

AD-A099 241

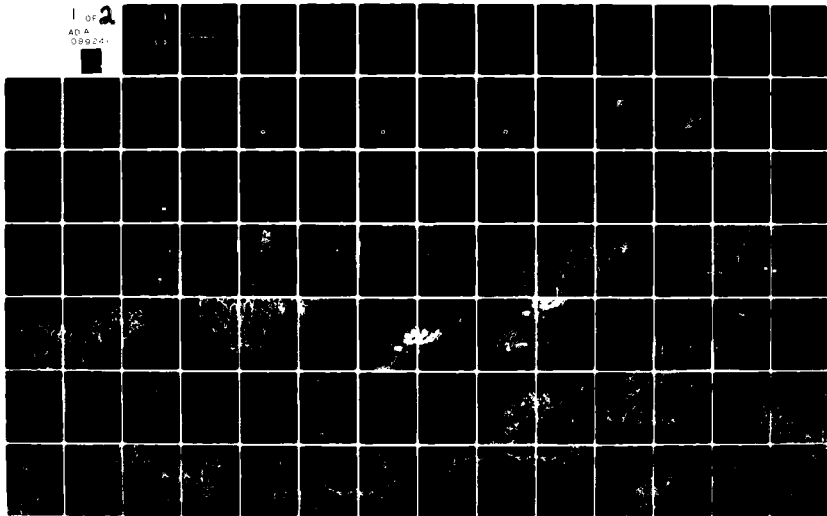
CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV  
A SUMMARY OF THE GEOLOGY OF EASTERN MASSACHUSETTS, (U)  
JUL 75 F W FESSENDEN, J AYERS, S L DEAN

F/G B/7

UNCLASSIFIED

NL

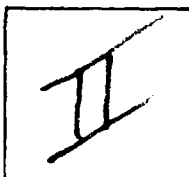
1 OF 2  
AD A  
089241



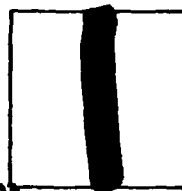
PHOTOGRAPH THIS SHEET

AD A099241

DTIC ACCESSION NUMBER



LEVEL



INVENTORY

Corps of Engineers, Waltham, MA  
New England Div.

A Summary of The Geology of Eastern  
Massachusetts

DOCUMENT IDENTIFICATION

July 75

DISTRIBUTION STATEMENT A

Approved for public release.  
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR	
NTIS	GRA&I <input checked="" type="checkbox"/>
DTIC	TAB <input type="checkbox"/>
UNANNOUNCED	<input type="checkbox"/>
JUSTIFICATION	
BY	
DISTRIBUTION / <i>Per Mr. on file</i>	
AVAILABILITY CODES	
DIST	AVAIL AND/OR SPECIAL
<i>A</i>	

DISTRIBUTION STAMP

**S** DTIC ELECTE **D**  
 MAY 21 1981  
**D**

DATE ACCESSIONED

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDA-2

AL A 099241

*A SUMMARY*  
*OF*  
**THE GEOLOGY OF**  
**EASTERN MASSACHUSETTS**

Prepared as a Planning Document  
for Wastewater Management Studies

*NEW ENGLAND DIVISION CORPS OF ENGINEERS*

JULY 1975

**DISTRIBUTION STATEMENT A**  
Approved for public release;  
Distribution Unlimited

79 03 27 108

A SUMMARY OF THE  
GEOLOGY OF EASTERN MASSACHUSETTS

Franklin W. Fessenden, Ph.D.  
Corps of Engineers

John Ayers, M.S.  
Goldberg-Zoino and Assoc.

Steven L. Dean, M.S.  
Whitman & Howard, Inc.

March 1975  
Corps of Engineers  
Planning Division  
New England Division

TABLE OF CONTENTS

	<u>Page</u>
I. INTRODUCTION	1
II. LOCATION	2
III. SUMMARY OF THE GEOLOGY OF THE STUDY AREA	2
IV. SOURCE MATERIAL	6
V. EXPLANATION OF LEGEND AND MAPPING PROCEDURES	8
VI. CONCLUSION	11
SELECTED BIBLIOGRAPHY	13

LIST OF TABLES

	<u>Following page</u>
1. Ages, Sequence and Names of Bedrock Formations from Existing Literature	6
2. Summary of Materials Used on Surficial Geology Maps	9
3. Engineering Characteristics of Surficial Deposits	9

LIST OF FIGURES AND MAP SHEETS

		<u>Following Page</u>
Figure 1	Location Map	2
Sheets I-1, I-2, I-3	Index Maps of Merrimack Basin in Massachusetts	7
Sheets EMB, EMS, EMW	Index Maps of Eastern Massachusetts Area	7
Figure B	Bedrock Geology of Merrimack Basin in Massachusetts	in Appendix
Figure S	Surficial Geology of Merrimack Basin in Massachusetts	in Appendix
Figure W	Groundwater Favorability of Merrimack Basin in Massachusetts	in Appendix
Sheets EMB-1, EMB-2, EMB-3	Bedrock Geology of Eastern Massachusetts	in Appendix
Sheets EMS-1, EMS-2, EMS-3	Surficial Geology of Eastern Massachusetts	in Appendix
Sheets EMW-1, EMW-2, EMW-3	Groundwater Favorability of Eastern Massachusetts	in Appendix

## A SUMMARY OF THE GEOLOGY OF EASTERN MASSACHUSETTS

### I. INTRODUCTION

The Corps of Engineers, along with other State and Federal agencies, has conducted broad-based studies of wastewater in eastern Massachusetts. A major portion of this study dealt with the feasibility and planning procedures for different methods of wastewater treatment and renovation in accordance with the goals expressed in Public Law 92-500. One of the alternatives studied was that of wastewater treatment by the method of land application. In this alternative, wastewater is applied to the ground and is treated as it flows on or through the soil and underlying rock material.

Knowledge of the geology of an area is of prime concern to any planning effort for land application of wastewater. The effectiveness of land treatment and the impact of the applied wastewater on the land, groundwater, and nearby streams and other surface bodies cannot be adequately addressed unless the surficial, groundwater and general bedrock geology of an area are known. To this end, the geology of eastern Massachusetts was compiled from existing sources and was displayed in both narrative and map form. The entire wastewater management study was divided into two parts based on geographic delineation. One study dealt with the Merrimack Valley in Massachusetts, the other with the rest of the State of Massachusetts east of approximately the 71° 52', 30" W longitude. The compilation of the geology of the Merrimack Valley in Massachusetts was prepared by Goldberg-Zoino and Associates, Inc. under the direction of Mr. John Ayres. The geology of the rest of the study area was compiled by Whitman and Howard, Inc., under the supervision of Mr. Steven Dean. The two efforts were coordinated by the senior author of this report, Franklin W. Fessenden of Bentley College and the Corps of Engineers.

The full description of the geologic investigations can be found in the main reports on each of the two study areas. The Merrimack Study is in Appendix I-A (Geologic - Hydrogeologic Investigations) of Volume 3, "Merrimack Wastewater Management, Key to a Clean River." The Eastern Massachusetts geology study is printed as an Addendum to the Boston Harbor -- Eastern Massachusetts Metropolitan Area Wastewater Study. Both of these reports were published by and are on file at the Corps of Engineers, New England Division.

This report is a summary of the two major geologic studies and is intended for those who wish a set of geologic maps of the Eastern Massachusetts area along with a list of source materials and references compiled in one volume. It should be emphasized that the material presented in this report is a compilation of available geologic knowledge existing prior to late 1973 and does not include original research.

## II. LOCATION

The area discussed in this report is that portion of the Commonwealth of Massachusetts east of longitude  $71^{\circ}, 52', 30''$ . The study area has been subdivided into two regions, the Merrimack River Basin in Massachusetts and the remaining part of the eastern half of the State outside of the Merrimack Basin. Figure 1 is a location map of the entire study area with the subdivision outlined.

## III. SUMMARY OF THE GEOLOGY OF THE STUDY AREA

### A. Bedrock Geology

The bedrock of the study area consists of igneous, sedimentary and metamorphic rocks mantled discontinuously by unconsolidated deposits. The ages of the bedrock range from pre-Cambrian to late Paleozoic with some minor volcanics of Triassic age also being mapped. The predominate igneous rocks are granite and granodiorite. Other igneous rocks mapped are syenites, volcanics and gabbrodiorities. Outcrops of sedimentary and metasedimentary rocks of chiefly confined to the eastern and southeastern parts of the study area in the Boston and Narragansett basins. Slates, argillites and conglomerates as well as some sandstones are mapped. Metamorphic rocks exhibiting both foliated (phyllites, schists, and gneisses) and non-foliated (quartzites) texture are abundant and outcrop in all parts of the study area.

### B. Surficial Geology

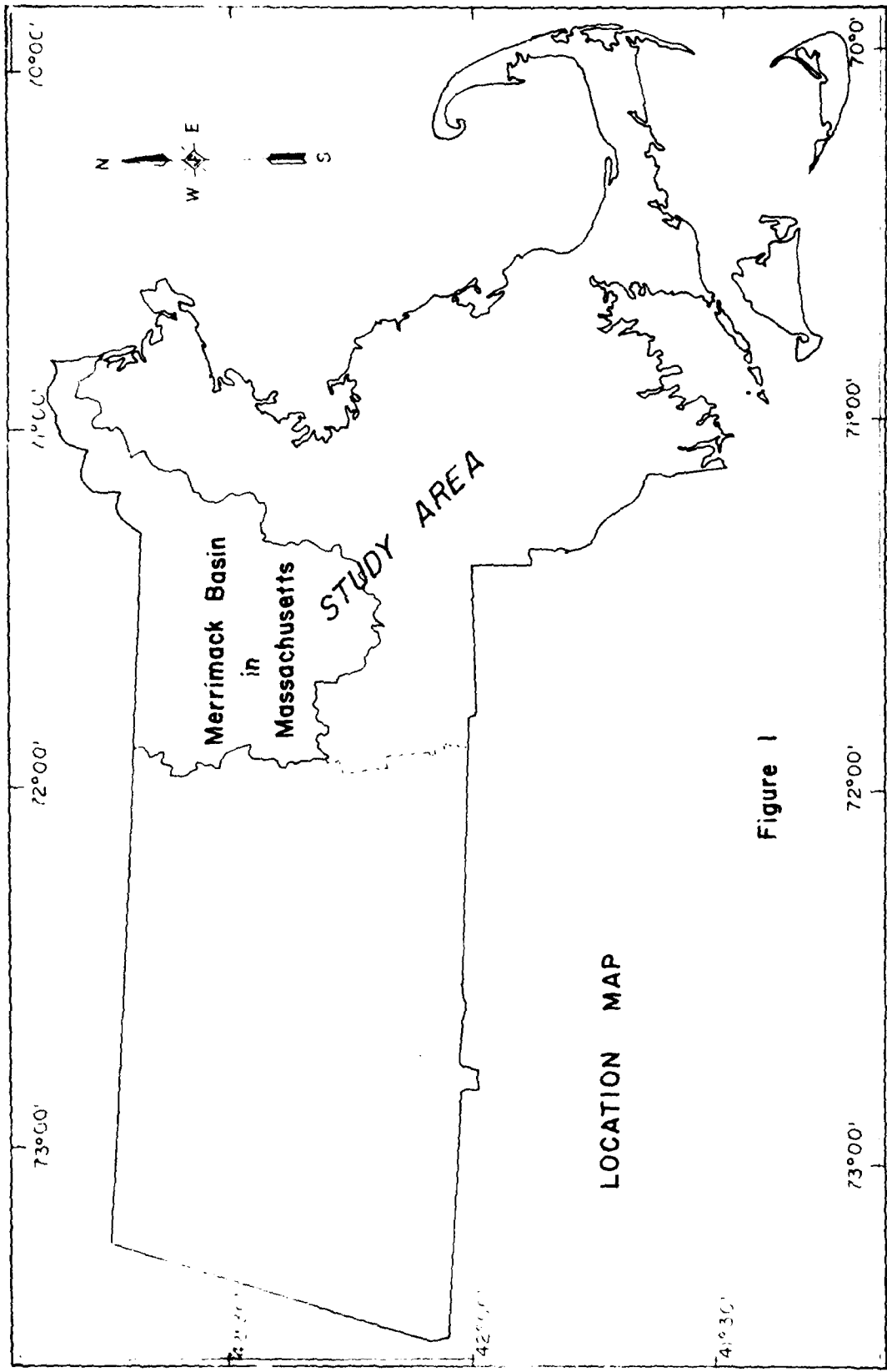
#### 1. General

Nearly all of the bedrock units of the study area are of Paleozoic age or older. The exceptions are a few diabase dikes of reported Triassic age. A long period of erosion followed the emplacement of the bedrock. During this interval, the rock was weathered and worn away and streams and rivers incised valleys in the bedrock floor.

Downcutting by these streams was interrupted by the advance and retreat of glacial ice sheets during the Pleistocene epoch. Much of the mantling cover of soil and weathered rock was removed by the ice sheets, and the underlying bedrock surfaces were subjected to glacial abrasion and scouring.

One or more layers of till or other glacial debris was deposited on this modified surface by the advancing ice. Later, as the ice melted, waterborne drift accumulated between, among, and over residual ice blocks, and settled in the basins of temporary glacial lakes.





Pre-glacial drainage patterns changed as many of the ancient pre-glacial valleys were blocked or filled with sediment and the streams, having been diverted from their original channels, developed new courses.

After the glacial ice had receded, the land mass began to rebound exposing some of the newly-deposited materials to further erosion. During and following this period, sea level fluctuated with the strand line first retreating and then re-advancing. Along the shores glacial sands were shaped into dunes by the wind, open waters were filled with sediments and on these a marsh system evolved.

Landward, the large glacial lakes were drained to the sea through successively lower elevation outlets. Rivers and streams became established in new courses and channels, and glacial-derived sediments were commonly reworked and redeposited as alluvium. Poorly drained upland areas and old lake bottoms, along with some of the deeper kettle holes in outwash areas, became partially filled with organic detritus.

## 2. Glacial Deposits

With the exception of local deposits of Tertiary clays and silts and sands along the south shore and the islands, all the various unconsolidated surficial materials in the study area are of Pleistocene or recent age. Several different types, grouped by lithologic character and mode of origin, are present in the area.

### Glacial Till

Till is the most widespread unconsolidated sediment. It consists for the most part of unsorted clayey or silty sands and gravels which commonly contain many boulders and cobbles. Till deposits generally average less than 20 feet in thickness and are deeper in the low land areas and thinner towards the top of rock cored hills. Thicker deposits are found in the several drumlins which are found in this area. No distinction is made between the so-called "older" and "younger" tills which have been the subject of much debate. All till in the study area is mapped as one unit.

### Glaciofluvial - Glaciolacustrine Deposits

Coarse grained stratified drift deposits are mapped and discussed together. Although the outwash and ice contact deposits may differ significantly in their origins and/or final topographic forms, they are similar in physical characteristics. Most often these deposits consist of sands or sand and gravel with minor amounts of silt and/or clay (less than 10%). They are usually stratified and moderate to well sorted.

Large quantities of these materials are found among deltaic deposits which accumulated in temporary glacial lakes, in outwash plains and as kames deposited on and next to the wasting ice.

The materials mapped and described as lake bottom deposits are limited to those finer grained materials that originally accumulated on the floors of temporary glacial lakes. They are most commonly seen today in valley floors and in level plain-like areas such as near Hanscom Field in Bedford.

The materials referred to as lake bottom deposits are primarily silts and/or sandy silts. Varve clays are reported from the Nashua and Sudbury Valleys, and to lesser extent elsewhere in the area.

#### Glaciomarine Deposits

Blue-gray silty clays are found along coastal sections of the study area. They are most often described as late-glacial and post-glacial age marine deposits. The occurrence of this clay well above modern sea level elevations indicates landward submergence during the time of its deposition.

Sands and silty sands, often associated with the glaciomarine clays described above, are mapped together with recent dune sands and beach sands. For the most part, the recent beach sands along the Atlantic coast have been derived from glacial materials.

### 3. Recent Deposits

#### Marine Organic Deposits

Recent age marine organic silts are found in coastal lowland regions, as for example in the large salt marsh behind Plum Island and the marshes along the North and South Rivers near Duxbury and Scituate. These deposits are commonly related to fluctuations in sea level as were cited above.

#### Fresh Water Organic Deposits

Fresh water swamp accumulations throughout the area consist of peat and other decomposed organic matter interbedded in places with sands and silts. They are most extensive in valleys and low-lands where they overlie lake bottom deposits, alluvium, or outwash. Elsewhere they occur locally in kettles, or in poorly drained upland rock basins and depressions in the ground moraine. The swamp deposits are generally thin in upland locations, but in several lowland areas are known to exceed fifty feet.

## River Terrace and Alluvium Deposits

Much of the material picked up, transported, and deposited by streams in the study area has been derived from glacial deposits. Some of this material was deposited in post-glacial times along river courses that are now abandoned or partially abandoned. River terraces and other features that represent these older stream courses are seen throughout the area. Alluvial material ranging in size from clay through coarse gravel and cobbles is currently being deposited by streams in their channels and along flood plains.

### C. Ground Water Geology

#### 1. Supply

Average precipitation in the study area ranges from 42-46" per year, well above the national average of 30". Of the yearly precipitation falling on the area, about 20-22" are evaporated or transpired, leaving 22-24" to recharge the ground water reservoir and provide runoff and base flow for surface streams. Thus, the study area as a whole is provided with an ample supply of both surface and ground water. Water table levels are relatively shallow ranging from 0 to 50-60 feet below the surface depending on local topographic and geologic conditions.

#### 2. Aquifer Descriptions

Ground water in the study area occurs in three different subsurface units: bedrock, glacial till, and stratified unconsolidated deposits. Ground water occurrence depends on porosity (percentage of void space) of the units and movement depends on permeability (relative ease with which the unit can transmit a liquid).

##### Bedrock

The rocks which underlie the basin are hard and compact. The frequency and distribution of fractures (the only significant source of porosity and permeability in these rocks) are highly variable, but commonly limited to an extent that essentially prohibits any regular large scale withdrawal of ground water.

##### Glacial Till

The porosity of till deposits may exceed 30 percent, but permeability is low because of the poor sorting and high silt and clay content. These relatively thin deposits provide limited ground water storage potential, and the low lateral permeability results in slow ground water movement. Only limited amounts of water may be withdrawn from till.

### Stratified Unconsolidated Deposits

Stratified deposits consisting of very fine sand, silt, and clay have relatively high porosity but low permeability, similar to till. The water table is commonly close to the surface, particularly during the early part of the growing season. Because of these factors, ground water storage potential is limited and lateral water movement is hindered. Fine grained deposits form poor aquifers.

Sand, and sand and gravel stratified deposits have high porosity and relatively high permeability. These deposits commonly occur within the valleys of large streams and their major tributaries. They are also found along abandoned or buried preglacial stream valleys. Some of these deposits form the best aquifers within the area.

#### IV. SOURCE MATERIAL

##### A. Bedrock Geology Maps

The available literature concerning the bedrock of eastern Massachusetts dates back to the early nineteenth century. However, the more extensive and exacting mapping of the Massachusetts bedrock really began in the early twentieth century with the publication in 1917 of the Geology of Massachusetts and Rhode Island by E. K. Emerson.

There have been no other studies to date which have mapped the bedrock of the entire study area, although several portions of the area have been investigated and mapped in detail. These other studies, which include U.S. Geological Survey Quadrangle Maps (both published and open file), U. S. Geological Survey Bulletins and Professional Papers, and State reports were used to complement and refine Emerson's work. In addition, several outside sources such as Billings' Geology of New Hampshire, were utilized to provide further data.

Attempts at coordinating and comparing the works of various authors presented some problems. It quickly became apparent that many of the individual geologists who had worked within the study area differed greatly in their interpretations of the age, sequence, structure, and even composition of the various rock units. For instance, it is not unusual to find two or more names applied to the same rock unit, nor is it a rare occurrence to find that several rock units classified and named by a given author have been lumped together by another writer. As may be seen on the following table, recent studies have identified significant differences in the relationships among the bedrock units. Age and structural relations in the study area are now considered to be quite different from those mapped by earlier workers. A summary of the ages, sequences, and names of the bedrock formations used by various authors for rock units is included in Table 1.

	Diabase Dikes
↑ Hubbardston Gra. Fitchburg Gra. Dracut Dio. Ayer Gra. Andover Gra. Straw Hollow Dio. Bolton Gneiss Brimfield Sch. Worcester Phy. Boylston Sch. Harvard Congl. Paxton Qtz. Sch. Oakdale Qtz. Merrimack Qtz. Beverly Syen. Mattapan Volc. Ironstone Qtz. Dio. Milford Gra. Dedham Granodio Newburyport Qtz. Dio. Salem Gabb Dio ↓ Newbury Volc	Andover Gra Dracut Dio. Beverly Syen. Merrimack Qtz. Lynn Volcanics Dedham Granodio Newburyport Qtz. Dio. Salem Gabb Dio

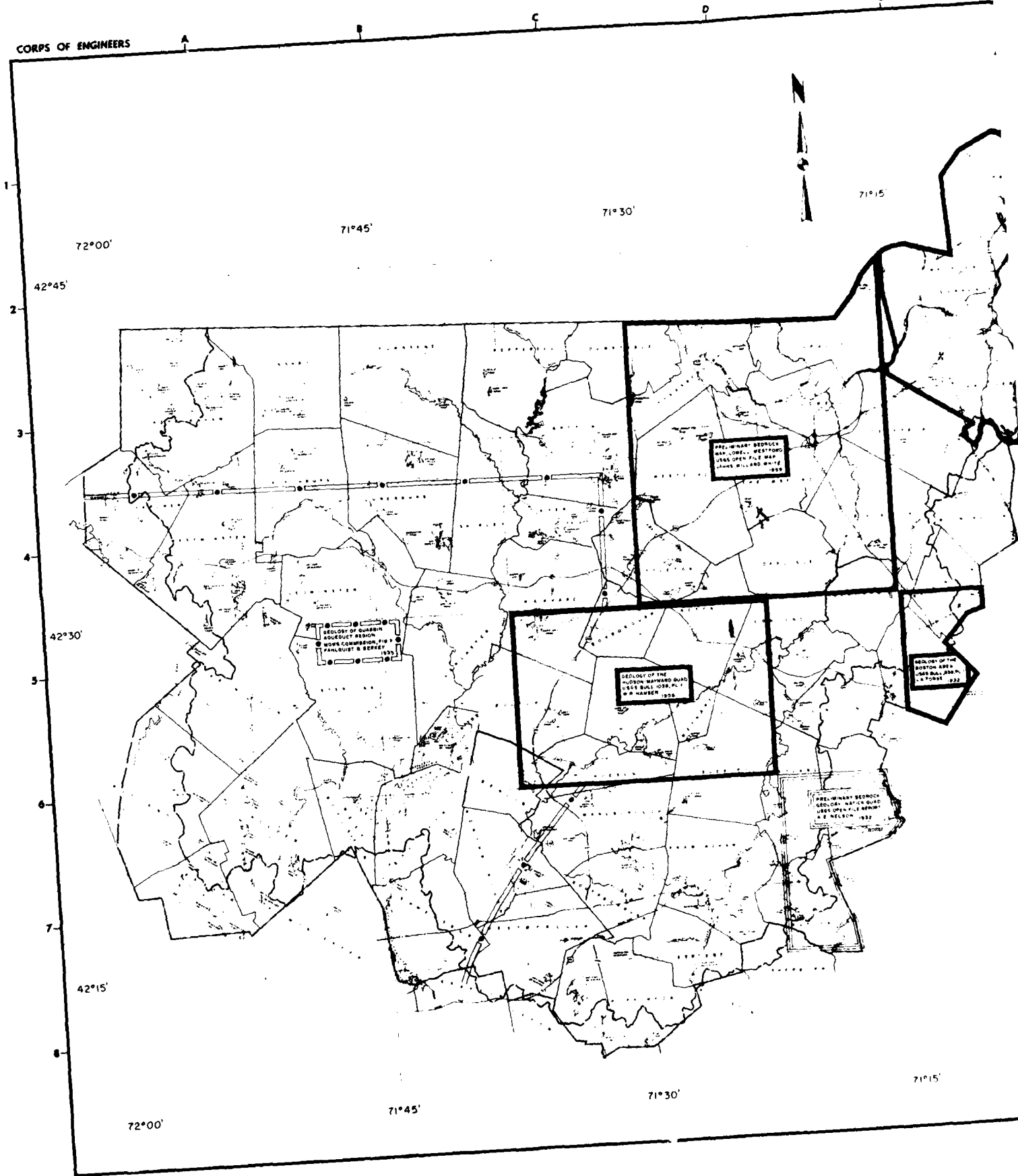
TABLE 1  
AGE, SEQUENCES AND NAMES OF  
BEDROCK FORMATIONS  
FROM EXISTING LITERATURE

<p>WILKINSON &amp; Min- Resources Hudson/ Hart Quad Bull. 1038 (S) 1956</p>	<p>BILLINGS Geol of NH NH Dept of Resources &amp; Econ. Devel.  1956</p>	<p>JAHNS, WIL- LARD WHITE, et al Prelim Bedrock Geol. of Lowell-Westford Area USGS open file 1959</p>	<p>TOULMIN Bedrock Geol of Salem Quad Bulletin 1162-A (USGS)  1961</p>	<p>CHUTE Bedrock Geol Blue Hills Quad, USGS GQ-106  1969</p>	<p>NELSON Prelim Be- rock Geol. Map of Nat. Quad USGS open file</p>
<p>Diabase Dikes</p>		<p>Diabase Dikes</p>	<p>?Diabase</p>		
<p>Andover Gra. Acton Gra. Hollow Dio. Ayer Qtz. Dio.</p>		<p>Andover Gra. Acton Gra. Ayer Gra. Dracut Norite</p>	<p>Beverly Syenite</p>		
<p>Worcester Hill Schist Nashoba FM Worcester FM includes Brim- field Schist &amp; Harvard Con- glomerate</p>	<p>Worcester Phyll. includes Brim- field Schist &amp; Harvard Conglomerate</p>	<p>Nashoba FM</p>		<p>Wamsutta FM Pondville Conglom</p>	<p>Cambridge Roxbury Brighton Metaphyr</p>
<p>Quincy Andover Gra. Ayer Granodio ?Fitchburg Gra. Dracut Dio.</p>	<p>?Quincy Gra</p>	<p>Worcester FM includes Brim- field Schist &amp; Harvard Conglomerate</p>		<p>?Cambridge Arg Roxbury Congl</p>	
<p>Dedham Granodio Salem Gabb Dio</p>	<p>Newbury Volc</p>	<p>?Merrimack Qtz includes "Chelmsford Granite"</p>	<p>Newbury FM</p>	<p>?Blue Hills Granite Porphyry ?Quincy Granite ?Mattapan Vol ?Sharon Syen</p>	<p>Mattapan V</p>
<p>Merrimack Group ?includes Oak- dale quartzite &amp; various gneiss &amp; sch</p>					
<p>Milford Gra. Dedham Grano- diorite</p>			<p>?Newburyport Qtz. Dio Salem Gabb Dio  ?Marlboro?FM</p>	<p>Braintree Arr Cambrian Qtzite  ?Westwood Gr. ?Dedham Grano- diorite ?Salem Gabbro- diorite</p>	<p>Dedham Gra Cherry Bro Kenda' Vol Westboro F Rice FM</p>

STE Brook Geol Hills ed. US GQ-796 1969	NELSON Prelim Bed- rock Geol Map of Natick Quad USGS open file 1973	VOLCKMAN Prelim Bed- rock Geol Map of Holliston Quad USGS open file 1973	BELL et al in USGS/DPW Coop Program Annual Report June 1972
Rutte FM adville Conglom	Cambridge Slate Roxbury Congl Brighton Metaphyre		
bridge Arg			
bury Congl			
he Hills Granite rohyry ncy Granite ttapan Vol aron Syen	Mattapan Volc.	Milford Gra Dedham Granodio	Cape Ann Plutonic Series Beverly Syenite et al
		Marlboro FM	Andover Gra et al
			↓
	Dedham Granodio Cherry Brook FM Kenda' Volc Westboro FM Rice FM		Nashoba FM Marlboro FM
aintree Arg brian Qtzite		Westboro Qtz	Dedham Grano- dio
etwood Gr adham Grano- lorite alem Gabbro- lorite			Marlboro FM (part) Westboro Qtz.



CORPS OF ENGINEERS



71°00'

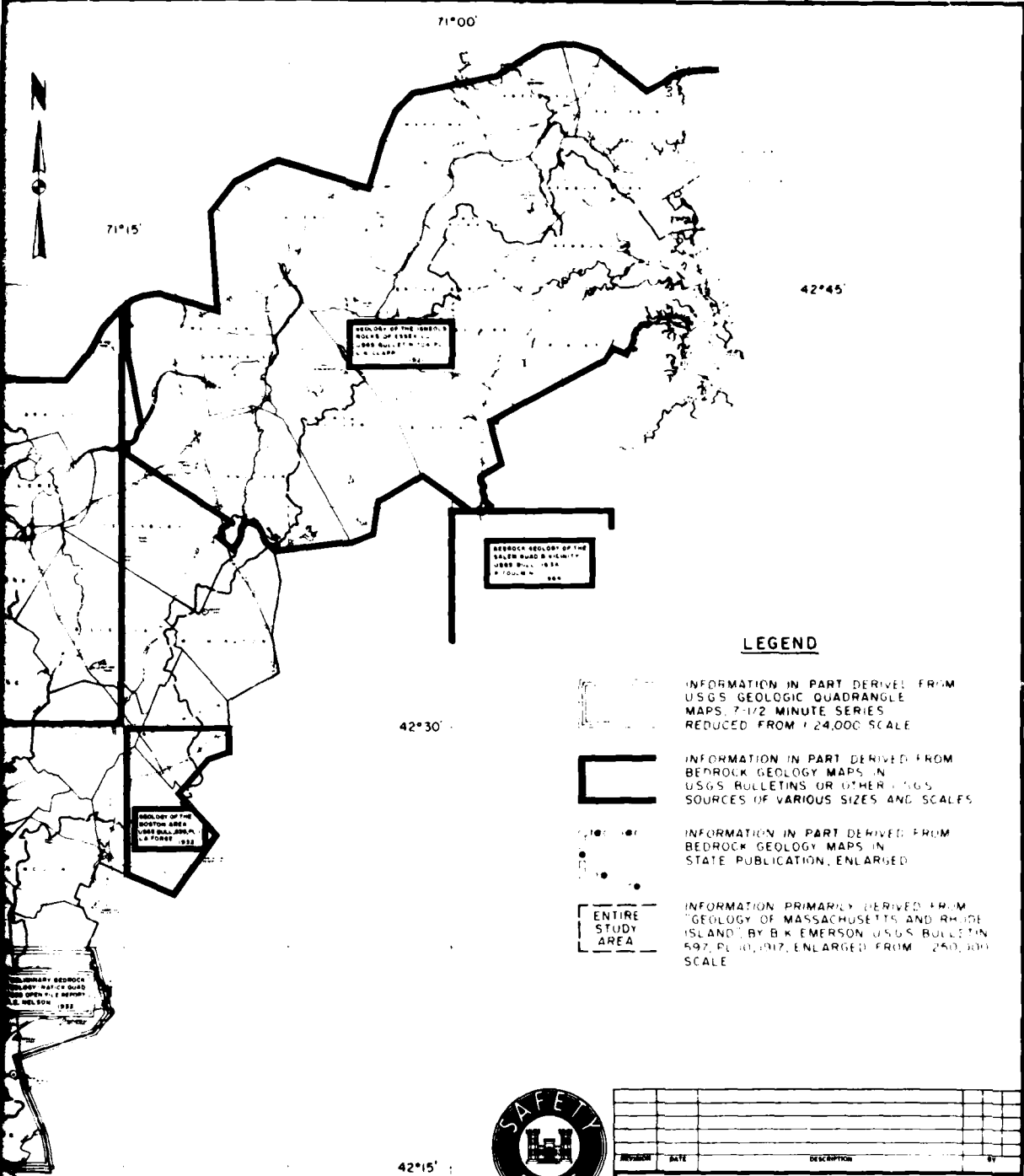
71°15'

42°45'






42°30'

42°15'

71°15'



**LEGEND**

-  INFORMATION IN PART DERIVED FROM USGS GEOLOGIC QUADRANGLE MAPS, 7-1/2 MINUTE SERIES, REDUCED FROM 1:24,000 SCALE
-  INFORMATION IN PART DERIVED FROM BEDROCK GEOLOGY MAPS IN USGS BULLETINS OR OTHER USGS SOURCES OF VARIOUS SIZES AND SCALES
-  INFORMATION IN PART DERIVED FROM BEDROCK GEOLOGY MAPS IN STATE PUBLICATION, ENLARGED
-  INFORMATION PRIMARILY DERIVED FROM "GEOLOGY OF MASSACHUSETTS AND RHODE ISLAND" BY B. K. EMERSON, USGS BULLETIN 597, PL. 10, 1917, ENLARGED FROM 1:250,000 SCALE
-  ENTIRE STUDY AREA



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION  
CORPS OF ENGINEERS  
WALTHAM, MASS.

DES. BY DRAWN BY CHECKED BY APPROVAL AUTHORITY DATE	<b>INDEX — SHOWING SOURCES OF INFORMATION FROM WHICH BEDROCK GEOLOGY MAPS WERE PREPARED</b>
APPROVAL AUTHORITY DATE	APPROVED DATE
SCALE	SPEC. NO. DRAWING NUMBER BEDROCK SERIES
<b>SHEET 1</b>	

PREPARED FOR CORPS OF ENGINEERS BY  
ANDERSON, NICHOLS CO. INC. AND  
GOLDBERG, ZOINO & ASSOC., INC.

CORPS OF ENGINEERS

A

B

C

D

E

1

72°00'

71°45'

71°30'

71°15'

42°45'

2

3

4

42°30'

5

6

7

42°15'

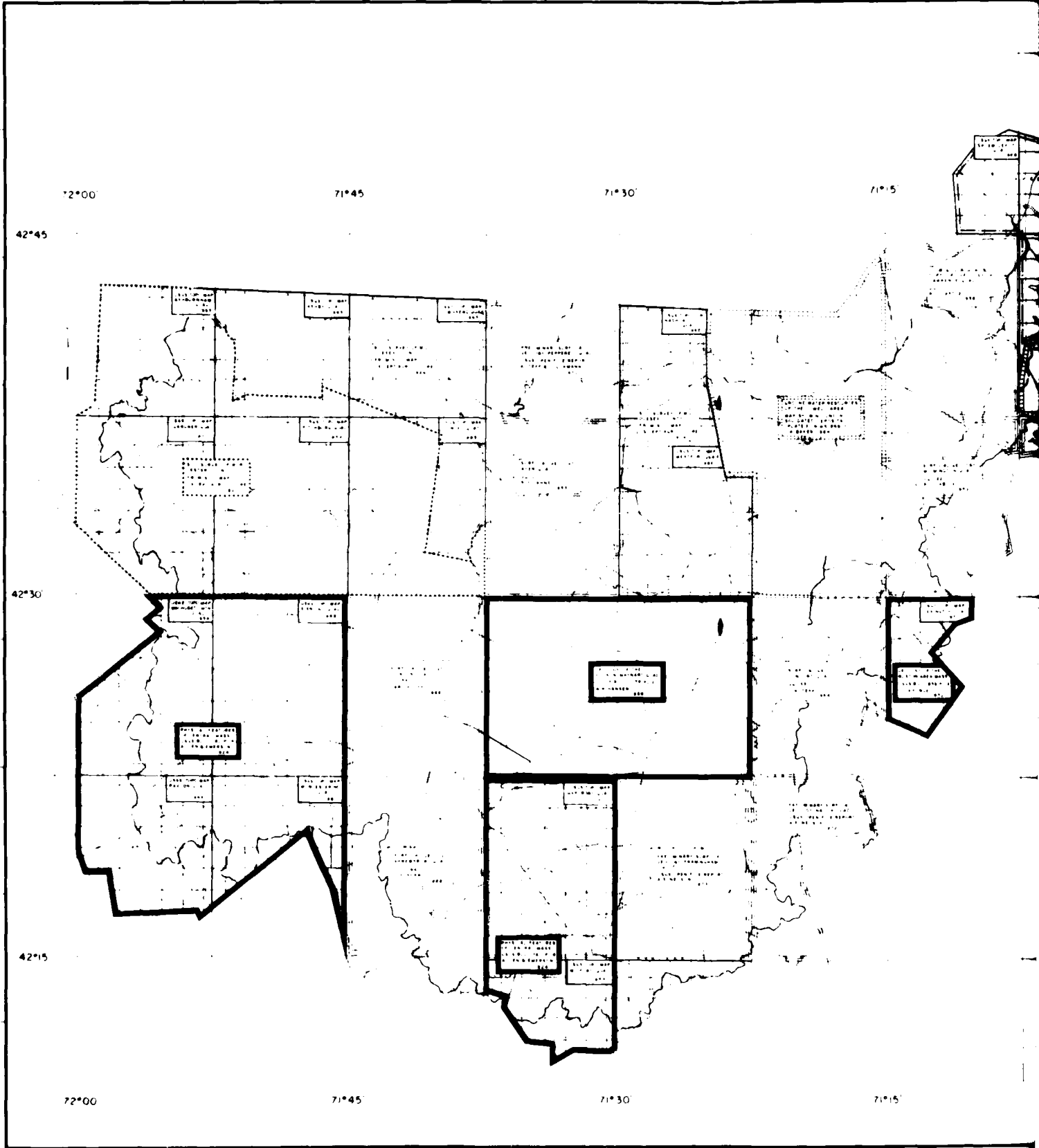
8

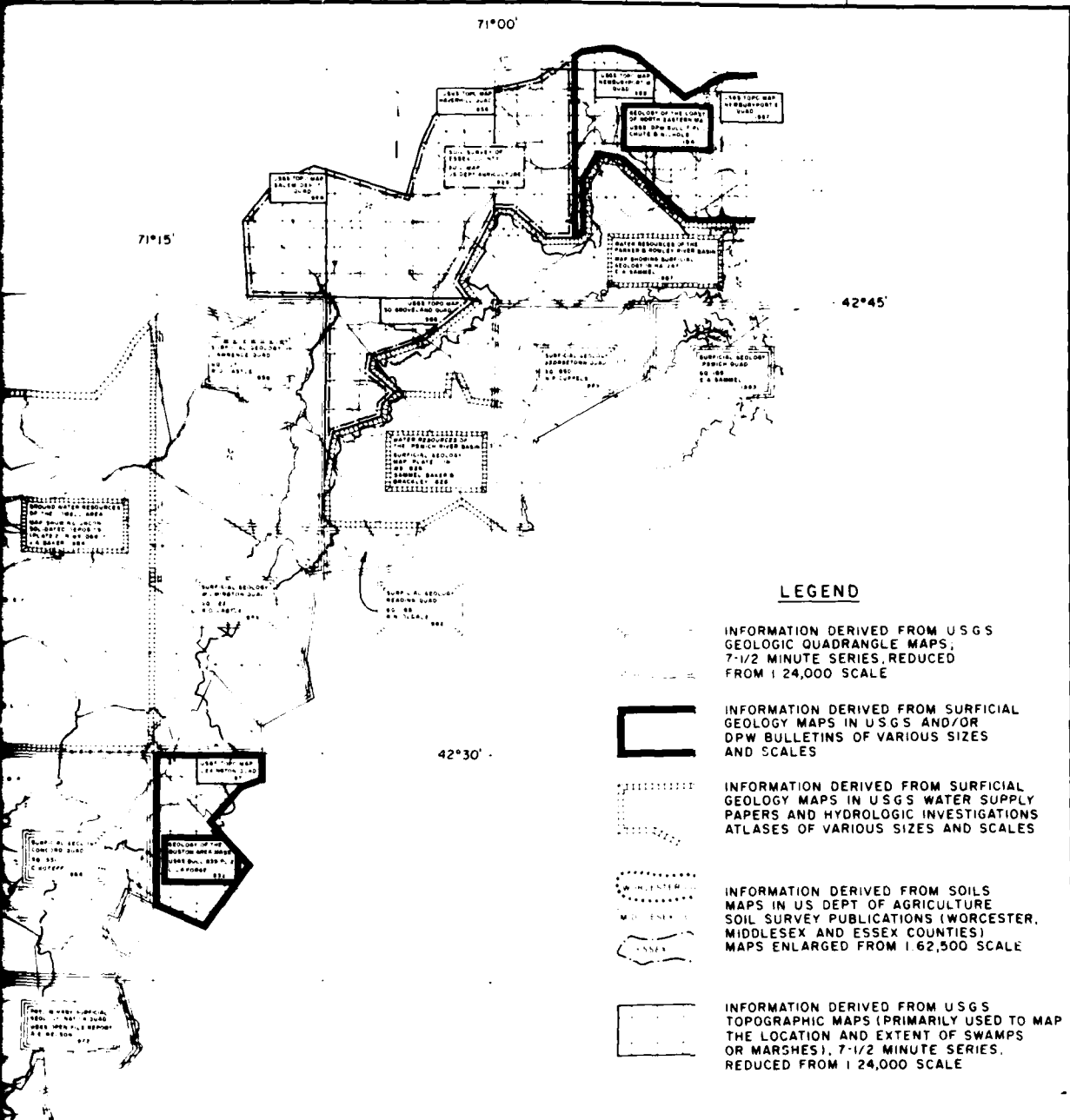
72°00'

71°45'






71°30'

71°15'





**LEGEND**

-  INFORMATION DERIVED FROM USGS GEOLOGIC QUADRANGLE MAPS, 7-1/2 MINUTE SERIES, REDUCED FROM 1:24,000 SCALE
-  INFORMATION DERIVED FROM SURFICIAL GEOLOGY MAPS IN USGS AND/OR DPW BULLETINS OF VARIOUS SIZES AND SCALES
-  INFORMATION DERIVED FROM SURFICIAL GEOLOGY MAPS IN USGS WATER PAPERS AND HYDROLOGIC INVESTIGATIONS ATLASES OF VARIOUS SIZES AND SCALES
-  INFORMATION DERIVED FROM SOILS MAPS IN US DEPT OF AGRICULTURE SOIL SURVEY PUBLICATIONS (WORCESTER, MIDDLESEX AND ESSEX COUNTIES) MAPS ENLARGED FROM 1:62,500 SCALE
-  INFORMATION DERIVED FROM USGS TOPOGRAPHIC MAPS (PRIMARILY USED TO MAP THE LOCATION AND EXTENT OF SWAMPS OR MARSHES), 7-1/2 MINUTE SERIES, REDUCED FROM 1:24,000 SCALE



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION  
CORPS OF ENGINEERS  
WALTHAM, MASS.

**INDEX — SHOWING  
SOURCES OF INFORMATION  
FROM WHICH SURFICIAL  
GEOLOGY MAPS WERE PREPARED**

DES. BY	DR. BY	CA. BY	DATE
SUBMITTED	CHIEF, SECTION	APPROVAL, RECOMMENDATION	DATE
CHIEF, TEST ENG. BRANCH	CHIEF, DIST. BRANCH	APPROVAL, DIST. BRANCH	DATE
CHIEF, BRANCH	CHIEF, BRANCH	APPROVAL, CHIEF ENGINEERING DIVISION	DATE
SCALE	SPEC. NO.	DRAWING NUMBER	SURFICIAL SERIES

OCTOBER 9 '53

SHEET 1 2

71°15'

PREPARED FOR CORPS OF ENGINEERS BY  
ANDERSON, NICHOLS CO. INC. AND  
GOLDBERG, ZIINO & ASSOC., INC.

CORPS OF ENGINEERS

A

B

C

D

E

1

72°00'

71°45'

71°30'

71°15'

42°45'

2

3

4

42°30'

5

6

7

42°15'

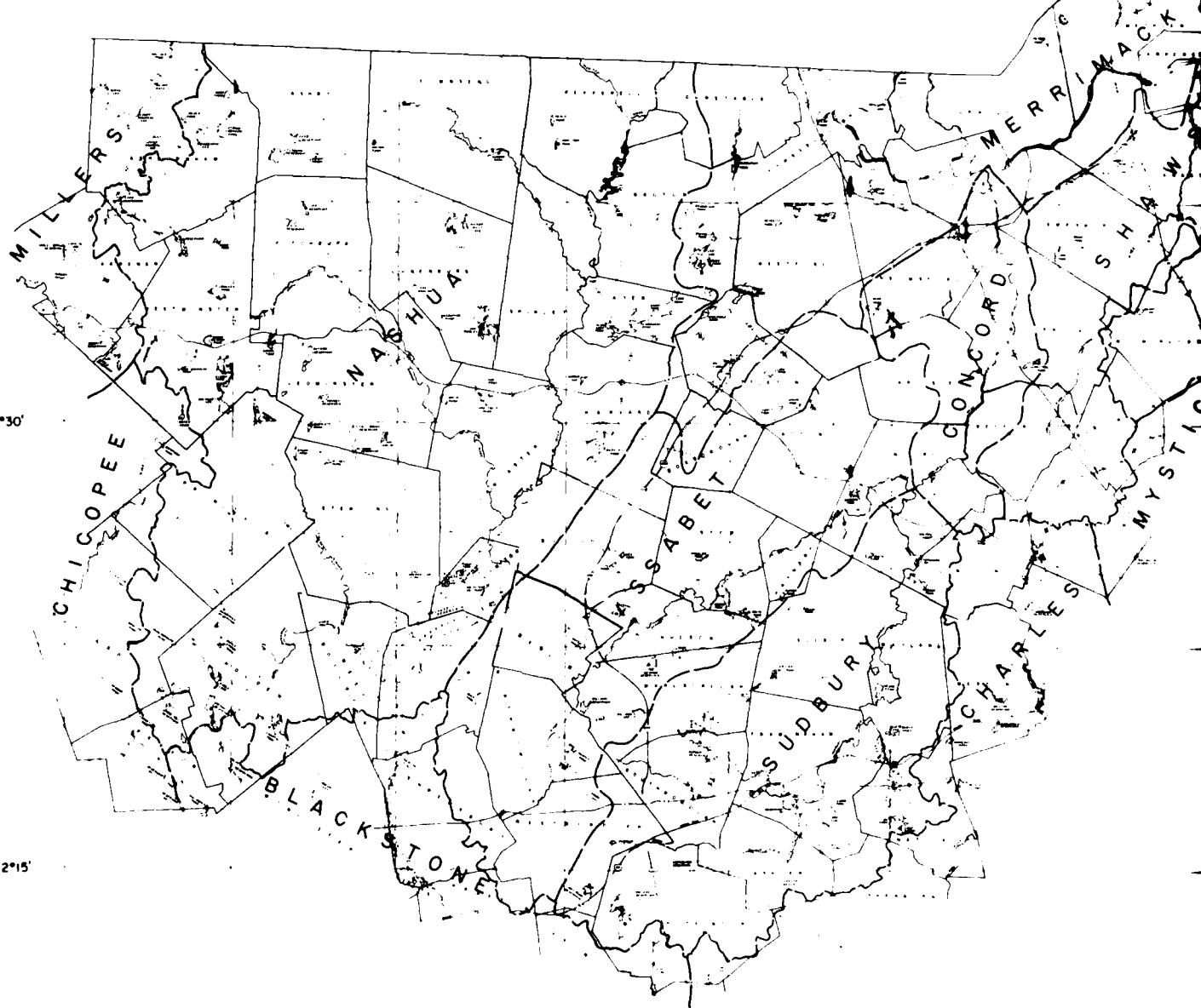
8

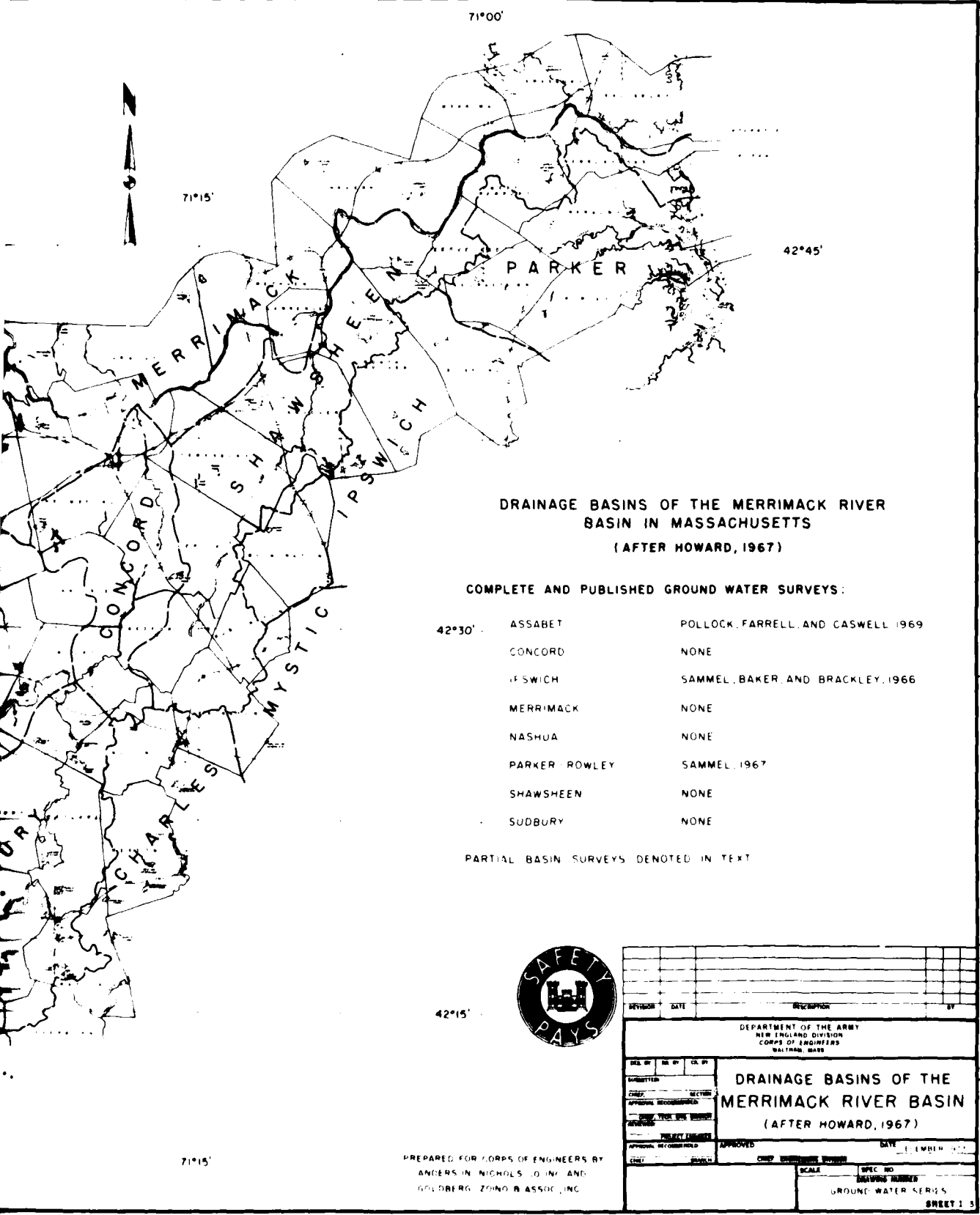
72°00'

71°45'

71°30'

71°15'





**DRAINAGE BASINS OF THE MERRIMACK RIVER  
BASIN IN MASSACHUSETTS  
(AFTER HOWARD, 1967)**

**COMPLETE AND PUBLISHED GROUND WATER SURVEYS:**

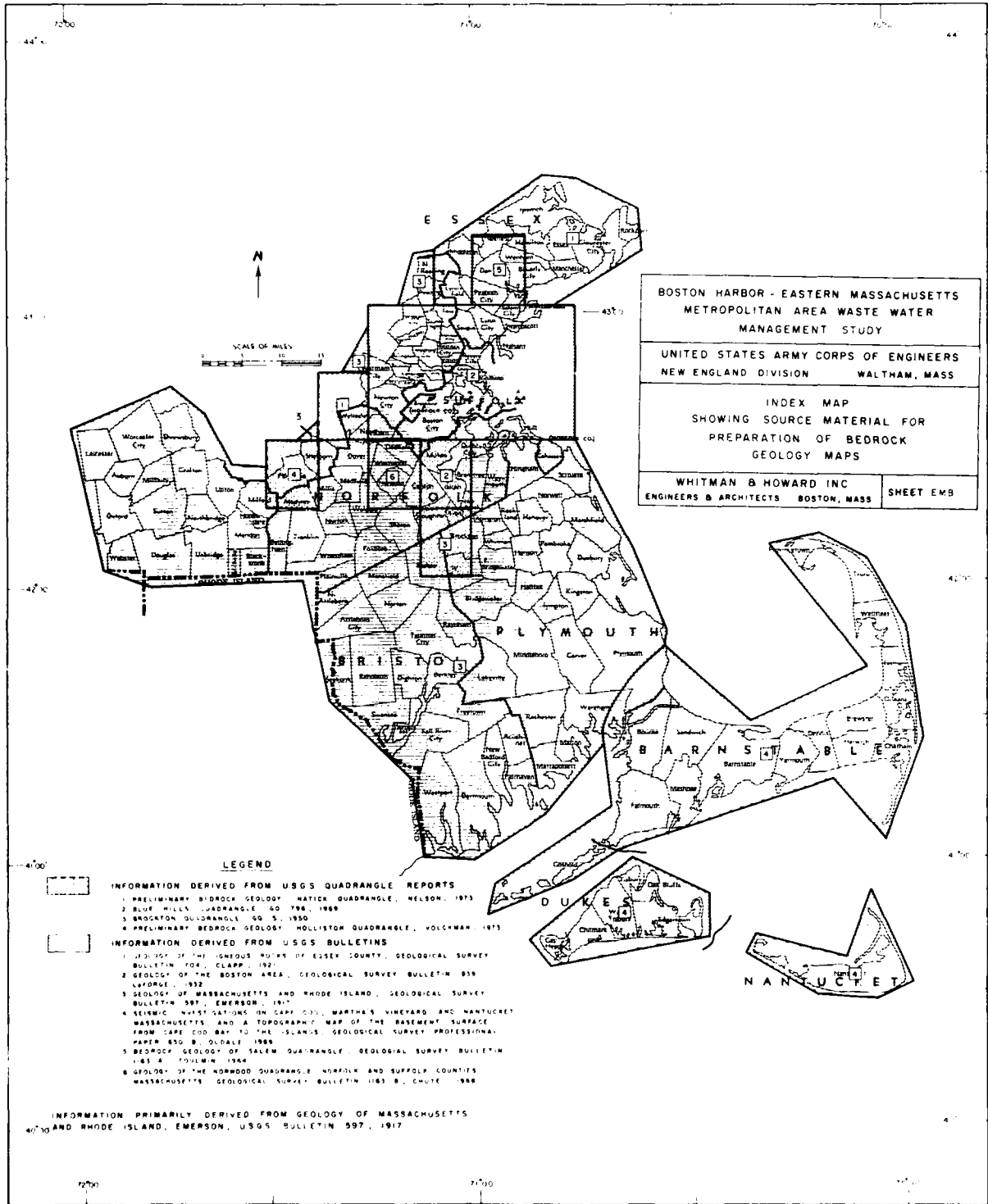
42°30'	ASSABET	POLLOCK, FARRELL, AND CASWELL 1969
	CONCORD	NONE
	IPSWICH	SAMMEL, BAKER, AND BRACKLEY, 1966
	MERRIMACK	NONE
	NASHUA	NONE
	PARKER ROWLEY	SAMMEL, 1967
	SHAWSHEEN	NONE
	SUDBURY	NONE

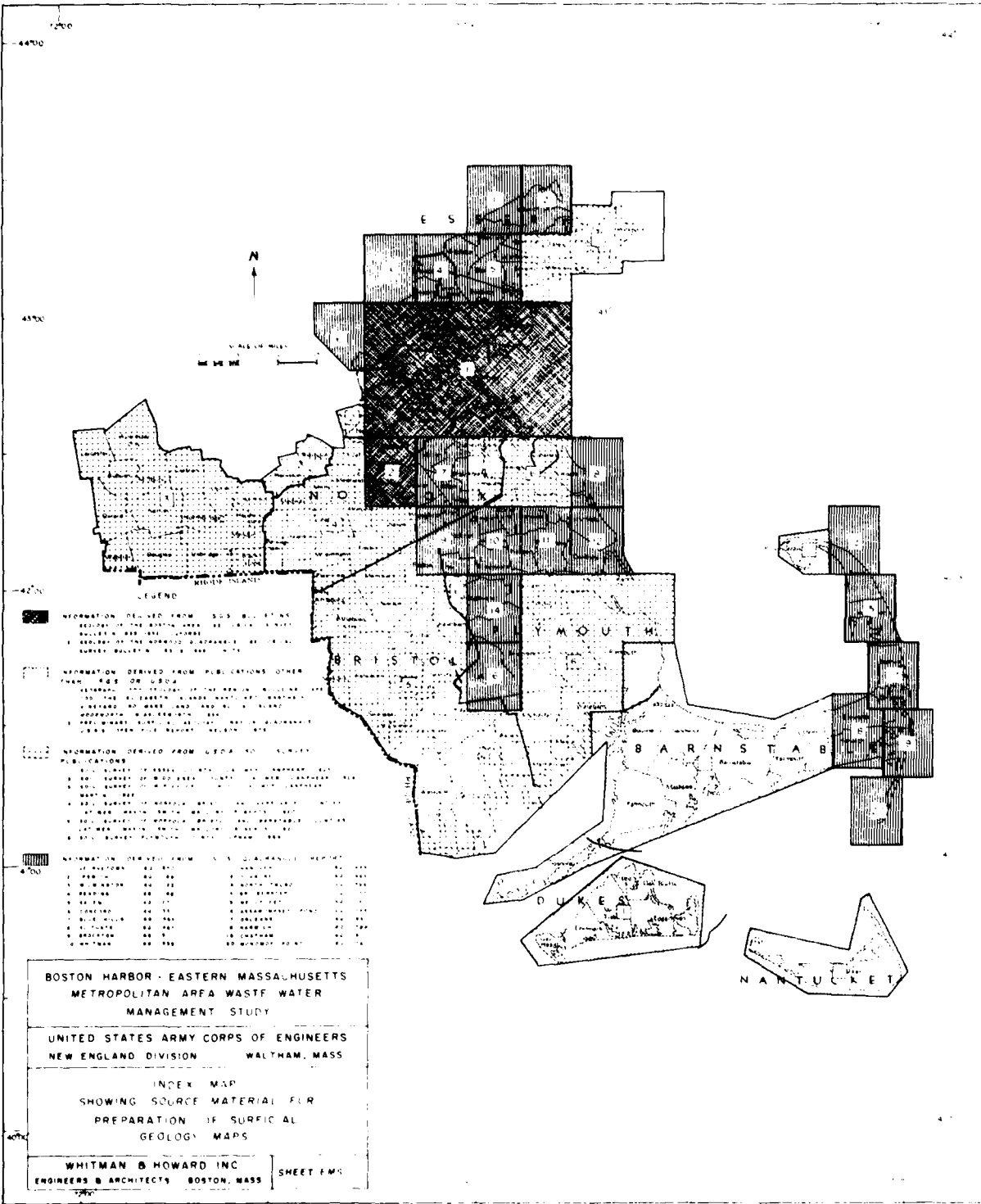
PARTIAL BASIN SURVEYS DENOTED IN TEXT



PREPARED FOR CORPS OF ENGINEERS BY  
ANDERS IN NICHOLS, JOHN AND  
GOLDBERG ZION & ASSOCIATES

REVISION	DATE	DESCRIPTION	BY
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.			
DESIGNED BY DRAWN BY CHECKED BY PROJECT ENGINEER APPROVAL, RECOMMENDED CHIEF	<b>DRAINAGE BASINS OF THE MERRIMACK RIVER BASIN (AFTER HOWARD, 1967)</b>		
APPROVED CHIEF ENGINEERING DIVISION	DATE: <u>  </u> <u>  </u> <u>  </u>		
SCALE SPEC. NO. DRAWING NUMBER GROUND WATER SERIES	SHEET 1 5		





- LEGEND**
- INFORMATION DERIVED FROM U.S. GEOLOGICAL SURVEY OF THE BOSTON AREA AND OTHER AREAS SURVEYED BY THE U.S. GEOLOGICAL SURVEY BUREAU OF GEOGRAPHIC NAMES, 1902-1904.
  - INFORMATION DERIVED FROM PUBLICATIONS OTHER THAN U.S. GEOLOGICAL SURVEY OF THE BOSTON AREA AND OTHER AREAS SURVEYED BY THE U.S. GEOLOGICAL SURVEY BUREAU OF GEOGRAPHIC NAMES, 1902-1904.
  - INFORMATION DERIVED FROM U.S. GEOLOGICAL SURVEY OF THE BOSTON AREA AND OTHER AREAS SURVEYED BY THE U.S. GEOLOGICAL SURVEY BUREAU OF GEOGRAPHIC NAMES, 1902-1904.
  - INFORMATION DERIVED FROM U.S. GEOLOGICAL SURVEY OF THE BOSTON AREA AND OTHER AREAS SURVEYED BY THE U.S. GEOLOGICAL SURVEY BUREAU OF GEOGRAPHIC NAMES, 1902-1904.
  - INFORMATION DERIVED FROM U.S. GEOLOGICAL SURVEY OF THE BOSTON AREA AND OTHER AREAS SURVEYED BY THE U.S. GEOLOGICAL SURVEY BUREAU OF GEOGRAPHIC NAMES, 1902-1904.

**BOSTON HARBOR - EASTERN MASSACHUSETTS  
 METROPOLITAN AREA WASTE WATER  
 MANAGEMENT STUDY**

---

**UNITED STATES ARMY CORPS OF ENGINEERS  
 NEW ENGLAND DIVISION      WALTHAM, MASS**

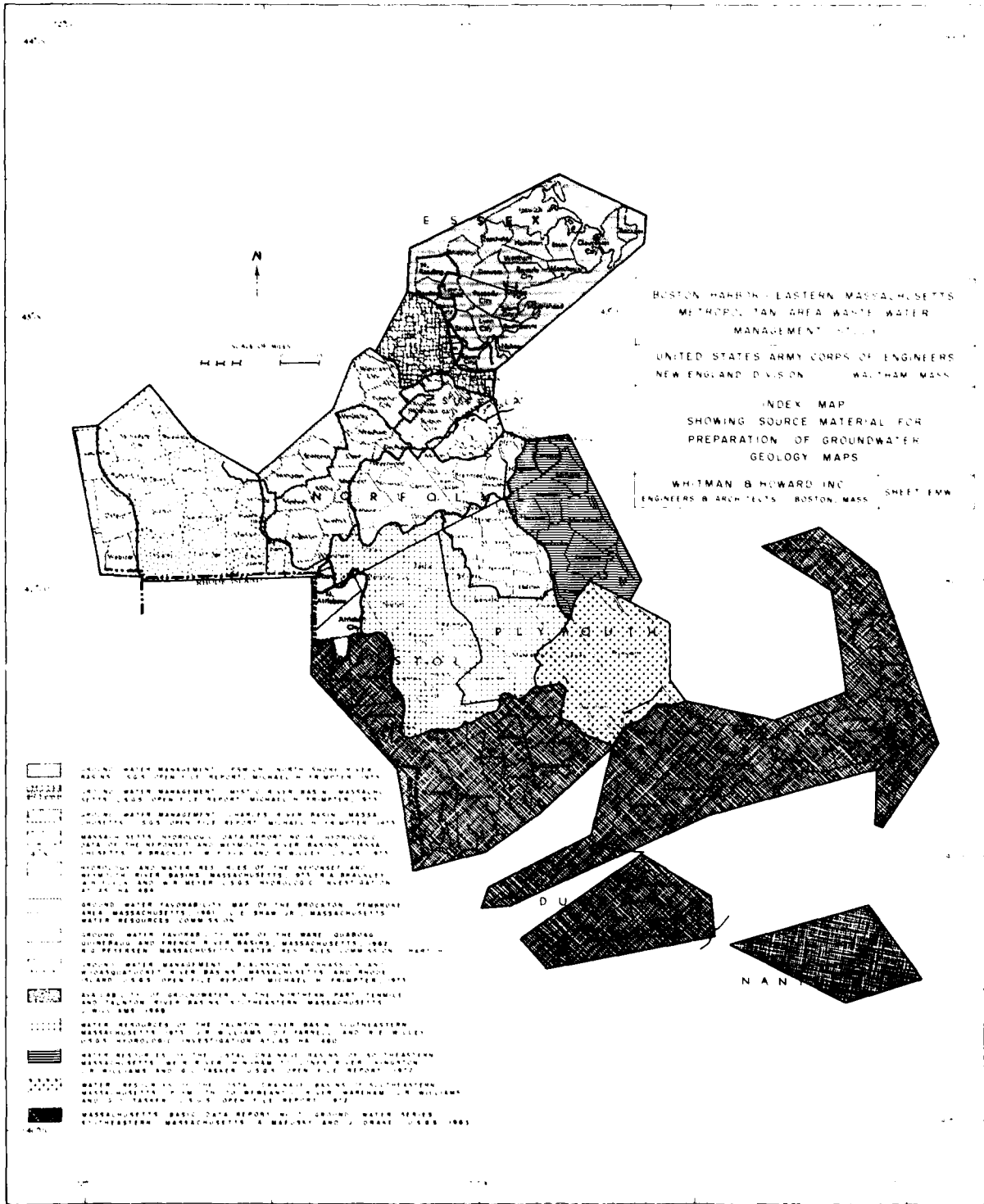
---

INDEX MAP  
 SHOWING SOURCE MATERIAL FOR  
 PREPARATION OF SURFICIAL  
 GEOLOGY MAPS

---

WHITMAN & HOWARD INC.      SHEET F-10  
 ENGINEERS & ARCHITECTS      BOSTON, MASS





## B. Surficial Geology Maps

The sources of available information from which the surficial geology maps were prepared include: U.S. Geological Survey Quadrangle Maps (GQ Series); Surficial Geology Maps in U.S. Geological Survey and Massachusetts DPW Bulletins; Surficial Geology Maps and "materials" maps in U.S. Geological Survey Water Supply Papers; Soil Maps in U.S. Department of Agriculture Publications and U.S. Geological Survey Topographic Maps (7-1/2 Minute quadrangles). Where applicable, information derived from studies other than described above were incorporated. These included open file reports and The Geography and Geology of the Region Including Cape Cod, the Elizabeth Islands, Nantucket, Martha's Vineyard, No Man's Land, and Block Island by J.B. Woodworth and E. Wigglesworth.

When available, the maps of the U.S.G.S. Bulletins, Quadrangle Reports and Open File Reports were regarded as the most accurate description of the surficial deposits and were, therefore, used without alteration. The maps contained in the Woodworth and Wigglesworth publication were used to describe those areas of the Cape and the Islands where no U.S.G.S. maps were available. Lastly, where no other source of information was available, the soils of Eastern Massachusetts were grouped together into categories determined by the type of surficial sediment which they most likely overlie. Then, using the various county soils maps and U.S.G.S. topographic maps (for swamp and marsh determination) the surficial deposits were plotted on the base map.

## C. Ground Water Geology Maps

Sources of information used in compiling the ground water geology maps of the study area consisted of maps and descriptive material included in: (a) ground water favorability studies by the U.S. Geological Survey and the Massachusetts Water Resources Commission; (b) U.S. Geological Survey Hydrologic Investigations Atlases; and (c) U.S. Geological Survey Open File Reports. Ground water data on file at the Ground Water Branch of the U.S. Geological Survey in Boston, Massachusetts and included in Massachusetts Basic Data Reports was also used.

## D. Index Maps

Listings of the specific maps and other source materials used for the various subdivision of the study area are given on the index maps immediately following this section of the report. Sheets I-1, I-2 and I-3 show the bedrock, surficial and ground water source material used to compile the Merrimack Basin part of the study and sheets EMB, EMS, and EMW list the respective source materials used in the Eastern Massachusetts portion of the study.

## V. EXPLANATION OF LEGEND AND MAPPING PROCEDURES

### A. Bedrock

Considering all the available information, a partial map illustrating the distribution and extent of rock units mapped by modern workers could be prepared. Or, on the other hand, a complete map showing the location and occurrence of rock units for the entire study area could be taken from the early study by Emerson in 1917. It would be impossible to completely reconcile the two contrasting series of data and yet maintain the meaning and intent of either. We have chosen the latter course of action, that being to use Emerson's work as the basis for our mapping. His bedrock units within the study area have been divided into two groups: (1) Igneous Rocks, and (2) Sedimentary and Meta-Sedimentary Rocks. Within these groups, Emerson's descriptions and names have been used for the various rock units he identified and mapped. More recent information has been added to the maps whenever it was sufficiently extensive so as to provide continuity among the mapped units. These data include new names applied to some of Emerson's unnamed formations, additional rock units identified by modern workers in certain areas, and regrouped or "lumped" rock units that today are thought to be similar in composition, age and structural relationships.

The bedrock beneath the area southeast of a line roughly parallel to, and approximately 15 miles northwest of, the Cape Cod Canal including the Cape itself, Martha's Vineyard, Nantucket and the smaller islands of Nantucket Sound is overlain by such thick surficial deposits that few wells have encountered bedrock. For this reason, little is known about the nature of the underlying rock. Where wells have penetrated the overlying cover and have reached bedrock, they have been plotted and the depth to bedrock (in feet below sea level) has been recorded. Interpretation of the cuttings has been recorded on the map for those wells for which there was available data. Otherwise, this area, which appears on sheet EMB-3 has been shown with contour lines indicating depth to bedrock in feet below sea level. These contours were largely taken from the seismic study of Cape Cod and the Islands published by R.N. Oldale in 1969. They have, however, been re-drawn where shown to be inaccurate near the presently existing well sites.

### B. Surficial Geology

The several source materials used in the preparation of the surficial maps varied both in the manner and the intent for which they were written. In some of the sources, the deposits were classified on lithology alone, in others the classification tended to be based on morphological characteristics (e.g. kame terraces and outwash plains) and in still others the classification was more genetic such as various lake stages or formational units. For purposes of this report, a classification system was developed which could incorporate and be compatible with all of the available data.

The surficial deposits of the area were divided into two primary groups: (a) coarse grained sediments and (b) fine grained and/or organic sediments. This distinction, while primarily based on grain size, also incorporates such closely-related properties as dry unit weight, water content, plasticity, porosity and consolidation. Each of the two primary groups was then subdivided into four categories on the basis of origin. Table 2 lists the various deposit classifications, the map symbols assigned for each, some comments regarding the origin and lithologic materials description of each category, and a list of representative land forms exhibited by each of the deposits.

Some of the deposits in the eastern Massachusetts area are quite small in areal size and thus are difficult to recognize on the maps of that part of the study area. For this reason they are assigned letter as well as pictorial symbols. The scale used in the eastern Massachusetts part of the study also required that the fine grained and/or organic soils be subdivided into two categories rather than the four categories used in the Merrimack study. Areas shown on the maps of the eastern Massachusetts portion of the study area by crosshatching represent glaciolacustrine and glaciomarine fine grained sediments. The former, consisting chiefly of glacial lake bottom sediments, are further designated by the letter Qlf and the latter, designated by Qmf, are the fine grained marine deposits of the once offshore marine terraces and plains.

The solid black symbol represents the organic deposits with the salt water organics distinguished from the freshwater organics by the symbols Qom and Qof respectively. Since most of the organic deposits were of freshwater origin, only those areas where there may be doubt were given the aforementioned distinguishing letter symbols, otherwise any solid black area is to be considered as a freshwater organic deposit. Generally, the freshwater deposits are found in old lake basins, cutoff river meanders, kettle holes or dammed off glacial valleys, whereas the marine organics are found near river mouths, along estuaries and in tidal flats and marshes.

One other type of deposit occurs only within the metropolitan Boston area of sheet EMS-1 in large enough extent to be mapped. This is the artificial fill that has built up over the past three hundred years, and upon which much of Boston, Cambridge, and Chelsea is built. This artificial fill is represented by the "patchwork quilting" type symbol directly below the standard legend on Map EMS-1.

Table 3 describes the engineering characteristics of the aforementioned eight types of surficial sediments. The information shown here was taken from the Engineering Geology of the Northeast Corridor, Washington, D.C., to Boston, Massachusetts, Coastal Plain and Surficial Geology, 1967, U.S.G.S. Miscellaneous Geologic Investigations Map I-514-B, Sheet 7.

### C. Ground Water Geology

Due to marked differences in availability and content of source material, the Merrimack and eastern Massachusetts portions of the study area were treated differently with respect to evaluation of ground water favorability. Index maps I-3 and EMW list the source materials and well illustrate the contrast between the abundance of data available for the eastern Massachusetts report and the relatively small amount of material which has been completed in the Merrimack Basin. One further point which will help in the interpretation of the ground water favorability categories formulated for both parts of the study area is the fact that much of the analysis in the Merrimack area was based on data gathered from private small yield wells while yields from municipal and other large wells made up a large part of the data used to draw up favorability maps for the eastern Massachusetts area.

#### Merrimack Basin

With the exception of a ground water favorability map of the Assabet Basin, little comprehensive data regarding ground water occurrence in the Merrimack River Basin in Massachusetts has been compiled and published. It was necessary, therefore, to employ the closely corresponding relationship between the surficial and ground water geology characteristics evidenced in areas which had been mapped for both and then extrapolate that relationship in other parts of the basin for which only the surficial geology is mapped. Complemented by some local data and some ground water geology maps of adjoining basins, the extrapolation was used as the means to formulate ground water favorability maps of the Merrimack Basin. The patterns shown on the maps must be considered reconnaissance estimates everywhere except in the Assabet basin.

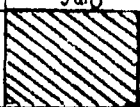

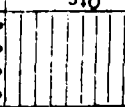
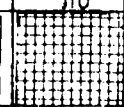

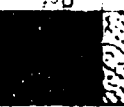


The same ground water favorability categories used by the U.S. Geological Survey in their study of the Assabet Basin were also used in this study of the entire Massachusetts portion of the Merrimack Basin. These categories are:

a. Areas where most wells will yield less than 25 gallons per minute. The aquifer consists of poorly permeable material, chiefly till and bedrock, but also includes some areas of sand and gravel, the saturated thickness of which is generally less than 25 feet. This category is unfavorable for the development of ground water supplies. The unfavorable areas are shown in sheet W as having no pattern other than surficial geology pattern.

b. Areas where yields from properly constructed wells may range from 25 to 75 gallons per minute (also includes some areas whose ground water potential is unknown). In these areas the aquifers consists of sand and gravel, the saturated thickness of which generally is greater than 25 feet. This category is favorable for development of moderate ground water supplies. These areas are shown as a pattern of closely-spaced stippling over the surficial geological map units.

TABLE 2

SUMMARY OF MATERIALS USED  
on  
SURFICIAL GEOLOGY MAPS

SYMBOL used on PLANS	DEPOSITS	ORIGIN (Transportational and/or Depositional Agent)	REPRESENTATIVE LAND FORMS	MATERIAL DESCRIPTION
	Glacio-fluvial Glacio-lacustrine (stratified drift; outwash and ice contact)	via Glacial streams	Outwash Plains, Kame Terraces, Kames, Eskers, Crevasse Fillings; Kame deltas, Esker deltas	SANDS or SANDS & GRAVELS; Silt and/or Clay portions usually minor - may include cobbles--stratified, moderate to well sorted.
	Glacio-marine Dune deposits	Reworked glacial & stream deposits-via tidal action, currents; wind blown	Marine terraces, Marine plains, Dunes, Beaches, Bars	primarily fine or fine to medium SANDS well sorted - often stratified and cross-bedded.
	Fluvium & River Terrace deposits	via Recent rivers and streams	Flood plains, Alluvial terraces, Alluvial flats, Alluvial fans, stream terraces	SAND, SILT, with minor amounts of Gravel and/or Clay - poorly to moderately sorted and stratified.
	Glacial Till (non-stratified drift deposits)	Subglacial, Superglacial (Lodgement & Ablation), Flow till	Ground Moraine, End Moraine, Drumlins, Slumped/Flow structures	Silty or Clayey SANDS & GRAVELS with cobbles and boulders - generally dense, non-stratified, unsorted mixture; locally variable.
	Glacio lacustrine (stratified drift)	via Glacial streams into glacial lake bottoms	Lake basins, Lake beds	SILTS, Clayey SILTS, Silty SANDS, varved Silts and Clays
	Glacio-Marine	via Glacial streams into offshore marine environment	Marine plains, marine terraces	Silty CLAYS, SILTS and CLAYS, SILTS, Silty fine SANDS.
	Fresh water Organic deposits	Eutrophication of ponds, lakes, etc	Kettle holes, morainal depressions, lake basins, river meanders	PEATS, Sandy PEATS, Silty PEATS, Organic Sands or Silts, Muck
	Marine Organic deposits	Accumulation of organic detritus associated with the flooding of coastal plains	Estuaries, tidal marsh and mud flats; river mouths	ORGANIC SILTS, Clayey Organic Silts, Organic Sands, Marsh Mats, Muck

Coarse-Grained Soils

Fine-Grained and/or Organic Soils

TABLE 3 ENGINEERING CHARACTERISTICS OF SURFICIAL DEPOSITS

Map Unit	Foundation Conditions <sup>1</sup>	Excavation Characteristics	Slope Stability <sup>2</sup>
Qsc	Bearing capacity of sand and gravel fair to good; of silt and clay, less. Local artesian water pressure reduces bearing values. Vibratory loading on sand may cause settlement.	Easy to excavate by power equipment; in valleys of tidal rivers may be excavated by dredge.	Excavations below water table require support.
Qmc	Bearing capacity poor to fair; improved by vibration.	Easy to excavate with power equipment. Beach sand to dredge.	Cut slopes stable to angle of repose; steeper slopes need lagging because sand is free running when dry; readily flows into excavations below water table.
Qcl	Bearing capacity poor to fair in sandy alluvium; very poor to poor on silt, clay. Structures founded over small lenses of sand possible clay or silt settle unevenly. Water table shallow. Compressibility and expansion negligible except in thick organic deposits.	Easy to excavate by power equipment; in rivers may be excavated by dredge.	Excavations below water table require support.
Qtc	Bearing capacity generally good because of high density and poor sorting. Expansion negligible.	Generally easy to redredately difficult to excavate with power equipment. Highly compacted till ("hardpan"), and very strong and bouldery till can be troublesome to excavate without special equipment.	Cuts higher than 40 ft. generally require individual stability analysis. For lower slopes, 1 1/2 on 1 to 2 or 1 generally considered safe. Vertical slopes up to 15 ft. common, particularly in more cohesive clayey till.

Map Unit	Foundation Conditions <sup>1</sup>	Excavation Characteristics	Slope Stability <sup>2</sup>
Q1f, Qmf	Bearing capacity generally poor. Where oxidized and preconsolidated, capacity fair. When confined and loaded, pore-water pressure increases and shearing strength decreases. Where saturated, dewatering may cause consolidation over large area. Compressibility high to low; expansion negligible to moderate.	Easy to excavate; wet conditions hamper construction equipment. "Quick" reaction to vibration in silt.	Generally unstable except in shallow dewatered cuts with gentle slopes. Support usually required. Clay is somewhat fissured and may fail along vertical joints. Sensitivity low.
Qof, Qom	Bearing capacity very poor. Compressibility high.	Easy to excavate by dredge or dragline.	Unstable; flows readily into underwater excavations.

<sup>1</sup>Bearing capacity - numerical values (tons per square foot) applied to qualifying adjectives:

Very poor	less than 1	Vertical	50
Poor	1-4	Near vertical	5-10
Fair	4-8	Steepl	15-20
Good	8-32	Moderate	30-45
Excellent	greater than 32	Gentle	0-30

<sup>2</sup>Cut slopes - numerical values, in degrees, applied to qualifying adjectives:

Compressibility - volume decrease in a soil mass in response to an external load.  
Expansion - volume increase that is a function of load, time, density, water content, and type of clay minerals.



c. Areas most favorable for the location of wells that may yield more than 75 gallons per minute. This unit generally consists of sand and gravel, the saturated thickness of which is greater than 25 feet. Although yields from wells in these areas may, in places, range as high as 500 gallons per minute, the most common safe yield from properly constructed wells is probably in the 100 to 150 gallons per minute range. This category is favorable for development of moderate to large volumes of ground water. These areas, which are shown in sheet W by the large dot stipplings, are considered the least completely mapped outside the Assabet, particularly along river channels and in towns where water supply data is not readily available.

#### Eastern Massachusetts

The legend produced for this study of the favorability of ground water is based on U.S.G.S. mapping legends which describe the aquifers and the potential ground water yields that can be expected from those aquifers in this area. This study defines three categories of aquifers and the expected yields to be obtained from them. The three categories are:

- a. Favorable for development of moderate to large volumes of ground water; saturated thickness generally larger than 40 feet; generally capable of yielding more than 300 gpm.
- b. Favorable for development of low to moderate volumes of ground water; saturated thickness generally from 20 to 40 feet; generally capable of yields from 100 to 300 gpm.
- c. Favorable for development of low volumes of ground water; saturated thickness generally less than 20 feet; generally capable of yields from 0 to 100 gpm with the lowest yields in till.

This legend should be interpreted as a qualitative description of ground water favorabilities. Not all the areas have quantitative data in the form of actual well yields.

#### VI. CONCLUSIONS

A report of the geology of eastern Massachusetts was compiled from existing literature. This study is a summary of two more detailed studies which deal with: (a) the geology of the Massachusetts portion of the Merrimack Basin and (b) the geology of Massachusetts east of longitude 71°, 52', 30" W, excluding the Merrimack Basin. These reports are on file at the U.S. Army Corps of Engineers, NED, Waltham, Massachusetts.

The bedrock, surficial and ground water geology of the study area is discussed along with the source material from which this information was derived. Maps illustrating the bedrock, surficial and ground water geology for the Merrimack and eastern Massachusetts portions of the study were prepared and printed with this report.

Index maps showing the various specific references used for various locations within the study area are included in this summary along with a selected bibliography listing published and unpublished source material.

SELECTED BIBLIOGRAPHY

- Alder, W.C., 1924, Physical features of central Massachusetts:  
U.S. Geological Survey Bulletin 760-B.
- Alden, W.C., and Emerson, B.K., Map showing quaternary geology of the  
Ware and Quinsigamond quadrangle, Massachusetts; in Alden, W.C.,  
1924, Physical features of central Massachusetts: U.S. Geological  
Survey Bulletin 760-B.
- Allen, W.B., Halberg, H.N., and Pistrang, M.A., 1952, Preliminary  
investigation of the groundwater resources of the Merrimack River  
drainage basin; New Hampshire and Massachusetts: U.S. Geological  
Survey open file release, p. 32.
- Baker, J.A., 1964, Groundwater resources of the Lowell area, Massachusetts:  
U.S. Geological Survey Water Supply Paper WS 1669-4.
- Barosky, P.J., 1969, Use of Seismic intensity data to predict effects  
of earthquakes and underground explosions in various geologic  
settings: U.S. Geological Bulletin 1279, p. 91.
- Bell, K.G., 1948, Geology of Boston Metropolitan Area, unpublished  
PHD Thesis, M.I.T.
- Bell, K.G., et. al, 1973, in USGS/DPW Cooperative Program Annual Report.
- Bentall, Ray, 1963, Methods of collecting and interpreting groundwater  
data, U.S. Geological Survey Water Supply Paper 1544-H.
- Billings, Marland P., 1956, The geology of New Hampshire, Part II,  
Bedrock geology: The Department of Resources and Economic  
Development, Concord, New Hampshire.
- Bloom, A.L. and Stuiver, M., 1963, Submergence of the Connecticut Coast;  
Science, V. 139, p. 322-334.
- Brackley, R., Fleck, W., and Willey, R.; 1973; Hydrologic Data of the  
Neponset and Weymouth River Basins, Massachusetts; Massachusetts  
Hydrologic Data Report No. 14; U.S.G.S.
- Brackley, R., Fleck, W., and Meyer, W.R.; 1973; Hydrology and Water  
Resources of the Neponset and Weymouth River Basins, Massachusetts;  
U.S.G.S. Hydrologic Investigation Atlas HA-484.
- Bradley, Edward, 1964, Geology and groundwater resources of southeastern  
New Hampshire: U.S. Geological Survey Water Supply Paper WS 1695.

- Brooks, S.J., Rev. J.E., 1959, A Study in seismicity and regional geology: Master's thesis, Boston College.
- Castle, R.O., 1958, Surficial geology of the Lawrence quadrangle, Massachusetts-New Hampshire: U.S. Geological Survey GQ-107.
- 1959, Surficial geology of the Wilmington quadrangle, Massachusetts: U.S. Geological Survey GQ-122.
- 1965, A Proposed Revision of the Subalkaline Intrusive Series of Northeastern Massachusetts: U.S. Geological Survey Professional Paper 525-C, p. C74-C-80.
- Chute, N.E., 1950, Bedrock Geology of the Brockton Quadrangle, Massachusetts; U.S.G.S. Quadrangle Report GQ-5.
- 1950, Surficial Geology of the Brockton Quadrangle, Massachusetts; U.S.G.S. Quadrangle Report GQ-6.
- 1959, Glacial geology of the Mystic Lakes-Fresh Pond area, Massachusetts: U.S. Geological Survey Bulletin 1061F.
- 1965, Surficial Geology of the Blue Hills Quadrangle, Norfolk, Suffolk and Plymouth Counties, Massachusetts; U.S.G.S. Quadrangle Report GQ-463.
- 1965, Geologic Map of the Duxbury Quadrangle, Plymouth County, Massachusetts; U.S.G.S. Quadrangle Report GQ-466.
- 1965, Geologic Map of the Scituate Quadrangle, Plymouth County, Massachusetts; U.S.G.S. Quadrangle Report GQ-467.
- 1966, Geology of the Norwood Quadrangle, Norfolk and Suffolk Counties, Massachusetts; U.S.G.S. Bull. 1163-B, p. B1-78.
- 1969, Bedrock Geologic Map of the Blue Hills Quadrangle, Massachusetts; U.S.G.S. Quadrangle Report GQ-796.
- Chute, N.E. and Nichols, 1941, Geology of the coast of northeastern Massachusetts: U.S. Geological Survey-Department of Public Works Bulletin 7.
- Chung, A., and Ingersoll, J.S., 1973, Unpublished seismicity data: Weston Geophysical Observatory.
- Clapp, Charles H., 1921, Geology of the igneous rocks of Essex County, Massachusetts: U.S. Geological Survey Bulletin 104.

- Crosby, I.B., 1937, Groundwater conditions in parts of Middlesex, Worcester and Norfolk Counties in the buried valleys of the pre-glacial Merrimack, Sudbury and Charles Rivers: Massachusetts Department of Public Health Annual Report, p. 219-224.
- 1939, Groundwater in the pre-glacial buried valleys of Massachusetts: New England Water Works Association Journal, V. 53, p. 372-383.
- Crosby, W.O., 1899, Geological history of the Nashua Valley during the Tertiary and Quaternary periods: Tech. Quart., V. 12, p. 288-324.
- Cupples, N.P., 1969, Surficial geologic map of the Georgetown quadrangle, Essex County, Massachusetts: U.S. Geologic Survey GQ-850.
- Currier, L.W., 1954, Gravel and sand resources of the New England-New York region: U.S. Geological Survey open file report.
- DeVane, S.J., Rev. J.F., & Holt, R.J., 1967, The seismic history of Massachusetts: in Farquhar, O.C., (ed.), Economic geology of Massachusetts, p. 373-377.
- Driver, Hrutfiord, Spyridakis, Welch & Wooldridge, 1972, Assessment of the effectiveness and effects of land disposal methodologies of wastewater management, Department of the Army, Corps of Engineers: Wastewater Management Report 72-1.
- Emerson, B.K., 1917, Geology of Massachusetts and Rhode Island: U.S. Geological Survey Bulletin 507.
- Estand, L., & Rosenbluth, E., 1964, The Spectra of earthquakes at moderate and large distances: Soc. Mex. Seis. Engr., V. 2, No. 1.
- Evernder, J.F., Hibbard, R.R., & Schneider, J.F., 1973, Interpretation of seismic intensity data: Bull. Seis. Soc. America, 63, p. 300-420.
- Fahlquist, F.S., & Berkey, C.F., 1935, Geology of region in which Quabbin Aqueduct and Quabbin Reservoir are located: Met. Dist. Water Supply Comm. Annual Report.
- Fenneman, N.M., 1937, Physiography of eastern United States: New York, McGraw-Hill Book Co., Inc.
- Frimpter, M.H., 1973, Groundwater Management-Ipswich-North Shore River Basins: U.S.G.S. Open File Report.
- 1973a, Groundwater Management - Mystic River Basin, Massachusetts: U.S.G.S. Open File Report.

1973b, Groundwater Management - Charles River Basin, Massachusetts; U.S.G.S. Open File Report.

1973c, Groundwater Management - Blackstone, Moshassuck and Woesaquatucket River Basins, Massachusetts and Rhode Island; U.S.G.S. Open File Report.

Goldsmith & Page, 1973, U.S. Geological Survey-Department of Public Works: Annual Report for fiscal year 1973.

Goldthwait, M.W., Goldthwait, L., & Goldthwait, R.P., 1961, The geology of New Hampshire: Part I, Surficial geology: New Hampshire Department of Resources & Economic Development, Concord, New Hampshire.

Hansen, W.R., 1956, Geology of the Hudson-Maynard quadrangle: U.S. Geologic Survey Bulletin 1038.

Hartshorn, J.H., 1960, Geology of the Bridgewater Quadrangle, Massachusetts; U.S.G.S. Quadrangle Report GQ-177.

Hartwell, Allan D., 1970, Hydrography and holocene sedimentation of the Merrimack River estuary, Massachusetts: Department of Geology, University of Massachusetts, Contribution No. 5-CRG.

Howard, Paul F., 1967, Use of geology in the development of groundwater supplies in New England: in Economic Geology in Massachusetts: University of Massachusetts publication.

Jackson, M.W., 1967, Thresholds of damage due to ground motion: in Proceedings, International symposium on wave propagation and dynamic properties of earth materials: University of New Mexico, Albuquerque, N.M., p. 161-173.

Jahns, R.H., 1953, Surficial geology of the Ayer quadrangle, Massachusetts: U.S. Geologic Survey GQ-71.

Jahns, Willard & White, 1954, Preliminary bedrock geologic map Lowell-Westford area, Massachusetts: U.S. Geologic Survey open file map.

Kanai, H., 1941, An empirical formula for the spectrum of strong earthquake motions: Bull. J. Res. Inst. Tokyo University, 49, p. 35-95.

Katz, Frank L., & Giffin, Arthur, 1961, The geology of Maine, New Hampshire and Massachusetts: U.S. Geologic Survey prof. paper 100, p. 11-12.

- Koteff, C., 1964, Surficial geology of the Concord quadrangle: U.S. Geologic Survey GQ-331.
- 1966, Surficial geologic map of the Clinton quadrangle, Worcester County, Massachusetts: U.S. Geologic Survey GQ-567.
- 1964, Geology of the Assawompset Pond Quadrangle, Massachusetts; U.S.G.S. Quadrangle Report GQ-265.
- 1964, Surficial Geology of the Concord Quadrangle, Massachusetts; U.S.G.S. Quadrangle Report GQ-331.
- Koteff, C., 1968, Geologic Map of the Monomoy Point Quadrangle, Barnstable County, Massachusetts; U.S.G.S. Quadrangle Report GQ-787.
- Koteff, C., Oldale, R.N., and Hartshorn, J.H., 1967, Geologic Map of the North Truro Quadrangle, Barnstable County, Massachusetts; U.S.G.S. Quadrangle Report GQ-599.
- Koteff, C., & Volckmann, R.P., 1972, Preliminary surficial geologic of the Pepperell quadrangle, Massachusetts-New Hampshire: U.S.G.S. open file report.
- LaForge, L., 1932, Geology of the Boston area, Massachusetts: U.S.G.S. Bulletin 839.
- Latimer, Maxon, Smith, Mallory and Roberts; 1920; Soil Survey for Norfolk, Bristol and Barnstable Counties: U.S.D.A. Soil Survey Series.
- Latimer & Lamphear, 1927, Soil Survey of Worcester County: U.S. Department of Agriculture, 1922 Series.
- 1929, Soil Survey of Middlesex County: U.S. Department of Agriculture, 1924 Series, No. 26.
- 1930, Soil Survey of Essex County: U.S. Department of Agriculture, 1925 Series, No. 14.
- Lee, F.W., Farnham, F.C., Raspet, A., & Currier, L.W., 1940, The seismic method for determining depths to bedrock as applied in the Lowell quadrangle, Massachusetts: Mass. Dept. of Public Works Special Paper 3.
- Maensky, A. and Drake, J., 1963, Massachusetts Basic Data Report No. 7 - Groundwater Series - Southeastern Massachusetts: U.S.G.S.

McCormick, C.L., 1968, Holocene Stratigraphy of the Marshes at Plum Island, Massachusetts: unpublished PhD Thesis, University of Massachusetts.

McIntire, W.G., and Morgan, J.P., 1963, Recent Geomorphic History of Plum Island, Massachusetts, and Adjacent Coasts: Louisiana State University, Coastal Studies, Series No. 8, p. 44.

Murrmann, Koutz, Richard, et. al, 1972, Wastewater management by disposal on the land: Department of the Army, Corps of Engineers, Special Report 171.

Nelson, A.E., 1972, Preliminary surficial geology of the Natick quadrangle, Middlesex and Norfolk Counties, Massachusetts: U.S.G.S. open file report.

1973, Preliminary bedrock geologic map of the Natick quadrangle, Middlesex and Norfolk Counties, Massachusetts: U.S.G.S. open file report.

1973, Preliminary surficial geology of the Framingham quadrangle, Middlesex and Worcester Counties, Massachusetts: U.S.G.S. open file report.

Oldale, R.N., 1962, Surficial geology of the Reading quadrangle, Massachusetts: U.S.G.S. GQ-168.

1964, Surficial geology of the Salem quadrangle, Massachusetts: U.S.G.S. GQ-271.

1968, Geologic Map of the Wellfleet Quadrangle, Barnstable County, Massachusetts; U.S.G.S. Quadrangle Report GQ-750.

1969; Geologic Map of the Harwich Quadrangle, Barnstable County, Massachusetts; U.S.G.S. Quadrangle Report GQ-786.

Oldale, R.N., 1969. Seismic Investigations on Cape Cod, Martha's Vineyard, and Nantucket Massachusetts, and a Topographic Map of the Basement Surface from Cape Cod Bay to the Islands; U.S.G.S. Prof. Paper 650-B., p. B. 102-107.

Oldale, R.N. and Koteff, C., 1970. Geologic Map of Chatham Quadrangle, Barnstable County, Massachusetts; U.S.G.S. Quadrangle Report GQ-911.

Oldale, R.N., Koteff, C., and Hartshorn, J.H.; 1971: Geologic Map of Orleans Quadrangle, Barnstable County, Massachusetts; U.S.G.S. Quadrangle Report GQ-931.



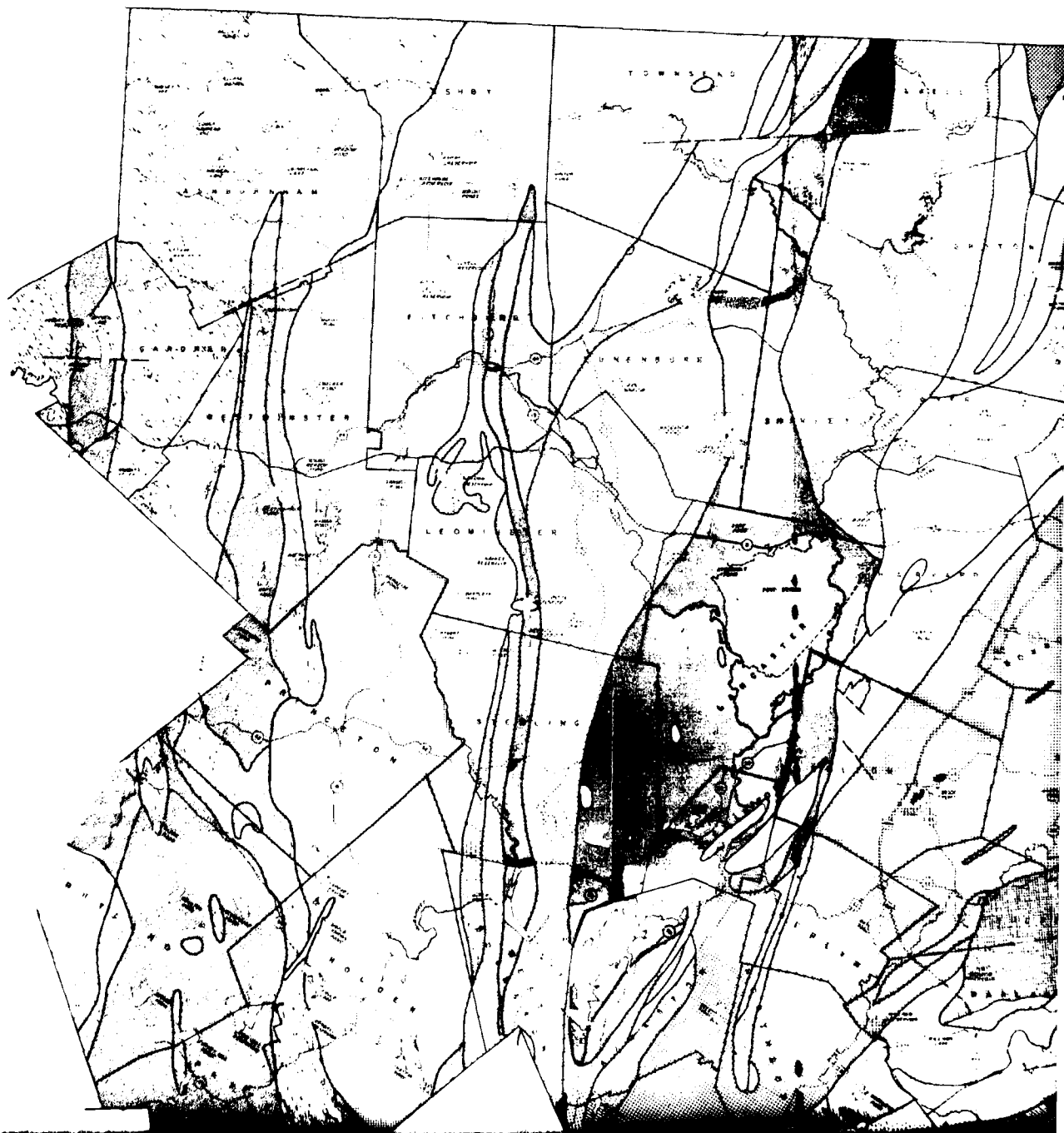
- Penn. Dept. of Environmental Resources, 1972, Spray irrigation manual: Bureau of Water Quality Management Publication No. 31.
- Perlmutter, N.M., 1962, Groundwater geology and hydrology of the Maynard area, Massachusetts: U.S.G.S. Water Supply Paper 1539-E, p. 68.
- Petersen, R.G., 1962, Groundwater Favorability Map of the Ware, Quaboag, Quinebaug and French River Basins, Massachusetts; Massachusetts Water Resources Commission, Chart HL-2.
- Petersen, R.G. and Shaw, C.E.: 1967; Surficial Geologic Map of the Whitman Quadrangle, Plymouth County, Massachusetts: U.S.G.S. Quadrangle Report GQ-632.
- Pollock, S.J., & Fleck, W.F., 1964, Assabet River basin: Massachusetts Basic Data, Report No. 8., Groundwater Series.
- Pollock, Farrell & Caswell, 1969, Water Resources of the Assabet River basin, central Massachusetts: U.S.G.S. Hydrologic Investigations Atlas HA-312.
- Sammel, E.A., 1963, Surficial geology of the Ipswich quadrangle, Massachusetts: U.S.G.S. GQ-189.
- 1967, Water resources of the Parker and Rowley River basin: U.S.G.S. Hydrologic Investigations Atlas HA-247.
- Sammel, Baker & Brackley, 1966, Water resources of the Ipswich River basin, U.S.G.S. Water Supply Paper WS-1826.
- Schafer, J.P., Hartshorn, J.H., 1965, The Quaternary of New England in The Quaternary of the United States, Wright, H.E. & Frey, D.G. (ed.): Princeton University Press, p. 113-122.
- Sears, J.H., 1905, The Physical Geography, Geology and Mineralogy and Paleontology of Essex County Massachusetts: Salem, Massachusetts, Essex Institute.
- Shaw, C.E., 1969, Surficial geologic map of the Shrewsbury quadrangle, Worcester County, Massachusetts: U.S.G.S. GQ-794.
- Shaw, Jr., C.E., 1961, Groundwater Favorability Map of the Brockton-Pembroke Area, Massachusetts; Massachusetts Water Resources Commission.
- Shaw, C.E. and Petersen, R.G., 1967, Surficial Geology of the Hanover Quadrangle, Plymouth County, Massachusetts; U.S.G.S. Quadrangle Report GQ-633.

- Skehan, J.W., 1967, Geology of the Wachusett-Marlborough tunnel, east central Massachusetts; in Economic Geology of Massachusetts, Farquhar, O.C., (ed.): University of Massachusetts, p. 237-244.
- 1967, Geologic setting of the Chelmsford granite; in Economic Geology in Massachusetts, Farquhar, O.C., (ed.): University of Massachusetts, p. 152-15
- Toulmin, Priestly III, 1964, Bedrock geology of the Salem quadrangle and vicinity, Massachusetts: U.S.G.S. Bulletin 1163-A.
- Upham, J.W., 1969, Soil Survey-Plymouth County, Massachusetts; U.S.D.A. Soil Conservation Service.
- U.S. Army Corps of Engineers, 1973, The study area today-Merrimack Wastewater Management Study: Corps of Engineers, NED Wastewater Studies section.
- U.S. Department of Agriculture, 1951, Soil Survey manual: U.S. Department of Agriculture handbook No. 18.
- U.S. Geological Survey, 1967, Engineering geology of the northeast corridor Washington, D.C., to Boston, Massachusetts: Miscellaneous Geologic Investigations 1-514.
- Volckmann, R.P., 1973, Preliminary bedrock geology map for the Holliston Quadrangle, Massachusetts: U.S.G.S. open file report.
- Williams, J., 1968, Availability of Groundwater in the Northern Part of the Ten Mile and Taunton River Basins, Southeastern Massachusetts.
- Williams, J. R., and Tasker, G.D., 1972, Water Resources of the Coastal Drainage Basins of Southeastern Massachusetts, Wier River, Hingham to Jones River, Kingston; U.S.G.S. open file report.
- Williams, J.R. and Tasker, G.D., 1972, Water Resources of the Coastal Drainage Basins of Southeastern Massachusetts, Plymouth to Weweantic River, Wareham; U.S.G.S. Open File Report.
- Williams, J.R., Farrell, D.F. and Willey, R.E., 1973, Water Resources of the Taunton River Basin, Southeastern Massachusetts; U.S.G.S. Hydrologic Investigation Atlas HA-460.
- Whitman, R.V., 1970, Introduction to seismic design for nuclear power plants, Hanson, R.J. (ed.): M.I.T. Press, Cambridge, Massachusetts, p. 1-68.
- Woodworth, J.B., and Wigglesworth, E., 1934, The Geography and Geology of the Region Including Cape Cod, The Elizabeth Islands, Nantucket, Martha's Vineyard, No Man's Land and Block Island; Memoirs of the Museum of Comparative Zoology at Harvard College, Volume 57.

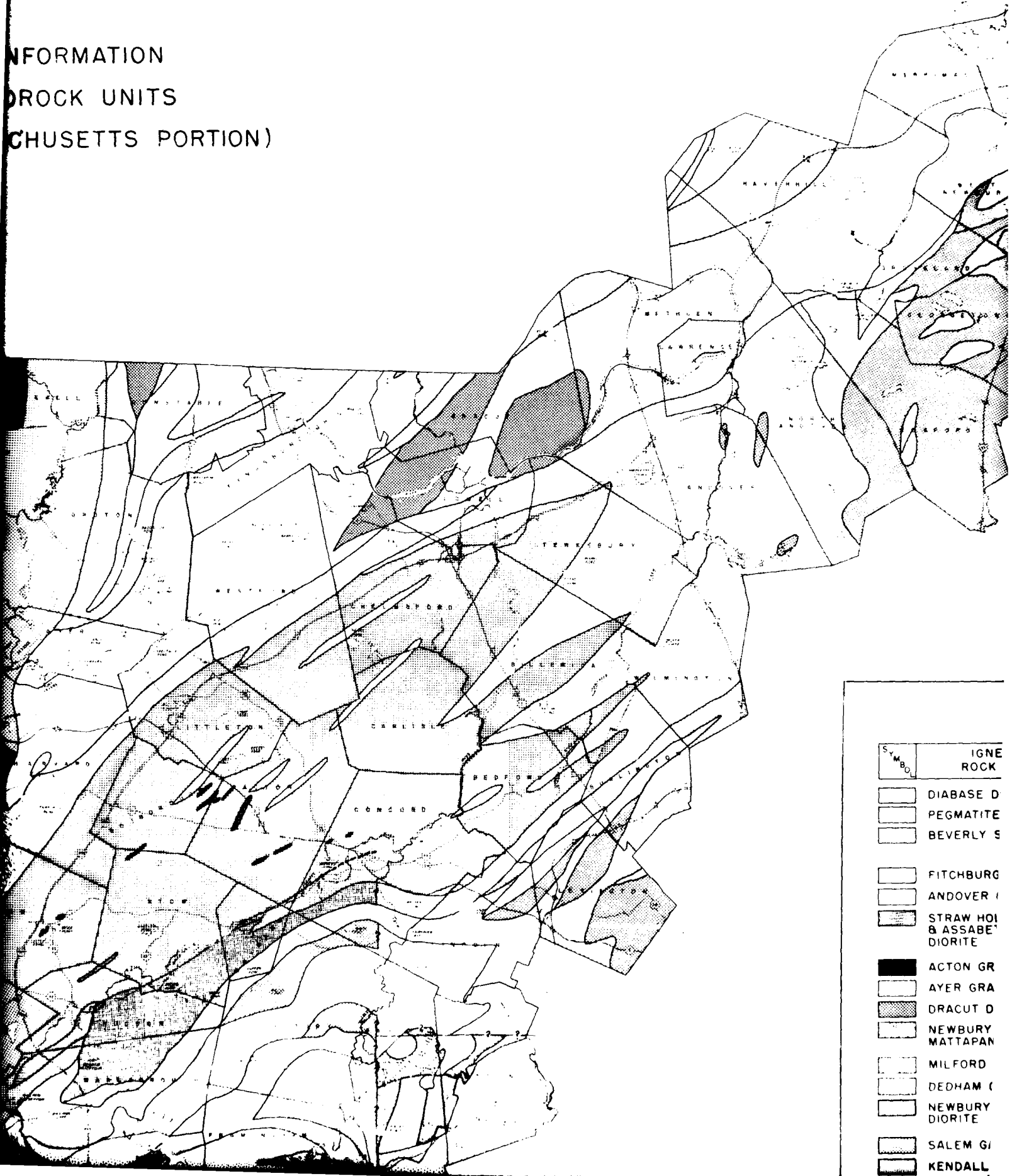
Appendix

GEOLOGIC MAPS OF  
EASTERN MASSACHUSETTS

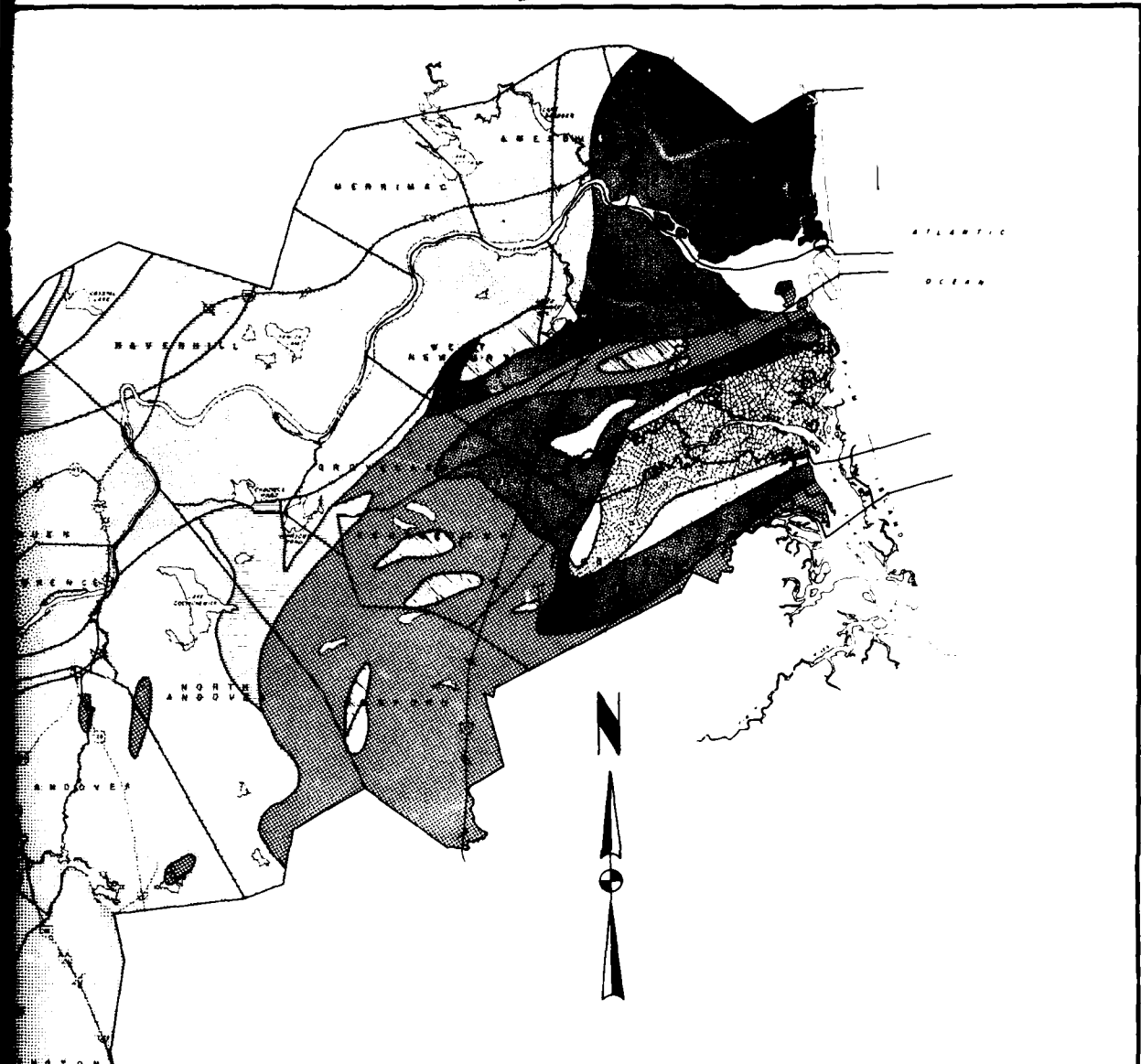
A SUMMARY OF THE AVAILABLE INFORMATION  
SHOWING THE DISTRIBUTION OF BEDROCK UNITS  
IN THE MERRIMACK RIVER BASIN (MASSACHUSETTS)



INFORMATION  
 ROCK UNITS  
 CHUSETTS PORTION)



SYMBOL	IGNE ROCK
[White box]	DIABASE D
[White box]	PEGMATITE
[White box]	BEVERLY S
[White box]	FITCHBURG
[White box]	ANDOVER I
[White box]	STRAW HOLE & ASSABET DIORITE
[Black box]	ACTON GR
[White box]	AYER GRA
[Diagonal lines box]	DRACUT D
[White box]	NEWBURY MATTAPAN
[White box]	MILFORD
[White box]	DEDHAM I
[White box]	NEWBURY DIORITE
[White box]	SALEM G
[White box]	KENDALL



### LEGEND

SYMBOL	IGNEOUS ROCK UNITS	SEDIMENTARY, META-SEDIMENTARY ROCK UNITS	SYMBOL
	DIABASE DIKES	GNEISSES & SCHISTS (TO OTHER FORMATIONS OR GROUPS)	
	PEGMATITE BODIES	HUBBARDSTON GRANITE with inclusions of BRIMFIELD SCHIST (BRIMFIELD-WARE) OR PAXTON QUARTZ SCHIST	
	BEVERLY SYENITE	<u>BOSTON GROUP</u>	
	FITCHBURG GRANITE	CAMBRIDGE SLATE	
	ANDOVER GRANITE	ROXBURY CONGLOMERATE	
	STRAW HOLLOW DIORITE & ASSABET QUARTZ DIORITE	GOSPEL HILL GNEISS	
	ACTON GRANITE	NASHOBA FORMATION	
	AYER GRANITE	BOYLSTON SCHIST	
	DRACUT DIORITE	<u>WORCESTER FORMATION</u>	
	NEWBURY AND MATTAPAN VOLCANICS	BRIMFIELD SCHIST	
	MILFORD GRANITE	WORCESTER PHYLLITE	
	DEDHAM GRANODIORITE	HARVARD CONGLOMERATE	
	NEWBURYPORT QUARTZ DIORITE	PAXTON QUARTZ SCHIST	
	SALEM GABBRO DIORITE	<u>MERRIMAC GROUP</u>	







# LEGEND

SYMBOL	IGNEOUS ROCK UNITS	SEDIMENTARY, META-SEDIMENTARY ROCK UNITS	SYMBOL
	DIABASE DIKES	GNEISSES & SCHISTS (TO OTHER FORMATIONS OR GROUPS)	
	PEGMATITE BODIES	HUBBARDSTON GRANITE with inclusions of BRIMFIELD SCHIST (BRIMFIELD-WARE) OR PAXTON QUARTZ SCHIST	
	BEVERLY SYENITE	<u>BOSTON GROUP</u>	
	FITCHBURG GRANITE	CAMBRIDGE SLATE	
	ANDOVER GRANITE	ROXBURY CONGLOMERATE	
	STRAW HOLLOW DIORITE & ASSABET QUARTZ DIORITE	GOSPEL HILL GNEISS	
	ACTON GRANITE	NASHOBA FORMATION	
	AYER GRANITE	BOYLSTON SCHIST	
	DRACUT DIORITE	<u>WORCESTER FORMATION</u>	
	NEWBURY AND MATTAPAN VOLCANICS	BRIMFIELD SCHIST	
	MILFORD GRANITE	WORCESTER PHYLLITE	
	DEDHAM GRANODIORITE	HARVARD CONGLOMERATE	
	NEWBURYPORT QUARTZ DIORITE	PAXTON QUARTZ SCHIST	
	SALEM GABBRO DIORITE	<u>MERRIMAC GROUP</u>	
	KENDALL VOLCANICS	OAKDALE QUARTZITE	
	PROBABLE FAULT	MERRIMAC QUARTZITE	
	BODY OF WATER (RIVERS, LAKES, PONDS, ETC.)	CHERRY BROOK FORMATION	
		MARLBORO FORMATION	
		WESTBORO QUARTZITE	
		RICE FORMATION	

## SCALE



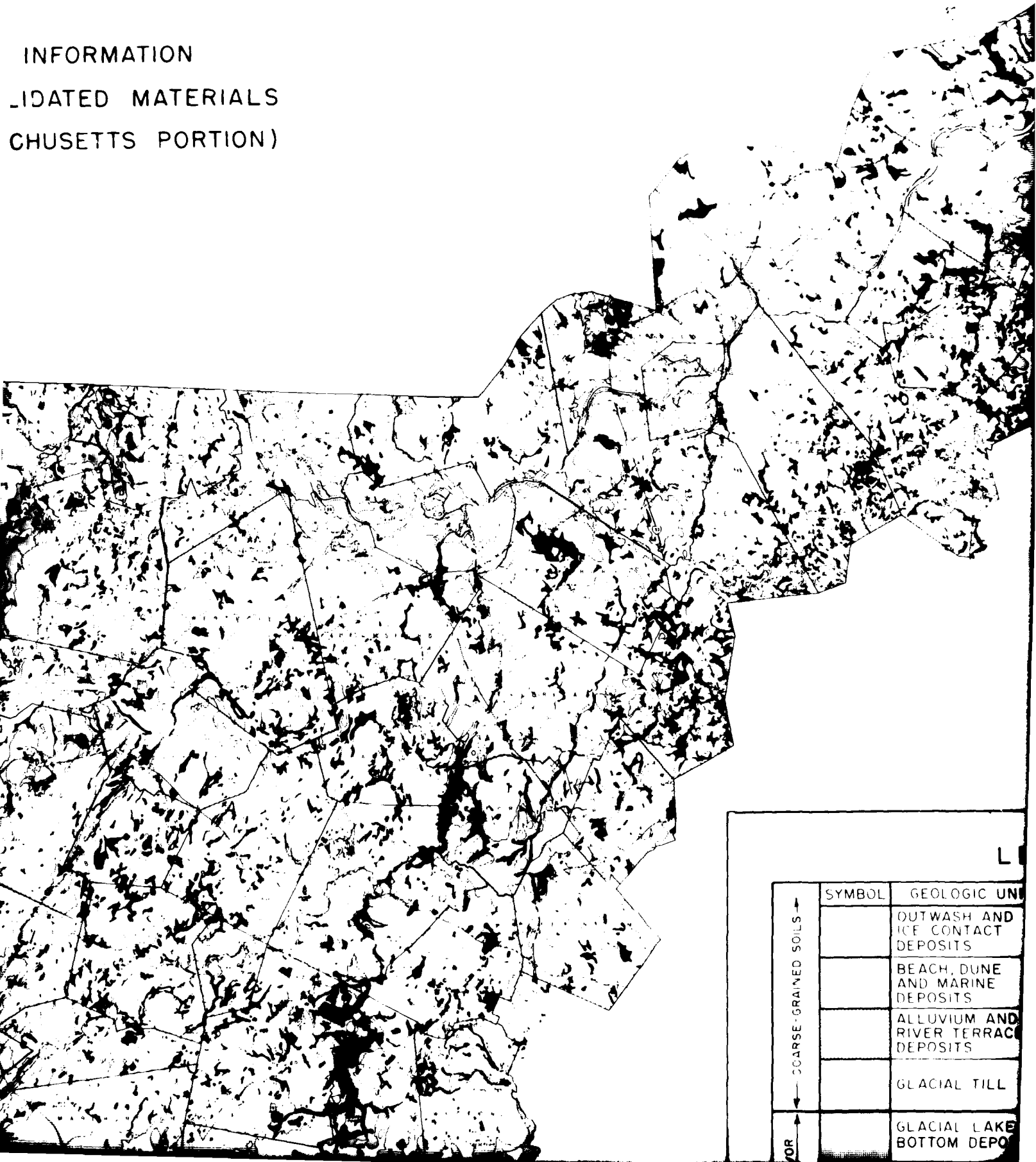
FIGURE B

A SUMMARY OF THE AVAILABLE INFORMATION  
SHOWING THE DISTRIBUTION OF UNCONSOLIDATED MATERIAL  
IN THE MERRIMACK RIVER BASIN (MASSACHUSETTS)



INFORMATION

OLIDATED MATERIALS  
(CHUSETTS PORTION)



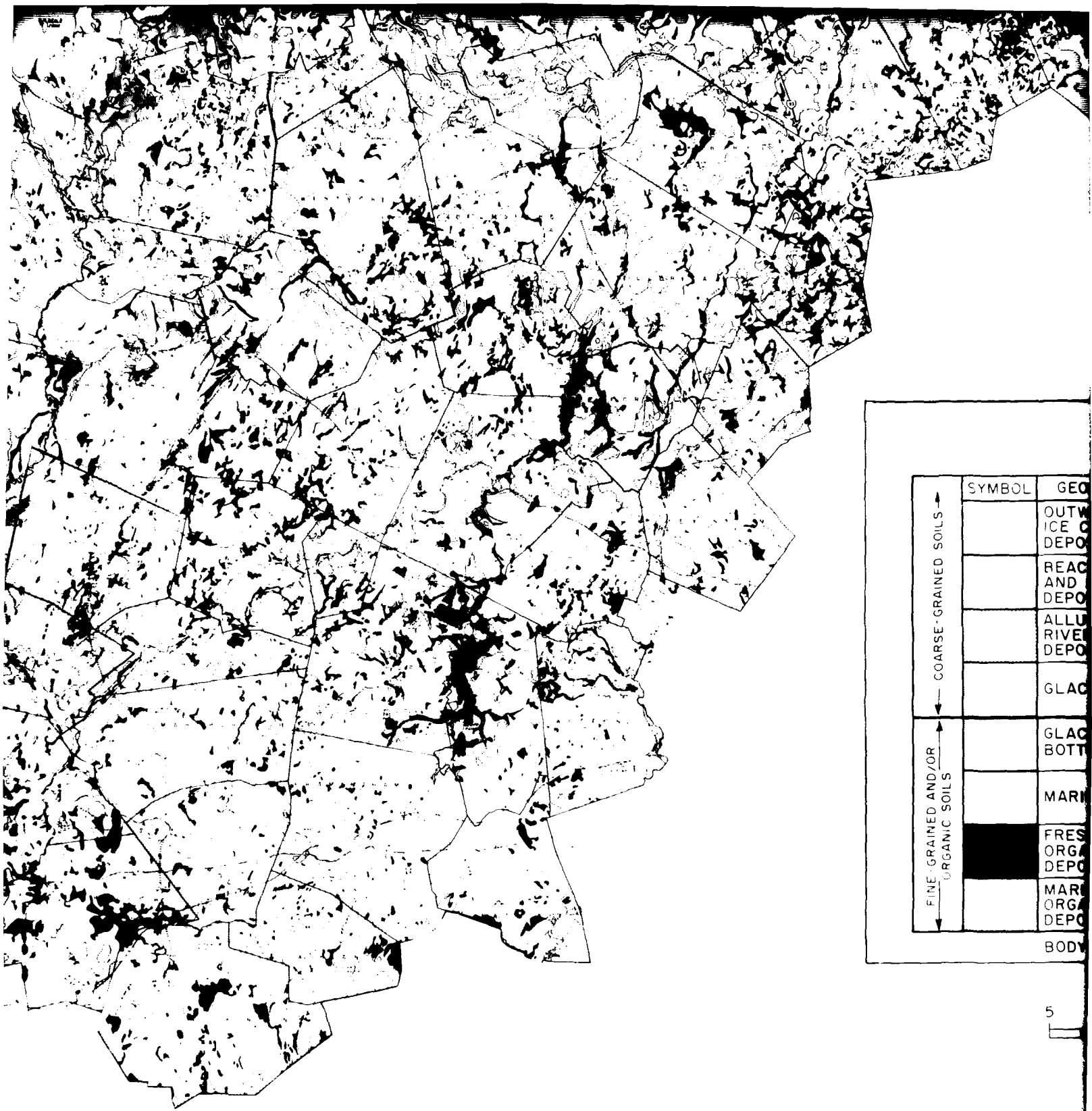
		SYMBOL	GEOLOGIC UNIT
FOR	COARSE-GRAINED SOILS		OUTWASH AND ICE CONTACT DEPOSITS
			BEACH, DUNE AND MARINE DEPOSITS
			ALLUVIUM AND RIVER TERRACE DEPOSITS
			GLACIAL TILL
			GLACIAL LAKE BOTTOM DEPOSITS



### LEGEND

	SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
COARSE-GRAINED SOILS		OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVEL. Silt and/or clay portions usually minor - stratified and sorted
		BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted - often stratified and cross bedded
		ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics - poorly to moderately sorted and stratified
		GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders - dense, non-stratified unsorted mixture
		GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays





	SYMBOL	GEO
↑ COARSE-GRAINED SOILS ↓		OUTW ICE C DEPO
		REAC AND DEPO
		ALLU RIVER DEPO
		GLAC
↑ FINE-GRAINED AND/OR ORGANIC SOILS ↓		GLAC BOT
		MARI
		FRES ORGA DEPO
		MARI ORGA DEPO

5





## LEGEND

SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
	OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS Silt and/or clay portions usually minor - stratified and sorted
	BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted - often stratified and cross bedded
	ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics - poorly to moderately sorted and stratified
	GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders - dense, non-stratified unsorted mixture
	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays
	MARINE DEPOSITS	Silty CLAYS, SILTS and CLAYS SILTS, Silty fine SANDS
	FRESH-WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS, Silty PEATS, Organic Sands and Silts, "MUCK"
	MARINE ORGANIC DEPOSITS	ORGANIC SILT, Clayey Organic Silts, Organic Sands Marsh Mats, "Ooze"

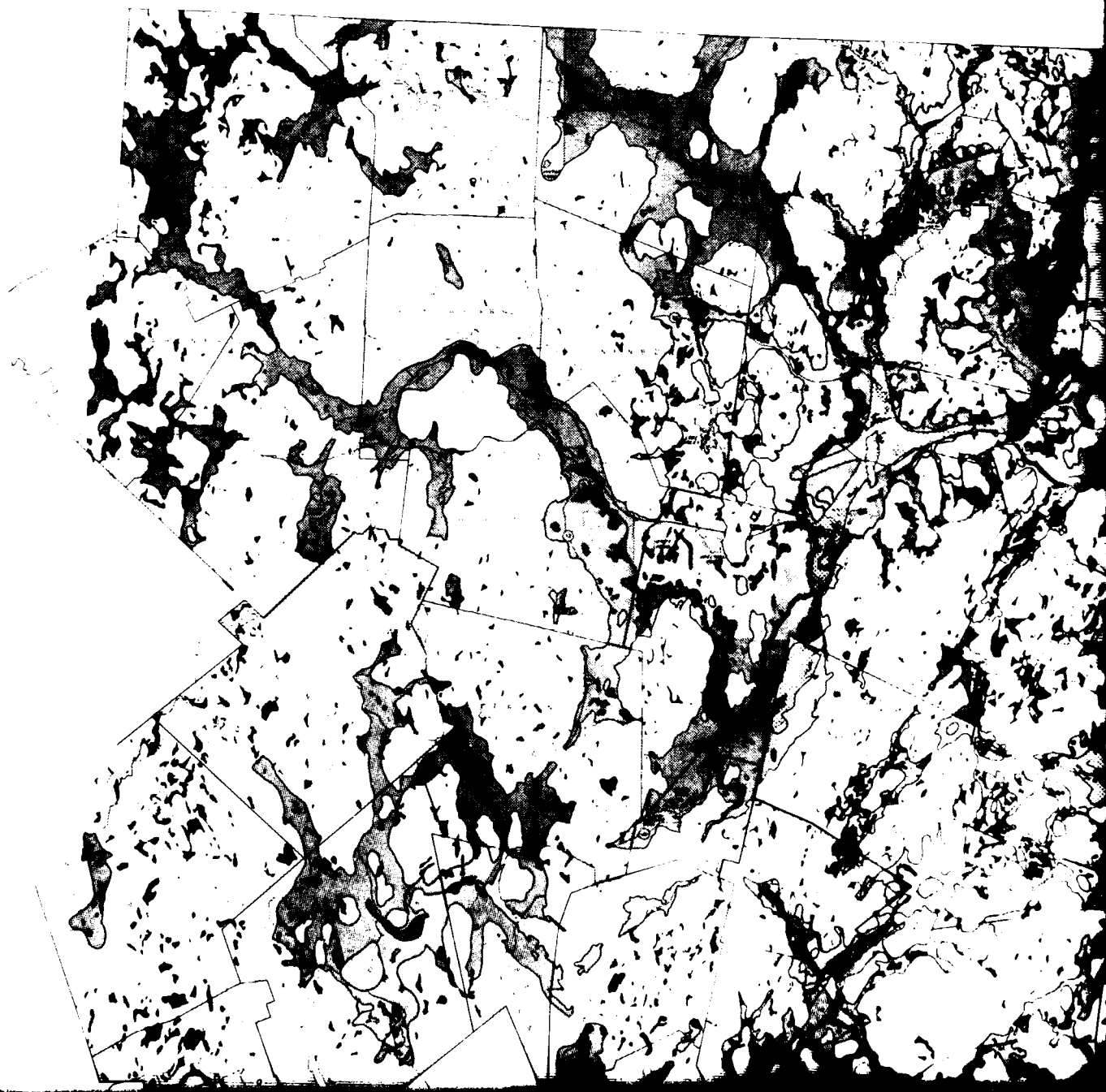
BODY OF WATER (Rivers, Lakes, Ponds, etc.)

### SCALE



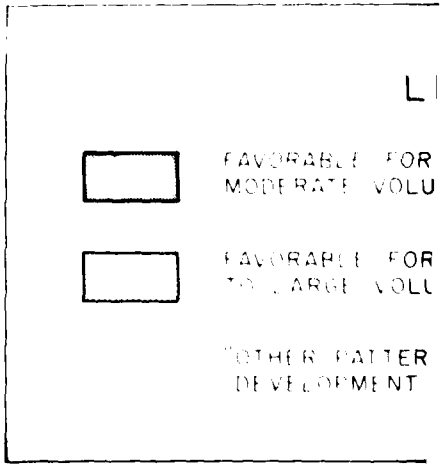
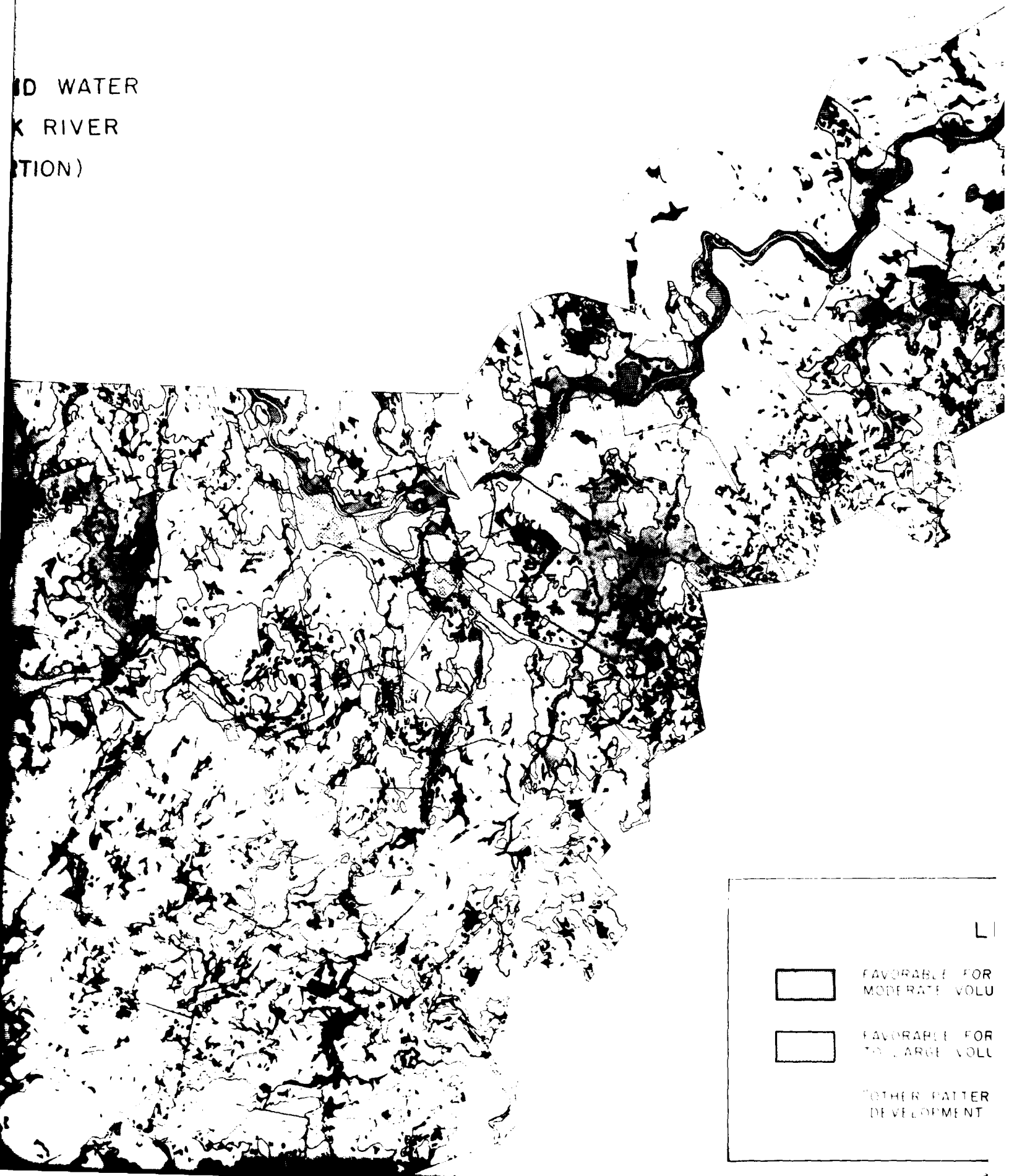
FIGURE S

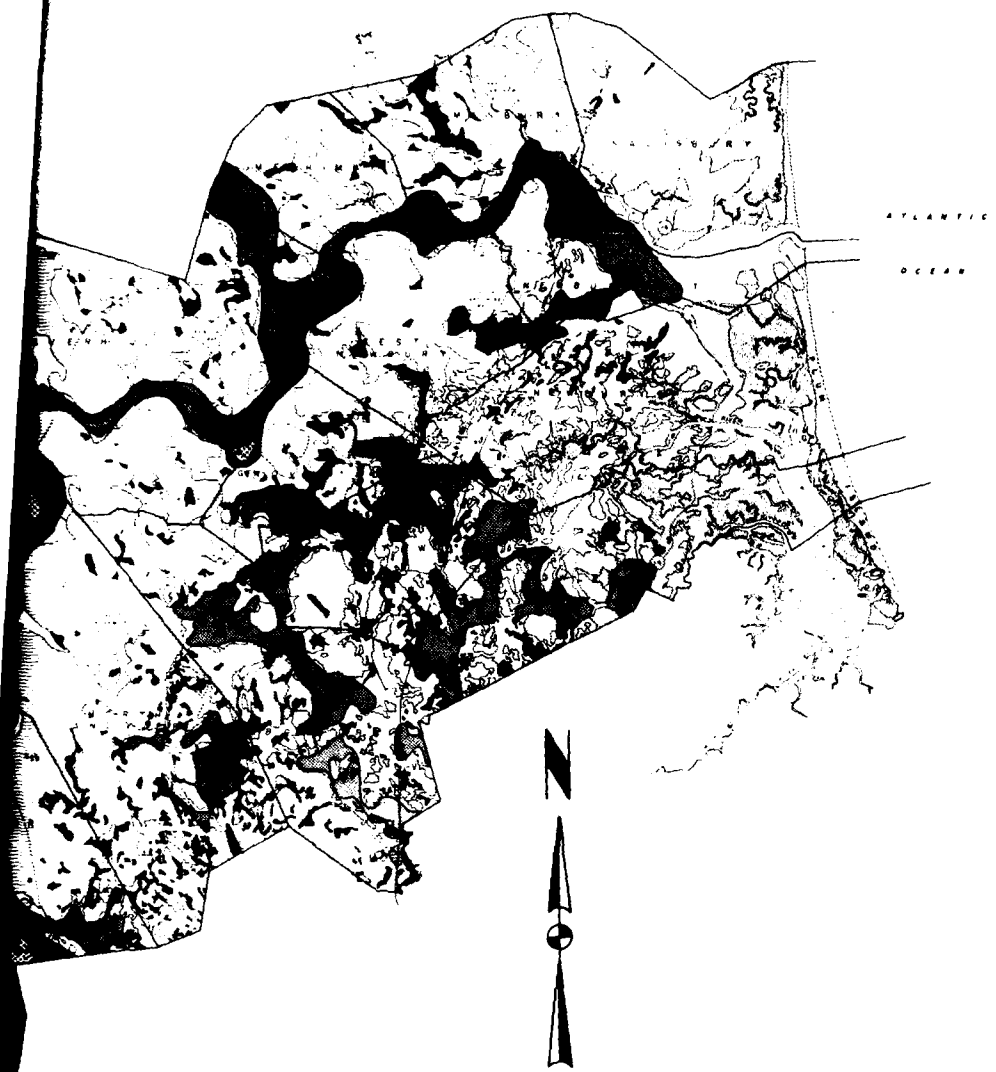
PRELIMINARY ESTIMATE OF GROUND WATER  
FAVORABILITY IN THE MERRIMACK RIVER  
BASIN (MASSACHUSETTS PORTION)







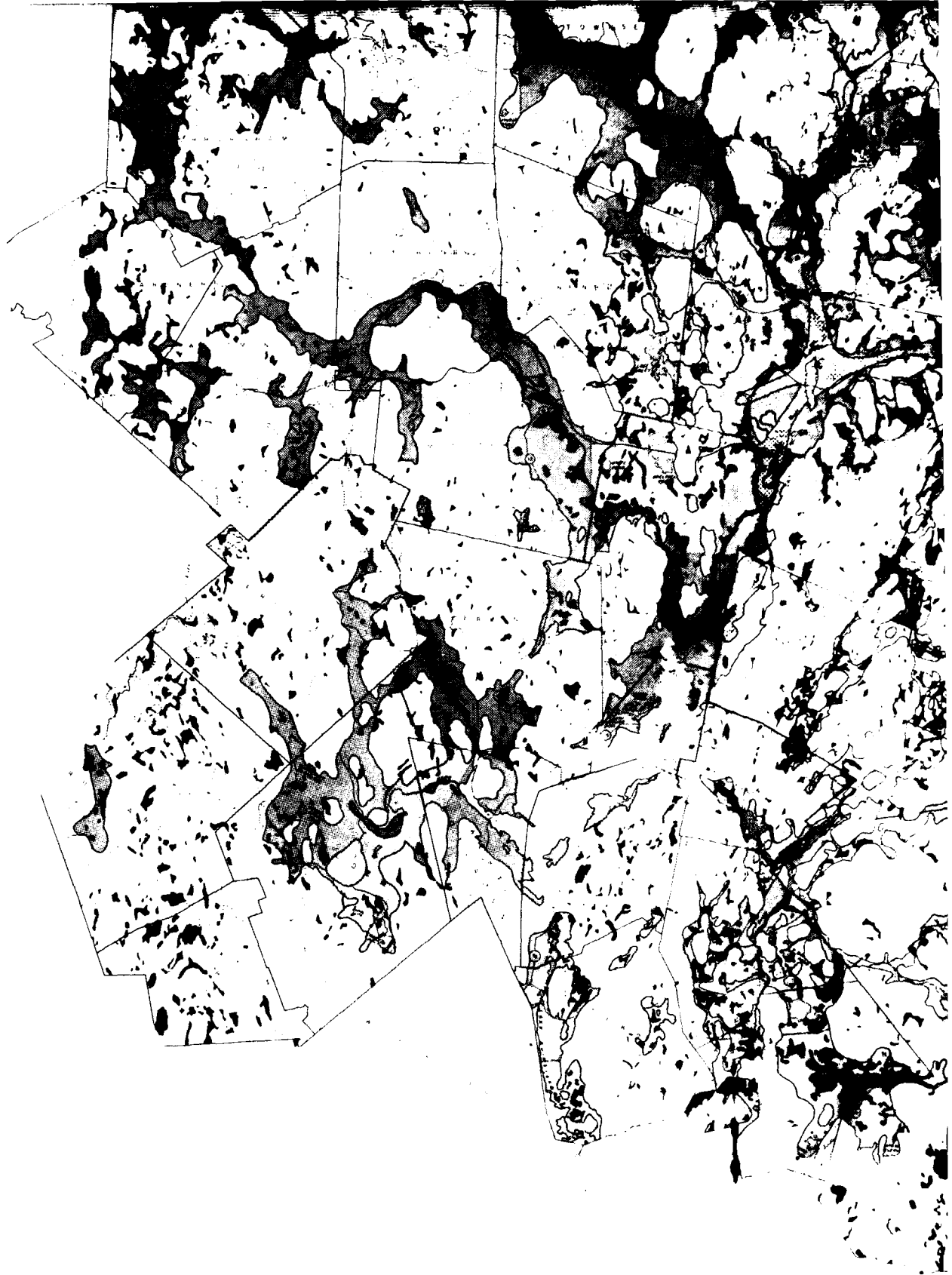
D WATER  
K RIVER  
TION)

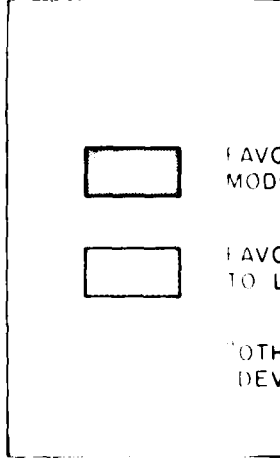
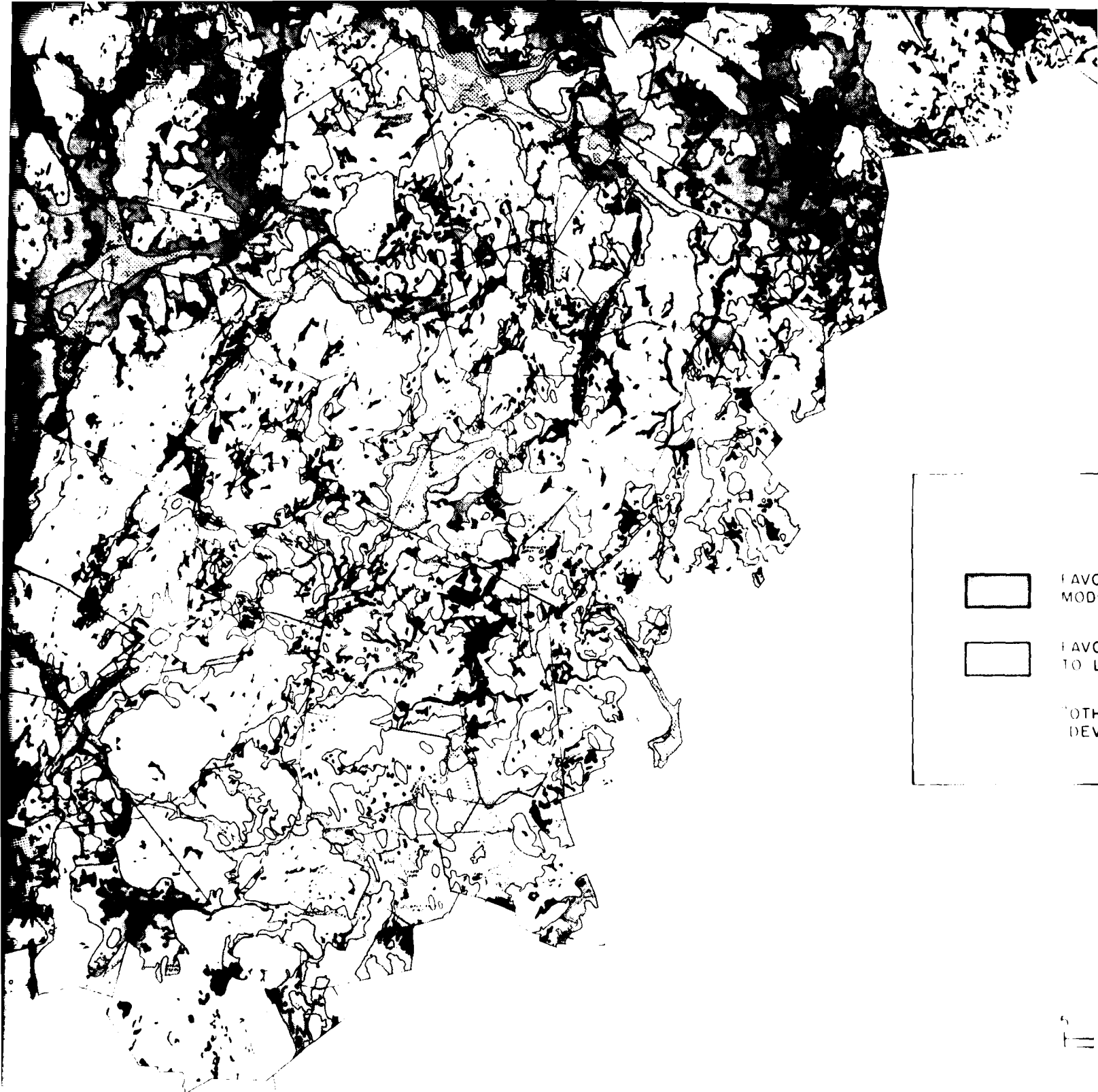




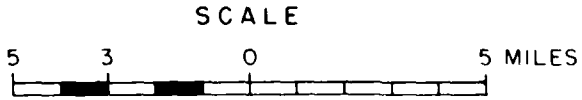
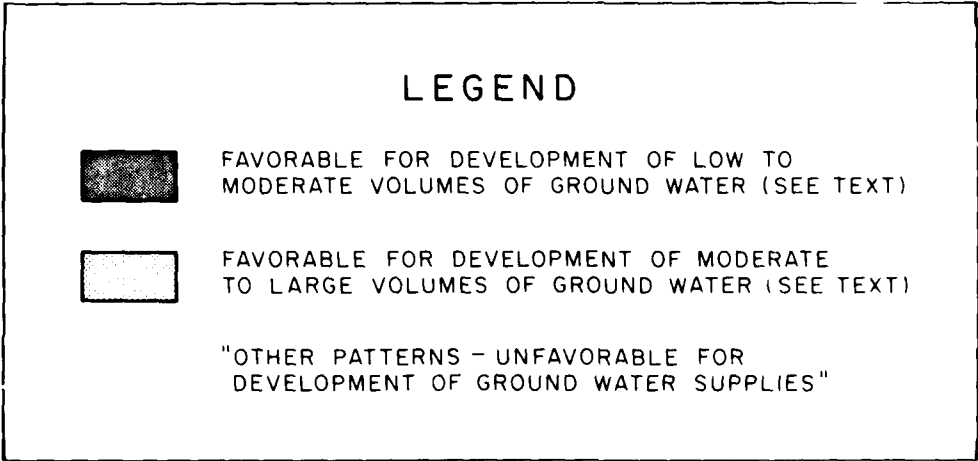
### LEGEND

-  FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUND WATER (SEE TEXT)
-  FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUND WATER (SEE TEXT)
- "OTHER PATTERNS - UNFAVORABLE FOR DEVELOPMENT OF GROUND WATER SUPPLIES"





11



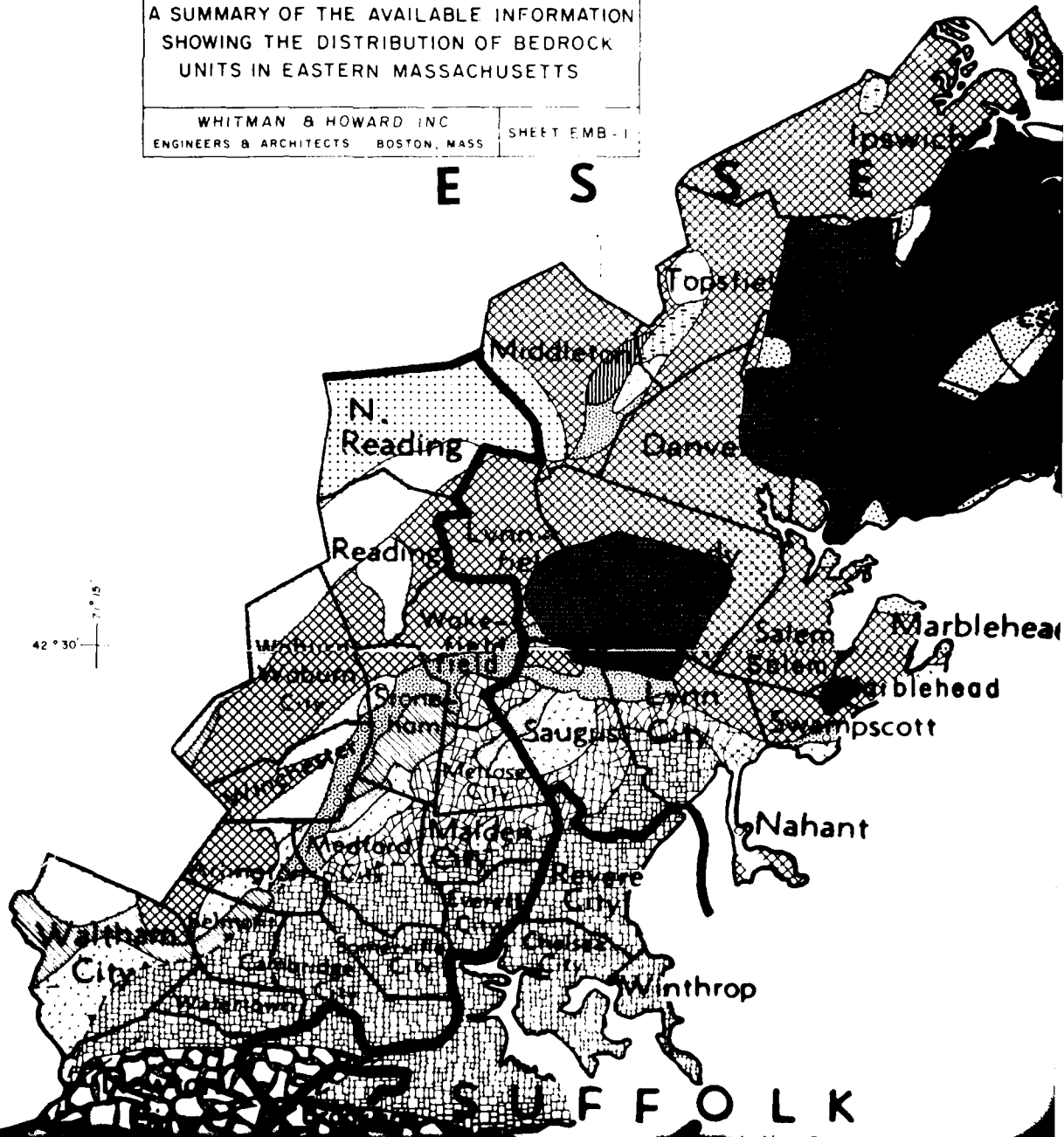
**FIGURE W**

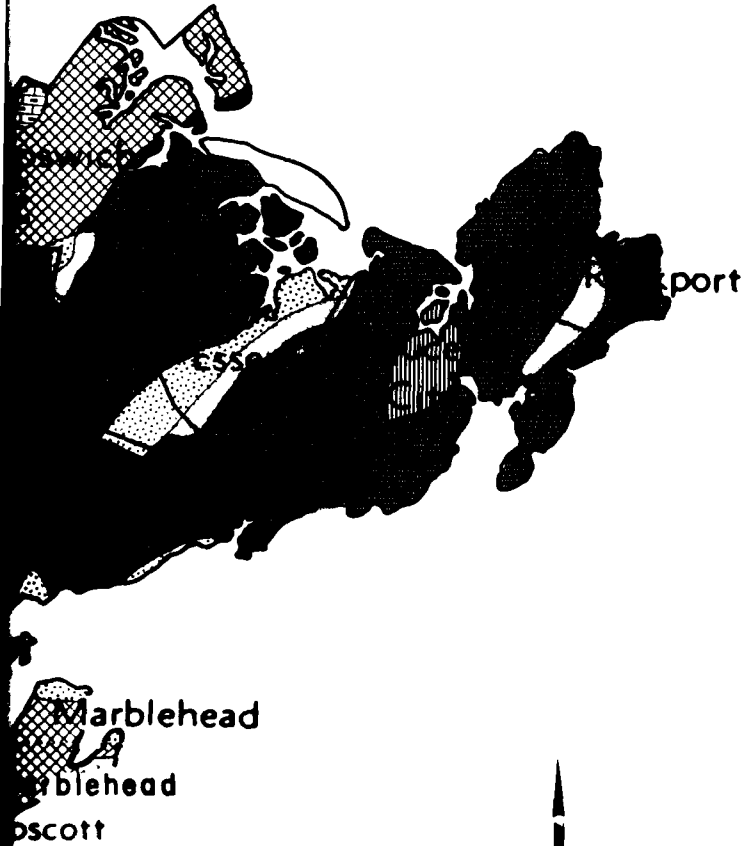
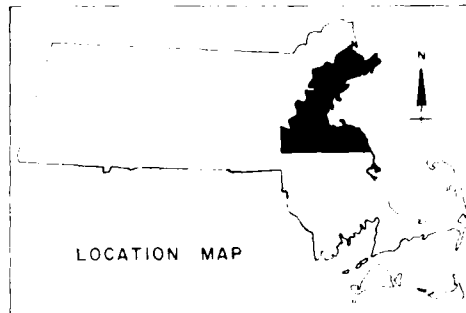
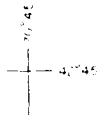
BOSTON HARBOR - EASTERN MASSACHUSETTS  
METROPOLITAN AREA WASTE WATER  
MANAGEMENT STUDY

UNITED STATES ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION WALTHAM, MASS

A SUMMARY OF THE AVAILABLE INFORMATION  
SHOWING THE DISTRIBUTION OF BEDROCK  
UNITS IN EASTERN MASSACHUSETTS

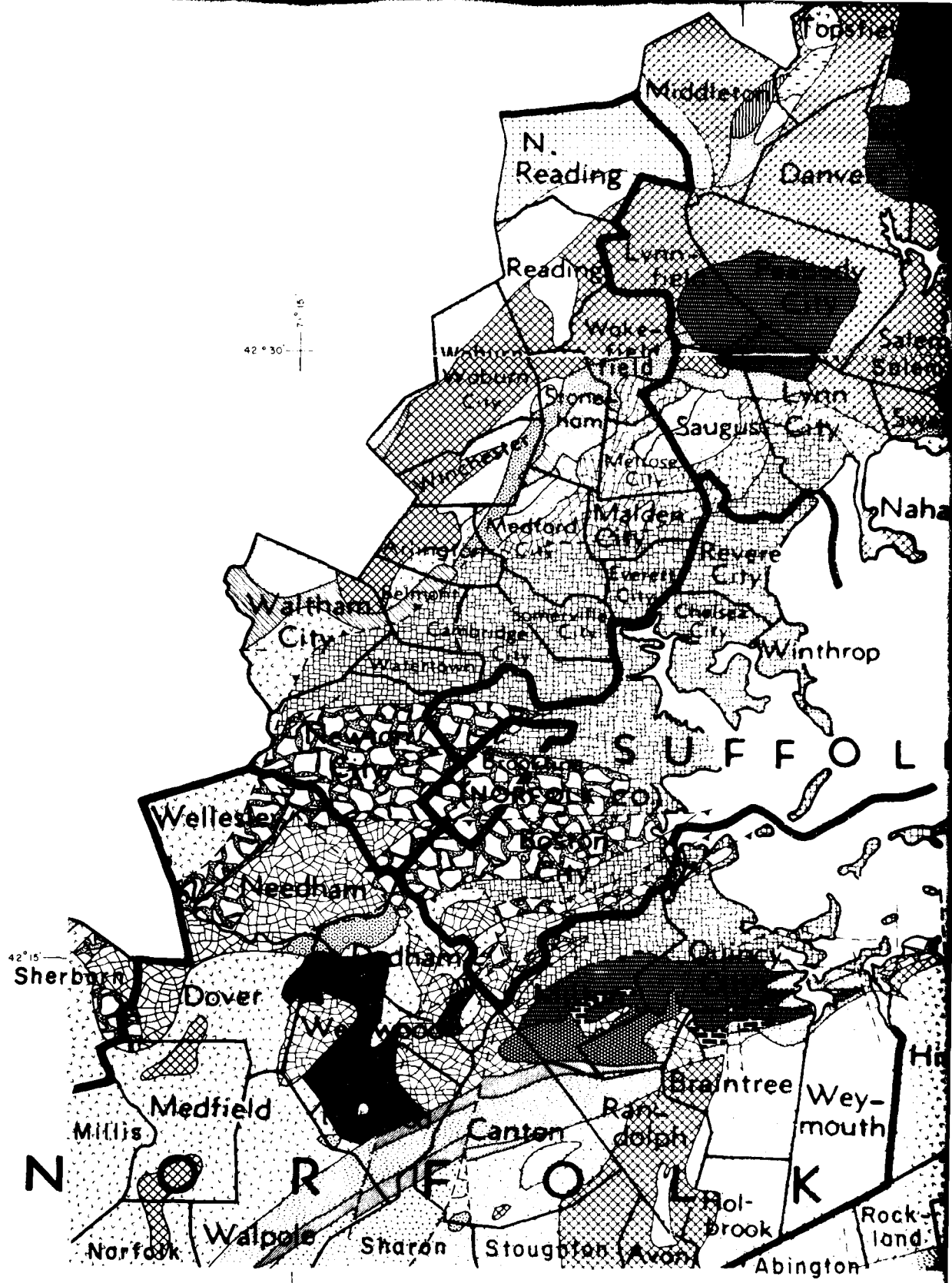
WHITMAN & HOWARD INC  
ENGINEERS & ARCHITECTS BOSTON, MASS SHEET EMB - I





### LEGEND

IGNEOUS ROCK UNITS	SEDIMENTARY, META SEDIMENTARY ROCK UNITS
ANDOVER GRANITE	BELLINGHAM CONGLOMERATE
AYER GRANITE	BRAINTREE ARGILLITE
BEVERLY SYENITE	BRAINTREE SLATE
BLUE HILL GRANITE PORPHYRY	BRIMFIELD SCHIST
DEDHAM GRANODIORITE	CAMBRIDGE SLATE
FITCHBURG GRANITE	MARLBORO FORMATION
MILFORD GRANITE	NASHOBA FORMATION
NEWBURY - MATTAPAN - LYNN VOLCANICS	NORTHBRIDGE GRANITE GNEISS
NEWBURYPORT QUARTZ DIORITE	CARDALE QUARTZITE
QUINCY GRANITE	OXFORD SCHIST
SALEM GABBRO - DIORITE	PAXTON QUARTZ SCHIST
SHARON SYENITE	PONDVILLE CONGLOMERATE
SQUAM GRANITE	RHODE ISLAND FORMATION
WESTWOOD GRANITE	ROXBURY CONGLOMERATE
UNASSIGNED PORPHYRITIC RIBBRITE GRANITE	WAMSUTTA FORMATION
UNASSIGNED QUARTZ SYENITE	WESTBORO QUARTZITE
UNASSIGNED VOLCANIC ROCKS	WEYMOUTH FORMATION
UNDIFFERENTIATED DEDHAM GRANODIORITE AND SALEM GABBRO - DIORITE	WORCESTER PHYLITE
UNASSIGNED GRANITE	UNASSIGNED GNEISS AND SCHISTS
	UNASSIGNED METAMORPHIC ROCKS
	DIGHTON AND PURGATORY CONGLOMERATES



42° 30'

42° 15'

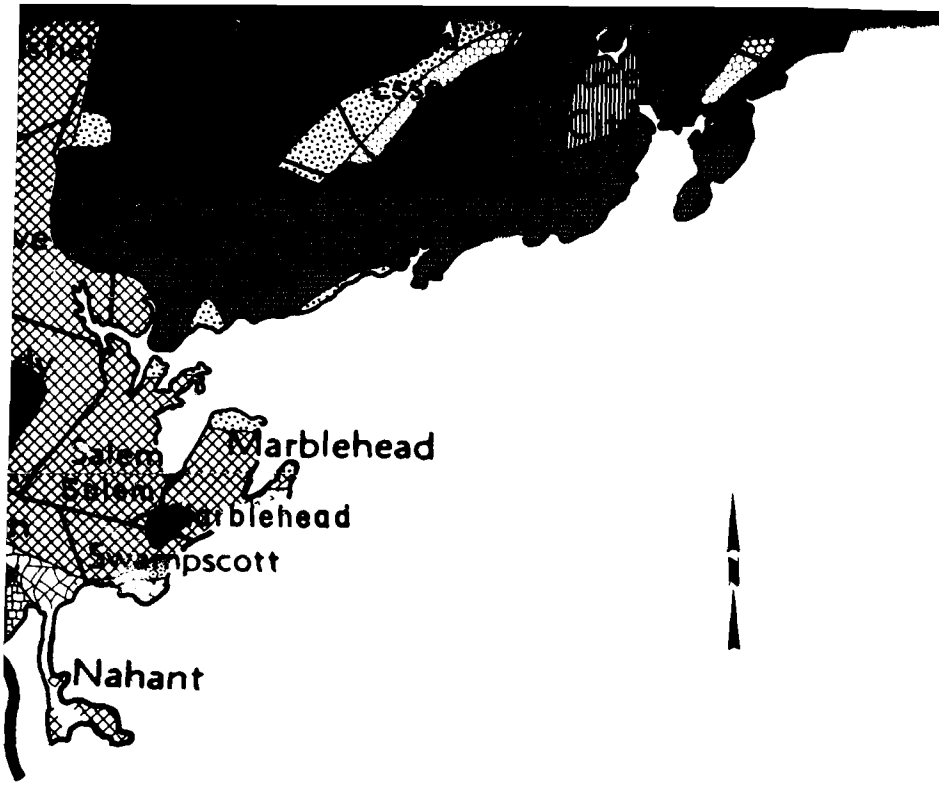
N

R

O

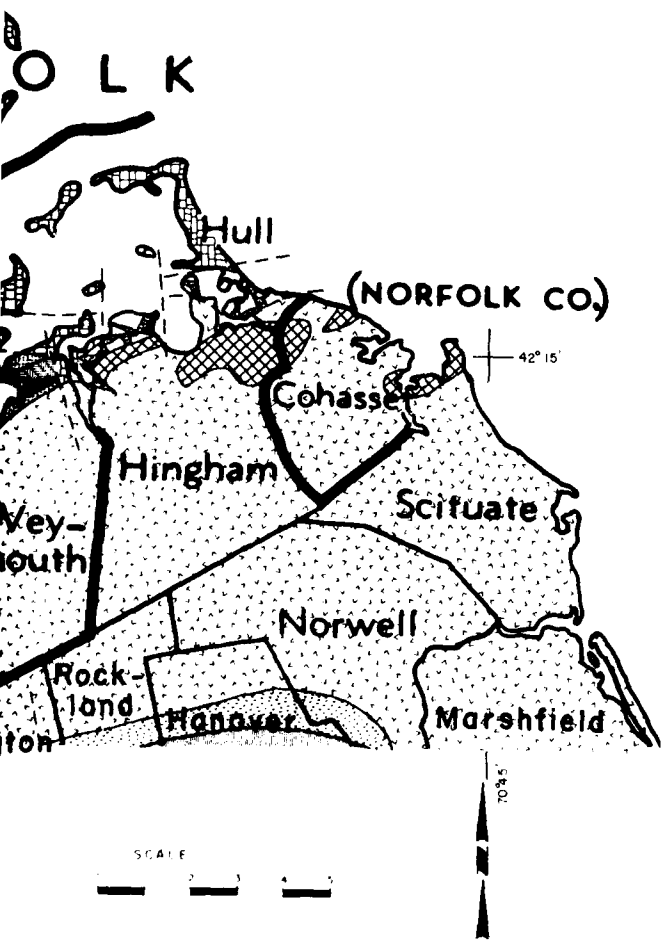
K



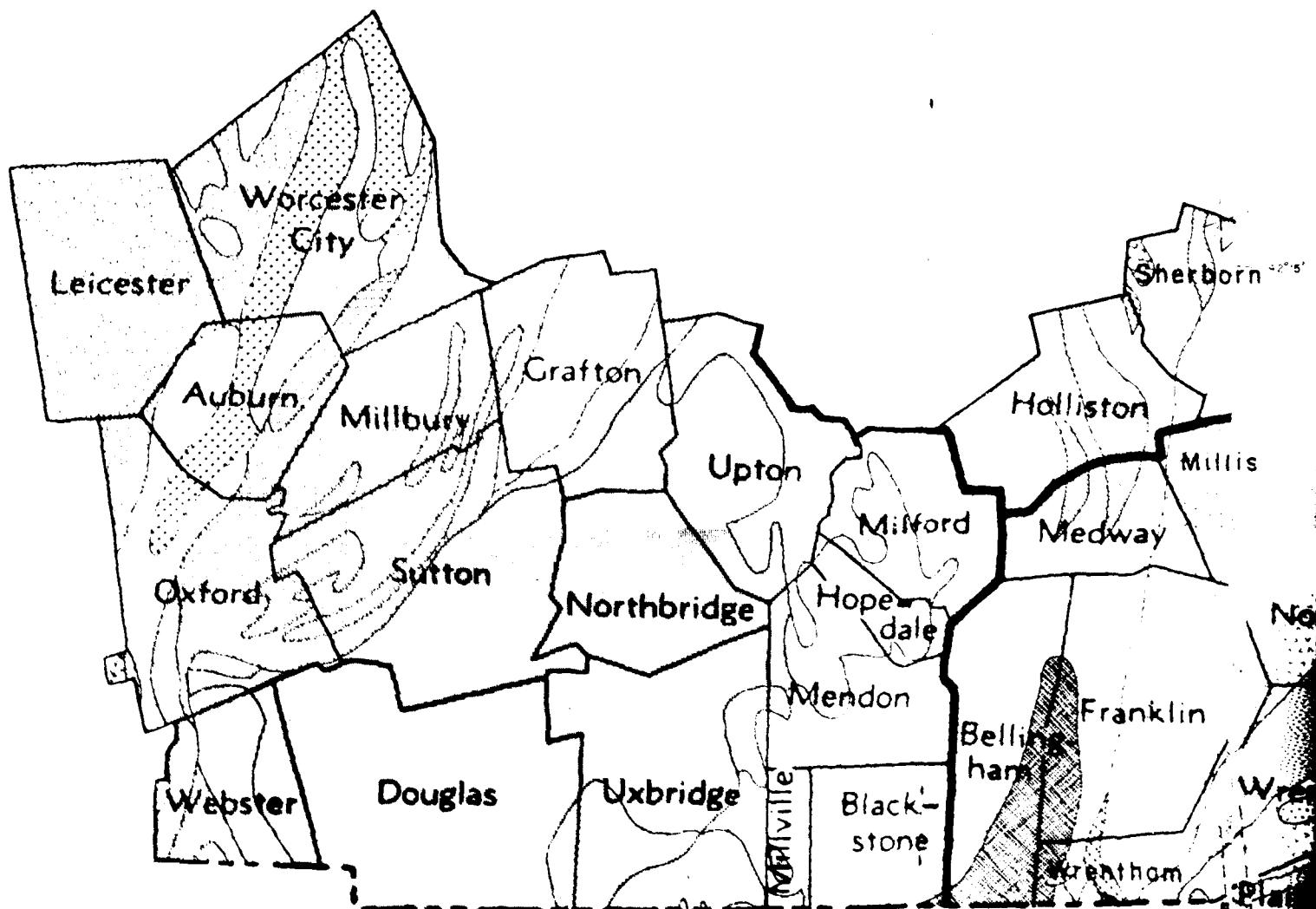


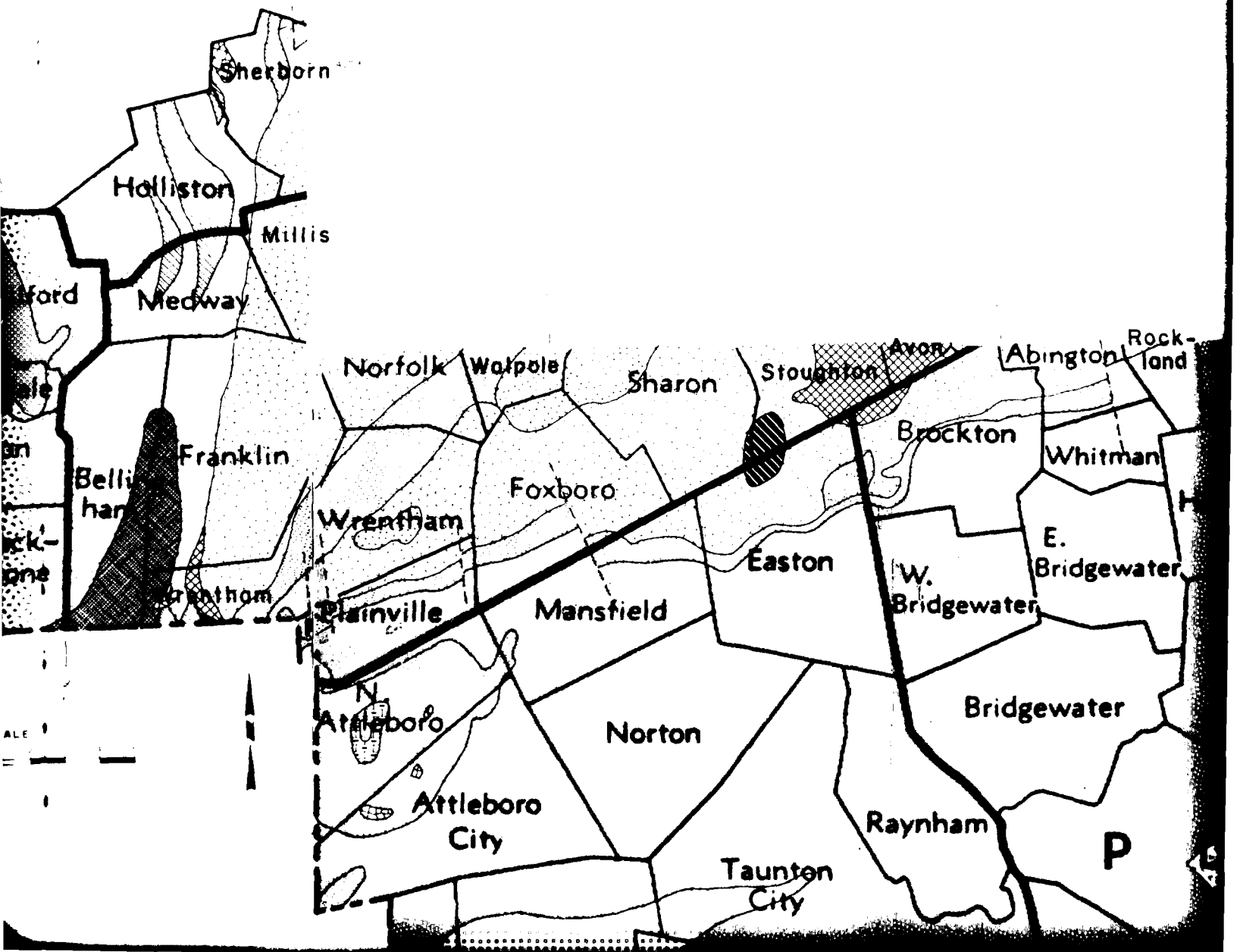
IGNEOUS ROCK UNITS		SEDIMENTARY ROCK UNITS	
	ANDOVER GRANITE		BELLINGHAM CONGLOMERATE
	AYER GRANITE		BRAINTREE ARGILLITE
	BEVERLY SYENITE		BRAINTREE SLATE
	BLUE HILL GRANITE PORPHYRY		BRIMFIELD SCHIST
	DEDHAM GRANDODIORITE		CAMBRIDGE SLATE
	FITCHBURG GRANITE		MARLBORO FORMATION
	MILFORD GRANITE		NASHOBA FORMATION
	NEWBURY - MATTAPAN - LYNN VOLCANICS		NORTHBRIDGE GRANITE GNEISS
	NEWBURYPORT QUARTZ DIORITE		OAKDALE QUARTZITE
	QUINCY GRANITE		OXFORD SCHIST
	SALEM GABBRO - DIORITE		PAXTON QUARTZ SCHIST
	SHARON SYENITE		PONDVILLE CONGLOMERATE
	SQUAM GRANITE		RHODE ISLAND FORMATION
	WESTWOOD GRANITE		ROXBURY CONGLOMERATE
	UNASSIGNED PORPHYRITIC RIEBECKITE GRANITE		WAMSUITA FORMATION
	UNASSIGNED QUARTZ SYENITE		WESTBORO QUARTZITE
	UNASSIGNED VOLCANIC ROCKS		WEYMOUTH FORMATION
	UNDIFFERENTIATED DEDHAM GRANDODIORITE AND SALEM GABBRO - DIORITE		WORCESTER PHYLITE
	UNASSIGNED GRANITE		UNASSIGNED GNEISSES AND SCHISTS
			UNASSIGNED METAMORPHIC ROCKS
			DIGHTON AND PURGATORY CONGLOMERATES

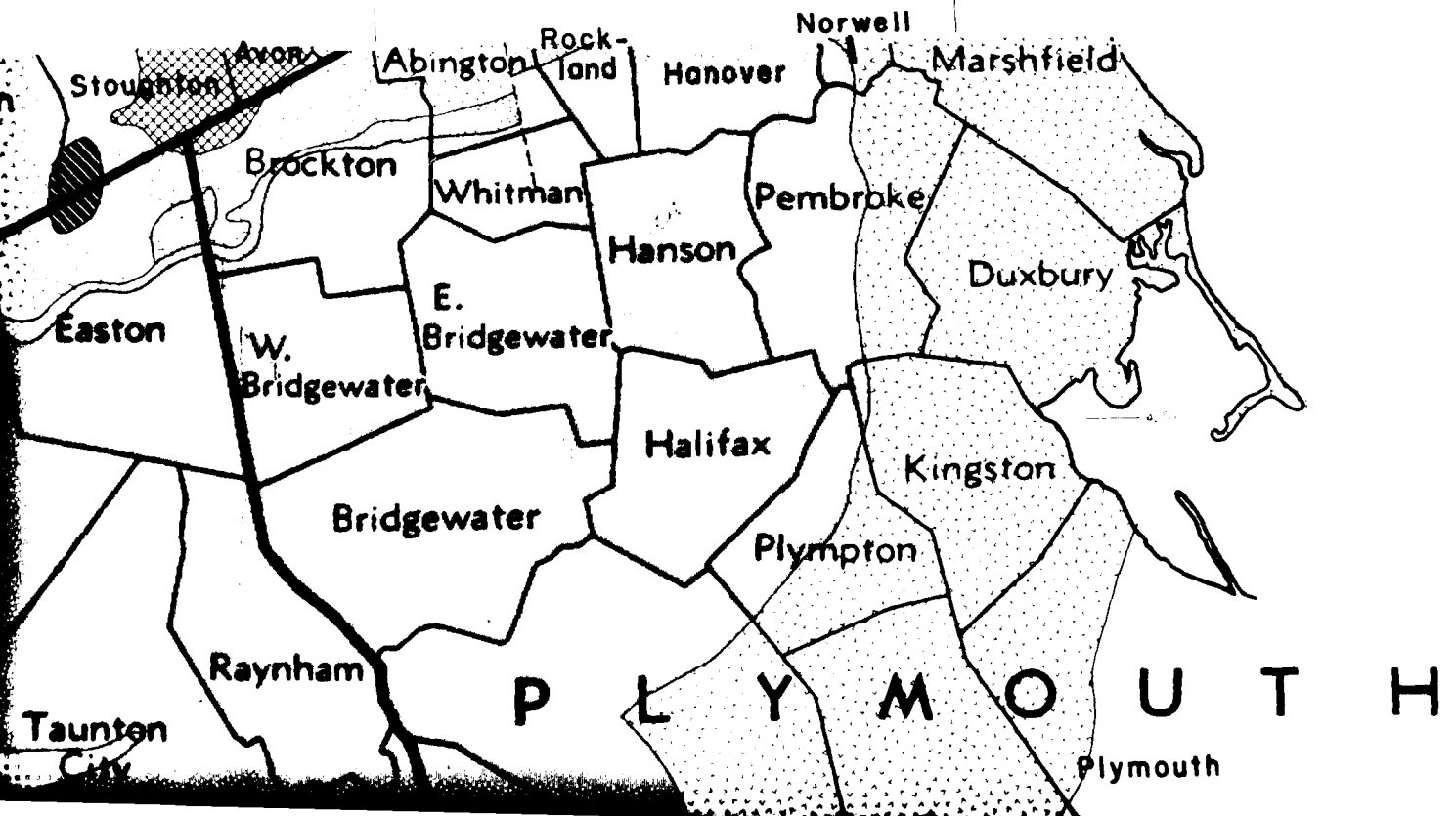
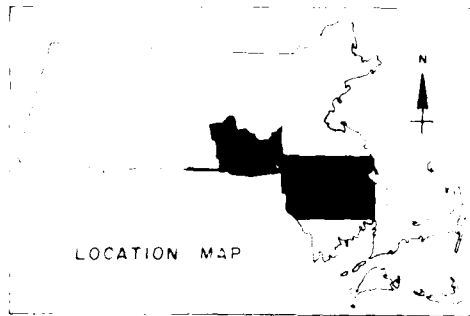
throp



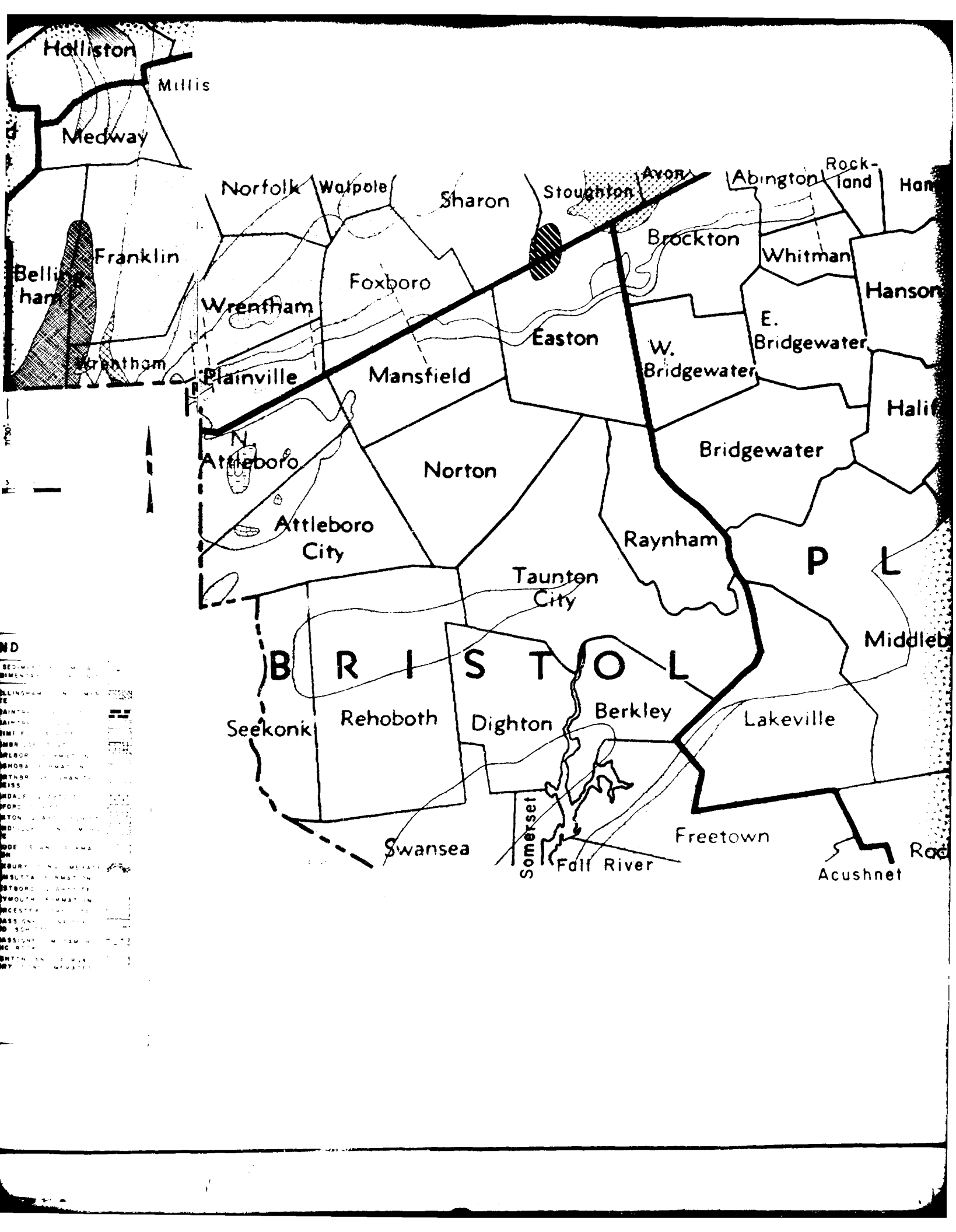
1 A











Holliston

Millis

Medway

Norfolk

Walpole

Sharon

Stoughton

Avon

Abington

Rockland

Hamp

Franklin

Brockton

Whitman

Hanson

Bellingham

Foxboro

Easton

W. Bridgewater

E. Bridgewater

Wrentham

Mansfield

Plainville

Halifax

Attleboro

Norton

Bridgewater

Attleboro City

Raynham

P

L

Taunton City

**B R I S T O L**

Middlebury

Seekonk

Rehoboth

Dighton

Berkley

Lakeville

Swansea

Somerset

Fall River

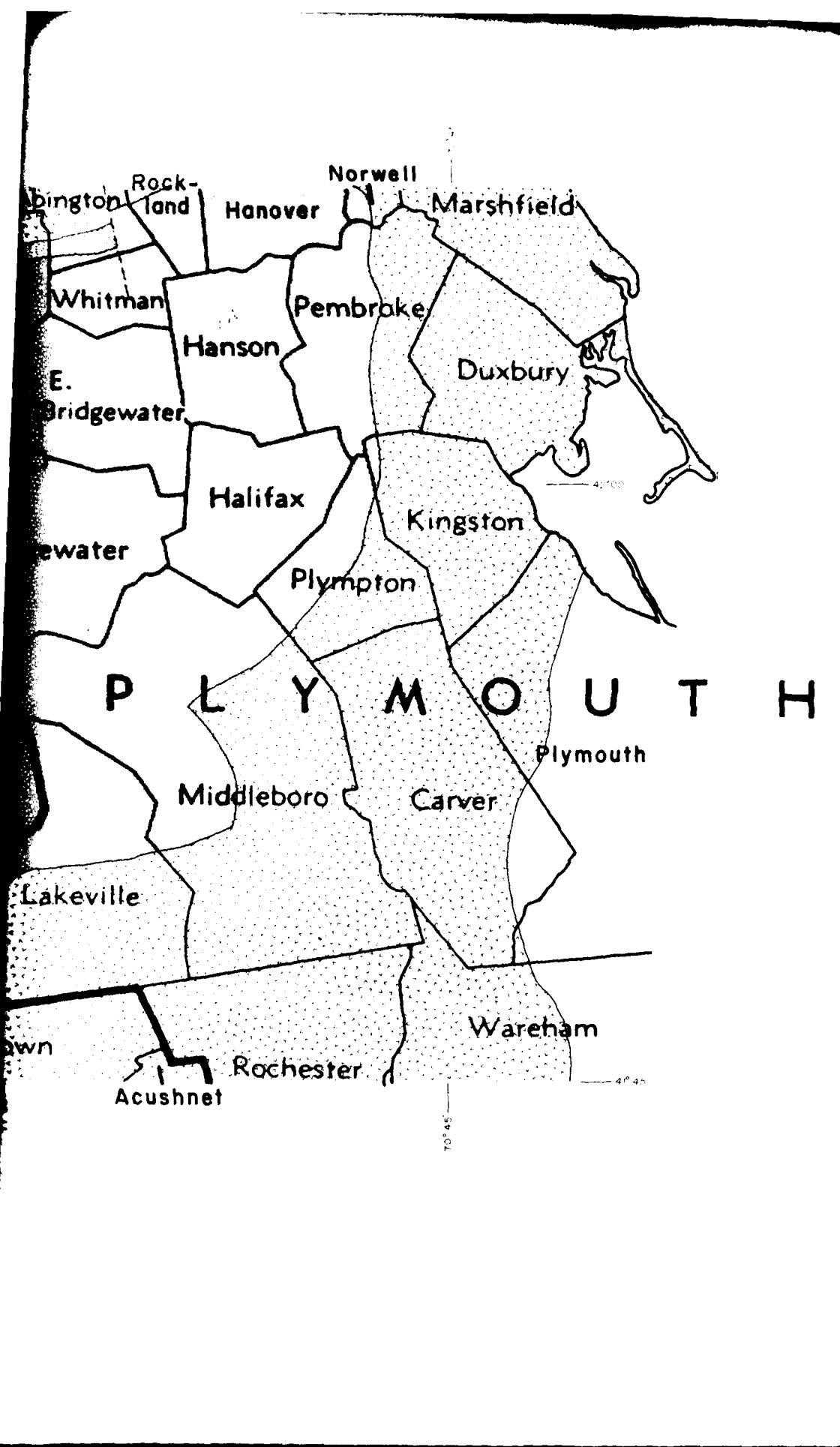
Freetown

Acushnet

Rod

ND

LEGEND  
BIRMINGHAM  
BRISTOL  
BURLINGTON  
CHESHIRE  
DORSET  
DURHAM  
GLoucestershire  
Hampshire  
HEREFORDSHIRE  
HULL  
KENT  
LEICESTERSHIRE  
LINCOLNSHIRE  
MIDDLESEX  
NOTTINGHAMSHIRE  
OXFORDSHIRE  
RUTLAND  
SOMERSET  
SUFFOLK  
SURREY  
WARWICKSHIRE  
WILTSHIRE  
WORCESTERSHIRE  
YORKSHIRE



**BOSTON HARBOR - EASTERN MASSACHUSETTS  
METROPOLITAN AREA WASTE WATER  
MANAGEMENT STUDY**

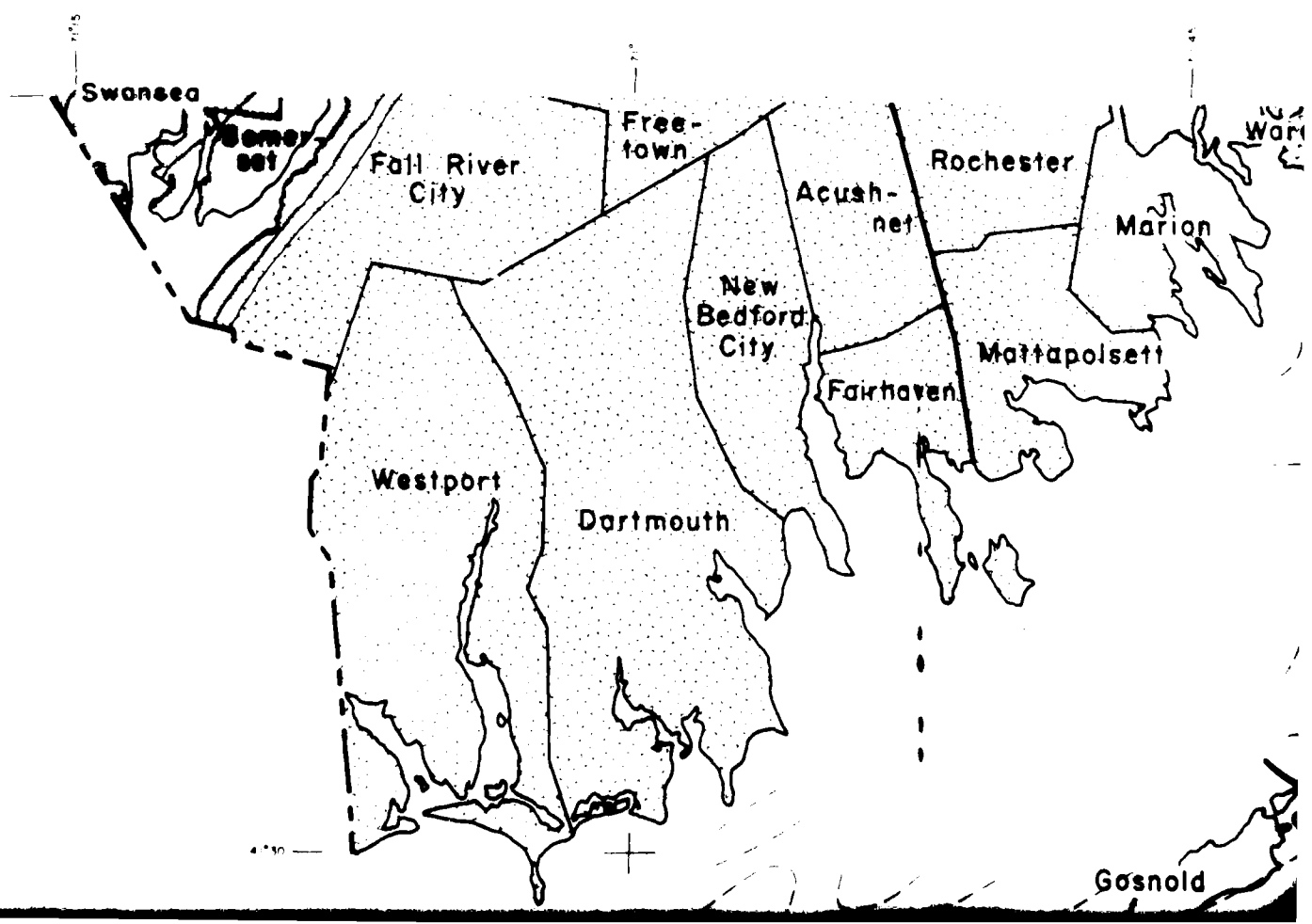
**UNITED STATES ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION WALTHAM, MASS.**

**A SUMMARY OF THE AVAILABLE INFORMATION  
SHOWING THE DISTRIBUTION OF BEDROCK  
UNITS IN EASTERN MASSACHUSETTS**

<b>WHITMAN &amp; HOWARD INC</b>	<b>SHEET EMB-3</b>
<b>ENGINEERS &amp; ARCHITECTS BOSTON, MASS</b>	

### LEGEND

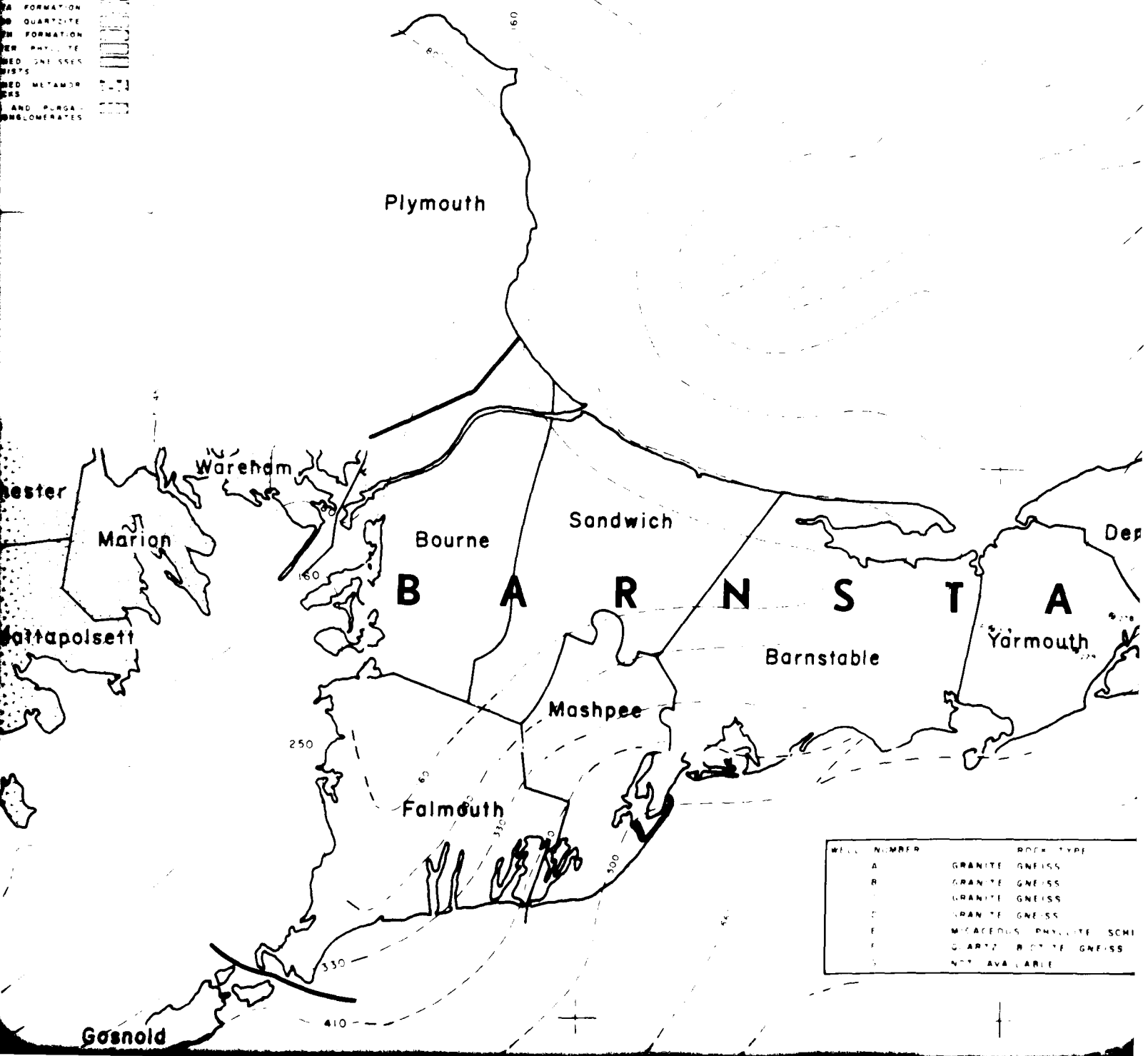
<ul style="list-style-type: none"> <li> UNASSIGNED GRANITE</li> <li> ANDOVER GRANITE</li> <li> AYER GRANITE</li> <li> RIVERSIDE SYENITE</li> <li> BLUE HILL GRANITE PORPHYRY</li> <li> DEDHAM GRANODIORITE</li> <li> FITCHBURG GRANITE</li> <li> MILFORD GRANITE</li> <li> NEWBURY - MATTAPAN LYNN VOLCANICS</li> <li> NEWBURYPORT QUARTZ DIORITE</li> <li> QUINCY GRANITE</li> <li> SALEM GABBRO-DIORITE</li> <li> SHARON SYENITE</li> <li> SQUAM GRANITE</li> <li> WESTWOOD GRANITE</li> <li> UNASSIGNED PORPHYRYC RIEBECKITE GRANITE</li> <li> UNASSIGNED QUARTZ SYENITE</li> <li> UNASSIGNED VOLCANIC ROCKS</li> <li> UNDIFFERENTIATED DEDHAM GRANODIORITE AND SALEM GABBRO-DIORITE</li> <li> UNASSIGNED GRANITE</li> </ul>	<ul style="list-style-type: none"> <li> UNDIFFERENTIATED METAMORPHIC ROCKS</li> <li> BELLINGHAM CONGLOMERATE</li> <li> BRANTREE GRANITE</li> <li> BRIMLEY SCHIST</li> <li> CAMBRIDGE SLATE</li> <li> MARBORO FORMATION</li> <li> NASHOBA FORMATION</li> <li> NORTHBRIDGE GRANITE GNEISS</li> <li> OXFORD QUARTZ SCHIST</li> <li> PAXTON QUARTZ SCHIST</li> <li> PONDUSSETT CONGLOMERATE</li> <li> RHODE ISLAND FORMATION</li> <li> ROXBURY CONGLOMERATE</li> <li> WAMSUTTA FORMATION</li> <li> WESTBORO QUARTZITE</li> <li> WEYMOUTH FORMATION</li> <li> WORCESTER PHYLLITE</li> <li> UNASSIGNED GNEISSES AND SCHISTS</li> <li> UNASSIGNED METAMORPHIC ROCKS</li> <li> DIGHTON AND PURGATORY CONGLOMERATES</li> </ul>
---	---



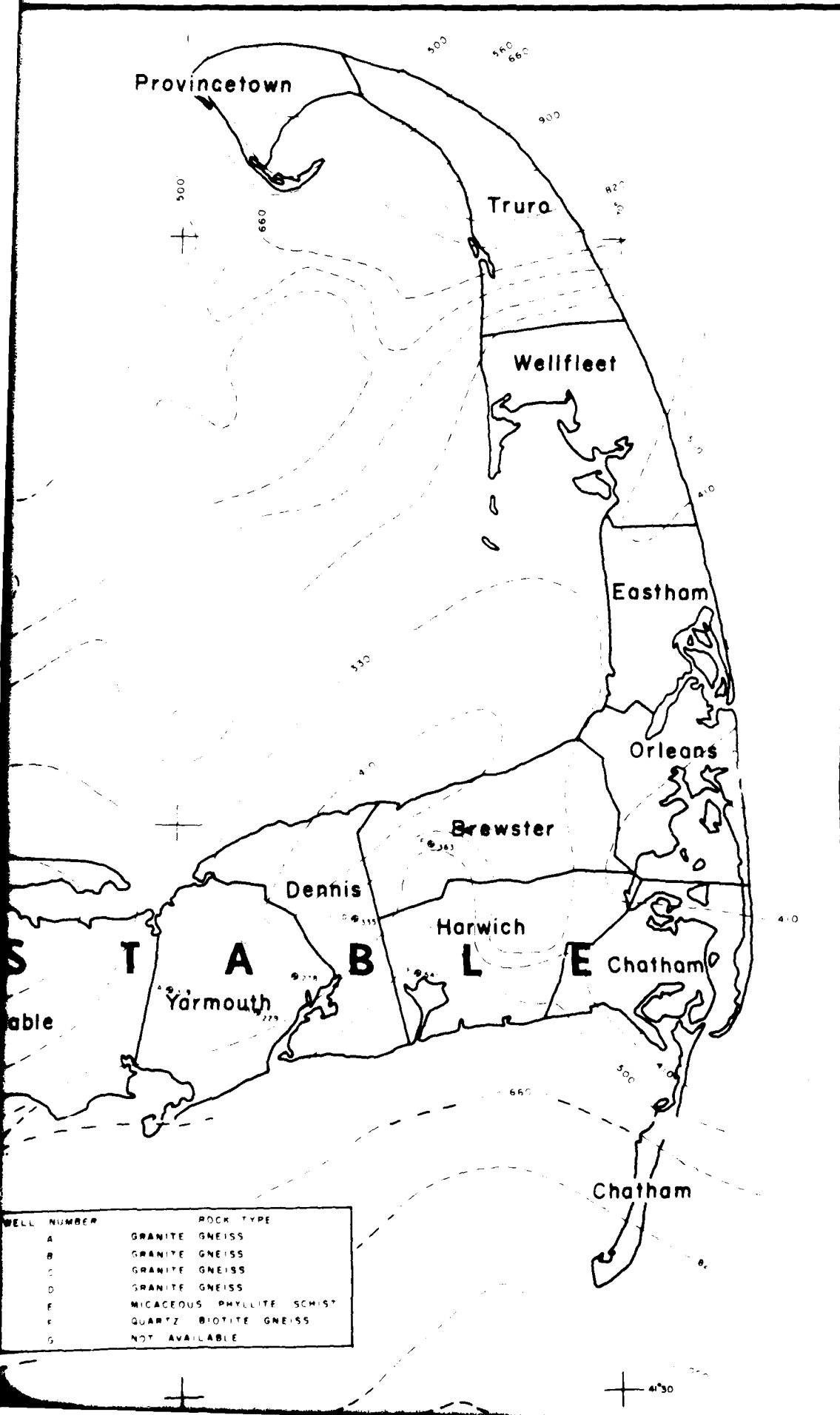


Provincetown

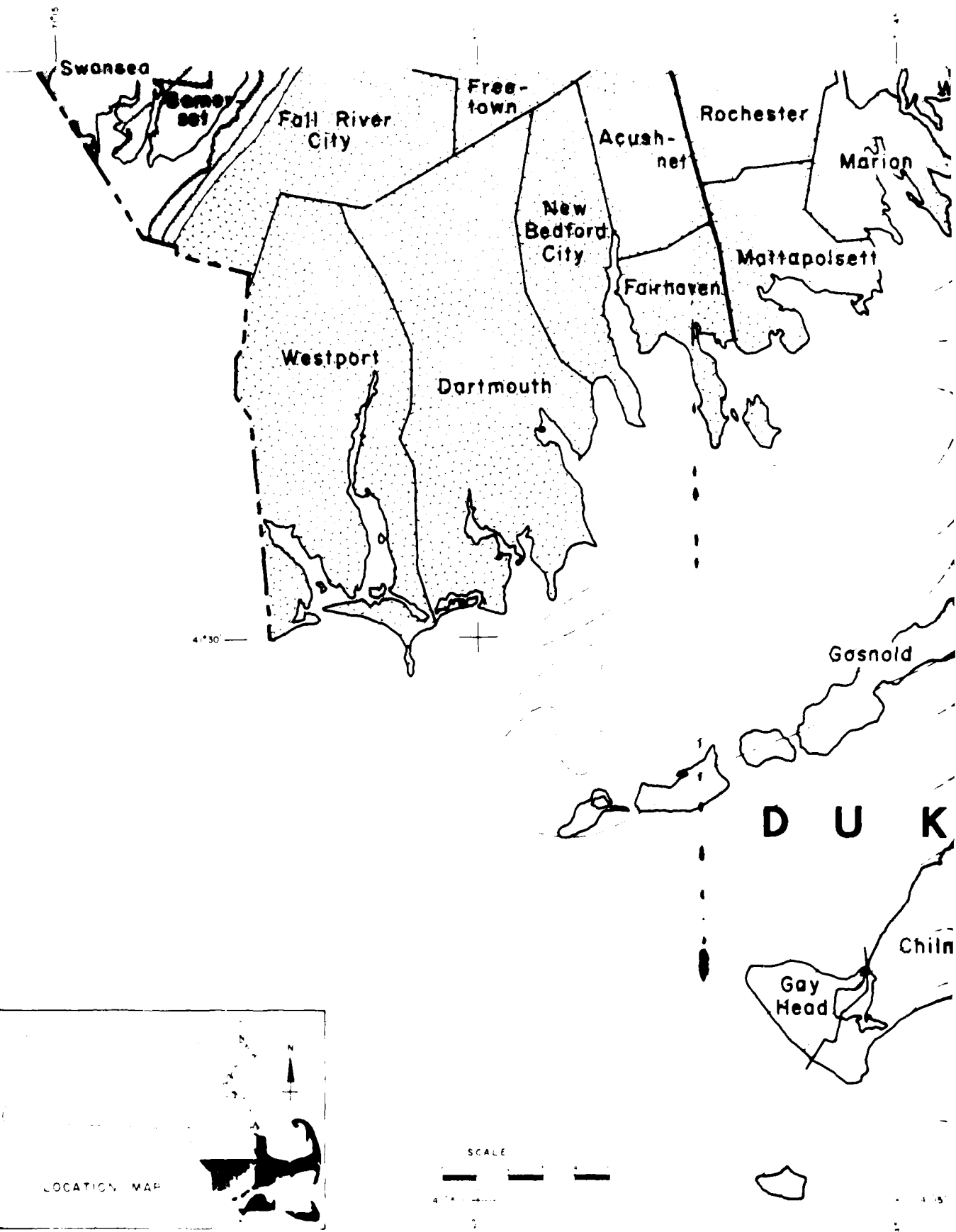
ATANTIC META	
ARY R. A.	
CONGLOMERATE	
ARILLITE	
SLATE	
SCHIST	
SLATE	
FORMATION	
FORMATION	
BISSÉ GRANITE	
QUARTZITE	
SCHIST	
QUARTZ SCHIST	
CONGLOMERATE	
ISLAND FORMATION	
CONGLOMERATE	
FORMATION	
QUARTZITE	
FORMATION	
PHYLLITE	
GNEISS	
METAMORPHOSIS	
PURGATION	
CONGLOMERATES	



WELL NUMBER	ROCK TYPE
A	GRANITE GNEISS
B	GRANITE GNEISS
C	GRANITE GNEISS
D	GRANITE GNEISS
E	MICACEOUS PHYLLITE SCHIST
F	QUARTZ DIOXYDE GNEISS
G	NOT AVAILABLE



WELL NUMBER	ROCK TYPE
A	GRANITE GNEISS
B	GRANITE GNEISS
C	GRANITE GNEISS
D	GRANITE GNEISS
E	MICACEOUS PHYLITE SCHIST
F	QUARTZ BIOTITE GNEISS
G	NOT AVAILABLE

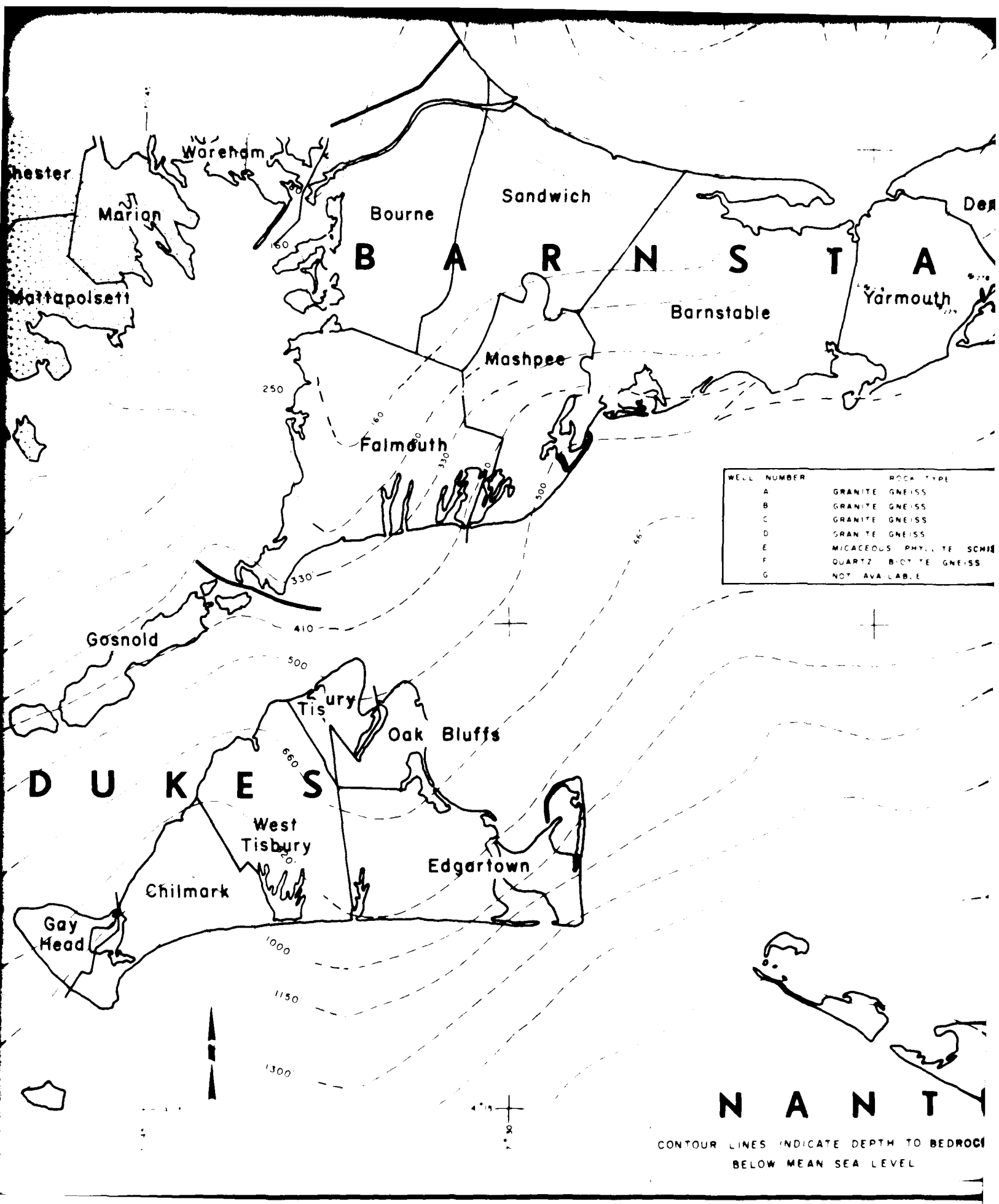


LOCATION MAP

SCALE

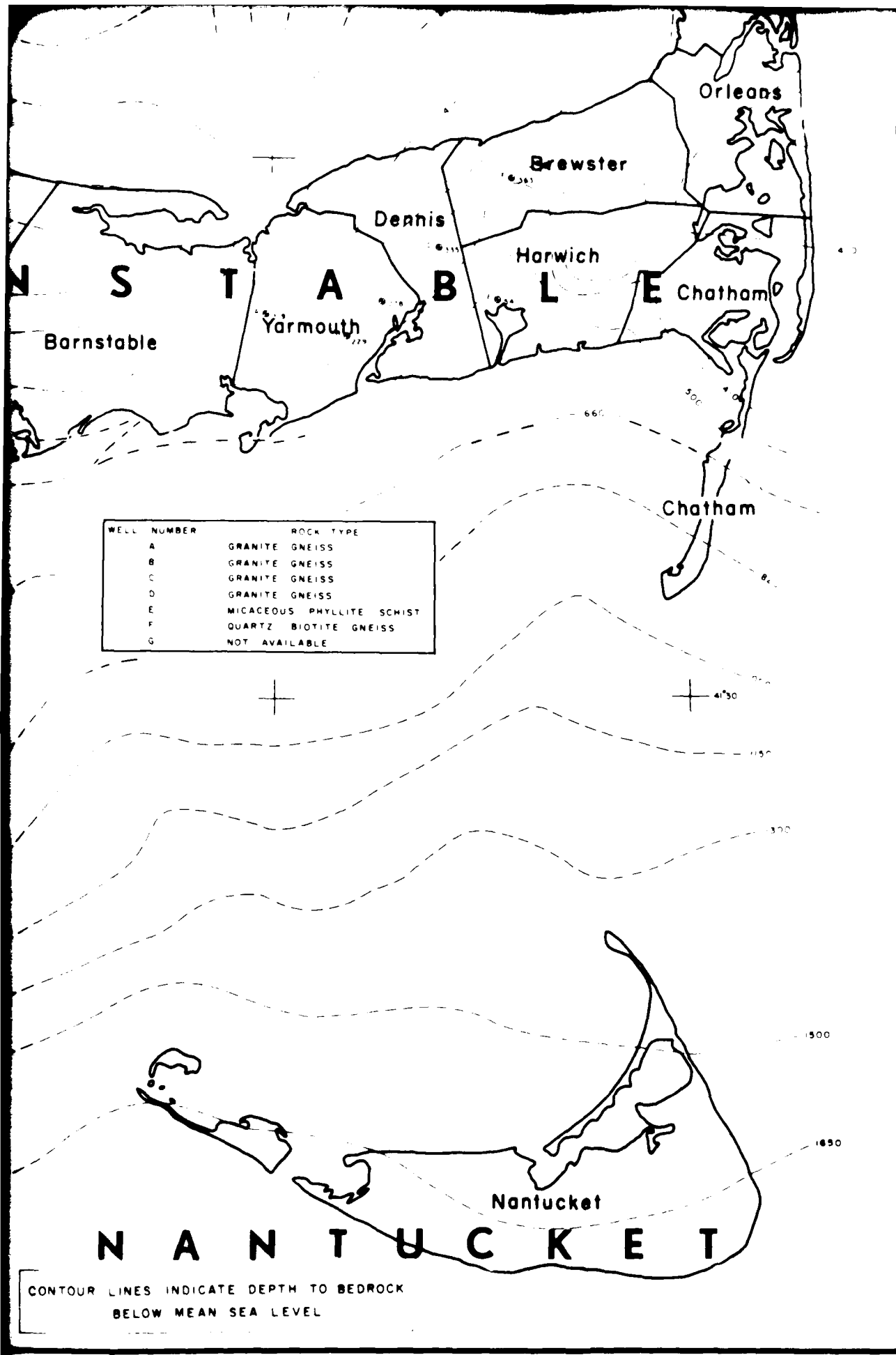
4 Miles

15

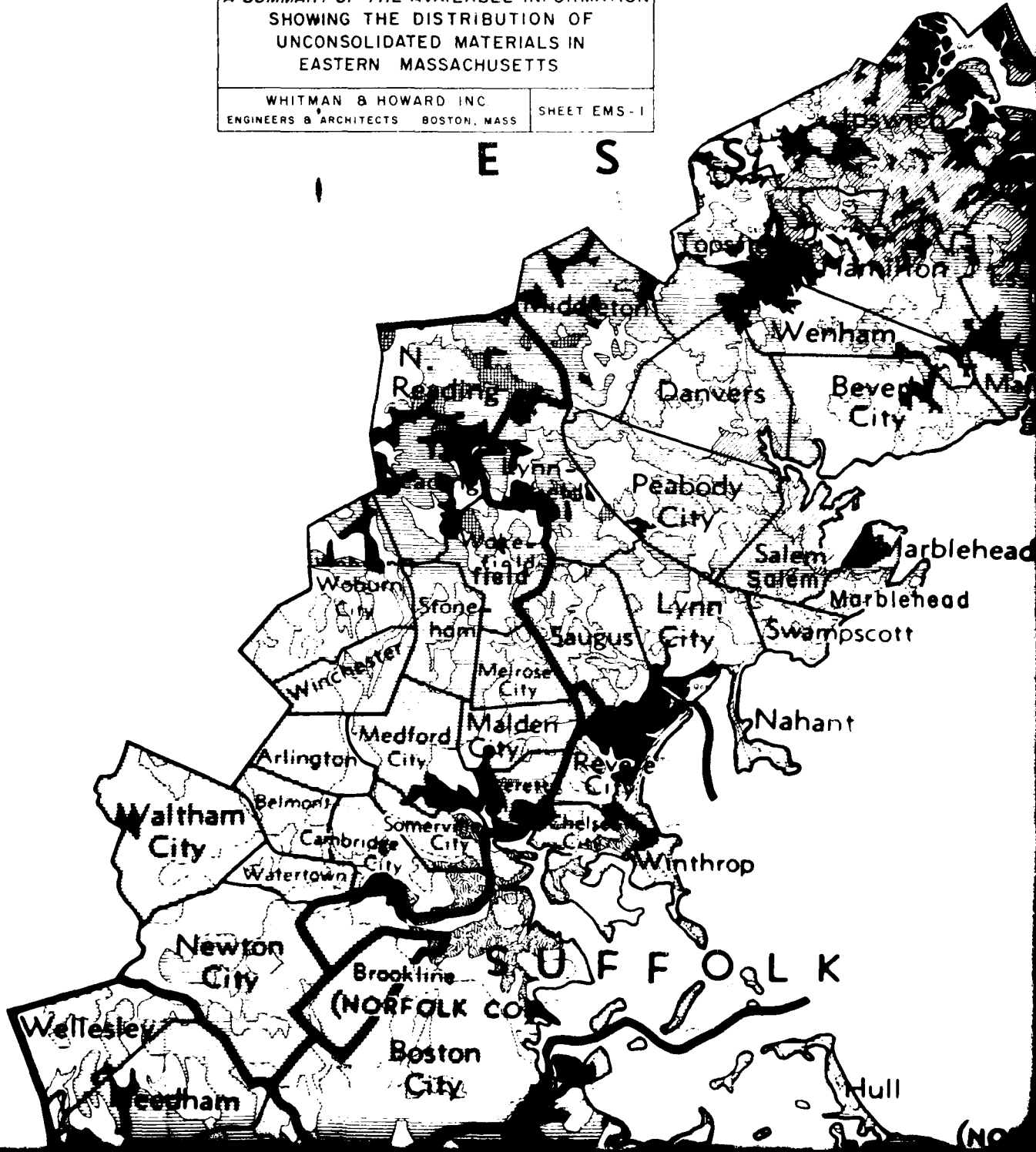


# NANT

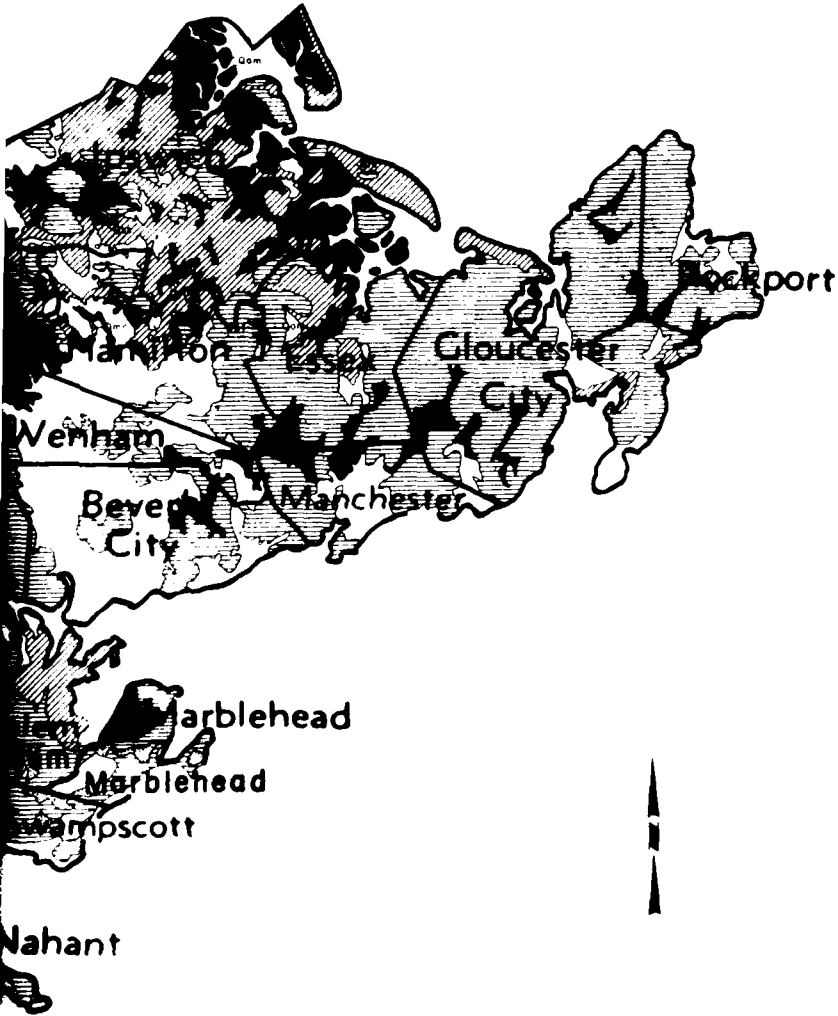
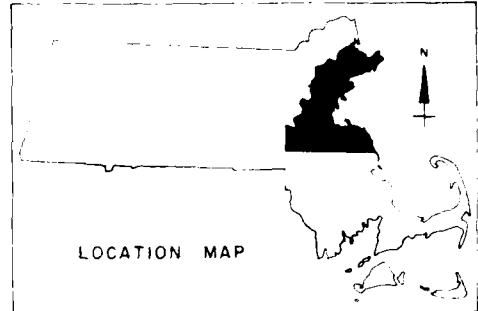
CONTOUR LINES INDICATE DEPTH TO BEDROCK BELOW MEAN SEA LEVEL



BOSTON HARBOR - EASTERN MASSACHUSETTS METROPOLITAN AREA WASTE WATER MANAGEMENT STUDY	
UNITED STATES ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION      WALTHAM, MASS	
A SUMMARY OF THE AVAILABLE INFORMATION SHOWING THE DISTRIBUTION OF UNCONSOLIDATED MATERIALS IN EASTERN MASSACHUSETTS	
WHITMAN & HOWARD INC ENGINEERS & ARCHITECTS      BOSTON, MASS	SHEET EMS - I



70°45'  
42°45'



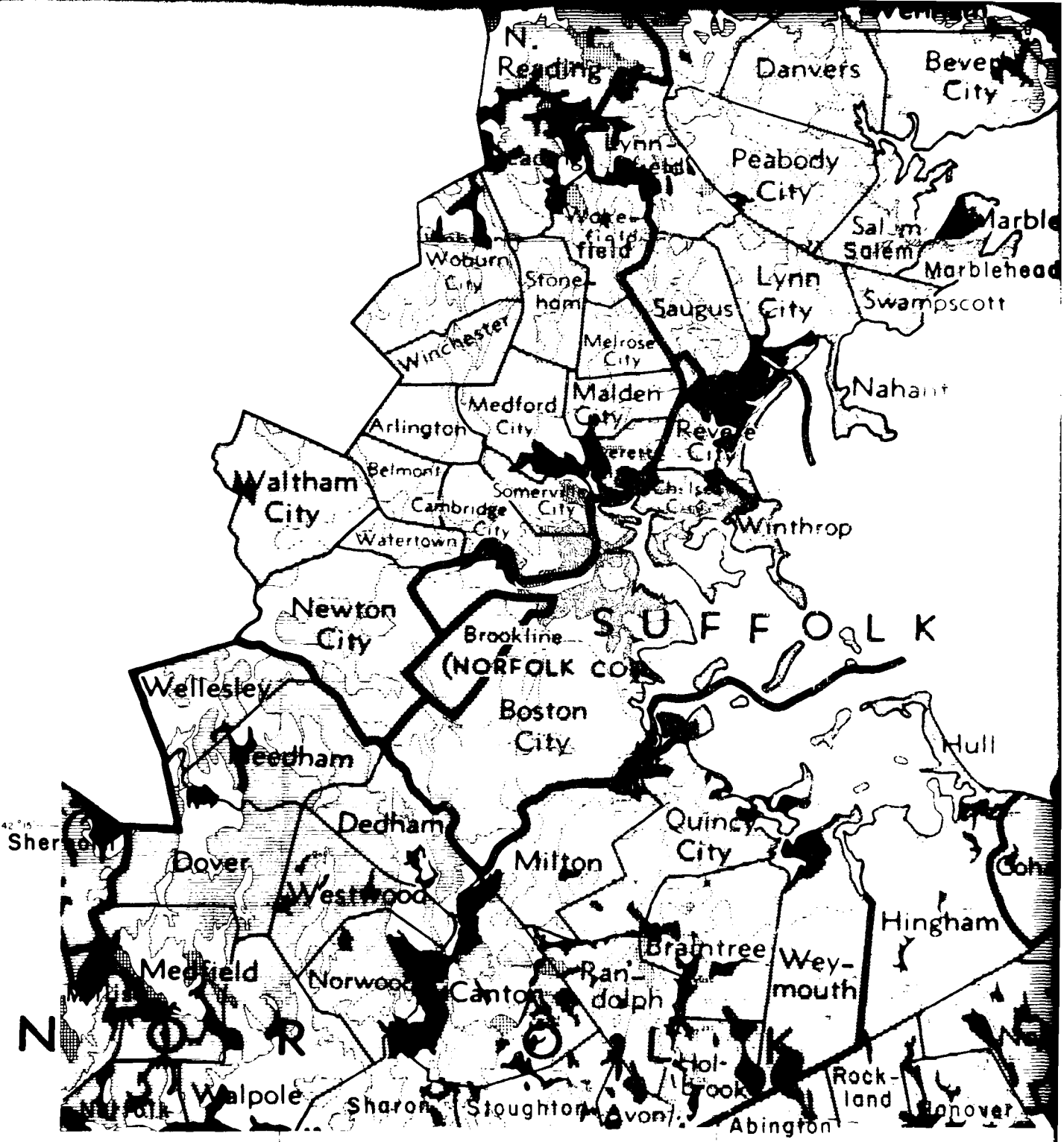
**LEGEND**

SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
Qac	OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS. Silt and/or clay portions usually minor, stratified and sorted.
Umc	BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted - often stratified and cross bedded.
Qac	ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics poorly to moderately sorted and stratified.
Qtc	GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders, dense, non-stratified unsorted mixture.
Qlt	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved SILTS and Clays.
Qmf	MARINE DEPOSITS	SILTY CLAYS, SILTS and CLAYS, SILTS, Silty fine SANDS.
Qof	FRESH-WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS, Silty PLATS, Organic Sands and SILTS, MUCK.
Qom	MARINE ORGANIC DEPOSITS	ORGANIC SILT, Clayey Organic SILTS, Organic Sands, Marine Muds, "Ooze".

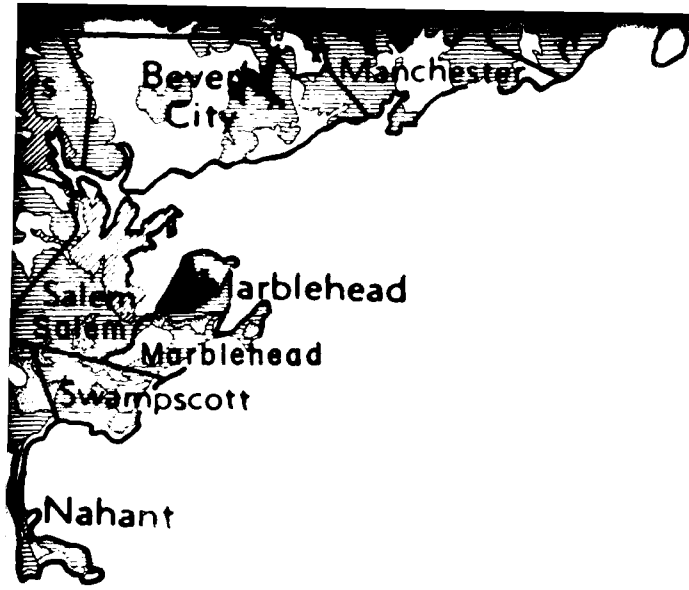
ART. 1 CLAY, E.L.

L K

Hull





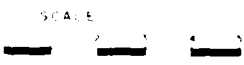
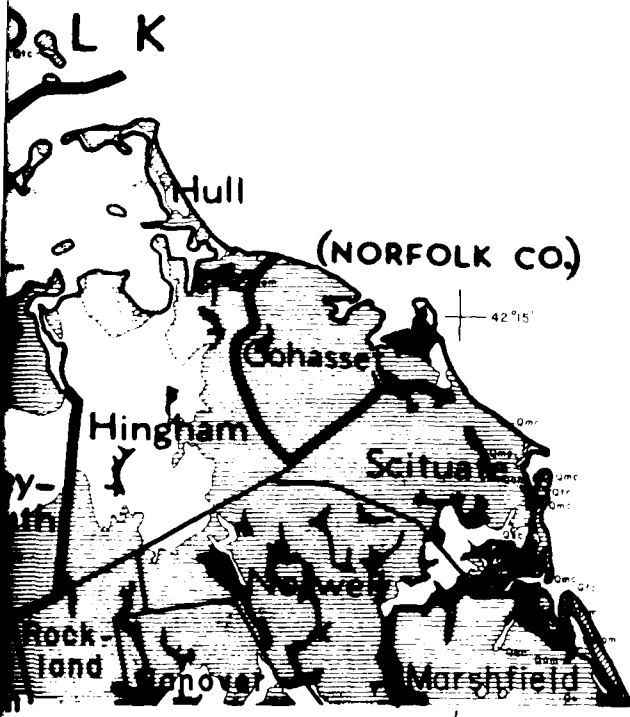


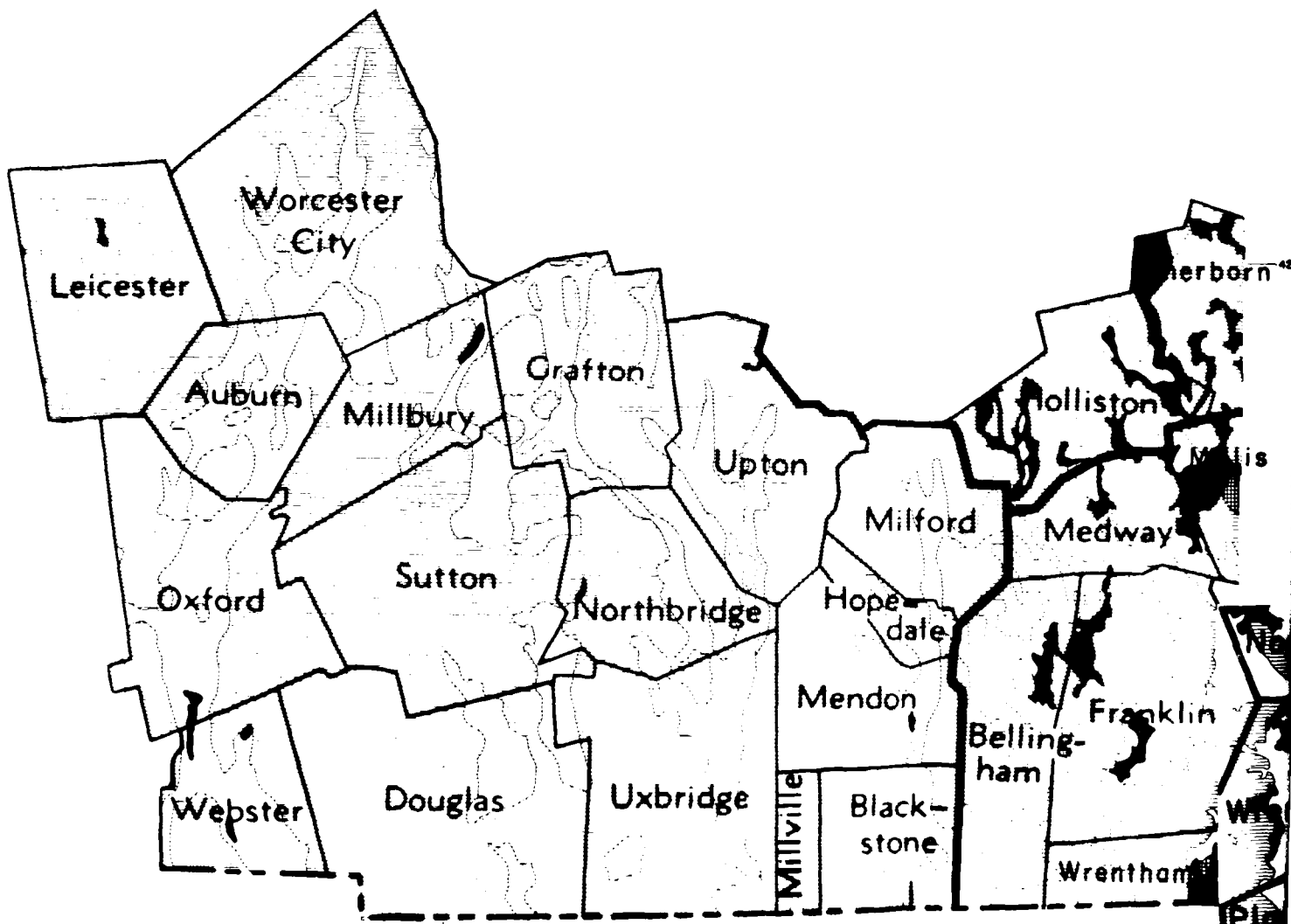
**LEGEND**

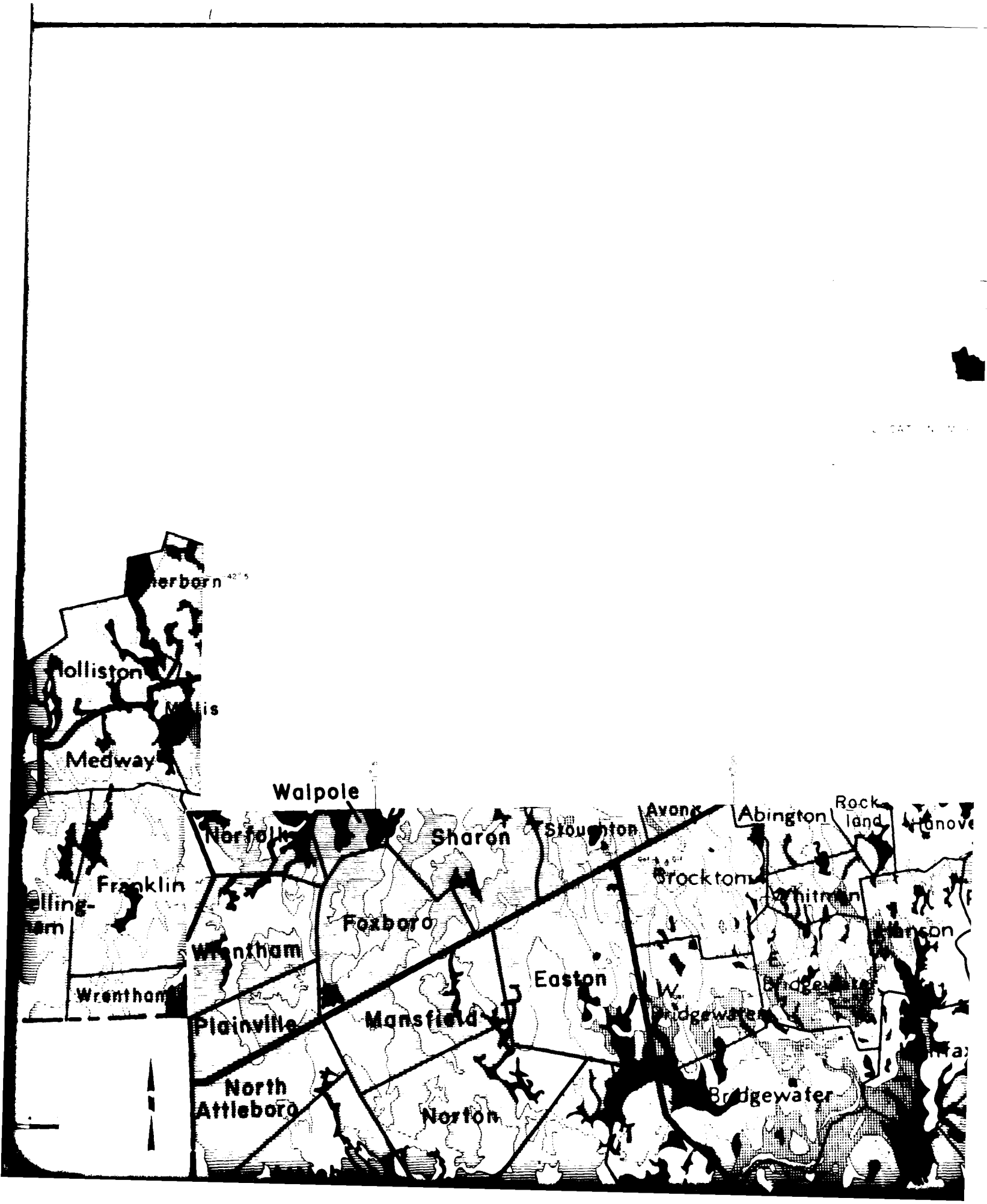
SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
Qdc	OUTWASH AND ALLUVIUM CONTACT DEPOSITS	SANDS OF SANDS and GRAVELS, SILT and/or clay part are usually minor, stratified and sorted
Qm	BEACH, DUNE AND MARINE DEPOSITS	Fine or fine to medium SANDS, well sorted, often stratified and shaly bedded
Qdr	ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of gravel, clay and/or organic matter to moderately sorted and stratified
Qgl	GLACIAL TILL	Silt of clayey SAND and GRAVEL with cobbles and boulders, dense non stratified unsorted mixture
Ql	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, clayey SILTS, SILT, SANDS, Varied Silt and clay
Qm	MARINE DEPOSITS	Silt, CLAYS, SILTS and CLAYS, SILTS, Silt, fine SANDS
Qof	FRESH WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS, SILT, PEATS, Organic Sands and SILTS
Qom	MARINE ORGANIC DEPOSITS	ORGANIC SILT, clayey SILT, Organic Silty Sands, Muds, Muds, etc.



top







Herborn 42° 5'

Holliston

Medway

Walpole

Norfolk

Sharon

Stoughton

Avon

Abington

Rockland

Hanover

Franklin

Foxboro

Brockton

Whitman

Wrentham

Mansfield

Easton

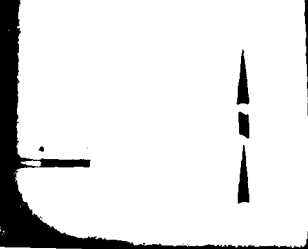
Bridgewater

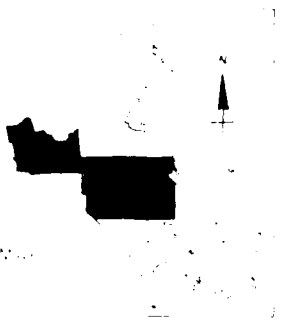
Plainville

North Attleboro

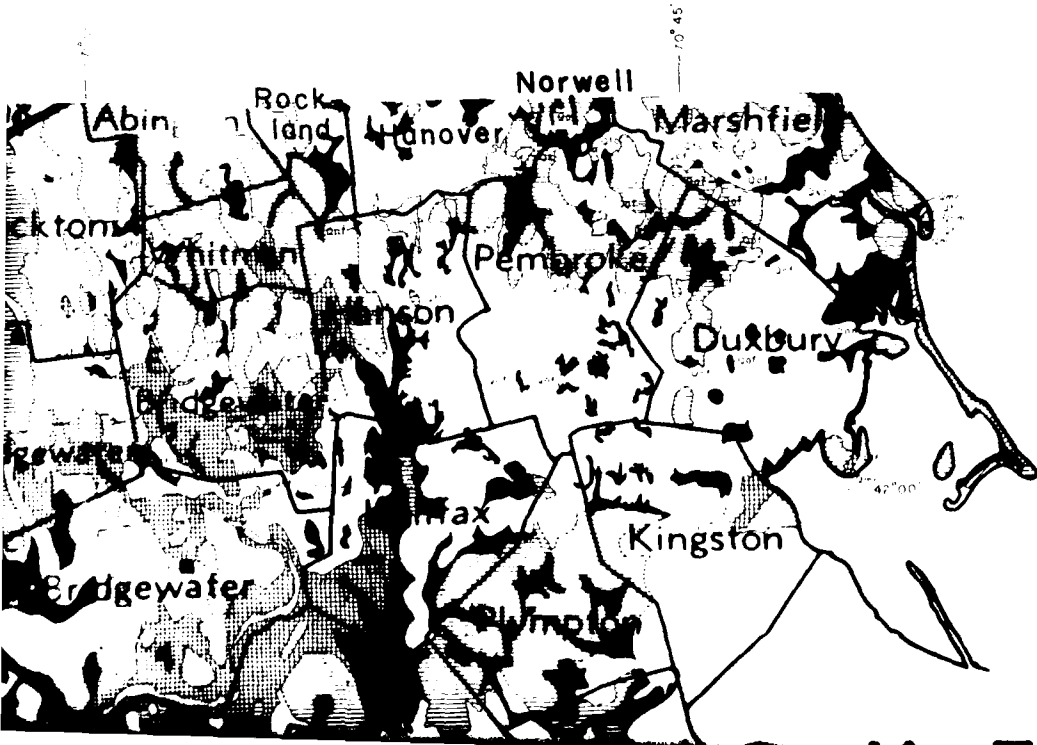
Norton

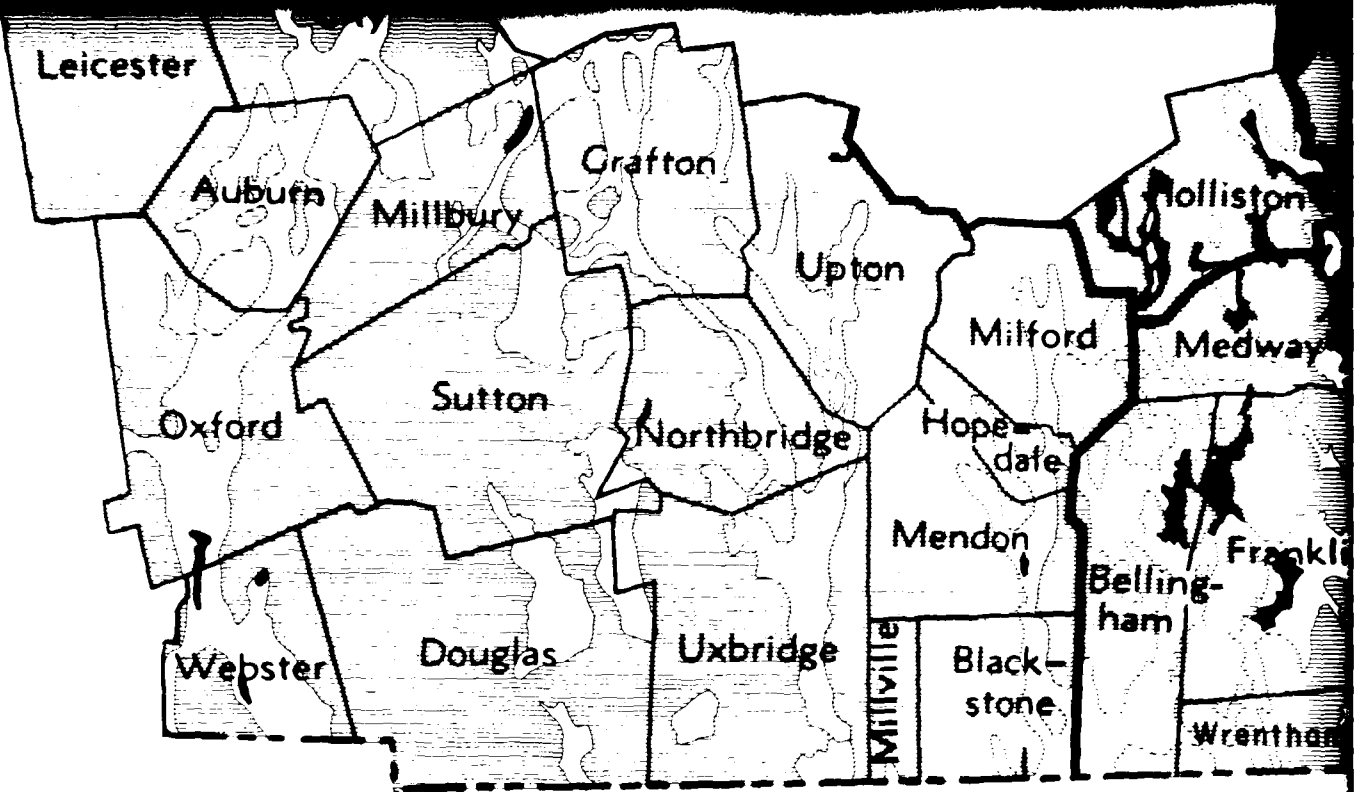
Bridgewater



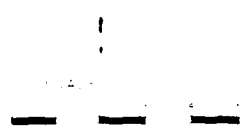


LOCATION MAP





71°45'



BOSTON HARBOR - EASTERN MASSACHUSETTS  
METROPOLITAN AREA WASTE WATER  
MANAGEMENT STUDY

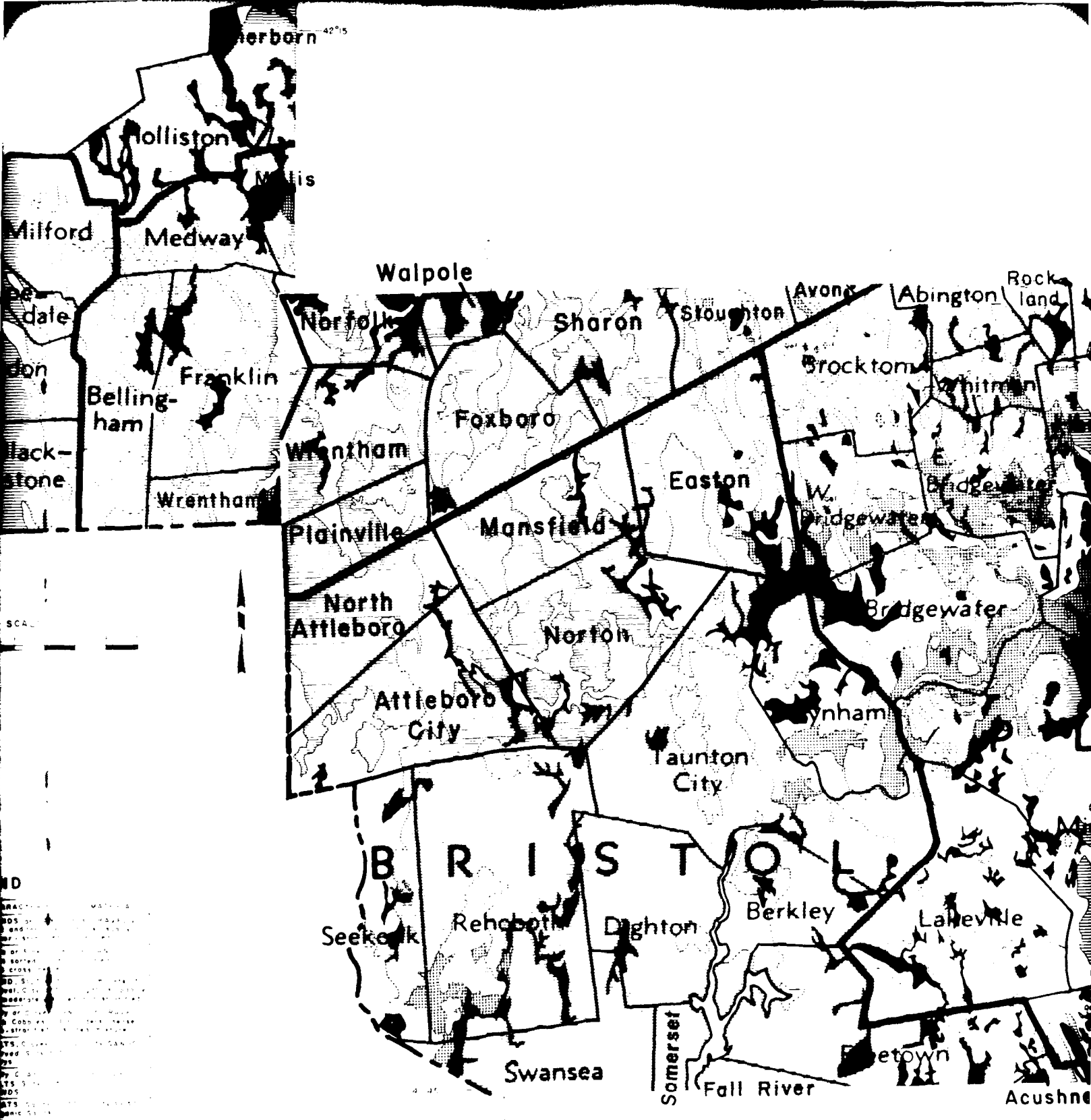
UNITED STATES ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION WALTHAM, MASS

A SUMMARY OF THE AVAILABLE INFORMATION  
SHOWING THE DISTRIBUTION OF  
UNCONSOLIDATED MATERIALS IN  
EASTERN MASSACHUSETTS

WHITMAN & HOWARD INC.  
ENGINEERS & ARCHITECTS BOSTON, MASS SHEET EMS-2

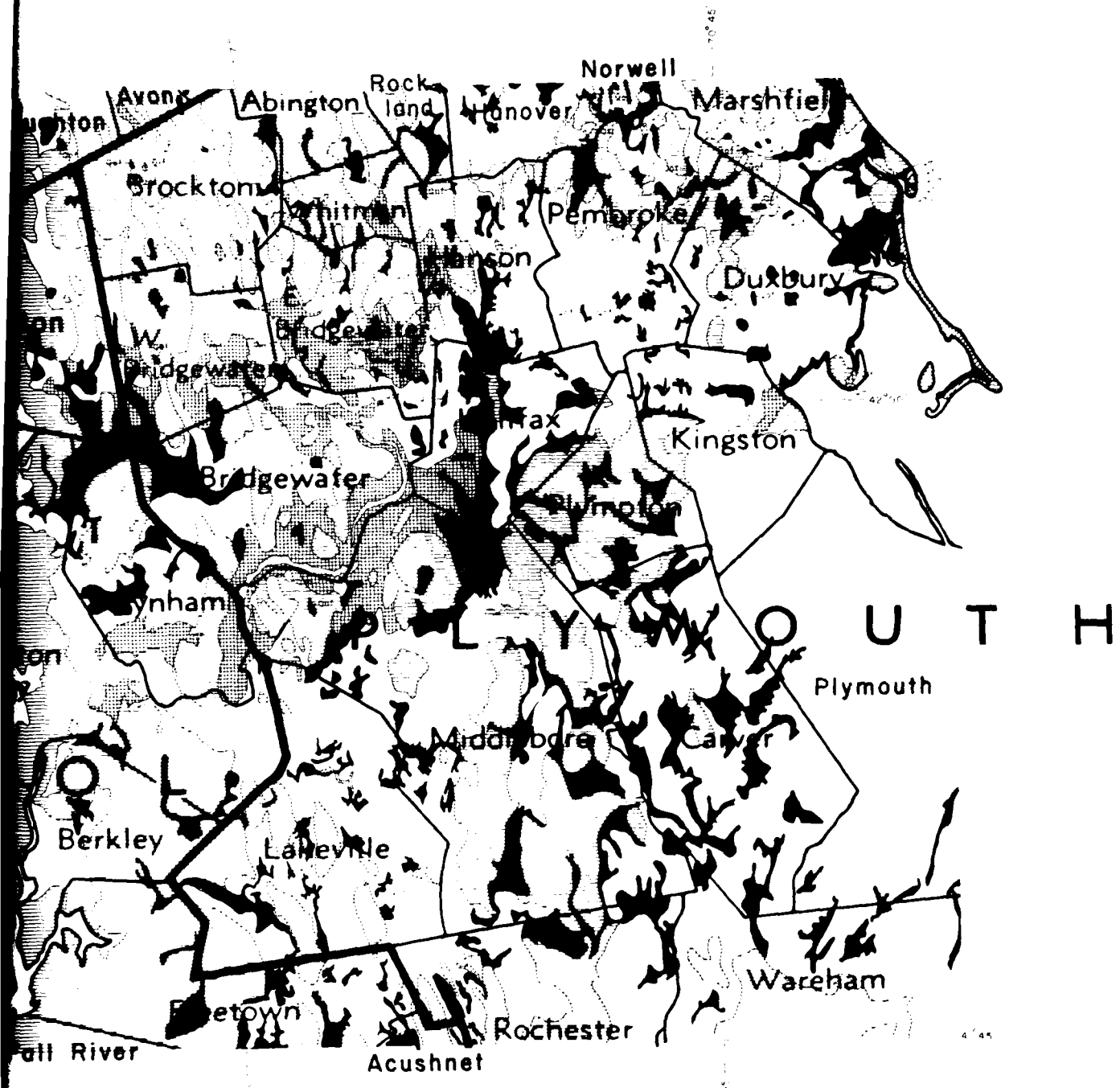
LEGEND

SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
Osc	OUTWASH AND ICE CONTACT DEPOSITS	GRAVELS AND SANDS AND GRAVELS WITH SOME FINE GRAINED MATERIALS
Umf	BEACH, DUNE AND MARINE DEPOSITS	GRAVELS AND SANDS WITH SOME FINE GRAINED MATERIALS
Qac	ALLUVIUM AND RIVER TERRACE DEPOSITS	SANDS AND SILTS WITH MINOR AMOUNTS OF GRAVELS AND SOME FINE GRAINED MATERIALS
Qgl	GLACIAL TILL	SANDS AND SILTS WITH MINOR AMOUNTS OF GRAVELS AND SOME FINE GRAINED MATERIALS
Ql	GLACIAL LAKE BOTTOM DEPOSITS	SANDS AND SILTS WITH MINOR AMOUNTS OF GRAVELS AND SOME FINE GRAINED MATERIALS
Uml	MARINE DEPOSITS	SANDS AND SILTS WITH MINOR AMOUNTS OF GRAVELS AND SOME FINE GRAINED MATERIALS
Qof	FRESH WATER ORGANIC DEPOSITS	PEATS AND SILTS WITH ORGANIC MATERIALS
Qom	MARINE ORGANIC DEPOSITS	PEATS AND SILTS WITH ORGANIC MATERIALS



SCALE

ND  
 BRISTOL COUNTY  
 MASSACHUSETTS  
 1880  
 W. C. CROSSLAND  
 GEOGRAPHER  
 100 STATE STREET  
 BOSTON  
 MASS.  
 1880



Weymouth

Avon

Abington

Rockland

Hanover

Norwell

Marshfield

Brockton

Whitman

Pembroke

Manson

Duxbury

W. Bridgewater

Bridgewater

Kingston

Kingston

Bridgewater

Newington

Lynnham

PLYMOUTH

Plymouth

Middleboro

Carver

Berkley

Lakeville

Wareham

Freetown

Freetown

Rochester

Acushnet

445

**BOSTON HARBOR - EASTERN MASSACHUSETTS  
METROPOLITAN AREA WASTE WATER  
MANAGEMENT STUDY**

---

UNITED STATES ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION      WALTHAM, MASS.

---

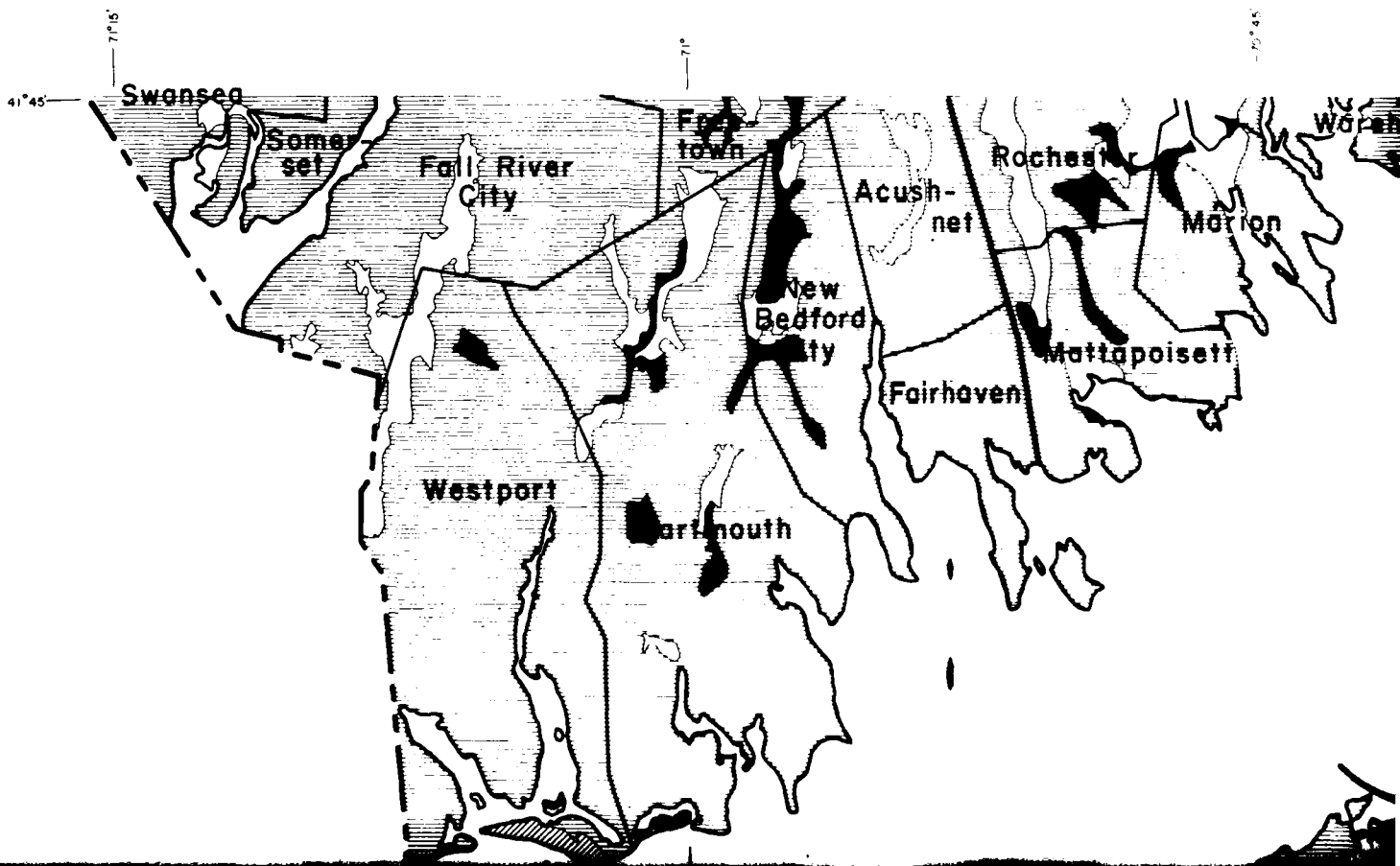
**A SUMMARY OF THE AVAILABLE INFORMATION  
SHOWING THE DISTRIBUTION OF  
UNCONSOLIDATED MATERIALS IN  
EASTERN MASSACHUSETTS**

---

WHITMAN & HOWARD INC.  
ENGINEERS & ARCHITECTS      BOSTON, MASS.      SHEET EMS - 3

**LEGEND**

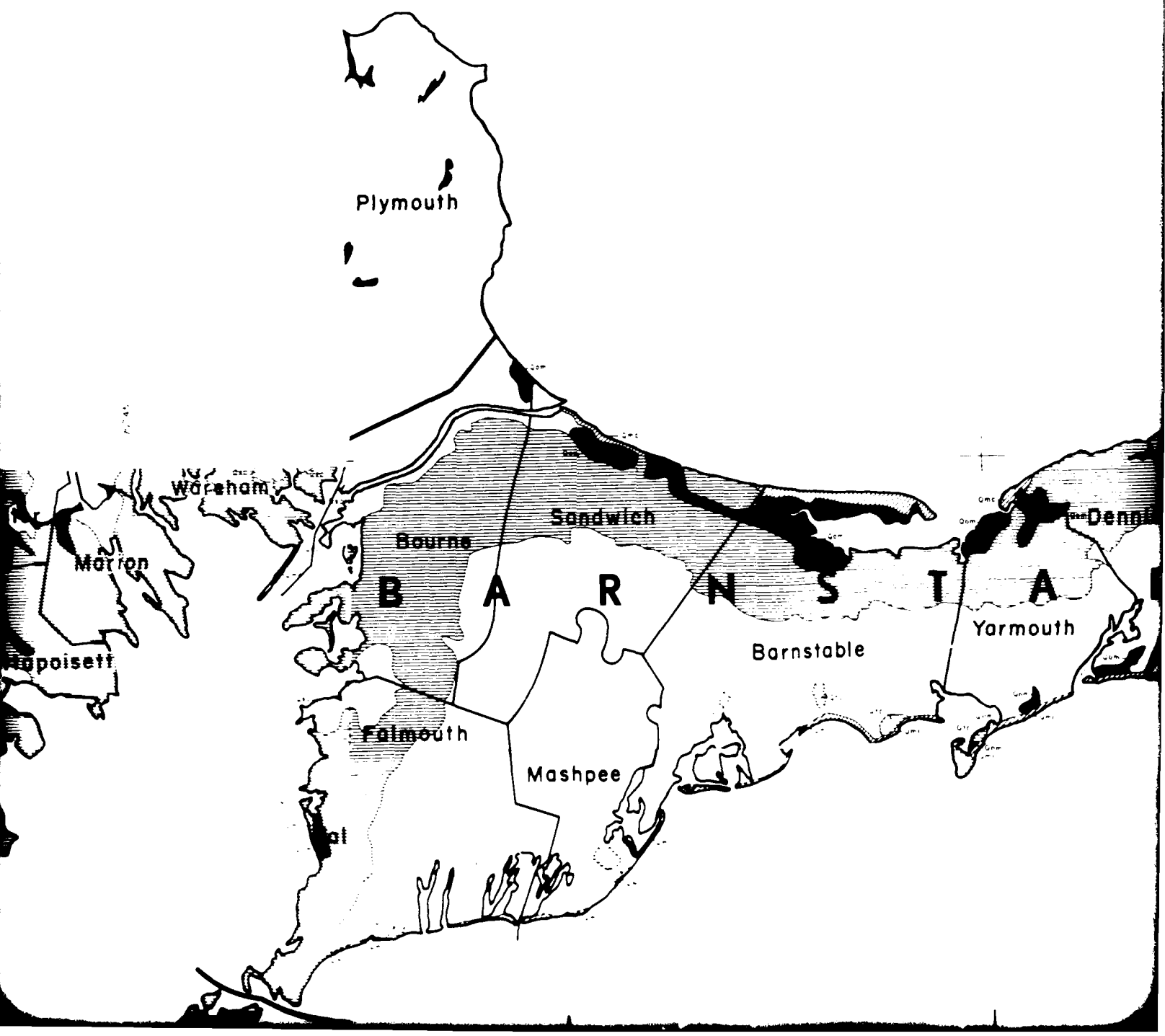
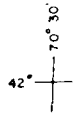
SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
Qsc	OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS. Silt and/or clay part are usually minor. Stratified and sorted.
Umc	BEACH, DUNE AND MARINE DEPOSITS	Fine or fine to medium SANDS well sorted. Often stratified and cross bedded.
Qac	ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics. Poorly to moderately sorted and stratified.
Qtc	GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders. dense, non stratified unsorted mixture.
Qlt	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved SILTS and CLAYS.
Qmt	MARINE DEPOSITS	SILTY CLAYS, SILTS and CLAYS SILTS, Silty fine SANDS.
Qot	FRESH-WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS, Silty PEATS, Organic Sands and SILTS, MUCK.
Qom	MARINE ORGANIC DEPOSITS	ORGANIC SILT, Clayey Organic SILTS, Organic Sands, Marine Muds, "Ooze".





END

- CHARACTERISTICS OF MATERIAL**
- SANDS** or SANDS and GRAVELS
  - Silt** and/or clay portions usually minor, stratified and sorted
  - Fine** or Fine to medium SANDS
  - Well** sorted, often stratified and cross bedded
  - SAND**, Silt with minor amounts of Gravel, clay and/or Organic; poorly to moderately sorted and stratified
  - Silt** or Clayey SAND and GRAVEL with pebbles and boulders, dense, often stratified unsorted mixture
  - SILTS**, Clayey SILTS, Silty SANDS, Varied SILTS and Clays
  - Silty CLAYS**, SILTS and CLAYS
  - SILTS**, Silty Fine SANDS
  - PEATS**, Sandy PEATS, Silty PEATS, Organic Sands and SILTS
  - MUCK**
  - ORGANIC**, Silt, Clayey Organic SILTS, Organic Sands Marsh Mats, Gels



Provincetown

Truro

Orfleet

Eastham

Orleans

Brewster

Dennis

Harwich

Chatham

Yarmouth

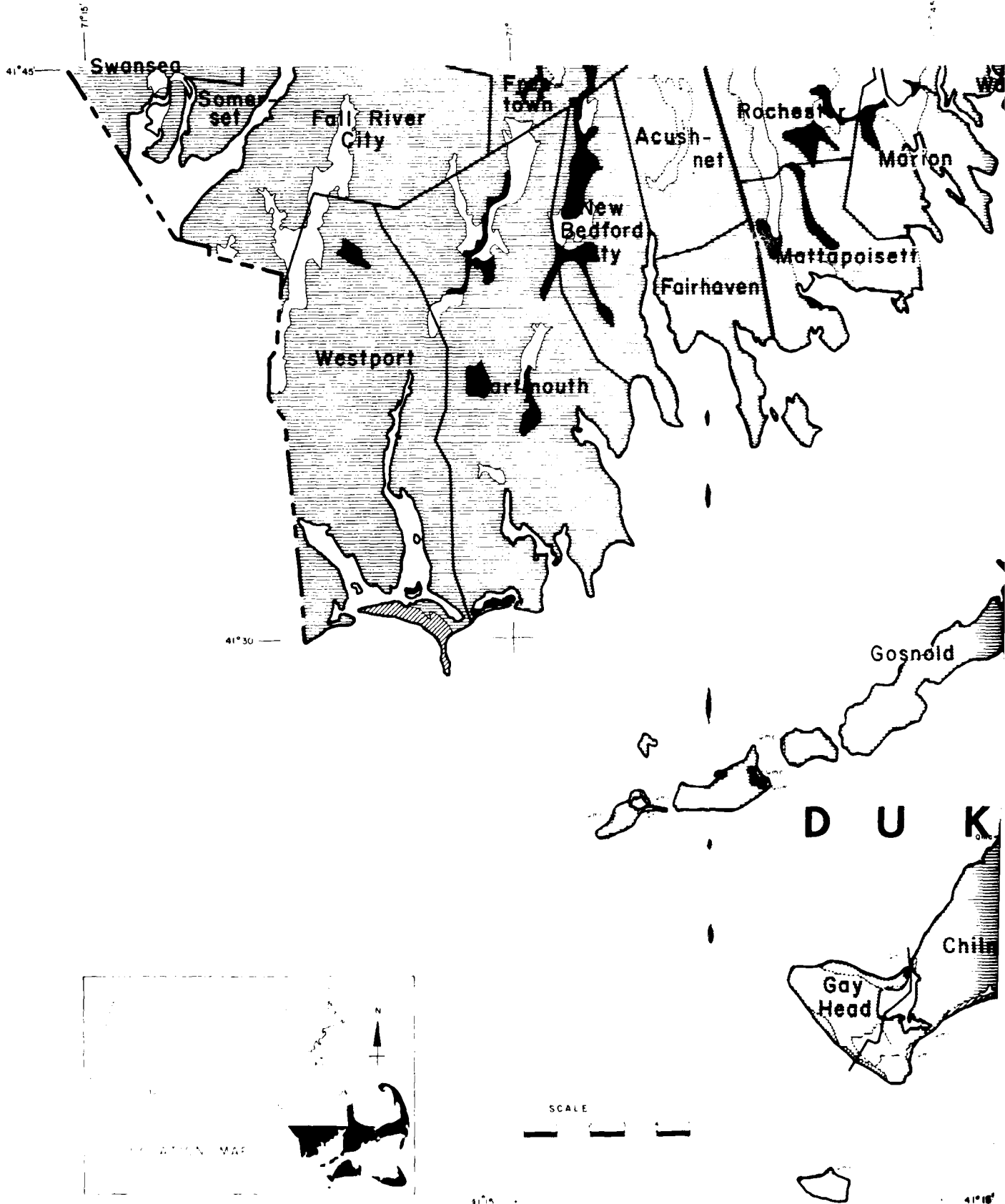
Wenham

Chatham

42°

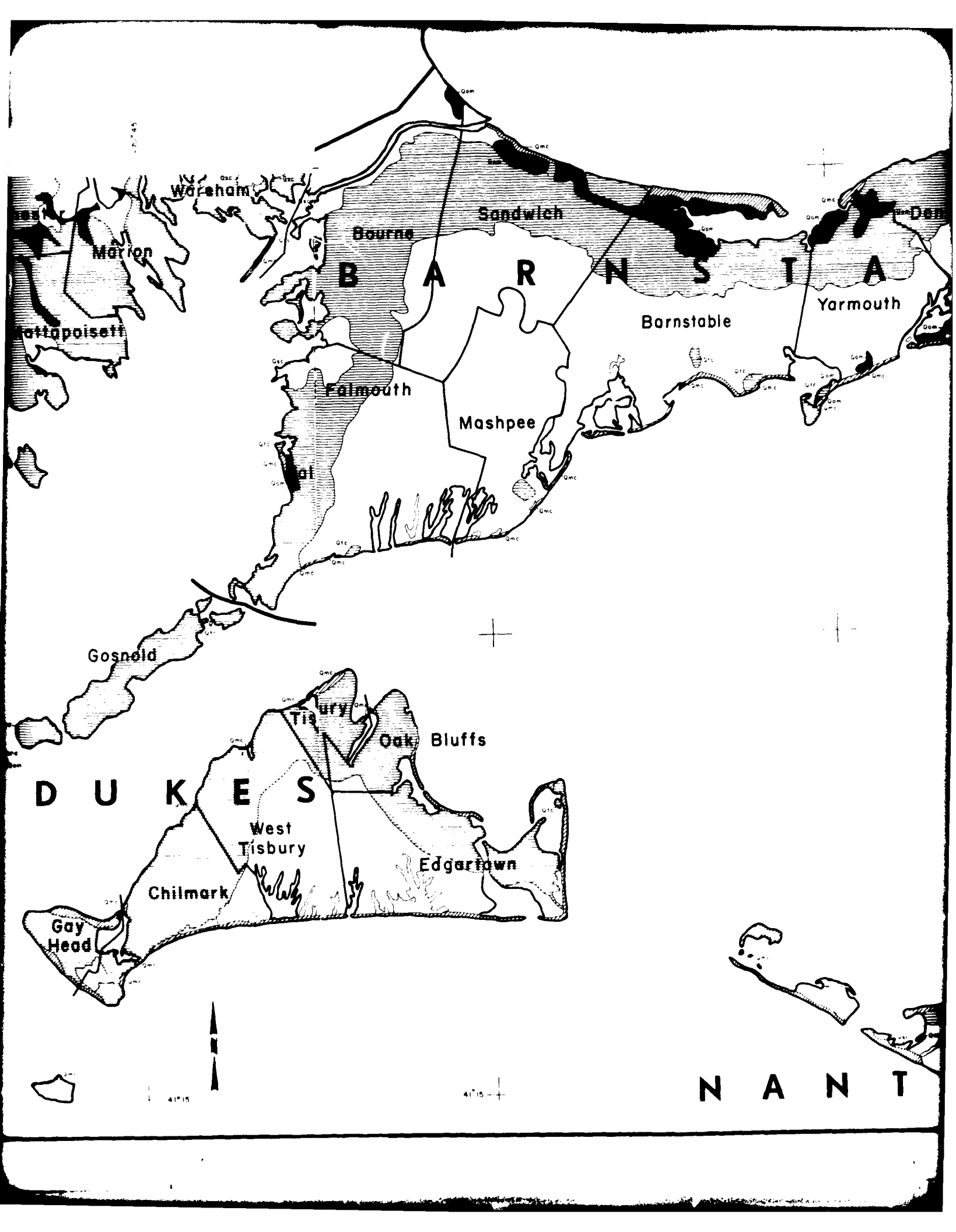
42° 30'





41°30'

71°10'



Wareham

Marion

Mattapoisett

Bourne

Sandwich

BARNSTABLE

Barnstable

Yarmouth

Falmouth

Mashpee

Gosnold

Tisbury

Oak Bluffs

D U K E S

West Tisbury

Edgartown

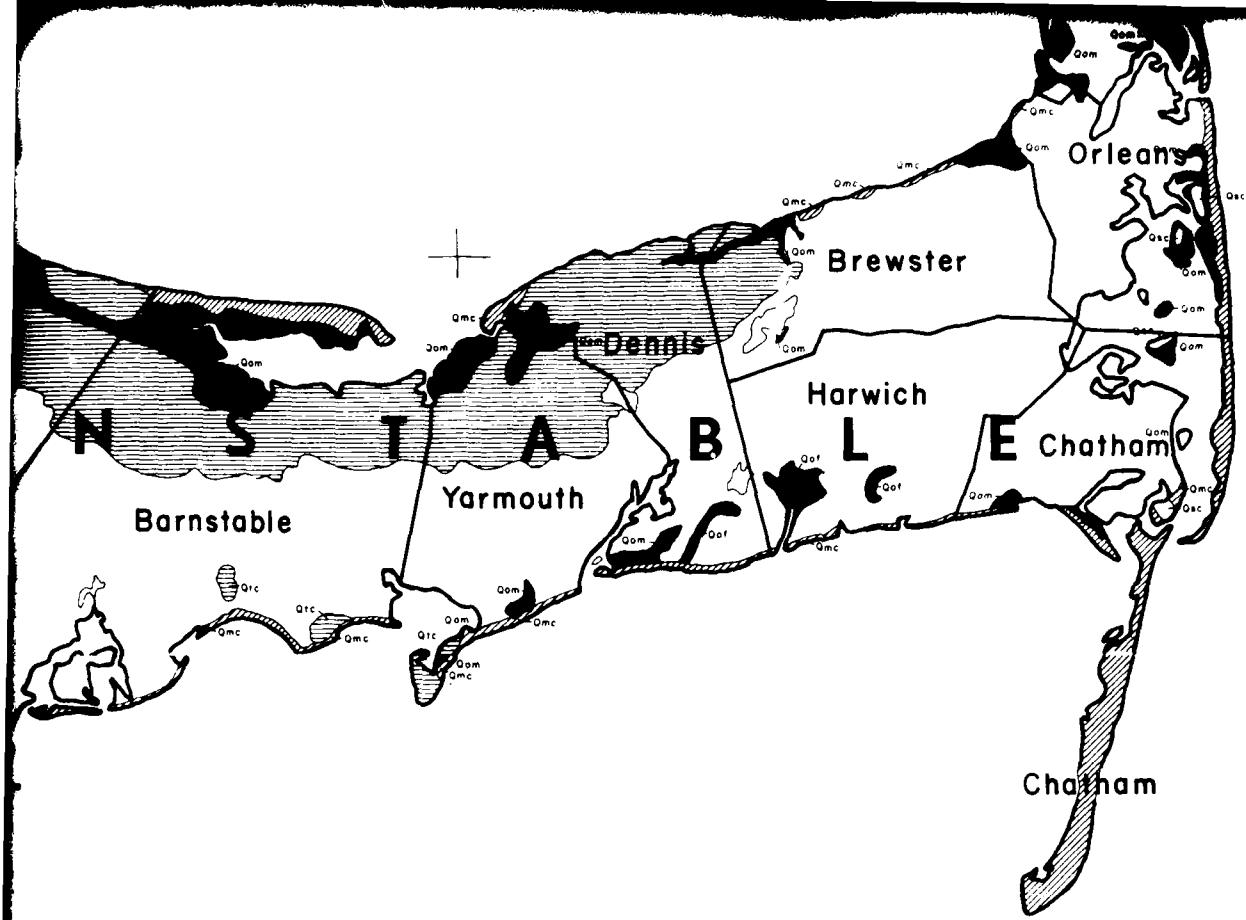
Chilmark

Gay Head

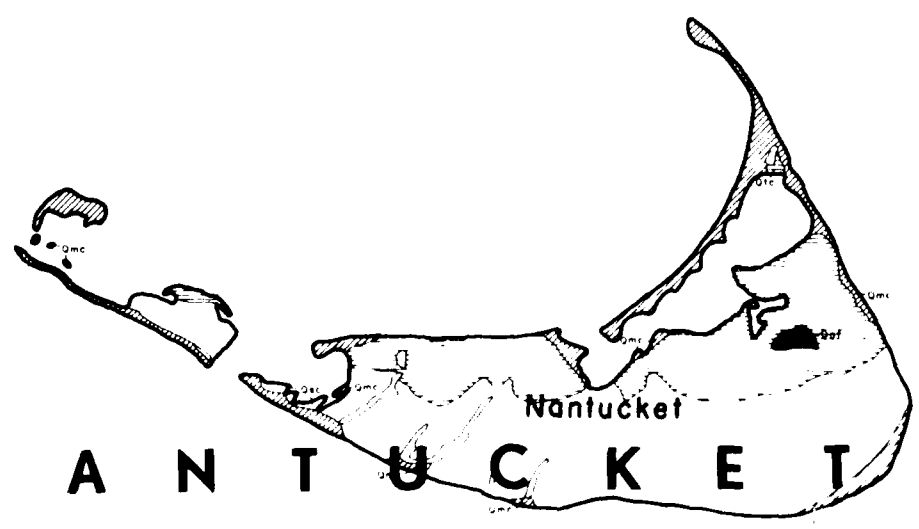
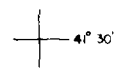
N A N T

41°15'

41°15'



Chatham



NANTUCKET

BOSTON HARBOR - EASTERN MASSACHUSETTS  
METROPOLITAN AREA WASTE WATER  
MANAGEMENT STUDY

UNITED STATES ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION WALTHAM, MASS

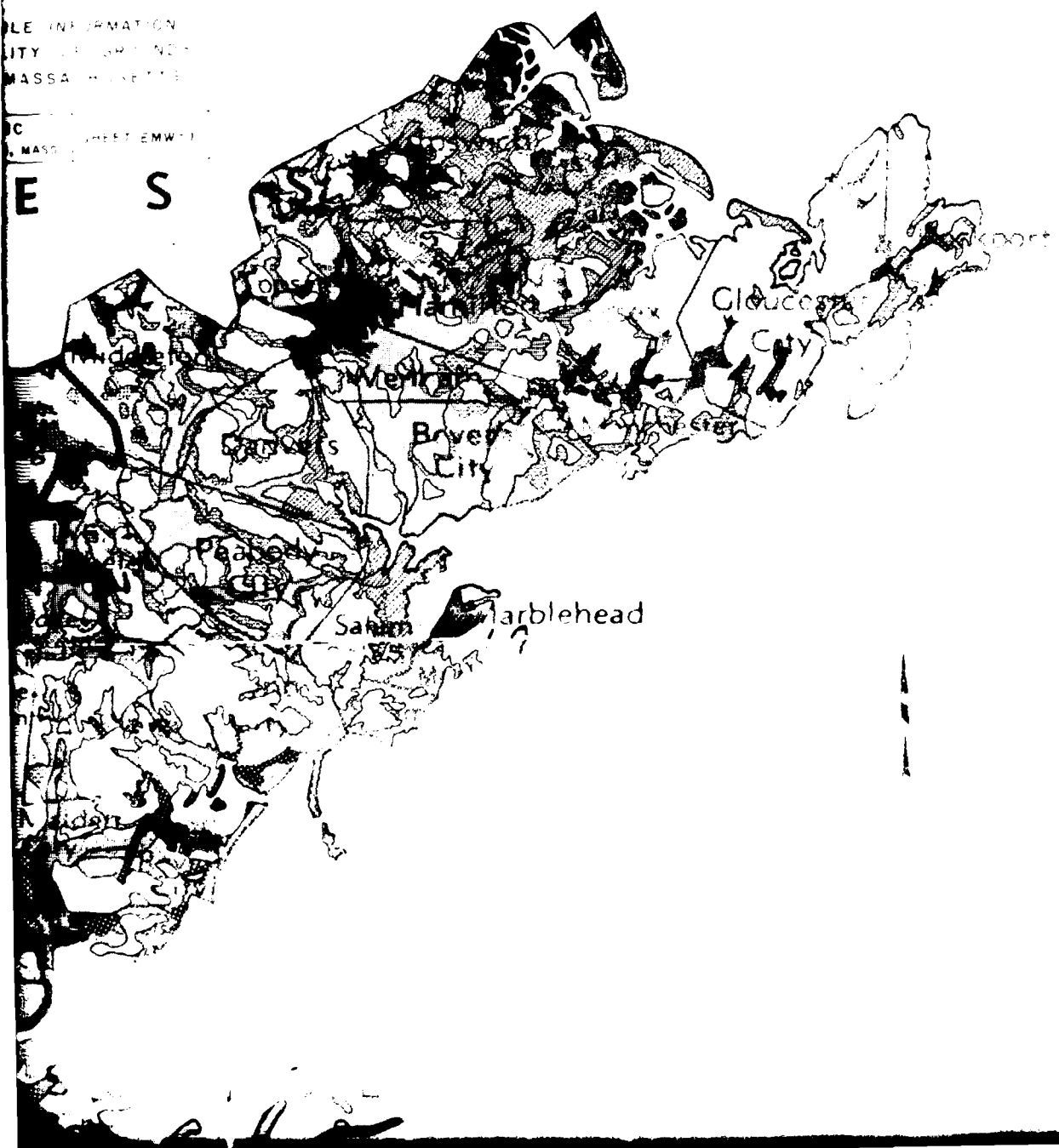
A SUMMARY OF AVAILABLE INFORMATION  
SHOWING THE FAVORABILITY OF GROUND-  
WATER IN EASTERN MASSACHUSETTS

WHITMAN & HOWARD INC  
ENGINEERS & ARCHITECTS BOSTON, MASS SHEET EMW-1

E S



MASSACHUSETTS  
 WASTE WATER  
 STUDY  
 CIVIL ENGINEERS  
 WASHINGTON, MASS.  
 FOR INFORMATION  
 CITY OF BOSTON  
 MASSACHUSETTS  
 C MASSACHUSETTS  
 SHEET EMW-1  
 E S



LEGEND

SYMBOL	AQUIFER	DEVELOPMENT
[Symbol: Dotted pattern]	GLACIAL FLUVIACIAL SANDS AND GRAVELS	WATER SUPPLY GENERALLY CAPABLE OF SUPPLYING 100 GPM
[Symbol: Horizontal lines]	GLACIAL CLAY	WATER SUPPLY GENERALLY CAPABLE OF SUPPLYING 10 GPM
[Symbol: Vertical lines]	GLACIAL SILT AND CLAY	WATER SUPPLY GENERALLY CAPABLE OF SUPPLYING 5 GPM
[Symbol: Diagonal lines]	GLACIAL SANDS AND GRAVELS	WATER SUPPLY GENERALLY CAPABLE OF SUPPLYING 100 GPM

LOCATION MAP



LEGEND

SYMBOL	AQUIFER DESCRIPTION
	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET; GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY FROM 20 TO 40 FEET; GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LESS THAN 20 FEET; GENERALLY CAPABLE OF YIELDS FROM 0 TO 100 GPM WITH THE LOWEST YIELDS IN TILL





AD-A099 241

CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV  
A SUMMARY OF THE GEOLOGY OF EASTERN MASSACHUSETTS, (U)  
JUL 75 F W FESSENDEN, J AYERS, S L DEAN

F/6 8/7

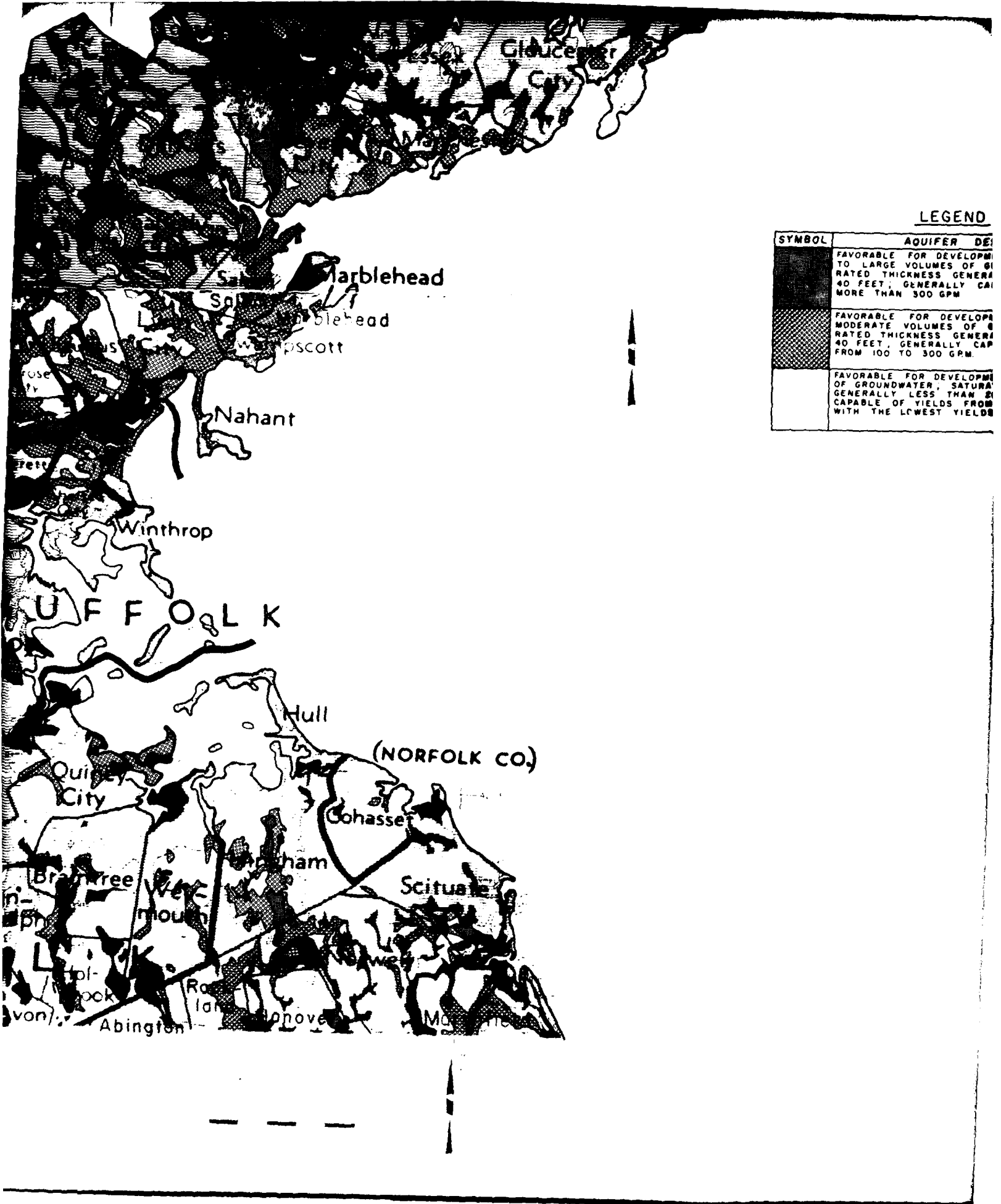
UNCLASSIFIED

NL




2 of 2

AD A  
099 241

END  
DATE  
FILMED  
6-81  
DTIC

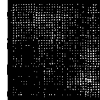
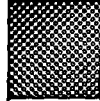



**LEGEND**

SYMBOL	AQUIFER DEVELOPMENT
	FAVORABLE FOR DEVELOPMENT TO LARGE VOLUMES OF WATER. THICKNESS GENERALLY 40 FEET. GENERALLY CAPABLE OF YIELDS MORE THAN 300 GPM.
	FAVORABLE FOR DEVELOPMENT TO MODERATE VOLUMES OF WATER. THICKNESS GENERALLY 40 FEET. GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 GPM.
	FAVORABLE FOR DEVELOPMENT TO SMALL VOLUMES OF GROUNDWATER. SATURATION GENERALLY LESS THAN 25%. CAPABLE OF YIELDS FROM 10 TO 100 GPM WITH THE LOWEST YIELDS.

port

### LEGEND

SYMBOL	AQUIFER DESCRIPTION
	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET; GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY FROM 20 TO 40 FEET; GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 G.P.M.
	FAVORABLE FOR DEVELOPMENT OF LOW VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LESS THAN 20 FEET; GENERALLY CAPABLE OF YIELDS FROM 0 TO 100 G.P.M. WITH THE LOWEST YIELDS IN TILL

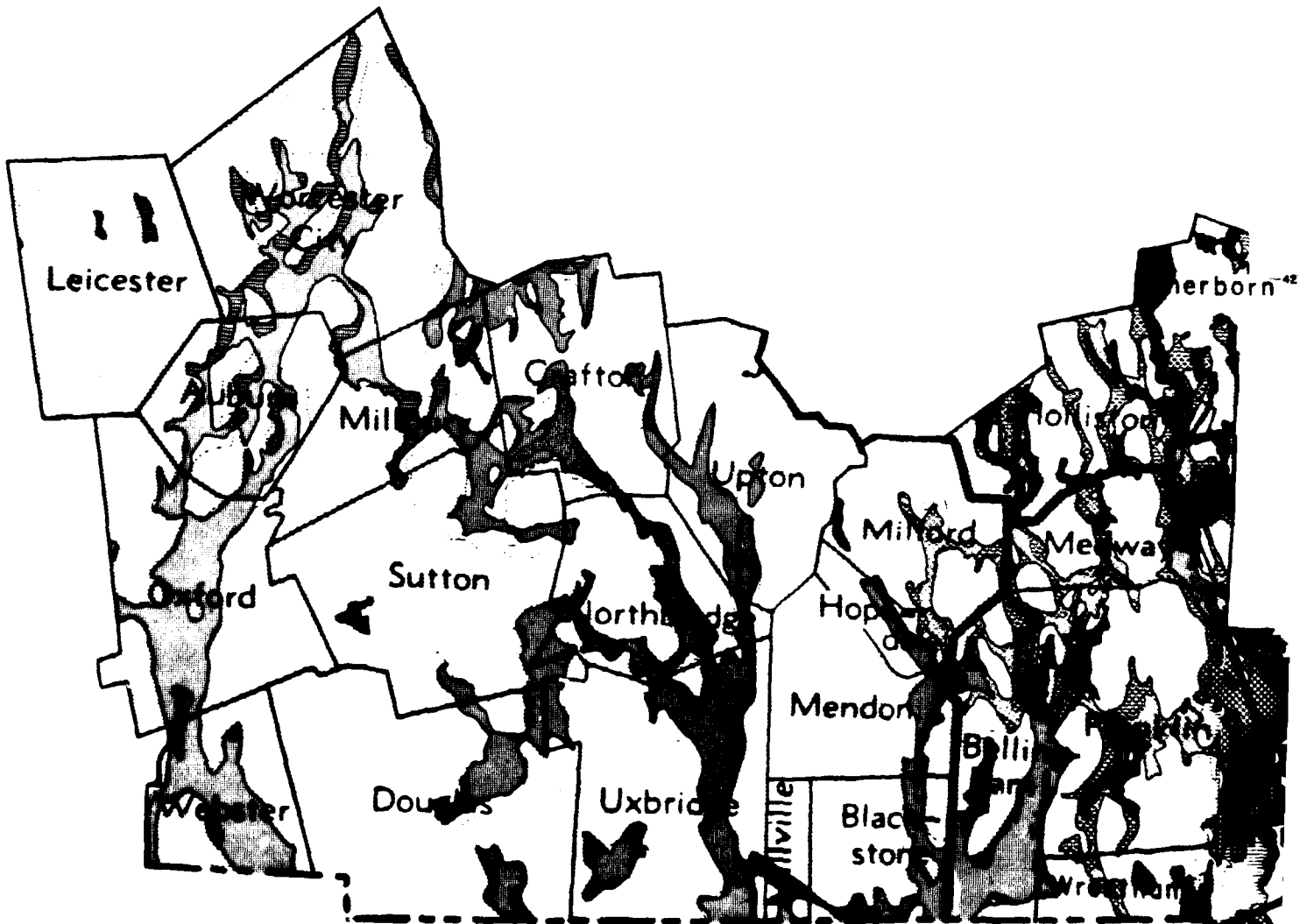


co.)

22 15

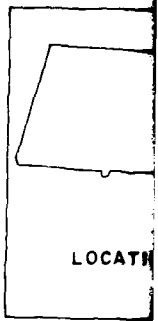


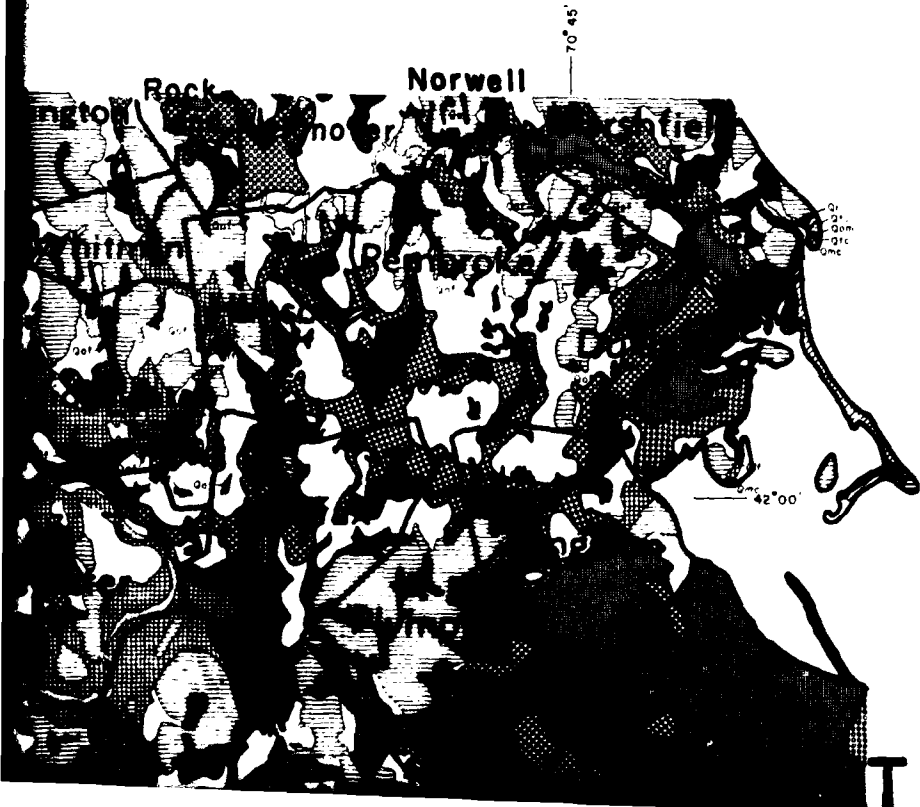
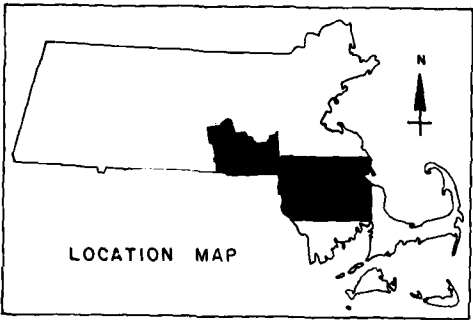
6

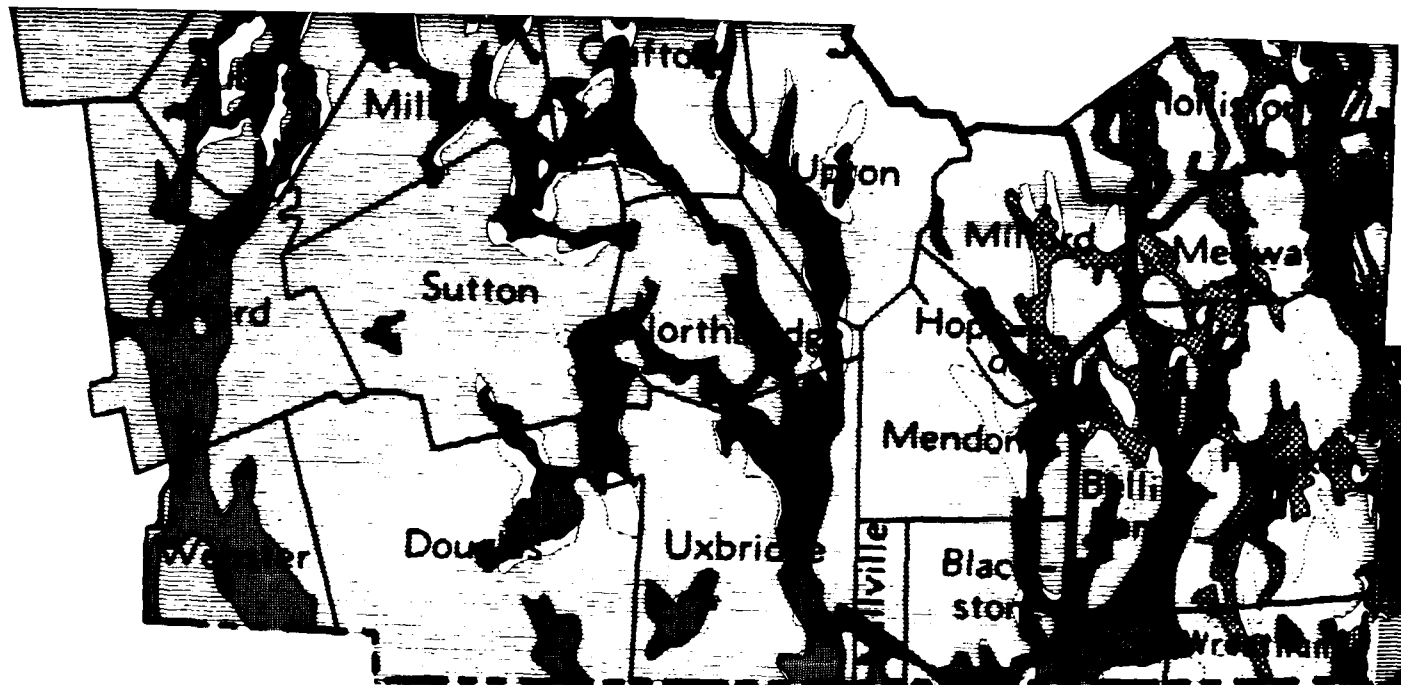


---

PIE  
AN







71° 45'

SCALE



See

**LEGEND**

SYMBOL	AQUIFER DESCRIPTION
[Solid black box]	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET; GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
[Cross-hatched box]	FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY FROM 20 TO 40 FEET; GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 GPM
[White box]	FAVORABLE FOR DEVELOPMENT OF LOW VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LESS THAN 20 FEET; GENERALLY CAPABLE OF YIELDS FROM 0 TO 100 GPM WITH THE LOWEST YIELDS IN TILL

**BOSTON HARBOR - EASTERN MASSACHUSETTS METROPOLITAN AREA WASTE WATER MANAGEMENT STUDY**

UNITED STATES ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION WALTHAM, MASS.

A SUMMARY OF AVAILABLE INFORMATION SHOWING THE FAVORABILITY OF GROUNDWATER IN EASTERN MASSACHUSETTS

WHITMAN & HOWARD INC.  
ENGINEERS & ARCHITECTS BOSTON, MASS

SHEET EMW-2





Walpole

Baron

Stoughton

Avon

Abington

Rock

Weymouth

Ne

Brockton

Whitman

Pen

Foxboro

Easton

W. Middleboro

W. Middleboro

Plainville

Manfred

North Attleboro

Norton

Bridgewater

Attleboro City

Synham

Taunton City

BRISTOL

Wardborough

Seekonk

Rehoboth

Dighton

Berkley

Lakeville

Swansea

Somerset

Fall River

Freetown

Acushnet

Rochester

41°45'

71°15'




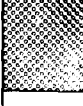

BOSTON HARBOR - EASTERN MASSACHUSETTS  
METROPOLITAN AREA WASTE WATER  
MANAGEMENT STUDY

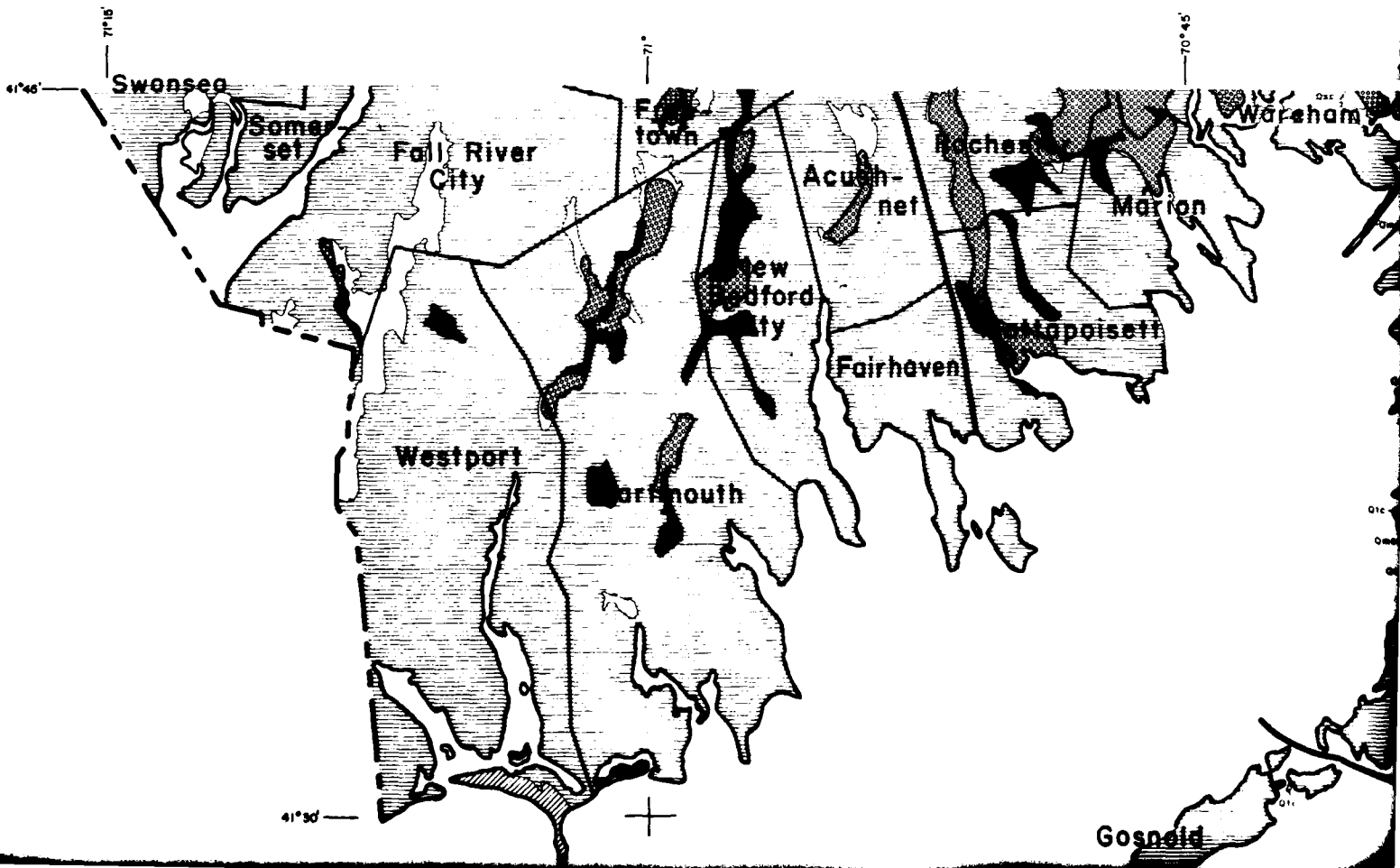
UNITED STATES ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION WALTHAM, MASS.

A SUMMARY OF AVAILABLE INFORMATION  
SHOWING THE FAVORABILITY OF GROUND-  
WATER IN EASTERN MASSACHUSETTS

WHITMAN & HOWARD INC.  
ENGINEERS & ARCHITECTS BOSTON, MASS. SHEET EMW-3

LEGEND

SYMBOL	AQUIFER DESCRIPTION
	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER, SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET, GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUNDWATER, SATURATED THICKNESS GENERALLY FROM 20 TO 40 FEET, GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW VOLUMES OF GROUNDWATER, SATURATED THICKNESS GENERALLY LESS THAN 20 FEET, GENERALLY CAPABLE OF YIELDS FROM 0 TO 100 GPM WITH THE LOWEST YIELDS IN TILL



**DESCRIPTION**

AMOUNT OF MODERATE GROUNDWATER, SATURATED THICKNESS, GENERALLY LARGER THAN AMOUNT OF YIELDS

AMOUNT OF LOW TO MODERATE GROUNDWATER, SATURATED THICKNESS, GENERALLY FROM 20 TO 100 FEET, GENERALLY 10 TO 100 GPM IN TILL

AMOUNT OF LOW VOLUMES OF GROUNDWATER, SATURATED THICKNESS, GENERALLY FROM 10 TO 20 FEET, GENERALLY 10 TO 100 GPM IN TILL

42° 70° 30'

+

70° 45'

