permit which is in conflict with an adopted areawide plan. (N.J.S.A. 58:11A-10)

5.2.2.1.1 Delaware and Raritan Canal Commission

5.2.2.1.1.1 Delaware and Raritan Canal State Park Law of 1974 Certificate of Approval necessary for governmental projects in the Review Zone. (N.J.S.A. 13:13A-14)

5.2.2.2 New Jersey Register of Historic Places Act

Prior authorization or consent of Commissioner of Environmental Protection for encroachment, damage or destruction. (N.J.S.A. 13:1B-15.131)

5.2.2.3 Division of Fish, Game, and Shellfish

5.2.2.3.1 Permit to shut off or draw off waters of any pond, stream, or lake, or to place a screen in the water body. (N.J.S.A. 23:5-59)

5.2.2.4 Division of Marine Services

5.2.2.4.1 Wetlands Act

Permit for the disposal of dredged spoil in coastal wetlands. (N.J.S.A. 13:9A-

5.2.2.4.2 Coastal and Waterfront Development Act

Waterfront permit for disposal of dredged spoil in waterfront of tidal or navigable waterway. (N.J.S.A. 12:5-3)

5.2.2.5 Division of Water Resources*

5.2.2.5.1 Flood Hazard Area Control Act

Permit for the construction, installation, or alteration of any structure or permanent fill along, in, or across the channel or floodway of any stream.

(N.J.S.A. 58:16A-50)

5.2.2.6 Division of Environmental Quality

5.2.2.6.1 Solid Waste Management Act

Permit for any system utilized for the storage, collection, transfer, transportation, separation, recovering, or disposal of solid waste. (N.J.S.A. 13:1E-1)

5.2.2.7 Division of Parks, Forests, and Greenacres

5.2.2.7.1 Special Use Approval

Authorization for moving physical features, structures, or properties on lands and waters under the jurisdiction of the State Park Service. (N.J.A.C. 7:2-2.10)

5.2.3 Department of Agriculture

5.2.3.1 Local Soil Conservation District Office or Exempt Municipality

5.2.3.1.1 Soil Erosion and Sediment Control Act

Approval of a plan for soil erosion and sediment control where there is disturbance of more than 5,000 square feet of land. (N.J.S.A. 4:24-43)

5.2.4 Department of Transportation

5.2.4.1 Regional DOT Offices

5.2.4.1.1 State Highway Laws

Requires permits for projects which impact on a State highway or its right of way. (N.J.S.A. 27:7-1)

5.2.5 County and Municipal Permits

The law presumes that State zoning and planning enabling statutes were not intended to give municipalities control over State agencies. Thus, State projects are immune from local ordinances. However, State agencies normally comply with local ordinances as a matter of comity.

* Division should be consulted about need for a NJPDES permit under N.J.S.A. 58:10A-6.

5.3 Environmental Impacts

The heavy and bulky trucks, cranes, pipes, backhoes, etc., used in the dredging of the Canal will affect the environment. So, too, will the very process of dredging, the transportation of dredge spoils, for dewatering and disposal, and the final disposal of the dredged material. The environmental effects will include releases of sediments to the water column; damage to vegetation and canal structures; disturbance or damage to cultural resources; noise; odors; spills; erosion; movements of material that could pollute groundwater to land or landfills; and possible dispersion of pollutants to surface waters and to the air. It is the evaluation of these impacts which will be considered in this section.

5.3.1 Alternatives

The decision points are:

- 1) dredging vs. no dredging
- 2) hydraulic dredging vs. dry dredging
- 3) sediment disposal sites
- 4) routes of transport
- 5) Replacing the Canal with a pipeline

5.3.1.1 Dredging vs. No Dredging

The water supply situation in New Jersey has been studied in detail and the conclusion and recommendations for the Northeastern Metropolitan Area include the full flow of 100 MGD in the Canal from the Delaware River Basin (Ref. 5.2). To obtain this flow the Canal will have to be dredged (Ref. 1.1). Furthermore, dredging will reduce weed growth and generally render the Canal more attractive. If the Canal is not dredged it will eventually be filled in by sediment.

In the opinion of the Rutgers Study Group, dredging is desirable and necessary since development of present alternatives or supplements to the Canal's 100 MGD water supply are limited and would require a substantial period of time.

5.3.1.2 Hydraulic Dredging vs. Dry Excavation

As described in Section 2.5, dry excavation is possibly reasonable. With minimal disruption of the present supply system all of the Canal, except that section downstream of Ten Mile Lock can be excavated in the dry. This type of excavation would be cheaper than hydraulic dredging.

As shown in Appendix 5.3, the preliminary engineer's estimated (1981) costs for removal and transport only are:

hydraulic dredging	\$20 per cu. yd.
dry dredging	\$12 per cu. yd.

To these costs would be added contractor's overhead, costs for legal and design services, disposal sites, and supervision; these costs may add about 25% to the above listed construction costs.

Thus, for the estimated 850,000 cu. yds. of sediment to be removed, the total costs (1981) might be about:

hydraulic dredging	$20 \times 1.25 \times 850,000 = \$21,250,000$
dry dredging	$12 \times 1.25 \times 850,000 = \$12,750,000$

In dry excavation, segments of the Canal would be unattractive mud flats. Hydraulic dredging would allow the Park to remain attractive, except for the segments being worked on. Hydraulic dredging would require double handling of material at the Canal region. This would increase duration of noise, air quality degradation and general nuisance.

5.3.1.2.1 Water Quality Characteristics

The process of hydraulic dredging will release sediment to the water column, most of which will resettle promptly; in the laboratory the settling was nearly complete in 12 hours (the water treatment plants normally reduce "turbidity" to a level less than one NTU). The significance of these releases to the water column are evaluated from the data obtained from the gravity-settled waters (Tables 2.11a, 2.11b) and the centrate (Tables 2.9a, 2.9b and 2.10). Most of the metals and organics in the solids fractions of the samples will remain with the solids (Ref. 4.1). The water draining from the wet solids in the dewatering process will have characteristics similar to the water column containing the resuspended matter.

From Tables 2.11a and 2.11b it is seen that there may be some release of fecal coliforms to the water column and also to the drain water. Except for the sediment at Raven Rock Lock all samples showed fecal coliform content less than the New Jersey Standards. The organisms could be from the excrement of ducks, geese or other animals in that area.

If the dredging is in the dry it is assumed that the interstitial waters are removed by evaporation; there would be little if any concern of the drain waters. However, if the interstitial waters are included in the drain waters, water quality must be considered as in the case of the drain waters from the dewatering process.

The two identified contaminants in the interstitial waters which may be of some concern are the fecal coliforms at Raven Rock Lock and asbestos in the vicinity of South Bound Brook (Tables 2.9a, 2.9b, 2.10, 2.11a and 2.11b). Two simple procedures for the fecal coliform solution would be (1) do not drain the interstitial waters--let them dry by evaporation, or (2) if the interstitial waters are drained (undoubtedly to the Delaware River) the waters may be treated easily by hand application of a powdered chlorine compound (HTH, for example).

Actually, dilution in the Delaware River should be adequate. As shown in Chapter 2.0 the fecal coliform content in the Delaware River exceeds at times the New Jersey Standards for FW 2 waters.

Asbestos may again be kept out of the interstitial drain waters by simply letting the waters be removed by evaporation. If, however, the interstitial waters are to be drained (undoubtedly to the Raritan River), a simple sand filter may be used to remove the asbestos. Actually, dilution in the Raritan River even at the low flow of 90 MGD should be adequate.

5.3.1.2.2 Disruption of Recreational Activities

During the period of hydraulic dredging the recreational uses of the Park will be disrupted in the segment being worked on. The hydraulic dredge will be quite noisy and the discharge pipe may run some several thousands of feet in the Canal, on its bank or towpath. The Canal's water will be muddied by the dredging process and the drainage from the dewatering site will likewise be muddy. Most of the aquatic life will be temporarily disrupted. However, at the same time, the undesirable rooted plants will be eliminated.

If dry dredging is used, the drained segment of the Canal will be without aquatic life. The fish would die if they were not netted and transported to other sections of the Canal. According to Ref. 1.6 the Canal is stocked with trout. The Canal is neither a trout-maintenance nor a trout-breeding body of water; trout fishing is on a put-and-take basis. Most of the fish in the Canal are pan fish and restocking a segment by capture from other segments might be difficult. Capturing the fish during the draining process would require a time of several days to several weeks. This would be an expense and would slow the procedure. Decisions on salvage of the fish will be required. The dredging process would be a cleaning process and the fish habitat would be changed and there might be some changes in fish species distribution.

5.3.1.2.3 Mosquito Breeding

There will be holes or pockets of water in the Canal after the draining. These could become mosquito breeding areas. Control, as recommended by a county mosquito control program, may be necessary.

5.3.1.2.4 Noise and Odor

Hydraulic dredges are normally powered by diesel engines comparable in size to a large truck engine. The noise and diesel exhaust for both the dredge and other earth moving equipment will be substantial; however, the noise can be reduced by use of mufflers. In congested areas a propane-powered dredge may be desired because of lowered exhaust pollutants; however, there are problems with a pressurized gas system which might be left untended at times. There will be some odor problems in the Canal if the draining for dry excavation is done in warm weather.

Hydraulic dredging will normally require double handling of the spoils, i.e. to the dewatering site and then, after dewatering, to the final disposal site. There will be three sources of noise--the dredge, the loader and the truck. Dry dredging will have the bulldozer-loader and truck noises. An estimate of the truck density is made as follows:

The solids content of either the dry excavation or the dewatered spoil is estimated to be 40%. As shown in Table 4.1, the weight of the 40% solids spoil would be about 7,800 tons or 7,000 cu. yds. for each 10,000 cu. yd./mile of sediment in the Canal. If a dump truck carries 20 tons or 18 cu. yds. per load, for each mile stretch, there would be 390 truck loads. With an equipment loading rate of about 120 cu. yds. per hour, 7 trucks could be loaded each hour, or the total loading time would be $390/7 = 55$ hours or 1.4 weeks at 40 hours/week.

From the above there would be about seven trucks per hour each way for about 1.4 weeks for each mile of Canal containing 10,000 cu. yds./mile of sediment. If a single road is to serve, say 10 miles of Canal, the truck density could increase to 70 trucks/hour each way for 1.4 weeks, seven trucks per hour each way for 14 weeks or any other combination of truck density and duration.

5.3.1.2.5 Dewatering Sites

Possible dewatering sites are shown on Fig. 2.2. In Trenton, there are no large areas suitable for dewatering, except possibly in Cadwalader Park; barges or tankers would probably be required for the Trenton region.

The water from the dewatering sites will be returned to the Canal or to contiguous water bodies--namely, the Delaware, Millstone, or Raritan Rivers. As described above, the water quality should not be a problem; however, the drain system may disrupt access or traffic movement.

As shown on Table 4.1, with a sediment volume of 10,000 cu. yds. per mile, the drain water will be about 700,000 gallons/mile dredged.

5.3.1.2.6 Damage to Vegetation and Canal Structures

The process of hydraulic dredging will necessitate lifting the dredge in and out of the Canal at locks and at a number of bridges. The lifting will be by crane from and to a wide body truck. Dredge pipelines may run along the Canal on the towpath or on barges floating in the Canal. Outlets for the pipeline to dewatering sites will be necessary. The dredge itself will probably bump into the banks and structures. Therefore, certain damages to vegetation and structure are to be expected.

The dry dredging process would be done with the Canal bottom exposed and will require wheeled or tracked vehicles. The operator will see what he is doing and would probably do less damage with the hydraulic dredge. And, of course, no pipeline would be needed. For any particular segment of the Canal, the consultant may find it necessary to specify points of access and tentative routes for the dredge and pipeline and, similarly, for the trucks or other equipment used in the dry dredging.

For structures that may be of specific concern, the Delaware and Raritan Canal Commission has compiled a list shown in Appendix 2.5 of this Report. To minimize damage to vegetation on the dewatering areas a scheme is presented in Chapter 2. Coordination of such plans with the Delaware and Raritan Canal Commission and the Division of Parks may be valuable in the development of the Canal Park. For example, clearing of the towpath could result in walkways or bikeways or a dewatering area could become a picnic ground.

5.3.1.3 Sediment Disposal

Disposal of the sediments to be removed does not seem to be a significant problem; except that in certain areas the sediment is badly contaminated. The limitations on land spreading appears to be controlled by annual metal contribution and by the PCB content in the sediment within and immediately downstream of the Trenton Tubes (D-16). There seems to be no limitation on land filling. The sediments, classified as industrial waste, can be disposed of in landfills so licensed. However, the large volumes of spoil to be disposed of may well cause problems. New landfills may be necessary. These may be established for this or for more general purposes by private industry or the State of New Jersey may consider establishing its own. If new landfills are established solely for these sediments, consideration may be given to reducing the level

of monitoring required for the industrial landfills. This should be discussed with the Bureau of Solid Waste Management of the Division of Environmental Quality of the N.J. Department of Environmental Protection.

Land spreading control should include not only the limitations discussed in Chapter 3.0 but also the mechanics of spreading to reduce return of the sediments to surface water drainage systems.

5.3.1.4 Routes of Transport

After establishment of disposal sites, the routes of transport will be determined by the consultant or contractor subject to approval of the NJDEP. Considerable noise from truck traffic is to be expected and the contractor should consider the alternatives of a short noise-intensive period to a long less noise-intensive program.

In all instances transport should be controlled to prevent spilling or dripping onto the pavement.

5.3.1.5 Replacing the Canal with a Pipeline

If the Canal were abandoned as a water transport system and were used solely as a park, sediment cleanout may not be required for many years and degradation of water quality would not be of concern to the WSFE. Some flow would be needed to maintain the park amenities. Some of this could be from tributary streams with additional water from the Delaware River. The desired flows have not been estimated.

The 100 MGD allocation from the Delaware Basin to the Raritan Basin could be divided into a flow to maintain the park with the remainder transported as a water supply source in a pipeline. The pipeline could lie under or along the Canal or run cross country from almost any point on the Delaware River

between Frenchtown and Trenton and discharge to the Raritan Basin someplace between Kingston and Bound Brook. Using as an example the present Canal and gravity flow in a pipeline placed within the Canal, the hydraulic gradient would be about 55 feet in 60 miles. For a flow of 80 MGD (124 cfs) and a reasonably smooth pipe the diameter of the pipe would be about 8 feet. As shown in Appendix 5.3, the estimated cost of installation of such a pipe would be about \$2.11 million per mile, and for the 58 miles of Canal a total of \$122 million. Additional costs of about 25% for contractors overhead, legal engineering services and supervision should be added to yield a total of about \$153 million.

Other locations for intake and discharge would require recalculation for pipe diameters and for supplemental pumping. The combinations are numerous. As an example, as shown in Appendix 5.3, a 30 mile pipeline could be constructed from the Delaware River directly to the Raritan Basin. The estimated construction cost for such a pipeline is \$45 million with the 25% for other costs - the total is \$60 million. The annual operating costs are estimated to be \$2.71 million at the present electrical rates.

If the park were to be abandoned and the Canal filled in the pipeline would be a more viable alternative. However, with the anticipated retention of the park, continuing the dual usage appears to the Rutgers Study Group to be more desirable.

5.3.2 Secondary Impacts

The dredging program to increase the Canal's capacity to 100 MGD will make more water available to the Raritan Basin and its service area. The increased amount may range from about 30 to 60 MGD depending upon the season of the year. The increased supply may have the secondary impact of encouraging industrial and population growth and increased irrigation. It is beyond the

scope of this study to make a regional water supply master plan. However, the recent drought, illustrated the lack of adequate water supplies in the northeastern region served in part by the Canal system. The only "surplus" water available is from the Spruce Run-Round Valley system and there is a proposal to transfer water out of the Raritan Basin to the Passaic Basin. Further, there is evidence of ground water depletion in the aquifers serving eastern Middlesex and northeastern Monmouth Counties.

It is suggested that the increased flow resulting from the dredging program will merely meet the present needs and will not encourage significant growth.

5.3.3 Cultural Resource Factors

Before the dredging project can begin it must be authorized by the Commissioner of Environmental Protection and approved by the Delaware and Raritan Canal Commission. In determining their actions both the Commissioner and the Commission will pay particular attention to the dredging project's impact on the Canal's cultural resources. These factors must receive attention, therefore, concomitant with the earliest stage of planning for the dredging of each segment of the Canal. The following procedures are intended to provide adequate planning for the protection of cultural resources and for proper implementation of those plans.

5.3.3.1

For each segment the consultant shall engage a historical archeologist or similarly qualified professional to investigate and produce a detailed schedule and maps of the elements that constitute the segment's cultural merit. As planning for the dredging project proceeds, cultural resources

adjacent to the Canal Historic District such as transport routes shall be investigated from the same standpoint. Sites falling within the purview of the New Jersey Register of Historic Sites Law shall be treated accordingly, as will those falling within the purview of Executive Order 53.

5.3.3.2

Based on the findings from 5.3.3.1, plans will be formulated for:

- a) protection and care not to damage or degrade the itemized elements;
- b) repair of inevitable or unavoidable damage to the itemized elements.

5.5.3.3

The Water Supply Facilities Element will then present its documented case in the form of an application letter to the Commissioner of Environmental Protection and to the Delaware and Raritan Canal Commission. The recommendations of the Historic Sites Council to the Commissioner, the findings of the Commissioner of Environmental Protection, and the decision of the Delaware and Raritan Canal Commission will be taken into consideration as the design process advances.

5.3.3.4

At all times during the dredging project the qualified professional should inspect the conduct of the work and report to the project supervisor and to the Office of Cultural and Environmental Services, New Jersey Department of Environmental Protection.

5.3.3.5

Each subdivision of a dredging project shall not be considered complete and the contract discharged until the cultural resources professional has

accepted that aspect of the work.

5.4 Conclusions

Dredging the Canal is necessary if its service area is to continue to have adequate water supplies.

Dry excavation is, on balance, decidedly superior to hydraulic dredging.

Table 5.1 is a comparison of the environmental impacts of each procedure.

REFERENCES

- 5.1 U.S. Environmental Protection Agency, Office of Research and Monitoring, EPA-RS-081. WATER POLLUTION ASPECTS OF STREET SURFACE CONTAMINATION. Prepared by Sartor, James D., and Boyd, Gail B. November 1972.
- 5.2 State of New Jersey, Department of Environmental Protection, Division of Water Resources. N.J. STATE WATER MASTER PLAN. 1981.

TABLE 5.1
Summary of
Comparison of Dry Excavation with Hydraulic Dredging

<u>Consideration</u>	<u>Dry Excavation</u>	<u>Hydraulic Dredging</u>
1. Continuous water supply	requires alternate sources to be utilized	little disruption
2. Costs	about 60% of hydraulic dredging	about 167% of dry excavation
3. Water quality	interstitial water evaporated	interstitial muddy water drains back to Canal
4. Handling of spoil	single	double
5. Noise, air quality, total elapsed time	fewer equipment hours	more equipment hours
6. Damage to Canal	Canal exposed; less damage expected	Canal under water; more damage expected
7. Damage to area adjoining Canal	less damage; no piping, no dewatering	requires piping and requires dewatering area
8. Auxiliary pumping to drain Canal and remove storm runoff	needed in some locations	not needed
9. Aquatic life	none in drained segments	temporary disruption
10. Mosquito control	some problems in depressions	some problems at dewatering sites
11. Recreation	no boating or fishing in drained segments	temporary disruption at dredge location
12. Odors	in warm weather, temporary odor problems	no change
13. Degree of geometric control	good	limited
14. Appearance	bottom exposed	no effect

CHAPTER 5.0

APPENDICES

- 5.1a LETTER FROM NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
- 5.1b LETTER FROM U.S. ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT
- 5.2 EXECUTIVE ORDER 53
- 5.3 ESTIMATED COSTS



State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES
STATE WATER SUPPLY FACILITIES
P.O. BOX 5196
CLINTON, NEW JERSEY 08809

April 1, 1981

Mr. Roy Denmark, Chief
Permits Branch
U.S. Army Corps of Engineers
Philadelphia District
Second and Chestnut Street
Custom House
Philadelphia, PA 19106

Re: Delaware and Raritan Canal
Dredging and Rehabilitation Program
Permits and Procedures

Dear Mr. Denmark:

The State of New Jersey Department of Environmental Protection, Division of Water Resources, Water Supply Facilities Element, through Legislative and Administrative action, is committed to a multi-year program to dredge appropriate lengths of the 60 mile Delaware and Raritan Canal to restore its hydraulic carrying capacity so that the State of New Jersey may exercise the provisions of the 1954 Decree of the United States Supreme Court which provides for a diversion rate "...not to exceed 100 MGD as a monthly average, with the diversion on any day not to exceed 120 million gallons."

In order to restore the aforementioned carrying capacity, the Water Supply Facilities Element in 1977 engaged Rutgers University, College of Engineering, Bureau of Engineering Research to conduct a detailed Hydrologic and Hydraulic Investigation. This work has been completed, and their report was delivered in June 1980. It is entitled "DELAWARE AND RARITAN CANAL HYDROLOGIC, HYDRAULIC, STRUCTURAL, WATER QUALITY AND INSTITUTIONAL REPORT," a copy of which is provided to you.

Mr. Denmark

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April 1, 1981

When that study began to wind down, a second study was proposed. The second study became executed in January 1980 and is due for completion in August 1981. The study is tentatively entitled "DELAWARE AND RARITAN CANAL DREDGING PROGRAM, ENVIRONMENTAL IMPACT ASSESSMENT." This study will consider the methods of dredging, access and storage location, and methods for disposal of the dredged spoils. A preliminary draft will be available about May 15, 1981, and a copy will be forwarded to you for comment.

On a parallel course, the Water Supply Facilities Element engaged Goodkind & O'Dea, Inc., Engineering Consultants of Clifton, New Jersey in February 1979 to prepare construction drawings and specifications for the cleaning of the U.S. Route 1 Freeway Conduit in Trenton, New Jersey. The Canal Conduit was built in 1950 and is a twin-cell 13' x 8' concrete box culvert, approximately 6,050 feet long. Because the westerly barrel receives storm drainage from approximately 300 acres of an urbanized portion of the City of Trenton, it now contains an estimated 5,400 cubic yards of silty material. A copy of the text of the "SCHEMATIC DESIGN REPORT," October 1979, by Goodkind & O'Dea, Inc. is provided to you.

During the preparation of Goodkind & O'Dea's work, this sediment was tested, and there appeared to be only minor problems with its disposal. However, during Rutgers University's EIA study, it became evident that an in-depth analysis of these sediments was necessary. This work began in September 1980 and was completed in December 1980. The results of this work are contained in Rutgers' January 1981 report entitled "EVALUATION OF THE WATER AND SEDIMENT IN THE WEST TUBE OF THE TRENTON CULVERT OF THE DELAWARE AND RARITAN CANAL." A copy of that report is also provided to you.

Goodkind & O'Dea, Inc. is now revising the construction specifications and should forward same before the end of April 1981. At that point, the Water Supply Facilities Element would then be prepared to obtain the necessary permits from the various Federal and State agencies so that the project may proceed to construction during the summer and fall of 1981.

Thus, it was on March 19, 1981 that I contacted your Office to establish a conference to explore the permit process with you so that: (1) the U.S. Route 1 Freeway Conduit Cleaning Project may now proceed in an expeditious fashion; and (2) the entire Dredging Program for the Delaware and Raritan Canal may now proceed to

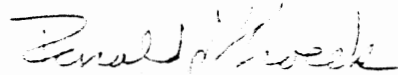
Mr. Denmark

- 3 -

April 1, 1981

the design stage and be accomplished in an orderly fashion. That conference date has been established as April 7, 1981, and I will be bringing with me Professor Robert C. Ahlert (Chemical and Biochemical Engineering) and Dr. William Goldfarb, Esq., of Rutgers University. Regretfully, Professor Marvin L. Granstrom, P.E. (Civil Engineering Department) has been incapacitated by an attack of gout.

Very truly yours,



Donald J. Kroeck, P.E.
Chief
Bureau of Water Supply
Development and Improvement

DJK:kn

- Enclosures:
- (1) "DELAWARE AND RARITAN CANAL HYDROLOGIC, HYDRAULIC, STRUCTURAL, WATER QUALITY AND INSTITUTIONAL REPORT" by Rutgers University
 - (2) "DELAWARE AND RARITAN CANAL DREDGING PROGRAM, ENVIRONMENTAL IMPACT ASSESSMENT" by Rutgers University
 - (3) "SCHEMATIC DESIGN REPORT" by Goodkind & O'Dea, Inc.
 - (4) "EVALUATION OF THE WATER AND SEDIMENT IN THE WEST TUBE OF THE TRENTON CULVERT OF THE DELAWARE AND RARITAN CANAL" by Rutgers University

cc: M. J. Galley, Assistant Director
R. C. Ahlert, Rutgers University
W. Goldfarb, Rutgers University
M. L. Granstrom, Rutgers University ✓
E. Henderson, Goodkind & O'Dea, Inc.
R. Gooddell, Delaware River Basin Comm.
J. C. Amon, D & R Canal Commission
L. Schmidt, DEP/Environmental Review
R. Spressart, DEP/Capital Improvements
D. Sullivan, DWR/Environmental Review



DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPOP-R-81-0268

06 MAY 1981

Mr. Donald J. Kroeck
New Jersey Department of
Environmental Protection
State Water Supply Facilities
P.O. Box 5196
Clinton, New Jersey 08809

[Handwritten signature]
5-11-81

Dear Mr. Kroeck:

This is in regard to your letters of 1 April 1981 and 9 April 1981, concerning Department of the Army jurisdiction over (1) the proposed cleaning of the U.S. Route 1 Freeway Conduit of the Delaware and Raritan Canal in Trenton, Mercer County, New Jersey and (2) the proposed dredging and rehabilitation of the Delaware and Raritan Canal from its Delaware River intake at Raven Rock, Hunterdon County to its Raritan River discharge point at New Brunswick, Middlesex County, New Jersey.

Current Federal regulations limit the Corps of Engineers' jurisdiction on this project to the discharge of dredged or fill material into waters of the United States including adjacent wetlands. Based on the information that you provided, it has been determined that the proposed cleaning of the U.S. Route 1 Freeway Conduit and the proposed dredging and rehabilitation of the Delaware and Raritan Canal within the Philadelphia District will not require the formal approval of this office provided that (1) no hydraulic dredging is done, (2) all dredged material is disposed above the ordinary high water mark on a non-wetland area, and (3) all work must be done in a manner that precludes the escape of any dredged material into the waterway or adjacent wetlands.

It should be noted that the jurisdiction of the Philadelphia District includes only the portion of the canal within the Delaware River basin.

5-24


NAPOP-R-81-0268
Mr. Donald J. Kroeck

For proposed work in the canal within the Raritan River basin, you should contact the New York District, Corps of Engineers at the following address:

District Engineer
U.S. Army Engineer District, New York
26 Federal Plaza
New York, New York 10007
ATTN: NANOP-E

If you have any questions regarding this matter, please contact Mr. John M. Olson of this office (215-597-4722).

Sincerely,



ROY E. DENMARK, JR.
Chief, Permits Branch

EXECUTIVE ORDER #53
Environmental Assessment

WHEREAS, the protection of the environment, which is the subject of a public trust administered by government for the benefit of all, is a primary responsibility of State government; and

WHEREAS, government must not only regulate but also must provide an example in the effort to protect the natural resources of the State; and

WHEREAS, the design and location of major State projects may have significant primary and consequential effects on the environment; and

WHEREAS, the protection of the environment, the management of development, and the wise and proper use of the State's limited land and other resources will be fostered by the proper location and design of State facilities; and

WHEREAS, the potentially adverse environmental impact of major proposed State projects will be reduced or eliminated if that impact is assessed before the approval of any proposed project, and changes made, if required, in the project design or location;

NOW, THEREFORE, I, WILLIAM T. CAHILL, Governor of the State of New Jersey, by virtue of the authority vested in me by the Constitution and by the Statutes of this State, do hereby order and direct;

1. All departments and agencies of the State shall prepare and submit to the Department of Environmental Protection a description and identification of the environmental impact of major construction projects.

These projects shall include:

Any construction project with a total cost greater than \$1,000,000.

A construction project with a total cost of less than \$1,000,000 which, by reason of its nature, location in a fragile or undeveloped area, or method of construction or operation, has the potential for

substantial adverse environmental impact.

Construction projects undertaken by local, county or regional governments or agencies for which a department or agency of the State has provided funding in excess of \$1,000,000.

Construction projects undertaken by local, county or regional governments or agencies for which a department or agency of the State has provided funding of less than \$1,000,000, but which, by reason of the project's nature, location in a fragile or undeveloped area, or method of construction or operation, has the potential for substantial adverse environmental impact.

From time to time, the Department of Environmental Protection may issue guidelines to assist proposing agencies in determining if a project with a cost of less than \$1,000,000 may have a potential for substantial adverse environmental impact.

2. Descriptions of such projects and brief identifications of environmental impact shall be submitted by the proposing department or agency to the Department of Environmental Protection prior to the completion of preliminary engineering design for each project. In the case of State funding for local projects, the funding department or agency shall submit the project description and environmental impact identification before awarding a grant.

The project description shall describe the location of the proposed project, the work to be accomplished, and shall include the drawings, plans, or maps required to give the Department of Environmental Protection a clear understanding of the scope and nature of the proposal.

The identification of environmental impact shall be a brief statement of the possible impact of the proposal on:

- a. water quality
- b. demand for water
- c. regional air quality
- d. plant and animal life in the area of the project
- e. land types at the project site

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- f. fragile land types or areas, which include but are not necessarily limited to wetlands, flood plains, groundwater recharge areas, the coastal area as defined in Chapter 185 of the Laws of 1973, the Pinelands as defined in Chapter 417 of the Laws of 1971, stream headwaters, and lands with a potential for severe erosion
- g. regional development or growth
- h. historic sites or sites of particular aesthetic importance to the State

3. The Department of Environmental Protection may from time to time issue guidelines for the preparation of descriptions and identifications of environmental impact for such projects.

The Department of Environmental Protection shall review project description and identification statements within four (4) weeks of their submission to it. It shall determine whether or not the proposed project as designed has a potential for substantial adverse environmental impact. If it so determines, it shall request the submission of a full environmental impact statement from the proposing agency. The impact statement shall follow the guidelines attached to, and made a part of, this Order. When such a statement is requested, the proposing agency shall furnish the Department of Environmental Protection with the statement. If the Department of Environmental Protection determines that the project will not have a substantial adverse environmental impact, it shall so notify the proposing agency, and additionally may make recommendations concerning the project's design or location to reduce environmental impact.

4. The Department of Environmental Protection shall review the environmental impact statement, and make recommendations to the proposing agency concerning the methods by which the adverse impact of the project may be minimized. Within four (4) weeks of the receipt of a complete statement, or within an additional two (2) weeks with the

consent of the proposing agency if the Department of Environmental Protection shall not have issued its report by the end of such time period the project will be deemed approved. The Department shall prepare a report of its review of the impact statement copies of which shall be furnished to the proposing agency and the State Planning Task Force.

5. Within four (4) weeks of the receipt of the Department of Environmental Protection's report, the proposing agency shall notify the State Planning Task Force in writing of its recommendations concerning the Department of Environmental Protection's analysis of the environmental impact statement. The report shall indicate which steps recommended by the Department of Environmental Protection the proposing agency will adopt to reduce the impact of the project. Where recommendations of the Department are not accepted by the proposing agency, it shall file a written statement of its reasons for not following the course recommended by the Department of Environmental Protection with the State Planning Task Force which shall consider and reconcile the differences between the Department of Environmental Protection and the proposing agency. The project shall not proceed until the procedures outlined above have been completed.

6. This Order shall not apply to projects now beyond the preliminary engineering stage.

7. The provisions of this Order shall not apply to projects which are reviewed pursuant to the National Environmental Policy Act, nor shall it apply to maintenance or repair projects.

8. This Order shall take effect immediately.

GIVEN, under my hand and seal, this 5th day of October, in the year of Our Lord, one thousand nine hundred and seventy-three, of the Independence of the United States, the one hundred and ninety-seventh.

/s/ William T. Cahill
GOVERNOR

[Seal]

ATTEST:

/s/ Jean E. Mulford
ACTING SECRETARY TO THE GOVERNOR

ENVIRONMENTAL IMPACT STATEMENT

General Policy Guidelines

The environmental impact statement shall provide the information needed to evaluate the effects of a proposed project upon the environment.

The statement shall generally include:

1. An inventory of existing environmental conditions at the project site and in the surrounding region which shall describe air quality, water quality, water supply, hydrology, geology, soils, topography, vegetation, wildlife, aquatic organisms, ecology, demography, land use, aesthetics, history, and archeology;
2. A project description which shall specify what is to be done and how it is to be done, during construction and operation;
3. A listing of all licenses, permits or other approvals as required by law and the status of each;
4. An assessment of the probable impact of the project upon all topics described in 1.;
5. A listing of adverse environmental impacts which cannot be avoided;
6. Steps to be taken to minimize adverse environmental impacts during construction and operation, both at the project site and in the surrounding region;
7. Alternatives to all or any part of the project with reasons for their acceptability or nonacceptability;
8. A reference list of pertinent published information relating to the project, the project site, and the surrounding region;
9. A Draft Environmental Impact Statement is attached hereto and made a part of these Guidelines.

A. DRAFT ENVIRONMENTAL IMPACT STATEMENT

Section 1. An environmental statement shall be prepared by the agency or such consultant or consultants as may be deemed qualified by virtue of their systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in accordance with the criteria and guidelines here-in-after set forth. The impacted area to be studied in detail shall be of sufficient width to encompass all of the alternatives considered.

Section 2. Criteria and Guidelines--the following are to be covered in the content of the Draft Statement:

a. A description of the proposed project including information and technical data adequate to permit a careful assessment of environmental impact including:

- (1) reason for the project;
- (2) the recommended or favored alternative mapped and/or described;
- (3) parks, recreational sites, wildlife, refuges and historic sites mapped and described;
- (4) existing land use, zoning and master plan delineation of project area mapped and described;
- (5) ambient environmental assets mapped and described.

b. The probable impact of the proposed project on the environment including impact on ecological systems such as wildlife, fish and marine life. Both primary and secondary significant consequences

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for the environment should be included in the analysis including, but not limited to:

- (1) implications of the proposed action for population distribution or concentration should be estimated and an assessment made of the effect of any possible change in population patterns upon the resource base, including land use, water and public services of the area impacted.

c. Any probable adverse environmental effects which cannot be avoided including:

- (1) water quality;
- (2) air quality;
- (3) noise, during and after construction;
- (4) undesirable land use patterns;
- (5) damage or destruction of significant plant or wildlife systems;
- (6) aesthetic values;
- (7) destruction of natural resources;
- (8) displacement of people and business;
- (9) displacement of viable farms;
- (10) employment and property tax;
- (11) destruction of man-made resources;
- (12) disruption of desirable community and regional growth;
- (13) health, safety and well-being of the public.

d. A thorough discussion of the steps to be taken, before, during and after construction of the project, to minimize the adverse environmental effects as described in Section 2c including:

- (1) the effect on the rules, regulations and

standards promulgated under State and/or Federal environmental statutes.

- e. Alternatives to the proposed project including:
- (1) that of no project;
 - (2) description of alternatives with an objective evaluation of alternatives might avoid some or all of the adverse environmental effects with the rationale for acceptability or nonacceptability of each alternative;
 - (3) an analysis of the costs and social impact of the alternatives including construction problems and benefit to the public which would be provided by the alternatives.
- f. The relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity assessing the project for cumulative long-term effects from the perspective that each generation is a trustee of the environment for future generations.
- g. A quantifiable identification of any irreversible and irretrievable commitments of resources which would be involved in the implementation of the project.

Section 3. Upon completion of the Draft Environmental Impact Statement, it shall be forwarded to the Commissioner of the Department of Environmental Protection for an assessment as to its completeness.

Section 4. The Commissioner, Department of Environmental Protection, shall within ten (10) days certify its completeness, shall notify the agency as to areas or sections of the Draft Statement which are deemed to be incomplete.

Section 5. The Department of Environmental Protection shall be furnished with six (6) copies of the environmental impact statement for review, comment and recommendations.

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APPENDIX 5.3

ESTIMATED COSTS

Summary

None of these estimates include owner costs, i.e., engineering, legal, land acquisition, right of way, inspection, contract management, etc.

1) Lay 96" pipe in bed of Canal		
	capital cost	\$127,200,000
2) Provide 72" force main with pumping station		
	capital cost	\$ 54,000,000
	annual power cost	\$ 2,700,000
3) Hydraulic Dredging		
	contract cost	\$ 17,000,000
4) Dry Dredging		
	contract cost	\$ 10,200,000

Total Volume of Dredge Spoil - 850,000 cu. yds. @ 30% solids. Preliminary estimate only. Final volumes likely to be greater.

Cost EstimatesQuotation

96" pipe - Low Pressure - \$250/ft delivered
 72" pipe - 200 PSI - \$180/ft delivered
 use about 60% for installation except in urban area - use 150% there

1) 96 Inch Gravity Pipeline

Lay 96" pipe in bed of Canal - gravity flow
 Length of pipeline about 58 miles
 Capital cost = $250 \times 1.60 \times 5280 \times 54 = \$114,000,000$
 (Trenton Area) $250 \times 2.50 \times 5280 \times 4 = 13,200,000$
 $\underline{\$127,200,000}$

2) 72 Inch Pressure Pipeline

Abandon Canal for water supply purposes.
 Take water from Delaware at Trenton and carry to Raritan near Bound Brook. Length of pipe about 30 miles. Static plus friction head about 300 ft. Assume 100 MGD for pipeline.

Pumping power required: $HP = \frac{100 \times 694 \times 8.33 \times 300}{33000} = 5,255 \text{ HP}$

assume 70% efficiency
 $HP \text{ input} = \frac{5255}{.70} = 7,500 \text{ HP}$

7,500 HP = 5,600 KW
 KWH/Yr = $5,600 \times 8,760 = 49,000,000$
 Considering demand and energy costs
 net cost - \$.055/KW
 Annual power cost = $.055 \times 49,000,000 = \$2,700,000$
 Capital cost for pipe = $180 \times 1.6 \times 5280 \times 23 = \$35,000,000$
 (Trenton Area) $180 \times 2.5 \times 5280 \times 7 = 16,600,000$
 Capital cost for pump station ~ $\underline{2,400,000}$

3) Dredging Costs - Hydraulic

Assume use of Mud Cat with 120 c.y/hr capacity. This is a 915 Mud Cat.

Machine uses 8-9 gals/hr of diesel fuel

about \$1.00/hr of lube oil

about \$5.00/hr for repairs and maintenance

Normally 2 man crew is sufficient. However for type of dredging in Canal with frequent handling of piping and guides use 3 men.

Assume 6 yrs operation - 2000 hrs/yr

Assume 15% rate of return

Assume cost of equipment = \$150,000

Assume salvage at end of 6 yrs = \$15,000

Annual depreciation cost = $\frac{150,000 - 15,000}{6} = \$22,500$

Average value of equipment = $\frac{p(m+1) + s(m-1)}{2m} = \frac{15000(7) + 15000(5)}{12} = \$93,75$

Annual investment cost = $.15 \times 93,750 = 14,100$

Total annual capital cost = \$36,600

Hourly capital cost = $\frac{36,600}{2,000} = \$18.30$

Diesel Fuel 9 @ 1.25	=	11.25
Lube oil	=	1.00
Maintenance	=	5.00
3 Men @ \$20.00 including fringes	=	60.00
Net hourly cost		<u>95.55</u>
Overhead @ .15		14.33
		<u>\$109.88</u>

In an 8 hour day assume 2 hours for setting up and 6 hours of dredging at 100 cubic hours of 15% solids with deposit at 30% solids.

at 30% solids

300 # solids	vol = 300/62.4 x 2.6 = 1.85 c.f.
700 # water	vol = 700/62.4 = 11.22 c.f.
	<u>13.07 c.f.</u>

for 300# solids @ 15% solids

300# solids	vol = 300/62.4 x 2.6 = 1.85
1700# water	vol = 1700/62.4 = 27.24
	<u>29.09</u>

%increase in vol = $\frac{29.09}{13.07} = 223\%$

100 c.y/hr of dredging is equivalent to $\frac{100}{2.23} = 44.8$ c.y in place.

cost/c.y of in place material = $\frac{109.88 \times 8}{6 \times 44.3} = \$3.27/\text{yd.}$

Assume dredged spoil dries to 40% solids. for 300# solids at 40%

300 # solids	vol = 300/62.4 x 2.6 = 1.85
450 # water	vol = 450/62.4 = 7.21
	<u>9.06</u>

dredged vol is reduced to $\frac{9.06}{29.09} = 31.1\%$

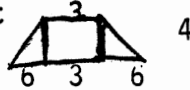
1-c.y of dried material is equivalent to $\frac{13.07}{9.06} = 1.44$ c.y of material in place.

Assume average spoil area 335 ft. square with 4' high berm. - This will handle about 12500 c.y. of dried material or $12500 \times 1.44 = 18000$ c.y. of material in place.

cost of developing spoil area

- 1) dig 16 drainage ditches 335 long
- 2) provide impervious liner
- 3) provide 6" sand bed
- 4) provide earthen embankment all around say $335 \times 4 = 1340'$ long
- 5) provide adjustable spillway say 50' long

- | | | | |
|----|---|---|---------|
| 1) | Drainage ditches 16x335 @ \$3.00 | = | \$16100 |
| 2) | Liner 335x335 @ .20 | = | 22400 |
| 3) | Sand bed: $335 \times 335 \times \frac{1}{27}$ @ \$12.00= | = | 25000 |
| 4) | Embankment | = | |



$$\left(\frac{3+6}{2}\right)(4)\left(\frac{1}{27}\right)(1340) @ 15.00 = 25000$$

- | | | | |
|----|---|---|-------|
| 5) | spillway 50 @ 200 | = | 10000 |
| 6) | Labor to adjust spillway say | = | 5000 |
| 7) | Remove Sandbed, liner and embankment, restore site say 1/2 of (2,3,4) | = | 36200 |

total \$139700

$$\text{cost/yd in place} = \frac{139,700}{18000} = \$7.76$$

Hauling Dried Spoil.

Material will be picked up by backhoe loaded into say 12 c.y truck. Move about 10 miles to disposal area. Use bulldozer to spread material at disposal area.

Backhoe with operator cost about \$50/hr. could probably handle 120 c.y./hr net, this would involve 10 truckloads/hour for 10 mile haul:

load time = .10 hr	
haul time = 1.00 hr	20 miles at 20 mph
unload time = .05 hr	
maneuver time = .15 hr	
1.30 hr	

No. of trucks rec'd. = $10 \times 1.30 = 13$ trucks
say operate 6 hrs in 8 hr day

Daily production = $6 \times 120 = 720$ c.y.

cost of backhoe = \$50 x 8	=	400	
cost of bulldozer = \$50 x 8	=	400	
cost of trucks = 13 x 8 x \$40	=	4160	
supervision = 8 x \$30	=	240	
		\$5200	

$$\text{cost/yd in place} = \frac{5200}{7.20 \times 1.44} = \$5.02$$

Total cost of Hydraulic Dredging	
Dredging =	3.27
Dewatering =	7.76
Hauling =	5.02
	<u>16.05</u>
contingencies @ 20%	3.21
	<u>19.26</u>
say \$20/c.y.	
with 850,000 ydrs	
total cost = 850,000 x 20 = \$17,000,000	

4) Estimate of Dredging in the Dry:

Use scheme of section 2.5
construct cofferdams at

- 1) the inlet
- 2) the Lockatong - with pumping facilities
- 3) the Wichecheoke- with pumping facilities
- 4) Upstream of Diamond Shamrock
- 5) Washington Crossing
- 6) Upstream of Stony Brook Plant
- 7) Downstream of Stony Brook Plant
- 8) Upstream of No. Brunswick Water Dept. intake
- 9) Downstream of No. Brunswick Water Dept. intake

to build and remove 9 cofferdams	
say 9 @ \$50,000	= \$450,000
Pumping costs during the	
time of operation say*	<u>\$500,000</u>
	say \$1,000,000
cost/yd = $\frac{1,000,000}{850,000}$	= \$1.18

Assume deposits are dewatered to 40% solids. In the bed of canal assume equipment requires backhoe loader, bulldozer and trucks with 2 laborers and one supervisor. Use 10 mile haul but increase cycle time to 2 hours to compensate for more limited access.

1 backhoe	\$50 x 8	= \$ 400
2 bulldozers	2 x \$50 x 8	= 800
costal trucks	20 x 8 x \$40	= 6400
supervision	8 x \$30	= 240
2 laborers	2 x 8 x \$20	= 320
		<u>\$8160</u>

cost/yd in place = $\frac{8160}{720 \times 1.44} = 7.87$

cost of construction	1.18
	<u>9.05</u>
cont at 20%	1.81
	<u>10.86</u>

say \$12/yd

with 850,000 ydrs
total cost = 850,000 x 12 = \$10,200,000

* Several crews working simultaneously

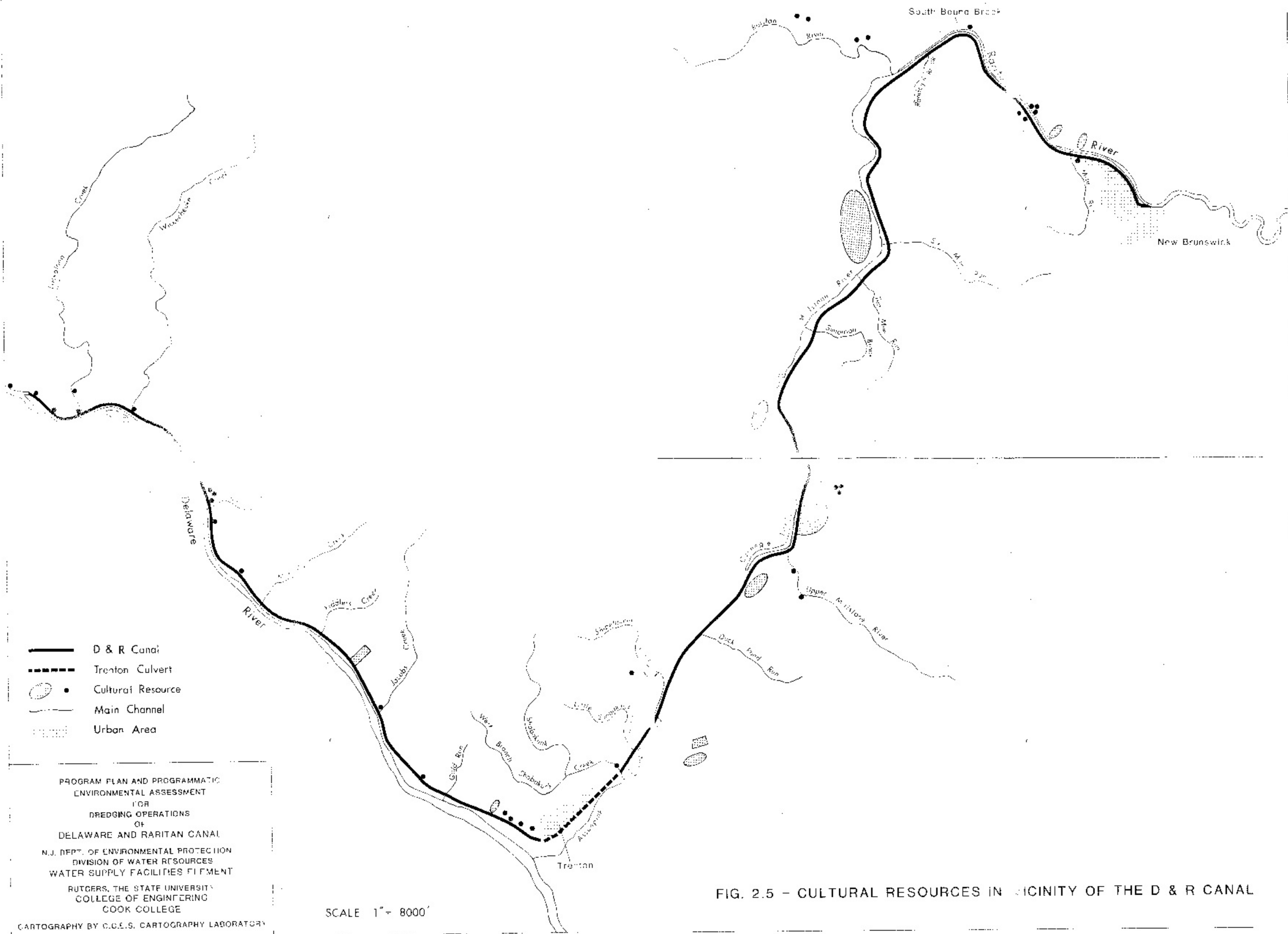
Time to do work

Assuming a crew can remove 120 cubic yards per hour, the total crew hours would be:

$$\frac{850,000}{120} = 7,083 \text{ hrs.}$$

At 40 hrs./week - 177 weeks or 3 years, 21 weeks

U



- D & R Canal
- - - Trenton Culvert
- • Cultural Resource
- Main Channel
- ▨ Urban Area

PROGRAM PLAN AND PROGRAMMATIC ENVIRONMENTAL ASSESSMENT FOR DREDGING OPERATIONS OF DELAWARE AND RARITAN CANAL
 N.J. DEPT. OF ENVIRONMENTAL PROTECTION
 DIVISION OF WATER RESOURCES
 WATER SUPPLY FACILITIES ELEMENT
 RUTGERS, THE STATE UNIVERSITY
 COLLEGE OF ENGINEERING
 COOK COLLEGE
 CARTOGRAPHY BY C.G.E.S. CARTOGRAPHY LABORATORY

SCALE 1" = 8000'

FIG. 2.5 - CULTURAL RESOURCES IN VICINITY OF THE D & R CANAL

1

