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Coastal Mapping

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Coastal Mapping Handbook

Melvin Y. Ellis, *Editor*

Cooperating organizations:

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U.S. D.O.A.A. / D.C.Z.M.
GB452.2 .C63 1978 C.2
6530760
JAN 21 1994

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1978

UNITED STATES DEPARTMENT OF COMMERCE

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Stock No. 024-001-03046-2/Library of Congress catalog-card No. 78-600000

COASTAL ZONE
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Preface

Passage of the Coastal Zone Management Act of 1972 focused attention on the Nation's coastal land and water areas. As plans for more effective management of the coastal zone evolved, it soon became apparent that improved maps and charts of these areas were needed.

This handbook was prepared with the requirements of the entire coastal community in mind, giving greatest attention to the needs of coastal zone managers and planners at the State and local levels. Its principal objective is to provide general information and guidance; it is neither a textbook nor a technical manual, but rather a primer on coastal mapping.

This handbook should help planners and managers of coastal programs to determine their mapping requirements, select the best maps and charts for their particular needs, and to deal effectively with personnel who gather data and prepare maps. The sections on "Sources of Assistance and Advice" and "Product and Data Sources" should be especially useful to all involved in mapping the coastal zone. Brief summaries of the mapping efforts of several State coastal zone management programs are included.

"Future outlook" discusses anticipated progress and changes in mapping procedures and techniques. Illustrations are inserted, where appropriate, to illustrate the products and equipment discussed. Because of printing restrictions, the colors in map illustrations may vary from those in the original publication. The appendixes include substantial material which also should be of interest. In addition a glossary and an index are included to provide easy and quick access to the terms and concepts used in the text.

For those interested in more technical detail than is provided in this handbook, the "Selected references" will be useful. Also, the publications of the professional societies listed in appendix 4 will provide technical information in detail.

CONTENTS

	Page
Preface	III
Abbreviations	VII
Delimiting the coastal zone	1
Coastal maps and charts	2
Planning uses	3
Management uses	3
Mapping the coastal wetlands	4
Selecting maps and charts	5
Special problems	6
Tidal datums	6
Shoreline changes	6
Boundaries	6
Data acquisition procedures	6
State coastal mapping programs	7
California	7
Delaware	7
Florida	8
New Jersey	8
Texas	9
Sources of assistance and advice	10
General information centers	10
National Cartographic Information Center	10
National Geodetic Survey Information Center	11
Environmental Data Service	12
EROS Data Center	12
Major Federal mapping and charting programs	12
U.S. Geological Survey	12
National Ocean Survey	14
USGS and NOS cooperative programs	15
Mapping and charting activities	16
Product and data sources	19
Distribution points	21
Datums	29
Horizontal datums	29
Vertical datums	29
Tidal datums	29
International Great Lakes Datum	29
Chart datum	30
National Geodetic Vertical Datum	30
Tidal datums and local marine boundaries	31
Lake levels and related local boundaries	32
Control surveys	33
Horizontal control	33
Vertical control	33
Other control	33
Map projections and grid systems	35
Properties of projections	35
Developable surfaces	35
Commonly used projections	36
Lambert conformal conic projection	36
Polyconic projection	36
Mercator projection	37
Transverse Mercator projection	38
Combination projections	38
Map projections and grid systems—continued	
Grid systems	38
State plane coordinate systems	38
Universal Transverse Mercator grid	40
Remote sensing	40
Photogrammetric mapping techniques	41
Project planning	42
Ground control	42
Aerial photography	43
Aerotriangulation	44
Map compilation	46
Field completion	48
Final drafting and review	48
Map reproduction	51
Maps	54
Planimetric maps	54
Topographic maps	54
Thematic maps	54
Digital maps	55
Line maps	55
Photomaps	55
Format	55
Content	55
Contour interval	56
Scale	56
Accuracy	60
Revision	60
Charts	60
Types	60
Format	61
Accuracy	61
Scale and content	61
Revision	62
Overprints and overlays	62
Uses	62
Examples of overlays for coastal management	62
Advantage and limitation	64
Data extraction techniques	64
Visual extraction	64
Feature separation	64
Automation	66
Land use and land cover classification and mapping	66
Definition of land use	67
Classification theory and principles	67
The decision process	67
Classification systems	89
Land use and land cover mapping	94
Future outlook	98
Automation	98
Computer-stored data	99
Updating	100
The metric system	100
The future	100

Selected references ---- 100
Glossary ---- 103
Appendixes
1. Cooperating agencies in the coastal zone ---- 117
2. USGS state mapping advisory committees in the coastal zone ---- 119
3. State coastal zone management program managers 120
4. Sources for information about private contractors 122
5. Coastal Zone Management Act and Amendments - 123
6. Accuracy standards
United States National Map Accuracy Standards 155
Accuracy standards recommended for hydrographic surveys ---- 155
7. Examples of products ---- 157
Index ---- 199

ILLUSTRATIONS

Page

Figure 1. Solar and lunar tide-producing forces ---- 30
2. Tidal datums and their relations to a generalized shore cross section ---- 31
3. Interrelations of tidal datums ---- 32
4. Distribution of tidal phases with diurnal, semidiurnal, and mixed tides ---- 34
5. Lambert conformal conic projection ---- 36
6. Polyconic projection ---- 37
7. Mercator projection ---- 37
8. Transverse Mercator projection ---- 38
9. The electromagnetic spectrum ---- 41
10. Typical aerial mapping cameras mounted in an aircraft ---- 43
11. Automatic color film processor ---- 45
12. Kelsh stereoplotting instrument ---- 46
13. Wild STK stereocomparator ---- 46
14. Stereoscopic viewing of a stereopair of aerial photographs ---- 47
15. Right- and wrong-reading positives and negatives ---- 49
16. Complete field scribing kit ---- 50
17. Preparation of an open-window guide using peel coat ---- 51
18. Application of waxed stickup type to a names sheet ---- 52
19. Five-color offset press ---- 53
20. Stafford, Virginia, area at 1:250,000 scale 57
21. Stafford, Virginia, area at 1:50,000 scale - 58
22. Stafford, Virginia, area at 1:24,000 scale - 59
23. Revision shown as purple overprint ---- 63
24. Overlay showing oil and gas fields ---- 64
25. Base map used with oil and gas overlay - 65
26. Roads ---- 69
27. Culture ---- 71
28. Urban tint ---- 73
29. Black lettering ---- 75
30. Combined black ---- 77
31. Drainage ---- 79
32. Open water ---- 81
33. Blue lettering ---- 83
34. Combined black, blue, and contours ---- 85
35. Published map ---- 87
36. Status of land use/land cover mapping --- 95
37. Level II land use and land cover ---- 97
38. Level III land use and land cover ---- 98

TABLES

Page

Table 1. Principal U.S. Geological Survey map series 12
2. Plane coordinate systems in coastal States -- 39
3. USGS land use and land cover classification system for use with remote sensor data --- 88
4. Soil Conservation Service land use classification system ---- 89
5. Florida land use and land cover classification system ---- 90
6. Standard land use coding manual ---- 93

ABBREVIATIONS

ASCS	Agricultural Stabilization and Conservation Service
BC	Bureau of the Census
BEG	Texas, Bureau of Economic Geology
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM	Bureau of Mines
BOR	Bureau of Outdoor Recreation
BPA	Bonneville Power Administration
BR	Bureau of Reclamation
COAP	California, Comprehensive Ocean Area Plan
CZMA	Coastal Zone Management Act
DMATC	Defense Mapping Agency Topographic Center
DOS	Department of State
DRBC	Delaware River Basin Commission
DWP	Deepwater ports
EDC	USGS/EROS Data Center
EDS	NOAA/Environmental Data Service
EPA	Environmental Protection Agency
ERC	Energy Regulatory Commission
ERL	NOAA/Environmental Research Laboratories
EROS	Earth Resources Observation Systems
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FIA	Federal Insurance Administration
FS	Forest Service
FWS	Fish and Wildlife Service
GPO	Government Printing Office
HUD	Housing and Urban Development
IBC	International Boundary Commission
IBWC	International Boundary and Water Commission
IGLD	International Great Lakes Datum
IHB	International Hydrographic Bureau
LC	Library of Congress
MHW	Mean high water
MRC	Mississippi River Commission
MSS	Multispectral Scanner
NAD	North American Datum
NARS	National Archives and Records Service
NASA	National Aeronautics and Space Administration
NCIC	USGS/National Cartographic Information Center
NGS	NOAA/NOS/National Geodetic Survey
NGSIC	NOAA/NOS/National Geodetic Survey Information Center
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NOS	NOAA/National Ocean Survey
NPS	National Park Service
NWS	NOAA/National Weather Service
OMB	Office of Management and Budget
RBV	Return Beam Vidicon
SCS	Soil Conservation Service
SGA	State Geologic Agencies
SMSA	Standard Metropolitan Statistical Areas
TVA	Tennessee Valley Authority
USA	U.S. Army
USAF	U.S. Air Force
USCE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
USN	U.S. Navy

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COASTAL MAPPING HANDBOOK

The coastal zone consists of open water, salt marshes, mudflats, twisting tidal channels, intracoastal waterways, islands, bays, natural and manmade levees, mosquito ditches, oceanfront and intracoastal developments, and estuaries. The coastal wetlands are generally composed of coastal vegetation and are under the influence, if not the daily flood, of the tide. They are the transition zone between the uplands and the sea and are influenced by both. The coastal wetlands are classified according to State and Federal definitions and interpretations.

DELIMITING THE COASTAL ZONE

The Coastal Zone Management Act of 1972, as amended (see app. 5), defines the coastal zone as:

> . . . the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends, in Great Lakes waters, to the international boundary between the United States and Canada and, in other areas, seaward to the outer limit of the United States territorial sea. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters. Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers, or agents.

The complex part of this definition lies in the sentence, "The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters." Selecting boundary lines based on this definition is not an easy task. The definition implies an inland boundary of the coastal zone which is basically delineated along natural features, especially rivers, streams, marshes, and their watersheds. When establishing boundaries along natural features, the interrelations of those features and their relations to the coastal resource system should be explored because of the dynamic nature of the features.

Tides sometimes cover the wetlands and may be of different phase and amplitude than the tide on open beach only a few kilometers away. Tidal rivers, streams, and freshwater surface runoff mix with the ocean water to form a brackish zone of changing salinity with a relatively few species of vegetation. The freshwater flow causes a hydrodynamic stage related more to the hydrologic cycle than to the lunar cycle. Marsh grasses a meter tall preclude photogrammetric measurement of the ground surface where elevation differences of a few centimeters are critical. It is not unusual for grass tops on the levees to be level with grass tops on lower ground behind the levee, giving the appearance of a continuous level surface. Tidal flow may reach an area by a long circuitous path through channels and breaks in natural levees.

A number of studies have attempted to relate mean high water lines to vegetative boundaries. The change between high vigor *spartina alterniflora* (resulting from a daily flooding by saline water) and a lower vigor form (resulting from occasional flooding) probably indicates a biological mean high water line. A similar effect has been noted between red and black mangrove. This close relationship is probably correct in many areas, but it is deficient in two operational criteria. First, establishing cadastral boundaries by engineering tidal surveys is an accepted legal procedure, and a biological survey may be supportive but not sufficient evidence in court. Second, the wetlands as defined by the growth of several species of vegetation often extend above the mean high water line. The regulation of wetlands is an exercise in the Government's authority to zone land and control use regardless of ownership. Therefore, the time, expense, and difficult ground surveying required to relate a vegetation boundary to a tidal datum may be unwarranted. If the only purpose of the mapping is to delineate the wetlands for regulatory action, then vegetative boundaries are appropriate. A cadastral survey re-

quires a tidal datum and is more costly; however, it provides legal boundaries.

The species composition of a coastal marsh reflects the salinity, soil characteristics, frequency of inundation, and elevation. Saline marshes contain *Spartina alterniflora* in three growth forms—the largest up to 3 m tall. Other species are found where the elevation is higher or the tidal inundation less frequent. The different species can usually be clearly identified on color infrared film.

The upper wetland boundary is often sharply defined by an abrupt change in topography. The marsh may extend as much as 10 m under the canopy of large trees in the border zone. Where a broad and gradual transition occurs with a mixture of plant species present, the upper wetland boundary is more difficult to define. With a knowledge of the plant species, the morphology of the land, the tidal cycle, and applicable laws, one can usually position the upper wetland boundary within 3–5 m horizontally during field inspection. The task is easier and equally accurate when the boundary is delineated from color infrared aerial photographs offering a much larger view. For 5–10 percent of the area, the task is more difficult than normal, whichever method is used. The transition in these areas may be very gradual and indistinct and require more judgment, careful surveys, and intelligent legislation. Litigation may be necessary because there is no one technique for providing unequivocal solutions to wetland boundary problems.

In practice, some coastal States may define the landward boundaries of their coastal zone along other than purely natural features. For example, a State may determine that the most feasible boundary might be based on a line, such as a 10-ft vertical distance above mean high water, that may roughly approximate a flood-plain level. The line would then be modified to correspond to the nearest township line or paved road. This modification would greatly simplify the administration of such a coastal zone boundary. Another approach might be to draw boundaries at a fixed horizontal distance inland from the MHW line.

For the purpose of planning topographic mapping in the coastal zone, the U.S. Geological Survey defines the inland edge of the zone as the landward boundaries of the coastal counties, townships, or parishes within the States and Territories eligible for grants under the CZMA. Alaska's coastal area is defined separately as the first two 15-min quadrangles inland from the shore, because the State is not organized by counties.

Other approaches to delimiting the coastal zone beyond those specified in the CZMA might include a concept of the seaward limit as the edge of the continental shelf rather than the outer limits of the territorial seas. This might be a more logical way to define the coastal zone if natural considerations and features are most important.

The coastal zone might also include those areas where the water influences the land, the reverse of the concept cited in the CZMA. It might be easier to delineate the extent of the water's influence on the land, for example, by using the 100-yr flood plain for the boundaries of coastal wetlands such as marshes and bogs. Numerous other schemes could be devised to define the coastal zone, each with its own advantages and disadvantages. However, in this handbook the CZMA definition is used.

COASTAL MAPS AND CHARTS

A map is a pictorial or graphical representation of a portion of the Earth's surface. In general, a coastal chart is a map that shows water depths, coastlines, and land features in a narrow band along the coast. Charts are generally used for navigation, but they have many other uses.

Maps and charts may be classified as either metric or nonmetric in quality. Most road maps, pictorial maps, and many atlas maps are for general information only and are not of metric quality, that is, they cannot be relied upon to provide accurate measurements. Only metric quality maps are considered in the handbook.

A metric quality map usually contains a graticule of meridians and parallels and a plane rectangular coordinate system to define specific locations, and it portrays the various map features in precise relation to each other and to the graticule or grid (except in cases of deliberate misplacement of symbols to avoid overcrowding). Distances and directions between features can be measured precisely, either on a single map sheet or between adjoining sheets on the same reference system and datum. A particular feature will have the same geographic position on other maps of the same area regardless of scale.

Map scale is the ratio between a unit distance (for example, 1 in or 1 cm) on the map and the corresponding distance on the ground. The scale of 1:24,000 means that 1 unit on the map represents 24,000 of the same units on the ground. Thus, 1 cm on the map represents 24,000 cm (240 m) on

the ground. This rule applies to all units of linear measurement.

The larger the denominator of the scale ratio, the smaller the map scale; for example, a 1:10,000-scale map has a larger scale than a 1:24,000-scale map. A large-scale map usually portrays a smaller area than a small-scale map, and the detail is greater. The scale is generally given in the legend or margin of the map.

PLANNING USES

The CZMA of 1972 provides a new mechanism for planning and managing activities in the coastal zone. Coastal planners at the Federal, State, and local levels will need maps of the coastal zone covering their areas of interest. A set of maps for the entire coastal zone of the United States (including the Great Lakes) and Territories is fundamental for an overview perspective. Federal and State planners will need maps at scales ranging from 1:10,000 to 1:250,000. Local government coastal zone planners also will need planning maps to relate their activities to others in the State. Such maps may be at scale ranging from of 1:2,400 to 1:24,000.

Effective planning can be simplified considerably if the data and results of resource inventories of the coastal zone are displayed graphically on the planning maps. These inventories can include natural resources such as woodlands, estuarine areas, freshwater marshes, beaches, wildlife, geologic features, and marine life and minerals. Also, planning maps can include statistical distributions, residential housing, commercial and industrial facilities, transportation routes, flood plains, cultural features, archeological sites, esthetic resources, and parks and other recreation areas. Furthermore, these maps can depict land and water use classifications and such phenomena as estuarine circulation patterns and predominant coastal currents.

The different types of information needed for planning can be shown on maps in a variety of ways. Sometimes the information is printed as a part of the base map, sometimes as an overprint on the base map, and sometimes as overlays keyed to the base map. The method used often depends upon the availability of existing maps, the variety and quantity of information to be displayed, the time allotted to display the information in cartographic form, and budget constraints.

The sections on "Sources of assistance and advice" and "Product and data sources" are included to assist coastal planners to develop effective coastal mapping programs tailored to their needs.

MANAGEMENT USES

Maps for coastal management generally would be of larger scale than general planning maps. Whereas the small-scale maps suitable for planning are frequently available from Federal agencies, the basic responsibility for producing large-scale maps for management of the coastal zone rests with the users—State and local governments. State coastal maps might range in scale from 1:2,400 to 1:24,000, depending on the geographic area of concern, the intensity of its development, and the length of the coastline to be mapped. Local governments may need maps of even larger scale for more detailed regulation and management of their coastal zone; perhaps in the range of 1:600 to 1:10,000. Large-scale maps for the entire coastline would be quite expensive. They should be made first for areas where immediate concentrated management is necessary, while somewhat smaller scale maps would suffice for areas needing less rigorous management. As the coastal management program evolves, larger scale management maps could be produced to cover the gaps. Management maps would be useful for monitoring, inventory, analysis, documentation, regulation, and enforcement. However, detailed maps can sometimes be a liability for management if they are misleading or if they do not define the precise location of the area being regulated. Maps are useful for indicating key natural areas or regulatory boundaries, but maps used as management or regulatory tools must be at an appropriately large scale, meet National Map Accuracy Standards (app. 6), and be up-to-date.

Large-scale maps, on which boundaries and other information can be delineated accurately, will also be needed in legal proceedings resulting from regulating land and water use. Maps submitted as evidence in court are subject to critical review. The need for accuracy and up-to-date information cannot be overemphasized. Old photographs are often compared with newer photographs of the same geographic area (sometimes in the form of orthophotomaps) to demonstrate how change has occurred. Obviously, adequate documentation of when and under what conditions the photographs were taken is vital. Accurate large-scale maps can also be used in court to indicate the proximity of proposed construction projects to valuable natural, esthetic, recreational, or economic resources that may be

affected by the proposed project. In these cases maps are best used in conjunction with such evidence as expert testimony, actual site visits, and other historical records and photographs.

Maps used in a group presentation must be large enough to be seen easily. Attempting to communicate a concept with an overly complex map can be counterproductive, especially if highly detailed keys are used. Managers may want to use a simplified version of the map or perhaps a sketch of the key information. Transparencies, slides, and overhead projectors are often effective in enlarging a portion of a map so the audience is not distracted by irrelevant information. In addition, the use of successive overlays on a base map can be most effective for some types of presentation. A planner or manager attempting to communicate with a diverse audience should use maps that are simple, clear, and to the point. Complex maps tend to confuse and overwhelm the general public. Obviously, those with specific interests such as coastal developers, local government officials, and members of public or private interest groups will be concerned with selected aspects of the coastal area and consequently with maps dealing with those aspects. In essence, considerable thought should be given to the type, format, content, scale, accuracy, and frequency of revision of the maps included in State or local planning and management programs.

It is important to note that coastal areas are dynamic biologically, geologically, demographically, and legally, and therefore, maps depicting coastal information have to be updated frequently. Using overlays on a good base map makes updating easier. (See the section "Overprints and overlays.")

Recent dramatic advances in remote-sensing technology have provided methods for revising maps of dynamic coastal areas. A variety of options exist with a wide cost range.

In the past, charts of water areas were used basically for navigation. However, as coastal programs evolve water and land use management will increase significantly, and new maps and charts will be needed.

MAPPING THE COASTAL WETLANDS

A review of present and proposed coastal wetland regulations of several States reveals that:

- There is a requirement to provide an accurate cartographic base on which upper wetland boundaries and other coastal features can be accurately plotted.
- It is desirable to give map users an orthophotobase showing more information about features that are not specifically delineated or that are necessarily generalized on the conventional map.
- Vegetative boundaries can be identified and delineated on color infrared film and transferred to the orthophoto.
- Selected areas of the coastal zone require map scales larger than 1:24,000.
- There are no universal conversion factors for relating tide, vegetation, contours, and cadastral boundaries.

In many areas, available USGS 1:24,000-scale topographic maps could be used as cartographic bases. The upper wetland boundary could be interpreted from recent color infrared photographs according to the applicable regulations and compiled on the map. This procedure would serve as a practical inventory at minimum cost and would satisfy general zoning regulations. It would provide a zone boundary between marsh and upland with a horizontal accuracy of about 12 m (40 ft), which is within the National Map Accuracy Standards. However, the increasingly popular orthophoto cartographic products have proved invaluable for mapping swamps, marshes, and other regions of overwhelming detail usually lost in conventional map symbolization. Compared with line-map portrayal, the orthophoto of a coastal marsh provides more information on the many features associated with identifying the boundary between upland and marsh. Besides matching the accuracy of conventional maps, the orthophotos show the actual pattern of vegetation and woodland, all visible roads and trails, the intricate meanderings of waterways, and other detail useful for determining position. Information on current land use can be derived from tonal differences in the photograph.

The Geological Survey has recently prepared several experimental color-image maps using two synchronized cartographic cameras in a single aircraft. One camera contains black-and-white panchromatic film and the other black-and-white infrared film. The two sets of photographs are processed into orthophotos at the correct scale. During printing, the two images are in perfect register. Through the use of various inks, several different color renditions are possible. These simulated color infrared composites represent a new dimension in the interpretation and delineation of coastal wetlands.

Vegetative boundaries can be compiled directly on the orthographic color image base, thus eliminating transfer of the wetland delineations from the color infrared photographs to an orthophoto image base.

SELECTING MAPS AND CHARTS

The choice of a working map or chart for use in a coastal management program depends on program considerations, such as the type of program and the purpose for which the map or chart will be used, and on map considerations, such as scale, content, and accuracy.

Generally, small-scale products (1:250,000 and smaller) cover a large area and provide adequate information of accuracy suitable for general planning. A single map should be used for an entire management area if possible. However, it is better to use several sheets at a larger scale if the area is so large that the scale required to fit onto one sheet of paper is too small to provide the desired content and accuracy. Specific management activities requiring greater accuracy and detail, such as boundary delineation and enforcement, require maps and charts at medium (1:100,000 to 1:50,000 scale) and large (1:24,000 and larger) scales.

Planimetric maps showing the position of major features (culture, transportation systems, wetlands, vegetation, and sometimes historical sites) are frequently adequate for planning land and water resources in the coastal zone. Although they do not show continuous relief data, planimetric maps usually indicate the position of major physiographic features.

Topographic maps offer much general information for land areas, although it is not all inclusive. Supplemental data from thematic maps covering such fields as geology, land use, land ownership, utilities, and population distribution are also needed by coastal managers.

Topographic and bathymetric maps at medium or large scale can be used to determine erosion and sedimentation locations. Although they do not directly represent erosion and sedimentation, they do depict relief and provide insight into land-mass denudation within the coastal zone. The topographic-bathymetric series being produced jointly by the U.S. Geological Survey (USGS) and the National Ocean Survey (NOS) is a good product for this purpose. These maps will be published at standard scales of 1:250,000, 1:100,000, and 1:24,000, with some at 1:10,000.

The greatest single source of data for water areas is the nautical chart and its related products. Nautical charts may be subdivided according to type, all containing virtually the same information but differing in scale and intended use. There are a number of special-purpose maps, charts, and diagrams dealing with water areas.

Bathymetric maps, produced by NOS at various scales and with varying content, are useful water-related products. Some bathymetric maps show magnetic and gravity data in addition to water depths; most cover extensive offshore areas and are helpful in planning offshore resource development.

More detailed information concerning water depths in a relatively small area may be found on copies of the smooth sheet—an intermediate NOS cartographic product on which all surveyed water depths are numerically plotted. A smooth sheet is a by-product of the chartmaking process and is not normally published; however, copies can be obtained on request.

Topographic sheets (T-sheets)—also byproducts of the NOS chartmaking process—show detailed information about a narrow strip of land and water alongshore. Topographic sheets dating back to the early 19th century are available. A chronological sequence of revised sheets provides useful information about shoreline and near-shore feature changes.

Aerial photographs and photographic products are used by coastal planners and managers because they show much more detail than conventional line maps. For example, orthophotomaps can be used to study vegetation and to determine the extent of wetlands. Spacecraft imagery can be used in wetland delineation and shallow-seas mapping. (See app. 7, fig. 1 for an example of space imagery that can be used in coastal planning and management.)

USGS and NOS can provide technical assistance for management projects requiring maps and charts at scales larger than 1:10,000 (normally not available from the Federal Government). Contact:

Chief, Office of Research and Technical Standards, Topographic Division
U.S. Geological Survey
MS 519 National Center
Reston, Virginia 22092
Telephone: 703-860-6291

or:

Chief, Coastal Mapping Division
National Ocean Survey
National Oceanic and Atmospheric Administration

6001 Executive Boulevard
Rockville, Maryland 20852
Telephone: 301-443-8744

There are a number of private mapping companies that produce aerial photographs and large-scale maps (see app. 4).

Help in selecting suitable maps, charts, and related data for coastal management may be obtained from the Coastal Mapping Division (NOS) or from:

User Services Section
National Cartographic Information Center
U.S. Geological Survey
MS 507 National Center
Reston, Virginia 22092
Telephone: 703-860-6045

The section "Sources of assistance and advice" gives a detailed description of Federal mapping and charting programs and sources of described products.

SPECIAL PROBLEMS

Coastal managers should recognize that while private contractors routinely make topographic and planimetric maps of land areas, few make bathymetric maps. Therefore, care must be taken in choosing a contractor for maps displaying shoreline detail and water depth. Coastal managers can direct questions to Federal agencies that make bathymetric products (see the section, "Product and data sources").

Some significant problems encountered in mapping the coastal zone concern (1) tidal datums, (2) rapid changes in shoreline and alongshore features, (3) coastal boundaries, and (4) data acquisition procedures.

TIDAL DATUMS

Tidal datums, base elevations defined by certain tide phases, are critical in the part of the coastal zone affected by tidal fluctuations. They provide the bases for establishing coastal boundaries, limits of the territorial sea and the contiguous zone, water depths and critical shorelines on maps and charts, and the limits of various regulatory activities and responsibilities affecting coastal management. Knowledge of the tides and tidal datums is essential for promoting and regulating safe navigation in a national water transportation system and for numerous engineering and scientific activities.

Lake levels in the Great Lakes area occupy a position comparable to that of tidal datums along the ocean coasts. Fluctuations of water levels in the Great Lakes result chiefly from meteorological forces; the magnitude of astronomic tides is greatly reduced. A lake-level datum is established from information acquired by methods and equipment similar to those used for ocean-tide observations, but the resulting data are processed differently because of the lack of lunisolar effect.

SHORELINE CHANGES

Changes in the shoreline occur frequently, and often quickly, as a result of actions of both natural and man-induced forces. Alongshore features are subject to rapid change, principally through the activities of man and most significantly in areas having the greatest development and congestion. Such changes soon make maps and charts obsolete and increase the workload required to conduct effective coastal management programs.

BOUNDARIES

Boundaries in the coastal zone range from the limits of private property to the international boundary. All of them are affected to some degree by tidal datums along the coast and along island shorelines. Corresponding boundaries in the Great Lakes area are fixed either by treaty or by acts of Congress, or are controlled by a lake level. Of all these boundaries, those between private and sovereign lands cause the greatest problems. Recent maps (prepared by modern techniques) and related data, such as aerial photographs and tidal information, are of great help in resolving boundary problems.

The recognized offshore boundary between Federal and most State areas is the 3-nmi (5.5 km) limit. Florida and Texas use a 9-nmi (16.6 km) limit. Distances are measured seaward from the mean low water line (Atlantic and Gulf Coasts) or the mean lower low water line (Pacific Coast) as shown on the large-scale coast charts of NOS.

DATA ACQUISITION PROCEDURES

Because tidal datums are usually needed before aerial photographs can be taken for shoreline mapping, a long lead time is required for observations and data reduction. Analysis and integration of tidal data over an extended area can become very complicated.

Procurement of acceptable aerial photographs for coastal mapping can present a number of problems that can be minimized through proper planning and patience. Tide-coordinated photographs must be taken at the time the desired tide stage occurs. Clouds and haze must be minimal, especially for color photography. Loss of imagery because of sunspots (reflection of the Sun from the water's surface directly into the camera lens) can be minimized or eliminated by proper flight direction, endlap, and time frame.

STATE COASTAL MAPPING PROGRAMS

California, Delaware, Florida, New Jersey, and Texas are some of the States that currently operate coastal mapping programs. For detailed information write to the State coastal zone managers listed in appendix 3.

CALIFORNIA

Various State agencies are engaged in projects for which accurate coastal maps would be useful. In 1967, under the California Comprehensive Ocean Area Plan (COAP), the first methodical aerial mapping of the California coastline was completed. Land use maps were compiled on USGS 7.5-min base maps. Both land use site-characteristics inventory maps and ownership inventory maps were printed at the scale of 1:31,680. For further information, or to order maps, write to:

California Coastal Zone Conservation Commission
1540 Market Street, 2nd Floor
San Francisco, California 94102

As part of COAP, the Department of Parks and Recreation did a mapping study entitled "The California Coastal Preservation and Recreation Plan." The Department does individual mapping studies of priority areas but has no continuing coastal mapping program.

The California Coastal Zone Conservation Commission presented its Coastal Plan to the State Legislature in 1975. Its coastal resources maps show the distribution of resources as described in the plan and identify problems concerning the coastal zone. Regional commissions within the State are expected to prepare more detailed maps at larger scales.

California coastal resources have been classified as follows: (1) Special marine environment, (2) wetland or estuary, (3) special land habitat, (4) other land habitat or open space area, (5) grazing, (6) cultivated agricultural lands and class I and II soils, (7) forestry resource area, (8) mineral extraction area, (9) developed area, and (10) existing recreation area.

During the past few years, the State has been involved in litigation to determine ownership boundaries in San Francisco Bay. In addition to making limited ground and aerial surveys, the State has contracted with NOS for historical information about tidal datums in that area. Although the project was undertaken because of contested ownership, the results of the mapping and tidal-datum studies will be useful as a more comprehensive program is established.

Because of increasing statewide interest and problems associated with the coastal zone, the need for a comprehensive program has become apparent. Coastal mapping needs have been identified in regulatory, ownership, development, and environmental fields. Mapping scales needed for such diversified interests would vary, and to date no technical specifications have been adopted.

DELAWARE

The Delaware coastal zone program includes three mapping efforts: Land use maps, a wetland atlas, and coastal-flooding maps. Land-use/natural-cover maps are being prepared for the entire State based on interpretation of infrared satellite and aircraft photographs, USGS aerial photographs, and other data. The wetlands atlas is based on interpretations of productivity, flood prevention, habitat, and water quality, and it includes data on significant marine species. The coastal-flooding maps (more detailed than the HUD flood-insurance maps) indicate areas subject to flood damage, the frequency and extent of damage, and other conditions for proper coastal development.

Standard scales used (in order of decreasing use) are 1:24,000, 1:9,600, 1:4,800, 1:63,360, 1:126,720, 1:253,440, and 1:2,400. The 1:24,000-scale maps in both aerial-mosaic and planimetric form are the base maps for Delaware's coastal zone program. They are used for the land use maps, to plot permit and development activities, and as graphics related to such studies as wetlands, coastal erosion, geology, and hydrology.

The State and all three county governments established the 1:9,600 scale as the standard for most planning and management purposes. That scale, on aerial-mosaic and planimetric bases, has been used since 1964. The maps were prepared by

a private contractor for the various governments as part of a joint venture and are routinely updated.

Maps of the USGS 1:24,000-scale 7.5-min quadrangle series have also been used as a planning base in Delaware, and were supplemented with 1973 aerial mosaics at quadrangle scale, although no new quadrangle maps were prepared. Other base materials are from the State Division of Highways and from respective county tax-assessment/property-ownership mapping programs completed in the past few years for most of the State.

The three county mapping efforts are being partially completed by contractors. Private consultants and the University of Delaware prepare draft copies. Final graphics, including maps, are prepared by the Delaware State Planning Office to assure consistency in format, scale, notation, and material.

Major problems encountered to date include basemap obsolescense and inconsistencies in scales and formats of source materials. These problems are being overcome by centralizing the final mapping and through acquisition of a set of USGS aerial photographs that are being used to generate base maps. An unsolved problem relates to obtaining accurate topographic maps with either a 2- or 5-ft (0.6- or 1.5-m) contour interval. This problem will not be solved by the current coastal zone management program because of the cost and time required.

FLORIDA

Florida's coastal zone program has had two primary objectives: (1) To provide a comprehensive data base (modified land use levels II and III of Anderson and others, 1976) to support activities of the Bureau of Coastal Zone Planning, and (2) to provide county/regional site analysis for selected work elements to support local requirements.

"Coastal Zone Management in Florida—1971" is a report on the pilot project used to design the format and methods for developing Florida's coastal-zone management program. The report consists of text, thematic maps, and a matrix display for each zoning category showing defined criteria and established and recommended State policy. The counties selected for the study were Escambia and Santa Rosa (collectively referred to as Escarosa) because they contain prime examples of hydrology, physiography, and economics common to the entire Florida coastal zone.

The "Florida Coastal Zone Management Atlas—1972" provides decisionmakers and concerned citizens with an overview of the components that make up the coastal environment of Florida. The atlas delineates the areas already developed and those physically suited to future development where it will have a minimum detrimental effect on the environment. The atlas contains an inventory of relatively undisturbed natural features and recommends preservation of essential segments to ensure the maintenance of marine life, esthetic qualities of the coast, and the physical integrity of the shorelands. A conservation zone is recommended between development and preservation areas where development is controlled by specific physical limitations.

The "Florida Keys Coastal Zone Management Study—1974" was prepared as a model for statewide coastal-zone planning. The design followed the same biophysical outline as the Management Atlas, except that a level-III data base was generated to provide site-analysis detail. Sections on socioeconomic and environmental-quality analysis were added.

The Bureau of Coastal Zone Planning and regional planning staffs have prepared a biophysical and socioeconomic analysis using the years 1973-74 as a data generation base. The biophysical analysis is a level II updating of the Management Atlas data with a scale of 1:126,720 and 40-acre data cells. The socioeconomic analysis maps are at 1:24,000 scale, with data cells ranging from 5 to 20 acres depending on the complexity of data and reproduction scale limitations. The methods and techniques for collecting, analyzing, and disseminating data follow much the same procedures used in the Florida Keys Management Study.

In FY 1977 data previously input on a site response basis will be revised and updated using level-III information and 1–5-acre data cells at 1:24,000 scale. Another thematic project is a synoptic map of the Florida coral reef system and associated bottom detail. This interagency program is a long-term study of relations between nature and man and their effect on the health of the reef system.

A number of cooperative programs between Florida and both USGS and NOS are discussed in "Sources of assistance and advice."

NEW JERSEY

New Jersey has two coastal mapping programs, wetlands and tidelands. The wetlands mapping program put into effect provisions of the New

Jersey Wetlands Act of 1970, which regulates private property to protect wetlands. Wetlands are defined in the act as "any bank, marsh, swamp, meadow, flat, or lowland subject to tidal action along any inlet, estuary, or tributary waterway including those areas now or formerly connected to tidal waters whose surface is at or below an elevation of 1 foot above local extreme high water, and which is capable of growing some but not all of" specified species (list available from the New Jersey coastal zone program manager, app. 3).

A study was contracted to determine existing wetlands mapping methods, availability of data, and funding. The study revealed that wetlands should be defined only in terms of the vegetation species without incorporating a specific elevation criterion. If these species are present, the elevation test is automatically satisfied. Also, color infrared photography should be used as the primary method to define plant species.

Aerial photographs with complete stereocoverage were acquired at 1:12,000 scale. Natural-color, color infrared, and black-and-white panchromatic films were exposed simultaneously. Black-and-white panchromatic photographs also were acquired at 1:30,000 scale for aerotriangulation. For delineation, base maps at 1:2,400 scale were developed using rectified black-and-white enlargements of color infrared photographs.

On each map the upper wetlands boundary and major vegetation associations were delineated by interpreting signatures of color infrared photographs in conjunction with natural-color photographs. Major species associations were defined as one or more species having an area of 5 acres (2 ha) or more and composing at least 25 percent of the vegetation. Stands of lesser size were not mapped unless it was in the interest of wildlife management. For example, 1-acre (0.4 ha) stands of wild rice were mapped because of value to waterfowl. Subsequent field checking showed that interpretation of color infrared signatures provided 85–90 percent of required biological data. A report containing explanations and names of the delineators accompanies each wetlands map.

Property-line overlays for each base map were compiled from tax maps and show lot and block numbers, with tabular listing of ownership. The 1:2,400-scale base map was chosen because it is similar to the scale of municipal tax maps, and the accuracy is defensible in court. Wetlands maps meet National Map Accuracy Standards below the elevation of 10 ft above mean sea level.

The New Jersey tidelands mapping program catalogs State riparian (now or formerly below mean high water) lands. Most maps will be made in-house; some may be contracted in the final drafting stage. Data will be drawn from over 200 tide gaging stations throughout the State. Old photographs, maps, surveys, and biological data (such as wetlands maps) will be used. NOS will help with data analysis and field direction.

Final products will be base maps and overlays at 1:2,400 scale meeting National Map Accuracy Standards. The mapping of State lands in the Hackensack Meadowlands was completed by 1974. Mapping for the entire State will be completed by 1980 at a cost of $6 million.

Photoquads were made to update land use patterns of the USGS topographic 7.5-min quadrangle maps of New Jersey. Aerial color infrared photographs were taken under contract at 12,200 m (40,000 ft). Final maps are 1:24,000 scale on transparent stable plastic for overlay on USGS topographic maps. The program took approximately 4 mo and cost $60,000. Updates are planned at 3-yr intervals.

TEXAS

The Texas Coastal Management Program has defined two tiers of counties inland from the coast as the coastal region. Although the coastal management zone is only a fraction of this area, an inventory of the whole region is necessary.

The base map for the inventory is a 1:250,000-scale composite of two kinds of projections: the polyconic of USGS 7.5-min sheets for wetlands, as prepared by the Bureau of Economic Geology, the University of Texas at Austin; and the universal transverse Mercator for inland areas, as prepared from Army Map Service–USGS 1:250,000-scale maps. The regional base map has been used for compilation of geologic substrate, potential mineral deposits, active processes, natural biologic assemblages, soil (agronomic) capabilities, water features, historical-archeological data, and current land use. These maps have been published at 1:500,000 scale with an accompanying report entitled "Resources of the Texas Coastal Region."

With the regional resource inventory as background material, composite resource areas constituting coastal waters (including all bay-estuarine and nearshore Gulf systems) and shorelands (including wetlands, active dune complexes, and beaches) have been mapped. Note that such

boundaries are not static but vary seasonally and secularly. Changes continually occur between State-owned (submerged) and private lands. Evaluation of data on the composite resource-areas map will show where various human activities can be sustained naturally. The composite resource-areas map was compiled at 1:24,000 scale and published at 1:250,000 scale and will be a basic planning document.

The Texas Coastal Management Program includes other important projects:

- A coordinated ground-controlled aerial-photographic survey with color infrared stereoscopic pairs of the Padre Island–Laguna Madre area in south Texas at 1:24,000 scale. Controlled imagery is needed because of changing landforms due to shifting sands.
- Controlled aerial photographs of the Padre Island–Laguna Madre area processed into orthophotomaps at 1:24,000 scale in a 7.5-min format conforming to USGS quadrangles in the area to allow use of control points after future aerial photographic flights without expensive ground resurveys.
- New color infrared aerial photographs have been taken at 1:24,000 scale for all bay margins and coastal wetlands.
- New NASA color-infrared images of the coast.
- Reconnaissance offshore mapping by BEG.
- Detailed revisions and updates of coastal wetlands maps at 1:24,000 scale.

The BEG functions as the State geological survey and focuses on problems concerning natural resources and engineering. Some BEG programs and publications are:

- Environmental geologic atlases of the Texas coastal zone.—A series of detailed reports on individual coastal areas. Includes environmental geology, physical properties, environments and biologic assemblages, land use, mineral and energy resources, active (geologic) processes, manmade features and water systems, rainfall and ground water, and topographic-bathymetric maps.
- "Natural Hazards of the Texas Coastal Zone."—Explains the natural hazards to life and property that result from such occurrences as hurricanes, floods, shoreline erosion, land-surface subsidence, and active surface faulting.
- Geological Circular 75-4.—Analysis of the historical changes in the Texas coastline. Describe the cartographic procedures used.
- Land resources laboratory map series.—Land- and water-use maps of the area under the jurisdiction of the Houston–Galveston Area Council of Governments. Maps include vegetation, minerals, energy, and subsidence and hurricane flooding.
- "Publications of the Bureau of Economic Geology."—List of reports and maps published by BEG.

For more information on BEG or to obtain literature, contact:

Bureau of Economic Geology
The University of Texas
Box X, University Station
Austin, Texas 78712

For more information on the Texas Coastal Management Program, contact:

Texas Coastal Management Program
General Land Office
1700 North Congress Avenue
Austin, Texas 78701

SOURCES OF ASSISTANCE AND ADVICE

Many Federal agencies are experienced in selecting and developing maps and mapping programs. Before undertaking an extensive mapping program, any agency should be aware of existing maps and other data from Federal, regional, State, and local sources. Building on existing information is generally the most economical and effective approach to coastal mapping. The establishment of intrastate, interstate, and State-Federal cooperative programs to maximize use of existing resources is particularly important.

GENERAL INFORMATION CENTERS

General information concerning the availability of map and chart data produced by Federal agencies can be obtained from a number of sources including the National Cartographic Information Center (NCIC), the National Geodetic Survey Information Center (NGSIC), the Environmental Data Service (EDS), and the EROS Data Center (EDC).

National Cartographic Information Center

The primary role of NCIC is to develop and maintain an information data base on the location and availability of cartographic data. Generally, mapping organizations store and distribute their own cartographic data, and users are encouraged to

deal directly with the agency concerned if they know what they need and where it can be found. However, NCIC assists those who need help to determine what is available and where it is located.

NCIC is headquartered at Reston, Virginia, and has six regional offices around the country.

National Cartographic Information Center
U.S. Geological Survey
MS 507 National Center
Reston, Virginia 22092
Telephone: 703–860–6045

National Cartographic Information Center
Eastern Mapping Center
U.S. Geological Survey
MS 536 National Center
Reston, Virginia 22092
Telephone: 703–860–6336

National Cartographic Information Center
Mid-Continent Mapping Center
U.S. Geological Survey
1400 Independence Road
Rolla, Missouri 65401
Telephone: 314–364–3680 x107

National Cartographic Information Center
Rocky Mountain Mapping Center
U.S. Geological Survey
Stop 510, Box 25046
Denver Federal Center
Denver, Colorado 80225
Telephone: 303–234–2326

National Cartographic Information Center
Western Mapping Center
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025
Telephone: 415–323–8111 x2427

National Cartographic Information Center
U.S. Geological Survey
National Space Technology Laboratories
Building 1100
NSTL Station, Mississippi 39529
Telephone: 601–688–3544

National Cartographic Information Center
EROS Data Center
U.S. Geological Survey
Sioux Falls, South Dakota 57198
Telephone: 605–594–6511 x507

Some States established affiliated offices that operate as extensions of the NCIC system.

Arizona
Arizona Department of Revenue
Arizona Resources Information System
Room 302
1624 West Adams Street
Phoenix, Arizona 85007
Telephone: 602–271–4061

Georgia
Geologic and Water Resources Division
Department of Natural Resources
19 Martin Luther King Drive
Atlanta, Georgia 30334
Telephone: 404–656–3214

Minnesota
Minnesota State Planning Agency
Environmental Planning Division
15 Capitol Square
550 Cedar Street
Saint Paul, Minnesota 55101
Telephone: 612–296–2613

New Mexico
Technology Application Center
University of New Mexico
2500 Central Avenue, SE.
Albuquerque, New Mexico 87131
Telephone: 505–277–3622

South Carolina
South Carolina Land Resources Conservation Commission
Suite 222
2221 Devine Street
Columbia, South Carolina 29205
Telephone: 803–758–7197 x41

Texas
Texas Natural Resources Information System
P.O. Box 13087
Austin, Texas 78711
Telephone: 512–475–3321

West Virginia
West Virginia Cartographic Center
West Virginia Geological and Economic Survey
P.O. Box 879 Whitehall
Morgantown, West Virginia 26505
Telephone: 304–292–6331 x256

National Geodetic Survey Information Center

The National Geodetic Survey, an office of NOS, is responsible for establishing and maintaining the Nation's horizontal and vertical control networks. Control survey data are available to the public from the National Geodetic Survey Information Center. In addition to information about NGS control, NGSIC receives input from a number of Federal agencies, including USGS, and from some State agencies. Eventually, NGSIC will be able to provide information on control surveys established by a greater number of agencies. For assistance in obtaining control survey data, contact:

National Geodetic Survey Information Center, C18
National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301–443–8631

Environmental Data Service

The resources of NOAA's Environmental Data Service are essential to environment-related coastal programs. They comprise baseline knowledge needed to plan, design, build, operate, and monitor the environmental effect of offshore energy facilities, such as drilling rigs, supertanker ports, and floating nuclear powerplants; to provide a standard by which to measure pollution and its impact upon the coastal environment; and to assess the natural state of the coastal environment for planning and management. EDS works with Federal, State, and local agencies to determine coastal environmental data and information needs and develops the necessary data to meet those needs. In addition, EDS provides experiment-design and data-management expertise plus referral to data and information holdings not in its own files. Finally, to meet NOAA's obligations under the Deepwater Ports Act of 1974, EDS evaluates and prepares recommendations regarding DWP license applications, related environmental impact statements, and adjacent coastal States statutes as specified in the Act. For assistance in obtaining these data, contact:

Director, Environmental Data Service
National Oceanic and Atmospheric Administration
Page Building 2
3300 Whitehaven Street, NW.
Washington, D.C. 20235
Telephone: 202–634–7318

EROS Data Center

The EROS Data Center, near Sioux Falls, S. Dak., is operated by the Earth Resources Observation Systems (EROS) Program of the Department of the Interior, and is managed by the Geological Survey's Land Information and Analysis Office. It provides access to imagery from Landsat, Skylab, USGS aerial photographs, NASA aircraft data, and other remote sensing products and training and assistance in the use of these data. EDC currently stores approximately 5.5 million master reproducibles that can be copied and sold to users.

For assistance in selecting imagery or to place an order, contact:

User Services Unit
EROS Data Center
U.S. Geological Survey
Sioux Falls, South Dakota 57198
Telephone: 605–594–6511

In addition to EDC, a network of EROS and NCIC affiliated offices has been established. They have microfilm copies of imagery held at EDC and provide assistance in determining what data are available and in ordering desired data.

These offices include the NCIC offices previously listed and the

EROS Applications Assistance Facility
University of Alaska
Geophysical Institute
College, Alaska 99701
Telephone: 907–479–7558

MAJOR FEDERAL MAPPING AND CHARTING PROGRAMS

The two major mapping and charting programs in the United States that influence the coastal zone are administered by USGS and NOS.

U.S. Geological Survey

The U.S. Geological Survey, as the primary civilian producer of maps, publishes several series of topographic maps of the United States as part of the Department of the Interior National Mapping Program. Other Federal agencies that sometimes prepare topographic maps in connection with their regular activities are the Defense Mapping Agency Topographic Center (DMATC), NOS, Tennessee Valley Authority (TVA), U.S. Forest Service (USFS), and Mississippi River Commission (MRC).

The principal USGS map series and their characteristics are given in table 1. In addition to the maps listed, USGS produces a number of others such as the National Park series (at various scales) that covers national parks, monuments, and historic sites. Many of the maps are available in shaded-relief editions on which the topography is

TABLE 1.—*Principal U.S. Geological Survey map series*

Series	Scale	1 cm represents (km)	Geographic coverage	1 inch represents
7.5-min	1:24,000	0.24	7.5'x7.5'	2,000 ft
Puerto Rico 7.5-min	1:20,000	.20	7.5'x7.5'	1,667 ft 2,000 ft
Alaska 1:24,000	1:24,000	.24	7.5'x15' or 18'	2,083 ft
Alaska 1:25,000	1:25,000	.25	7.5'x11.25'	4,167 ft
1:50,000 county	1:50,000	.50	County	
15-min	1:62,500	.625	15'x15'	nearly 1 mi
Alaska 1:63,360	1:63,360	.6336	15'x20', 22.5', 30', or 36'	1 mi
1:100,000 county	1:100,000	1.0	County	8,333 ft
U.S. 1:100,000	1:100,000	1.0	30'x1°	8,333 ft
U.S. 1:250,000	1:250,000	2.5	1°x2°	nearly 4 mi
IMW 1:1,000,000	1:1,000,000	10.0	4°x6°	nearly 16 mi

Note.—In Alaska the sizes of the 1:250,000 and 1:1,000,000-scale quadrangles vary from the above figures.

made to appear three-dimensional by shadow effects. State base maps at scales of 1:500,000 (1 cm represents 5 km) and 1:1,000,000 are available for all States except Alaska and Hawaii, which are covered by maps at other scales. Byproducts of State base maps are State hydrologic unit maps that show regions and subregions used by the Water Resources Division to plan detailed studies of water and related land resources. They also show accounting units used for managing the national water data system. For some States, topographic and shaded-relief editions are also available. Maps of the United States are available in sizes and scales ranging from letter size (1:16,500,000 scale) to a two-sheet wall map (1:2,500,000 scale). A new 50-State map is the first detailed USGS map of the United States that shows Alaska and Hawaii in their proper size and position relative to the other 48 States.

Topographic maps of special format are produced for many principal rivers and their flood plains. Topographic-bathymetric maps are also being produced, and research is being conducted in wetlands mapping. In addition, land use overlays are being prepared for the Geography Program of the USGS Land Information and Analysis Office.

The products mentioned in this section do not define the limits of USGS mapping functions. USGS is receptive to the needs of map users and is prepared to undertake new programs and special projects, including cooperative mapping programs, when they are needed.

Detailed information on USGS mapping programs can be obtained from the following sources:

Alaska and Texas
Branch of Plans and Production
Rocky Mountain Mapping Center
U.S. Geological Survey
Stop 510, Box 25046
Denver Federal Center
Denver, Colorado 80225
Telephone: 303–234–3739

Atlantic Coast States, Alabama, Indiana, Ohio, Pennsylvania, Puerto Rico, and the Virgin Islands
Branch of Plans and Production
Eastern Mapping Center
U.S. Geological Survey
MS 559 National Center
Reston, Virginia 22092
Telephone: 703–860–6393

Illinois, Louisiana, Michigan, Minnesota, Mississippi, and Wisconsin
Branch of Plans and Production
Mid-Continent Mapping Center
U.S. Geological Survey
1400 Independence Road
Rolla, Missouri 65401
Telephone: 314–364–3680

Pacific Coast States, Hawaii, American Samoa, and Guam
Branch of Plans and Production
Western Mapping Center
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025
Telephone: 415–323–2411

Entire coastal zone
Office of Plans and Program Development
U.S. Geological Survey
MS 514 National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092
Telephone: 703–860–6706

National Cartographic Information Center
U.S. Geological Survey
MS 507 National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092
Telephone: 703–860–6045

The Geological Survey has a revision program designed to update its standard products. Emphasis is given to the 7.5-min topographic series because, besides being the primary series, it is also used to update other products. Each year a number of quadrangle maps are revised, based on periodic review in several categories.

Maps in urban areas are normally reviewed for revision every 5 years; those in agricultural areas, every 10 years; in remote areas, every 20 years. Not all maps are revised on review; approximately 50 percent of those reviewed warrent the expense of revision.

Maps of urbanized portions of the Standard Metropolitan Statistical Areas (SMSA's) defined by the Bureau of the Census are maintained on a 5-yr cycle. At the request of the Federal Aviation Administration, quadrangle maps within 10 nmi of 600 selected airports are revised on a 5-yr cycle.

Other categories considered for review (not necessarily in the order listed) are:

1. SMSA's extended (nonurban portion).
2. Coastal zone.
3. A-16 multiple requests (quadrangles requested by other Federal agencies through the Office of Management and Budget (OMB) Circular A-16.
4. Cities and towns outside SMSA's.
5. Energy areas.
6. Parks and recreation areas.
7. Transportation corridors.

There are some exceptions to the normal review. For example, a cooperative mapping program may call for review of an area on a shorter cycle. Such areas usually receive priority consideration.

The Geological Survey is increasing emphasis on production and revision of maps in the coastal zone to provide users with accurate and up-to-date maps for the entire zone.

There are approximately 3,600 7.5-min quadrangle areas in the coastal zone of the conterminous United States, Alaska, Hawaii, and Puerto Rico. The number includes shoreline quadrangles plus adjacent inland quadrangles. Of these, about 700 need new mapping and 2,000 need revision. Quick-response products, such as orthophotoquads and interim revisions, will be provided for many coastal areas.

Research projects have played an important role in the USGS mapping program. For example, the Water Resources and Topographic Divisions cooperated in mapping the wetlands on the Doboy Sound, Ga., 7.5-min quadrangle. Spectral signatures of vegetation groupings were interpreted from color infrared photographs. Orthophotoquads (1:10,000 scale, 2.5′x3.75′ format) were used as bases for the wetlands compilation. The experiment showed that remote sensing coupled with field investigation can be used to delineate the defined wetlands. Two additional USGS projects dealing with mapping and environmental assessments of wetlands are underway.

National Ocean Survey

The National Ocean Survey publishes nautical charts of the waters of the United States and its territories. Charts of the coastal zone are available, but not always at a scale suitable for all coastal management functions. Nautical charts are produced in various sizes and formats, with differing degrees of detail. The charts are produced by the Marine Chart Division from basic hydrographic, oceanographic, and topographic surveys conducted by other NOS components. The Coastal Mapping and Oceanographic Divisions retain such data as aerial photographs, large-scale maps, tide and current data, and sea water temperatures, which are of considerable value in coastal affairs.

In addition to presenting data from NOS operations, nautical charts are the principal means for disseminating navigation data provided by other agencies. For example, the full benefit of aids to navigation—improved channels and harbors, traffic separation schemes, and navigation regulations—can be realized only by bringing together all the information on the charts in a form that is easily understood and readily usable by mariners.

The large single-sheet flat charts usually averaging 33x42 in (84x107 cm) are called "conventional charts." This distinguishes them from the more compact, folded, small-craft charts which vary in size, but are generally smaller than 8x19 in (20x48 cm) when folded.

Chart maintenance is a vital part of charting responsibility. Shoaling or dredging in channels, changes in both visual and electronic aids to navigation, and natural and manmade changes to the shoreline and alongshore structures necessitate frequent revision to provide navigators with up-to-date information.

Revision of a chart is based on new aerial photographs, field-generated data, or a combination of both, and is usually limited to specific areas on the chart where sufficient change has occurred to warrant updating. For economic reasons, an area is completely remapped only when the scope of the change so dictates or when new formats, larger scale products, or special-purpose charts are required.

The charts are revised on various maintenance schedules: 2-3 years for more active areas and 4-12 years for less active areas. A few, such as charts of New York and Baltimore Harbors, are revised and printed on a 6-month schedule.

For further information on nautical charts, contact:

Chief, Marine Chart Division
National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301-443-8741

In cooperation with USGS, NOS publishes a series of maps as primary planning bases to help State and local communities and Federal agencies optimize use of the coastal zone. Under this program, NOS provides information seaward of the shoreline, and USGS provides the landward details. The maps include the following series: a 1:10,000-scale series that depicts mean high water, mean low water, or mean lower low water tidal datum lines which are boundary base lines for the United States and its possessions; an enhanced 1:24,000-scale series in the same format as the USGS standard 7.5-min quadrangle series; a new 1:100,000-scale series of particular value to States and regional commissions; and a 1:250,000-scale

series useful for State, regional, and Federal planning. These maps are produced after coordination of NOS and USGS mapping programs and after consultation with State and Federal agencies. Priorities are established on the basis of State needs and the availability of cost-sharing funds.

The coastal mapping program of NOS provides aerial photographic and office compilation services to map the shoreline and locate nearshore features. The estuarine and lake level programs provide measurement, analysis, prediction, and dissemination services for tides, currents, lake levels, and river flows in the coastal and estuarine areas of the United States, including the Great Lakes and interconnecting waterways.

For further information, contact:

Chief, Marine Chart Division
National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301–443–8741

Detailed field surveys at 600 airports designated by the Federal Aviation Administration and production of obstruction charts covering 10 nmi around those airports have been assigned to NOS. Obstruction charts and control survey data near major airports can be obtained from:

Chief, Coastal Mapping Division
National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301–443–8744

USGS AND NOS COOPERATIVE PROGRAMS

Federal mapping agencies cooperate on projects that contribute to national mapping and charting, including special products as well as standard map series. States, Commonwealths, or Territories, their political subdivisions, and their agencies may enter into cooperative agreement in which map production is funded equally by the State agency and the Federal Government. The cost of publication normally is borne by the Federal Government. The effect of cooperative agreements is to expedite mapping of areas of particular interest to the cooperating agency because the cooperators help select new project areas. Cooperators are listed in appendix 1. The list is by no means exclusive; additional cooperative programs can be arranged with other organizations within the same jurisdictions.

Occasionally agencies enter into cost-sharing agreements to support specified parts of map preparation. For example, an agency could provide all or some of the funds for compiling the planimetry but not the contouring of a topographic map. Similarly, State agencies have shared costs for determining tidal datums and coastal boundaries. If the work to be performed does not directly contribute to national mapping and charting, a repay or reimbursable project may be arranged.

In repay projects the work is done by the Federal Government, but the entire cost of the project is paid by the requesting agency. Acceptance of a reimbursable agreement depends on the nature of the work and the ability of the Federal agency to fit the job into its production schedule.

In addition to mapping and charting projects, the Federal Government cooperates on surveying and tidal-determination projects. Recent cooperative geodetic surveying programs were undertaken with New York, Georgia, Maine, Connecticut, Oregon, California, and Louisiana. These programs vary widely; further information may be obtained from the Director of NOS.

Since the mid-1970's, NOS has been conducting tidal datum surveys in cooperation with Florida, New Jersey, and California. In the near future cooperative tidal datum surveys and coastal mapping will be planned for all coastal areas. The planned program involves cooperative establishment of the tidal datums prior to mapping the desired tidal datum lines to NOS accuracy specifications.

For information about a cooperative agreement with USGS, the following offices may be contacted:

Alaska and Texas
Chief, Rocky Mountain Mapping Center
U.S. Geological Survey
Stop 510, Box 25046
Denver Federal Center
Denver, Colorado 80225
Telephone: 303–234–2351

Atlantic Coast States plus Alabama, Indiana, Pennsylvania, Ohio, Puerto Rico, and the Virgin Islands
Chief, Eastern Mapping Center
U.S. Geological Survey
MS 567 National Center
Reston, Virginia 22092
Telephone: 703–860–6352

Illinois, Louisiana, Michigan, Minnesota, Mississippi, and Wisconsin
Chief, Mid-Continent Mapping Center
U.S. Geological Survey
1400 Independence Road
Rolla, Missouri 65401
Telephone: 314–364–3680

Pacific Coast States plus Hawaii, American Samoa, and Guam
Chief, Western Mapping Center
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94075
Telephone: 415–323–2411

Headquarters office
Chief, Topographic Division
U.S. Geological Survey
MS 516 National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092
Telephone: 703–860–6231

For information about a cooperative program with NOS, contact:

Director, National Ocean Survey
National Oceanic and Atmospheric Administration
6001 Executive Boulevard
Rockville, Maryland 20852
Telephone: 301–443–8744

Both USGS and NOS recognize the need for providing technical assistance to other organizations—Federal, State, or private. Technical information in the form of mapping instructions and professional papers may be obtained from:

Technical Information Office
U.S. Geological Survey
MS 520 National Center
Reston, Virginia 22092
Telephone: 703–860–6275

Coastal Mapping Division
National Ocean Survey
National Oceanic and Atmospheric Administration
6001 Executive Boulevard
Rockville, Maryland 20852
Telephone: 301–443–8744

The USGS technical assistance program includes such services as providing technical instructions, accepting research projects on a repay basis, and training non-Federal personnel at the headquarters or at any of the regional offices across the country. Requests for such arrangements should be directed to:

Office of Research and Technical Standards
U.S. Geological Survey
MS 519 National Center
Reston, Virginia 22092
Telephone: 703–860–6291

or to the Director of NOS.

In addition to the handbook, there are other cooperative programs between NOS and USGS. One is the topographic-bathymetric map series which will incorporate the data previously shown separately on USGS topographic maps and NOS bathymetric maps into one format and edition. The integrated product is designed to serve the cartographic needs of oceanographers, marine geologists, land use planners, physical scientists, conservationists, and others interested in managing the coastal zone, the wetlands, and the offshore environment.

A portion of the 1:250,000-scale topographic-bathymetric map for Wilmington, Del.–N.J.–Pa.–Md., is shown in appendix 7, figure 12. Other maps have been authorized at that scale and at 1:100,000 scale. Eventually such maps will be available at 1:24,000 scale and in some cases at 1:10,000 scale.

MAPPING AND CHARTING ACTIVITIES

The following offices are sources of information about the mapping and charting programs of the particular agency listed. Cartographic data are not always available at these offices. See the following section, "Product and data sources," for a list of data distribution points.

Agricultural Stabilization and Conservation Service
Aerial Photography Field Office
Agricultural Stabilization and Conservation Service
(2222 West, 2300 South)
Box 30010
Salt Lake City, Utah 84109
Telephone: 801–524–5856

Bonneville Power Administration
Information Office
Bonneville Power Administration
1002 NE. Holliday Street
Portland, Oregon 97208
Telephone: 503–234–3361 x5133

Bureau of Indian Affairs
Public Information Office
Bureau of Indian Affairs
18th and C Streets, N.W.
Washington, D.C. 20245
Telephone: 202–343–7435

Bureau of Land Management
Division of Cadastral Survey
Bureau of Land Management (420)
Washington, D.C. 20240
Telephone: 202–343–8205

Bureau of Mines
Office of Technical Data Services
Bureau of Mines
Columbia Plaza
2401 E St., N.W.
Washington, D.C. 20241
Telephone: 202–634–1110

Bureau of Outdoor Recreation
Deputy Director for Planning
Bureau of Outdoor Recreation
4415 Interior Building
18th and C Streets, NW.
Washington, D.C. 20240
Telephone: 202–343–7375

Bureau of Reclamation
Information Branch
Office of Public Affairs
Bureau of Reclamation
7640 Interior Building
18th and C Streets, NW.
Washington, D.C. 20240
Telephone: 202–343–4662

Bureau of the Census
Geography Division
Bureau of the Census
Washington, D.C. 20233
Telephone: 301–763–2668

Delaware River Basin Commission
Executive Director
Delaware River Basin Commission
(25 State Police Drive)
P.O. Box 7360
West Trenton, New Jersey 08628
Telephone: 609–883–9500

Department of State
Office of the Geographer
Bureau of Intelligence and Research
8744 State Department Building
2201 C Street, NW.
Washington, D.C. 20520
Telephone: 202–632–1428

Energy Regulatory Commission
Office of Public Information
Energy Regulatory Commission
825 North Capitol Street, N.E.
Washington, D.C. 20426
Telephone: 202–275–4006

Environmental Protection Agency
Office of Public Awareness
Environmental Protection Agency
401 M Street, SW.
Washington, D.C. 20460
Telephone: 202–755–0715

Federal Communications Commission
Public Information Office
Federal Communications Commission
Room 202
1919 M Street, NW.
Washington, D.C. 20554
Telephone: 202–632–7260

Federal Highway Administration
Office of Public Affairs
Federal Highway Administration
Room 4208
400 7th Street, SW.
Washington, D.C. 20590
Telephone: 202–426–0677

Federal Insurance Administration
Assistant Administrator for Flood Insurance
Federal Insurance Administration
Room 5272
451 7th Street, SW.
Washington, D.C. 20410
Telephone: 202–755–5581

Fish and Wildlife Service
Division of Realty
Fish and Wildlife Service
555 Matomic Building
1717 H Street, NW.
Washington, D.C. 20240
Telephone: 202–343–4676

Forest Service
Publications Office
Office of Information
U.S. Forest Service
Washington, D.C. 20013
Telephone: 202–447–3957

International Boundary Commission
U.S. Commissioner
International Boundary Commission
United States and Canada
United States Section
Room 150
425 I Street, N.W.
Washington, D.C. 20536
Telephone: 202–783–9151

International Boundary and Water Commission
U.S. Commissioner
International Boundary and Water Commission
United States and Mexico
United States Section
(4110 Rio Bravo, Executive Center)
P.O. Box 20003
El Paso, Texas 79998
Telephone: 915–543–7300

Mississippi River Commission
Executive Assistant
Mississippi River Commission
(Mississippi River Commission Building)
P.O. Box 80
Vicksburg, Mississippi 39180
Telephone: 601–636–1311 x201

National Aeronautics and Space Administration
User Affairs Office
Office of Applications
National Aeronautics and Space Administration
247 Federal Office Building
600 Independence Avenue, SW.
Washington, D.C. 20546
Telephone: 202–755–2070

National Oceanic and Atmospheric Administration
Environmental Data Service
Director
Environmental Data Service
National Oceanic and Atmospheric Administration
2001 Wisconsin Avenue, NW.
Washington, D.C. 20235
Telephone: 202–634–7318

Environmental Research Laboratories
Office of Programs
Environmental Research Laboratories
National Oceanic and Atmospheric Administration
3100 Marine Avenue
Boulder, Colorado 80302
Telephone: 303–499–6212

National Ocean Survey
Program Development Division
National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301–443–8548

Physical Science Services Branch
Scientific Services Division
National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301–443–8031

National Weather Service
National Weather Service
National Oceanic and Atmospheric Administration
Gramax Building
8060 13th Street
Silver Spring, Maryland 20910
Telephone: 301–427–7622

National Park Service
Office of Communications
National Park Service
3043 Interior Building
18th and C Streets, NW.
Washington, D.C. 20240
Telephone: 202–343–6843

Soil Conservation Service
Education and Publication Branch
Information Division
Soil Conservation Service
U.S. Department of Agriculture
Washington, D.C. 20250
Telephone: 202–447–5063

U.S. Air Force
Office of Information
Office of the Secretary
U.S. Air Force
The Pentagon
Washington, D.C. 20330
Telephone: 202–695–4602

U.S. Army
Public Affairs Office
Office of the Chief of Engineers
Department of the Army
James Forrestal Building
Washington, D.C. 20314
Telephone: 202–693–6326

U.S. Army Corps of Engineers

Maps and charts
Public Affairs Office
Office of the Chief of Engineers
Department of the Army
James Forrestal Building
Washington, D.C. 20314
Telephone: 202–693–6326

Photographs
Coastal Engineering Research Center
Kingman Building
Fort Belvoir, Virginia 22060
Telephone: 202–325–7000

U.S. Coast Guard
Public Affairs Division
U.S. Coast Guard
400 7th Street, SW.
Washington, D.C. 20590
Telephone: 202–426–1587

U.S. Geological Survey

General cartographic information
User Services Section
National Cartographic Information Center
U.S. Geological Survey
MS 507 National Center
Reston, Virginia 22092
Telephone: 703–860–6045

Map information
Public Inquiries Office [1]
U.S. Geological Survey
108 Skyline Building
508 2d Avenue
Anchorage, Alaska 99501
Telephone: 907–277–0577

Public Inquiries Office [2]
U.S. Geological Survey
7638 Federal Building
300 North Los Angeles Street
Los Angeles, California 90012
Telephone: 213–688–2850

Public Inquiries Office [2]
U.S. Geological Survey
504 Customs House
555 Battery Street
San Francisco, California 94111
Telephone: 415–556–5627

Public Inquiries Office [2]
U.S. Geological Survey
1C45 Federal Building
1100 Commerce Street
Dallas, Texas 75202
Telephone: 214–749–3230

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[1] Area of concern is limited to Alaska.

[2] Area of concern is limited to the States within the particular region of the country. The Los Angeles and San Francisco offices provide information on Hawaii.

U.S. Geological Survey—continued

Public Inquiries Office
U.S. Geological Survey
1036 General Services Building
19th and F Streets, NW.
Washington, D.C. 20240
Telephone: 202–343–8073

Public Inquiries Office
U.S. Geological Survey
MS 302 National Center
Reston, Virginia 22092
Telephone: 703–860–6167

Public Inquiries Office [2]
Publications Division
U.S. Geological Survey
678 U.S. Court House
West 920 Riverside Avenue
Spokane, Washington 99201
Telephone: 509–456–2524

Technical information
Technical Information Office
U.S. Geological Survey
MS 520 National Center
Reston, Virginia 22092
Telephone: 703–860–6275

Photographic information
User Services Unit
EROS Data Center
U.S. Geological Survey
Sioux Falls, South Dakota 57198
Telephone: 605–594–6511

U.S. Marine Corps
Information Branch
Information Division
U.S. Marine Corps
Arlington Annex
Columbia Pike and Arlington Ridge Rd.
Arlington, Virginia 20370
Telephone: 202–694–1492

U.S. Navy
Research and Public Inquiries Office
Public Information Division
Office of Information
U.S. Navy
The Pentagon
Washington, D.C. 20350
Telephone: 202–695–0965

For assistance and advice on State mapping programs, contact the State representatives listed in appendixes 1, 2, and 3. These sources should also be able to provide information about municipal and private mapping efforts in the States. Other sources of information about private mapping and aerial surveying companies are listed in appendix 4.

[2] Area of concern is limited to the states within the particular region of the country.

PRODUCT AND DATA SOURCES

Maps, charts, and related data that may be helpful in coastal management are listed below. Addresses of distribution offices follow. Information offices are listed in the preceding section, "Sources of assistance and advice."

Products	*Producing agency*	*Available from*
Aeronautical charts	NOS	NOS
Boundary information		
United States and Canada	IBC	IBC
United States and Mexico	IBWC	IBWC
Boundary and annexation surveys of incorporated places with 2,500 or more inhabitants	BC	GPO
Civil subdivisions and reservations	BLM	BLM
State/Federal	DOS	DOS
Census data (social and economic statistics)	BC	GPO
Climatic maps	NWS	NWS
Earthquake hazard map	USGS	USGS
Federal property maps		
Bureau of Reclamation	BR	BR
Fish and Wildlife Service	FWS	FWS
National Aeronautics and Space Administration	NASA	NASA
National forests	FS	FS
National Park Service	NPS	NPS
Military reservations		
Air Force	USAF	USAF
Army	USA	USA
Coast Guard	USCG	USCG
Marines	USMC	USMC
Navy	USN	USN
State map of lands administered by Bureau of Land Management	BLM	BLM
U.S. map of lands administered by Bureau of Land Management	BLM	BLM
Flood-plain maps	DRBC	DRBC
	FIA	FIA
	MRC	MRC
	NOS	FIA
	SCS	SCS
	USCE	USCE
	USGS	USGS
Geodetic control data	NGS	NGS
	USCE	USCE
	USGS	NGS/NCIC
Geologic maps		
Coal investigations	USGS	USGS
General geologic	SGA	SGA
	USGS	USGS

Products	Producing agency	Available from
Geologic maps—continued		
Geophysical investigations	NOAA	EDS
	NOAA	ERL
	USGS	USGS
Mineral investigations	USGS	USGS
Mines	BM	BM
Oil and gas investigations	USGS	USGS
Geographic maps	NOS	NOS
Land use	USGS	USGS
Highway maps		
County	FHWA	States
Indian lands	BIA	BIA
Federal lands	FHWA	FHWA
Federally funded roads	FHWA	GPO
Federal primary and secondary	FHWA	GPO
Interstate	FHWA	FHWA
Traffic flow	FHWA	States
Urban	FHWA	States
Federal Highway Map of the United States	FHWA	GPO
Historical maps and charts	LC, All Federal agencies.	LC, NARS
Hydrographic charts and bathymetric maps	NOS	NOS
	USCE	USCE
	USGS	USGS
Coastal data		
Beach erosion	USCE	USCE
Coastal boundary orthophotomaps	NOS	NOS
	USGS	USGS
Coastal boundary planimetric maps	NOS	NOS
	USGS	USGS
Coastal United States shoreline survey maps	NOS	NOS
Delaware River Basin outline map	DRBC	DRBC
Estuarine coastline measurement maps	EPA	EPA
Outer continental shelf diagram and resource management maps	BLM	BLM
	USGS	USGS
Shellfish area mapping	EPA	EPA
Tidal data	NOS	NOS
Water quality—digital data	EPA	EPA
Great Lakes	NOS	NOS
Hydrographic surveys	NOS	NOS
	USGS	USGS
Nautical charts	NOS	NOS
	USCE	USCE
Navigable waterways maps	USCE	USCE
River and stream surveys	MRC	MRC
Hydrographic charts and bathymetric maps—continued		
River basin/watershed studies	ERC	ERC
	SCS	SCS
	USGS	USGS
River surveys	BR	BR
	USGS	USGS
Wildlife and scenic river jurisdiction	BLM	BLM
Hydrologic investigation atlases	USGS	USGS
Indian reservations land surveys	BIA	GPO
United States map of Indian lands	BIA	GPO
Land plats	BLM	BLM
	BLM	NA
	NPS	NPS
	USCE	USCE
National Atlas of the United States	USGS	USGS
Photographic products		
Aerial photographs	ASCS	ASCS
	BLM	BLM
	BLM	EDC
	BPA	BPA
	DIA	DIA
	NASA	EDC
	FHWA	FHWA
	FS	EDC
	FS	NCIC
	FWS	EDC
	FWS	NCIC
	NOS	NOS
	NPS	NPS
	SCS	SCS
	USCE	USCE
	USFS	USFS
	USGS	NCIC/EDC
Orthophotomaps	BIA	BIA
	NOS	NOS
	USGS	USGS
Space imagery		
Landsat (ERTS)	NASA	ASCS, EDC, EDS.
NASA manned spacecraft	NASA	EDC
Nimbus	NWS	NWS
Skylab	NASA	ASCS, EDC.
Tiros	NWS	NWS
Recreation maps	BLM	BLM
	BOR	BOR
Seismicity maps and charts	ERL	ERL
	USGS	USGS
Soils	SCS	SCS
Soils—substation quality	BPA	BPA
Topographic maps	MRC	MRC
	NASA	NASA
	USGS	USGS
Utilities maps		
Ground conductivity map of the United States	FCC	GPO

Products	Producing agency	Available from
Utilities maps—continued		
Major natural-gas-pipelines map of the United States	ERC	GPO
Principal electric-facilities map of the United States	ERC	GPO
Principal natural-gas-pipelines map of the United States	ERC	GPO
Water resources development data	USGS	USGS
Miscellaneous data		
Clinometric (slope) maps	USGS	USGS
Gravity survey charts	EDS	EDS
	NOS	NOS
	USGS	USGS
Income distribution maps	BC	GPO
Isogonic charts	USGS	USGS
Isomagnetic charts	NOS	NOS
Magnetic charts	EDS	EDS
National science trail maps	SCS	SCS
State indexes of fish hatcheries and national wildlife refuges	FWS	FWS
Storm evacuation maps	NOS	NOS
Tree danger (to power lines) detection map	BPA	BPA
U.S. location map of fish hatcheries and national wildlife refuges	FWS	FWS

DISTRIBUTION POINTS

The following offices can provide maps, charts, and cartographic data. Catalogs, ordering instructions, and order forms are usually provided free on request. Photocopies of published, but out-of-print, Federal maps can be obtained from the Geography and Map Division of The Library of Congress, 845 S. Picket Street, Alexandria, Virginia 22034.

Agriculture Stabilization and Conservation Service
Aerial Photography Field Office
Agricultural Stabilization and Conservation Service
(2222 West, 2300 South)
Box 30010
Salt Lake City, Utah 84109
Telephone: 801–524–5856

Bonneville Power Administration
Bonneville Power Administration
(1002 NE. Holladay Street)
P.O. Box 3621
Portland, Oregon 97208
Telephone: 503–234–3361

Bureau of Indian Affairs
Bureau of Indian Affairs
18th and C Streets, N.W.
Washington, D.C. 20245
Telephone: 202–343–7435

Bureau of Land Management

Alaska
Alaska State Office
Bureau of Land Management
555 Cordova Street
Anchorage, Alaska 99501
Telephone: 907–277–1561

California
California State Office
Bureau of Land Management
E–2841 Federal Office Building
2800 Cottage Way
Sacramento, California 95825
Telephone: 916–484–4724

Eastern States
Eastern States Office
Bureau of Land Management
7981 Eastern Avenue
Silver Spring, Maryland 20910
Telephone: 301–427–7440

Oregon
Oregon State Office
Bureau of Land Management
(729 NE. Oregon Street)
P.O. Box 2965
Portland, Oregon 97208
Telephone: 503–234–4024

Western States
Denver Service Center
Bureau of Land Management
Building 50
Denver Federal Center
Denver, Colorado 80225
Telephone: 303–234–2204

Outer Continental Shelf Offices

Alaska
Alaska Outer Continental Shelf Office
Bureau of Land Management
(800 A Street)
P.O. Box 1159
Anchorage, Alaska 99510
Telephone: 907–276–2955

Atlantic (except Florida)
New York Outer Continental Shelf Office
Bureau of Land Management
Room 32–120
26 Federal Plaza
New York, New York 10007
Telephone: 212–264–2961

Gulf of Mexico and Florida
New Orleans Outer Continental Shelf Office
Bureau of Land Management
841 Hale Boggs Federal Building
500 Camp Street
New Orleans, Louisiana 70130
Telephone: 504–589–6541

Bureau of Land Management—continued
Outer Continental Shelf Offices—continued

Pacific (excluding Alaska)
Pacific Outer Continental Shelf Office
Bureau of Land Management
Room 7127
300 North Los Angeles Street
Los Angeles, California 90012
Telephone: 213–688–7234

Bureau of Mines
Mine Map Repository
Bureau of Mines
4800 Forbes Avenue
Pittsburgh, Pennsylvania 15213
Telephone: 412–621–4500

Mine Map Repository
Bureau of Mines
Denver Federal Center
Denver, Colorado 80225
Telephone: 303–234–4161

Environmental Affairs Field Office
Bureau of Mines
Wilkes-Barre, Pennsylvania 18701
Telephone: 717–825–6811

Bureau of Outdoor Recreation
Federal Land Acquisition Division
Bureau of Outdoor Recreation
4223 Interior Building
18th and C Streets, NW.
Washington, D.C. 20240
Telephone: 202–343–7665

Bureau of Reclamation
Chief, Publications and Photography Branch
General Services Division
Bureau of Reclamation
7442 Interior Building
18th and C Streets, NW.
Washington, D.C. 20240
Telephone: 202–343–4683

Bureau of the Census
Users Services Staff
Data Users Services Division
Bureau of the Census
Washington, D.C. 20233
Telephone: 301–763–2400

Delaware River Basin Commission
Executive Director
Delaware River Basin Commission
(25 State Police Drive)
Post Office Box 7360
West Trenton, New Jersey 08628
Telephone: 609–883–9500

Department of State
Office of the Geographer
Bureau of Intelligence and Research
8744 State Department Building
2201 C Street, NW.
Washington, D.C. 20520
Telephone: 202–632–1428

Energy Regulatory Commission
Office of Public Information
Energy Regulatory Commission
825 North Capitol Street, NE.
Washington, D.C. 20426
Telephone: 202–275–4006

Environmental Protection Agency
Office of Public Awareness
Environmental Protection Agency
401 M Street, SW.
Washington, D.C. 20460
Telephone: 202–755–0715

Federal Highway Administration
Office of Public Affairs
Federal Highway Administration
Room 4208
400 7th Street, SW.
Washington, D.C. 20590
Telephone: 202–426–0677

Aerial Surveys Branch
Highway Design Division
Room 3130A
400 7th Street, SW.
Washington, D.C. 20590
Telephone: 202–426–0296

Federal Insurance Administration
National Flood Insurance Program
P.O. Box 34294
Bethesda, Maryland 20034
Telephone: 800–424–8872
800–638–6620

Fish and Wildlife Service
Division of Realty
Fish and Wildlife Service
555 Matomic Building
1717 H Street, NW.
Washington, D.C. 20240
Telephone: 202–343–4676

Forest Service
Maps
California
Headquarters, California Region
U.S. Forest Service
630 Sansome Street
San Francisco, California 94111
Telephone: 415–556–7739

Oregon and Washington
Headquarters, Northwest Region
U.S. Forest Service
(319 SW. Pine Street)
P.O. Box 3623
Portland, Oregon 97208
Telephone: 503–221–3614

Forest Service—continued

Florida, Mississippi, North Carolina, Puerto Rico, and South Carolina
Headquarters, Southern Region
U.S. Forest Service
1720 Peachtree Road, NW.
Atlanta, Georgia 30309
Telephone: 404–526–3749

Michigan, Minnesota, and Wisconsin
Headquarters, Eastern Region
U.S. Forest Service
710 N. 6th Street
Milwaukee, Wisconsin 53203
Telephone: 414–224–3193

Alaska
Headquarters, Alaska Region
U.S. Forest Service
(Federal Office Building)
P.O. Box 1628
Juneau, Alaska 99801
Telephone: 907–586–7266

States not listed have no national forest lands within their coastal zone.

Aerial photographs
U.S. Forest Service
P.O. Box 2417
Washington, D.C. 20013
Telephone: 703–235–8638

Government Printing Office
Assistant Public Printer
(Superintendent of Documents)
U.S. Government Printing Office
N. Capitol and H Streets, NW.
Washington, D.C. 20402
Telephone: 202–275–3345

International Boundary Commission
U.S. Commissioner
International Boundary Commission
United States and Canada
United States Section
Room 150
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Washington, D.C. 20536
Telephone: 202–783–9151

International Boundary and Water Commission
U.S. Commissioner
International Boundary and Water Commission
United States and Mexico
United States Section
(4110 Rio Bravo, Executive Center)
P.O. Box 20003
El Paso, Texas 79998
Telephone: 915–543–7300

Library of Congress
Geography and Map Division
Library of Congress
845 S. Picket Street
Alexandria, Virginia 22304
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Mississippi River Commission
Executive Assistant
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(Mississippi River Commission Building)
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Vicksburg, Mississippi 39180
Telephone: 601–636–1311 x–201

National Aeronautics and Space Administration—Contact the facility office of the installation concerned.

National Archives and Records Service
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Environmental Data Service
National Oceanic and Atmospheric Administration
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Telephone: 704–258–2850

National Oceanographic Data Center
Environmental Data Service
National Oceanic and Atmospheric Administration
3300 Whitehaven Street, NW.
Washington, D.C. 20235
Telephone: 202–655–4000

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3100 Marine Avenue
Boulder, Colorado 80302
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National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
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National Oceanic and Atmospheric Administration
Riverdale, Maryland 20840
Telephone: 301–436–6990

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Washington Science Center
National Oceanic and Atmospheric Administration
Rockville, Maryland 20840
Telephone: 301–443–8031

National Oceanic and Atmospheric Administration—continued
National Ocean Survey—continued

Chart sales and geodetic data (limited area)

Alaska
Chart Sales and Control Data Office
National Ocean Survey
National Oceanic and Atmospheric Administration
652 6th Avenue
Anchorage, Alaska 99501
Telephone: 907-265-4476

Atlantic and Gulf Coasts
Atlantic Marine Center, CAM02
National Ocean Survey
National Oceanic and Atmospheric Administration
439 W. York Street
Norfolk, Virginia 23510
Telephone: 804-441-6686

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Pacific Marine Center
National Ocean Survey
National Oceanic and Atmospheric Administration
1801 Fairview Avenue, E.
Seattle, Washington 98102
Telephone: 206-442-7657

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National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301-443-8631

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National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301-443-8031

Tidal data
Oceanographic Division, C33
National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, Maryland 20852
Telephone: 301-443-8467

National Weather Service
National Climatic Center
National Weather Service
National Oceanic and Atmospheric Administration
Federal Building
Asheville, North Carolina 28801
Telephone: 704-258-2850

National Meteorological Center
National Weather Service
National Oceanic and Atmospheric Administration
5200 Auth Road
Camp Springs, Maryland 20233
Telephone: 301-763-8016

National Park Service
Office of Communications
National Park Service
3043 Interior Building
18th and C Street, NW.
Washington, D.C. 20240
Telephone: 202-343-6843

Soil Conservation Service
Cartographic Staff
Soil Conservation Service
Hyattsville, Maryland 20782
Telephone: 202-447-6923

State Geologic Agencies

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Geological Survey of Alabama
P.O. Drawer O
University, Alabama 35486
Telephone: 205-349-2852

Alaska
Division of Geological and Geophysical Sciences
Department of Natural Resources
3001 Porcupine Drive
Anchorage, Alaska 99504
Telephone: 927-586-6352

California
Division of Mines and Geology
California Department of Conservation
Room 1341
1416 9th Street
Sacramento, California 95814
Telephone: 916-445-1825

Connecticut
Natural Resource Center
Department of Environmental Protection
553 State Office Building
Hartford, Connecticut 06115
Telephone: 203-566-3540

Delaware
Delaware Geological Survey
University of Delaware
101 Penny Hall
Newark, Delaware 19711
Telephone: 302-738-2833

Florida
Bureau of Geology
Department of Natural Resources
903 W. Tennessee Street
Tallahassee, Florida 32304
Telephone: 904-488-4191

Georgia
Geologic and Water Resources Division
Georgia Department of Natural Resources
19 Martin Luther King, Jr., Drive, SW.
Atlanta, Georgia 30334
Telephone: 404-656-3214

State Geologic Agencies—continued

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Division of Water and Land Development
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809
Telephone: 808–548–2211

Illinois
Illinois State Geological Survey
Natural Resources Building
6th and Peabody
Urbana, Illinois 61801
Telephone: 217–344–1481

Indiana
Geological Survey
Department of Natural Resources
611 N. Walnut Grove
Bloomington, Indiana 47401
Telephone: 812–337–2862

Louisiana
Louisiana Geological Survey
Box G, University Station
Baton Rouge, Louisiana 70893
Telephone: 504–389–5812

Maine
Maine Geological Survey
Department of Conservation
Ray Building
Augusta, Maine 04330
Telephone: 207–289–2801

Maryland
Maryland Geological Survey
Merryman Hall
Johns Hopkins University
Baltimore, Maryland 21218
Telephone: 301–235–0771

Massachusetts
State Geologist
Room 532
100 Nashua Street
Boston, Massachusetts 02114
Telephone: 617–727–4793

Michigan
Geological Survey Division
Michigan Department of Natural Resources
Box 30028
Lansing, Michigan 48909
Telephone: 517–373–1256

Minnesota
Minnesota Geological Survey
University of Minnesota
1633 Eustis Street
St. Paul, Minnesota 55108
Telephone: 612–373–3372

State Geologic Agencies—continued

New Hampshire
Department of Geology
James Hall
University of New Hampshire
Durham, New Hampshire 03824
Telephone: 603–862–1216

New Jersey
New Jersey Bureau of Geology and Topography
Division of Natural Resources
(709 John Fitch Plaza)
P.O. Box 2809
Trenton, New Jersey 08625
Telephone: 609–292–2576

New York
Geological Survey
New York State Museum and Science Service
973 New York State Education Annex
Albany, New York 12224
Telephone: 518–474–5816

North Carolina
Office of Earth Resources
Department of Natural and Economic Resources
P.O. Box 27687
Raleigh, North Carolina 27611
Telephone: 919–733–3833

Ohio
Division of Geological Survey
Ohio Department of Natural Resources
Fountain Square
Columbus, Ohio 43224
Telephone: 614–466–5344

Oregon
State Department of Geology and Mineral Industries
1069 State Office Building
Portland, Oregon 97201
Telephone: 503–229–5580

Pennsylvania
Bureau of Topographic and Geological Survey
914 Executive House
Harrisburg, Pennsylvania 17101
Telephone: 717–787–2169

South Carolina
Division of Geology
South Carolina State Development Board
Harbison Forest Road
Columbia, South Carolina 29210
Telephone: 803–758–6431

Texas
Bureau of Economic Geology
University of Texas at Austin
University Station, Box X
Austin, Texas 78712
Telephone: 512–471–1534

State Geologic Agencies—continued

Virginia
Division of Mineral Resources
Department of Conservation and Economic Development
(Natural Resources Building)
P.O. Box 3667
Charlottesville, Virginia 22903
Telephone: 804–293–5121

Washington
Geologic and Earth Resources Division
Department of Natural Resources
Olympia, Washington 98504
Telephone: 206–753–5327

Wisconsin
Wisconsin Geological and Natural History Survey
University of Wisconsin
1815 University Avenue
Madison, Wisconsin 53706
Telephone: 608–262–1705

U.S. Army—Contact the commander of the base concerned.

U.S. Air Force—Contact the information officer of the base concerned.

U.S. Corps of Engineers

Minnesota, Wisconsin (Lake Superior), and Michigan (western half of Upper Peninsula)
U.S. Army Engineer District, St. Paul
1135 U.S. Post Office and Customs House
St. Paul, Minnesota 55101
Telephone: 612–725–7501

Michigan (excluding western half of Upper Peninsula), and Toledo, Ohio, area
U.S. Army Engineer District, Detroit
(477 Michigan Avenue)
P.O. Box 1027
Detroit, Michigan 48231
Telephone: 313–226–6762

Ohio (excluding Toledo area), Pennsylvania, and western New York
U.S. Army Engineer District, Buffalo
1776 Niagara Street
Buffalo, New York 14207
Telephone: 716–876–5454

Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut
U.S. Army Engineer Division, New England
424 Trapelo Road
Waltham, Massachusetts 02154
Telephone: 617–894–2400

Long Island, New York City area, and northern New Jersey
U.S. Army Engineer District, New York
26 Federal Plaza
New York, New York 10007
Telephone: 212–264–0100

U.S. Corps of Engineers—continued

Southern New Jersey and Delaware
U.S. Army Engineer District, Philadelphia
U.S. Customs House
2d and Chestnut Street
Philadelphia, Pennsylvania 19106
Telephone: 215–597–4848

Maryland
U.S. Army Engineer District, Baltimore
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P.O. Box 1715
Baltimore, Maryland 21203
Telephone: 301–962–4545

Virginia
U.S. Army Engineer District, Norfolk
803 Front Street
Norfolk, Virginia 23510
Telephone: 804–446–3500

North Carolina
U.S. Army Engineer District, Wilmington
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P.O. Box 1890
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South Carolina (Savannah River Basin excluded)
U.S. Army Engineer District, Charleston
(Federal Building, 334 Meeting Street)
P.O. Box 919
Charleston, South Carolina 29402
Telephone: 803–577–4171

Georgia and Savannah River Basin of South Carolina
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P.O. Box 889
Savannah, Georgia 31402
Telephone: 912–233–8822

Florida Peninsula and Puerto Rico
U.S. Army Engineer District, Jacksonville
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P.O. Box 4970
Jacksonville, Florida 32201
Telephone: 904–791–2241

Mississippi, Alabama, and Florida Panhandle
U.S. Army Engineer District, Mobile
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Mobile, Alabama 36628
Telephone: 205–690–2511

Louisiana
U.S. Army Engineer District, New Orleans
(Foot of Prytania Street)
P.O. Box 60267
New Orleans, Louisiana 70160
Telephone: 504–865–1121

Texas
U.S. Army Engineer District, Galveston
(155A Essayons Building)
(400 Barracuda Avenue)
P.O. Box 1229
Galveston, Texas 77550
Telephone: 713–763–1211

U.S. Corps of Engineers—continued

Southern California
U.S. Army Engineer District, Los Angeles
(300 N. Los Angeles Street)
P.O. Box 2711
Los Angeles, California 90053
Telephone: 213–688–5300

Northern and Central California
U.S. Army Engineer District, San Francisco
100 McAllister Street
San Francisco, California 94102
Telephone: 415–556–3660

Oregon and Columbia River Basin of Washington
U.S. Army Engineer District, Portland
(2850 SE. 82d Avenue)
P.O. Box 2946
Portland, Oregon 97208
Telephone: 503–777–4441

Washington (Columbia River Basin excluded)
U.S. Army Engineer District, Seattle
4735 E. Marginal Way S.
Seattle, Washington 98134
Telephone: 206–764–3690

Alaska
U.S. Army Engineer District, Alaska
(Building 21-700)
(Elmendorf Air Force Base)
P.O. Box 7002
Anchorage, Alaska 99510
Telephone: 907–752–9114

Hawaii, American Samoa, and Guam
U.S. Army Engineer Division, Pacific Ocean
(Building 230)
(Fort Shafter, Hawaii)
APO San Francisco 96558
Telephone: 808–422–2711 or 471–7411

U.S. Coast Guard
Oceanographic Unit
U.S. Coast Guard
Building 159E, Washington Navy Yard Annex
Washington, D.C. 20390
Telephone: 202–426–4630

U.S. Geological Survey

Maps by mail

Alaska
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U.S. Geological Survey
101 12th Avenue
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Telephone: 907-456-7535

States east of Mississippi River plus Puerto Rico
Branch of Distribution, Eastern Region
Publications Division
U.S. Geological Survey
1200 South Eads Street
Arlington, Virginia 22202
Telephone: 703–557–2781

U.S. Geological Survey—continued

States west of Mississippi River plus Hawaii, Guam, and American Samoa
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MS 306, Box 25286
Denver Federal Center
Denver, Colorado 80225
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Alaska (selected)
Public Inquiries Office
Publications Division
U.S. Geological Survey
1012 Federal Building
1961 Stout Street
Denver, Colorado 80202
Telephone: 303–837–4169

Alaska, California, Washington, Oregon, and Hawaii
Public Inquiries Office
Publications Division
U.S. Geological Survey
7638 Federal Building
300 N. Los Angeles Street
Los Angeles, California 90012
Telephone: 213–688–2850

Public Inquiries Office
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U.S. Geological Survey
504 Custom House
555 Battery Street
San Francisco, California 94111
Telephone: 415–556–5627

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678 U.S. Court House
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Spokane, Washington 99201
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Public Inquiries Office
Publications Division
U.S. Geological Survey
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1100 Commerce Street
Dallas, Texas 75202
Telephone: 214–749–3230

U.S. Geological Survey—continued

Entire coastal zone
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U.S. Geological Survey
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19th and F Streets, NW.
Washington, D.C. 20242
Telephone: 202–343–8073

Public Inquiries Office
Publications Division
U.S. Geological Survey
National Center, Room 1C402
Reston, Virginia 22092
Telephone: 703–860–6167

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Telephone: 605–594–6511

Maps, aerial photographs, and control data
Alaska and Texas
National Cartographic Information Center
Rocky Mountain Mapping Center
MS 510, Box 25046
Denver Federal Center
Denver, Colorado 80225
Telephone: 303–234–2326

U.S. Geological Survey—continued

Atlantic Coast States plus Alabama, Indiana, Pennsylvania, Ohio, Puerto Rico, and the Virgin Islands
National Cartographic Information Center
Eastern Mapping Center
U.S. Geological Survey
MS 536, National Center
Reston, Virginia 22092
Telephone: 703–860–6316

Illinois, Louisiana, Michigan, Minnesota, Mississippi, and Wisconsin
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Mid-Continent Mapping Center
U.S. Geological Survey
1400 Independence Road
Rolla, Missouri 65401
Telephone: 314–364–3680 x42

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Western Mapping Center
U.S. Geological Survey
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Menlo Park, California 94075
Telephone: 415–323–2427

All cartographic data
User Services Section
National Cartographic Information Center
U.S. Geological Survey
MS 507, National Center
(12201 Sunrise Valley Drive)
Reston, Virginia 22092
Telephone: 703–860–6045

U.S. Navy and Marines Corps—Contact the commander of the base concerned.

TECHNICAL INFORMATION

DATUMS

A datum is any numerical or geometrical quantity or set of quantities that serves as a reference or base for other quantities. In surveying, mapping, and charting, datums are essential for correlation of measurements and for determining and portraying relative positions and elevations (or other characteristics) of points at different locations.

The two basic types of survey datums are horizontal and vertical. A datum is defined by quantities (for example, position, elevation, direction, a reference surface) at an initial point from which measurements are made to other points. The reference surface, particularly for the horizontal datum, usually is not the physical surface of the Earth but some easily defined mathematical surface such as an ellipsoid.

HORIZONTAL DATUMS

A horizontal datum is defined by five quantities: the latitude and longitude of an initial point; the azimuth of a line from that point; and two constants that define the reference ellipsoid most nearly approximating the Earth in the area of interest. In the conterminous United States and Alaska, the current horizontal datum is the North American Datum (NAD) of 1927; its reference surface is the Clarke Spheroid of 1866. The following datums are used for the State of Hawaii and for the Territories, all on the Clarke Spheroid of 1866:

Area	*Datum*
Hawaii	Old Hawaiian Datum.
Puerto Rico	Puerto Rico Datum.
Virgin Islands	Puerto Rico Datum.
Guam	Guam Datum of 1963.
American Samoa	American Samoa Datum of 1962.
Other Pacific Islands	Various datums.

From measurements of distances and directions from the initial (or subsequent) points and subsequent computations, positions (latitude, longitude) and distances can be determined for any number of other points on the same datum, tying them into a unified survey.

VERTICAL DATUMS

A vertical datum is the surface to which heights, elevations, or depths are referred. It can be a leveling datum, a tidal datum, a chart datum, or a geodetic vertical datum.

Tidal datums

The simplest datum is the tidal datum—a base elevation defined by a certain phase of the tide (fig. 1) and used as a reference from which local heights and depths are reckoned. Local datums should not be extended into adjacent areas where a different tidal regime may exist. Mean high water, mean low water, and mean lower low water (fig. 2), are the tidal datums most significant to mapping and charting in the coastal zone. Local mean sea level (that is, mean sea level at a tide station) is the basic tidal datum for a harmonic analysis of observations at that station. It does not have a direct relationship to either charting or mapping. Half-tide level (fig. 3) is halfway between mean high water and mean low water and is computed for each tidal station. However, it also has no direct effect on mapping and charting. Mean sea level and half-tide level may be equal or may differ depending on the tidal characteristics at the specific location.

International Great Lakes Datum

The International Great Lakes Datum (IGLD) of 1955, established jointly with Canada, is the basic level datum for charting water depths of the Great Lakes and connecting waterways. The datum is used by NOS and the Corps of Engineers in Great Lakes operations that require a vertical datum. Although some bench marks are common to the IGLD of 1955 and the National Geodetic Vertical Datum (NGVD) of 1929, the two datums are not the same and cannot be converted mathematically.

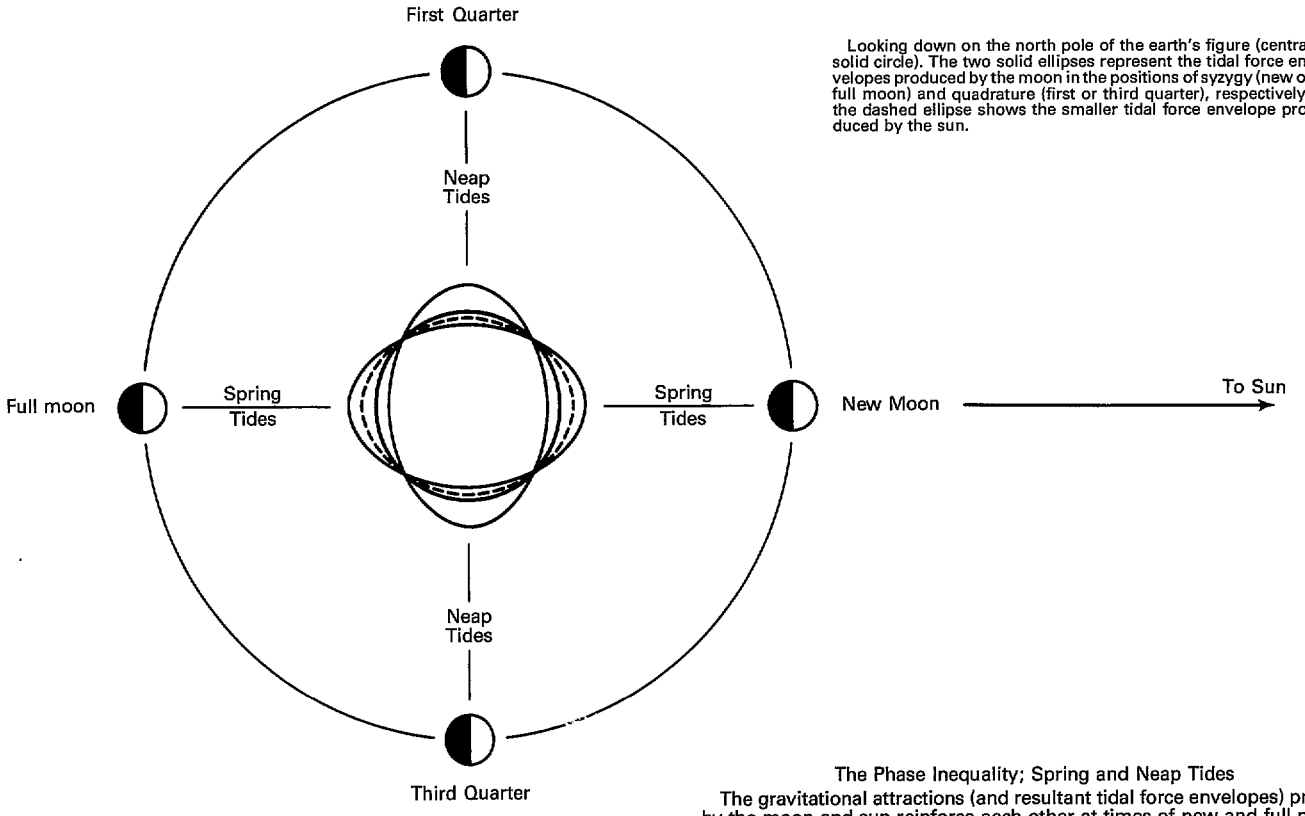


FIGURE 1.—Solar and lunar tide-producing forces.

Chart Datum

The surface to which depths are referred on bathymetric maps and nautical charts is called a chart datum. It is a tidal datum in tidal waters, mean low water in the Atlantic Ocean and the Gulf of Mexico, and mean lower low water in the Pacific and Arctic Oceans. Special datums sometimes are used for a body of coastal water where tidal characteristics are significantly altered by the physiography of the basin; each is generally based on a selected tidal datum. Chart datums for the Great Lakes are low lake levels, defined as elevations referred to the IGLD of 1955 as determined from water level observations at selected gaging stations. Sloping datums are necessary for some connecting waterways because of the natural gradient of the waterway bed.

Soundings, or measurements of water depth, made during bathymetric and hydrographic surveys, must be referred to the appropriate vertical datum. The preferred datum, especially in hydrographic surveying, is the chart datum. However, because the tide observations for establishing the datum are made during the course of the survey and several weeks are needed to establish the various datums at a tide station, the hydrographer usually refers his observations to a temporary sounding datum that is corrected to the final datum before map or chart production.

National Geodetic Vertical Datum

The National Geodetic Vertical Datum (NGVD) of 1929 (formerly called the Sea Level Datum of 1929) covers too large an area to be based on a single local tidal datum. It is therefore based on, but not necessarily equal to, mean sea level at 26 tide stations in the United States and Canada, with the best fit over a broad area resulting from the 1929 general adjustment of the United States and Canadian leveling networks. The NGVD of 1929 and local mean sea level cannot be interchanged because their relationship varies from place to place. All elevations in the National Vertical Control Network are referred to the NGVD of 1929. These elevations are

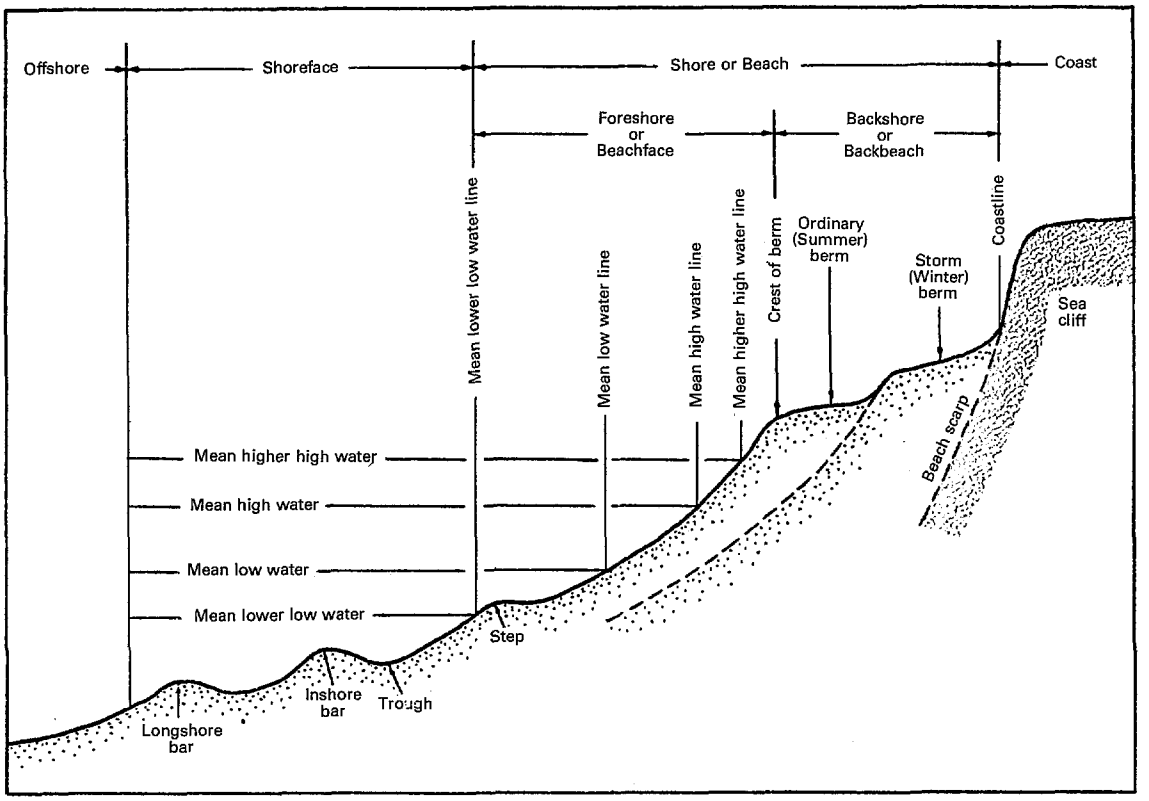


FIGURE 2.—Tidal datums and their relations to a generalized shore cross section. Figure 4 shows the tidal heights in relation to a tidal day.

used in topographic mapping, geodesy, engineering studies, construction work, and similar activities. The elevations are not applied directly to mapping boundaries that depend on a tidal datum (in tidal waters) or on a lake level (in the Great Lakes region). Both the NGVD of 1929 and the National Vertical Control Network are used in the conterminous United States and part of Alaska. Other geodetic vertical datums are used in Alaska, Puerto Rico, the Virgin Islands, Hawaii, Guam, other oceanic islands, and islands fairly near the mainland that cannot be connected to the NGVD by leveling. They are based on tidal datums (usually local mean sea level) where practical.

TIDAL DATUMS AND LOCAL MARINE BOUNDARIES

The mean high water line forms the boundary between sovereign and private property in 14 of the 24 States bordering tidal waters. It is shown as the shoreline on USGS topographic maps and NOS nautical charts. However, publication scales of those products are generally too small for them to be of practical benefit to boundary affairs in the coastal zone. Furthermore, tidal datums at many places were established for hydrographic surveys and may not be adequate for precise boundary applications.

In seven of the ten exceptions noted above, the boundary between sovereign and private property is the mean low water line. That line is compiled on NOS nautical charts when scale permits. Except on the 1:10,000-scale NOS boundary series (app. 7, fig. 22) it is not compiled on most small-scale charts or on any topographic maps published by USGS.

Anyone concerned with local boundaries based on tidal datums should assure himself that the maps and tidal datums he is using, or intends to use, are adeqate for the purpose. Advice, assistance, and products can be obtained from:

Oceanographic Division, C-33
National Ocean Survey
National Oceanic and Atmospheric Administration
6001 Executive Boulevard
Rockville, Maryland 20852
Telephone: 301-443-8274

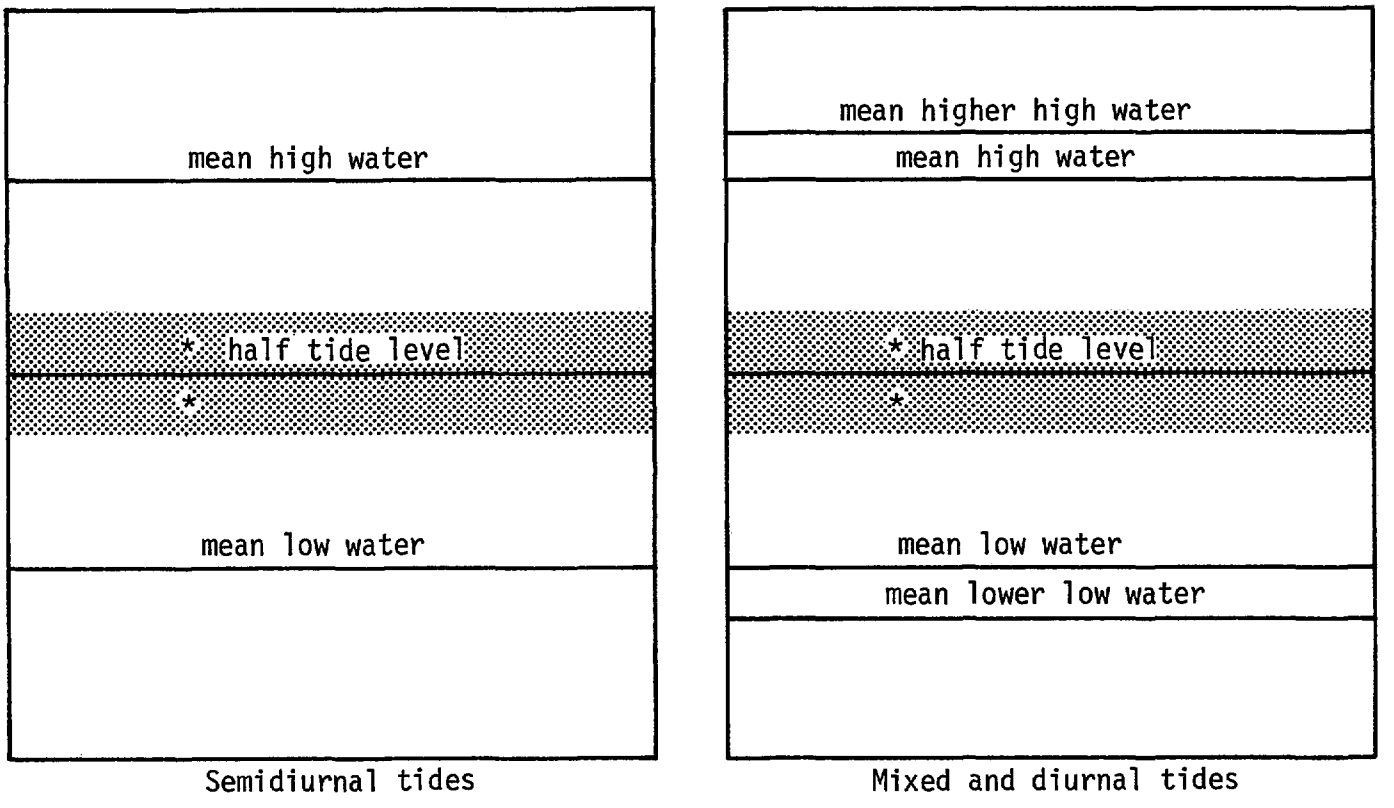


FIGURE 3.—Interrelations of tidal datums. Mean sea level may coincide with half tide level, but seldom does; the variation (represented by the dot pattern) is generally about 3 cm (0.1 ft) and rarely exceeds 6 cm (0.2 ft).

LAKE LEVELS AND RELATED LOCAL BOUNDARIES

The Great Lakes States have selected several ways to define the boundary between public trust waters and private property. Some States use the ordinary (mean) high water mark, others use a line which fluctuates with the lake level, and still others use a specific lake level. Except on Lake Michigan, the States have proprietary interest in the waters of the Great Lakes lying between the appropriate State-private line and the boundary between the United States and Canada, subject to the interest of the general public (including Canada and other foreign nations) in navigation and access. The boundary between Michigan and Illinois and Wisconsin follows a large part of the approximate centerline of Lake Michigan. The States retain the right to control or limit access to natural resources in and under the water outside the line chosen to represent the State-private boundary.

Since there is no measurable rise and fall of tide in the Great Lakes, it is not relevant to attempt to determine the ordinary high water mark by analysis of water level gage records for diurnal or semidiurnal effects.

The height of water levels in the Great Lakes varies in an irregular and apparently noncyclical pattern due to meterological conditions (rainfall and snowfall) in the upper watershed areas. There is no predictable cycle, but the variation is predominantly annual. Thus to determine the ordinary high water mark requires resolution and interpretation of water level gage recordings over many years.

Advice, assistance, and products relative to the heights of the water surfaces of the Great Lakes can be obtained from:

Tides and Water Levels Branch
National Ocean Survey
National Oceanic and Atmospheric Administration
6001 Executive Boulevard
Rockville, Maryland 20852
Telephone: 301-443-8441

CONTROL SURVEYS

Control, in general, consists of coordinated and correlated elevation or position data that form a framework to which detailed surveys are adjusted. Basic control is horizontal, vertical, or both, and is usually established with greater precision and accuracy than subsequent dependent surveys. Both horizontal and vertical control are fundamental to mapping and charting. Except for operations directly referenced to tidal datums, both horizontal and vertical control for coastal mapping must be established by geodetic methods.

The two basic geodetic control networks in the United States are the National Horizontal Control Network and the National Vertical Control Network established and maintained by the National Geodetic Survey, NOS. Other Federal agencies such as USGS, Bureau of Reclamation, and U.S. Army Corps of Engineers (USCE), as well as many State agencies, establish geodetic control. For surveys of second or higher order accuracy, the instruments, methods, and techniques must meet the criteria set by NGS, and the records and observations acquired by the establishing agency are accepted by NGS and adjusted to the national network. The National Horizontal Control Network covers the conterminous United States and Alaska; independent networks cover Hawaii and the oceanic islands. The National Vertical Control Network covers the conterminous United States and part of Alaska; independent networks cover the rest of Alaska, Hawaii, and the oceanic islands.

HORIZONTAL CONTROL

Horizontal control makes it possible for cartographers to orient and scale their maps accurately, to position them properly on the Earth, and to compile details in correct positions and relations. The network maintained by NGS usually provides control sufficient for mapping and charting. The few gaps in the basic schemes can normally be bridged with modern photogrammetric techniques to avoid the expense of field geodetic surveys.

VERTICAL CONTROL

The first operational use of vertical control for coastal mapping is in photogrammetric aerotriangulation—a phase that does not necessarily require a vertical geodetic datum. Planimetric mapping can proceed with reference only to the horizontal geodetic datum. However, if relief is to be shown on the maps (that is, topographic maps) then a common vertical datum must be used. In the conterminous United States, the NGVD of 1929 is the vertical datum most suitable for showing relief. Local datums are used in Hawaii, the Pacific islands, Puerto Rico, the Virgin Islands, and parts of Alaska because the NGVD of 1929 does not extend to them. Each local datum is based on tidal datums established at selected tide stations and is specified in the geodetic control data provided for each of these areas.

OTHER CONTROL

The vertical control of greatest significance to coastal mapping is provided by tidal observations. The datum computed from the observation depends on tidal characteristics (fig. 4). In general, the tide along the Atlantic Coast is classified as semidiurnal (two nearly equal high waters and two nearly equal low waters each day). The elevations of tidal bench marks refer to mean low water. In addition, data are provided for mean high water, half tide level, mean sea level, and mean low water. In the Gulf of Mexico and the Pacific Ocean the tide is classified either as diurnal (one high water and one low water each day) or as mixed. The mixed tide is similar to the semidiurnal tide except that there is a marked difference in the height of the two high waters and (or) in the height of the two low waters each day (called diurnal inequality).

Tidal bench marks along the Gulf Coast refer to mean low water and those along the Pacific Coast refer to mean lower low water. For many tide stations in the Gulf of Mexico, along the Pacific Coast, Alaska, Hawaii, and the Pacific islands, data are also provided for mean higher high water, mean high water, half tide level, mean sea level, mean low water, and mean lower low water. Mean sea level at any point is simply the mean level of the sea at that point. Technically, it is the arithmetic mean of hourly water elevations observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). Mean sea level is the primary tidal datum. All other tidal datums are derived from various tide stages, but are referenced to mean sea level. Local mean sea level is not generally valid elsewhere and should not be confused with the NGVD of 1929 which is an average of numerous local stations.

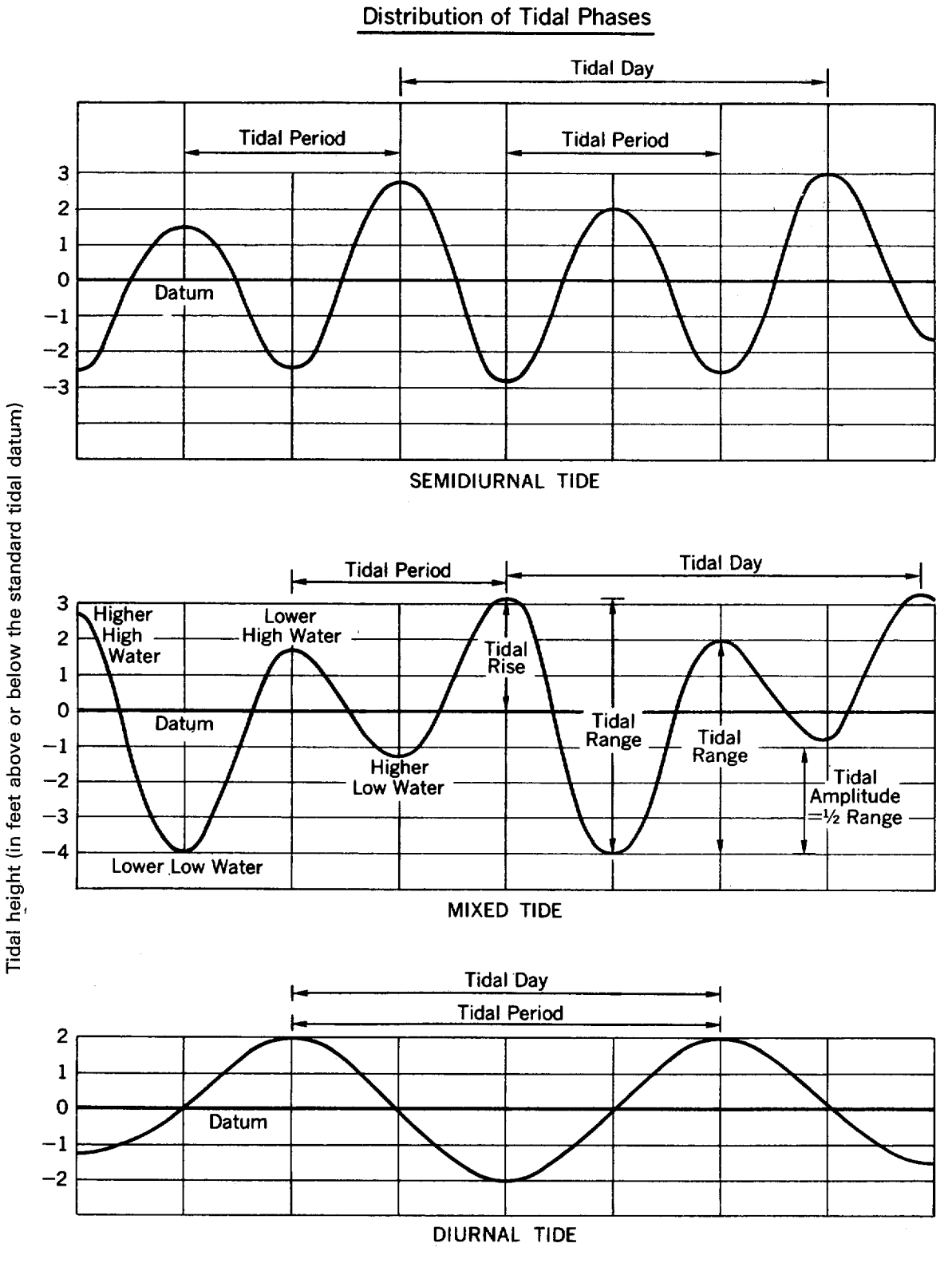


FIGURE 4.—Distribution of tidal phases of diurnal, semidiurnal, and mixed tides.

MAP PROJECTIONS AND GRID SYSTEMS

Most maps are printed on paper or other flat surface. Since the Earth is nearly spherical, it is impossible to represent its features on a plane without introducing distortions. The method by which the information is transferred determines the nature of the map projection, which is geometrically defined on the map by the graticule, representing parallels of latitude and meridians of longitude.

The Greek astronomer, Hipparchus, is credited with superimposing on the Earth the system of parallels and meridians to provide the means by which the locations of features can be stated uniquely. Since only one meridian and one parallel can be drawn through a given point, the intersection of a meridian and a parallel defines a single location. When meridians and parallels are represented on a flat surface by means of a projection, points on the Earth can be represented uniquely on that surface to form a map.

PROPERTIES OF PROJECTIONS

All maps contain distortions inherent in their particular projections. These distortions affect the portrayal of area, shape, direction, and distance. Projections can be selected to eliminate or minimize one or more of the distortions at the expense of others, or to partially control several and thereby minimize the general distortion.

Some projections maintain a constant areal scale. In simple terms this means that an object, such as a coin, placed on a map covers the same amount of geographical area wherever it is placed. Such projections are termed "equal-area" and are used when measurements or comparisons of areas are of primary importance. To achieve equal-area properties (equivalency) a projection must distort shapes and angles.

In contrast, a projection that retains shapes and angles is called conformal and cannot be equal-area. Conformal projections show small areas, such as lakes and ponds, with the same shapes as they have on the globe. To do so, the parallels and meridians must meet at right angles, and the local scale around any point must not vary. Most modern maps, particularly at larger scales, are constructed on conformal projections because of the importance of true shape and direction.

All projections have lines along which distances are shown correctly. They are called standard lines and are usually selected meridians or parallels. Certain projections show true distances from a selected point and are termed equidistant.

Most directions between points on the Earth are correctly shown on all conformal projections, but the longest distances are less accurately represented. When exact directions from a specific point are needed, azimuthal (zenithal) projections are used.

DEVELOPABLE SURFACES

The term projection can be explained by the concept of a point light source shining through a model of the Earth causing the graticule to cast its shadow on an object. The object can be any number of geometric surfaces, but the most commonly used are the cone and its limiting shapes, the plane (cone with an altitude of 0 (zero) and an apex of 180°) and the cylinder (cone with an altitude of infinity and an apex angle of 0°). Both the cone and the cylinder can be flattened to a plane without further distortions and thus are known as developable surfaces.

Conic projections are transferred to an imaginary cone placed over the Earth, sometimes obliquely but usually so their axes coincide. The side of the cone can be tangent to the Earth along a selected parallel of latitude or can intersect the Earth along two parallels. Parallels of tangency and secancy are called standard parallels and maintain a constant scale. Distortions increase away from the standard parallels.

Azimuthal projections are transferred to a plane that is intersecting the Earth, tangent to it, or neither. The perspective center (light source) of the projection can be at the center of the Earth, on the surface, somewhere between, or at a point in space.

Cylindrical projections are transferred to an imaginary cylinder placed tangent to or intersecting the Earth. The lines of tangency can be standard parallels, standard meridians, or any selected great circle (a circle whose center lies at the center of the Earth and whose diameter equals that of the Earth). Lines of intersection (secancy) are standard lines and need not coincide with lines of the graticule.

Variations in projections also occur with changes in the orientation of the developable surface with respect to the Earth's axis. The orientation of a plane can be polar (perpendicular to the axis and centered at a Pole), equatorial (parallel to the axis and centered at a point on the Equator), or oblique (intersecting the axis at an acute angle). Likewise,

the axis of a cylinder can be coincident with, perpendicular to, or oblique from the Earth's axis. Generally, a cone's axis coincides with that of the Earth.

Another fundamental of projections is the method of transfer (projection) from the Earth's surface. Transfer by extending rays from the perspective center is a simple geometric projection in which rays connect the Earth's surface features to the projection surface. However, most map projections are mathematically transformed and are not defined geometrically. The mathematical transformation is defined to provide the specific property sought, such as conformality or equivalency.

Thus, a given projection involves three basic considerations, (1) selection of a developable surface, (2) orientation of the surface to the Earth's axis, and (3) a transformation (usually mathematical) by which the Earth's surface features are transferred to the projection surface. The projection surface is then developed into a plane, resulting in a map with defined geometric characteristics.

COMMONLY USED PROJECTIONS

Map projections are too numerous to give descriptions of all of them here. Therefore, only a few of the projections more commonly used by engineers are discussed. Many other projections are available for particular uses, especially in small-scale mapping. A number are described by Dietz and Adams (1944).

Lambert Conformal Conic Projection

The Lambert conformal conic projection was devised in 1772 by Johann Heinrich Lambert. It assumes a cone intersecting (secant to) the Earth along two standard parallels (fig. 5) passing through the mapped area. The axis of the cone coincides with the Earth's axis.

Scale is correct along both standard parallels, too small between them, and too large beyond them. The distortions grow as one moves away from the standard parallels. Because scale is correct along two parallels, the Lambert projection is often preferred to the simple conic projection with only one standard parallel.

Because of the north-south distortions, this projection is most suitable for mapping areas that are elongated east-west. It is used for the 1:1,000,000-scale world aeronautical charts, the 1:500,000-scale sectional aeronautical charts, the 1:500,000-scale State base maps, and the 1:24,000-scale 7.5-min topographic quadrangles that lie in zones where the Lambert projection is the base for the State plane coordinate system.

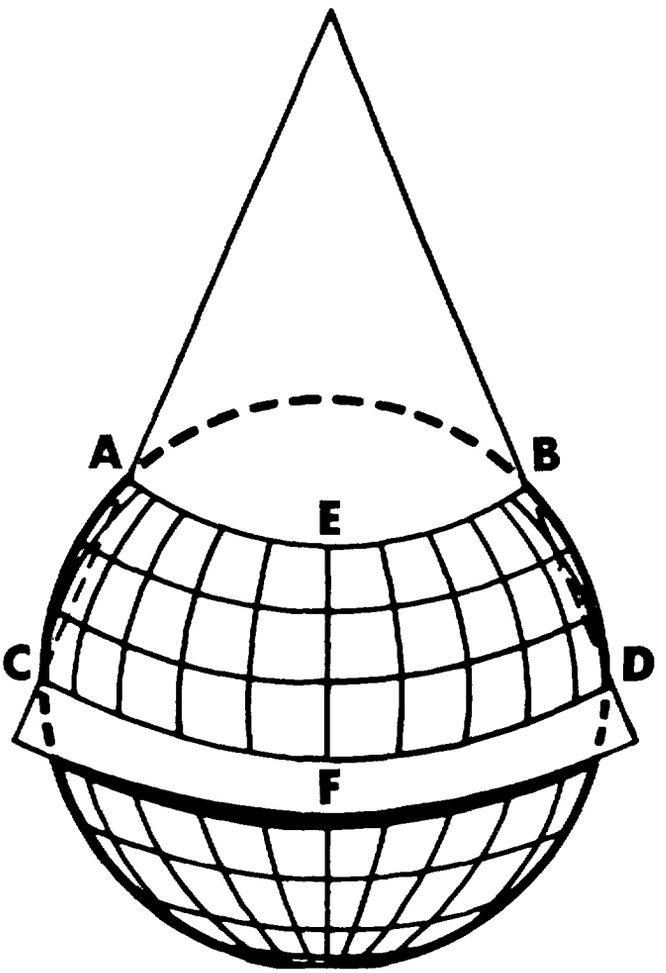


FIGURE 5.—Lambert conformal conic projection; a secant cone having two standard parallels, lines AEB and CFD. Line EF is the central meridian.

Polyconic Projection

The polyconic projection (fig. 6) was devised by Ferdinand Hassler, the first superintendent of the U.S. Coast Survey (later U.S. Coast and Geodetic Survey, now NOS). It projects the Earth's surface on a series of cones, each tangent to the Earth along a different selected parallel of latitude. Scale is correct along each standard parallel and along the central meridian, but not elsewhere.

The principal virtue of the polyconic projection is that it is easy to construct and plot by hand on map

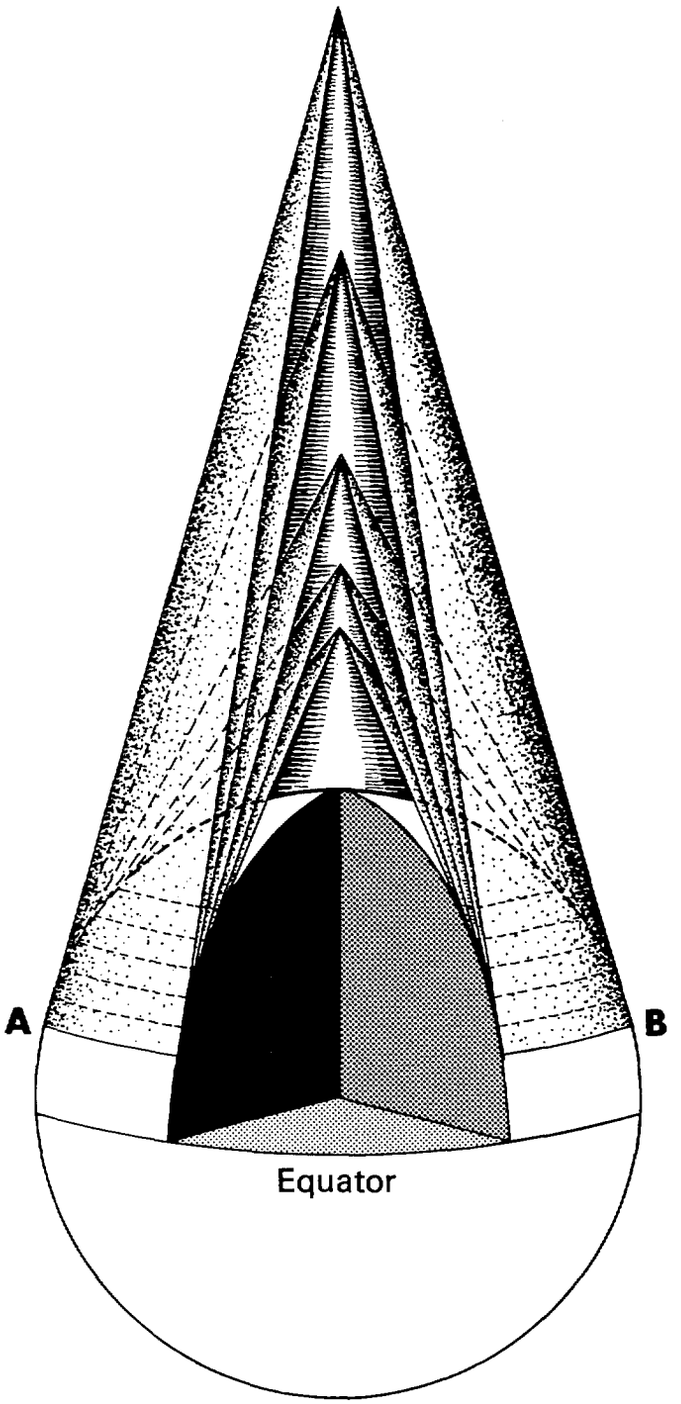


FIGURE 6—Polyconic projection uses a series of cones on identical axes. Line AB is the standard parallel for the largest cone shown; dashed lines parallel to AB are standard parallels for other cones.

base sheets. Also, it minimizes the effects of all distortions over a limited area. For this reason it is suitable for large-scale sectional maps such as quadrangle maps. Because of the small distortion of polyconic projections, the State plane coordinate grids can be superimposed on them without significant error. Although it has minimal distortion over small areas, the polyconic projection is neither conformal nor equal-area.

The polyconic projection was widely used as the standard for medium- and large-scale maps of the United States. USGS used the projection for quadrangle maps until the 1950's when rectangular coordinate plotters were adopted for plotting base sheets.

Mercator Projection

The Mercator projection takes its name from the Latin surname of Gerhard Kramer, who devised it. The projection first appeared in 1569 when Mercator published a map of the world.

The Earth's surface is projected on a cylinder tangent at the Equator or secant along two parallels with its axis coincident with the Earth's axis (fig. 7), then the cylinder is cut and unrolled to a flat surface.

The Mercator projection is conformal. All meridians are straight parallel lines uniformly spaced. Lines of latitude are also straight and parallel and are perpendicular to the meridians, but are not uniformly spaced. Scale is correct at the Equator, but increases rapidly with latitude.

The original Mercator map became the prototype for nautical charts. The projection is particularly

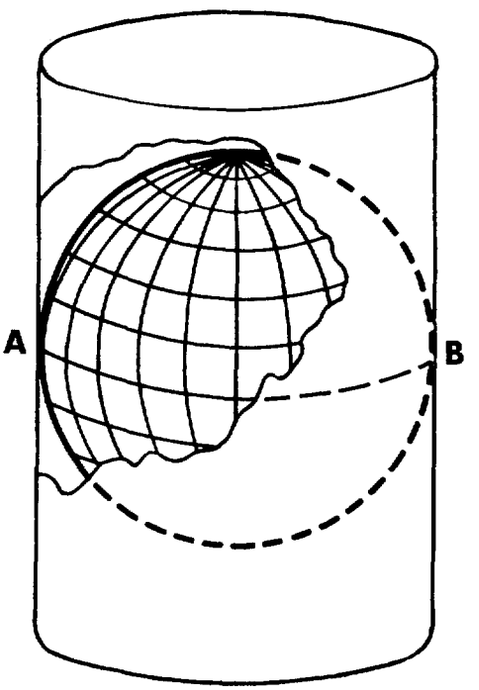


FIGURE 7.—Mercator projection using a cylinder tangent at the Equator, line AB.

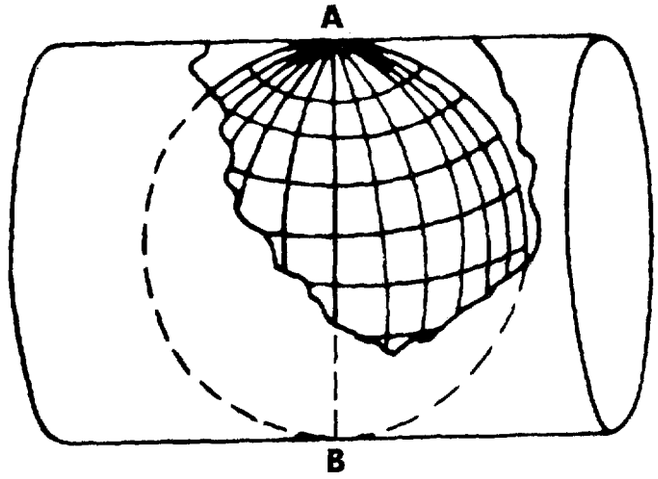


FIGURE 8.—Transverse Mercator projection using a cylinder tangent at a standard meridian, line AB.

suitable for navigation because lines of fixed azimuth (rhumb lines) form straight lines. Most of the nautical charts issued by NOS are on the Mercator projection.

Transverse Mercator Projection

The transverse Mercator projection (fig. 8), originally devised by Lambert, is essentially the standard Mercator rotated through 90°. However, its appearance, characteristics, and use are quite different. The curved surface of the Earth is projected to a cylinder that is tangent along a central meridian or usually secant along small circles parallel to and equidistant from the central meridian. The cylinder is then cut and unrolled to a plane.

Scale is correct along the central meridian when a tangent cylinder is used, but increases rapidly east or west. Except for the central meridian, all meridians and parallels are curved lines. Because the greatest distortions increase to the east and west, the projection is suitable for mapping areas that are elongated north-south.

The transverse Mercator projection is used for large-scale mapping throughout the world (in Europe it is sometimes called the Gauss-Kruger projection). Many USGS 7.5-min quadrangle maps are cast on it. A special use of this projection is as the basis for the Universal Transverse Mercator (UTM) grid, discussed later.

Combination Projections

When the size or shape of an area is not ideally suited to the characteristics of a particular projection that might otherwise be desirable, the area can be divided into sections or zones, each to be mapped on its own projection. If an area is too large to be mapped on a single sheet at the desired scale, the projection can be designed for the entire area or zone, and each sheet mapped as part of the comprehensive projection.

GRID SYSTEMS

It is difficult to measure the relations between points referenced to the graticule because on most projections parallels or meridians are curved. Running plane land surveys with geographic coordinates would require complex computations. Using plane rectangular grids alleviates the probem.

Plane rectangular grids are constructed as two sets of straight parallel lines that intersect each other at right angles to form squares. A grid is superimposed on the graticule of a projection in such a way that there is a precise mathematical relationship between the grid lines and the graticule. Then every grid intersection has a unique relationship to every graticule intersection, and every point on the map (or on the Earth) has a unique latitude and longitude plus a unique location expressed in values of x and y on the selected grid. Thus, coordinates and other relations in one system can be easily converted mathematically to the other. Grid systems greatly simplify the use of maps and reduce computations of distances, directions, coordinates, and areas to the realm of plane trigonometry. Nevertheless, the grids are subject to the same distortions as projections.

State Plane Coordinate Systems

Most modern large-scale maps show the State plane coordinate grid in addition to the graticule. There is a plane coordinate system for each of the 50 States and for the oceanic islands. All the systems are presently expressed in feet, except the metric grid for Guam. However, USGS maps of Puerto Rico show plane coordinates in meters. NOS publishes tables for converting positions between geographic and plane coordinates for the 50 States plus Puerto Rico and the Virgin Islands, but not Guam.

Zones in which the longer dimension is north-south have a grid based on the transverse Mercator projection. Those in which the longer dimension is east-west have a grid based on the Lambert conformal conic projection. Table 2 lists the zones and

TABLE 2.—*Plane coordinate systems in coastal States*

State and Zone	Grid
Alabama	
East	Tr. Merc.
West	Tr. Merc.
Alaska	
Zone 1	Oblique Merc.
Zone 2	Tr. Merc.
Zone 3	Tr. Merc.
Zone 4	Tr. Merc.
Zone 5	Tr. Merc.
Zone 6	Tr. Merc.
Zone 7	Tr. Merc.
Zone 8	Tr. Merc.
Zone 9	Tr. Merc.
Zone 10	Lambert
California	
Zone 1	Lambert
Zone 2	Lambert
Zone 3	Lambert
Zone 4	Lambert
Zone 5	Lambert
Zone 6	Lambert
Zone 7	Lambert
Connecticut	Lambert
Delaware	Tr. Merc.
Florida	
East	Tr. Merc.
West	Tr. Merc.
North	Lambert
Georgia	
East	Tr. Merc.
West	Tr. Merc.
Hawaii	
Zone 1	Tr. Merc.
Zone 2	Tr. Merc.
Zone 3	Tr. Merc.
Zone 4	Tr. Merc.
Zone 5	Tr. Merc.
Illinois	
East	Tr. Merc.
West	Tr. Merc.
Indiana	
East	Tr. Merc.
West	Tr. Merc.
Louisiana	
North	Lambert
South	Lambert
Maine	
East	Tr. Merc.
West	Tr. Merc.
Maryland	Lambert
Massachusetts	
Mainland	Lambert
Island	Lambert
Michigan [1]	
North	Lambert
Central	Lambert
South	Lambert
Minnesota	
North	Lambert
Central	Lambert
South	Lambert
Mississippi	
East	Tr. Merc.
West	Tr. Merc.
New Hampshire	Tr. Merc.
New Jersey	Tr. Merc.
New York	
Long Island	Lambert
East	Tr. Merc.
Central	Tr. Merc.
West	Tr. Merc.
North Carolina	Lambert
Ohio	
North	Lambert
South	Lambert
Oregon	
North	Lambert
South	Lambert
Pennsylvania	
North	Lambert
South	Lambert
Rhode Island	Tr. Merc.
South Carolina	
North	Lambert
South	Lambert
Texas	
North	Lambert
North Central	Lambert
Central	Lambert
South Central	Lambert
South	Lambert
Virginia	
North	Lambert
South	Lambert
Washington	
North	Lambert
South	Lambert
Wisconsin	
North	Lambert
Central	Lambert
South	Lambert

[1] Coordinates in Michigan are also referenced to the transverse Mercator projection with east, central, and west zones, but this system will be dropped with adoption of the North American Datum of 1983 in favor of the State-legislated Lambert system.

projections for coastal States. Most zones within a single State are based on the same projection, but Alaska, Florida, and New York have zones on both projections. Alaska has 10 zones: zone 1 in southeast Alaska is on an oblique Mercator projection; zone 2 through 9 are on the transverse Mercator projection; and zone 10 in the Aleutian Islands is on the Lambert projection.

Universal Transverse Mercator Grid

The Universal Transverse Mercator (UTM) grid is designed for world use between 84° N. and 80° S. The area bounded by these latitudes is divided into 60 zones running north-south, each 6° wide and bounded by meridians that are multiples of 6°. Each zone is projected on the transverse Mercator projection and has a central meridian that is an odd multiple of 3°. The zones are numbered consecutively, starting with zone 1 between 180° and 174° W. and increasing eastward to zone 60 between 174° and 180° E.

Using the intersection of a central meridian and the Equator as an origin or starting point, a location can be given by stating its linear distance north or south of the Equator and east or west of the central meridian of the zone. However, this would require the use of north or south and east or west or the use of plus and minus values to identify the location relative to the origin. This inconvenience has been diminished by assigning to the origin numerical values that keep the coordinate values positive for all points within a zone.

The value of 500,000 m east is assigned to the central meridian to avoid negative numbers at the west or the use of plus or minus values to identify as false eastings and increase numerically from west to east. For north-south values in the Northern Hemisphere the Equator is designated zero m north and northings increase numerically toward the North Pole. In the Southern Hemisphere the Equator is designated 10,000,000 m north and the northings decrease toward the South Pole. These are known as false northings. (For more information on the UTM grid see Raisz, 1962, and Robinson and Sale, 1969.)

REMOTE SENSING

Remote sensing is the science of gathering information from a distance. In practice, remote sensing uses cameras and other information-gathering devices carried by aircraft and spacecraft to observe conditions on the surface of the Earth, in the atmosphere, and on other planets. Remote sensing is used principally to detect and record energy (emitted or reflected radiation) in a selected portion of the electromagnetic spectrum (fig. 9).

Remote sensors operating in the electromagnetic spectrum are either passive or active. Passive systems record the natural level of radiation; active systems utilize artificial energy sources such as radar pulses and laser beams.

Photographic cameras operate in the visible, infrared, and ultraviolet portion of the spectrum. Black-and-white panchromatic film is the most economical and most commonly used. Color film increases the value of photography for the identification of features such as rocks and soils, vegetation, surface water conditions, and building materials in houses, roads, and other structures. Infrared films respond to wavelengths up to about 900 nm. Exposure is made through a yellow filter that blocks the passage of blue light and admits green, red, and infrared light. One kind of infrared film produces a black-and-white image. A second type, color infrared, records in colors that are not true to nature but are designed to make it easier to distinguish conditions of vegetation. Originally developed for camouflage detection, color infrared film records infrared energy representative of live vegetation, enhancing the contrast between it and dead vegetation. Leaves of healthy plants generally have high reflectance in the infrared; the amount of reflectance varies with leaf structure and geometry and with plant vitality and chlorophyll level. Thus, variations of red on color infrared prints may indicate the presence of different species, and the diminuation or absence of red in certain members of a single planting is likely to indicate diseased or dead plants.

Optical-mechanical scanning radiometers, or scanners, operate in the ultraviolet, visible, infrared, and microwave energy regions. Unlike cameras that record all parts of a scene simultaneously, scanners sense one spot at a time, covering the surface by sweeping their view from side to side as the aircraft proceeds. This is accomplished with a rotating or oscillating mirror. The incoming radiation is focused on a detector, which translates its intensity into a corresponding electrical signal. The signal may be used to activate a cathode-ray tube that reconstructs the scene line by line in the manner of a television set, and the resulting picture can then be photographed. Alternatively, the signal may be used to energize a glow tube that ex-

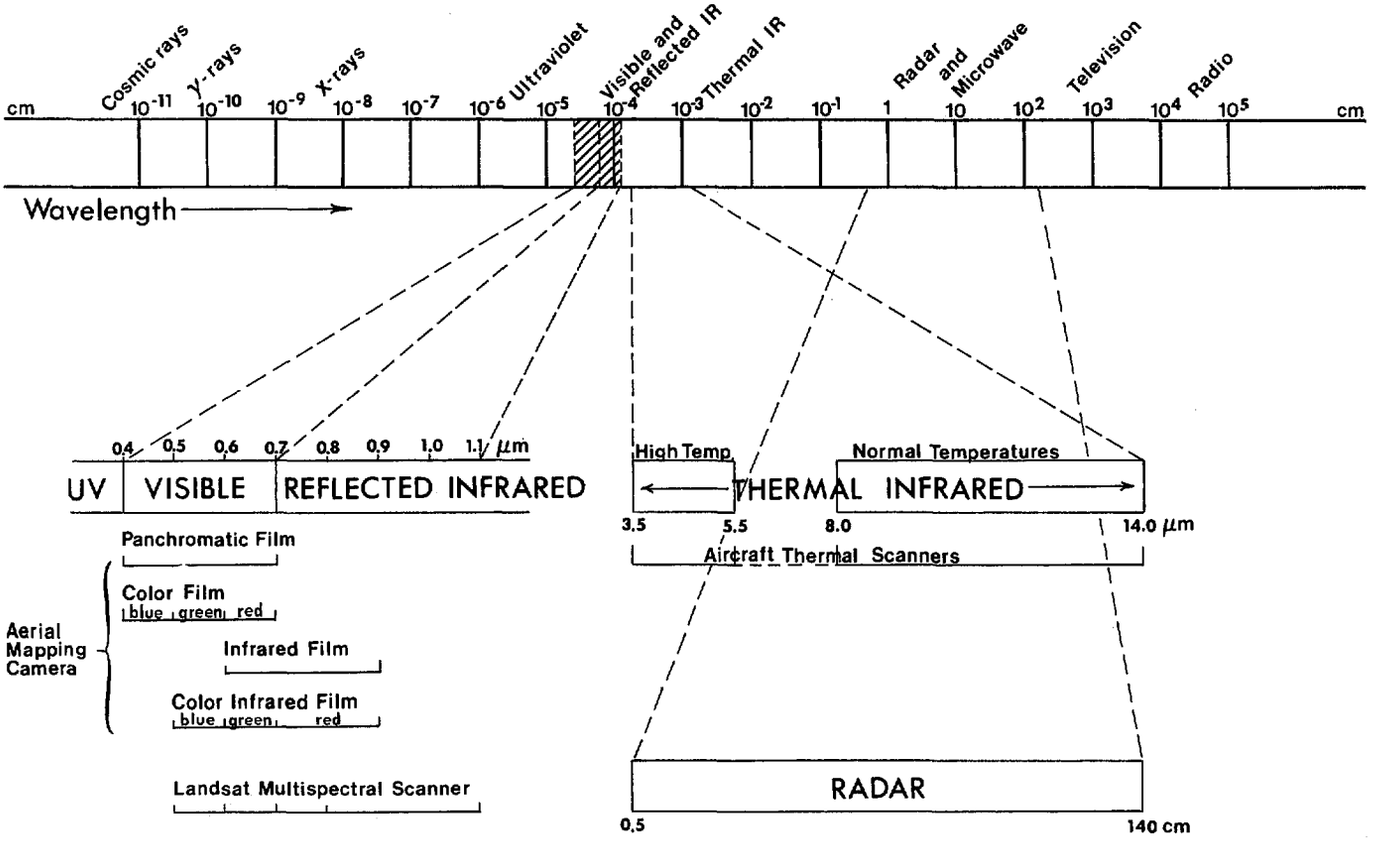


FIGURE 9.—The electromagnetic spectrum.

poses film directly, or it may be recorded on magnetic tape for later processing.

Measuring temperatures and mapping their distributions are valuable in resource and environment studies. Infrared scanner imagery can reveal surface temperatures that indicate volcanic activity, burning in abandoned coal mines, diseased plants, animals obscured by darkness, and heated buildings. It can reveal surface temperature distributions in water which aids in discovering sources of water or oil discharge into lakes, rivers, and oceans. Temperature differences also reveal currents and show the surface boundaries between fresh and salt water in bays and estuaries. Infrared scanners are useful in mapping the distribution of soil moisture near the surface because variations of soil temperature are related to variations of moisture.

Landsat-1 and -2 each carry two sensor systems, the return beam vidicon (RBV) cameras and the multispectral scanner (MSS). Each Landsat image represents a synoptic view of 34,253 km² (13,225 mi²) that permits recognition of some large features not previously recognized on the ground or on low-altitude photographs. Landsat repeats each orbit every 18 days. The repetitive coverage provides information for land use planning and makes it possible to monitor crop production, rangeland conditions, snow cover, floods, and many other dynamic phenomena. The Landsat imagery is obtained in spectral bands (RBV, three bands; MSS, four bands) from which the data may be used alone or in combination. Color infrared imagery (app. 7, fig. 1) enhances the identification of special features such as vegetation in vigorous growth, water, and certain kinds of pollution.

PHOTOGRAMMETRIC MAPPING TECHNIQUES

Photogrammetry is the science or art of making accurate measurements by means of photography. Today maps are produced largely from aerial photographs with a minimum of fieldwork.

Modern mapping procedures rely almost ex-

clusively on photogrammetry for preparation and processing of basic data. Instruments and operational phases vary among agencies and with applications, but basic procedures do not differ significantly. Costs increase rapidly when extensive fieldwork is required. Recent developments in instruments, materials, and methods have eliminated or rescheduled fieldwork, saving much time and money.

The basic operational phases are:

- Project planning.
- Ground control.
- Aerial photography.
- Aerotriangulation.
- Compilation.
- Field completion.
- Final drafting and review.
- Reproduction.

The order of phases may be altered, or two or more may be combined. Each phase is discussed briefly below. Consult references in the bibliography for technical details.

PROJECT PLANNING

The first step in planning a mapping project is to define the boundaries. The entire coastal zone of a State may be too large to cover in one project. As a general rule mapping projects should be kept to a managable size. Senior managers may define the area, or it may be dictated by legislation. In either case, qualified mapping personnel should assist in the decisionmaking.

Detailed technical planning can begin after mapping limits have been determined. The planning should be assigned to qualified personnel within the organization, or arrangements should be made to obtain their services from outside.

Whether a mapping project is done in-house or under contract, managers will be faced with many of the same problems. Managers without a mapping department will have the most difficult decisions. Some of the decisions will concern (1) publication scale, map size, and paper size, (2) method of aerotriangulation, (3) method and scale of compilation, (4) contour interval (if relief is to be compiled), (5) evaluation of established control, (6) photography (camera, filter, emulsion, and scale of photographs), and (7) operational schedules.

A project diagram is prepared, showing map limits and horizontal and vertical control stations. After photographs are acquired, the center of each is marked on the diagram. Specific instructions for both field and office operations are prepared either as a part of planning or immediately before assignment of each operation.

GROUND CONTROL

Photogrammetric mapping requires adequate ground control to show map features in the correct relationship to each other and to the Earth's surface. Both horizontal and vertical control are needed, horizontal to establish correct scale, position, and orientation, and vertical to establish the level datum.

It is frequently difficult to evaluate established control because adequate and current information is lacking. However, extra effort in using established control may result in significant cost reduction and improved scheduling by reducing or avoiding fieldwork for supplemental control. In addition to providing published control data, NGS may be able to supply advance information about data being prepared for publication.

Adequate horizontal control is essential in preparing coastal maps that meet established accuracy standards. In most areas, the established network with the addition of a minimum of supplemental control will be adequate for modern techniques. The network meets all requirements in a few areas, but in others attrition of monuments from the network (from destruction or obliteration) may be serious enough to require extensive supplemental control.

To prevent excessive costs, qualified personnel should analyze and monitor requirements for horizontal control. The aerotriangulation method significantly affects the amount of required control and mapping costs.

Horizontal control points are often paneled or targeted in the field before mapping photographs are taken. Paneling consists in fastening three or four strips of cloth or plastic to the ground to form a pattern identifying the exact location of the control monument (or some other precisely surveyed nearby point that is visible from the air). The color of the marking material should provide good contrast with the ground.

The spacing of horizontal control points depends on the required accuracy and limitations of the photogrammetric method. For example, in 7.5-min topographic quadrangle mapping, horizontal control stations are established at 7.5-min spacing on the perimeter of the project. Horizontal control within the project area is established by aerotriangulation.

Similarly, vertical control is needed for correct plotting of contours. Therefore, the elevations of

selected points must be determined in the field. As a rule, more vertical stations are required than horizontal stations. Vertical control is a major expense in topographic mapping because of the amount needed. A minimum of four vertical control points, which need not be (and seldom are) monumented control stations are needed for each stereomodel. Many are image points whose positions and elevations have been determined by photogrammetric methods: the important requirement is photoidentifiability—examples are road intersections and fence corners. Therefore, one of the major field operations is establishing elevations (often by planetable and alidade).

Vertical control for routine preparation of base maps, excluding mapping of most features below the chart datum, usually can be obtained from tidal data and from available topographic maps.

AERIAL PHOTOGRAPHY

Acquisition of aerial photographs for coastal mapping is perhaps the easiest and least expensive phase of mapping. Mapping quality, that is, clarity, accuracy, and stability sufficient for distance measurement, is the chief requisite of aerial photographs intended for aerotriangulation and basic compilation. Information such as thermal infrared data can be obtained only from instruments that do not have the necessary metric quality. Thermal information can, if needed, be added to manuscripts after proper processing despite the lack of metric quality. Optical systems of most modern mapping cameras, with appropriate filters and films, can yield photographs of the required quality provided that the exposed film and subsequent photographic products are processed properly.

Aerial photographs already available are often unsuitable for actual mapping for various reasons. For example, they may be outdated, at the wrong scale, or unsuitably spaced or oriented. Also, the photographs may have been taken with the tide at the wrong stage.

Planning for aerial photography is based on the project specifications plus the following considerations:

- Season of the year, affecting:
  a. Sun angle (shadows, reflections, glare).
  b. Ground cover (snow, leaves, crops, floods).
  c. Local weather conditions.
- Type of photography (orientation, focal length, format, emulsion).
- Direction of flights (for most efficient coverage).
- Flight height:
  a. Capabilities of stereoplotter; relation to stereomodel scale.
  b. Contour interval; C-factor of the stereoscopic instrument system.
  c. Visibility and interpretability of planimetric detail.
- Number and spacing of flight lines; width-height ratio.
- Spacing of photographs along flight lines; base-height ratio.
- Federal Aviation Administration regulations governing flight operations in Federally controlled and special-use airspace.

A flight plan is plotted on the best available map of the area, showing the centerline of each flight. Photographs are taken with modern mapping cameras (fig. 10), on panchromatic, black-and-white infrared, natural color, and color infrared films.

Panchromatic emulsions are the original and most popular emulsions because they are lowest in cost and easy to use. Disadvantages result from the rendition of all images in shades of gray. Fieldwork is needed to resolve discrepancies.

FIGURE 10.—Typical aerial mapping cameras, the Wild RC 10 and RC 8, mounted in an aircraft.

Natural color aerial film was not readily available until the 1960's. Natural color emulsions record images of objects in fairly natural hues, tints, and tones insofar as these qualities are not altered by atmospheric filtering. Reliability and speed of photointerpretation essential to photogrammetric mapping can be greatly improved by using color emulsions. However, at higher flight altitudes, which vary with location, color contrast is reduced to a monotone tint because of atmospheric effects.

Black-and-white infrared film has a special panchromatic emulsion with response into the near infrared. The film is normally exposed through a filter that blocks visible light. Spectral response is thus rather narrow, about 740–900 nm in the near infrared region. The film is valuable in mapping because it records the land-water relationship accurately and sharply. It is not sensitive to long infrared waves and therefore does not record thermal or heat energy.

Color infrared film (sometimes called "false color") is a relative newcomer to aerial photography. The three sensitized layers of the emulsion respond to green, red, and near-infrared wavelengths. The film must be exposed through a filter such as the Wratten 12 to stop the blue light to which all three layers are sensitive. When the emulsion is properly exposed and processed, infrared-reflective objects, such as healthy trees, appear bright red, hence the use of the term "false color." The sharp contrasts between various types of features make color infrared film of special value in coastal mapping.

Photographs are taken within a specified time, with weather largely determining the actual flight times. The exposed film is developed preferably in a modern automatic processor (fig. 11), which permits exact quality control. After processing, proof prints are made and stapled together in relative position, and the composite is examined to determine whether coverage is complete and has the required overlap. If the negatives are acceptable, contact prints are made and each is marked with the date of photography, frame number, and project code. An index photomosaic is prepared to aid subsequent operations. Sometimes duplicate negatives are made to preserve the originals as archival material, and transparent positives are made for checking and editing.

AEROTRIANGULATION

Aerotriangulation photogrammetrically extends established control to meet the requirements of a mapping project. Either horizontal or horizontal and vertical control can be extended, thereby reducing or eliminating costly field surveys.

Various aerotriangulation methods have been devised since the advent of photogrammetry. Development has been successfully directed toward increased accuracy and economy (mainly by reduction of field control) and capability to extend vertical control that meets accuracy standards for mapping and charting. Also, general efficiency increased as stereoscopic plotting instruments and related systems were developed and improved. The aerotriangulation methods in use today can be broadly classed as graphic, analog, and analytical. In actual practice, methods are combined and modified as needed to produce results conforming to accuracy requirements and available resources.

Graphical aerotriangulation, such as radial line plotting and using various types of templets, is seldom used now except in emergencies because of inefficiency and relatively poor accuracy. A hybrid type, stereotemplets, can be used effectively because the unit of measurement is a stereomodel rather than the single photograph, so that errors due to the perspective nature of photographs are virtually eliminated before adjustment in the templet laydown. Another advantage of stereotemplets is the use of simple, relatively inexpensive plotting instruments to prepare the templets (fig. 12). However, none of the graphical methods can be used to extend vertical control.

Analog aerotriangulation requires use of some form of stereoplotting instrument. The simplest form, now obsolete, is called long-bar bridging because as many as 20 projectors are successively oriented to stimulate the flight strip in miniature. Adjustment of closure errors along the strip and between strips is by graphical or other approximation methods. A similar procedure can be used with a single large and expensive stereoplotter, such as the Wild Autograph and Zeiss Stereoplanigraph plotters. In these so-called bridging instruments, the left and right projectors can be interchanged by optical switches. The principle is the same as with long-bar bridging, but the photographs are placed alternately left and right in the projectors of the instrument as aerotriangulation proceeds along the strip.

The results of analog aerotriangulation can be adjusted by several methods, including mathematical computation by automatic data processing, which effectively produces another hybrid system, semianalytical aerotriangulation. In this context, proce-

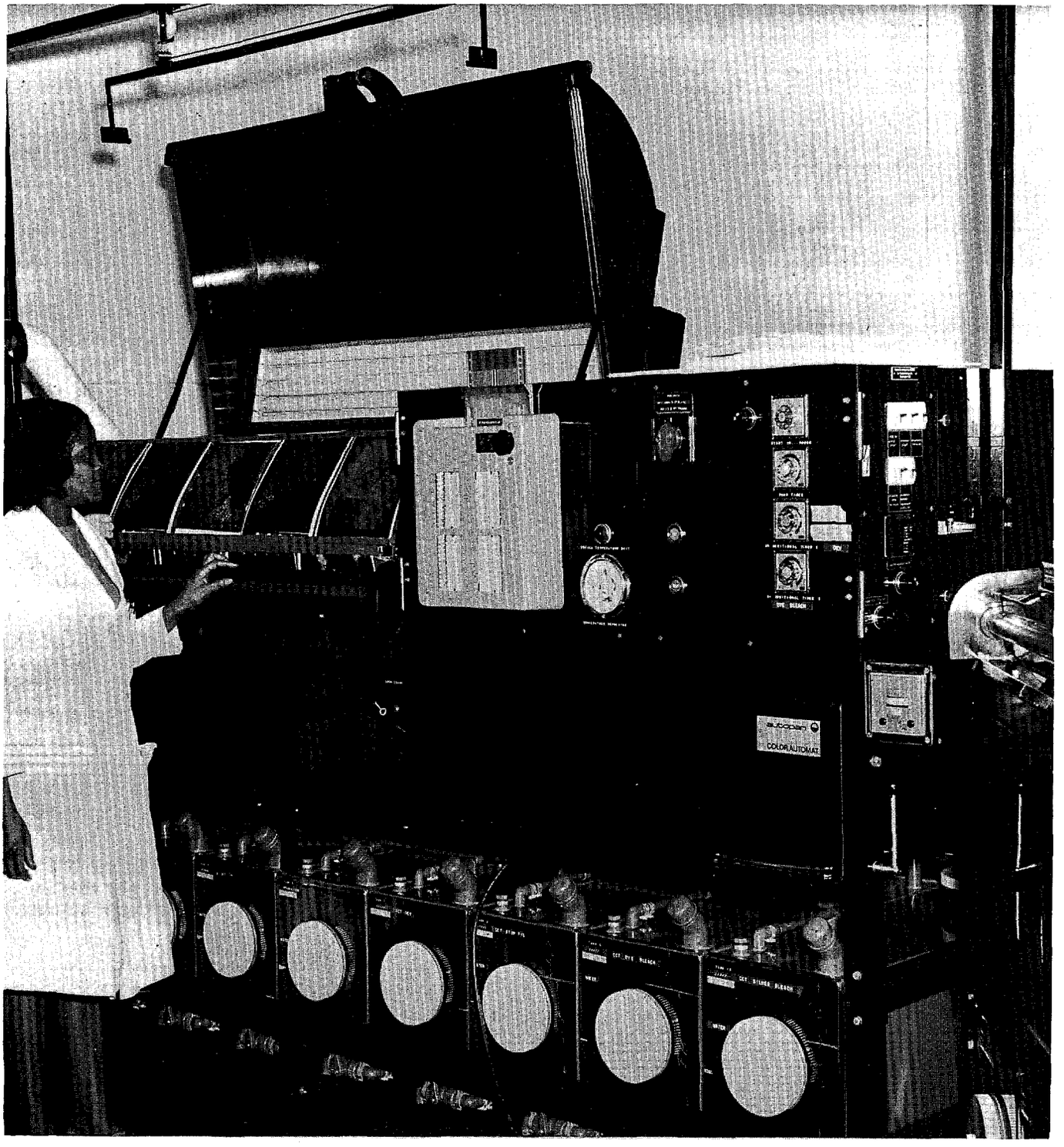


FIGURE 11.—Automatic color film processor for color films, plates, and prints.

dures similar to those used for preparing stereotemplets can be used to gather digital x, y, and z axis measurements from individual stereomodels set up by a stereoplotter equipped with digital encoders. In some methods of analog aerotriangulation, vertical control can be extended, but not always reliably and seldom for control of mapping at small contour intervals (1, 2, and 5 m).

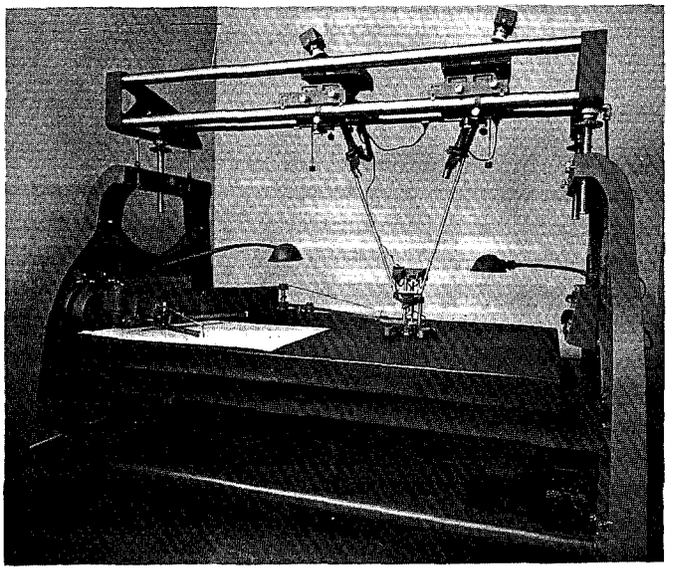


FIGURE 12.—Kelsh stereoplotting instrument, which can be used for aerotriangulation.

Fully analytical aerotriangulation is currently the most advanced method for extending control for mapping, both horizontal and vertical. Except for identifying and establishing a minimum of field control, all operations can be completed within the office, measuring coordinates on photographs with a comparator (fig. 13) and preparing the data for computer analysis. This method, which the celebrated Otto von Gruber considered merely an academic exercise in the 1930's, has become practical and cost effective with the development of large computers. Today even small firms can use computer services on contract and thereby apply the best methods available.

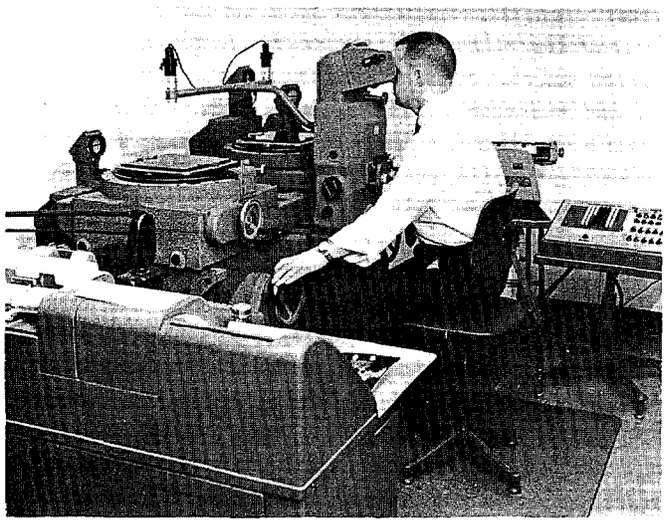


FIGURE 13.—Wild STK stereocomparator, used for accurate coordinate measurement for analytical aerotriangulation.

MAP COMPILATION

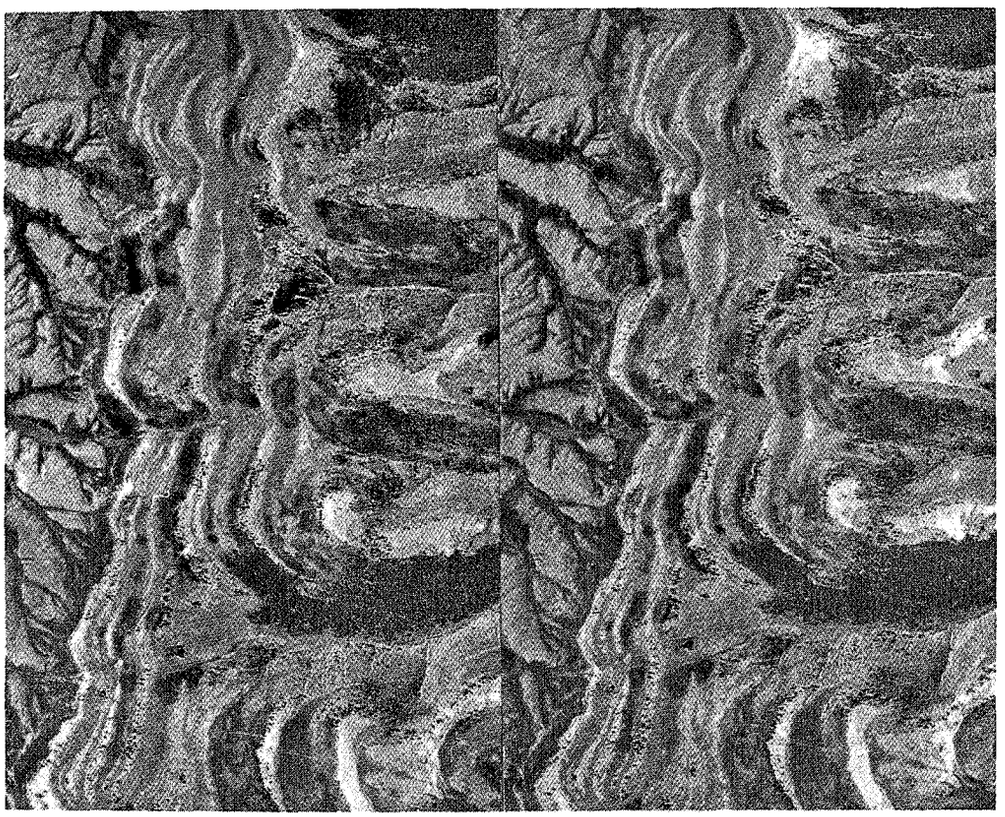
After aerotriangulation, the map manuscripts are compiled. In compilation, mapworthy details are transferred from source materials to a specially prepared dimensionally stable manuscript base. Lines and symbols portray the details on conventional maps and charts. Orthophotomaps are compiled from rectified photographs, with selected features enhanced by symbols. On topographic maps, relief is portrayed by contour lines. Features must be generalized on maps because the manuscript area is very small in relation to the ground area. Selection of features requires a knowledge of photogrammetry, the ability to interpret images correctly, and the ability to draw lines and symbols accurately.

Dimensional stability and suitability of the drawing surface are important factors in selecting a medium for map manuscripts, now generally polyester sheets with a suitable coating. Variations in temperature and humidity little affect polyester bases, eliminating serious cartographic problems. Manuscript preparation begins with drawing the geographic graticule on the selected map projection and the grid lines for a plane coordinate system. Today, this operation is usually automated to the extent of using a coordinatograph, or x, y plotter. Control data are plotted at the same time. The manuscript may be compiled in ink or pencil.

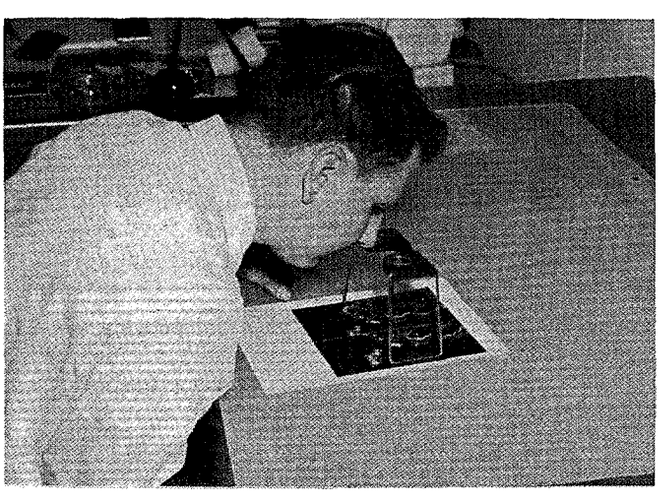
Map manuscripts are also compiled on stereoscopic plotting instruments from diapositives, positive transparent prints on glass plates or film. The instruments range from relatively simple types to complex plotters. Some complex plotters are being incorporated into automated mapping systems. When properly used, all are efficient and capable of producing maps that meet accuracy standards.

In a stereoplotter two overlapping images are viewed simultaneously to provide a three-dimensional model. The stereoscopic effect is produced when the operator views the same ground area on two perspective photos, one with each eye, at the same time (fig. 14). The different perspective views result from the progressive movement of the aircraft between exposure stations.

Although stereocompilers can interpret much of the map detail from the stereomodel, they need help in interpreting some features and in distinguishing between others. Questions always arise, and regardless of how expert the compiler may be, errors in



A



B

FIGURE 14.—When viewed stereoscopically this pair of photographs, *A*, gives the impression of a three-dimensional image. *B*, A simple pocket stereoscope.

interpretation can occur. In addition, changes in features, especially cultural features, may have occurred since photography.

Field classification usually is an annotation directly on the aerial photograph or the photoindex. Annotations include (1) classification of buildings, (2) classification of roads and trails, (3) delineation of boundaries, (4) identification of cultural features, (5) location and labeling of control stations, (6) delineation of streams and classification as intermittent or perennial, (7) delineation of wetlands, (8) delineation of U.S. land lines and labeling of townships and sections, (9) classification of sample woodland areas, and (10) identification of names. Classification and various elements of map completion may occur after compilation of the map manuscript. However, these surveys are generally limited to specific problems and questions, not a general review of the compiled map, so that time and money are always saved by completing the classification in advance along with the control.

Stereoplotters are equipped with a reference mark in the field of view that can be moved in three dimensions by the operator. As the reference mark is moved in contact with the apparent surface of the stereomodel, a drawing pencil automatically traces the horizontal motions on the base sheet. Contours are drawn by moving the reference mark along the surface of the model at a preset elevation. Planimetric features are compiled first, directly on the base sheet. Other features, such as woodland and contours, usually are compiled on separate manuscripts. Drainage may be compiled with either culture or contours.

The features compiled directly on the base sheet are usually scribed stereomodel by stereomodel. Then, the data are photoprinted onto successive manuscript sheets to guide the compilation of other features. Each manuscript is reviewed after compilation to assure compliance with established specifications and standards. Corrections are made after review.

Compilers record all difficulties encountered during compilation. Sometimes they cannot positively identify the image of an object. Sometimes structures are only partially complete at the time of photography. All problem areas are noted on the copy of the manuscript that is sent to the field for final inspection.

Photogrammetric techniques can be used to acquire data vital to coastal management aside from production of maps and charts. For example, offshore activities such as structure location; pipeline and cable routing; aquaculture and mariculture design, location, and operation; and recovery of living and nonliving marine resources require a knowledge of water circulation patterns. Lagrangian current measurements obtained by a photogrammetric circulatory survey made concurrently with and in support of a Eulerian current survey provides an enormous quantity of data at reasonable cost. Acquisition of the same data by Eulerian methods exclusively would be prohibitively expensive and, because of equipment limitations, impossible in shallow water. The photogrammetric data can be processed rapidly for presentation in tabular form or in chart format.

FIELD COMPLETION

As previously noted, efficient production combines all field surveys into a single pass through the area to the extent possible, before the map is actually compiled. If the combined operation is not possible, field completion or field editing surveys remove deficiencies and resolve discrepancies noted during compilation. The mapped features are carefully and methodically compared with ground detail, and horizontal and vertical accuracy tests are applied as required. The field editor certifies that the map is correct and complete. After the additions are completed and verified in the office, the manuscript is ready for final drafting and review, and copies can be made for limited distribution and use.

FINAL DRAFTING AND REVIEW

Most maps are produced from either scribed or inked drawings. Scribing and inking differ in several ways. Inking forms a positive image and is right-reading; scribing forms a negative image and is normally wrong-reading (right and left reversed) so that positive contact prints are right-reading (fig. 15).

In inking, the features to be shown in a specific color are drawn in black ink on a nonphotographic blue guide image of the map detail. In scribing, plastic sheets coated with photographically opaque paint are overprinted with the guide image, and the lines and symbols are cut into the coating with engraving tools (see fig. 16). Corrections can easily be made by covering mistakes with opaquing fluid and rescribing.

The effect of scribing can also be obtained photomechanically. The scribecoated sheet is photosensitized and contact-printed with a line drawing or film positive. After exposure, the sheet is developed with an etching solution to remove the opaque coat-

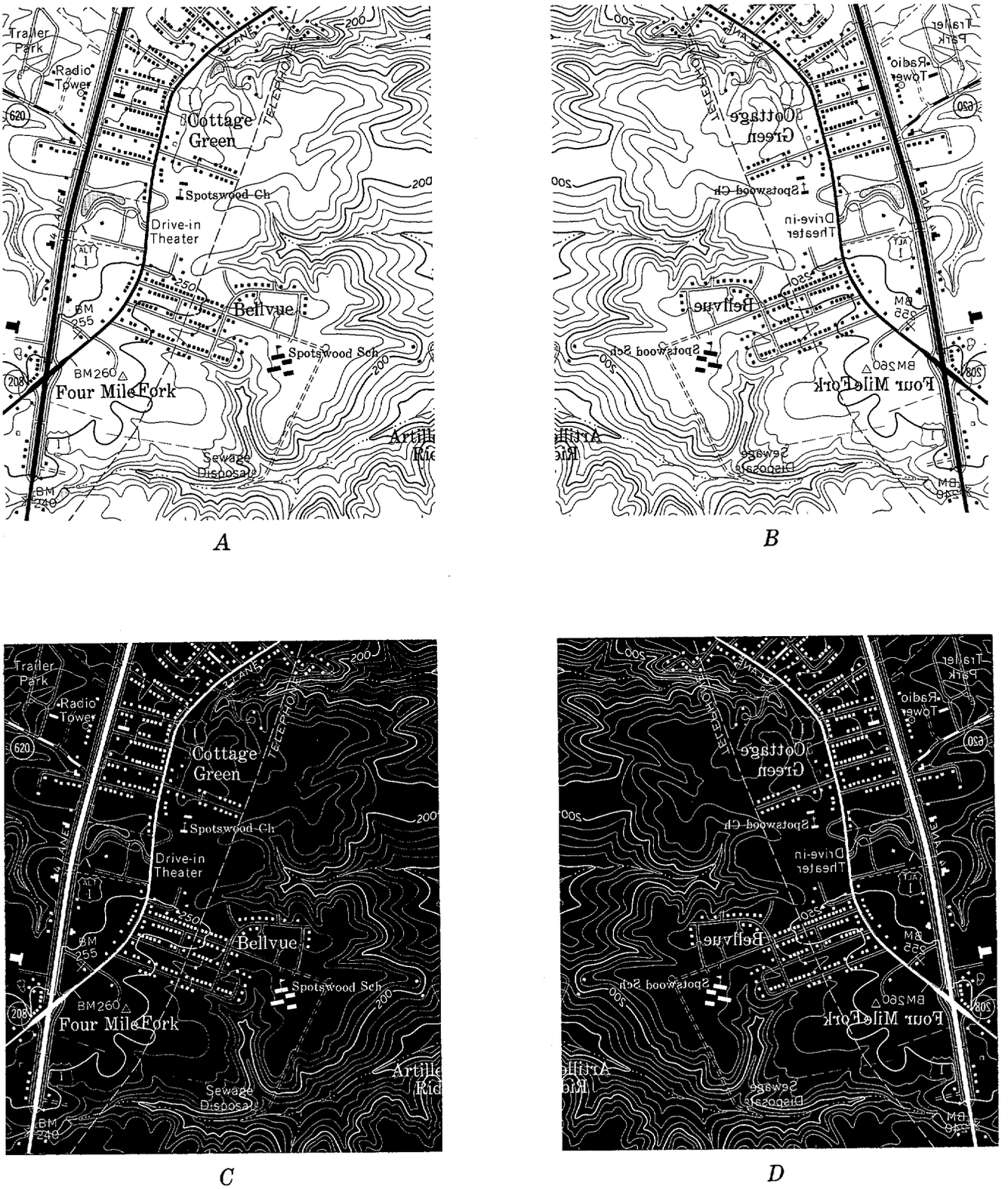


FIGURE 15.—Sample of a topographic map showing production orientations. *A*, Right-reading positive, *B*, Wrong-reading positive, *C*, Right-reading negative, *D*, Wrong-reading negative.

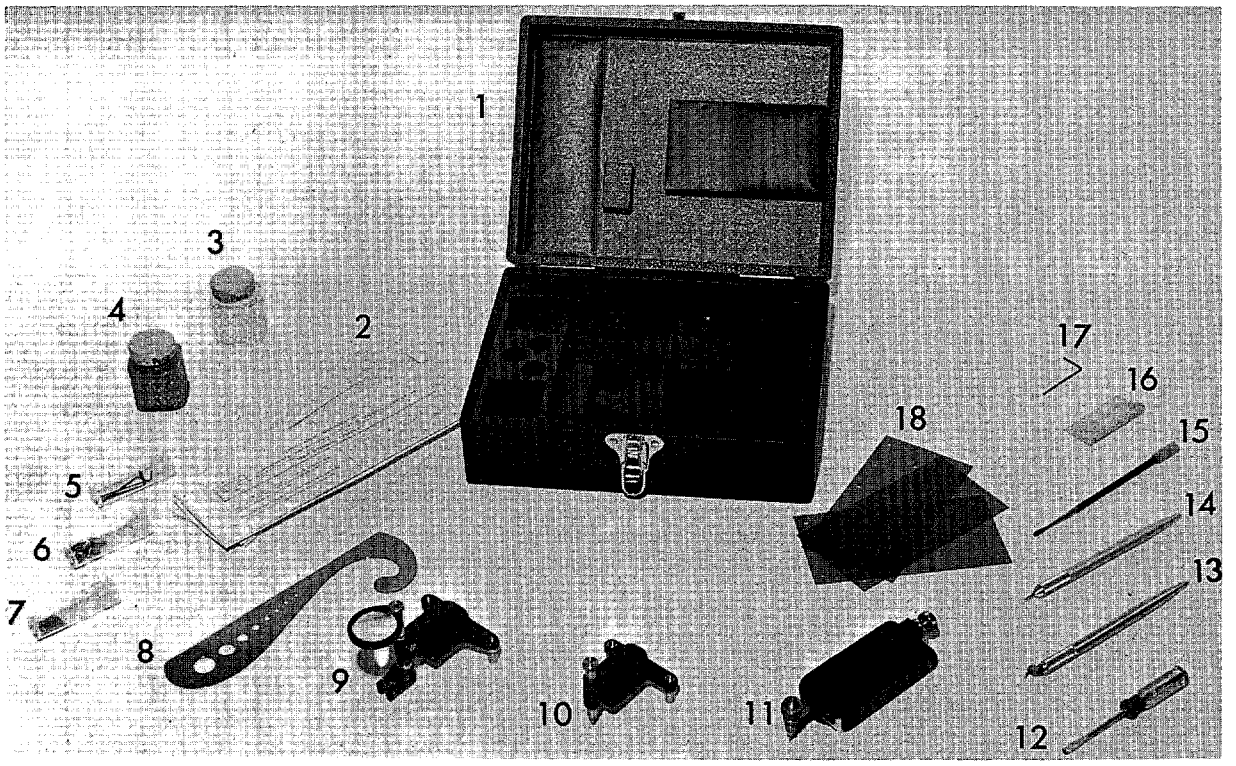


FIGURE 16.—A field scribing kit includes (1) field scribing kit container (large), (2) instructions for use of plastic templet and for sharpening points, (3) thinner, (4) correction fluid, (5) Allen wrenches for swivel graver, (6) register studs, (7) scribing points, (8) combination straightedge-curve, (9) swivel graver, (10) rigid graver, (11) building graver, (12) screwdriver, (13) angle fineline graver, (14) straight fineline graver, (15) correction fluid brush, (16) sharpening stone, (17) Allen wrench for rigid graver, and (18) plastic symbol templet.

ing wherever map detail prevented light from reaching the sheet so that a negative image of the original is produced.

The etching process is used when a finished positive copy is available, particularly if the reproduction contains a large quantity of numbers and symbols. Often contours are thus reproduced when a map is being revised. Generally, contours do not need as much revision as other map features so that contour guides frequently can be reused; the etching process is a quick and easy way to prepare copy. The disadvantage is that the lines sometimes print less crisply than desired. However, minor repair work can be done with a simple scribing needle in much less time than it would take to rescribe or reink the entire plate.

Solid-tint areas, which symbolize water, woodland, and urban areas on topographic maps or areas of equal distribution on thematic maps, usually are produced by peeling or stripping. An outline of the tinted area is compiled and contact-printed onto a sheet coated with a special "peelcoat" material. The line image is etched into the peelcoat, and with the etched lines as a boundary, the tint areas are easily peeled away with a small knife, leaving open windows (fig. 17).

Sometimes lettering and symbols are prepared on transparent adhesive material called stickup or stripfilm (fig. 18), positioned on the appropriate manuscript, and burnished or rubbed on to adhere. Lettering can also be applied manually or with an electronic lettering machine.

If a map is to be multicolored, color-separation guides (not to be confused with feature-separation guides) must be made. The normal separation of colors is:

Black—Culture, control, grids and coordinates, labels, marginal data.
Blue—Drainage.
Green—Vegetation.
Brown—Relief.
Red—Highway numbers and classification, land lines, and fence lines.

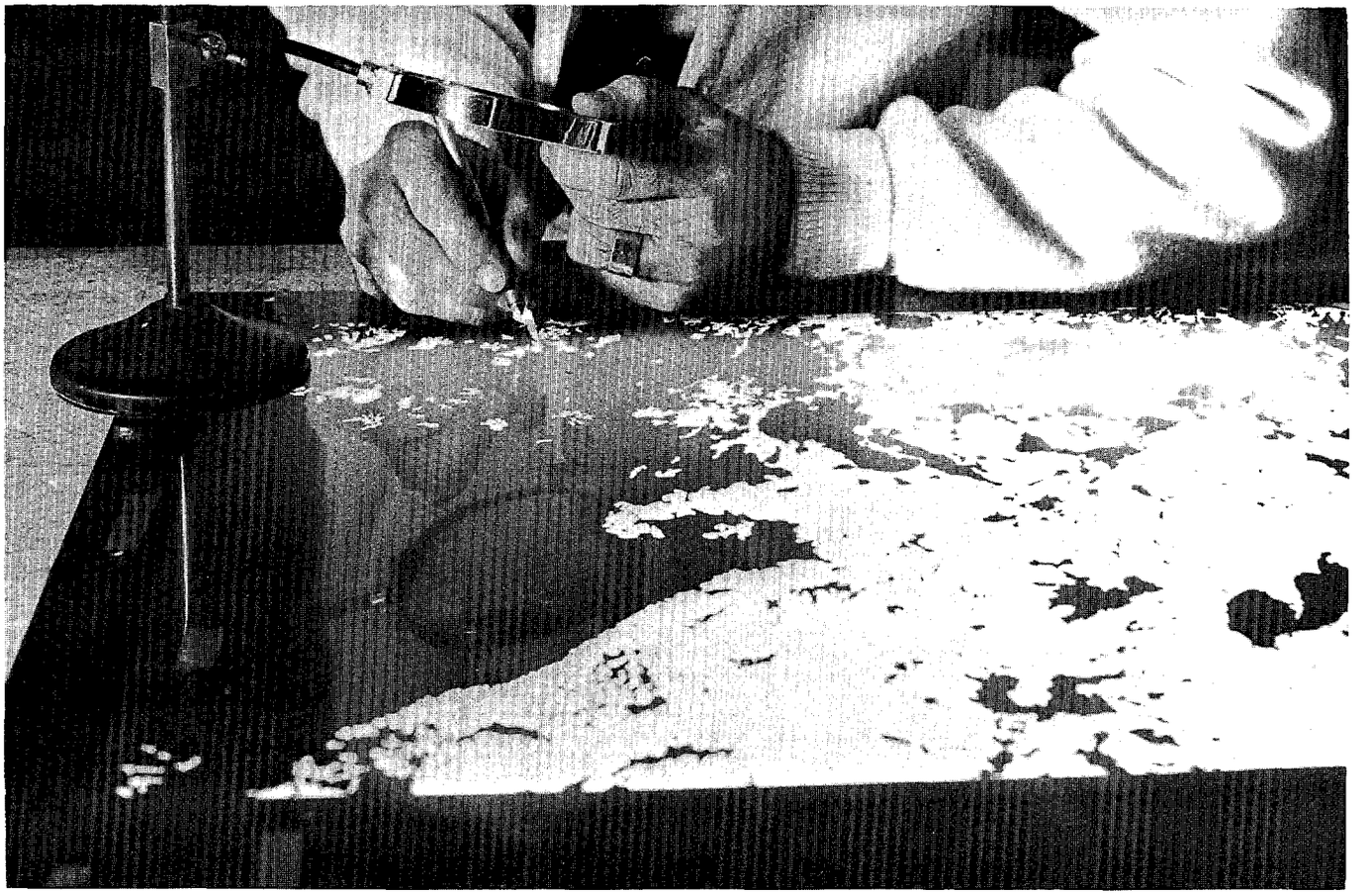


FIGURE 17.—Preparing an open-window guide by peeling areas of the opaque layer from an etched peelcoat.

At least one color separation guide must be prepared for each color, containing only the data to be printed in that color. These guides can be scribed, film, or open-window negatives. For good register, they are prepared on a printed image reproduced from the compilation manuscripts. The important difference between compilation manuscripts and guides is that the manuscripts are normally drawn right-reading while guides are normally drawn wrong-reading because they are used for the contact exposure of photosensitive pressplates.

To make a color composite proof for checking, the color-separation guides are successively contact printed in their assigned colors on a white base. The editor easily identifies errors and indicates changes on the guides. In a complex multicolored map, such as a topographic map, corrections can sometimes cause new errors. Therefore, the editing-correcting-editing cycle should be repeated once or twice before publication.

Final review is the last phase before map reproduction. The manuscript and accompanying data are examined for accuracy, adequacy, completeness, and conformance to specifications. The reproduction materials are sent to the printing plant, and the related materials are sent for archival storage. Depending on agency or company policy, when all maps in an individual project are finished, the reviewer may prepare a report summarizing information pertaining to the production of the project, supplementing reports prepared for individual maps. The reports contain preparation data that cannot be shown on the maps and that do not duplicate any of the map content. The reports can be invaluable in answering questions about how the maps were prepared, especially in case of litigation.

MAP REPRODUCTION

Most maps are now printed in quantity on rotary offset presses from aluminum pressplates. For only limited distribution, manuscripts can also be repro-

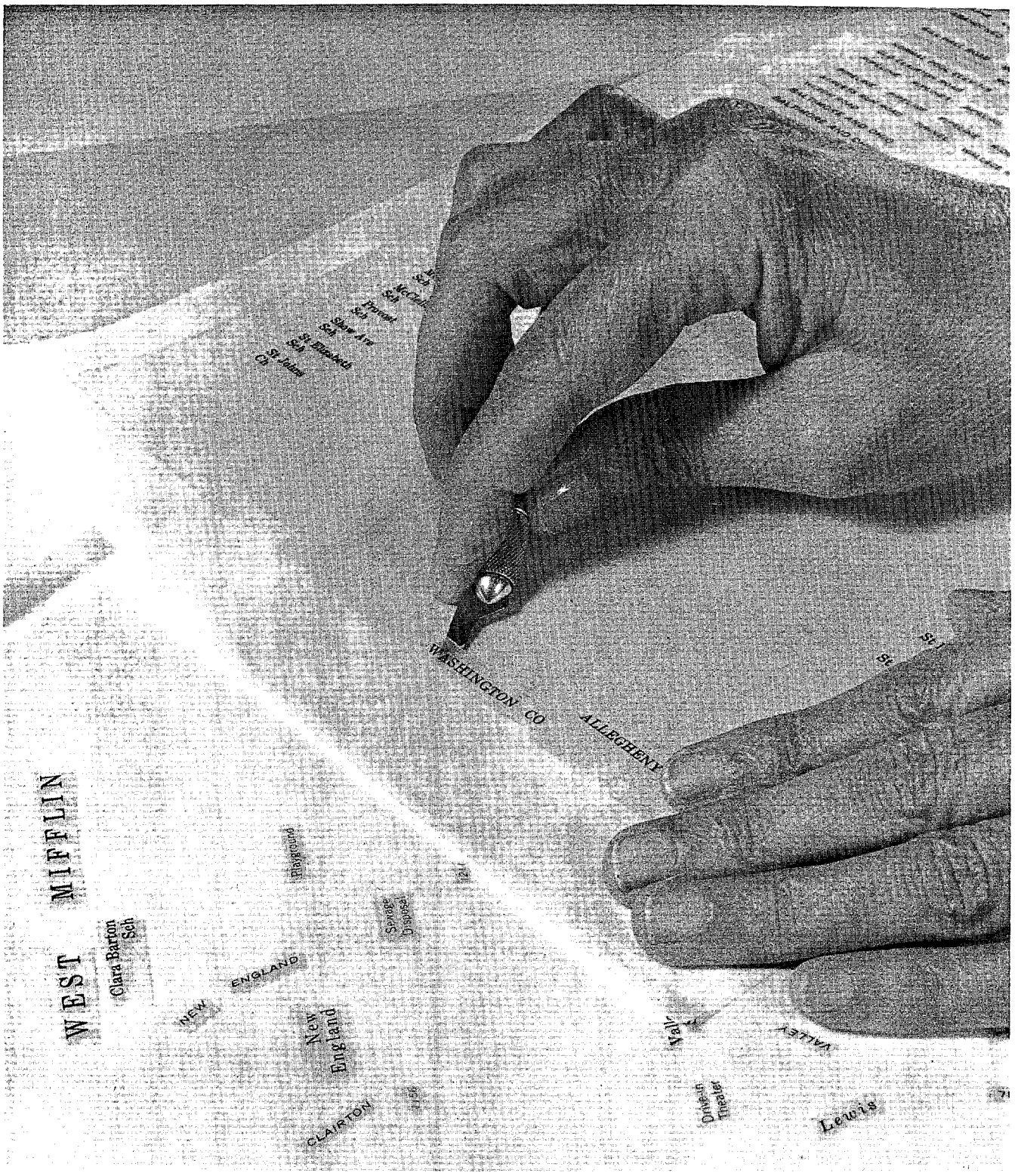


FIGURE 18.—Applying waxed stickup or stripfilm to a names sheet, one sheet used to produce the black printing plate.

duced photomechanically. Other types of printing—such as letterpress, gravure, and diazo—are described by Melcher and Larick (1966). The aluminum pressplates are prepared by contact photography using the color-separated reproducibles, one plate for each color. Multiple exposures of a plate are needed if all the features to be printed in one color have not been combined into a single reproducible, for example, drainage detail may be on a scribed drawing with water tint on a separate open-window drawing. Various types of screens are used to produce tints and shades by blocking out specific percentages of the image. Therefore, it is possible to print several shades of a color from one pressplate.

In offset printing the ink image is transferred from the pressplate to an intermediate rubber blanket and from the blanket to the paper, forming one impression. For multicolor maps, a separate impression is needed for each color. Moreover, the impressions must be in exact register with each other to form an accurate map.

For the standard five-color topographic map (black, blue, brown, red, and green) the impressions can be obtained in five separate runs through a single press, which must be shut down, washed, replated, and reinked between runs. The same five impressions are more efficiently obtained on a five-color press (fig. 19), which consists of five press units operating in tandem, each unit printing a different color. Blank paper is fed into one end of the press, and completely printed maps emerge at the other end. A large volume of maps must be produced to justify spending the money needed to buy a five-color press.

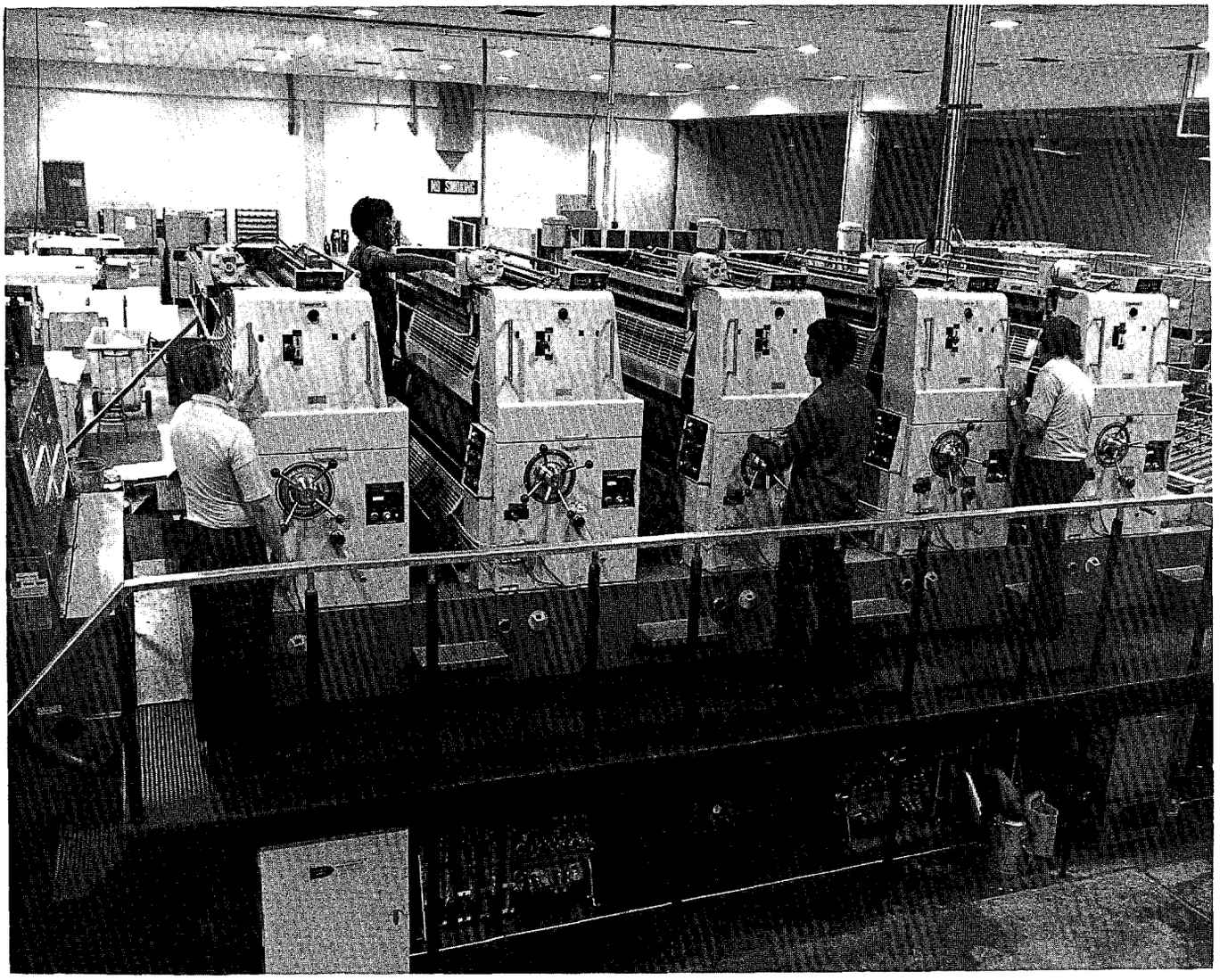


FIGURE 19.—Five-color offset press with five units in tandem, each printing a different color.

MAPS

A map is a graphic representation, usually on a plane surface and at an established scale, of selected natural and manmade features on or below the surface of the Earth. Symbolization is used to enhance certain details according to the intended purpose of the map.

The number of types of maps that can be made for different uses is practically unlimited. Generally, however, maps can be classified in one or more of the following categories: planimetric, topographic, thematic, digital, line, or photographic.

PLANIMETRIC MAPS

Planimetric maps present the horizontal position of selected features but do not show relief in measurable form. Examples of planimetric maps are base, cadastral, line-route, and outline maps.

Base maps are used to plan or to compile data for the production of specialized maps.

Cadastral maps show the boundaries of subdivisions of land (usually with bearings and lengths and the areas of individual tracts) for describing and recording ownership. One type of cadastral map is the plat which often constitutes, or is an essential part of, a legal description of a parcel of land. The Bureau of Land Management is the major single producer of land plats.

Line-route maps are used by utility companies. They show the routes and type of construction of pipelines or wire circuits, plus the locations of facilities such as switchboards, valves, and telegraph stations.

An outline map presents only the information needed to provide a basis for the compilation of additional data. Outline maps often show only national and State boundaries and major drainage systems.

TOPOGRAPHIC MAPS

In addition to the features shown on planimetric maps, topographic maps portray the shape and elevation of the terrain, usually by contours, form lines, shading, color gradients, or hachures. Any map portraying relief by one of these conventions can be called a hypsometric map. A map on which the elevations are referred to a specific datum is called a hypsographic map. Standard topographic maps are in both categories.

In the United States the best known type of topographic map is the quadrangle series, which range in scale from 1:20,000 to 1:250,000. The quadrangle series are used in development, for selecting industrial sites, planning highways, routing utility lines, selecting damsites, and locating communication facilities. They are also popular in recreation for hunting, fishing, and camping.

Other types of topographic maps include engineering, flood control, landscape, and bathymetric. Engineering maps are used for planning and cost estimating for projects. Flood control and storm evacuation maps are special-purpose topographic maps used to study areas subject to flooding. Landscape maps are used by architects to plan buildings that will conform to the topography of the site. Gardeners use landscape maps to maintain parks, playgrounds, and private estates. Bathymetric maps show water depths and underwater topography. Water depth ranges are generally portrayed by various colors or shades. Usually, uniform depth intervals are connected by solid lines called bottom contour lines. USGS and NOS produce bathymetric maps.

THEMATIC MAPS

Thematic maps are also called geographic, special-purpose, or distribution maps. They emphasize a single topic such as geology, climatology, or crop distribution, and the entire map is devoted to presenting this distribution or concentration. Geographers use thematic maps to show the distribution of subjects such as population, languages, crop production, soil, climate, vegetation, land use, and industry. The distributions are shown by several methods, including dots, choropleths, or isopleths.

Dots are used to represent quantities such as 1,000 people or 500 acres of corn. The size and value of dots are selected so that the dots coalesce in areas of densest distribution. Sometimes dots of varying sizes are used for different quantities.

Choropleth maps are thematic maps in which sections determined by civil boundaries or other arbitrary division are colored, shaded, dotted, or hatched to make darker or lighter areas in proportion to the density of distribution. Because of the arbitrary selection of sections, choropleth maps can be somewhat misleading by showing an abrupt change between sections where the change is actually gradual.

Isopleth maps are used to show numerical values for continuous distributions (such as rainfall and temperature) rather than discrete variables. Isopleths are lines connecting places of equal value of distribution and have the same inherent virtues and deficiencies as contour lines. They provide exact information throughout their entirety but do not

show what happens in the intervals. Tinting or shading is sometimes used between isopleths.

There are various types of thematic maps, including geologic, forestry, soil, land use, slope, and historical. Geologic maps portray a number of different geologic conditions. Forestry maps show the size, density, kind, and values of trees in a given area. Soil maps portray soil conservation parameters. Land use maps depict land use by colors, letters, or numbers within small areas.

Slope maps use colors or shades to graphically represent different degrees of slope and are used in studies related to land use. Slopes can be determined mechanically by the distance between contours on a relief map, or they may be generated by computer printout from digital terrain data.

Thematic maps dedicated to the explanation of the past are called historical maps. They show such features as battlefields, military routes, and boundary changes. Although all maps are historical because of the time interval between compilation and publication or use, not all historical maps are thematic. Only those intended to illustrate statistics can be classified as thematic.

DIGITAL MAPS

The digital map is a recent addition to map classifications. It is a graphic produced automatically from a computer bank of map data. Often the user can retrieve selected information either in map or list form (see "Future outlook").

LINE MAPS

Any map produced from scribed, inked, or paste-on line copy is considered a line drawing or line map.

PHOTOMAPS

The photomap is an alternative to the line map—it shows nonselective details requiring photointerpretation by the user. Any aerial photographic image can be considered a photomap. However, although aerial photographs are map substitutes because they show surface features, they may contain serious scale distortions caused by camera tilt or topographic relief. Most photomaps include some cartographic enhancement to help the user—perhaps only marginal information, an overprinted line drawing, or names.

Aircraft tilt and relief cause certain image distortions and displacements on photographs. Distortions caused by camera tilt can be removed by simple rectification. Distortions caused by relief can be removed by an Orthophotoscope or other differential-rectification system which produces orthophotographs, correct in scale and relative position.

Orthophotoquads and orthophotomaps have been developed using simple and differential rectification, which remove tilt- and relief-caused scale distortions. Both are made from an orthophotograph or an orthophotomosaic, and both contain marginal information including grid and projection lines or ticks. Orthophotoquads are black-and-white or color orthophotographic images in quadrangle format with a minimum of cartographic treatment. The major highways and a few principal places or features are labeled for orientation. The orthophotoquad user must interpret most features for himself. Orthophotomaps are hybrids that contain both orthophotoimagery and cartographic symbolization including color separation and enhancement. Color enhancement can often present features in colors more easily recognized than those nature provides. A variety of shades of green, blue, and brown accentuate such detail as saltwater encroachment, marshland limits, faults, and physical characteristics of prominent geologic features. With additional cartographic treatment (contours, elevations, boundaries, labels), orthophotomaps require approximately the same production effort as line maps, but the photoimagery is an advantage in the study of special interest areas by hydrologists, geologists, and other earth scientists.

FORMAT

Maps generally have a rectangular format that may include the entire area of a political division of interest. Generally, some map detail is shown beyond the political boundary to fill the entire area within the outer drafted neatline. However, sometimes compilation ends at the political boundary, and the map then conforms to the shape of the political unit.

A quadrangle map is bounded by meridians of longitude and parallels of latitude. Examples of standard quadrangle formats are 7.5′x7.5′, 15′x15′, 30′x1°, and 1°x2°. Adjacent quadrangles can be fitted together to form a large continuous map. Maps and charts of water areas generally are bounded by meridians and parallels.

CONTENT

General-purpose maps contain all or some of the following data:

- Control.

  a. Horizontal and vertical stations.
  b. Spot elevations.
- Reference systems.
  a. Geographic (latitude and longitude).
  b. Universal Transverse Mercator grid.
  c. State plane coordinate grids.
  d. Public land system (township and section lines and corners).
- Culture—roads, buildings, dams, utility lines, and other works of man.
- Drainage—swamps, rivers, streams, ponds, lakes, and oceans.
- Vegetation—woodland, scrub, orchards, and vineyards.
- Relief—contours, hachures, form lines, color gradients.

CONTOUR INTERVAL

The contour interval is the difference in elevation between adjacent contours on a map. Selection of the interval is a basic consideration in topographic and bathymetric mapping, depending mainly on scale and to some extent on the intended use of the map. A large interval may be acceptable for small-scale and reconnaissance maps, but natural resource development usually requires an interval small enough to portray all significant details of the terrain. Too small an interval may cause contour crowding or show insignificant details; too large an interval may prevent adequate representation of the terrain. An interval that is appropriate at one scale may not be satisfactory at another.

Occasionally, selecting a contour interval is difficult because portions of the terrain or sea bottom need a smaller interval between contours more than other portions. For example, a 5,000-ft interval on a bathymetric map may miss a 3,000-ft mountain range within a 6,000-ft deep basin. Supplementary contours (dashed or dotted) are frequently shown between the regular contours in parts of a map where finer detail would otherwise be missed. USGS adopted standard contour intervals of 5, 10, 20, 40, and 80 ft for large- and intermediate-scale topographic maps. Standard intervals for the 1:250,000-scale series are 25, 50, 100, and 200 ft. Other contour intervals are used for larger scales and for maps of Alaska. (See "Future outlook" for how conversion to the metric system affects these intervals.)

The National Ocean Survey has established standards for using contour intervals on bathymetric maps and nautical charts based on the accuracy of measured depths, the spacing of the sounding lines, type of topographic detail encountered, and slope. In accordance with the International Hydrographic Bureau SP 44 and the NOS Hydrographic Manual (see app. 6.), continuous profile sounding lines are spaced at 1.0 cm (0.4 in) or less at the scale of the survey (not applicable to old surveys). Inshore at entrances to harbors, in areas adjacent to spits or rocky points, and in areas where major changes in bottom contours are found, the spacing is frequently reduced to 0.5 cm or less. The maximum allowable errors for depth measurements are:

Depth	*Allowable error*
0–20 m (0–11 fm)	0.3 m (1.0 ft).
20–100 m (11–55 fm)	1.0 m (0.5 fm).
Deeper than 100 m (55 fm)	1 percent of depth.

SCALE

The scale of a map is one of its most important characteristics. Scale is the mathematical relationship between a unit distance on the map and its corresponding distance on the ground, and may be expressed as a representative fraction or ratio; thus 1/24,000 (or 1:24,000) indicates that any linear measurement on the map represents 24,000 times that measurement on the ground. The same scale may also be shown by giving a unit distance on the map and its equivalent on the ground; for example, 1 cm on the map represents 24,000 cm (240 m) on the ground.

The terms "small scale" and "large scale" are relative and refer to ratios with large and small denominators; for example, 1:24,000 is a larger scale than 1:250,000. Figures 20-22 show the Stafford, Va., area at different scales, 1:250,000, 1:50,000, and 1:24,000. A bar scale (graphic scale) is normally placed in the margin or legend of a map to aid linear measurements. The bar scale is a line of convenient length which is subdivided and labeled with the distances (generally in feet, miles, and kilometers) that its parts represent on the Earth.

The amount of detail that can be shown on a map varies with the scale. Unexpected problems sometimes occur when the map scale is changed photographically. Enlargements can make symbolization too big; reduction can make them too small. Changing scale using a pantograph allows changes in symbol size and detail. Some problems in map scale reduction can be solved by removing some of the separation guides. The map user must consider the effect that a change in scale has on detail.

On large-scale maps, such as standard 7.5-min topographic quadrangles, the scale is generally con-

FIGURE 20.—Stafford, Va., area at 1:250,000 scale. From the USGS Washington, D.C.-Md.-Va., 1:250,000-scale topographic quadrangle map.

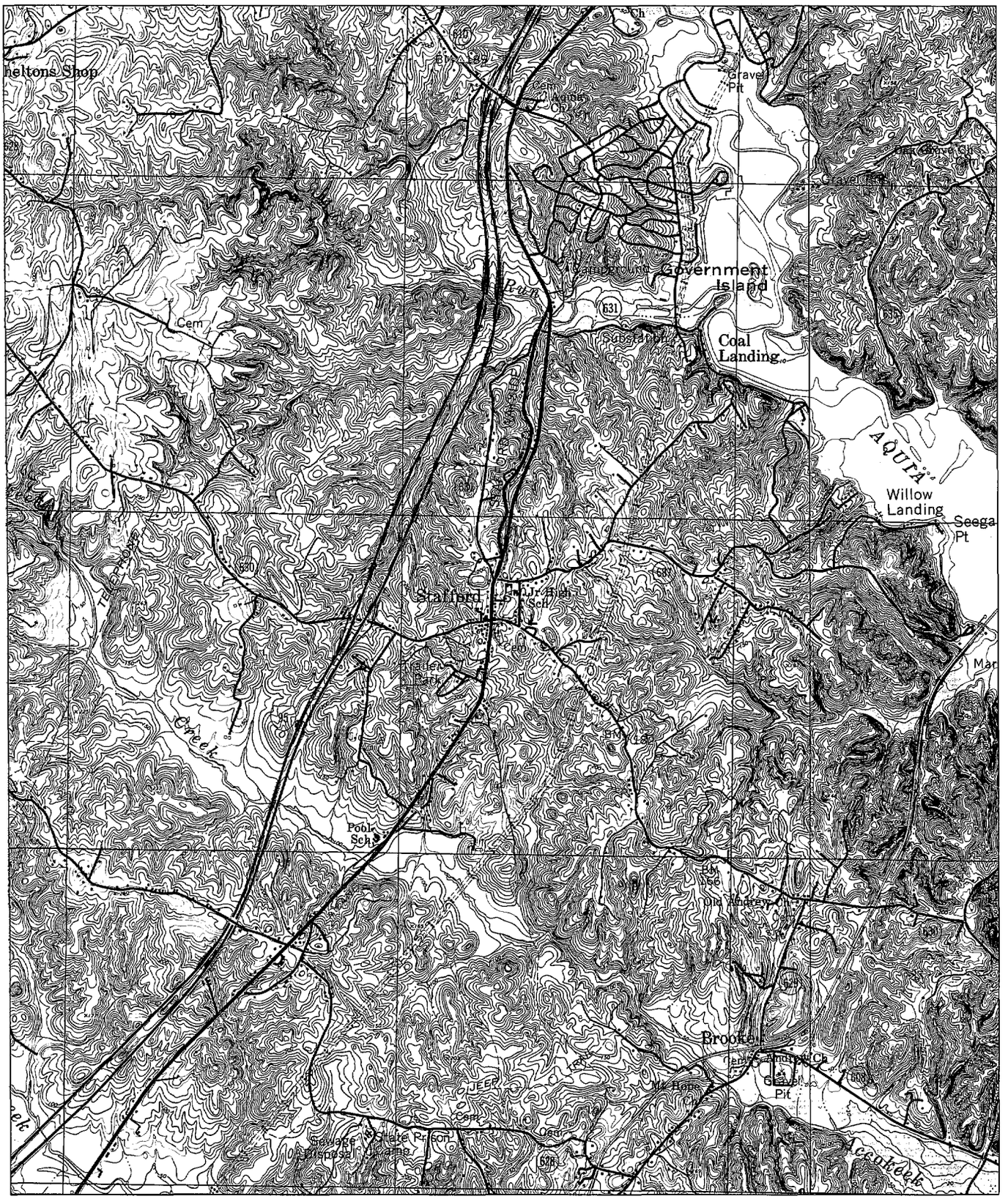


FIGURE 21.—Stafford, Va., area at 1:50,000 scale. From the USGS Stafford County, Va., topographic map.

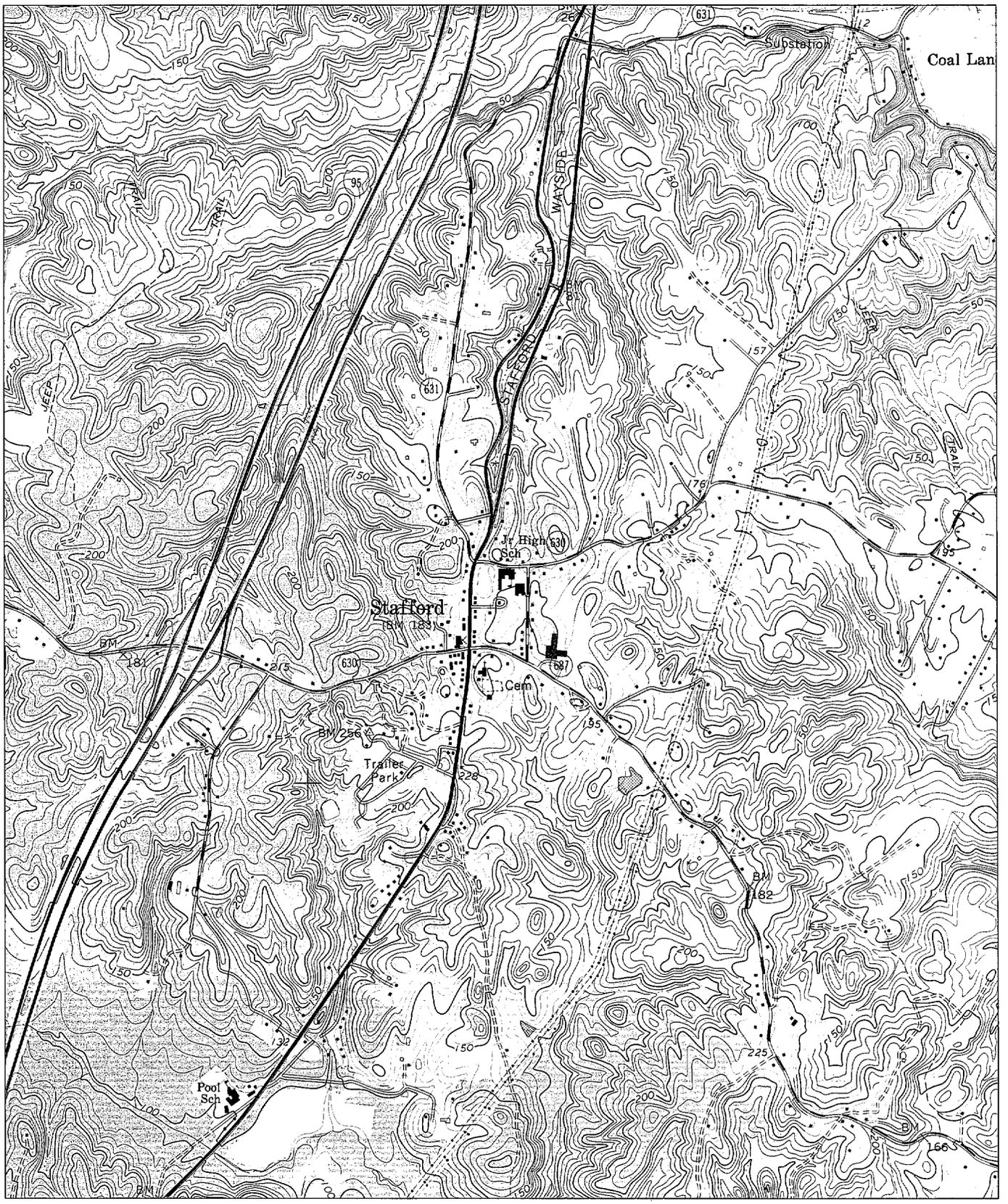


FIGURE 22.—Stafford, Va., area at 1:24,000 scale. From the USGS Stafford, Va., 7.5-min topographic quadrangle map.

sistent throughout the mapped area. However, on small-scale maps covering large areas, the scale can change gradually from one point to another. Depending on the projection, the nominal scale shown may refer to the center of the map or to one or two lines within the map. In a series of maps on the same projection (such as a quadrangle series), the nominal scale may apply to points or lines outside the actual map sheet but within a block of adjacent maps (as along standard parallels of the State plane coordinate systems). Scale variations seldom concern map users working with paper prints and ordinary rulers because paper distortion is likely to be greater than any scale change due to the projection.

ACCURACY

Map accuracy is closely related to map scale. The National Map Accuracy Standards (app. 6) were devised to provide cartographers with practical criteria for certifying their maps. Note that the standards cannot be stated in positive terms because no practical amount of testing can assure them.

The standard for horizontal accuracy requires that no more than 10 percent of the well-defined map points tested be in error more than 0.02 in at the publication scale. The tolerance corresponds to 40 ft (12.2 m) on the ground for 1:24,000-scale maps and about 100 ft (30.5 m) for 1:62,500-scale maps. The standard for vertical accuracy requires that no more than 10 percent of elevations interpolated from the contour lines be in error more than half the contour interval.

The standards for hydrography (app. 6) adopted by the Federal Government are those agreed upon by the International Hydrographic Organization (Accuracy Standards Recommended for Hydrographic Surveys, IHB Special Publication 44, Monaco, 1968). The standards are comparable to the National Map Accuracy Standards; however, they apply to the accuracy of basic control and the vertical datum rather than the graphic product. The basic acceptable horizontal position error is 0.05 in (0.127 cm) on the map, and the acceptable vertical error is 1 percent of the water depth.

REVISION

In a sense, accuracy implies currentness. The compilation date on a map indicates whether its content is likely to be up-to-date. Certain types of maps generally need little revision, especially those showing geology or relief. Major revisions are mainly needed for manmade features. Although minor revisions may be needed on nearly all map plates, most of the work concerns such features as new roads, buildings, and reservoirs. Changes also occur in the shape of the shoreline as a result of weathering and erosion. Since rate and amount of change vary greatly from area to area, not all maps are revised at definite intervals and to the same extent. Maps are selected for revision according to the requirements of users for current maps that meet modern standards.

CHARTS

Maps are defined in the glossary and in the section "Maps." A chart is a map on which highly specialized data have been included to serve a specific purpose—most commonly, aerial or marine navigation.

Various kinds and types of charts are prepared and published by NOS to promote safety in aerial and marine navigation. Because charts are important to the safety of life and property, accuracy sufficient for the intended purpose is basic in their data acquisition, design, and construction. Data invaluable for coastal activities are available as by-products from the sources used in chart production.

TYPES

In addition to aeronautical and nautical charts, airport obstruction, isogonic, isopach, and tidal current charts also present data of value in the coastal zone.

In designing and preparing charts for aerial navigation, features critical for the pilot and navigator are emphasized. Scale must be relatively small because of the flight speed. Terminal control area (TCA), sectional aeronautical, and world aeronautical charts are the most likely to contain coastal information of any value; they are produced at 1:250,000, 1:500,000, and 1:1,000,000-scale, respectively.

Nautical charts (app. 7, fig. 17) are classified according to the specific navigational phase each serves. For example, a sailing chart is appropriate for an ocean crossing, but a coast chart is needed as land is approached or for a voyage generally parallel to the coast. Harbor charts (app. 7, fig. 18) replace the coast charts as vessels enter restricted waterways with congested traffic and navigational hazards. Small-craft charts (app. 7, fig. 19) are convenient aboard small craft and other vessels where space is limited. The primary differences between these charts are scale and the features emphasized.

Isogonic charts show lines of equal variation of

the magnetic compass. They are compiled on a suitable base map, usually at a small scale, to show the variation of magnetic bearing and its annual rate of change. The basic data are obtained from field observations.

Tidal current charts (app. 7, fig. 24) provide information about the direction and speed of the current in a specific area at intervals through the entire tidal cycle. They are currently limited to major harbors, but coverage is being extended to important coastal waters. These charts can be valuable in coastal management operations.

With few exceptions, the charts mentioned are basically line drawings, relying on colors and symbols to emphasize significant features. A new series contains an orthophotomosaic base to present information usually shown by lines and symbols. Landmarks and similar features important to navigators are emphasized by color or symbolization.

FORMAT

The different charts are issued in various formats, depending principally on the intended use and the environment.

Aeronautical charts (app. 7, fig. 35) of value to coastal activities cover differing areas and are normally issued in accordion-folded format. Terminal Control Area charts, available only for selected major airports, cover the immediate vicinity. They vary little in physical size. Sectional aeronautical charts (scale 1:500,000) cover areas defined by geographic coordinates. They are printed on both sides, each covering 2° latitude and from 6° to 8° longitude. Because of the smaller scale (1:1,000,000), world aeronautical charts differ from sectional charts in the area covered. Each side covers 4° latitude and from 12° to 16° longitude. Airport obstruction charts cover approximately circular areas that include runway approach and departure zones, and are fairly uniform in dimensions. They are not published, but diazo copies are produced as needed.

Nautical charts vary widely in physical dimensions. They are designed to cover all or part of a body of water, or a section of coast between major ports or other important geographic features. When practical, coverage and dimensions of individual charts within each series are kept uniform for the convenience of the mariner. Depending on the area of coverage, isogonic charts vary widely in dimensions and are usually small scale. Tidal current charts are issued in bound volumes consisting of 12 or 13 diagrams prepared on the same base.

ACCURACY

Navigational charts are relied on for safety in two major transportation systems. Accuracy is therefore a major concern in production. Accuracy requirements vary with the kind of chart and are most critical for nautical charts.

Base maps that meet National Map Accuracy Standards provide the terrain data for aeronautical and nautical chart bases. Base maps for nautical charts, except in rare instances, are prepared by NOS from aerial photographs at a scale at least twice that of the final chart. When a new hydrographic survey is not scheduled, base topography is sometimes prepared directly at charting scale. Features critical to safe marine navigation are mapped to standards stricter than the national standards. For example, the shoreline (usually the mean high water line) and the mean low water line must be plotted within 0.5 mm (at map scale) of the true position, about 16 ft (4.9 m) on the ground at 1:10,000 scale, compared to 28 ft (8.5 m) under the national standards. Fixed aids to navigation and objects to be charted as landmarks must be plotted within 0.3 mm (about 10 ft.—3 m—at 1:10,000 scale) of true position. Similar accuracy is not required for aeronautical charts, but radio navigational aids and obstructions to safe operation of aircraft are located and charted with accuracy suitable for publication scale. Bases for all the other types of charts usually are prepared from the most suitable aeronautical or nautical charts.

SCALE AND CONTENT

Chart content depends on use and publication scale. At large scales more detail can be shown without congestion and legibility can be increased with larger symbols and type, but areal coverage is reduced. At small scales larger areas can be covered, but details must be omitted to avoid congestion.

Chart content of value in coastal activities varies with the kind of chart. In general, small-scale charts are suitable for general planning or for preparing gross inventories. For example, sectional aeronautical charts can be used for planning, but large-scale charts are of the greatest value to users. Scale can be changed by photographic or mechanical enlargement or reduction. However, enlargement is not recommended (except as an expedient) because errors made in producing the chart are enlarged so that the new larger scale chart is

not as accurate as its scale implies. Excessive photoenlargement can reduce legibility.

Some chart data may be common to several different kinds of charts. Shoreline, for example, is critically important to a ship's navigator and is always shown prominently on nautical charts. The shoreline is not as important to an aircraft navigator, and is therefore less prominently displayed on aeronautical charts.

REVISION

Obsolete contents can quickly destroy a chart's utility. Charts become obsolete mainly by the acts of man. Most aeronautical charts are revised semiannually; those of remote areas are revised less often. Changes usually affect airways data and navigational facilities and they therefore have little affect on the coastal zone. Nautical charts are usually revised annually for congested areas. Charts of remote areas are revised less often. Isogonic charts are recompiled every 5 years; isopach charts have no established revision schedule. Airport obstruction charts are revised every 3 years when resources permit—less frequently for some smaller airports with light traffic.

OVERPRINTS AND OVERLAYS

Overprinting is printing additional information on an already printed map. An overlay is a transparent or translucent photograph or drawing at the same scale as the base map made to register with it. The added information shows new details without changing the original.

USES

Overprints can be used to add new roads, buildings, dams, and reservoirs to original maps with a new press run. An extra color for revision data permits users to readily identify and evaluate changes (fig. 23). Overprints can also be used to direct attention to special data, such as by adding an arrow pointing to the particular feature.

Overlays can provide the same information as an overprint. However, they are used in conjunction with the original base map and do not become a permanent part of it. Sometimes several overlays are used in combination to show changes over a prolonged period.

Overlays are used in the planning and production of maps in the following typical ways:

- Compiling administrative data (costs, priorities, and locations of field parties).
- Planning control.
- Planning, procuring, and annotating photographs.
- Editing compilation manuscripts.
- Layout of contour numbers or soundings.
- Name placement and type style.

The USGS Land Use Data and Analysis (LUDA) program is an example of the effective use of overlays. The 1:250,000-scale topographic maps are used as bases to produce overlays (film positives) showing classification of land uses throughout the country. These film positives can be used in conjunction with the base map, or they can be combined with selected plates from the base map and published as land-use maps.

Figures 24 and 25 show a base map and a corresponding overlay locating oil and gas fields.

EXAMPLES OF OVERLAYS FOR COASTAL MANAGEMENT

Although overprints can be used in coastal mapping, overlays are usually more suitable. Examples are:

1. 100-year flood plain.
2. Soils.
3. Geology.
4. Population.
5. Estuarine studies.
   a. Discharge.
   b. Run-off.
   c. Physical characteristics.
      (1) Salinity.
      (2) Slope analysis.
6. Oceanography.
   a. Hydrodynamics.
   b. Sediments.
      (1) Bottom.
      (2) Near-surface.
   c. Currents.
      (1) Surface.
      (2) Subsurface.
   d. Tidal.
      (1) Location of station.
      (2) Data.
      (3) Bench marks.
7. Climatic studies.
   a. Temperature.
   b. Rainfall.
      (1) Seasonal.
      (2) Annual.

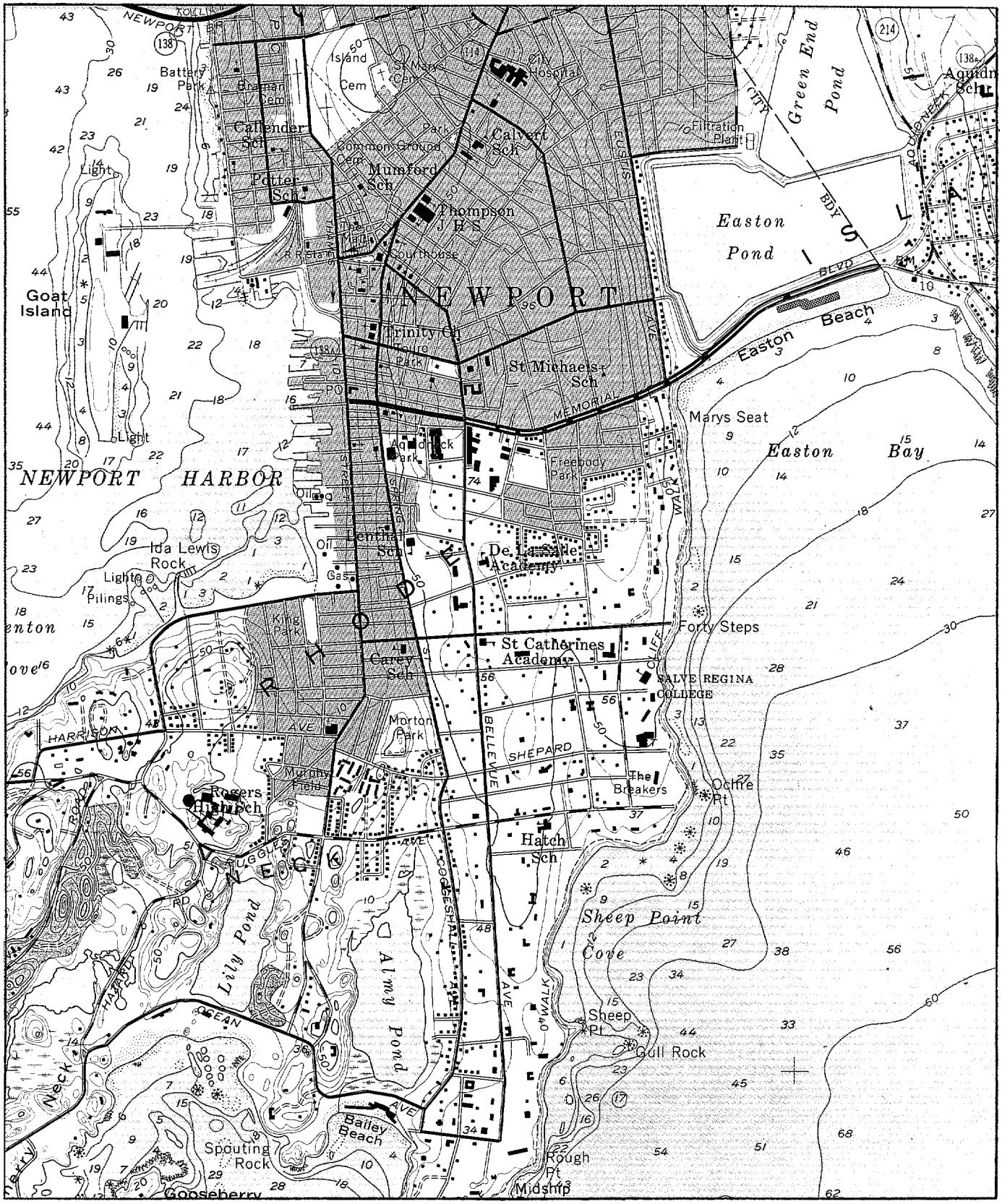


FIGURE 23.—Revision by purple overprint. From the USGS Newport, R.I., 7.5-min topographic quadrangle map.

8. Resources.
   a. Living.
   b. Nonliving.
9. Land use.
10. Wetlands.
    a. Vegetation.
    b. Limits.
11. Sanctuaries and refuges.
    a. Public.
    b. Private.
12. Historical and archeological sites.
13. Land ownership.
14. Recreation.
    a. Parks.
    b. Marinas.
15. Pollution.
    a. Sewage outfalls, ocean dumping, etc.
    b. Air.
    c. Noise.
16. Support services.
    a. Primary.
       (1) Sewage disposal.
       (2) Fresh water.
       (3) Solid waste disposal.
       (4) Electricity.
       (5) Transportation.
    b. Secondary.
       (1) Schools.
       (2) Hospitals.
       (3) Fire stations.
       (4) Police stations.

ADVANTAGES AND LIMITATIONS

Overprints can be used to keep a map from becoming cumbersome, in cases where more than one overlay would be required. However, because an overprint is a permanent part of a map, the entire map may have to be revised if the overprint becomes undesirable. Overprinting requires at least one additional press run and register may not be exact because of printing on top of published maps whose size may have changed with time. Overprinting must be limited to data that will not cause cluttered detail or confusion.

The greatest advantage of overlays is that they avoid crowding map detail. Overlays, in keeping with the feature-separation system, show unlimited types of information related to the same base map and to each other. Production costs for small quantities of overlays can be less than that for overprinting published maps. Nevertheless, overlays usually require special printing methods which consequently increase costs.

DATA EXTRACTION TECHNIQUES

It is not generally practical to produce maps meeting the individual needs of every user, nor is it practical to print every possible combination of map guides. Most maps contain more information than a user needs. Users must select data, and they may have to be content with less information than they need.

VISUAL EXTRACTION

Whoever reads a map is extracting data. Whether he is conscious of the fact or not, a user selects information that he wants and disregards the rest. A person who reads a map to find his way visually interprets the data and chooses his route. Some readers may be interested in interpreting every aspect of specific map features, by mental calculation or with aids such as scales, protractors, compasses, cartometers, and planimeters.

FEATURE SEPARATION

As explained in the section, "Photogrammetric mapping techniques," pressplates for multicolor maps are produced from color-separation guides. Each color can be broken down further. For example, one blue pressplate can be made from several blue guides—one for lakes and ponds, one for streams, and one for swamps.

There can be greater separation, as the following list shows:

1. Black.
   a. Transportation systems.
      (1) Major highways.
      (2) Secondary roads.
      (3) Tertiary roads.
      (4) Unimproved roads.
      (5) Trails.
      (6) Railroads.
      (7) Airports.
   b. Control.
   c. Labels (names).
   d. Culture.
      (1) Buildings.

FIGURE 24.—Overlay showing oil and gas fields. From the current land use plate of the Port Lavaca sheet, Environmental Geologic Atlas, Texas Bureau of Economic Geology.

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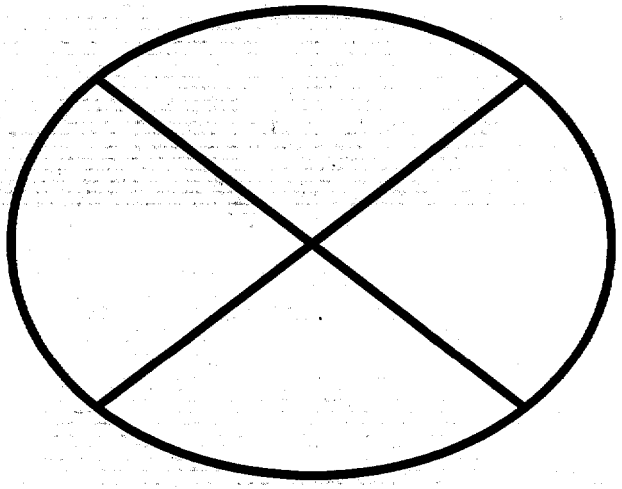

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Document ID: Map Overlay
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for map Figure 25

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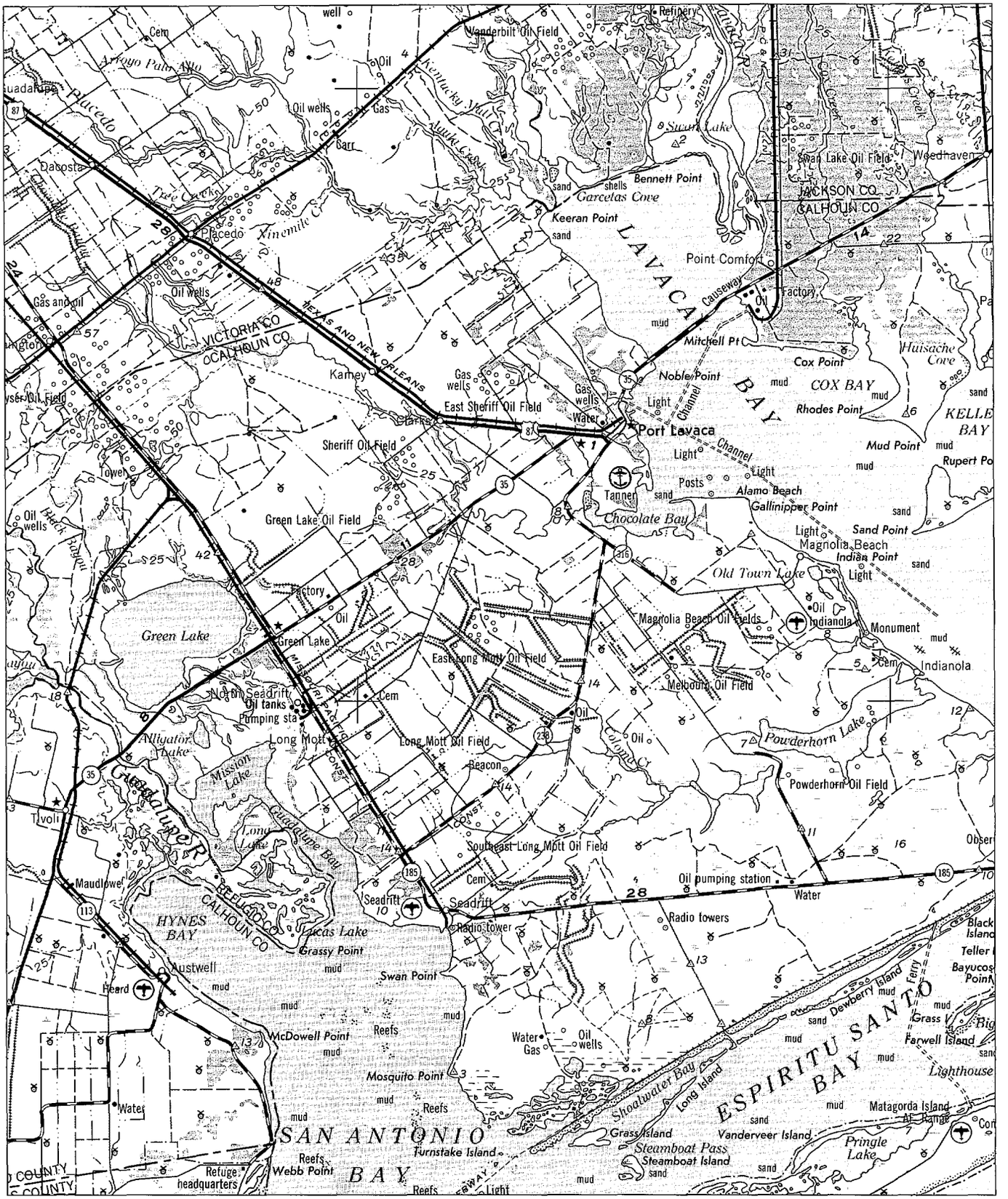


FIGURE 25.—Base map used with oil and gas overlay. From the USGS Beeville, Texas, 1:250,000-scale topographic quadrangle.

(2) Schools, churches, or cemeteries.
(3) Wells: oil, gas, water.
(4) Mines.
(5) Recreation areas.
(6) Marinas.
(7) Military reservations.
(8) Boundaries.
(9) Utilities.
(a) Power transmission lines.
(b) Pipelines.
(c) Telephone lines.

2. Brown.
   a. Contours.
      (1) Index contours.
      (2) Intermediate contours.
      (3) Supplemental contours.
   b. Sand.
      (1) Beach.
      (2) Dunes.
   c. Tailings.
   d. Levees.
   e. Strip mines.
3. Blue.
   a. Streams.
      (1) Perennial.
      (2) Intermittent.
   b. Ponds.
   c. Swamps.
   d. Inundated areas.
   e. Depth curves.
   f. Rice paddies.
4. Green.
   a. Woodland.
   b. Orchards.
   c. Scrub.
   d. Mangrove (symbol usually requires blue also).
   e. Vineyards.
5. Red.
   a. Major highway classification.
   b. Highway route numbers.
   c. Land lines.
   d. Urban tint.

Feature separation makes it possible for a map user to omit extraneous information and compile his data with ease. He can also select from the available guides and combine them in different ways. Changes in color combinations can be used in conjunction with feature separation to emphasize features of particular interest.

By feature separation, users can select maps of different scales from the same basic data. Decreasing the scale could cause data crowding, which can be avoided by removing a number of guides from the original map materials before reduction. For example, the primary and secondary road guides from several 1:24,000-scale feature-separated maps could be reduced and combined to compile a road map at 1:50,000 or 1:100,000 scale.

Figures 26 through 35 show various sample guides of a feature-separated map.

AUTOMATION

Computers and related machinery have eased the task of preparing maps and extracting map data. Although automated cartography still is in its infancy, some steps have been taken toward the goal of automation.

One approach is an automated coordinatograph, an instrument that plots points or lines by their x and y coordinates. Map data can be stored on punched cards or magnetic tapes to be recalled later and fed to the coordinatograph to plot a graphic from the stored information. The plotted data can be edited by correcting, deleting, or adding, and the edited data can be returned to storage. Some editing can be done automatically.

The usefulness of stored data can be enhanced by feature separation. Information can be stored in a data bank for selective recall. For example, a user can select all towns with a specific population or all contours within a stated range. The user can make his own feature separation from the available information and can combine separate features as he chooses. Sometimes he can select the scale or even the projection on which the graphic output is drawn.

If the user's goal is to compile statistics, he can extract the data from published maps and compile his lists manually. However, digitized map data can be retrieved in list form, eliminating the need for map interpretation and saving the time needed to compile a list by hand.

LAND USE AND LAND COVER CLASSIFICATION AND MAPPING

To make sound decisions, a modern nation needs adequate information about many complex, interrelated activities. Land use has become increasingly important in overcoming problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime and unique agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat. Land use and land cover

data are needed to analyze environmental processes and problems that must be understood to improve living conditions and standards or to maintain them at current levels.

Because of increasing emphasis on coastal development, various agencies are collecting land use and land cover data. The handbook should stimulate more uniformity and standardization in this data collection.

DEFINITION OF LAND USE

Although most people have a general idea of what constitutes "land use," the term is surrounded by confusion and misunderstanding. In the handbook, land use is comprised of two components—land use and land cover. Land use is activity related, that is, how a parcel of land or water is used. Land cover refers to vegetation or artificial structures on the land. The land cover of an area might be classified as nonforested wetland, whereas the actual use may be as a wildlife refuge, an oil extraction operation, or a waste disposal operation. Aircraft or satellite remote sensing used to map these data makes the distinction more important because activity is not always discernible. Land cover can be used sometimes instead of activity, but not always.

CLASSIFICATION THEORY AND PRINCIPLES

There are no ideal methods for inventorying or classifying natural resources or land use and land cover. A detailed inventory is adequate only for a relatively short time because land use patterns change with resource demands. Users of this type of information want an inventory that reflects change and satisfies most of their needs.

Depending on needs, a classification system can be oriented to people, resources, or both. Wide acceptance and use shows that a combination is preferred.

As remote sensing technology improves, more and more inventories are made with remote-sensor source material obtained from both aircraft and satellites. Whether it is an aerial photograph or a Landsat image in digital tape format, the source material requires interpretation for use in the inventory. Although supplemental material may be needed, the inventory will include only what can be identified with acceptable accuracy. Remote sensors using relatively inexpensive and generally unbiased source material provide many desirable features that may outweigh their limitations. The information they provide is gathered at a specified time and is usually obtained under conditions favorable to identification.

Classification systems can be derived inductively or deductively. In inductive classification, where observed features are recorded and categorized, the number of observable features is limited to what the remotely sensed source material can detect. Therefore, the classification and inventory will be limited. In deductive classification, where preconceived categories are established, using remote sensors limits some of the categories because they may not be observable. Usually, a miscellaneous category is used for unclassifiable features.

A land use and land cover classification system that can effectively use orbital and high-altitude remote-sensor data should meet the following criteria (Anderson, 1971).

- The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote-sensor data is at least 85 percent.
- The accuracy of interpretation for the categories is approximately equal.
- Repeatable or repetitive results are obtainable from one interpreter to another and from one time of sensing to another.
- The system is applicable over extensive areas.
- The categories permit vegetation and other land cover to be used to replace activity.
- The system is usable with remote-sensor data obtained at different times of the year.
- Subcategories that can be obtained from ground surveys or from larger scale or enhanced remote-sensor data are used.
- Aggregation of categories is possible.
- Comparison with future land use data is possible.
- Multiple uses of land are recognized when possible.

THE DECISION PROCESS

Clearly defined categories are rarely found in land use classification. Fine points, such as how to separate water and land, are debated. At first the class selection seems obvious, but becomes clouded when one considers problems of seasonally wet areas or coastal tidal flats, or marshes, swamps, and bogs with various types of plants providing some degree of crown cover.

Most types of land use classified in the inventory

FIGURE 26

Roads. Primary roads are shown in red; secondary roads are in black. Primary roads could have been shown in black as in figure 29.

Guides included:

1. Primary roads ..... red
2. Secondary roads ..... black
3. Red lettering ..... red

25
35
1
2
165
165

FIGURE 27

Culture. Primary and secondary culture are combined on one guide. The secondary culture can be eliminated, if desired.

Guides included:

1. Primary culture ..... black
2. Secondary culture ..... black

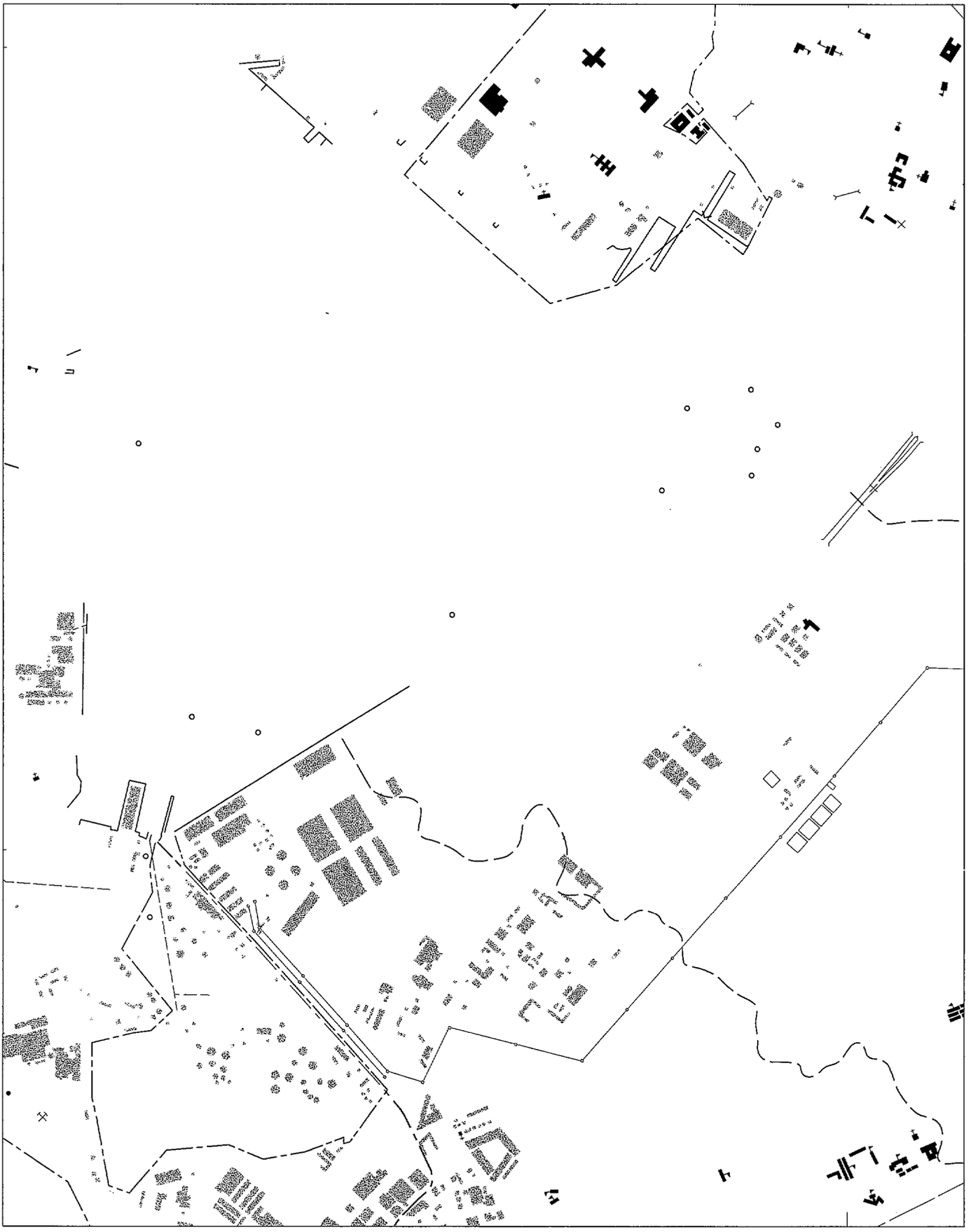


FIGURE 28

Urban tint. House omission area shown in gray. Feature separation allows users to change colors. For example, red could be used.

Guide included:

1. Urban tint ..... black

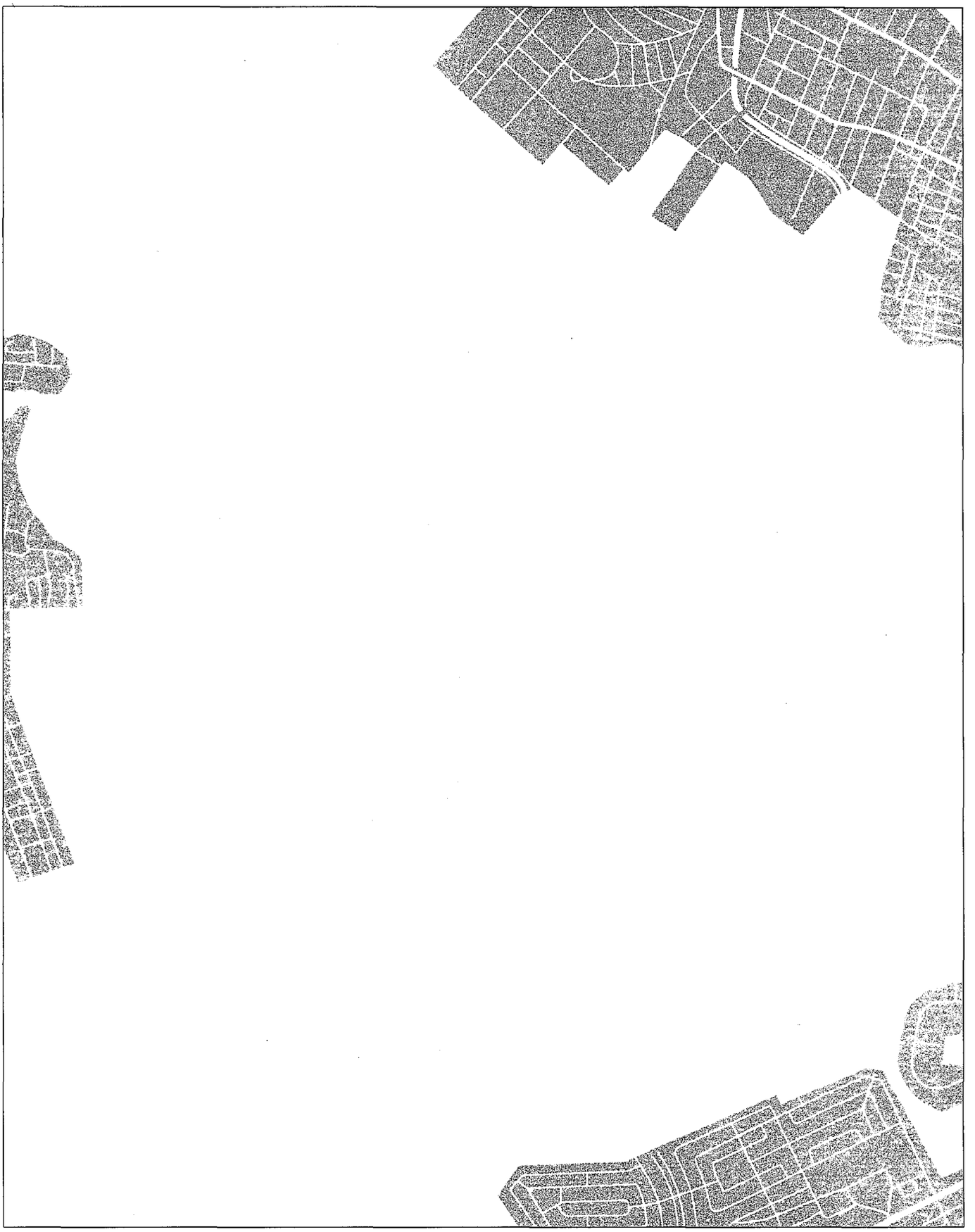


FIGURE 29

Black lettering. Names shown in black can be deleted by removing one guide or can be used in combination with other black guides. Another possibility is combining black and blue guides (including blue names, fig. 32) to make a monocolored map.

Guide included:

1. Black lettering ..... black

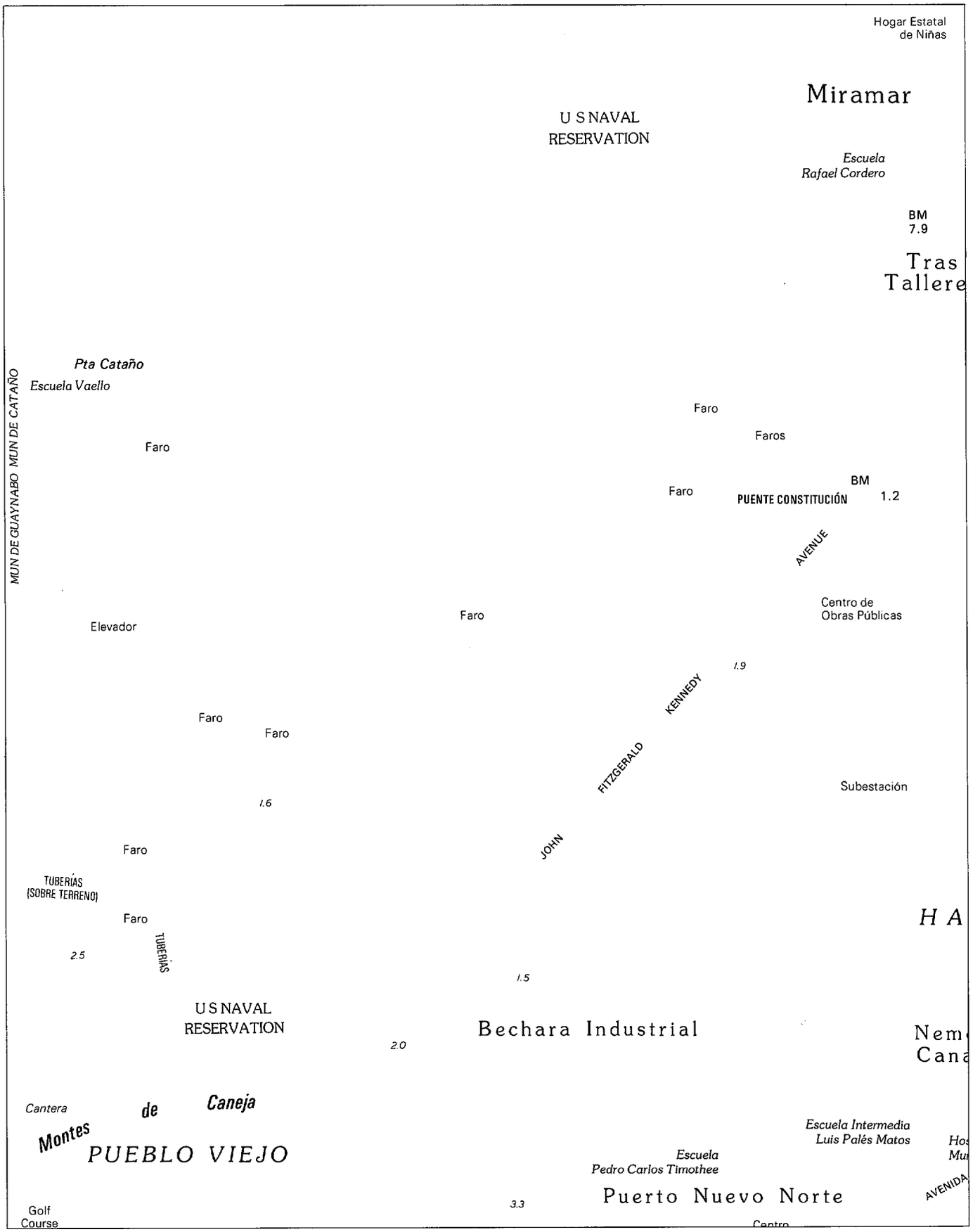

Hogar Estatal
de Niñas
Miramar
U S NAVAL
RESERVATION
Escuela
Rafael Cordero
BM
7.9
Tras
Tallere
Pta Cataño
Escuela Vaello
MUN DE GUAYNABO MUN DE CATAÑO
Faro
Faro
Faros
Faro
BM
PUENTE CONSTITUCIÓN
1.2
AVENUE
Centro de
Obras Públicas
Elevador
Faro
1.9
KENNEDY
Faro
Faro
FITZGERALD
Subestación
1.6
JOHN
Faro
TUBERÍAS
(SOBRE TERRENO)
Faro
H A
TUBERÍAS
2.5
1.5
U S NAVAL
RESERVATION
Bechara Industrial
2.0
Nem
Cana
Cantera
de
Caneja
Montes
PUEBLO VIEJO
Escuela Intermedia
Luis Palés Matos
Escuela
Pedro Carlos Timothee
Puerto Nuevo Norte
AVENIDA
Golf
Course
3.3
Centro

FIGURE 30

Combined black. All black plates are combined into a single guide. Primary roads shown in red in figure 25 are shown in solid black here.

Guides included:

1. Base format ..... black
2. Primary roads ..... black
3. Secondary roads ..... black
4. Primary culture ..... black
5. Secondary culture ..... black
6. Urban tint ..... black
7. Sand ..... black
8. Black lettering ..... black
9. Road lettering ..... black

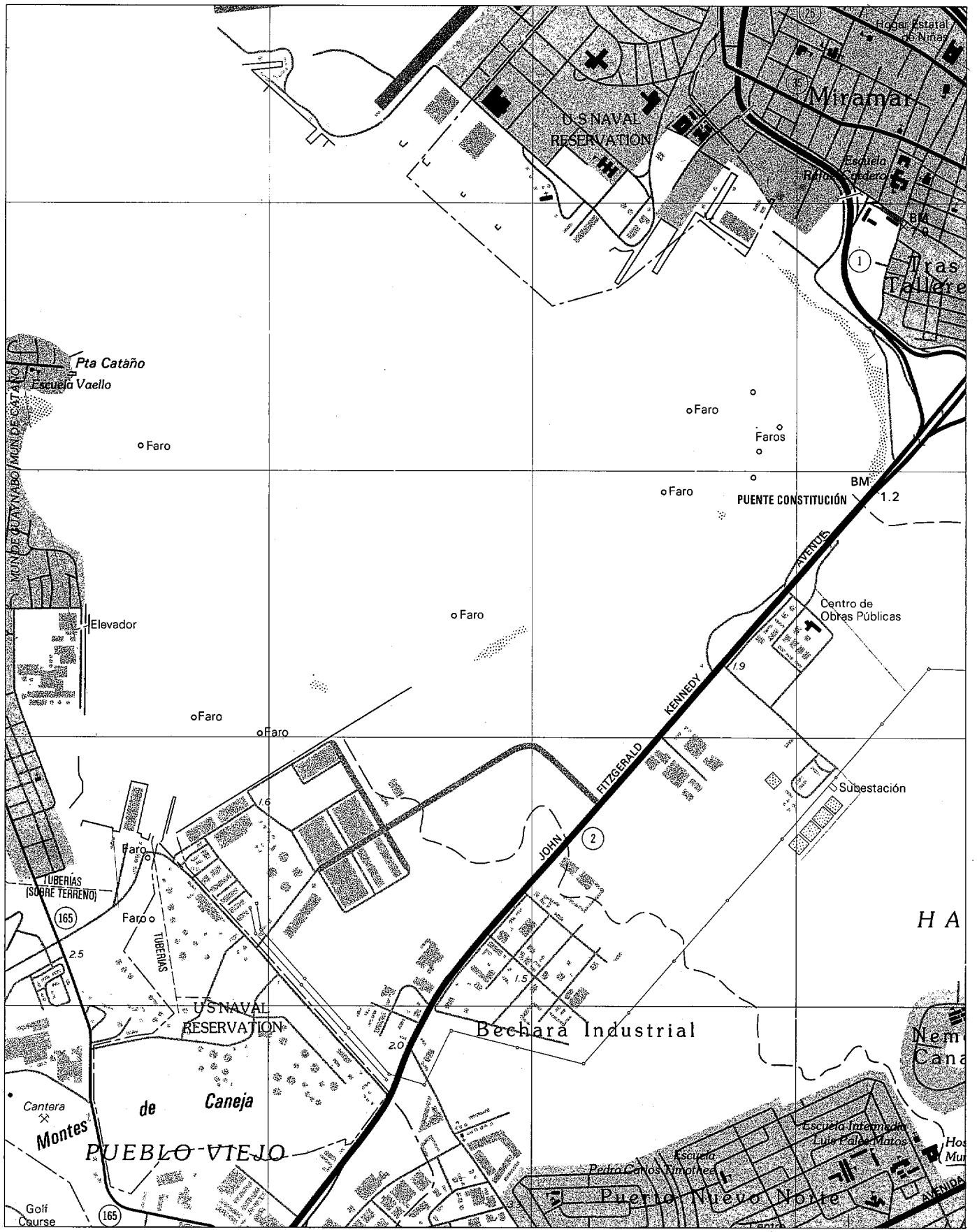

Hogar Estatal de Niñas
Miramar
U S NAVAL RESERVATION
Escuela Rafael Cordero
BM 7.9
Tras Tallere
Pta Cataño
Escuela Vaello
MUN DE CATAÑO
MUN DE GUAYNABO
Faro
Faros
BM 1.2
PUENTE CONSTITUCIÓN
AVENUE
Centro de Obras Públicas
Elevador
KENNEDY
FITZGERALD
JOHN
Subestación
TUBERÍAS (SOBRE TERRENO)
TUBERÍAS
165
2.5
1.6
1.9
1.5
2.0
U S NAVAL RESERVATION
Bechara Industrial
Cantera
Montes de Caneja
PUEBLO VIEJO
Golf Course
Escuela Intermedia Luis Palés Matos
Escuela Pedro Carlos Timothee
Puerto Nuevo Norte
AVENIDA

FIGURE 31

Drainage. Drainage usually includes any blue linework such as channel outlines, shorelines, and depth curves as well as streams. Wide streams and open bodies of water require a blue tint in addition to the linework shown here.

Guide included:

1. Drainage ..... blue

FIGURE 32

Open water. The blue tint is usually shown with the drainage guide, but here the tint is on a separate guide so that the drainage can be used alone.

Guide included:

1. Open water ..... blue

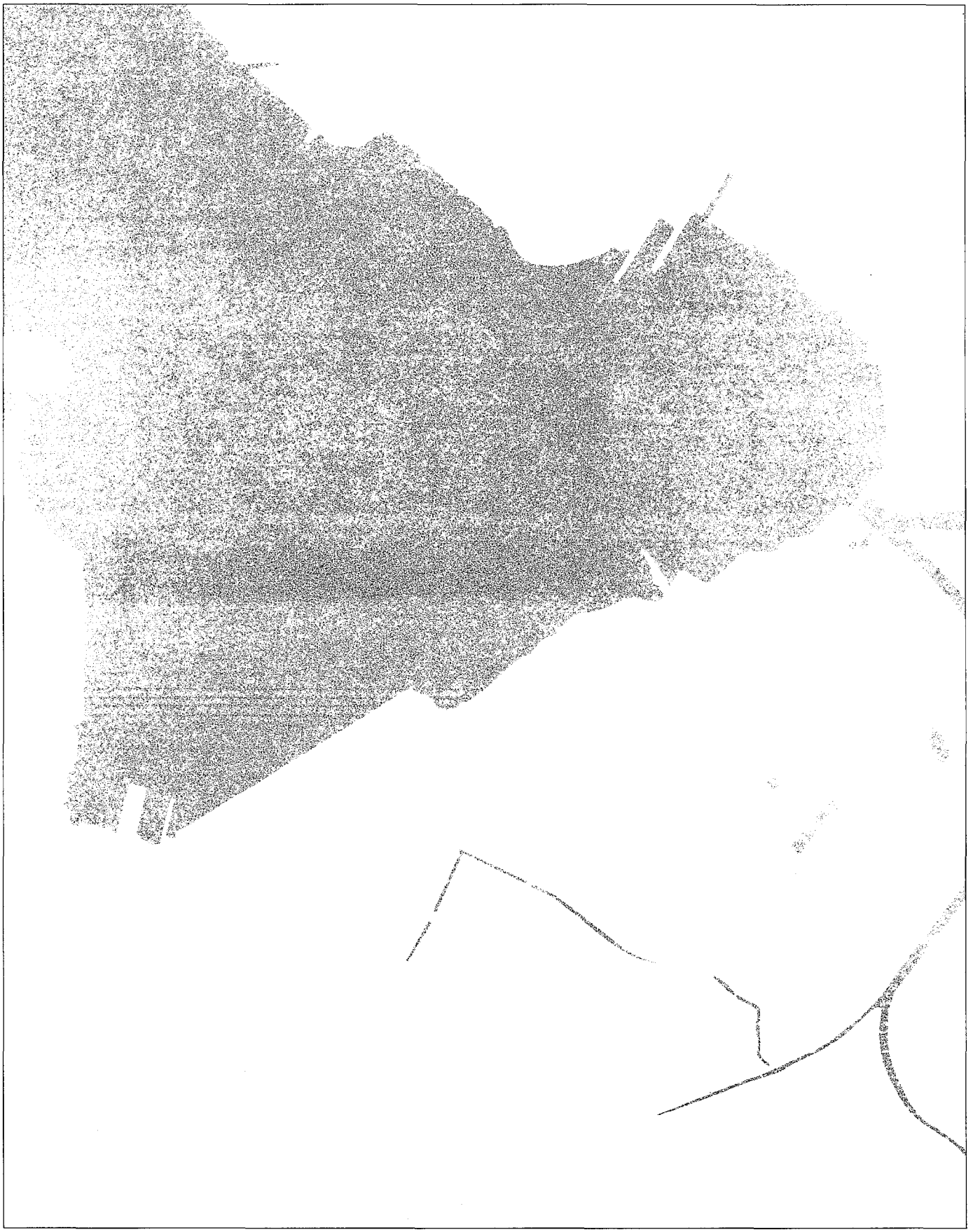


FIGURE 33

Blue lettering. Blue names can be combined with other blue guides, combined with black and blue guides in a monocolored map, or deleted.

Guides included:

1. Blue lettering ..... blue

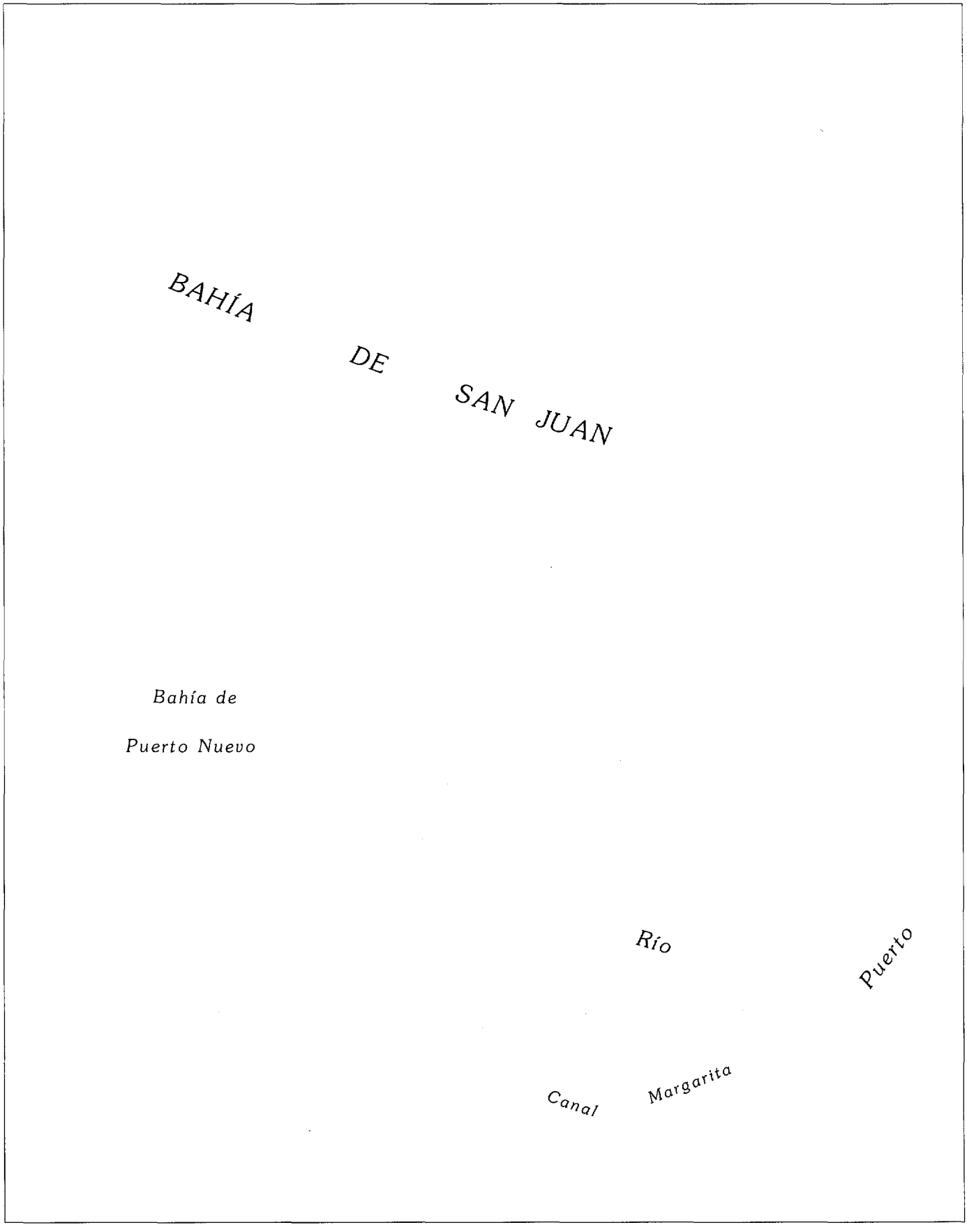

BAHÍA
DE
SAN JUAN
Bahía de
Puerto Nuevo
Río
Puerto
Canal
Margarita

FIGURE 34

Combined black, blue, and contours. All of the black guides (primary roads and road lettering could have been shown in red), all of the blue guides, and contour guides are combined. Having three contour guides facilitates scale reduction, since guides may be deleted as necessary.

Guides included:

1. Base format ..... black
2. Primary roads ..... black
3. Secondary roads ..... black
4. Primary culture ..... black
5. Secondary culture ..... black
6. Urban tint ..... black
7. Sand ..... black
8. Black lettering ..... black
9. Road lettering ..... black
10. Index contours ..... brown
11. Intermediate contours ..... brown
12. Supplementary contours and levees ..... brown
13. Contour numbers ..... brown
14. Drainage ..... blue
15. Open water ..... blue
16. Mangrove ..... blue
17. Blue lettering ..... blue
18. Depth curve numbers ..... blue

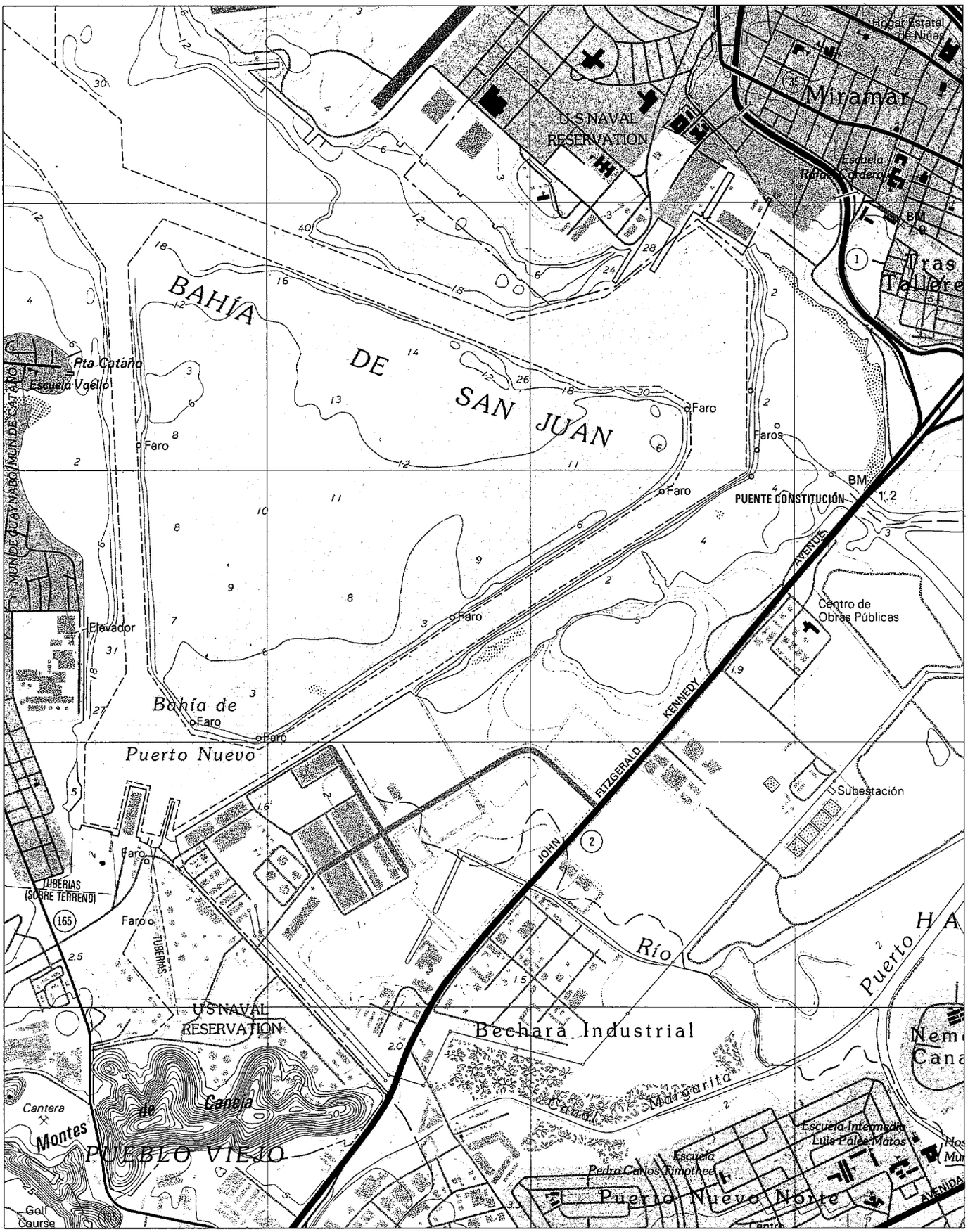

Hogar Estatal de Niñas
Miramar
U S NAVAL RESERVATION
Escuela Rafael Cordero
BM 7.0
Tras Talleres
BAHÍA DE SAN JUAN
Pta Cataño
Escuela Vaello
MUN DE GUAYNABO
MUN DE CATAÑO
Faro
Faros
BM 1.2
PUENTE CONSTITUCIÓN
AVENUE
Centro de Obras Públicas
Elevador
Bahía de Puerto Nuevo
JOHN FITZGERALD KENNEDY
Subestación
TUBERIAS (SOBRE TERRENO)
165
TUBERIAS
Río
Puerto
U S NAVAL RESERVATION
Bechara Industrial
Canal Margarita
Cantera
Montes de Caneja
PUEBLO VIEJO
Escuela Intermedia Luis Palés Matos
Escuela Pedro Carlos Timothee
Puerto Nuevo Norte
AVENIDA
Golf Course

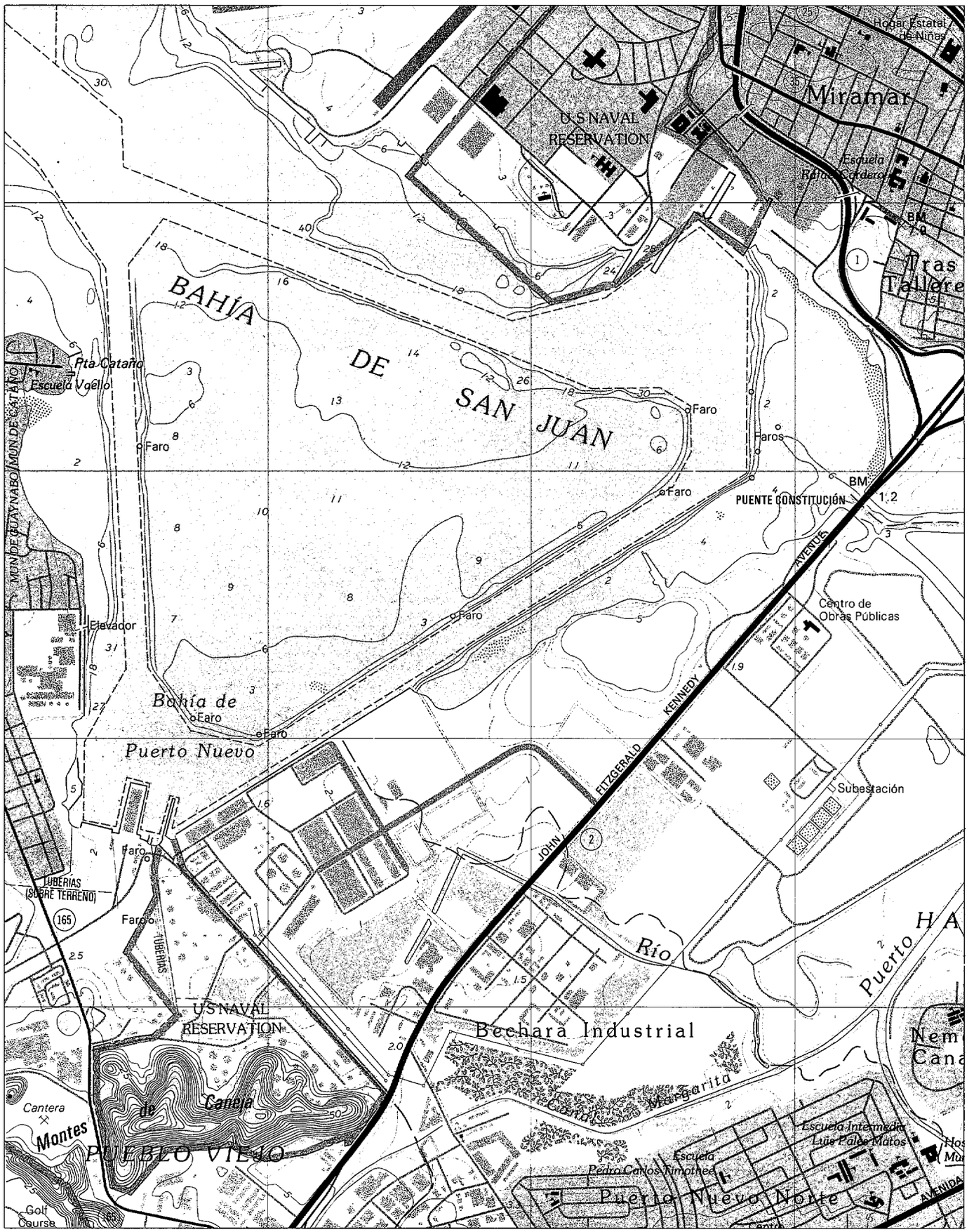
FIGURE 35

Published map, San Juan, P.R., 1:20,000-scale. All guides are shown in standard colors.

Guides included:

1.	Base format	black
2.	Secondary roads	black
3.	Primary culture	black
4.	Secondary culture	black
5.	Urban tint	black
6.	Sand	black
7.	Black lettering	black
8.	Index contours	brown
9.	Intermediate contours	brown
10.	Supplementary contours and levees	brown
11.	Boundary tint	brown
12.	Contour numbers	brown
13.	Drainage	blue
14.	Open water	blue
15.	Blue lettering	blue
16.	Mangrove	blue
17.	Woodland[1]	blue
18.	Depth curve numbers	blue
19.	Primary roads	red
20.	Red lettering	red
21.	Base tint	yellow
22.	Cemetery and park tint	yellow
23.	Boundary tint	yellow
24.	Woodland[1]	yellow

[1] The woodland plate is printed in both blue and yellow to form a green tint that represents woodland (mangrove where the blue mangrove symbol also appears).


Hogar Estatal de Niñas
Miramar
U.S NAVAL RESERVATION
Escuela Rafael Cordero
BM
Tras Talleres
BAHÍA DE SAN JUAN
Pta Cataño
Escuela Vgello
MUN DE GUAYNABO/MUN DE CATAÑO
Faro
Faros
PUENTE CONSTITUCIÓN
AVENUE
Centro de Obras Públicas
Elevador
Bahía de
Puerto Nuevo
KENNEDY
FITZGERALD
JOHN
Subestación
TUBERIAS (SOBRE TERRENO)
TUBERIAS
Río
Puerto H A
U.S NAVAL RESERVATION
Bechara Industrial
Cantera
Montes
de
Canela
PUEBLO VIEJO
Escuela Intermedia Luis Palés Matos
Escuela Pedro Carlos Timothee
Puerto Nuevo Norte
Golf Course

appear in a continuous gradation from 0 (no use) to 100 (full use). The problem is where to place boundaries. How large an area should have a particular use before that use is acknowledged? How are the problems resolved in areas having heterogeneous mixtures of equally significant land use? Such questions are not easily answered.

Documentation and description of classification criteria help identify where on the gradation scale a land use change occurs. If the size of an area is a deciding factor, the size should be stated on the basis of the information source and the decision criteria.

For example, on land where agriculture has ceased there are various stages of reforestation. Much of the land cannot be properly classified as forestland because there is gradation of cover beginning with woody plant materials that start to grow when the land is dropped from crop production. There are areas with no discernible line where low sparse bush growth changes to stands of marketable timber. In the past, the solution has hinged on well-documented decisions about where the line should be drawn. Remote-sensing platforms can help by providing a vantage point that is not available on the ground.

The above example reemphasizes the significance of user needs in developing a classification system. The interest of commercial foresters differs from that of planners or transportation engineers. Expected use usually determines where boundaries are drawn.

Another problem is the interface of land uses. An example is the large area of suburban-influenced land around urban areas. Factors, including information sources, available funds, significance of land use area, and minimum map units, are used to decide how the land use should be classified and mapped. Similarly, in areas of multiple uses (such as grazed woodlands), several factors are considered. Sometimes a separate class is used to avoid making a decision favoring one class over the other.

Problems also arise in satisfying inventory users when there is a conflict between cover and activity. Many recreational activities are in this category. For example, hunting is a common recreational land use, but most hunting is done on land that is better classified as forestland, rangeland, or agricultural land. Consequently, hunting as a land use may require a different classification. Hunting does not easily fit into an inventory based on remote-sensing sources.

Sometimes problems of dual land use can be solved by classifying the land according to greatest use, significant information, or point information sources. Areas with multiple uses can be mapped

TABLE 3.—*USGS land use and land cover classification system for use with remote-sensor data*

LEVEL I		LEVEL II	
1	Urban or built-up land	11	Residential.
		12	Commercial and services.
		13	Industrial.
		14	Transportation, communications, and utilities.
		15	Industrial and commercial complexes.
		16	Mixed urban or built-up land.
		17	Other urban or built-up land.
2	Agricultural land	21	Cropland and pasture.
		22	Orchards, groves, vineyards, nurseries, and ornamental horticultural areas.
		23	Confined feeding operations.
		24	Other agricultural land.
3	Rangeland	31	Herbaceous rangeland.
		32	Shrub and brush rangeland.
		33	Mixed rangeland.
4	Forest land	41	Deciduous forest land.
		42	Evergreen forest land.
		43	Mixed forest land.
5	Water	51	Streams and canals.
		52	Lakes.
		53	Reservoirs.
		54	Bays and estuaries.
6	Wetland	61	Forested wetland.
		62	Nonforested wetland.
7	Barren land	71	Dry salt flats.
		72	Beaches.
		73	Sandy areas other than beaches.
		74	Bare exposed rock.
		75	Strip mines, quarries, and gravel pits.
		76	Transitional areas.
		77	Mixed barren land.
8	Tundra	81	Shrub and brush tundra.
		82	Herbaceous tundra.
		83	Bare ground tundra.
		84	Wet tundra.
		85	Mixed tundra.
9	Perennial snow or ice	91	Perennial snowfields.
		92	Glaciers.

efficiently by putting each use on a separate overlay, thus retaining the basic data for map users who are not interested in the combination of uses.

In other cases, confusion over large areas of multiple land uses can be clarified by including general statements or guidelines as marginal information. Technically, grazing is rangeland use whether it is in the East or the West. However, management practices in the East are substantially different from those in the West, and it is hard to resolve the difference in classification description. Deciding where the term "range" is to be used instead of the term "pasture" will resolve most of the conflict.

CLASSIFICATION SYSTEMS

Land use classification schemes are abundant. Some are very general; others are highly detailed, having as many as four levels. It is not practical to discuss all classification systems here. The examples included in the handbook were chosen because of their wide acceptance or appropriateness.

National in scope, the USGS land use classification system (Anderson and others, 1976) relies mostly on remote-sensor data. The system was developed for Federal and State agencies that needed a current overview of land use and land cover with uniform categories at the more generalized levels I and II, and that is receptive to data from satellite and aircraft remote sensors. The system incorporates features from widely used classification systems that are compatible with data derived from remote sensing. The classification is intentionally left open-ended so that Federal, regional, State, and local agencies can be flexible in developing more detailed classifications at the third and fourth levels to meet their needs, and so that they can remain compatible with each other and the national system. The revised system incorporates the results of extensive testing and reviewing of categorization and definitions. The classification is shown in table 3.

An example of how the USGS classification system can be used as a framework for more detailed categorization is the system that was developed in the Land Inventory and Monitoring Division of the Soil Conservation Service (table 4). Categories such as cropland in conservation use, or temporarily idle and grazed and nongrazed commercial and noncommercial forestland cannot be identified solely from remote-sensor data. Therefore, other sources of information are needed.

Many States have developed and used their own classification system or have modified existing sys-

TABLE 4.—*Land use classification system developed for the Soil Conservation Service*

1. Urban or built-up land.
   - 1.1 Roads and railroads.
   - 1.2 Residential, commercial, industrial, mixed, and other.
2. Agricultural land.
   - 2.1 Nonirrigated cropland.
     - 2.11 Row crops.
     - 2.12 Close grown crops.
     - 2.13 Summer fallow.
     - 2.14 Rotation hay and pasture.
     - 2.15 Hayland.
     - 2.16 In conservation use.
     - 2.17 Temporarily idle.
   - 2.2 Irrigated cropland.
     - 2.21 Row crops.
     - 2.22 Close grown crops.
     - 2.23 Summer fallow.
     - 2.24 Rotation hay and pasture.
     - 2.25 Hayland.
     - 2.26 In conservation use.
     - 2.27 Temporarily idle.
   - 2.3 Nonirrigated pasture.
   - 2.4 Irrigated pasture.
   - 2.5 Nonirrigated orchards, groves, vineyards, nurseries, and ornamental horticultural areas.
   - 2.6 Irrigated orchards, groves, vineyards, nurseries, and ornamental horticultural areas.
   - 2.7 Confined feeding operations.
   - 2.8 Other agricultural land.
3. Rangeland.
   - 3.1 Herbaceous range.
   - 3.2 Shrub-brushland range.
   - 3.3 Mixed range.
4. Forest land.
   - 4.1 Deciduous forest.
     - 4.11 Grazed commercial forestland.
     - 4.12 Not grazed commercial forestland.
     - 4.13 Grazed noncommercial forestland.
     - 4.14 Not grazed noncommercial forestland.
   - 4.2 Evergreen forest.
     - 4.21 Grazed commercial forestland.
     - 4.22 Not grazed commercial forestland.
     - 4.23 Grazed noncommercial forestland.
     - 4.24 Not grazed noncommercial forestland.
   - 4.3 Mixed forest.
     - 4.31 Grazed commercial forestland.
     - 4.32 Not grazed commercial forestland.
     - 4.33 Grazed noncommercial forestland.
     - 4.34 Not grazed noncommercial forestland.
5. Water.
   - 5.1 Ponds, lakes, reservoirs, 2.5 to 40 acres in size.
   - 5.2 Ponds, lakes, and reservoirs more than 40 acres in size.
   - 5.3 Canals, streams, and rivers 165 to 660 ft wide.
   - 5.4 Canals, streams, and rivers more than 660 ft wide.
6. Wetlands.
   - 6.1 Deciduous forest wetlands.
   - 6.2 Evergreen forest wetlands.
   - 6.3 Mixed forest wetlands.
   - 6.4 Nonforested wetlands.

TABLE 4.—*Continued*

7. Barren land.
   - 7.1 Salt flats.
   - 7.2 Beaches and mudflats.
   - 7.3 Nonbeach sandy areas.
   - 7.4 Exposed rock.
   - 7.5 Stripmines, quarries, sand and gravel pits.
   - 7.6 Mixed.
   - 7.7 Other.
8. Tundra.
   - 8.1 Shrub and brush tundra.
   - 8.2 Herbaceous tundra.
   - 8.3 Bare ground tundra.
   - 8.4 Wet tundra.
   - 8.5 Mixed tundra.
9. Perennial snow and ice.
   - 9.1 Perennial snowfields.
   - 9.2 Glaciers.

tems. Florida needed a coordinated land-data classification system as a first step in establishing an overall information program. A committee of representatives from the State land-use and resource-planning agencies compiled a workable system. They added level III categories to the USGS classification system (table 5) to provide additional detail that was needed for various land use planning and management activities in Florida.

The "Standard Land Use Coding Manual," published in 1965, achieved greater uniformity in classifying land use. The coding manual was released jointly by the Urban Renewal Administration and the Bureau of Public Roads. It incorporated the "Standard Industrial Code" prepared by the Bureau of the Budget and published in 1957.

TABLE 5.—*Florida Land Use/Cover Classification System*

Level I	*Level II*	*Level III*
100 Urban or built-up land.	110 Residential	111 Single unit, low density (less than 2 DUPA [1]).
		112 Single unit, medium density (2–5 DUPA).
		113 Single unit, high density (6 & over DUPA).
		114 Mobile homes, medium density (less than 6 DUPA).
		115 Mobile homes, high density (6 & over DUPA).
		116 Multiple dwelling, low-rise (2 stories or less) DUPA may be designated by user.
		117 Multiple dwelling, high-rise (3 stories or more) DUPA may be designated by user.
		118 Mixed residential.
		119 Residential under construction.
	120 Commercial and services	121 Retail sales and services.
		122 Wholesale sales and services, including trucking & warehousing (except warehousing associated with industrial use).
		123 Offices and professional services.
		124 Hotels and motels.
		125 Cultural and entertainment.
		126 Oil & gas storage facilities (except where associated with industrial use).
		127 Mixed commercial and services.
		128 Commercial under construction.
	130 Industrial	131 Light industrial.
		132 Heavy industrial.
		133 Industrial under construction.
	140 Transportation	141 Airports, including runways, parking areas, hangers, and terminals.
		142 Railroads, including yards and terminals.
		143 Bus and truck terminals.
		144 Major roads and highways.
		145 Port facilities.
		146 Navigable waterways.
		147 Auto parking facilities (when not directly related to another land use).

[1] DUPA—Gross dwelling units per acre.

NOTE.—At level II, low, medium, and high residential density may be designated as in level III, based upon visual impact assessment from stereo viewing, and the resolution of the level II imagery. Numbers shown may be used for computer programing and mapping designations.

TABLE 5.—*Florida Land Use/Cover Classification System—Continued*

Level I	*Level II*	*Level III*
		148 Oil and gas long-distance transmission pipeline.
		149 Transportation facilities under construction.
	150 Communications and utilities	151 Electrical power facilities.
		152 Major long-distance transmission lines.
		153 Broadcasting or transmission towers.
		154 Water supply plants (including pumping stations).
		155 Sewage treatment facilities.
		156 Solid waste disposal site.
		157 Other communication facilities.
		158 Other utility facilities.
		159 Communication and utilities under construction.
	160 Institutional	161 Educational facilities, including colleges, universities, high schools, and elementary schools.
		162 Religious facilities, excluding schools.
		163 Medical and health care facilities.
		164 Correctional facilities.
		165 Military facilities.
		166 Governmental, administrative, and service facilities.
		167 Cemeteries.
		168 Institutional facilities under construction.
		169 Other.
	170 Recreational	171 Swimming beaches and shores.
		172 Golf courses.
		173 Parks, zoos.
		174 Marinas.
		175 Stadiums.
		176 Fairgrounds.
		177 Community recreational facilities.
		178 Racing tracks.
		179 Other recreational.
	180 Mixed—any mixture of urban or built-up where no single use predominates.	
	190 Open land and other	191 Undeveloped land within urban areas.
		192 Inactive land with street patterns but without structures.
		193 Land undergoing active development without indication of intended use.
200 Agriculture	210 Cropland and pastureland	211 Row crops.
		212 Field crops.
		213 Improved pasture.
	220 Orchards, groves (except citrus), vineyards, nurseries, and ornamental horticultural areas.	221 Tropical fruit orchards.
		222 Deciduous fruit orchards.
		223 Nurseries.
		224 Ornamental horticultural areas.
		225 Vineyards.
	230 Citrus groves	231 Orange.
		232 Grapefruit.
		233 Other citrus.
	240 Confined feeding operations	241 Cattle.
		242 Poultry.
		243 Hogs.
		244 Other.
	250 Specialty farms	251 Horse farms.
		252 Kennels.

TABLE 5.—*Florida Land Use/Cover Classification System—Continued*

Level I	*Level II*	*Level III*
		253 Mariculture.
		254 Other.
	260 Other agriculture.	261 Inactive agricultural lands.
		262 Other.
300 Rangeland	310 Grassland	
	320 Shrub and brushland	321 Palmetto prairies.
		322 Coastal scrub.
		323 Other scrub and brush.
	330 Mixed rangeland	
400 Forested uplands	410 Coniferous forest	411 Pine flatwoods.
		412 Longleaf pine.
		413 Sand pine scrub.
		414 Other.
	420 Hardwood forest.	421 Xeric oak.
		422 Other hardwood.
	430 Mixed forest.	431 Mixed coniferous-hardwood forest.
	440 Planted forest	441 Coniferous.
		442 Hardwood.
	450 Clear-cut areas	
500 Water	510 Streams and canals	
	520 Lakes	
	530 Reservoirs	
	540 Bays and estuaries	
	550 Open marine waters	
	560 Open water areas	561 Marine grass beds.
		562 Coral reefs.
		563 Oyster beds.
600 Wetlands	610 Wetland-coniferous forest	611 Cypress.
		612 Pond pine.
	620 Wetland-hardwood forest.	621 Freshwater swamp.
		622 Saltwater swamp (mangroves).
	630 Wetland-mixed forest.	631 Mixed coniferous-hardwood forest.
	640 Wetland-vegetated non-forested	641 Freshwater marsh.
		642 Saltwater marsh.
	650 Non-vegetated wetland.	651 Tidal flats.
		652 Other non-vegetated wetlands.
700 Barren land	710 Beaches	
	720 Sand other than beaches.	
	730 Exposed rock	
	740 Altered lands	741 Scraped areas.
		742 Dredge and fill.
		743 Spoil banks.
	750 Extractive	751 Mineral extraction.
		752 Stone quarries.
		753 Sand, gravel, clay.
		754 Oil and gas wells.
		755 Abandoned mining operations.
	760 Other barren lands	

The "Standard Land Use Coding Manual" (table 6), provides a four-digit categorization of land use developed mainly for urban and suburban areas in the United States. Ground observation and enumeration are essential; consequently, the system is not designed to be used with remote sensors. Inventory of the whole nation would be very expensive to complete and maintain. However, for limited areas where detailed land use information is needed, this system provides a useful framework. The first two levels are presented here. A further breakdown to levels III and IV for selected manufacturing and recreation categories is also presented to illustrate the detailed aspects of the system.

TABLE 6.—Portion of land use classification system used in the *"Standard Land Use Coding Manual"*

[Selected manufacturing and recreation categories are presented at levels III and IV. NEC, not elsewhere coded.]

1 Residential.
- 11 Household units.
- 12 Group quarters.
- 13 Residential hotels.
- 14 Mobile home parks or courts.
- 15 Transient lodgings.
- 19 Other residential, NEC.

2 Manufacturing.
- 21 Food and kindred products.
- 22 Textile mill products.
- 23 Apparel and other finished products made from fabrics, leather, and similar materials.
  - 231 Men's, youth's, and boy's suits, coats, and overcoats.
  - 232 Men's, youth's, and boy's furnishings, work clothing, and allied garments.
  - 233 Women's, misses', juniors', girls', children's, and infants' outerwear.
  - 234 Women's, misses' children's, and infants' undergarments.
  - 235 Hats, caps, and millinery.
  - 236 Leather and leather products.
    - 2361 Leather tanning and finishing.
    - 2362 Industrial leather belting and packing.
    - 2363 Boot and shoe cut stock and findings.
    - 2364 Footwear (except rubber).
    - 2365 Leather gloves and mittens.
    - 2366 Luggage.
    - 2367 Handbags and other personal leather goods.
    - 2369 Other leather products manufacturing, NEC.
  - 237 Fur goods.
  - 238 Miscellaneous apparel and accessories.
  - 239 Other fabricated textile products manufacturing, NEC.
- 24 Lumber and wood products (except furniture).
- 25 Furniture and fixtures.
- 26 Paper and allied products.
- 27 Printing, publishing, and allied industries.
- 28 Chemicals and allied products.
- 29 Petroleum refining and related industries.

3 Manufacturing (continued).
- 31 Rubber and miscellaneous plastic products.
- 32 Stone, clay, and glass products.
- 33 Primary metal industries.
- 34 Fabricated metal products.
- 35 Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks.
- 39 Miscellaneous manufacturing, NEC.

4 Transportation, communication, and utilities.
- 41 Railroad, rapid rail transit, and street railway transportation.
- 42 Motor vehicle transportation.
- 43 Aircraft transportation.
- 44 Marine craft transportation.
- 45 Highway and street right-of-way.
- 46 Automobile parking.
- 47 Communication.
- 48 Utilities.
- 49 Other transportation, communication, and utilities, NEC.

5 Trade.
- 51 Wholesale trade.
- 52 Retail trade—building materials, hardware, and farm equipment.
- 53 Retail trade—general merchandise.
- 54 Retail trade—food.
- 55 Retail trade—automotive, marine craft, aircraft, and accessories.
- 56 Retail trade—apparel and accessories.
- 57 Retail trade—furniture, home furnishings, and equipment.
- 58 Retail trade—eating and drinking.
- 59 Other retail trade, NEC.

6 Services.
- 61 Finance, insurance, and real estate services.
- 62 Personal services.
- 63 Business services.
- 64 Repair services.
- 65 Professional services.
- 66 Contract construction services.
- 67 Government services.
- 68 Educational services.
- 69 Miscellaneous services.

7 Cultural, entertainment, and recreational.
- 71 Cultural activities and nature exhibitions.
- 72 Public assembly.
- 73 Amusements.
- 74 Recreational activities.
- 75 Resorts and group camps.
  - 751 Resorts.
    - 7511 General resorts.
    - 7512 Dude ranches.
    - 7513 Health resorts.
    - 7514 Ski resorts.
    - 7515 Hunting and fishing clubs.
    - 7519 Other resorts, NEC.
  - 752 Group or organized camps.
- 76 Parks.
- 79 Other cultural, entertainment, and recreational, NEC.

TABLE 6.—*Continued*

8 Resource production and extraction.
- 81 Agriculture.
- 82 Agricultural related activities.
- 83 Forestry activities and related services.
- 84 Fishing activities and related services.
- 85 Mining activities and related services.
- 89 Other resource production and extraction, NEC.

9 Undeveloped land and water areas.
- 91 Undeveloped and unused land area (excluding noncommercial forest development).
- 92 Noncommercial forest development.
- 93 Water areas.
- 94 Vacant flood area.
- 95 Under construction.
- 99 Other undeveloped land and water areas, NEC.

Other States besides Florida have developed classification systems and made land use maps in varying degrees of detail and sophistication. Below are some coastal State organizations that have made land use maps.

Alabama
Alabama Development Office
Montgomery, Alabama 36104

California
California Department of Water Resources
Sacramento, California 95814

Connecticut
State of Connecticut
Planning and Budgeting Division
340 Capital Avenue
Hartford, Connecticut 06115

Delaware
Director, State Planning Office
Office of the Governor
Dover, Delaware 19901

Maryland
Maryland Department of State Planning
301 W. Preston Street
Baltimore, Maryland 21201

Massachusetts and Rhode Island
Department of Forestry and Wildlife Management
Holdsworth Hall
University of Massachusetts
Amherst, Massachusetts 01002

Minnesota
Minnesota State Planning Agency
St. Paul, Minnesota 55101

New York
State of New York
Office of Planning Services
488 Broadway
Albany, New York 12207

The coastal States that are completely mapped under 50–50 cost-sharing agreements with USGS are Louisiana and Florida. Mapping is in progress under similar agreements with Alabama, Georgia, and Pennsylvania.

LAND USE AND LAND COVER MAPPING

Land use maps are usually the result of an inventory. The maps may be made for a specific purpose and are not necessarily in reproducible form for public use. The lack of comparable land use maps for extensive areas has often been a handicap to the planning process, at least at the Federal level and usually at the regional and State levels.

USGS has begun nationwide land use mapping to provide a systematic and comprehensive collection of land use and land cover data appropriate for large areas which are expensive to map in great detail. Figure 36 shows the current status of this mapping.

Specific products provided by the land use mapping program are:

- Maps at 1:250,000 scale showing the present land use at level II of the classification system developed by USGS in conjunction with Federal and State agencies and others. For each of the land use/land cover maps produced, overlays are also compiled to show Federal land ownership, river basins and subbasins, counties, and census county subdivisions. State land ownership is shown when USGS has the appropriate information from the State.
  Land use and land cover data are keyed to the enlarged culture and drainage color-separation plates of the standard USGS 1:100,000- or 1:250,000-scale topographic sheets. The minimum mapping unit for urban and built-up uses, water areas, confined feeding operations, other agricultural land, and strip mines, quarries, and gravel pits is 10 acres. The minimum mapping unit for other categories is 40 acres. Federal land holdings are shown for tracts of 40 acres or larger, and State land holdings are similarly delineated when data are available.
- Selected experimental demonstration land use and land cover maps at 1:24,000 or 1:50,000 scale are also being prepared for selected areas. These maps show how land use and land cover mapping at a regional scale can be related to more detailed mapping at larger scales.
- Computerized graphic displays and statistical data on current land use and land cover will be

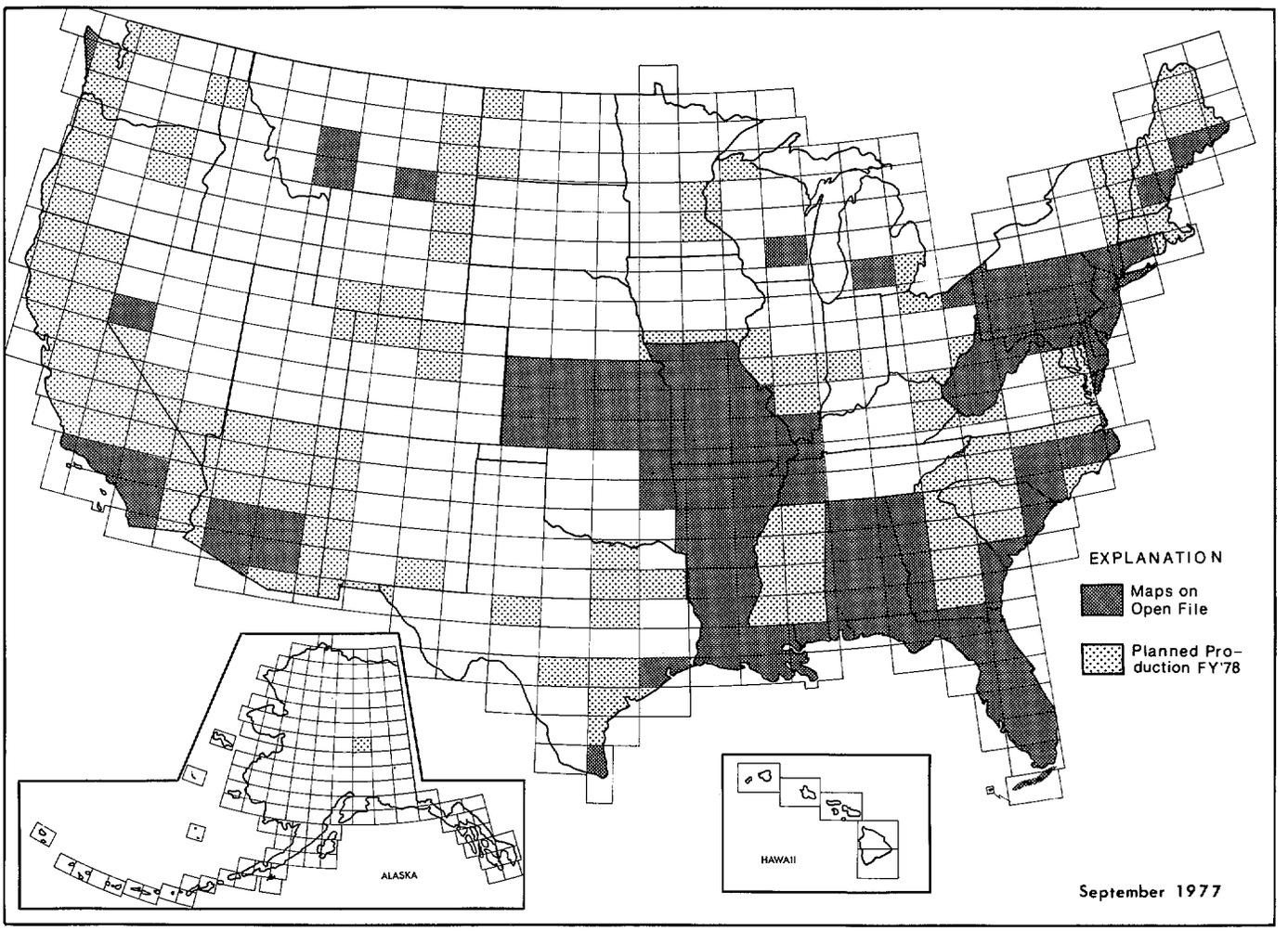


FIGURE 36.—Land use/land cover map production status in the United States.

available through this program for use with other data. Statistical data are compiled by counties, areas of Federal ownership, river basins and subbasins, and statistical units such as census tracts or other census county subdivisions.

Land use and land cover data are digitized in polygon format (each individual area comprises a polygon). Conversion of land-use polygons to land-use grid cells of varying sizes can be made when desired.

Because of the dynamics of land use, the emphasis for preparing and distributing all products is on supplying information to the users as soon as possible. Research in data and information requirements, inventory methods and data use, and interpretative studies is also being carried out under the USGS land use mapping program. The program uses advanced technology, NASA high-altitude photographs, aerial photographs acquired for USGS topographic mapping, and Landsat data.

For more information on land use and land cover mapping, contact:

Chief Geographer
U.S. Geological Survey
MS 710 National Center
Reston, Virginia 22092
Telephone: 703–860–6344

The rest of this section concentrates on the general aspects of land-use mapping, such as source material, minimum size, and accuracy. Procedures are not described in the handbook because several books and manuals are already available (see "Selected references").

The types and amounts of land use and land cover information that can be obtained from different sensors depend on the altitude and the resolution of each sensor. Presently, no one sensor or system will produce good data at all altitudes. Each source and application of remote-sensing data must be evaluated solely on the basis of its qualities and characteristics. Data are usually transferred to a base map, although a base map is difficult to use without extracting some additional data from it. Topographic maps, road maps, and detailed city maps generally contribute detail beyond the capabilities of the remote-sensor data.

Different sensors provide data at varying resolutions depending on altitude and scale. In general, the following relationships are true for a camera with a 6-in focal length.

Level	*Typical data characteristics*
I	Landsat type data.
II	High-altitude data at 12,200 m (40,000 ft) or above, (less than 1:80,000 scale).
III	Medium-altitude data obtained between 3,000 and 12,200 m (10,000 and 40,000 ft) (1:20,000 to 1:80,000 scale).
IV	Low-altitude data taken below 3,000 m (10,000 ft) (more than 1:20,000 scale).

Although land use data obtained at any level certainly is neither restricted to a particular user group nor to a particular presentation scale, information at levels I and II (fig. 37) usually interests users who need data on a nationwide, interstate, or statewide basis. Generally, more detailed land use and land cover data, such as that categorized at levels III (fig. 38) and IV is used more frequently by those who need and who generate local information at the intrastate, regional, county, or municipal level.

The relationship between the categorization level and the data source is not intended to restrict users to particular scales, either in the original source from which the land use information is compiled or in the final graphic. For example, level I land use information, while efficiently and economically gathered over large areas by a Landsat-type satellite or from high-altitude imagery, could also be interpreted from conventional large-scale aircraft imagery or compiled by ground survey. The same information can be displayed at a wide variety of scales ranging from a standard 1:24,000-scale topographic map to the much smaller 1:1,000,000-scale orbital imagery overlay. Similarly, several level II categories have been interpreted from Landsat data although they can be obtained more accurately from high-altitude photographs at present. Some level III and IV land use and land cover data can also be obtained from high-altitude imagery. This categorization level can also be presented at a wide range of scales. However, as the more detailed categorization levels are used, more dependence must be placed on higher resolution remote-sensor data and supplemental ground surveys.

The principal remote-sensor source for level II data is high-altitude color infrared photographs. Scales smaller than 1:80,000 are characteristic of high-altitude photographs, although scales from 1:24,000 to 1:250,000 generally have been used for final map products.

The same photographs used to construct or update 1:24,000-scale topographic maps or similarly scaled orthophotoquads are potential sources for inventorying land use and land cover. The orthophoto bases permit rapid interpretation of level I and II information at relatively low cost. However, the cost of acquiring more detailed levels of land use and land cover data may be too expensive to include the data on large-scale maps.

In most land use applications, USGS is interested in the smallest area that can be recognized to have an interpretable type of land use or land cover. The smallest area that can be recognized depends not only on the type and characteristics of the imaging system, but also on the order of image generation (how many reproduction stages is the study image from the original). The user needs the most recent information available to determine the resolution parameters of the system.

The smallest area that can be placed in a land use category also depends on the compilation and publication scales. Sometimes land uses cannot be identified with the accuracy level needed for the smallest unit being mapped. At other times, specific land uses can be identified, although they are too small to be mapped. For example, farmsteads are not usually distinguished from other agricultural land uses when mapping at more generalized classification levels. On the other hand, these farmsteads may be interpretable at more detailed levels, but they may be too small to be represented at the final scale. Similar situations may arise when using other categories.

When a map is the medium for presenting land use data, any unit area smaller than 2.5 mm (0.1 in) on a side is difficult to represent. Smaller areas also cause legibility problems for the map reader. Users of computer-generated graphics are similarly constrained by the computer printout size.

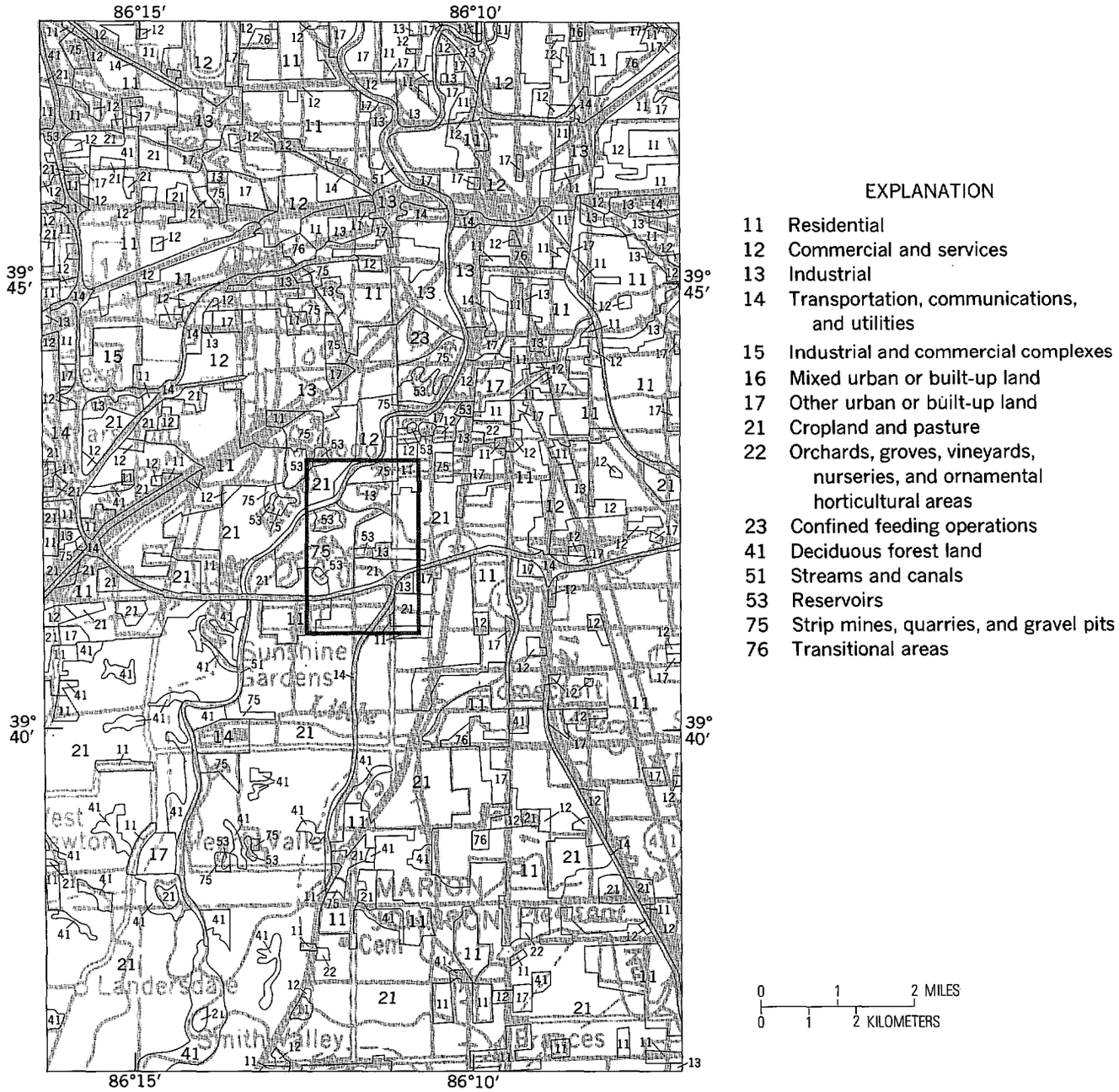
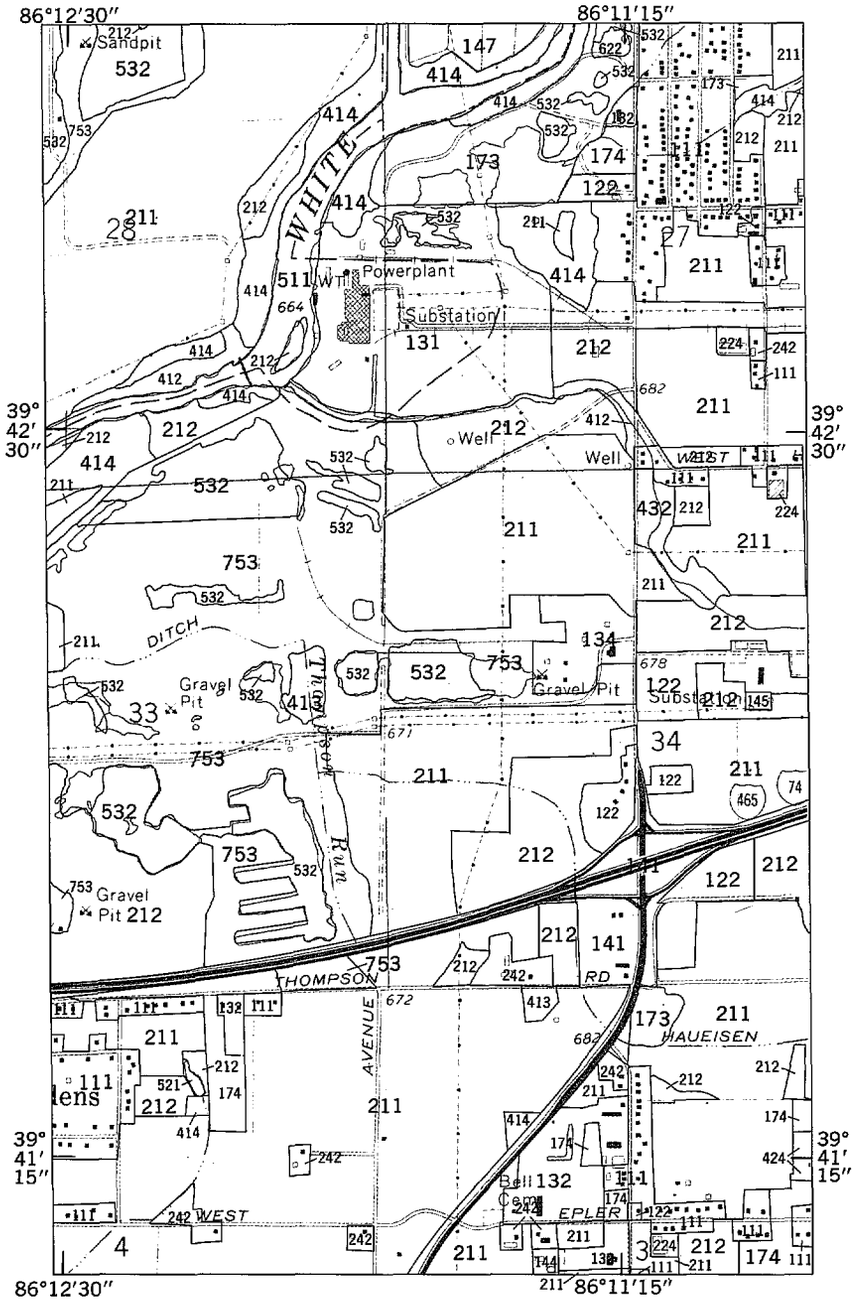


FIGURE 37.—Level II land use and land cover in an enlarged part of the northeast quarter of the USGS Indianapolis, Ind.–Ill., 1:250,000-scale quadrangle base map. The area outlined in the center is shown in figure 38.

There are three types of accuracy considerations for mapping land use and land cover by remote sensing. First is the accuracy with which areas are delineated to show the exact outline as it exists on the Earth's surface. The compilation scale will have some effect; however, using photographic source materials will make the outline as precise as the scale allows. Second is the interpretation accuracy. Various field checks or field validation techniques and processes can establish interpretation accuracy. An accuracy of 85 percent or better can be achieved by using qualified interpreters. Third is the positional accuracy associated with the plotting base. Generally, the larger the scale, the better the positional accuracy. Rectified photomosaics and large-scale topographic quadrangles have very good positional accuracy.



EXPLANATION

111	Single family
122	Retail trade
131	Primary processing
132	Fabrication
134	Extraction facilities
141	Highways
144	Airports
145	Communications
147	Utilities
173	Waste dumps
174	Urban undeveloped
211	Cropland
212	Pastureland
224	Nurseries and floriculture
242	Farmsteads
412	10–30 percent crown cover, deciduous
413	30–70 percent crown cover, deciduous
414	>70 percent crown cover, deciduous
424	>70 percent crown cover, evergreen
432	10–30 percent crown cover, mixed
511	Streams
521	Lakes
532	Water-filled quarries
622	Mudflats
753	Sand and gravel pits (active)

FIGURE 38.—Level III land use and land cover in part of the Maywood, Ind., 7.5-min quadrangle base map. This area is included in fig. 37.

FUTURE OUTLOOK

AUTOMATION

Maps and charts are based on a framework of ground-survey control points. The cost of providing the framework and producing the maps is increasing at the same time that the demand for maps rises. The Federal Government is solving this problem by automating as many surveying and mapping operations as are practical.

Field surveying is being augmented by new computer techniques for photogrammetric control ex-

tension (aerotriangulation). Satellites also are being used to extend control to regions where none has been established. These developments and other electronic advances have contributed greatly to automating procedures for acquiring and processing ground survey data.

Hydrographic chart production is also being automated. Water depths and ship positions are being recorded in automated format. Along with digitized land features, data are being processed by computer and will be eventually plotted by machine.

Topographic surveys are a different problem because the basic map data are still generally interpreted by an operator. Some work is now being done by semiautomated stereoplotting machines under operator control. Development of automatic scanning and correlating devices may eventually remove the major burden of interpretation from the operator, allowing him to monitor the machine operation and intervene when necessary.

Remote-sensing techniques to inventory and manage the Nation's resources and monitor the environment show great promise. For example, because if its synoptic coverage, Landsat imagery has permitted identification of previously unmapped geologic structures as targets for exploration for oil, gas, copper, and other minerals, and is being used to inventory water impoundment areas.

The repetitive coverage of satellite data provides information for land use planning with a timeliness not previously possible. The capability of detecting changes in land and water use has proved effective in monitoring strip mines and reclaiming worked-out areas. The coverage will be useful in identifying beach erosion and gaging the environmental impact of projects, such as construction of the Alaskan pipeline.

Satellite-collected data, in addition to that of Landsat, include the monitoring capability of Skylab and other spacecraft, such as weather satellites. In the cartographic field these data may be used to identify and locate new features, such as interstate highways, and to monitor the spread of urban areas. Revision of small-scale maps from data obtained by satellite remote sensing is already a reality. For example, the maps of the Amazon Basin were revised after space imagery resolved misconceptions concerning the drainage pattern.

The technique of satellite geodesy has proved to be extremely valuable in remote parts of the world. Tracking systems can produce ground accuracies of ± 1.5 m. Geodetic positions are derived from processing radio signals transmitted by special satellites. The satellite signals are received by a sophisticated ground receiver and processed by computer. This surveying method will be used more in the future.

Computer-stored Data

When cartographic information is stored in digital form, the data can be retrieved and processed later by automatic means. The primary advantage of the digital form is the capability of automatic access. It is important to provide the most efficient and flexible storage system possible.

Digital map data fall into three basic categories—point data, line data, and area data. Point data include such features as control stations, boundary monuments, and wells. They are recorded by coordinates and include any feature that can be located by a point. An expansion of the point concept leads to line data, which include roads, railroads, and streams. Linear features constitute sequences of closely spaced point coordinates. Area data are those that require a tint or pattern, such as woodland, swamp, and urban areas. Although the boundaries of areas can be defined by lines, use of a pixel (picture element) array simplifies the task of digitizing area data.

In general, the larger the amount of stored data, the greater are the accuracy and flexibility in selective retrieval; however, an attempt to record an overabundance of data may result in both storage problems and high costs. Compacting the digital information and developing a less costly storage system should be considered.

Data directly available in digital form can be input to a map data bank with relative ease. However, most of the data would come from line drawings and published maps. Automatic line-following devices are being developed for digitizing drawings. Similar scanning devices for area data and techniques for digitizing map data during compilation are also being studied.

Computer-stored cartographic data can be retrieved automatically either as a printout or as a line drawing, depending upon whether statistical data or a graphical analysis is desired.

The statistics derived from a single data base may vary according to the judgment of the statisticians. Because the original source data are retained, a digital map allows each user to judge for himself without the influence of prejudices inevitably imposed on a printed map by its compilers. Because the basic data are somewhat permanent, the user is free to make his own interpretation.

Updating

Often a map or chart is out of date before it is published because of the time needed for the many steps of compilation and publication. However, a computerized map or chart can be corrected regularly. Erroneous or obsolete information can be changed by inserting a correction instruction; actual additions or deletions to copy are unnecessary. The initial task of digitizing published maps and charts is monumental, but digital maps and charts of the future will be produced and revised more easily.

For detailed information about research and current methods in automated cartography, refer to the journals and information services of the technical sources listed in appendix 4.

THE METRIC SYSTEM

Adoption of the metric system in the United States is having a marked effect on mapping procedures. For the most part, cartographers will deal with metric units of length. Fortunately, the ground control used in mapping is generally extended from the National Geodetic Network, which has always been based on the meter. Many of the electronic distance-measuring devices used for horizontal control measurements read out in meters. Vertical control by leveling has been measured in either feet or meters, depending on the equipment used —the trend is toward the use of metric rods and compatible instruments. Where elevations have already been obtained in feet, conversion to meters is simple. However, rewriting station descriptions that are referenced to feet, yards, and miles would be a monumental task.

Manufacturers of photogrammetric instruments usually design their products in the metric system. Most stereocompilation instruments provide for direct elevation readout in either system. With instruments whose elevation readout is in the U.S. customary system, metrication is being effected by a minor change in equipment.

Because of the conversion to the metric system, changes in format, scale, contour intervals and drafting specifications are necessary. To facilitate metric scaling there may be greater use of even publication scales such as 1:20,000 and 1:100,000. The scales of previously published maps may be changed photomechanically with a minimum of cartographic work. Scale changes may require format changes to reduce sheet size; for example, a series with a 7.5-min quadrangle format could be replaced by one with a metric grid format. Drafting specifications for symbol size and line weight usually are stated as fractions of an inch; they can easily be rewritten in millimeters. However, some tools may have to be modified to accomodate this change.

Probably the greatest problem of metric conversion will be changing contour intervals. Commonly used intervals of 5, 10, 20, 40, and 80 ft will be replaced by intervals of 1, 2, 5, 10, and 20 m. Thousands of contour manuscripts must be redrawn when intervals become metric.

Federal plans include complete conversion to metric products as soon as practical. All new series will be metric when feasible. Series that are nearly finished probably will be completed in the U.S. customary system, but revisions will be metricated.

THE FUTURE

No doubt there will be significant changes in the techniques of surveying and mapping during the next few decades. M.M. Thompson (1974) discusses changes in methods that have taken place in the last quarter century, the current procedures and equipment that are likely to be replaced by new systems, and a projected state of the art in surveying and mapping for the year 2000. Predictions of the shape of surveying techniques in the years to come can be based on advanced systems already under development.

SELECTED REFERENCES

Technical references are too numerous to be included in this list. Some of the publications are used frequently by USGS and NOAA to establish policies or to provide mapping and charting specifications. The rest contain information and data of general interest and value.

American Congress on Surveying and Mapping and the American Society of Civil Engineers, 1972, Definitions of surveying and associated terms: Washington, 205 p.

American Society of Photogrammetry, 1966, Manual of photogrammetry, Morris M. Thompson, Editor-in-Chief: Falls Church, Va., v. 1 and 2, 1,199 p.

——— 1968, Manual of color aerial photography, John T. Smith, Editor-in-Chief: Falls Church, Va., 550 p.

——— 1975, Manual of remote sensing, Robert G. Reeves, Editor-in-Chief: Falls Church, Va., v. 1 and 2, 2,144 p.

Anderson, J. R., 1971, Land use classification schemes and the need for standardization: Proceedings of the Conference on Land Use Information and Classification, June 28–30, 1971, Washington, U.S. Department of the Interior, Geological Survey, and the National Aeronautics and Space Administration, p. 4–25.

——— 1971, Land use classification schemes used in selected recent geographic applications of remote sensing: Photogrammetric Engineering, v. 37, no. 4, p. 379–387.

Anderson, J. R., Hardy, E. E., Roach, J. T., and Whitmer, R. E., 1976, A land use and land cover classification system for use with remote sensor data: U.S. Geol. Survey Prof. Paper 964, 28 p., 4 figs., 4 tables.

Anderson, R. R., 1972, Applications of high-altitude remote sensing to coastal zone ecological studies: Proceedings of Seminar on Operational Remote Sensing, American Society of Photogrammetry, p. 191–195.

Anderson, R.R., and Wobber, F. J., 1973, Wetlands mapping in New Jersey: Photogrammetric Engineering, v. 39, no. 4, p. 353–358.

Bartlett, D. S., Daiber, F. C., and Klemas, V., 1973, Mapping Delaware's coastal vegetation and land use from aircraft and satellites: Proceedings of the Fall Convention, American Society of Photogrammetry, p. 926–937.

Bouchard, Harry, 1965, Surveying, revised by F. H. Moffitt: Scranton, Pa., International Textbook Co., 754 p.

Clawson, Marion, 1972, America's land and its uses: Baltimore, Resources for the Future, by The Johns Hopkins Press, 166 p.

Clawson, Marion, and Stewart, C. L., 1965, Land use information: A critical survey of U.S. statistics including possibilities for greater uniformity: Baltimore, Resources for the Future, by The Johns Hopkins Press, 102 p.

Cravat, H. R., and Glaser, Raymond, 1971, Color aerial stereograms of selected coastal areas of the United States: NOAA/National Ocean Survey, 93 p.

Csati, Erno, ed., 1974, Automation and new trends in cartography, Final report on the CIA Commission III (Automation in Cartography) Scientific Working Session, August 1973: Budapest, The Geocartographic Research Department, Institute of Surveying and Mapping, 372 p.

Davis, R. E., Foote, F. S., and Kelly, J. W., 1966, Surveying theory and practice: New York, McGraw-Hill.

Defense Mapping Agency Topographic Center, 1973, Glossary of mapping, charting, and geodetic terms: Washington, Department of Defense, 281 p.

Dietz, C. H., and Adams, O. S., 1944, Elements of map projection: U.S. Coast and Geodetic Survey Spec. Pub. 68, 200 p.

Grimes, B. H., and Hubbard, J. C. E., 1971, A comparison of film type and the importance of season for interpretation of coastal marshland vegetation: Photogrammetric Record, v. 7, no. 38, p. 213–222.

Klemas, V., Bartlett, D., and Rogers, R., 1975, Coastal zone classification from satellite imagery: Photogrammetric Engineering and Remote Sensing, v. 41, no. 4, p. 499–513.

Maloney, F. E., and Ausness, R. C., 1974, The use and legal significance of the mean high water line in coastal boundary mapping: North Carolina Law Review, v. 53, no. 2, p. 185–273.

McEwen, R. B., Kosco, W. J., and Carter, V. P., 1976, Coastal wetland mapping: Photogrammetric Engineering and Remote Sensing, v. 42, no. 2, p. 221–232.

Melcher, Daniel, and Larick, Nancy, 1966, Printing and Promotion Handbook: New York, McGraw-Hill, 451 p.

Mitchell, H. C., 1948, Definitions of terms used in geodetic and other surveys: U.S. Coast and Geodetic Survey Spec. Pub. 242, 87 p.

Moffitt, F. H., 1967, Photogrammetry: Scranton, Pa., 2nd edition, International Textbook Co., 540 p.

NOAA/National Ocean Survey, 1974, Classification, standards of accuracy and general specifications of geodetic control surveys: Rockville, Md., 12 p.

——— 1975, Specifications to support classification, standards of accuracy, and general specifications of geodetic control surveys: Rockville, Md., 30 p.

——— Photogrammetric instructions: NOAA/NOS, Rockville, Md. (issued irregularly).

Nunnally, N. R., and Whitmer, R. E., 1970, Remote sensing for land-use studies: Photogrammetric Engineering, v. 36, no. 5, p. 449–453.

O'Hargan, P. T., 1973, Wetland boundaries: Proceedings of the Fall Convention, American Congress on Surveying and Mapping, p. 179–185.

Raisz, Erwin, 1962, Principles of cartography: New York, McGraw-Hill, 315 p.

Reimold, R. J., Gallagher, J. L., and Thompson, D. E., 1973, Remote sensing of tidal marsh: Photogrammetric Engineering, v. 39, no. 5, p. 477–488.

Robinson, A. H., and Sale, R. D., 1969, Elements of cartography: New York, John Wiley and Sons, 415 p.

Rosenberg, Paul, Erikson, K. E., and Rowe, G. C., 1974, Digital mapping glossary: Prepared by Keuffel and Esser Company, Morristown, New Jersey, for the U.S. Army Engineer Topographic Laboratories, U.S. Army Mobility Equipment Research and Development Center, Fort Belvoir, Va., 62 p.

Shalowitz, A. L., 1962, Shore and sea boundaries: Washington, U.S. Government Printing Office, v. 1, 420 p.

——— 1964, Shore and sea boundaries: Washington, U.S. Government Printing Office, v. 2, 749 p.

Shaw, S. P. and Fredine, C. G., 1971, Wetlands of the United States: U.S. Fish and Wildlife Service, Circ. 39, 67 p.

Schureman, Paul, and Hicks, S. D., 1975, Tide and current glossary: Rockville, Md., NOAA/National Ocean Survey, 25 p.

Strahler, A. N., 1969, Physical geography: New York, John Wiley and Sons, Third ed., 733 p.

Swanson, R. L., 1974, Variability of tidal datums and accuracy in determining datums from short series of observation: NOAA Tech. Rept. NOS 64, 41 p.

Thompson, D. E., 1972, Airborne remote sensing of Georgia tidal marshes: Proceedings of Seminar on Operational Remote Sensing, American Society of Photogrammetry, p. 126–139.

Thompson, Morris M., 1972, Water Features on Topographic Maps: Journal of the Surveying and Mapping Division, ASCE, v. 98, no. SU 1, p. 1–16.

——— 1974, Surveying and mapping in the year 2000: Proceedings of the ASP/ACSM Fall 1975 Technical Meeting, Phoenix, Ariz., p. 362–368.

Umbach, M. J., 1960, Hydrographic manual: NOAA/National Ocean Survey: Rockville, Md., 283 p.

U.S. Geological Survey, Topographic Instructions of the United States Geological Survey: Reston, Va. (issued irregularly).

U.S. Urban Renewal Administration, Housing and Home Finance Agency, and Bureau of Public Roads, 1965, Standard land use coding manual, a standard system for identifying and coding land use activities: Washington, D.C., 111 p.

Weidel, J. W., and Kleckner, Richard, 1974, Using remote sensor data for land use mapping and inventory: A user guide: U.S. Geol. Survey Interagency Rept., USGS–253, 63 p.

GLOSSARY

accretion—Accumulation resulting from the action of natural forces.

accuracy—Degree of conformity with a standard. Accuracy relates to the quality of a result and is distinguished from precision which relates to the quality of the operation by which the result is obtained.

adjustment—Equitable distribution of errors and known distortions, which affect a computed result.

aerotriangulation (aerial triangulation)—Triangulation for the extension of horizontal and (or) vertical control accomplished by means of aerial photographs.

angle—Relationship of lines or surfaces which is measured by the amount of rotation necessary to make one coincide with or parallel another.

angle of coverage—Apex angle of the cone of rays passing through the front nodal point of a lens.

apparent shoreline—Line drawn on a map or chart in lieu of the mean high water line (MHWL) or the mean water level line (MWLL) in areas where either may be obscured by marsh, mangrove, cypress, or other types of marine vegetation. This line represents the intersection of the appropriate datum with the outer limits of vegetation and appears to the navigator as the shoreline.

automatic tide gage—Instrument that automatically records the rise and fall of the tide. Some instruments print the heights at regular intervals; others print a continuous graph in which the height of the tide is represented by the ordinates of the curve and the corresponding time by the abscissae.

avulsion—Rapid erosion of shoreland by waves during a storm.

azimuth—Horizontal direction reckoned clockwise from the meridian plane.

azimuth mark (geodetic)—Marked point established in connection with a triangulation (or traverse) station to provide a starting azimuth for dependent surveys.

backshore—That part of a beach which is usually dry, being reached only by the highest tides, and by extension, a narrow strip of relatively flat coast bordering the sea.

bank—Edge of a cut or fill; the margin of a watercourse; an elevation of the sea floor located on a continental shelf or an island shelf and over which the depth of water is relatively shallow but sufficient for safe surface navigation (reefs or shoals, dangerous to surface navigation, may rise above the general depths of a bank).

base line (seaward boundaries)—Reference used to position limits of the Territorial Sea and the Contiguous Zone. Source data from which the base line is determined are the mean low water line (MLWL) on the Atlantic and Gulf Coasts and the mean lower low water line (MLLWL) on the Pacific Coast, Alaska, and Hawaii. The United Nations Conference on the Law of the Sea defined the low waterline along a coast, as shown on large-scale charts of the coastal State (country) to be the base line for determining the limit of the territorial sea.

base line (triangulation)—One side of a series of connected triangles, the length of which is measured with prescribed accuracy and precision, and from which the lengths of the other triangle sides are obtained by computation. Important factors in the accuracy and precision of base measurements are the use of standardized invar tapes, controlled conditions of support and tension, and corrections for temperatures, inclination, and alinement. Base lines in triangulation are classified according to the character of the work they are intended to control, and the instruments and methods used in their measurement are such that prescribed probable errors for each class are not exceeded. These probable errors, expressed in terms of the lengths, are as follows: first order, 1 part in 1,000,000; second order, 1 part in 500,000; and third order, 1 part in 250,000.

bathymetry—Science of measuring water depths (usually in the ocean) in order to determine bottom topography.

beach (or seabeach)—Zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). A beach includes foreshore and backshore.

beach berm—Nearly horizontal portion of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several.

beach erosion—Carrying away of beach materials by wave action, tidal or littoral currents, or wind.

bench mark—Relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known.

bench mark, tidal—Bench mark set to reference a tide staff at a tidal station, the elevation of which is determined with relation to the local tidal station.

berm—Nearly horizontal portion of a beach or backshore having an abrupt fall and formed by wave deposition of material and marking the limit of ordinary high tides.

berm crest (berm edge)—Seaward limit of a berm.

boundary monument—Material object placed on or near a boundary line to preserve and identify the location of the boundary line on the ground.

boundary survey—Survey made to establish or to reestablish a boundary line on the ground, or to obtain data for constructing a map or plat showing a boundary line.

C-factor—Empirical evaluation of the vertical (elevation) measuring capability of a stereoscopic instrument system.

cartometer—Device consisting of a small wheel and a calibrated dial used to measure distances on a map by following the desired route.

chart—Special-purpose may designed for navigation or to present specific data or information. The term chart is applied chiefly to maps made primarily for nautical and aeronautical navigation, and to maps of the heavens, although the term is sometimes used to describe other special-purpose maps.

chart, aeronautical—Chart designed to meet requirements of aerial navigating, produced in several series, each on a specified map projection and differing in scale, format, and content, for use as dictated by type of aircraft and whether flight is to be conducted under visual or instrument flight rules.

chart, airport obstruction—Chart depicting the major planimetric features in the vicinity of U.S. commercial airports placing emphasis on all objects, whether natural or artificial, that penetrate any of variously defined imaginary surfaces and thereby constitute obstruction to flight.

chart, bathmetric—See map, bathymetric.

chart, isoclinic—Chart showing magnetic dip with isoporic lines.

chart, isogonic—Chart showing magnetic declination with isogonic lines and the annual rate of change in declination with isoporic lines.

chart, isopach—Chart employing a system of lines joining points of equal thickness of a sedimentary layer.

chart, nautical—Representation of a portion of the navigable waters of the Earth and adjacent coastal areas on a specified map projection, and designed specifically to meet requirements of marine navigation. Included on most nautical charts are: depths of water, characteristics of the bottom, elevations of selected topographic features, general configuration and characteristics of the coast, the shoreline (usually the mean high water line), dangers, obstructions and aids to navigation, limited tidal data, and information about magnetic variation in the charted area.

chart, tidal current—Set of twelve charts depicting, by means of arrows and numerals, the direction and speed of the tidal current for each hour of the tidal cycle. These charts, which may be used for any year, present a comprehensive view of the tidal current movement in twelve major harbors and waterways as a whole and provide a means for readily determining the direction and speed of the current at various places throughout the water areas covered.

chart datum—Datum to which soundings on a chart are referred. It is usually taken to correspond to a low water stage of the tide, and its depression below mean sea level is represented by the symbol Z.

charted depth—Vertical distance from the chart datum to the bottom.

coast—General region of indefinite width that extends from the sea inland to the first major change in terrain features.

coastal area—Land and sea area bordering the shoreline.

coastal boundary—Boundary within the coastal zone, excluding one established by treaty or by the U.S. Congress. A general term for a boundary defined as the line (or measured from the line or points thereon) used to depict the intersection of the ocean surface and the land at an elevation of a particular datum.

coastal plain—Any plain which has its margin on the shore of a large body of water, particularly the sea, and generally represents a strip of geologically recent emerged sea bottom.

coastline—Configuration made by the meeting of land and sea.

color separation—Process of preparing a separate drawing, engraving, or negative for each color required in the printing production of a map or chart.

comparison of simultaneous observations—Reduction process in which a short series of tide or current observations at any place is compared with simultaneous observations at a control station where tidal or tidal current constants have previously been determined from a long series of observations. For tides, the technique is generally used to adjust constants from a subordinate station to the equivalent of that which would be obtained from a 19-year series.

compass direction—Direction as indicated by a compass without any allowances for instrument error.

compilation—Preparation of a new or revised map or chart, or portion thereof, from existing maps, aerial photographs, field surveys, and other sources.

contiguous zone—Band of water outside or beyond the territorial sea in which the coastal nation may exercise custom control and enforce public health regulations, etc. It is measured from the same base line as the territorial sea, and may extend no more than 12 miles seaward from it.

continuous tone—Image not broken into dots by photographic screen; contains unbroken gradient tones from black to white, and may be either in negative or positive form. Aerial photographs are examples of continuous-tone prints. Contrasted with halftone (screened) and line copy.

contour —Imaginary line on the ground, all points of which are at the same elevation above or below a specified datum.

contour interval—Difference in elevation between two adjacent contours.

control, basic—Coordinated and correlated positional data forming a framework to which detail surveys are adjusted.

control, geodetic—System of control stations established by geodetic methods.

control, National, survey nets—Two control survey nets being extended over the United States by the National Geodetic Survey for the control of nautical charts and topographic maps, and comprising:

1. The horizontal-control survey net consisting of arcs of first- and second-order triangulation, and lines of first- and second-order traverse, a few of which have been run by the U.S. Geological Survey, the Corps of Engineers, and other organizations. The derived data in this survey are being coordinated and correlated on the North American Datum of 1927.

2. The vertical-control survey net consisting of lines of first- and second-order spirit leveling which determine the elevations of thousands of bench marks above a common datum, mean sea level. This net also includes lines run by the U.S. Geological Survey, the Corps of Engineers, and other organizations.

control station—Point on the ground whose position (horizontal or vertical) is used as a base for a dependent survey.

convergent photography—Aerial photography using an assembly of two cameras that take simultaneous photographs and are mounted so as to maintain a fixed angle between their optical axes. The effect is to increase the angular coverage in one direction, usually along the longitudinal axis of the aircraft.

coordinates—Linear and (or) angular quantities that designate the position of a point in relation to a given refer-

ence frame. There are two general divisions of coordinates used in surveying, polar and rectangular. Each may be subdivided into three classes: plane, spherical, and space coordinates.

coordinates, origin of—Point in a system of coordinates which serves as zero point in computing its elements or in prescribing its use.

coordinatograph—Instrument used in cartography and photogrammetry to plot in terms of plane coordinates.

culture—Features that are under, on, and above the ground which are delineated on the map and were constructed by man. These features include roads, trails, buildings, canals, sewer systems, and boundary lines. In a broad sense, the term also applies to all names, other identification, and legends on a map.

current meter—Instrument for measuring current speed.

current speed—Rate at which the water moves either horizontally or vertically; usually expressed in knots, mi/day, ft/s, or cm/s.

current velocity—Rate of motion in which direction as well as speed of flow is considered.

datum—Any numerical or geometrical quantity or set of such quantities which may serve as a reference or base for other quantities. For a group of statistical references, the plural form is data, as geographic data for a list of latitudes and longitudes. Where the concept is geometrical and particular, rather than statistical and inclusive, the plural form is datums. For example, "Two geodetic horizontal datums. . . ."

Datum, Mean Sea Level, 1929—Determination of mean sea level (last adjusted in 1929) that has been adopted as a standard datum for heights. The sea level is subject to some variations from year to year, but as the permanency of any datum is of prime importance in engineering work, a sea-level datum should in general be maintained indefinitely even though differing slightly from later determinations based on longer series of observations. The datum itself can be considered to be an adjustment based on the tide observations taken at various tide stations along the coasts of the United States over a number of years.

Datum, National Geodetic Vertical (NGVD)—Fixed reference adopted as a standard geodetic datum for heights. The datum was derived for land surveys from a general adjustment of the first-order level nets of both the United States and Canada. In the adjustment 21 tide stations in the United States and 5 in Canada were held as fixed. The geodetic datum now in use in the United States is the National Geodetic Vertical Datum of 1929. The year indicates the time of the last general adjustment.

The geodetic datum is fixed and does not take into account the changing stands of sea level. Because there are many variables affecting sea level, and because the geodetic datum represents a best fit over a broad area, the relationship between the geodetic datum and local mean sea level is not consistent from one location to another in either time or space. For this reason, the National Geodetic Vertical Datum should not be confused with mean sea level.

Datum, National Geodetic Vertical, of 1929 (NGVD 1929; formerly the Mean Sea Level Datum of 1929)—Datum to which all elevations in the National Geodetic Vertical Network are referred, as well as terrain elevations on maps of the National Topographic Map Series.

Datum, North American, of 1927—Geodetic datum which is defined by the following geographic position of triangulation station Meades Ranch and the azimuth from that station to Waldo, on the Clarke spheroid of 1866:

Latitude of Meades Ranch	39°13'26.686" N.
Longitude of Meades Ranch	98°32'30.506" W.
Azimuth, Meades Ranch to Waldo	75°28'09.64"

datum plane—Misnomer for collection of datums used in mapping—charting and geodesy are not strictly planar. This term should not be used.

datum, vertical—For marine applications, a base elevation used as a reference from which to reckon heights or depths. It is called a tidal datum when defined by a certain stage of the tide. Tidal datums are local datums and should not be extended into areas which have differing topographic features without substantiating measurements. (In general, these local datums are valid only in the general vicinity of the tide station recording the observations from which the datums were determined.) *See* chart datum.

The basic vertical datum for the Great Lakes and connecting waterways is a level datum, designated the International Great Lakes Datum, 1955. Topographic mapping of the conterminous United States is based on the National Geodetic Vertical Datum of 1929. Various vertical datums are used in Alaska, Hawaii, the oceanic islands, and other offshore areas not accessible for connecting to the NGVD of 1929, each based on mean sea level at a specified tide station.

depth curve—Line on a map or chart connecting points of equal depth below the datum.

diapositive—Photographic positive transparency on glass or film often used in photogrammetry.

dike—Bank of earth or stone used to form a barrier, frequently and confusingly interchanged with levee. A dike restrains water within an area that normally is flooded. *See* levee.

displacement—Horizontal shift of the plotted positions of a topographic feature from its true position, caused by required adherence to prescribed line weights and symbol sizes. Any shift in the position of an image on a photograph which does not alter the perspective characteristics of the photograph; that is, shift due to tilt of the photograph, scale changes in the photograph, and relief of the objects photographed.

ebb current—Movement of a tidal current away from shore or down a tidal stream.

echo sounder—Instrument used to determine water depth by measuring the time interval required for sound waves to go from a source of sound near the surface to the bottom and back again.

electronic distance measuring (EDM) devices—Instruments that measure the phase difference between transmitted and reflected or retransmitted electromagnetic waves of known frequency, or that measure the round-trip transit time of a pulsed signal, from which distance is computed.

elevation—Vertical distance of a point above or below a reference surface or datum.

emulsion—Suspension of a light-sensitive silver salt (especially silver chloride or silver bromide) in a colloidal medium (usually gelatin), which is used for coating photographic films, plates, and papers. Types of photographic

emulsions commonly used are panchromatic (black and white), color negative, color positive, color infrared, and black-and-white infrared.

epoch—As used in tidal datum determinations, the 19-year Metonic cycle over which tidal height observations are meaned in order to establish the various datums. As there are periodic and apparent secular trends in sea level, a specific 19-year cycle called the National Tidal Datum Epoch (NTDE) is selected so that all tidal datum determinations throughout the United States and its possessions will have a common reference. The NTDE officially adopted by NOS is 1941–59. The NTDE will be reviewed for possible revision at 25-year intervals.

erosion—Transportation of weathered (decomposed) rock material or soil by natural forces.

estuary—That portion of a stream influenced by the tide of the body of water into which it flows; an arm of the sea at a river mouth.

etch—To move selected areas of emulsion either chemically or manually. Chemical treatment of a lithographic plate to make nonprinting areas grease-repellent and water-receptive or to produce the image on deep-etch plates. An acid solution mixed with the dampening fountain water on an offset press to help control ink on the pressplate.

Eulerian current measurement—Direct observation of the current speed and (or) direction during a period of time as it flows past a recording instrument such as the Ekman or Roberts current meters. *See* Lagrangian current measurement.

exposure—Total quantity of light received per unit area on a sensitized plate or film; may be expressed as the product of the light intensity and the exposure time; the act of exposing a light-sensitive material to a light source. One individual picture of a strip of photographs.

fathom—Common unit of depth in the ocean equal to 1.83 m (6 ft). Also, it is sometimes used in expressing horizontal distances, in which case 120 fathoms make 1 cable.

feature separation—Process of preparing a separate drawing, engraving, or negative for selected types of data in the preparation of a map or chart.

field edit (field completion)—Final field operation in the production of a map or chart, where the manuscript is compared to ground conditions to correct deficiencies and to resolve discrepancies.

field inspection—Initial field operation in the preparation (through modern techniques employing aerial photogrammetry) of a map or chart scheduled before the start of manuscript compilation and intended to provide information needed to correctly interpret photographic images, hues, and tones. The inspection provides data not obtainable from photographs. Development of new materials and methods in recent years has reduced the scope of field inspection and, in some cases, has made it unnecessary.

fishing zone—Offshore zone in which exclusive fishing rights and management are held by the coastal nation. The U.S. fishing zone, known as the fishery conservation zone, is defined under P.L. 94–265. The law states, "The inner boundary of the fishery conservation zone is a line coterminous with the seaward boundary of each of the coastal States, and the outer boundary of such zone is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured."

flood plain—Belt of low flat ground bordering a stream channel that is flooded when runoff exceeds the capacity of the stream channel.

focal length—Distance between the center, vertex, or rear node of a lens (or the vertex of a mirror), and the point where the image of an infinitely distant object comes into critical focus.

geodesy—Often used to include both the science which must depend upon determinations of the figure and size of the Earth from direct measurements made on its surface (triangulation, leveling, astronomic, and gravity determinations), and the art which utilizes the scientific determinations in a practical way and is usually termed geodetic surveying or geodetic engineering.

geographic graticule—System of coordinates of latitude and longitude used to define the position of a point on the surface of the Earth with respect to the reference spheroid. (Use of the word "grid" with geographic in this application is incorrect.)

geoid—Figure of the Earth visualized as a mean sea-level surface extended continuously through the continents.

geological oceanography—Study of the floors and margins of the oceans, including description of submarine relief features, chemical and physical composition of bottom materials, interaction of sediments and rocks with air and seawater, and action of various forms of wave energy in the submarine crust of the Earth.

geomagnetism (terrestrial magnetism)—Magnetic phenomena, collectively considered, exhibited by the Earth and its atmosphere.

geomorphology—Branch of both geography and geology that deals with the form of the Earth, the general configuration of its surface, and the changes that take place in the evolution of land forms.

geophysics—Study of the composition and physical phenomena of the Earth and its liquid and gaseous envelopes; it embraces the study of terrestrial magnetism, atmospheric electricity, and gravity; and it includes seismology, volcanology, oceanography, meterology, and related sciences.

geosphere—Portion of the Earth, including land (lithosphere) and water (hydrosphere) masses, but excluding the atmosphere.

hachures—Short lines on topographic maps or nautical charts to indicate the slope of the ground or submarine bottom. They usually follow the direction of the slope. *See* contour. Also, inward-pointing short lines or "ticks" around the circumference of a closed contour indicating a depression or a minimum.

half tide level (mean tide level)—Hypothetical surface midway between mean high water and mean low water.

halftone—Photomechanical printing surface or the impression therefrom in which detail and tone values are represented by a series of evenly spaced dots of varying size and shape, varying in direct proportion to the intensity of the tones they represent.

harmonic analysis—Process by which the observed tide or current at any place is separated into elementary harmonic constituents.

harmonic prediction—Method of predicting tides and tidal currents by combining the harmonic constituents into a single tide curve. The work is usually done mechanically

by means of a machine designed for the purpose.

height of the tide—Vertical distance from a reference datum to the water surface at any stage of the tide.

high seas—All water beyond the outer limit of the territorial sea. Although the high seas are in part coextensive with the waters of the contiguous zone, the fishing zone, and those over the continental shelf, freedom of the seas is not invalidated by the zonal overlap.

high water (HW)—Maximum height reached by a rising tide. The height may be due solely to the periodic tidal forces or it may have superimposed upon it the effects of prevailing meteorological conditions. Use of the term "high tide" is discouraged.

high water line—Intersection of the land with the water surface at an elevation of high water.

high water mark—Line or mark left upon tidal flats, beach, or alongshore objects indicating the elevation of the intrusion of high water.

horizon, apparent—Apparent intersection of the Earth and sky as seen by an observer.

hydrographic survey—Survey of a water area, with particular reference to submarine relief, and any adjacent land. *See* oceanographic survey.

hydrography—Science that deals with the measurement and description of the physical features of the oceans, seas, lakes, rivers, and their adjoining coastal areas, with particular reference to their use for navigation.

hydrology—Scientific study of the waters of the Earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of ground water.

hypsography—Topography referred to a sea-level datum. The science or art of describing heights of land surfaces with reference to sea level.

imagery—Visible representation of objects and (or) phenomena as sensed or detected by cameras, infrared and multispectral scanners, radar, and photometers. Recording may be on a photographic emulsion (directly as in a camera or indirectly after being first recorded on magnetic tape as an electrical signal) or recorded on magnetic tape for subsequent conversion and display on a cathode-ray tube.

infrared scanner (thermal mapper)—Instrument that detects infrared radiation and converts the detected energy to an electrical signal for recording on photographic film or magnetic tape.

inshore—In beach terminology, the zone of variable width between the shoreface and the seaward limit of the breaker zone.

inshore limits of wetland—Junction of wetland and stable ground.

International Hydrographic Organization—Institution for coordinating the hydrographic work of the participating governments. It had its origin in the International Hydrographic Conference in London in 1919 and was finally organized in June 1921. It has permanent headquarters (International Hydrographic Bureau) in the Principality of Monaco and is supported by funds provided by the participating nations.

interpolated water elevation (IWE)—Water elevation interpolated from established datums at two adjacent tide stations.

isopleth—Line of constant value of a given quantity with respect to either space or time. Examples of isopleths are contours, connecting points of equal elevation, isobars, connecting points of equal barometric pressure, and isogons, connecting points of equal magnetic declination.

Lagrangian current measurement—Direct observation of the current speed and (or) direction by a recording device such as a parachute drogue, which follows the movement of a water mass through the ocean. *See* Eulerian current measurement.

landmark—Monument or material mark or fixed object used to designate a land boundary on the ground; any prominent object on land that may be used to determine a location or a direction in navigation or surveying.

land-mass denudation—Evolution (erosion) of a large region, such as the Eastern United States, through the stages of youth, maturity, and old age as the result of the influence of the forces of nature.

land use classification system—Coding system of categories and subcategories designed for use on a map to designate land or water use.

latitude—Coordinate distance, linear or angular, from an east-west reference line; on a sphere, the angle at the center of the sphere between the plane of the Equator and the line to the point on the surface of the sphere; in plane surveying, the perpendicular distance in a horizontal plane of a point from an east-west axis of reference.

lens distortion—Lens aberrations shifting the position of images off the axis in which objects at different angular distances from the axis undergo different magnifications.

levee—Artificial bank confining a stream channel or limiting adjacent areas subject to flooding; an embankment bordering a submarine canyon or channel, usually occurring along the outer edge of a curve.

leveling—Surveying operation in which heights of objects and points are determined relative to a specified datum.

level surface—Surface which at every point is perpendicular to the plumb line or the direction in which gravity acts.

line drawing—Map copy suitable for reproduction without the use of a screen; a drawing composed of lines as distinguished from continuous-tone copy.

lithography—Planographic printing method based on the chemical repulsion between grease and water to separate the printing from nonprinting areas.

longitude—Angular distance in a great circle of reference reckoned from an accepted origin to the projection of any point on that circle. Longitude on the Earth's surface is measured on the Equator east and west of the meridian of Greenwich, England, and may be expressed either in degrees or in hours, the hour being equivalent to 15° of longitude.

lower high water (LHW)—The lower of the two high waters of any tidal day.

lower low water (LLW)—The lower of the two low waters of any tidal day. The single low water occurring daily during periods when the tide is diurnal is considered to be a lower low water.

lower low water datum (LLWD)—Approximation to the hypothetical surface of mean lower low water that has been adopted as a standard reference for a limited area, and is retained for an indefinite period regardless of the fact that it may differ slightly from a better determination of mean lower low water from a subsequent series of observations. Used primarily for river and harbor engineering

purposes. The Columbia River lower low water datum is an example.

low water (LW)—Minimum height reached by a falling tide. The height may be due solely to the periodic tidal forces or it may have superimposed upon it the effects of meteorological conditions.

low water datum (LWD)—1. The dynamic elevation for each of the Great Lakes and Lake St. Clair and the corresponding sloping surfaces of the St. Marys, St. Clair, Detroit, Niagara, and St. Lawrence Rivers to which are referred the depths shown on the navigation charts and the authorized depths for navigation improvement projects. Elevations of these planes are referred to the International Great Lakes of Datum of 1955 and are:

Lake Superior	600.0 ft
Lakes Michigan and Huron	576.8 ft
Lake St. Clair	571.7 ft
Lake Erie	568.6 ft
Lake Ontario	242.8 ft

2. An approximation of mean low water that has been adopted as a standard reference for a limited area and is retained for an indefinite period regardless of the fact that it may differ slightly from a better determination of mean low water from a subsequent series of observations. Used primarily for river and harbor engineering purposes. Boston Harbor low water datum is an example.

low water line—Intersection of the land with the water surface at an elevation of low water. Not to be confused with mean low water line.

magnetometer—Instrument for measuring the intensity and (or) direction of the Earth's magnetic field.

manuscript, map—The original drawing of a map on a suitable medium, usually dimensionally stable, from which direct reproduction copies are sometimes made.

map—Graphic representation of the physical features (natural, artificial, or both) of a part or the whole of the Earth's surface, by means of signs and symbols or photographic imagery, at an established scale, on a specified projection and with the means of orientation indicated.

map, base—Map on which information may be placed for purposes of comparison or geographical correlation. The term "base map" was at one time applied to a class of maps now known as outline maps. It may be applied to topographic maps, also termed "mother" maps, that are used in the construction of other types of maps by the addition of particular data.

map, bathymetric—Map delineating the form of the bottom of a body of water, or a portion thereof, by the use of depth contours (isobaths).

map, cadastral—Map showing the boundaries of subdivisions of land, often with the bearings and lengths thereof and the areas of individual tracts, for purposes of describing and recording ownership. It may also show culture, drainage, and other features relating to the value and use of land. *See* plat.

map, choropleth—Map showing statistical data by means of shading, dotting, hatching, coloring, or otherwise identifying a range of distribution within an area determined by political boundaries.

map, coastal zone—Map that depicts natural and cultural features in a section of the coastal zone. An orthophoto base is sometimes used for the area immediately inshore. The mean high and the mean low water lines (the mean lower-low where applicable), aids to navigation, landmarks for charts, and other data of specific interest are printed in red. The scale is usually 1:10,000.

map, engineering—Map showing information that is essential for planning an engineering project or development and for estimating its cost. It usually is a large-scale map of a small area or of a route. It may be entirely the product of an engineering survey, or reliable information may be collected from various sources for the purpose, and assembled on a base map.

map, flood control—Map designed for studying and planning control projects in areas subject to flooding.

map, forestry—Map prepared principally to show the size, density, kind, and value of trees in a designated area.

map, geologic—Map showing the structure and composition of geologic features.

map, historical—Map showing data of historical significance or one that has been replaced by a more recent publication.

map, hypsographic—Map showing relief with elevations referred to a sea-level datum.

map, hypsometric—Map showing relief by any convention, such as contours, hachures, shading, or tinting.

map, isopleth—Map showing statistical data by use of lines connecting points of equal value.

map, land use—Map showing by means of a coding system the various purposes for which parcels of land are being used by man.

map, line—Map composed of lines as distinguished from continuous-tone copy. Strictly, the map material may consist only of copy suitable for reproduction without use of a screen. Broadly, the term may be applied to maps composed of open-window copy, which requires tint screening.

map, line-route—Map showing the routes and types of construction of utility lines.

map, outline—Map that presents just sufficient geographic information to permit the correlation of additional data placed upon it.

map, planimetric—Map that presents only the horizontal positions for features represented; distinguished from a topographic map by the omission of relief in measurable form. The natural features usually shown on a planimetric map include rivers, lakes, and seas; mountains, valleys, and plains; forests, prairies, cities, farms, transportation routes, and public utility facilities; and political and private boundary lines. A planimetric map intended for special use may present only those features that are essential to the purpose to be served.

map, shoreline—Map prepared to provide data required for nautical charting operations. Similar to a planimetric map in content except limited to a relatively narrow zone parallel to the shore. The most common scale is 1:10,000, but maps at 1:5,000 and 1:20,000 scale are available in many areas.

map, slope (clinometric map)—Map showing the degree of steepness of the Earth's surface by the use of various colors or shading for critical ranges of slope.

map, soil—Map that shows the constitution, structure, and texture of the soil and identifies ongoing erosion.

map, storm evacuation—Map designed to identify coastal areas subject to flooding, to indicate recommended areas of refuge, and to emphasize available evacuation routes.

map, thematic—Map designed to provide information on a single topic, such as geology, rainfall, population.

map, topographic—Map that presents the horizontal and vertical positions of the features represented; distinguished from a planimetric map by the addition of relief in measurable form.

map digitization—Conversion of map data from graphic to digital form.

map projection—Orderly system of lines on a plane representing a corresponding system of imaginary lines on an adopted terrestrial or celestial datum surface. Also the mathematical concept of such a system.

marsh, coastal—Area of salt-tolerant vegetation in brackish- and (or) saline-water habitats subject to tidal inundation.

marsh, fresh-water—Tract of low wet ground, usually miry and covered with rank vegetation.

mean high water (MHW)—Tidal datum that is the arithmetic mean of the high water heights observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, simultaneous observations are made with a primary control tide station to derive the equivalent of a 19-year value. Use of the term "mean high tide" is discouraged.

For a semidiurnal or mixed tide, the two high waters of each tidal day are included in the mean. When any lower high water is indistinct, it is determined by record examination. For a diurnal tide, the one high water of each tidal day is used in the mean. In the event a second high water occurs, only the diurnal high water is included. So determined, this mean high water, based on the diurnal tide, is the equivalent of mean higher high water of a mixed tide. *See* datum *and* type of tide.

mean high water line (MHWL)—Intersection of the land with the water surface at the elevation of mean high water. *See* shoreline.

mean higher high water (MHHW)—Tidal datum that is the arithmetic mean of the higher high waters of a mixed tide observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). Only the higher high water of each pair of high waters of a tidal day is included in the mean. For stations with shorter series, simultaneous observations are made with a primary control tide station to derive the equivalent of a 19-year value. *See* datum and type of tide.

mean low water (MLW)—Tidal datum that is the arithmetic mean of the low water heights observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, simultaneous observations are made with a primary control tide station in order to derive the equivalent of a 19-year value. Use of the synonymous term "mean low tide" is discouraged.

For a semidiurnal or mixed tide, the two low waters of each tidal day are included in the mean. When any higher low water is indistinct, it is determined by record examination. For a diurnal tide, the first low water of each tidal day is used in the mean. In the event a second low water occurs, only the diurnal low water is included. So determined, this mean low water, based on the diurnal tide, is the equivalent of mean lower low water of a mixed tide. *See* datum *and* type of tide.

mean low water line (MLWL)—Intersection of the land with the water surface at the elevation of mean low water. *See* base line (seaward boundaries).

mean lower low water (MLLW)—Tidal datum that is the arithmetic mean of the lower low water heights of a mixed tide observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). Only the lower low water of each pair of low waters of a tidal day is included in the mean. For stations with shorter series, simultaneous observations are made with a primary control tide station to derive the equivalent of a 19-year value. *See* datum *and* type of tide.

mean lower low water line (MLLWL)—Intersection of the land with the water surface at the elevation of mean lower low water. *See* base line (seaward boundaries).

mean range of tide (Mn)—Difference in height between mean high water and mean low water.

mean river level—Tidal datum that is the average height of the surface of a tidal river at any point for all stages of the tide observed over a 19-year Metonic cycle (the National Tidal Datum Epoch), usually determined from hourly height readings. In rivers subject to occasional freshets the river level may undergo wide variations, and for practical purposes certain months of the year may be excluded in the determination of tidal datums. For charting purposes, tidal datums for rivers are usually based on observations during selected periods when the river is at or near low water stage.

mean sea level (MSL)—Tidal datum that is the arithmetic mean of hourly water elevations observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). Shorter series are specified in the name; that is, monthly mean sea level and yearly mean sea level. *See* datum.

mean tide level (TML)—*See* half tide level.

mean water level (MWL)—Mean surface elevation as determined by averaging the height of the water at equal intervals of time, usually at hourly intervals. MWL is used in lieu of MHW in inland tidal waters when the nontidal changes in water level are greater than, or on the same order of magnitude as, the range of tide.

mean water level line (MWLL)—Line formed by the intersection of the land with the water surface at an elevation of mean water level.

meridian—North-south line from which longitudes (or departures) and azimuths are reckoned; or a plane, normal to the geoid or spheroid, defining such a line.

Metonic cycle—Period of 235 lunations or about 19 years. Devised by Meton, an Athenian astronomer (5th century B.C.) for the purpose of obtaining a period at the end of which the phases of the Moon recur in the same order and on the same days as in the preceding cycle.

metric system—Decimal system of weights and measures based on the meter as a unit length and the kilogram as a unit mass.

mixed current—Tidal current characterized by a conspicuous speed difference between the two floods and (or) two ebbs usually occurring each tidal day. *See* type of tide.

mixed tide—Tide with a large inequality in either the high and (or) low water heights, with two high waters and two low waters usually occurring each tidal day. Strictly, all tides are mixed as the name is usually applied to the tides intermediate to those predominantly semidiurnal and those predominantly diurnal. *See* type of tide.

monument—Material object or collection of objects that indicate the position a survey station or land corner.

mosaic, aerial—Assembly of aerial photographs whose edges

usually have been torn or cut selectively and matched to the imagery on adjoining photographs to form a continuous representation of a portion of the Earth's surface.

nadir—Point on the celestial sphere vertically below the observer; 180° from the zenith.

Narrow-angle lens—Lens whose focal length is equal approximately to twice the diagonal of the format.

National Map Accuracy Standards—Specifications promulgated by the U.S. Office of Management and Budget to govern accuracy of topographic and other maps produced by Federal agencies.

National Tidal Datum Epoch—Specific 19-year cycle adopted by the National Ocean Survey as the official time segment over which tide observations are taken and reduced to obtain mean values for tidal datums. It is necessary for standardization because of apparent periodic and apparent secular trends in sea level. The present National Tidal Datum Epoch is 1941–59. It will be reviewed for possible revision every 25 years.

navigable waters—Waters usable, with or without improvements, as routes for commerce in the customary means of travel on water.

negative—Photographic image on film, plate, or paper, in which the subject tones to which the emulsion is sensitive are reversed or complementary. In cartography, any drawing or film on which map copy is either white or transparent against a black or opaque background.

normal-angle lens—Lens whose focal length is equal approximately to the diagonal of the format.

ocean—Great body of salt water which occupies two-thirds of the surface of the Earth, or one of its major subdivisions. The sea as opposed to the land.

oceanographic survey—Study or examination of conditions in the ocean or any part of it, with reference to animal or plant life, chemical elements present, temperature gradients, etc. *See* hydrographic survey.

oceanography—Study of the sea, embracing and integrating all knowledge pertaining to the sea's physical boundaries, the chemistry and physics of sea water, and marine biology. Strictly, oceanography is the description of the marine environment, whereas oceanology is the study of the oceans and related sciences.

ocean waters—For application to provisions of the Marine Protection, Research, and Sanctuaries Act of 1972, those waters of the open seas lying seaward of the base line from which the territorial sea is measured.

offshore—Comparatively flat zone of variable width that extends from the outer margin of the rather steeply sloping shoreface to the edge of the continental shelf.

offshore water—Water adjacent to land in which the physical properties are slightly influenced by continental conditions.

offset lithography—Indirect method of printing whereby an ink image is transferred from a pressplate to an intermediate rubber blanket and from that to the paper.

order of accuracy—Accuracy specifications governing the establishment of horizontal and vertical control for mapping, charting, and geodesy, promulgated under auspices of the Office of Management and Budget.

ordinary tides—Expression not used in a technical sense by NOS; the word "ordinary," when applied to tides, may be taken as the equivalent of the word "mean." Thus, "ordinary high water line" may be assumed to be the same as "mean high water line."

origin of coordinates—Point in a coordinate system that serves as zero-point in computing its elements or in prescribing its use.

orientation—Establishing correct relationship in direction with reference to points of the compass; the state of being in correct relationship in direction with reference to the points of the compass.

orthophotograph—Photographic copy prepared from a perspective photograph in which the displacements of images due to tilt and relief have been removed.

orthophotomap—A photomap made from an assembly of orthophotographs. It incorporates special cartographic treatment, photographic edge enhancement, color separation, or a combination of these.

outer edge of vegetation—*See* apparent shoreline.

orthophotomosaic—Assembly of orthophotographs forming a uniform-scale mosaic.

orthophotoscope—Photomechanical device used in conjunction with a double-projection stereoplotter for producing orthophotographs.

orthophotoquad—Orthophotograph or orthophotomosaic presented in quadrangle format with marginal data but with little or no cartographic enhancement.

overlay—Printing or drawing on a transparent or translucent medium intended to be placed in register on a map or other graphic and which shows details not appearing, or requiring special emphasis on the base material.

overprint—New material printed on a map or chart to show data of importance or special use, in addition to that originally printed.

paneling—Marking a ground station in advance of scheduled aerial photography to positively identify the station without additional fieldwork; the position of the marked station may or may not be known. Panels constitute a material marking so arranged as to form a distinctive pattern over a geodetic or other control-point marker, on a property corner or line, or at the position of an identifying point above an underground facility or feature.

parallel of latitude—A circle, or approximation of a circle, on the surface of the Earth, parallel to the equator, and connecting points of equal latitude; a circle of the celestial sphere parallel to the ecliptic, and connecting points of equal celestial latitude.

physiography—Classification of the genesis of land forms.

pixel (picture element)—Smallest resolvable element in a scanned remote-sensor image.

plain—Region of uniform general slope, comparatively level, of considerable extent, and not broken by marked elevations and depressions (it may be an extensive valley floor or a plateau summit); an extent of level or nearly level land; a flat, gently sloping, or nearly level region of the sea floor.

plat—Diagram drawn to scale showing all essential data pertaining to the boundaries and subdivisions of a tract of land, as determined by survey or protraction. As used by BLM, the drawing which represents the particular area included in a survey, such as a township, private land claim, or mineral claim, and the lines surveyed, established, or retraced, showing the direction and length of each such line; the relation to the adjoining official surveys; the boundaries, descriptions, and area of each parcel of land

subdivided; and, as nearly as may be practicable, a representation of the relief and improvements within the limits of the survey.

positive—Photographic image on film, plate, or paper having approximately the same tonal rendition as the original subject; that is light for light and dark for dark.

pressplate—Thin metal, plastic, or paper sheet that carries the printing image.

primary control tide station—Tide station at which continuous observations have been made over a minimum of a 19-year Metonic cycle. Its purpose is to provide data for computing accepted values of the harmonic and nonharmonic constants essential to tide predictions and to the determination of tidal datums for charting and coastal boundaries. The data series from this station serves as a primary control for the reduction of relatively short series from subordinate tide stations by comparing simultaneous observations, and for monitoring long-period sea-level trends and variations. *See* tide station and subordinate tide station.

prime meridian—Meridian of longitude 0°, used as the origin for measurements of longitude. The meridian of Greenwich, England, is the internationally accepted prime meridian on most charts. However, local or national prime meridians are occasionally used.

projection, map—Systematic formation of lines on a surface (usually a plane) to represent the parallels of latitude and the meridians of longitude of the Earth.

public land system—Public lands are subdivided by a rectangular system of surveys established and regulated by BLM. The standard format for subdivision is by townships measuring 6 miles (480 chains, 9.6 km) on a side. Townships are further subdivided into 36 numbered sections of 1 square mile (640 acres, 259 ha) each.

quadrangle—Four-sided area, bounded by parallels of latitude and meridians of longitude used as an area unit in mapping (dimensions are not necessarily the same in both directions). Also a geometric figure of significance in geodetic surveying.

range of tide—Difference in height between consecutive high and low waters. The mean range is the difference in height between mean high water and mean low water.

recession (retrogression)—Continuing landward movement of the shoreline; a net landward movement of the shoreline over a specified time.

rectification, simple—Projection of an aerial photograph (mathematically, graphically, or photographically) from its plane onto a horizontal plans by translation, rotation, and (or) scale change to remove displacement due to tilt of the aircraft.

reference station—Tide or current station for which independent daily predictions are given in tide or current tables from which corresponding predictions are obtained for other stations by means of differences and ratios.

registration—Correct positioning of one component of a composite map image in relation to the other components. Achieved, for example, by punching sets of holes, having a fixed horizontal relationship to each other, in each component sheet and then attaching the components together using specially designed fasteners.

reliction—Gradual withdrawal of the water in the sea, a lake, or a stream leaving permanently exposed and uncovered land whose title then vests in the owner of adjacent land. *See* accretion.

relief—Elevations and depressions of the land or sea bottom.

remote sensing—Process of detecting and (or) monitoring chemical or physical properties of an area by measuring its reflected and emmitted radiation.

representative fraction—Scale of a map or chart expressed as a fraction or ratio that relates unit distance on the map to distance measured in the same unit on the ground.

reproduction—Summation of all the processes involved in printing copies from an original drawing. A printed copy of an original drawing made by the processes of reproduction.

right-reading copy—Printed or drawn page on which the lettering and (or) images are presented in their normal orientation, for example, reading from left to right. *See* wrong-reading copy.

salt-water wedge—Intrusion of a tidal estuary by sea water in the form of a wedge underneath the less-dense fresh water.

sanctuary, estuarine—Research area which may include any part or all of an estuary, adjoining transitional areas, and adjacent uplands, constituting to the extent feasible a natural unit, set aside to provide scientists and students the opportunity to examine over a period of time the ecological relationships within the area. Established under provisions of CZMA.

sanctuary, habitat—Marine sanctuary established for the preservation, protection, and management of essential or specialized habitats representative of important marine systems.

sanctuary, marine—Area established under provisions of the Marine Protection, Research, and Sanctuaries Act of 1972, Public Law 92-532 (86 Stat. 1052), for the preservation and restoration of its conservation, recreational, ecological, or esthetic values. Such an area may lie in ocean waters as far seaward as the outer edge of the continental shelf, in coastal waters where the tide ebbs and flows, or in the Great Lakes and connecting waters, and, may be classified as a habitat, species, research, recreational and esthetic, or unique area.

sanctuary, recreational and esthetic—Marine sanctuary established for its esthetic or recreational value.

sanctuary, research—Marine sanctuary established for scientific research in support of management programs, and to establish ecological baselines.

sanctuary, species—Sanctuary established for the conservation of marine life.

sanctuary, unique—Marine sanctuary established to protect a unique or nearly unique geologic, oceanographic, or living resource feature.

scale—Relationship existing between a distance on a map, chart, photograph, and the corresponding distance on the Earth.

screen—Grating of opaque lines on glass or film, crossing at right angles, producing transparent apertures between intersections. Screens are used to break up a solid or continuous-tone image into a pattern of small dots.

scribing—Marking material with a pointed instrument. Removal of portions of a photographically opaque coating from a transparent base with engraving tools.

sea level (water level)—Height of the surface of the sea at any time.

seaward boundary—Limits of any area or zone offshore from the mean low, or mean lower low water line and established by an act of the U.S. Congress, or agreed to by treaty. *See* mean low water line.

sedimentation—Deposition of eroded particles by hydraulic action.

seiche—Stationary wave oscillation of a water body with a period varying from a few minutes to an hour or more, but somewhat less than the tidal periods. They are usually attributed to strong winds or changes in barometric pressure and are found both in enclosed bodies of water and superimposed upon the tide waves of the open ocean.

seismic sea wave—Wave caused by an earthquake.

sensor—Technical means, usually electronic, to extend man's natural senses by detecting emmitted or reflected energy. The energy may be nuclear, electromagnetic, including the visible and invisible portions of the spectrum, chemical, biological, thermal, or mechanical.

shore—Land covered and uncovered by the rise and fall of the normal tide. In its strictest use, the term applies only to land along tidal water.

shoreface—Narrow zone seaward from the low tide shoreline, permanently covered by water, over which the beach sands and gravels actively oscillate with changing wave conditions.

shoreline—Intersection of the land with the water surface. The shoreline shown on charts represents the line of contact between the land and a selected water elevation. In areas affected by tidal fluctuations, this line of contact is usually the mean high water line. In confined coastal waters of diminished tidal influence, the mean water level line may be used.

shore profile—Intersection of the shore with a vertical plane that is perpendicular to the shoreline. The profile may extend from the top of the dune line to the seaward limit of sand movement; but for shoreline mapping purposes, extends from the berm crest offshore of the mean low water line or mean lower low water line.

smooth sheet—Final plot of field control and hydrographic development such as soundings, fathom curves, bottom samples, and obstructions, dangers, and aids to navigation resulting from a hydrographic survey.

spectrum—Visual display, a photographic record, or a plot of the distribution of the intensity of energy dispersion of a given kind as a function of its wavelength, frequency, momentum, mass, or any related quantity.

spot elevation—Point on a map or chart whose height above a specified datum is noted, usually by a dot or a small sawbuck and elevation value. Elevations are shown, wherever practicable, for road forks and intersections, grade crossings, summits of hills, mountains and mountain passes, water surfaces of lakes and ponds, stream forks, bottom elevations in depressions, and large flat areas.

standard metropolitan statistical area (SMSA)—Integrated economic and social unit with a population nucleus of at least 50,000. An SMSA always includes a city (cities) of specified population which constitutes the central city and the county (counties) in which it is located.

state plane coordinate systems—Coordinate systems established by the U.S. Coast and Geodetic Survey (now the National Ocean Survey), one for each State, for use in defining positions of geodetic stations in terms of plane rectangular (x,y) coordinates.

stereocompilation—Production of a map or chart manuscript from aerial photographs and geodetic control data by means of photogrammetric instruments.

stereomodel (stereoscopic model)—Mental impression of a three-dimensional model which results from two overlapping perspective views, as in photogrammetric instruments.

stereoplotter—Instrument for plotting a map or obtaining spatial solutions by observation of stereomodels formed by pairs of photographs.

stereoscopic vision—Binocular vision that enables the observer to obtain the impression of depth by means of two different perspectives of an object (as two photographs taken from different camera stations).

stick-up—Adhesive-backed or wax-backed film or paper on which map names, symbols, and descriptive terms, have been printed for application to a transparent base in map and chart production.

still water level—Level that the sea surface would assume in the absence of wind waves; not to be confused with mean sea level or half tide level.

storm surge (storm tide, storm wave, tidal wave)—Rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane or other intense storm also includes the rise in level due to atmospheric pressure reduction as well as that due to wind stress. A storm surge is more severe when it occurs in conjunction with a high tide.

subordinate tide station—1. Tide station from which a relatively short series of observations is reduced by comparison with simultaneous observations from a tide station with a relatively long series of observations. 2. A station listed in the tide tables for which predictions are to be obtained by means of differences and ratios applied to the full predictions at a reference station. *See* primary control tide station and reference station.

subsidence—Decrease in the elevation of land without removal of surface material due to tectonic, seismic, or artificial forces.

surf zone—Area between the outermost breaker and the limit of wave uprush.

survey—Orderly process of determining data relating to any physical or chemical characteristics of the Earth. The associated data obtained in a survey. An organization engaged in making a survey.

territorial sea—Zone off the coast of a nation immediately seaward from a base line. Complete sovereignty is maintained over this zone by the coastal nation, subject to the right of innocent passage to ships of all nations. The United States recognizes this zone as extending 3 mi (4.8 km) from the base line. *See* fishing zone.

tidal basin—Basin affected by tides, particularly one in which water can be kept at a desired level by means of a gate.

tidal bench mark—*See* bench mark.

tidal current—Horizontal movement of the water caused by gravitational interactions between the Sun, Moon, and Earth. The horizontal component of the particulate motion

of a tidal wave. Part of same general movement of the sea that is manifested in the vertical rise and fall, called tide. *See* tidal wave, tide, *and* current.

tidal current chart diagrams—Series of 12 monthly diagrams to be used with the tidal current charts. Each diagram contains lines that indicate the specific tidal current chart of each series to use, and the speed factor to apply to that chart.

tidal current charts—Charts on which tidal current data are graphically depicted. Tidal current charts for a number of important waterways are published by NOS. Each consists of a set of charts giving the speed and direction of the current for each hour or equal interval of the tidal cycle, thus presenting a comprehensive view of the tidal current movement.

tidal current tables—Tables which give daily predictions of the times and velocities of the tidal currents. These predictions are usually supplemented by current differences and constants through which additional predictions can be obtained for numerous other places.

tidal wave—Shallow water wave caused by the gravitational interactions between the Sun, Moon, and Earth. High water is the crest of a tidal wave and low water is the trough. Tide is the vertical component of the particulate motion; tidal current is the horizontal. The observed tide and tidal current can be considered the result of the combination of several tidal waves, each of which may vary from nearly pure progressive to nearly pure standing and with differing periods, heights, phase relationships, and directions.

tide—Periodic rise and fall of the water resulting from gravitational interactions between the Sun, Moon, and Earth. The vertical component of the particulate motion of a tidal wave. Although the accompanying horizontal movement of the water is part of the same phenomenon, it is preferable to designate this motion as tidal current.

tide, diurnal—Having a period or cycle of approximately one tidal day.

tide, semidiurnal—Having a period or cycle of approximately one-half of a tidal day. The predominating type of tide throughout the world is semidiurnal, with two high waters and two low waters each tidal day. The tidal current is said to be semidiurnal when there are two flood and two ebb periods each day.

tide curve—Graphic representation of the rise and fall of the tide in which time is represented by the abscissas and the height of the tide by ordinates of the curve. For a normal tide, the graphic representation approximates a cosine curve.

tide gage—Instrument for measuring the rise and fall of the tide.

tidehead—Inland limit of water affected by a tide.

tidemark—High-water mark left by tidal water; the highest point reached by a high tide; a mark placed to indicate the highest point reached by a high tide, or occasionally, any specified stage of tide.

tide staff—Tide gage consisting of a vertical graduated staff from which the height of the tide can be read directly. It is called a fixed staff when it is secured in place so that is cannot be easily removed. A portable staff is one that is designed for removal from the water when not in use. For such a staff a fixed support is provided, and the staff itself has a metal stop secured to the back so that it will always have the same elevation when installed.

tide station—Geographic location at which tidal observations are conducted. Also, the facilities used to make tidal observations. These may include a tide house, tide gage, tide staff, and tidal bench marks. *See* primary control tide station *and* subordinate tide station.

tide tables—Tables which give daily predictions of the times and heights of high and low waters. These predictions are usually supplemented by tidal differences and constants through which additional predictions can be obtained for numerous other places.

tidewater or tidal water—Water affected by tides or sometimes that part of it which covers the tideland. The term is sometimes used broadly to designate the seaboard.

topography—Configuration (relief) of the land surface; the graphic delineation or portrayal of that configuration in map form, as by contour lines; in oceanography the term is applied to a surface such as the sea bottom or a surface of given characteristics within the water mass.

transparency—Photograph on a clear base, especially adaptable for viewing by transmitted light. Also, the light-transmitting capability of a material.

triangulation—Method of extending horizontal position on the surface of the Earth by measuring the angles of triangles and the included sides of selected triangles.

trilateration—Method of surveying wherein the lengths of the triangle sides are measured, usually by electronic methods, and the angles are computed from the measured lengths. Compares with triangulation.

turbidity—Reduced water clarity resulting from the presence of suspended matter. Water is considered turbid when its load of suspended matter is conspicuous, but all waters contain some suspended matter and therefore are turbid.

tsunami—Sea wave caused by an earthquake.

type of tide—Classification based on characteristic forms of a tide curve. Qualitatively, when the two high waters and two low waters of each tidal day are approximately equal in height, the tide is said to be semidiurnal; when there is a relatively large diurnal inequality in the high or low waters or both, it is said to be mixed; and when there is only one high water and one low water in each tidal day, it is said to be diurnal.

Universal Transverse Mercator grid—Military grid system based on the transverse Mercator projection, applied to maps of the Earth's surface extending from the Equator to 84° N. and 80° S. latitudes.

upland—Highland; ground elevation above the lowlands along rivers or between hills.

upper wetland boundary—Junction of wetland and stable ground.

vanishing tide—In a mixed tide with very large diurnal inequality, the lower high water (or higher low water) frequently becomes indistinct (or vanishes) at times of extreme declinations. During these periods the diurnal tide has such overriding dominance that the semidiurnal tide, although still present, cannot be readily seen on the tide curve.

velocity of current—Rate at which the water moves horizontally, usually expressed in knots (nautical miles per hour), but sometimes in ft/s or cm/s.

waterline—Juncture of land and sea. This line fluctuates, changing with the tide or other fluctuations in the water

APPENDIXES

Appendix 1

Cooperating Agencies in the Coastal Zone

The following State organizations were cooperators with USGS in 1977 but not all had active programs during the year. Cooperative agreements with several agencies may be established within the same State.

Alabama
State Geologist and Oil and Gas Supervisor
Geological Survey of Alabama
P.O. Drawer O
University, Alabama 35486

California
Chief, Statewide Planning Branch
Division of Planning
Department of Water Resources
P.O. Box 388
Sacramento, California 95802

Connecticut
Director and State Geologist
Connecticut Geological and National History Survey
Department of Environmental Protection
561 State Office Building
Hartford, Connecticut 06115

Delaware
State Geologist
Delaware Geological Survey
University of Delaware
101 Penny Hall
Newark, Delaware 19799

Florida
State Topographic Engineer
Department of Transportation
Burns Building
605 Suwannee Street
Tallahassee, Florida 32304

Executive Director
Department of Natural Resources
513 Crown Building
202 Blount Street
Tallahassee, Florida 32304

Georgia
Director and State Geologist
Geologic and Water Resources Division
Georgia Department of Natural Resources
19 Martin Luther King, Jr., Drive, SW.
Atlanta, Georgia 30334

Hawaii
Manager and Chief Engineer
Division of Water and Land Development
Department of Land and Natural Resources
P.O. Box 373
Honolulu, Hawaii 96809

Illinois
Chief
Illinois State Geological Survey
State Department of Registration and Education
121 Natural Resources Building
Urbana, Illinois 61801

Indiana
Head, Surveying and Mapping Section
Division of Water
Department of Natural Resources
606 State Office Building
100 North Senate Avenue
Indianapolis, Indiana 46204

Louisiana
Chief Engineer
Department of Public Works
P.O. Box 44155, Capitol Station
Baton Rouge, Louisiana 70804

Maine
Director and State Geologist
Bureau of Geology
Department of Conservation
211 State Office Building
Augusta, Maine 04330

Maryland
Director
Maryland Geological Survey
Merryman Hall
The Johns Hopkins University
Baltimore, Maryland 21218

Massachusetts
Department of Public Works
100 Nashua Street
Boston, Massachusetts 02114

Deputy Chief Engineer
Bureau of Project Development
Executive Office of Transportation and Construction
100 Nashua Street
Boston, Massachusetts 02114

Michigan
State Geologist
Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48926

Minnesota
Director
Minnesota Geological Survey
1633 Eustis Street
St. Paul, Minnesota 55108

Natural Resources Planner
State Planning Agency
100 Capitol Square Building
550 Cedar Street
St. Paul, Minnesota 55101

New Hampshire
State Geologist
Department of Resources and Economic Development
Geologic Branch, Department of Geology
James Hall
University of New Hampshire
Durham, New Hampshire 03824

New Jersey
State Geologist
New Jersey Bureau of Geology and Topography
Division of Natural Resources
(709 John Fitch Plaza)
P.O. Box 1889
Trenton, New Jersey 08625

New York
Chief, Cartography Section
Program Analysis Bureau
New York State Department of Transportation
1220 Washington Avenue
Albany, New York 12226

North Carolina
Director
Division of Resource Planning and Evaluation
Department of Natural and Economic Resources
P.O. Box 27687
Raleigh, North Carolina 27611

Ohio
Chief Engineer
Aerial Engineering Section
Ohio Department of Transportation
25 South Front Street
Columbus, Ohio 43216

Oregon
State Engineer
Water Resources Division
778 Chemeketa Street, NE.
Salem, Oregon 97310

Pennsylvania
Director and State Geologist
Department of Environmental Resources
Bureau of Topographic and Geological Survey
P.O. Box 2357
Harrisburg, Pennsylvania 17120

Puerto Rico
Executive Director
Puerto Rico Highway Authority
G.P.O. Box 3909
Santurce, Puerto Rico 00910

Rhode Island
Marine Specialist
Coastal Resources Center
University of Rhode Island
Kingston, Rhode Island 02881

South Carolina
State Geologist
Division of Geology
South Carolina State Development Board
Harbison Forest Road
Columbia, South Carolina 29210

Texas
Principal Engineer
Texas Water Development Board
P.O. Box 13087, Capitol Station
Austin, Texas 78711

Virginia
State Geologist and Commissioner
Division of Mineral Resources
Department of Conservation and Economic Development
P.O. Box 3667
Charlottesville, Virginia 22903

Washington
State Geologist
Geologic and Earth Resources Division
Department of Natural Resources
Olympia, Washington 98501

Wisconsin
State Geologist and Director
Wisconsin Geological and Natural History Survey
1815 University Avenue
Madison, Wisconsin 53706

Chief, Engineering Services Section
Wisconsin Division of Highways
P.O. Box 1487
Madison, Wisconsin 53702

Wisconsin State Cartographer
144 Science Hall
544 North Park Street
Madison, Wisconsin 53706

Appendix 2

USGS State Mapping Advisory Committees in the Coastal Zone

Alaska
Chairman
State Mapping Advisory Committee
Department of Natural Resources
Juneau, Alaska 99801

Maine
Chairman
State Mapping Advisory Committee
Maine Geological Survey
Augusta, Maine 04330

Michigan
Chairman
State Mapping Advisory Committee
Michigan Department of Natural Resources
515 West Michigan
Lansing, Michigan 48926

Minnesota
Chairman
State Mapping Advisory Committee
Environmental Quality Control State Planning Agency
550 Cedar Street
St. Paul, Minnesota 55101

Texas
Chairman
State Mapping Advisory Committee
Texas Water Development Board
Austin, Texas 78701

Appendix 3

State Coastal Zone Management Program Managers

Alabama
Alabama Development Office
State Capitol
Montgomery, Alabama 36130

Alaska
Policy Development and Planning Division
Office of the Governor
Pouch AD
Juneau, Alaska 99801

American Samoa
Executive Secretary
Environmental Quality Commission
Office of the Governor
Pago Pago, American Samoa 96799

California
Chairman
California Coastal Zone Conservation Commission
1540 Market Street
San Francisco, California 94102

Bay Conservation and Development Commission
Room 2011
30 Van Ness Avenue
San Francisco, California 94102

Connecticut
Coastal Area Management Program
Department of Environmental Protection
71 Capitol Avenue
Hartford, Connecticut 06115

Delaware
State Planning Office
Thomas Collins Building
530 South Dupont Highway
Dover, Delaware 19901

Florida
Bureau of Coastal Zone Planning
Pennington Building
115 Bloxham Street
Tallahassee, Florida 32304

Georgia
Planning Division
Office of Planning and Budget
Room 613
270 Washington Street, SW.
Atlanta, Georgia 30334

Guam
Bureau of Planning
Government of Guam
P.O. Box 2950
Agana, Guam 96910

Hawaii
Department of Planning and Economic Development
P.O. Box 2359
Honolulu, Hawaii 96804

Illinois
Illinois Coastal Zone Management Program
Room 1010
300 North State Street
Chicago, Illinois 60610

Indiana
State Planning Services Agency
Harrison Building
143 West Market Street
Indianapolis, Indiana 46204

Louisiana
State Planning Office
4528 Bennington Avenue
Baton Rouge, Louisiana 70808

Maine
State Planning Office
Resource Planning Division
189 State Street
Augusta, Maine 04333

Maryland
Energy and Coastal Zone Administration
Department of Natural Resources
Tawes State Office Building
Annapolis, Maryland 21401

Massachusetts
Executive Office of Environmental Affairs
100 Cambridge Street
Boston, Massachusetts 02202

Michigan
Division of Land Use Programs
Department of Natural Resources
Stevens T. Mason Building
Lansing, Michigan 48926

Minnesota
State Planning Agency
100 Capitol Square Building
550 Cedar Street
St. Paul, Minnesota 55155

Mississippi
Mississippi Marine Resources Council
P.O. Drawer 959
Long Beach, Mississippi 39560

New Hampshire
Office of Comprehensive Planning
Division of Regional Planning
State Annex
Concord, New Hampshire 03301

New Jersey
Office of Coastal Zone Management
Department of Environmental Protection
P.O. Box 1889
Trenton, New Jersey 08625

New York
Division of State Planning
Department of State
162 Washington Street
Albany, New York 12231

North Carolina
Department of Natural and Economic Resources
Box 27687
Raleigh, North Carolina 27611

Ohio
Division of Water
Department of Natural Resources
Building E
Fountain Square
1930 Belcher Drive
Columbus, Ohio 43224

Oregon
Land Conservation and Development Commission
1175 Court Street, NE.
Salem, Oregon 97310

Pennsylvania
Division of Outdoor Recreation
Third and Reily Streets
P.O. Box 1467
Harrisburg, Pennsylvania 17120

Puerto Rico
Department of Natural Resources
P.O. Box 5887
Puerto de Tierra, Puerto Rico 00906

Rhode Island
Statewide Planning Program
Department of Administration
265 Melrose Street
Providence, Rhode Island 02907

South Carolina
Wildlife and Marine Resources Department
1116 Bankers Trust Tower
Columbia, South Carolina 29201

Texas
State Land Commissioner
Texas Coastal Management Program
1705 Guadelupe
1700 North Congress Avenue
Austin, Texas 78711

Virgin Islands
Virgin Islands Planning Office
P.O. Box 2606
Charlotte Amalie, St. Thomas
U.S. Virgin Islands 00801

Virginia
Office of Commerce and Resources
Division of State Planning and Community Affairs
5th floor, Ninth Street Office Building
Richmond, Virginia 23219

Washington
Department of Ecology
State of Washington
Olympia, Washington 98504

Wisconsin
State Planning Office
Room B-130
1 West Wilson Street
Madison, Wisconsin 53702

Appendix 4

Sources for Information About Private Contractors

American Congress on Surveying and Mapping
210 Little Falls Street
Falls Church, Virginia 22046

American Society of Cartographers
P.O. Box 1493
Louisville, Kentucky 40201

American Society of Civil Engineers
345 East 47th Street
New York, New York 10017

American Society of Photogrammetry
105 N. Virginia Avenue
Falls Church, Virginia 22046

Association of American Geographers
1710 16th Street, NW.
Washington, D.C. 20009

Engineers Joint Council
2029 K Street, NW.
Washington, D.C. 20006

International Remote Sensing Institute
6151 Freeport Boulevard
Sacramento, California 95822

Technical Officer—Mapping Contracts
Office of Research and Technical Standards
Topographic Division
U.S. Geological Survey
MS 519 National Center
Reston, Virginia 22092

APPENDIX 5

COASTAL ZONE MANAGEMENT ACT AND AMENDMENTS

Public Law 92-583
92nd Congress, S. 3507
October 27, 1972

An Act

86 STAT. 1280

To establish a national policy and develop a national program for the management, beneficial use, protection, and development of the land and water resources of the Nation's coastal zones, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act entitled "An Act to provide for a comprehensive, long-range, and coordinated national program in marine science, to establish a National Council on Marine Resources and Engineering Development, and a Commission on Marine Science, Engineering and Resources, and for other purposes", approved June 17, 1966 (80 Stat. 203), as amended (33 U.S.C. 1101–1124), is further amended by adding at the end thereof the following new title:

Marine Resources and Engineering Development Act of 1966, amendment.

80 Stat. 998; 84 Stat. 865.

TITLE III—MANAGEMENT OF THE COASTAL ZONE

SHORT TITLE

SEC. 301. This title may be cited as the "Coastal Zone Management Act of 1972".

CONGRESSIONAL FINDINGS

SEC. 302. The Congress finds that—

(a) There is a national interest in the effective management, beneficial use, protection, and development of the coastal zone;

(b) The coastal zone is rich in a variety of natural, commercial, recreational, industrial, and esthetic resources of immediate and potential value to the present and future well-being of the Nation;

(c) The increasing and competing demands upon the lands and waters of our coastal zone occasioned by population growth and economic development, including requirements for industry, commerce, residential development, recreation, extraction of mineral resources and fossil fuels, transportation and navigation, waste disposal, and harvesting of fish, shellfish, and other living marine resources, have resulted in the loss of living marine resources, wildlife, nutrient-rich areas, permanent and adverse changes to ecological systems, decreasing open space for public use, and shoreline erosion;

(d) The coastal zone, and the fish, shellfish, other living marine resources, and wildlife therein, are ecologically fragile and consequently extremely vulnerable to destruction by man's alterations;

(e) Important ecological, cultural, historic, and esthetic values in the coastal zone which are essential to the well-being of all citizens are being irretrievably damaged or lost;

(f) Special natural and scenic characteristics are being damaged by ill-planned development that threatens these values;

(g) In light of competing demands and the urgent need to protect and to give high priority to natural systems in the coastal zone, present state and local institutional arrangements for planning and regulating land and water uses in such areas are inadequate; and

(h) The key to more effective protection and use of the land and water resources of the coastal zone is to encourage the states to exercise their full authority over the lands and waters in the coastal zone by assisting the states, in cooperation with Federal and local governments and other vitally affected interests, in developing land and water use programs for the coastal zone, including unified policies, criteria, standards, methods, and processes for dealing with land and water use decisions of more than local significance.

DECLARATION OF POLICY

SEC. 303. The Congress finds and declares that it is the national policy (a) to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations, (b) to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone giving full consideration to ecological, cultural, historic, and esthetic values as well as to needs for economic development, (c) for all Federal agencies engaged in programs affecting the coastal zone to cooperate and participate with state and local governments and regional agencies in effectuating the purposes of this title, and (d) to encourage the participation of the public, of Federal, state, and local governments and of regional agencies in the development of coastal zone management programs. With respect to implementation of such managament programs, it is the national policy to encourage cooperation among the various state and regional agencies including establishment of interstate and regional agreements, cooperative procedures, and joint action particularly regarding environmental problems.

DEFINITIONS

SEC. 304. For the purposes of this title—

(a) "Coastal zone" means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends, in Great Lakes waters, to the international boundary between the United States and Canada and, in other areas, seaward to the outer limit of the United States territorial sea. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters. Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers or agents.

(b) "Coastal waters" means (1) in the Great Lakes area, the waters within the territorial jurisdiction of the United States consisting of the Great Lakes, their connecting waters, harbors, roadsteads, and estuary-type areas such as bays, shallows, and marshes and (2) in other areas, those waters, adjacent to the shorelines, which contain a measurable quantity or percentage of sea water, including, but not limited to, sounds, bays, lagoons, bayous, ponds, and estuaries.

(c) "Coastal state" means a state of the United States in, or bordering on, the Atlantic, Pacific, or Arctic Ocean, the Gulf of Mexico, Long Island Sound, or one or more of the Great Lakes. For the purposes of this title, the term also includes Puerto Rico, the Virgin Islands, Guam, and American Samoa.

(d) "Estuary" means that part of a river or stream or other body of water having unimpaired connection with the open sea, where the sea water is measurably diluted with fresh water derived from land drainage. The term includes estuary-type areas of the Great Lakes.

(e) "Estuarine sanctuary" means a research area which may include any part or all of an estuary, adjoining transitional areas, and adjacent uplands, constituting to the extent feasible a natural unit, set

aside to provide scientists and students the opportunity to examine over a period of time the ecological relationships within the area.

(f) "Secretary" means the Secretary of Commerce.

(g) "Management program" includes, but is not limited to, a comprehensive statement in words, maps, illustrations, or other media of communication, prepared and adopted by the state in accordance with the provisions of this title, setting forth objectives, policies, and standards to guide public and private uses of lands and waters in the coastal zone.

(h) "Water use" means activities which are conducted in or on the water; but does not mean or include the establishment of any water quality standard or criteria or the regulation of the discharge or runoff of water pollutants except the standards, criteria, or regulations which are incorporated in any program as required by the provisions of section 307(f).

(i) "Land use" means activities which are conducted in or on the shorelands within the coastal zone, subject to the requirements outlined in section 307(g).

MANAGEMENT PROGRAM DEVELOPMENT GRANTS

SEC. 305. (a) The Secretary is authorized to make annual grants to any coastal state for the purpose of assisting in the development of a management program for the land and water resources of its coastal zone.

(b) Such management program shall include:

(1) an identification of the boundaries of the coastal zone subject to the management program;

(2) a definition of what shall constitute permissible land and water uses within the coastal zone which have a direct and significant impact on the coastal waters;

(3) an inventory and designation of areas of particular concern within the coastal zone;

(4) an identification of the means by which the state proposes to exert control over the land and water uses referred to in paragraph (2) of this subsection, including a listing of relevant constitutional provisions, legislative enactments, regulations, and judicial decisions;

(5) broad guidelines on priority of uses in particular areas, including specifically those uses of lowest priority;

(6) a description of the organizational structure proposed to implement the management program, including the responsibilities and interrelationships of local, areawide, state, regional, and interstate agencies in the management process.

(c) The grants shall not exceed 66⅔ per centum of the costs of the program in any one year and no state shall be eligible to receive more than three annual grants pursuant to this section. Federal funds received from other sources shall not be used to match such grants. In order to qualify for grants under this section, the state must reasonably demonstrate to the satisfaction of the Secretary that such grants will be used to develop a management program consistent with the requirements set forth in section 306 of this title. After making the initial grant to a coastal state, no subsequent grant shall be made under this section unless the Secretary finds that the state is satisfactorily developing such management program. Limitation.

(d) Upon completion of the development of the state's management program, the state shall submit such program to the Secretary for

review and approval pursuant to the provisions of section 306 of this title, or such other action as he deems necessary. On final approval of such program by the Secretary, the state's eligibility for further grants under this section shall terminate, and the state shall be eligible for grants under section 306 of this title.

Grants, allocation.

(e) Grants under this section shall be allocated to the states based on rules and regulations promulgated by the Secretary: *Provided, however*, That no management program development grant under this section shall be made in excess of 10 per centum nor less than 1 per centum of the total amount appropriated to carry out the purposes of this section.

(f) Grants or portions thereof not obligated by a state during the fiscal year for which they were first authorized to be obligated by the state, or during the fiscal year immediately following, shall revert to the Secretary, and shall be added by him to the funds available for grants under this section.

(g) With the approval of the Secretary, the state may allocate to a local government, to an areawide agency designated under section 204 of the Demonstration Cities and Metropolitan Development Act of 1966, to a regional agency, or to an interstate agency, a portion of the grant under this section, for the purpose of carrying out the provisions of this section.

80 Stat. 1262; 82 Stat. 208. 42 USC 3334.

Expiration date.

(h) The authority to make grants under this section shall expire on June 30, 1977.

ADMINISTRATIVE GRANTS

Limitation.

SEC. 306. (a) The Secretary is authorized to make annual grants to any coastal state for not more than 66⅔ per centum of the costs of administering the state's management program, if he approves such program in accordance with subsection (c) hereof. Federal funds received from other sources shall not be used to pay the state's share of costs.

Allocation.

(b) Such grants shall be allocated to the states with approved programs based on rules and regulations promulgated by the Secretary which shall take into account the extent and nature of the shoreline and area covered by the plan, population of the area, and other relevant factors: *Provided, however*, That no annual administrative grant under this section shall be made in excess of 10 per centum nor less than 1 per centum of the total amount appropriated to carry out the purposes of this section.

Program requirements.

(c) Prior to granting approval of a management program submitted by a coastal state, the Secretary shall find that:

(1) The state has developed and adopted a management program for its coastal zone in accordance with rules and regulations promulgated by the Secretary, after notice, and with the opportunity of full participation by relevant Federal agencies, state agencies, local governments, regional organizations, port authorities, and other interested parties, public and private, which is adequate to carry out the purposes of this title and is consistent with the policy declared in section 303 of this title.

(2) The state has:

(A) coordinated its program with local, areawide, and interstate plans applicable to areas within the coastal zone existing on January 1 of the year in which the state's management program is submitted to the Secretary, which plans have been developed by a local government, an areawide agency designated pursuant to regulations established under section 204 of the Demonstration

Cities and Metropolitan Development Act of 1966, a regional agency, or an interstate agency; and 80 Stat. 1262; 82 Stat. 208, 42 USC 3334.

(B) established an effective mechanism for continuing consultation and coordination between the management agency designated pursuant to paragraph (5) of this subsection and with local governments, interstate agencies, regional agencies, and areawide agencies within the coastal zone to assure the full participation of such local governments and agencies in carrying out the purposes of this title.

(3) The state has held public hearings in the development of the management program.

(4) The management program and any changes thereto have been reviewed and approved by the Governor.

(5) The Governor of the state has designated a single agency to receive and administer the grants for implementing the management program required under paragraph (1) of this subsection.

(6) The state is organized to implement the management program required under paragraph (1) of this subsection.

(7) The state has the authorities necessary to implement the program, including the authority required under subsection (d) of this section.

(8) The management program provides for adequate consideration of the national interest involved in the siting of facilities necessary to meet requirements which are other than local in nature.

(9) The management program makes provision for procedures whereby specific areas may be designated for the purpose of preserving or restoring them for their conservation, recreational, ecological, or esthetic values.

(d) Prior to granting approval of the management program, the Secretary shall find that the state, acting through its chosen agency or agencies, including local governments, areawide agencies designated under section 204 of the Demonstration Cities and Metropolitan Development Act of 1966, regional agencies, or interstate agencies, has authority for the management of the coastal zone in accordance with the management program. Such authority shall include power—

(1) to administer land and water use regulations, control development in order to ensure compliance with the management program, and to resolve conflicts among competing uses; and

(2) to acquire fee simple and less than fee simple interests in lands, waters, and other property through condemnation or other means when necessary to achieve conformance with the management program.

(e) Prior to granting approval, the Secretary shall also find that the program provides:

(1) for any one or a combination of the following general techniques for control of land and water uses within the coastal zone;

(A) State establishment of criteria and standards for local implementation, subject to administrative review and enforcement of compliance;

(B) Direct state land and water use planning and regulation; or

(C) State administrative review for consistency with the management program of all development plans, projects, or land and water use regulations, including exceptions and variances thereto, proposed by any state or local authority or private developer, with power to approve or disapprove after public notice and an opportunity for hearings.

(2) for a method of assuring that local land and water use regulations within the coastal zone do not unreasonably restrict or exclude land and water uses of regional benefit.

(f) With the approval of the Secretary, a state may allocate to a local government, an areawide agency designated under section 204 of the Demonstration Cities and Metropolitan Development Act of 1966, a regional agency, or an interstate agency, a portion of the grant under this section for the purpose of carrying out the provisions of this section: *Provided*, That such allocation shall not relieve the state of the responsibility for ensuring that any funds so allocated are applied in furtherance of such state's approved management program.

80 Stat. 1262; 82 Stat. 208. 42 USC 3334.

Program modification.

(g) The state shall be authorized to amend the management program. The modification shall be in accordance with the procedures required under subsection (c) of this section. Any amendment or modification of the program must be approved by the Secretary before additional administrative grants are made to the state under the program as amended.

Segmental development.

(h) At the discretion of the state and with the approval of the Secretary, a management program may be developed and adopted in segments so that immediate attention may be devoted to those areas within the coastal zone which most urgently need management programs: *Provided*, That the state adequately provides for the ultimate coordination of the various segments of the management program into a single unified program and that the unified program will be completed as soon as is reasonably practicable.

INTERAGENCY COORDINATION AND COOPERATION

SEC. 307. (a) In carrying out his functions and responsibilities under this title, the Secretary shall consult with, cooperate with, and, to the maximum extent practicable, coordinate his activities with other interested Federal agencies.

(b) The Secretary shall not approve the management program submitted by a state pursuant to section 306 unless the views of Federal agencies principally affected by such program have been adequately considered. In case of serious disagreement between any Federal agency and the state in the development of the program the Secretary, in cooperation with the Executive Office of the President, shall seek to mediate the differences.

(c)(1) Each Federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved state management programs.

(2) Any Federal agency which shall undertake any development project in the coastal zone of a state shall insure that the project is, to the maximum extent practicable, consistent with approved state management programs.

Certification.

(3) After final approval by the Secretary of a state's management program, any applicant for a required Federal license or permit to conduct an activity affecting land or water uses in the coastal zone of that state shall provide in the application to the licensing or permitting agency a certification that the proposed activity complies with the state's approved program and that such activity will be conducted in a manner consistent with the program. At the same time, the applicant shall furnish to the state or its designated agency a copy of the certification, with all necessary information and data. Each coastal state shall establish procedures for public notice in the case of all such

certifications and, to the extent it deems appropriate, procedures for public hearings in connection therewith. At the earliest practicable time, the state or its designated agency shall notify the Federal agency concerned that the state concurs with or objects to the applicant's certification. If the state or its designated agency fails to furnish the required notification within six months after receipt of its copy of the applicant's certification, the state's concurrence with the certification shall be conclusively presumed. No license or permit shall be granted by the Federal agency until the state or its designated agency has concurred with the applicant's certification or until, by the state's failure to act, the concurrence is conclusively presumed, unless the Secretary, on his own initiative or upon appeal by the applicant, finds, after providing a reasonable opportunity for detailed comments from the Federal agency involved and from the state, that the activity is consistent with the objectives of this title or is otherwise necessary in the interest of national security. Notification.

(d) State and local governments submitting applications for Federal assistance under other Federal programs affecting the coastal zone shall indicate the views of the appropriate state or local agency as to the relationship of such activities to the approved management program for the coastal zone. Such applications shall be submitted and coordinated in accordance with the provisions of title IV of the Intergovernmental Coordination Act of 1968 (82 Stat. 1098). Federal agencies shall not approve proposed projects that are inconsistent with a coastal state's management program, except upon a finding by the Secretary that such project is consistent with the purposes of this title or necessary in the interest of national security. 42 USC 4231.

(e) Nothing in this title shall be construed—

(1) to diminish either Federal or state jurisdiction, responsibility, or rights in the field of planning, development, or control of water resources, submerged lands, or navigable waters; nor to displace, supersede, limit, or modify any interstate compact or the jurisdiction or responsibility of any legally established joint or common agency of two or more states or of two or more states and the Federal Government; nor to limit the authority of Congress to authorize and fund projects;

(2) as superseding, modifying, or repealing existing laws applicable to the various Federal agencies; nor to affect the jurisdiction, powers, or prerogatives of the International Joint Commission, United States and Canada, the Permanent Engineering Board, and the United States operating entity or entities established pursuant to the Columbia River Basin Treaty, signed at Washington, January 17, 1961, or the International Boundary and Water Commission, United States and Mexico.

(f) Notwithstanding any other provision of this title, nothing in this title shall in any way affect any requirement (1) established by the Federal Water Pollution Control Act, as amended, or the Clean Air Act, as amended, or (2) established by the Federal Government or by any state or local government pursuant to such Acts. Such requirements shall be incorporated in any program developed pursuant to this title and shall be the water pollution control and air pollution control requirements applicable to such program. Ante, p. 816. 81 Stat. 485; 84 Stat. 1676. 42 USC 1857 note.

(g) When any state's coastal zone management program, submitted for approval or proposed for modification pursuant to section 306 of this title, includes requirements as to shorelands which also would be subject to any Federally supported national land use program which may be hereafter enacted, the Secretary, prior to approving such pro-

gram, shall obtain the concurrence of the Secretary of the Interior, or such other Federal official as may be designated to administer the national land use program, with respect to that portion of the coastal zone management program affecting such inland areas.

PUBLIC HEARINGS

SEC. 308. All public hearings required under this title must be announced at least thirty days prior to the hearing date. At the time of the announcement, all agency materials pertinent to the hearings, including documents, studies, and other data, must be made available to the public for review and study. As similar materials are subsequently developed, they shall be made available to the public as they become available to the agency.

REVIEW OF PERFORMANCE

SEC. 309. (a) The Secretary shall conduct a continuing review of the management programs of the coastal states and of the performance of each state.

Financial assistance, termination.

(b) The Secretary shall have the authority to terminate any financial assistance extended under section 306 and to withdraw any unexpended portion of such assistance if (1) he determines that the state is failing to adhere to and is not justified in deviating from the program approved by the Secretary; and (2) the state has been given notice of the proposed termination and withdrawal and given an opportunity to present evidence of adherence or justification for altering its program.

RECORDS

SEC. 310. (a) Each recipient of a grant under this title shall keep such records as the Secretary shall prescribe, including records which fully disclose the amount and disposition of the funds received under the grant, the total cost of the project or undertaking supplied by other sources, and such other records as will facilitate an effective audit.

Audit.

(b) The Secretary and the Comptroller General of the United States, or any of their duly authorized representatives, shall have access for the purpose of audit and examination to any books, documents, papers, and records of the recipient of the grant that are pertinent to the determination that funds granted are used in accordance with this title.

ADVISORY COMMITTEE

Costal Zone Management Advisory Committee, establishment; membership.

SEC. 311. (a) The Secretary is authorized and directed to establish a Coastal Zone Management Advisory Committee to advise, consult with, and make recommendations to the Secretary on matters of policy concerning the coastal zone. Such committee shall be composed of not more than fifteen persons designated by the Secretary and shall perform such functions and operate in such a manner as the Secretary may direct. The Secretary shall insure that the committee membership as a group possesses a broad range of experience and knowledge relating to problems involving management, use, conservation, protection, and development of coastal zone resources.

Compensation, travel expenses.

(b) Members of the committee who are not regular full-time employees of the United States, while serving on the business of the committee, including traveltime, may receive compensation at rates not exceeding $100 per diem; and while so serving away from their

homes or regular places of business may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5, United States Code, for individuals in the Government service employed intermittently. 80 Stat. 499; 83 Stat. 190.

ESTUARINE SANCTUARIES

SEC. 312. The Secretary, in accordance with rules and regulations promulgated by him, is authorized to make available to a coastal state grants of up to 50 per centum of the costs of acquisition, development, and operation of estuarine sanctuaries for the purpose of creating natural field laboratories to gather data and make studies of the natural and human processes occurring within the estuaries of the coastal zone. The Federal share of the cost for each such sanctuary shall not exceed $2,000,000. No Federal funds received pursuant to section 305 or section 306 shall be used for the purpose of this section. Grants. Federal share.

ANNUAL REPORT

SEC. 313. (a) The Secretary shall prepare and submit to the President for transmittal to the Congress not later than November 1 of each year a report on the administration of this title for the preceding fiscal year. The report shall include but not be restricted to (1) an identification of the state programs approved pursuant to this title during the preceding Federal fiscal year and a description of those programs; (2) a listing of the states participating in the provisions of this title and a description of the status of each state's programs and its accomplishments during the preceding Federal fiscal year; (3) an itemization of the allocation of funds to the various coastal states and a breakdown of the major projects and areas on which these funds were expended; (4) an identification of any state programs which have been reviewed and disapproved or with respect to which grants have been terminated under this title, and a statement of the reasons for such action; (5) a listing of all activities and projects which, pursuant to the provisions of subsection (c) or subsection (d) of section 307, are not consistent with an applicable approved state management program; (6) a summary of the regulations issued by the Secretary or in effect during the preceding Federal fiscal year; (7) a summary of a coordinated national strategy and program for the Nation's coastal zone including identification and discussion of Federal, regional, state, and local responsibilities and functions therein; (8) a summary of outstanding problems arising in the administration of this title in order of priority; and (9) such other information as may be appropriate.

(b) The report required by subsection (a) shall contain such recommendations for additional legislation as the Secretary deems necessary to achieve the objectives of this title and enhance its effective operation.

RULES AND REGULATIONS

SEC. 314. The Secretary shall develop and promulgate, pursuant to section 553 of title 5, United States Code, after notice and opportunity for full participation by relevant Federal agencies, state agencies, local governments, regional organizations, port authorities, and other interested parties, both public and private, such rules and regulations as may be necessary to carry out the provisions of this title. 80 Stat. 383.

AUTHORIZATION OF APPROPRIATIONS

SEC. 315. (a) There are authorized to be appropriated—

(1) the sum of $9,000,000 for the fiscal year ending June 30, 1973, and for each of the fiscal years 1974 through 1977 for grants under section 305, to remain available until expended;

(2) such sums, not to exceed $30,000,000, for the fiscal year ending June 30, 1974, and for each of the fiscal years 1975 through 1977, as may be necessary, for grants under section 306 to remain available until expended; and

(3) such sums, not to exceed $6,000,000 for the fiscal year ending June 30, 1974, as may be necessary, for grants under section 312, to remain available until expended.

(b) There are also authorized to be appropriated such sums, not to exceed $3,000,000, for fiscal year 1973 and for each of the four succeeding fiscal years, as may be necessary for administrative expenses incident to the administration of this title.

Approved October 27, 1972.

LEGISLATIVE HISTORY:

HOUSE REPORTS: No. 92-1049 accompanying H.R. 14146 (Comm. on Merchant Marine and Fisheries) and No. 92-1544 (Comm. of Conference).
SENATE REPORT No. 92-753 (Comm. on Commerce).
CONGRESSIONAL RECORD, Vol. 118 (1972):
Apr. 25, considered and passed Senate.
Aug. 2, considered and passed House, amended, in lieu of H.R. 14146.
Oct. 12, House and Senate agreed to conference report.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 8, No. 44:
Oct. 28, Presidential statement.

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Public Law 94-370
94th Congress, S. 586
July 26, 1976

An Act

To improve coastal zone management in the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Coastal Zone Management Act Amendments of 1976".

Coastal Zone Management Act Amendments of 1976.
16 USC 1451 note.

SEC. 2. FINDINGS.

Section 302 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1451) is amended—

(1) by inserting "ecological," immediately after "recreational," in subsection (b);

(2) by striking out—

(A) the semicolon at the end of subsections (a), (b), (c), (d), (e), and (f), respectively, and

(B) "; and" at the end of subsection (g),

and inserting in lieu of such matter at each such place a period; and

(3) by inserting immediately after subsection (h) the following:

"(i) The national objective of attaining a greater degree of energy self-sufficiency would be advanced by providing Federal financial assistance to meet state and local needs resulting from new or expanded energy activity in or affecting the coastal zone.".

SEC. 3. DEFINITIONS.

Section 304 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1453) is amended—

(1) by redesignating paragraph (a) as paragraph (1), and by amending the first sentence of such paragraph (1) (as so redesignated)—

(A) by striking out "'Coastal" and inserting in lieu thereof "The term 'coastal"; and

(B) by inserting immediately after "and includes" the following: "islands,";

(2) by redesignating paragraph (b) as paragraph (2), and by amending such paragraph (2) (as so redesignated)—

(A) by striking out "'Coastal" and inserting in lieu thereof "The term 'coastal"; and

(B) by striking out "(1)" and "(2)" and inserting in lieu thereof "(A)" and "(B)", respectively;

(3) by striking out "(c) 'Coastal" and inserting in lieu thereof "(3) The term 'coastal";

(4) by inserting immediately before paragraph (d) thereof the following:

"(4) The term 'coastal energy activity' means any of the following activities if, and to the extent that (A) the conduct, support, or facilitation of such activity requires and involves the siting, construction, expansion, or operation of any equipment or facility; and (B) any technical requirement exists which, in the determination of the Secretary, necessitates that the siting, construction, expansion, or

74-836 O

operation of such equipment or facility be carried out in, or in close proximity to, the coastal zone of any coastal state;

"(i) Any outer Continental Shelf energy activity.

"(ii) Any transportation, conversion, treatment, transfer, or storage of liquefied natural gas.

"(iii) Any transportation, transfer, or storage of oil, natural gas, or coal (including, but not limited to, by means of any deepwater port, as defined in section 3(10) of the Deepwater Port Act of 1974 (33 U.S.C. 1502(10))).

For purposes of this paragraph, the siting, construction, expansion, or operation of any equipment or facility shall be 'in close proximity to' the coastal zone of any coastal state if such siting, construction, expansion, or operation has, or is likely to have, a significant effect on such coastal zone.

"(5) The term 'energy facilities' means any equipment or facility which is or will be used primarily—

"(A) in the exploration for, or the development, production, conversion, storage, transfer, processing, or transportation of, any energy resource; or

"(B) for the manufacture, production, or assembly of equipment, machinery, products, or devices which are involved in any activity described in subparagraph (A).

The term includes, but is not limited to (i) electric generating plants; (ii) petroleum refineries and associated facilities; (iii) gasification plants; (iv) facilities used for the transportation, conversion, treatment, transfer, or storage of liquefied natural gas; (v) uranium enrichment or nuclear fuel processing facilities; (vi) oil and gas facilities, including platforms, assembly plants, storage depots, tank farms, crew and supply bases, and refining complexes; (vii) facilities including deepwater ports, for the transfer of petroleum; (viii) pipelines and transmission facilities; and (ix) terminals which are associated with any of the foregoing.";

(5) by striking out "(d) 'Estuary' " and inserting in lieu thereof "(6) The term 'estuary' ";

(6) by redesignating paragraph (e) as paragraph (7) and by amending such paragraph (7) (as so redesignated)—

(A) by striking out " 'Estuarine" and inserting in lieu thereof "The term 'estuarine", and

(B) by striking out "estuary, adjoining transitional areas, and adjacent uplands, constituting" and inserting in lieu thereof the following: "estuary and any island, transitional area, and upland in, adjoining, or adjacent to such estuary, and which constitutes";

(7) by striking out paragraph (f) and inserting in lieu thereof the following:

"(8) The term 'Fund' means the Coastal Energy Impact Fund established by section 308(h).

Post, p. 1019.

"(9) The term 'land use' means activities which are conducted in, or on the shorelands within, the coastal zone, subject to the requirements outlined in section 307(g).

Post, p. 1018.

"(10) The term 'local government' means any political subdivision of, or any special entity created by, any coastal state which (in whole or part) is located in, or has authority over, such state's coastal zone and which (A) has authority to levy taxes, or to establish and collect user fees, or (B) provides any public facility or public service which is financed in whole or part by taxes or user fees. The term includes, but is not limited to, any school district, fire district, transportation authority, and any other special purpose district or authority.";

(8) by striking out "(g) 'Management" and inserting in lieu thereof "(11) The term 'management";

(9) by inserting immediately after paragraph (11) (as redesignated by paragraph (8) of this section) the following:

"(12) The term 'outer Continental Shelf energy activity' means any exploration for, or any development or production of, oil or natural gas from the outer Continental Shelf (as defined in section 2(a) of the Outer Continental Shelf Lands Act (43 U.S.C. 1331(a))), or the siting, construction, expansion, or operation of any new or expanded energy facilities directly required by such exploration, development, or production.

"(13) The term 'person' means any individual; any corporation, partnership, association, or other entity organized or existing under the laws of any state; the Federal Government; any state, regional, or local government; or any entity of any such Federal, state, regional, or local government.

"(14) The term 'public facilities and public services' means facilities or services which are financed, in whole or in part, by any state or political subdivision thereof, including, but not limited to, highways and secondary roads, parking, mass transit, docks, navigation aids, fire and police protection, water supply, waste collection and treatment (including drainage), schools and education, and hospitals and health care. Such term may also include any other facility or service so financed which the Secretary finds will support increased population.

"(15) The term 'Secretary' means the Secretary of Commerce.";

(10) by striking out "(h) 'Water" and inserting in lieu thereof "(16) The term 'water"; and

(11) by striking out paragraph (i).

SEC. 4. MANAGEMENT PROGRAM DEVELOPMENT GRANTS.

Section 305 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1454) is amended to read as follows:

"MANAGEMENT PROGRAM DEVELOPMENT GRANTS

"SEC. 305. (a) The Secretary may make grants to any coastal state—

"(1) under subsection (c) for the purpose of assisting such state in the development of a management program for the land and water resources of its coastal zone; and

"(2) under subsection (d) for the purpose of assisting such state in the completion of the development, and the initial implementation, of its management program before such state qualifies for administrative grants under section 306.

Post, p. 1017.

Requirements.

"(b) The management program for each coastal state shall include each of the following requirements:

"(1) An identification of the boundaries of the coastal zone subject to the management program.

"(2) A definition of what shall constitute permissible land uses and water uses within the coastal zone which have a direct and significant impact on the coastal waters.

"(3) An inventory and designation of areas of particular concern within the coastal zone.

"(4) An identification of the means by which the state proposes to exert control over the land uses and water uses referred to in

paragraph (2), including a listing of relevant constitutional provisions, laws, regulations, and judicial decisions.

"(5) Broad guidelines on priorities of uses in particular areas, including specifically those uses of lowest priority.

"(6) A description of the organizational structure proposed to implement such management program, including the responsibilities and interrelationships of local, areawide, state, regional, and interstate agencies in the management process.

"(7) A definition of the term 'beach' and a planning process for the protection of, and access to, public beaches and other public coastal areas of environmental, recreational, historical, esthetic, ecological, or cultural value.

"(8) A planning process for energy facilities likely to be located in, or which may significantly affect, the coastal zone, including, but not limited to, a process for anticipating and managing the impacts from such facilities.

"(9) A planning process for (A) assessing the effects of shoreline erosion (however caused), and (B) studying and evaluating ways to control, or lessen the impact of, such erosion, and to restore areas adversely affected by such erosion.

No management program is required to meet the requirements in paragraphs (7), (8), and (9) before October 1, 1978.

"(c) The Secretary may make a grant annually to any coastal state for the purposes described in subsection (a)(1) if such state reasonably demonstrates to the satisfaction of the Secretary that such grant will be used to develop a management program consistent with the requirements set forth in section 306. The amount of any such grant shall not exceed 80 per centum of such state's costs for such purposes in any one year. No coastal state is eligible to receive more than four grants pursuant to this subsection. After the initial grant is made to any coastal state pursuant to this subsection, no subsequent grant shall be made to such state pursuant to this subsection unless the Secretary finds that such state is satisfactorily developing its management program.

Post, p. 1017.

"(d)(1) The Secretary may make a grant annually to any coastal state for the purposes described in subsection (a)(2) if the Secretary finds that such state meets the eligibility requirements set forth in paragraph (2). The amount of any such grant shall not exceed 80 per centum of the costs for such purposes in any one year.

Eligibility.

"(2) A coastal state is eligible to receive grants under this subsection if it has—

"(A) developed a management program which—

"(i) is in compliance with the rules and regulations promulgated to carry out subsection (b), but

"(ii) has not yet been approved by the Secretary under section 306;

"(B) specifically identified, after consultation with the Secretary, any deficiency in such program which makes it ineligible for approval by the Secretary pursuant to section 306, and has established a reasonable time schedule during which it can remedy any such deficiency;

"(C) specified the purposes for which any such grant will be used;

"(D) taken or is taking adequate steps to meet any requirement under section 306 or 307 which involves any Federal official or agency; and

Post, p. 1018.

"(E) complied with any other requirement which the Secretary, by rules and regulations, prescribes as being necessary and appropriate to carry out the purposes of this subsection.

"(3) No management program for which grants are made under this subsection shall be considered an approved program for purposes of section 307.

Post, p. 1018.

"(e) Grants under this section shall be made to, and allocated among, the coastal states pursuant to rules and regulations promulgated by the Secretary; except that—

Rules and regulations.

"(1) no grant shall be made under this section in an amount which is more than 10 per centum of the total amount appropriated to carry out the purposes of this section, but the Secretary may waive this limitation in the case of any coastal state which is eligible for grants under subsection (d); and

"(2) no grant shall be made under this section in an amount which is less than 1 per centum of the total amount appropriated to carry out the purposes of this section, but the Secretary shall waive this limitation in the case of any coastal state which requests such a waiver.

"(f) The amount of any grant (or portion thereof) made under this section which is not obligated by the coastal state concerned during the fiscal year for which it was first authorized to be obligated by such state, or during the fiscal year immediately following, shall revert to the Secretary who shall add such amount to the funds available for grants under this section.

"(g) With the approval of the Secretary, any coastal state may allocate to any local government, to any areawide agency designated under section 204 of the Demonstration Cities and Metropolitan Development Act of 1966, to any regional agency, or to any interstate agency, a portion of any grant received by it under this section for the purpose of carrying out the provisions of this section.

"(h) Any coastal state which has completed the development of its management program shall submit such program to the Secretary for review and approval pursuant to section 306. Whenever the Secretary approves the management program of any coastal state under section 306, such state thereafter—

Infra.

"(1) shall not be eligible for grants under this section; except that such state may receive grants under subsection (c) in order to comply with the requirements of paragraphs (7), (8), and (9) of subsection (b); and

"(2) shall be eligible for grants under section 306.

"(i) The authority to make grants under this section shall expire on September 30, 1979.".

Expiration date.

SEC. 5. ADMINISTRATIVE GRANTS.

Section 306 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1455) is amended—

(1) by amending subsection (a) to read as follows:

"(a) The Secretary may make a grant annually to any coastal state for not more than 80 per centum of the costs of administering such state's management program if the Secretary (1) finds that such program meets the requirements of section 305(b), and (2) approves such program in accordance with subsections (c), (d), and (e).";

Ante, p. 1015.

(2) by amending subsection (c)(2)(B) by striking out the period at the end thereof and inserting in lieu thereof the following: "; except that the Secretary shall not find any mechanism to be 'effective' for purposes of this subparagraph unless it includes each of the following requirements:

Notice.

"(i) Such management agency is required, before implementing any management program decision which would conflict with any local zoning ordinance, decision, or other action, to send a notice of such management program decision to any local government whose zoning authority is affected thereby.

"(ii) Any such notice shall provide that such local government may, within the 30-day period commencing on the date of receipt of such notice, submit to the management agency written comments on such management program decision, and any recommendation for alternatives thereto, if no action is taken during such period which would conflict or interfere with such management program decision, unless such local government waives its right to comment.

"(iii) Such management agency, if any such comments are submitted to it, with such 30-day period, by any local government—

"(I) is required to consider any such comments,

"(II) is authorized, in its discretion, to hold a public hearing on such comments, and

"(III) may not take any action within such 30-day period to implement the management program decision, whether or not modified on the basis of such comments.";

(3) by amending subsection (c) (8) to read as follows—

"(8) The management program provides for adequate consideration of the national interest involved in planning for, and in the siting of, facilities (including energy facilities in, or which significantly affect, such state's coastal zone) which are necessary to meet requirements which are other than local in nature. In the case of such energy facilities, the Secretary shall find that the state has given such consideration to any applicable interstate energy plan or program.";

(4) by amending subsection (g) to read as follows:

"(g) Any coastal state may amend or modify the management program which it has submitted and which has been approved by the Secretary under this section, pursuant to the required procedures described in subsection (c). Except with respect to any such amendment which is made before October 1, 1978, for the purpose of complying with the

Ante, p. 1015.

requirements of paragraphs (7), (8), and (9) of section 305(b), no grant shall be made under this section to any coastal state after the date of such an amendment or modification, until the Secretary approves such amendment or modification.".

SEC. 6. CONSISTENCY AND MEDIATION.

Section 307 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1456) is amended—

(1) by striking out "INTERAGENCY" in the title of such section;

(2) by striking out the last sentence of subsection (b);

(3) by amending subsection (c) (3) by inserting "(A)" immediately after "(3)", and by adding at the end thereof the following:

"(B) After the management program of any coastal state has been

Ante, p. 1017.

approved by the Secretary under section 306, any person who submits to the Secretary of the Interior any plan for the exploration or development of, or production from, any area which has been leased under the Outer Continental Shelf Lands Act (43 U.S.C. 1331 et seq.) and regulations under such Act shall, with respect to any exploration, development, or production described in such plan and affecting any land use or water use in the coastal zone of such state, attach to such

plan a certification that each activity which is described in detail in such plan complies with such state's approved management program and will be carried out in a manner consistent with such program. No Federal official or agency shall grant such person any license or permit for any activity described in detail in such plan until such state or its designated agency receives a copy of such certification and plan, together with any other necessary data and information, and until—

"(i) such state or its designated agency, in accordance with the procedures required to be established by such state pursuant to subparagraph (A), concurs with such person's certification and notifies the Secretary and the Secretary of the Interior of such concurrence;

"(ii) concurrence by such state with such certification is conclusively presumed, as provided for in subparagraph (A); or

"(iii) the Secretary finds, pursuant to subparagraph (A), that each activity which is described in detail in such plan is consistent with the objectives of this title or is otherwise necessary in the interest of national security.

If a state concurs or is conclusively presumed to concur, or if the Secretary makes such a finding, the provisions of subparagraph (A) are not applicable with respect to such person, such state, and any Federal license or permit which is required to conduct any activity affecting land uses or water uses in the coastal zone of such state which is described in detail in the plan to which such concurrence or finding applies. If such state objects to such certification and if the Secretary fails to make a finding under clause (iii) with respect to such certification, or if such person fails substantially to comply with such plan as submitted, such person shall submit an amendment to such plan, or a new plan, to the Secretary of the Interior. With respect to any amendment or new plan submitted to the Secretary of the Interior pursuant to the preceding sentence, the applicable time period for purposes of concurrence by conclusive presumption under subparagraph (A) is 3 months."; and

(4) by adding at the end thereof the following new subsection:

"(h) In case of serious disagreement between any Federal agency and a coastal state—

"(1) in the development or the initial implementation of a management program under section 305; or

Ante, p. 1015.

(2) in the administration of a management program approved under section 306;

Ante, p. 1017.

the Secretary, with the cooperation of the Executive Office of the President, shall seek to mediate the differences involved in such disagreement. The process of such mediation shall, with respect to any disagreement described in paragraph (2), include public hearings which shall be conducted in the local area concerned.".

SEC. 7. COASTAL ENERGY IMPACT PROGRAM.

The Coastal Zone Management Act of 1972 is further amended by redesignating sections 308 through 315 as sections 311 through 318, respectively; and by inserting immediately after section 307 the following:

16 USC 1457-1464.

"COASTAL ENERGY IMPACT PROGRAM

"SEC. 308. (a)(1) The Secretary shall administer and coordinate, as part of the coastal zone management activities of the Federal Government provided for under this title, a coastal energy impact program. Such program shall consist of the provision of financial

16 USC 1456a.

assistance to meet the needs of coastal states and local governments in such states resulting from specified activities involving energy development. Such assistance, which includes—

"(A) grants, under subsection (b), to coastal states for the purposes set forth in subsection (b)(4) with respect to consequences resulting from the energy activities specified therein;

"(B) grants, under subsection (c), to coastal states for study of, and planning for, consequences relating to new or expanded energy facilities in, or which significantly affect, the coastal zone;

"(C) loans, under subsection (d)(1), to coastal states and units of general purpose local government to assist such states and units to provide new or improved public facilities or public services which are required as a result of coastal energy activity;

"(D) guarantees, under subsection (d)(2) and subject to the provisions of subsection (f), of bonds or other evidences of indebtedness issued by coastal states and units of general purpose local government for the purpose of providing new or improved public facilities or public services which are required as a result of coastal energy activity;

"(E) grants or other assistance, under subsection (d)(3), to coastal states and units of general purpose local government to enable such states and units to meet obligations under loans or guarantees under subsection (d) (1) or (2) which they are unable to meet as they mature, for reasons specified in subsection (d)(3); and

"(F) grants, under subsection (d)(4), to coastal states which have suffered, are suffering, or will suffer any unavoidable loss of a valuable environmental or recreational resource;

shall be provided, administered, and coordinated by the Secretary in accordance with the provisions of this section and under the rules and regulations required to be promulgated pursuant to paragraph (2). Any such financial assistance shall be subject to audit under section 313.

Post, p. 1030.

Rules and regulations.
16 USC 1463.

"(2) The Secretary shall promulgate, in accordance with section 317, such rules and regulations (including, but not limited to, those required under subsection (e)) as may be necessary and appropriate to carry out the provisions of this section.

"(b)(1) The Secretary shall make grants annually to coastal states, in accordance with the provisions of this subsection.

Calculations.

"(2) The amounts granted to coastal states under this subsection shall be, with respect to any such state for any fiscal year, the sum of the amounts calculated, with respect to such state, pursuant to subparagraphs (A), (B), (C), and (D):

"(A) An amount which bears, to one-third of the amount appropriated for the purpose of funding grants under this subsection for such fiscal year, the same ratio that the amount of outer Continental Shelf acreage which is adjacent to such state and which is newly leased by the Federal Government in the immediately preceding fiscal year bears to the total amount of outer Continental Shelf acreage which is newly leased by the Federal Government in such preceding year.

"(B) An amount which bears, to one-sixth of the amount appropriated for such purpose for such fiscal year, the same ratio that the volume of oil and natural gas produced in the immediately preceding fiscal year from the outer Continental Shelf acreage which is adjacent to such state and which is leased by the Federal

Government bears to the total volume of oil and natural gas produced in such year from all of the outer Continental Shelf acreage which is leased by the Federal Government.

"(C) An amount which bears, to one-sixth of the amount appropriated for such purpose for such fiscal year, the same ratio that the volume of oil and natural gas produced from outer Continental Shelf acreage leased by the Federal Government which is first landed in such state in the immediately preceding fiscal year bears to the total volume of oil and natural gas produced from all outer Continental Shelf acreage leased by the Federal Government which is first landed in all of the coastal states in such year.

"(D) An amount which bears, to one-third of the amount appropriated for such purpose for such fiscal year, the same ratio that the number of individuals residing in such state in the immediately preceding fiscal year who obtain new employment in such year as a result of new or expanded outer Continental Shelf energy activities bears to the total number of individuals residing in all of the coastal states in such year who obtain new employment in such year as a result of such outer Continental Shelf energy activities.

"(3)(A) The Secretary shall determine annually the amounts of the grants to be provided under this subsection and shall collect and evaluate such information as may be necessary to make such determinations. Each Federal department, agency, and instrumentality shall provide to the Secretary such assistance in collecting and evaluating relevant information as the Secretary may request. The Secretary shall request the assistance of any appropriate state agency in collecting and evaluating such information.

"(B) For purposes of making calculations under paragraph (2), outer Continental Shelf acreage is adjacent to a particular coastal state if such acreage lies on that state's side of the extended lateral seaward boundaries of such state. The extended lateral seaward boundaries of a coastal state shall be determined as follows:

"(i) If lateral seaward boundaries have been clearly defined or fixed by an interstate compact, agreement, or judicial decision (if entered into, agreed to, or issued before the date of the enactment of this paragraph), such boundaries shall be extended on the basis of the principles of delimitation used to so define or fix them in such compact, agreement, or decision.

"(ii) If no lateral seaward boundaries, or any portion thereof, have been clearly defined or fixed by an interstate compact, agreement, or judicial decision, lateral seaward boundaries shall be determined according to the applicable principles of law, including the principles of the Convention on the Territorial Sea and the Contiguous Zone, and extended on the basis of such principles.

"(iii) If, after the date of enactment of this paragraph, two or more coastal states enter into or amend an interstate compact or agreement in order to clearly define or fix lateral seaward boundaries, such boundaries shall thereafter be extended on the basis of the principles of delimitation used to so define or fix them in such compact or agreement.

"(C) For purposes of making calculations under this subsection, the transitional quarter beginning July 1, 1976, and ending September 30, 1976, shall be included within the fiscal year ending June 30, 1976.

"(4) Each coastal state shall use the proceeds of grants received by it under this subsection for the following purposes (except that priority shall be given to the use of such proceeds for the purpose set forth in subparagraph (A)):

"(A) The retirement of state and local bonds, if any, which are guaranteed under subsection (d)(2); except that, if the amount of such grants is insufficient to retire both state and local bonds, priority shall be given to retiring local bonds.

"(B) The study of, planning for, development of, and the carrying out of projects and programs in such state which are—

"(i) necessary, because of the unavailability of adequate financing under any other subsection, to provide new or improved public facilities and public services which are required as a direct result of new or expanded outer Continental Shelf energy activity; and

"(ii) of a type approved by the Secretary as eligible for grants under this paragraph, except that the Secretary may not disapprove any project or program for highways and secondary roads, docks, navigation aids, fire and police protection, water supply, waste collection and treatment (including drainage), schools and education, and hospitals and health care.

"(C) The prevention, reduction, or amelioration of any unavoidable loss in such state's coastal zone of any valuable environmental or recreational resource if such loss results from coastal energy activity.

"(5) The Secretary, in a timely manner, shall determine that each coastal state has expended or committed, and may determine that such state will expend or commit, grants which such state has received under this subsection in accordance with the purposes set forth in paragraph (4). The United States shall be entitled to recover from any coastal state an amount equal to any portion of any such grant received by such state under this subsection which—

"(A) is not expended or committed by such state before the close of the fiscal year immediately following the fiscal year in which the grant was disbursed, or

"(B) is expended or committed by such state for any purpose other than a purpose set forth in paragraph (4).

Before disbursing the proceeds of any grant under this subsection to any coastal state, the Secretary shall require such state to provide adequate assurances of being able to return to the United States any amounts to which the preceding sentence may apply.

"(c) The Secretary shall make grants to any coastal state if the Secretary finds that the coastal zone of such state is being, or is likely to be, significantly affected by the siting, construction, expansion, or operation of new or expanded energy facilities. Such grants shall be used for the study of, and planning for (including, but not limited to, the application of the planning process included in a management program pursuant to section 305(b)(8)) any economic, social, or environmental consequence which has occurred, is occurring, or is likely to occur in such state's coastal zone as a result of the siting, construction, expansion, or operation of such new or expanded energy facilities. The amount of any such grant shall not exceed 80 per centum of the cost of such study and planning.

Ante, p. 1015.

Loans.

"(d)(1) The Secretary shall make loans to any coastal state and to any unit of general purpose local government to assist such state or unit to provide new or improved public facilities or public services, or

both, which are required as a result of coastal energy activity. Such loans shall be made solely pursuant to this title, and no such loan shall require as a condition thereof that any such state or unit pledge its full faith and credit to the repayment thereof. No loan shall be made under this paragraph after September 30, 1986.

"(2) The Secretary shall, subject to the provisions of subsection (f), guarantee, or enter into commitments to guarantee, the payment of interest on, and the principal amount of, any bond or other evidence of indebtedness if it is issued by a coastal state or a unit of general purpose local government for the purpose of providing new or improved public facilities or public services, or both, which are required as a result of a coastal energy activity.

"(3) If the Secretary finds that any coastal state or unit of general purpose local government is unable to meet its obligations pursuant to a loan or guarantee made under paragraph (1) or (2) because the actual increases in employment and related population resulting from coastal energy activity and the facilities associated with such activity do not provide adequate revenues to enable such state or unit to meet such obligations in accordance with the appropriate repayment schedule, the Secretary shall, after review of the information submitted by such state or unit pursuant to subsection (e)(3), take any of the following actions:

"(A) Modify appropriately the terms and conditions of such loan or guarantee.

"(B) Refinance such loan.

"(C) Make a supplemental loan to such state or unit the proceeds of which shall be applied to the payment of principal and interest due under such loan or guarantee.

"(D) Make a grant to such state or unit the proceeds of which shall be applied to the payment of principal and interest due under such loan or guarantee.

Notwithstanding the preceding sentence, if the Secretary—

"(i) has taken action under subparagraph (A), (B), or (C) with respect to any loan or guarantee made under paragraph (1) or (2), and

"(ii) finds that additional action under subparagraph (A), (B), or (C) will not enable such state or unit to meet, within a reasonable time, its obligations under such loan or guarantee and any additional obligations related to such loan or guarantee;

the Secretary shall make a grant or grants under subparagraph (D) to such state or unit in an amount sufficient to enable such state or unit to meet such outstanding obligations.

"(4) The Secretary shall make grants to any coastal state to enable such state to prevent, reduce, or ameliorate any unavoidable loss in such state's coastal zone of any valuable environmental or recreational resource, if such loss results from coastal energy activity, if the Secretary finds that such state has not received amounts under subsection (b) which are sufficient to prevent, reduce, or ameliorate such loss.

Rules and regulations.

"(e) Rules and regulations with respect to the following matters shall be promulgated by the Secretary as soon as practicable, but not later than 270 days after the date of the enactment of this section:

Financial assistance, formula and procedures.

"(1) A formula and procedures for apportioning equitably, among the coastal states, the amounts which are available for the provision of financial assistance under subsection (d). Such formula shall be based on, and limited to, the following factors:

"(A) The number of additional individuals who are expected to become employed in new or expanded coastal

energy activity, and the related new population, who reside in the respective coastal states.

"(B) The standardized unit costs (as determined by the Secretary by rule), in the relevant regions of such states, for new or improved public facilities and public services which are required as a result of such expected employment and the related new population.

"(2) Criteria under which the Secretary shall review each coastal state's compliance with the requirements of subsection (g)(2).

Criteria and procedures for repayment.

"(3) Criteria and procedures for evaluating the extent to which any loan or guarantee under subsection (d) (1) or (2) which is applied for by any coastal state or unit of general purpose local government can be repaid through its ordinary methods and rates for generating tax revenues. Such procedures shall require such state or unit to submit to the Secretary such information which is specified by the Secretary to be necessary for such evaluation, including, but not limited to—

"(A) a statement as to the number of additional individuals who are expected to become employed in the new or expanded coastal energy activity involved, and the related new population, who reside in such state or unit;

"(B) a description, and the estimated costs, of the new or improved public facilities or public services needed or likely to be needed as a result of such expected employment and related new population;

"(C) a projection of such state's or unit's estimated tax receipts during such reasonable time thereafter, not to exceed 30 years, which will be available for the repayment of such loan or guarantee; and

"(D) a proposed repayment schedule.

The procedures required by this paragraph shall also provide for the periodic verification, review, and modification (if necessary) by the Secretary of the information or other material required to be submitted pursuant to this paragraph.

"(4) Requirements, terms, and conditions (which may include the posting of security) which shall be imposed by the Secretary, in connection with loans and guarantees made under subsections (d) (1) and (2), in order to assure repayment within the time fixed, to assure that the proceeds thereof may not be used to provide public services for an unreasonable length of time, and otherwise to protect the financial interests of the United States.

Interest rate.

"(5) Criteria under which the Secretary shall establish rates of interest on loans made under subsections (d) (1) and (3). Such rates shall not exceed the current average market yield on outstanding marketable obligations of the United States with remaining periods to maturity comparable to the maturity of such loans.

In developing rules and regulations under this subsection, the Secretary shall, to the extent practicable, request the views of, or consult with, appropriate persons regarding impacts resulting from coastal energy activity.

"(f)(1) Bonds or other evidences of indebtedness guaranteed under subsection (d)(2) shall be guaranteed on such terms and conditions as the Secretary shall prescribe, except that—

"(A) no guarantee shall be made unless the indebtedness involved will be completely amortized within a reasonable period, not to exceed 30 years;

"(B) no guarantee shall be made unless the Secretary determines that such bonds or other evidences of indebtedness will—

"(i) be issued only to investors who meet the requirements prescribed by the Secretary, or, if an offering to the public is contemplated, be underwritten upon terms and conditions approved by the Secretary;

"(ii) bear interest at a rate found not to be excessive by the Secretary; and

"(iii) contain, or be subject to, repayment, maturity, and other provisions which are satisfactory to the Secretary;

"(C) the approval of the Secretary of the Treasury shall be required with respect to any such guarantee, unless the Secretary of the Treasury waives such approval; and

"(D) no guarantee shall be made after September 30, 1986.

"(2) The full faith and credit of the United States is pledged to the payment, under paragraph (5), of any default on any indebtedness guaranteed under subsection (d)(2). Any such guarantee made by the Secretary shall be conclusive evidence of the eligibility of the obligation involved for such guarantee, and the validity of any such guarantee so made shall be incontestable in the hands of a holder of the guaranteed obligation, except for fraud or material misrepresentation on the part of the holder, or known to the holder at the time acquired.

"(3) The Secretary shall prescribe and collect fees in connection with guarantees made under subsection (d)(2). These fees may not exceed the amount which the Secretary estimates to be necessary to cover the administrative costs pertaining to such guarantees. Fees.

"(4) The interest paid on any obligation which is guaranteed under subsection (d)(2) and which is received by the purchaser thereof (or the purchaser's successor in interest), shall be included in gross income for the purpose of chapter 1 of the Internal Revenue Code of 1954. The Secretary may pay out of the Fund to the coastal state or the unit of general purpose local government issuing such obligations not more than such portion of the interest on such obligations as exceeds the amount of interest that would be due at a comparable rate determined for loans made under subsection (d)(1). 26 USC 1 et seq.

"(5)(A) Payments required to be made as a result of any guarantee made under subsection (d)(2) shall be made by the Secretary from sums appropriated to the Fund or from moneys obtained from the Secretary of the Treasury pursuant to paragraph (6).

"(B) If there is a default by a coastal state or unit of general purpose local government in any payment of principal or interest due under a bond or other evidence of indebtedness guaranteed by the Secretary under subsection (d)(2), any holder of such bond or other evidence of indebtedness may demand payment by the Secretary of the unpaid interest on and the unpaid principal of such obligation as they become due. The Secretary, after investigating the facts presented by the holder, shall pay to the holder the amount which is due such holder, unless the Secretary finds that there was no default by such state or unit or that such default has been remedied.

"(C) If the Secretary makes a payment to a holder under subparagraph (B), the Secretary shall—

"(i) have all of the rights granted to the Secretary or the United States by law or by agreement with the obligor; and

"(ii) be subrogated to all of the rights which were granted such holder, by law, assignment, or security agreement between such holder and the obligor.

Such rights shall include, but not be limited to, a right of reimbursement to the United States against the coastal state or unit of general purpose local government for which the payment was made for the amount of such payment plus interest at the prevailing current rate as determined by the Secretary. If such coastal state, or the coastal state in which such unit is located, is due to receive any amount under subsection (b), the Secretary shall, in lieu of paying such amount to such state, deposit such amount in the Fund until such right of reimbursement has been satisfied. The Secretary may accept, in complete or partial satisfaction of any such rights, a conveyance of property or interests therein. Any property so obtained by the Secretary may be completed, maintained, operated, held, rented, sold, or otherwise dealt with or disposed of on such terms or conditions as the Secretary prescribes or approves. If, in any case, the sum received through the sale of such property is greater than the amount paid to the holder under subparagraph (D) plus costs, the Secretary shall pay any such excess to the obligor.

"(D) The Attorney General shall, upon the request of the Secretary, take such action as may be appropriate to enforce any right accruing to the Secretary or the United States as a result of the making of any guarantee under subsection (d)(2). Any sums received through any sale under subparagraph (C) or recovered pursuant to this subparagraph shall be paid into the Fund.

"(6) If the moneys available to the Secretary are not sufficient to pay any amount which the Secretary is obligated to pay under paragraph (5), the Secretary shall issue to the Secretary of the Treasury notes or other obligations (only to such extent and in such amounts as may be provided for in appropriation Acts) in such forms and denominations, bearing such maturities, and subject to such terms and conditions as the Secretary of the Treasury prescribes. Such notes or other obligations shall bear interest at a rate determined by the Secretary of the Treasury on the basis of the current average market yield on outstanding marketable obligations of the United States on comparable maturities during the month preceding the issuance of such notes or other obligations. Any sums received by the Secretary through such issuance shall be deposited in the Fund. The Secretary of the Treasury shall purchase any notes or other obligations issued under this paragraph, and for this purpose such Secretary may use as a public debt transaction the proceeds from the sale of any securities issued under the Second Liberty Bond Act, as now or hereafter in force. The purposes for which securities may be issued under that Act are extended to include any purchase of notes or other obligations issued under this paragraph. The Secretary of the Treasury may at any time sell any of the notes or other obligations so acquired under this paragraph. All redemptions, purchases, and sales of such notes or other obligations by the Secretary of the Treasury shall be treated as public debt transactions of the United States.

31 USC 774.

"(g)(1) No coastal state is eligible to receive any financial assistance under this section unless such state—

"(A) has a management program which has been approved under section 306;

Ante, p. 1017.

"(B) is receiving a grant under section 305(c) or (d); or

Ante, p. 1015.

"(C) is, in the judgment of the Secretary, making satisfactory progress toward the development of a management program which is consistent with the policies set forth in section 303.

16 USC 1433.

"(2) Each coastal state shall, to the maximum extent practicable, provide that financial assistance provided under this section be apportioned, allocated, and granted to units of local government within such state on a basis which is proportional to the extent to which such units need such assistance.

"(h) There is established in the Treasury of the United States the Coastal Energy Impact Fund. The Fund shall be available to the Secretary without fiscal year limitation as a revolving fund for the purposes of carrying out subsections (c) and (d). The Fund shall consist of— Coastal Energy Impact Fund. Establishment.

"(1) any sums appropriated to the Fund;

"(2) payments of principal and interest received under any loan made under subsection (d) (1);

"(3) any fees received in connection with any guarantee made under subsection (d) (2); and

"(4) any recoveries and receipts under security, subrogation, and other rights and authorities described in subsection (f).

All payments made by the Secretary to carry out the provisions of subsections (c), (d), and (f) (including reimbursements to other Government accounts) shall be paid from the Fund, only to the extent provided for in appropriation Acts. Sums in the Fund which are not currently needed for the purposes of subsections (c), (d), and (f) shall be kept on deposit or invested in obligations of, or guaranteed by, the United States.

"(i) The Secretary shall not intercede in any land use or water use decision of any coastal state with respect to the siting of any energy facility or public facility by making siting in a particular location a prerequisite to, or a condition of, financial assistance under this section.

"(j) The Secretary may evaluate, and report to the Congress, on the efforts of the coastal states and units of local government therein to reduce or ameliorate adverse consequences resulting from coastal energy activity and on the extent to which such efforts involve adequate consideration of alternative sites.

"(k) To the extent that Federal funds are available under, or pursuant to, any other law with respect to—

"(1) study and planning for which financial assistance may be provided under subsection (b) (4) (B) and (c), or

"(2) public facilities and public services for which financial assistance may be provided under subsection (b) (4) (B) and (d),

the Secretary shall, to the extent practicable, administer such subsections—

"(A) on the basis that the financial assistance shall be in addition to, and not in lieu of, any Federal funds which any coastal state or unit of general purpose local government may obtain under any other law; and

"(B) to avoid duplication.

"(l) As used in this section— Definitions.

"(1) The term 'retirement', when used with respect to bonds, means the redemption in full and the withdrawal from circulation of those which cannot be repaid by the issuing jurisdiction in accordance with the appropriate repayment schedule.

"(2) The term 'unavoidable', when used with respect to a loss of any valuable environmental or recreational resource, means a loss, in whole or in part—

"(A) the costs of prevention, reduction, or amelioration of which cannot be directly or indirectly attributed to, or assessed against, any identifiable person; and

"(B) cannot be paid for with funds which are available under, or pursuant to, any provision of Federal law other than this section.

"(3) The term 'unit of general purpose local government' means any political subdivision of any coastal state or any special entity created by such a state or subdivision which (in whole or part) is located in, or has authority over, such state's coastal zone, and which (A) has authority to levy taxes or establish and collect user fees, and (B) provides any public facility or public service which is financed in whole or part by taxes or user fees.".

SEC. 8. INTERSTATE GRANTS.

The Coastal Zone Management Act of 1972 is further amended by adding immediately after section 308 (as added by section 7 of this Act) the following:

"INTERSTATE GRANTS

16 USC 1456b.

"SEC. 309. (a) The coastal states are encouraged to give high priority—

"(1) to coordinating state coastal zone planning, policies, and programs with respect to contiguous areas of such states; and

"(2) to studying, planning, and implementing unified coastal zone policies with respect to such areas.

Such coordination, study, planning, and implementation may be conducted pursuant to interstate agreements or compacts. The Secretary may make grants annually, in amounts not to exceed 90 per centum of the cost of such coordination, study, planning, or implementation, if the Secretary finds that the proceeds of such grants will be used for purposes consistent with sections 305 and 306.

Ante, p. 1015, 1017.

Agreements or compacts.

"(b) The consent of the Congress is hereby given to two or more coastal states to negotiate, and to enter into, agreements or compacts, which do not conflict with any law or treaty of the United States, for—

"(1) developing and administering coordinated coastal zone planning, policies, and programs pursuant to sections 305 and 306; and

"(2) establishing executive instrumentalities or agencies which such states deem desirable for the effective implementation of such agreements or compacts.

Such agreements or compacts shall be binding and obligatory upon any state or party thereto without further approved by the Congress.

"(c) Each executive instrumentality or agency which is established by an interstate agreement or compact pursuant to this section is encouraged to adopt a Federal-State consultation procedure for the identification, examination, and cooperative resolution of mutual problems with respect to the marine and coastal areas which affect, directly or indirectly, the applicable coastal zone. The Secretary, the Secretary of the Interior, the Chairman of the Council on Environmental Quality, the Administrator of the Environmental Protection Agency, the Secretary of the department in which the Coast Guard is operating, and the Administrator of the Federal Energy Administration, or their designated representatives, shall participate ex officio on behalf of the Federal Government whenever any such Federal-State consultation is requested by such an instrumentality or agency.

"(d) If no applicable interstate agreement or compact exists, the Secretary may coordinate coastal zone activities described in subsection (a) and may make grants to assist any group of two or more coastal states to create and maintain a temporary planning and coordinating entity to—

"(1) coordinate state coastal zone planning, policies, and programs with respect to contiguous areas of the states involved;

"(2) study, plan, and implement unified coastal zone policies with respect to such areas; and

"(3) establish an effective mechanism, and adopt a Federal-State consultation procedure, for the identification, examination, and cooperative resolution of mutual problems with respect to the marine and coastal areas which affect, directly or indirectly, the applicable coastal zone.

The amount of such grants shall not exceed 90 per centum of the cost of creating and maintaining such an entity. The Federal officials specified in subsection (c), or their designated representatives, shall participate on behalf of the Federal Government, upon the request of any such temporary planning and coordinating entity.".

SEC. 9. RESEARCH AND TECHNICAL ASSISTANCE.

The Coastal Management Act of 1972 is further amended by adding immediately after section 309 (as added by section 8 of this Act) the following:

"RESEARCH AND TECHNICAL ASSISTANCE FOR COASTAL ZONE MANAGEMENT

16 USC 1456c.

"SEC. 310. (a) The Secretary may conduct a program of research, study, and training to support the development and implementation of management programs. Each department, agency, and instrumentality of the executive branch of the Federal Government may assist the Secretary, on a reimbursable basis or otherwise, in carrying out the purposes of this section, including, but not limited to, the furnishing of information to the extent permitted by law, the transfer of personnel with their consent and without prejudice to their position and rating, and the performance of any research, study, and training which does not interfere with the performance of the primary duties of such department, agency, or instrumentality. The Secretary may enter into contracts or other arrangements with any qualified person for the purposes of carrying out this subsection.

Contracts or other arrangements.

"(b) The Secretary may make grants to coastal states to assist such states in carrying out research, studies, and training required with respect to coastal zone management. The amount of any grant made under this subsection shall not exceed 80 per centum of the cost of such research, studies, and training.

"(c)(1) The Secretary shall provide for the coordination of research, studies, and training activities under this section with any other such activities that are conducted by, or subject to the authority of, the Secretary.

"(2) The Secretary shall make the results of research conducted pursuant to this section available to any interested person.".

SEC. 10. REVIEW OF PERFORMANCE.

Section 312(a) of the Coastal Zone Management Act of 1972, as redesignated by section 7 of this Act (16 U.S.C. 1458(a)) is amended to read as follows:

"(a) The Secretary shall conduct a continuing review of—

"(1) the management programs of the coastal states and the performance of such states with respect to coastal zone management; and

"(2) the coastal energy impact program provided for under section 308.".

Ante, p. 1017.

SEC. 11. AUDIT OF TRANSACTIONS.

Section 313 of the Coastal Zone Management Act of 1972, as redesignated by section 7 of this Act (16 U.S.C. 1459), is amended—

(1) by inserting "AND AUDIT" after "RECORDS" in the title of such section;

(2) by amending subsection (a)—

(A) by inserting immediately after "grant under this title" the following: "or of financial assistance under section 308", and

(B) by inserting after "received under the grant" the following: "and of the proceeds of such assistance"; and

(3) by amending subsection (b) to read as follows:

"(b) The Secretary and the Comptroller General of the United States, or any of their duly authorized representatives, shall—

"(1) after any grant is made under this title or any financial assistance is provided under section 308(d); and

Ante, p. 1017.

"(2) until the expiration of 3 years after—

"(A) completion of the project, program, or other undertaking for which such grant was made or used, or

"(B) repayment of the loan or guaranteed indebtedness for which such financial assistance was provided,

have access for purposes of audit and examination to any record, book, document, and paper which belongs to or is used or controlled by, any recipient of the grant funds or any person who entered into any transaction relating to such financial assistance and which is pertinent for purposes of determining if the grant funds or the proceeds of such financial assistance are being, or were, used in accordance with the provisions of this title.".

SEC. 12. ACQUISITION OF ACCESS TO PUBLIC BEACHES AND OTHER PUBLIC COASTAL AREAS.

Section 315 of the Coastal Zone Management Act of 1972, as redesignated by section 7 of this Act (16 U.S.C. 1461), is amended to read as follows:

"ESTUARINE SANCTUARIES AND BEACH ACCESS

"SEC. 315. The Secretary may, in accordance with this section and in accordance with such rules and regulations as the Secretary shall promulgate, make grants to any coastal state for the purpose of—

"(1) acquiring, developing, or operating estuarine sanctuaries, to serve as natural field laboratories in which to study and gather data on the natural and human processes occurring within the estuaries of the coastal zone; and

"(2) acquiring lands to provide for access to public beaches and other public coastal areas of environmental, recreational, historical, esthetic, ecological, or cultural value, and for the preservation of islands.

The amount of any such grant shall not exceed 50 per centum of the cost of the project involved; except that, in the case of acquisition of any estuarine sanctuary, the Federal share of the cost thereof shall not exceed $2,000,000.".

SEC. 13. ANNUAL REPORT.

The second sentence of section 316(a) of the Coastal Zone Management Act of 1972, as redesignated by section 7 of this Act (16 U.S.C. 1462(a)), is amended by striking out "and (9)" and inserting in lieu thereof "(12)"; and by inserting immediately after clause (8) the following: "(9) a description of the economic, environmental, and

social consequences of energy activity affecting the coastal zone and an evaluation of the effectiveness of financial assistance under section 308 in dealing with such consequences; (10) a description and evaluation of applicable interstate and regional planning and coordination mechanisms developed by the coastal states; (11) a summary and evaluation of the research, studies, and training conducted in support of coastal zone management; and".

SEC. 14. AUTHORIZATION OF APPROPRIATIONS.

Section 318 of the Coastal Zone Management Act of 1972, as redesignated by section 7 of this Act (16 U.S.C. 1464), is amended to read as follows:

"AUTHORIZATION OF APPROPRIATIONS

"SEC. 318. (a) There are authorized to be appropriated to the Secretary—

"(1) such sums, not to exceed $20,000,000 for each of the fiscal years ending September 30, 1977, September 30, 1978, and September 30, 1979, respectively, as may be necessary for grants under section 305, to remain available until expended;

"(2) such sums, not to exceed $50,000,000 for each of the fiscal years ending September 30, 1977, September 30, 1978, September 30, 1979, and September 30, 1980, respectively, as may be necessary for grants under section 306, to remain available until expended;

"(3) such sums, not to exceed $50,000,000 for each of the 8 fiscal years occurring during the period beginning October 1, 1976, and ending September 30, 1984, as may be necessary for grants under section 308(b); Ante, p. 1017.

"(4) such sums, not to exceed $5,000,000 for each of the fiscal years ending September 30, 1977, September 30, 1978, September 30, 1979, and September 30, 1980, respectively, as may be necessary for grants under section 309, to remain available until expended; Ante, p. 1028.

"(5) such sums, not to exceed $10,000,000 for each of the fiscal years ending September 30, 1977, September 30, 1978, September 30, 1979, and September 30, 1980, respectively, as may be necessary for financial assistance under section 310, of which 50 per centum shall be for financial assistance under section 310(a) and 50 per centum shall be for financial assistance under section 310(b), to remain available until expended;

"(6) such sums, not to exceed $6,000,000 for each of the fiscal years ending September 30, 1977, September 30, 1978, September 30, 1979, and September 30, 1980, respectively, as may be necessary for grants under section 315(1), to remain available until expended;

"(7) such sums, not to exceed $25,000,000 for each of the fiscal years ending September 30, 1977, September 30, 1978, September 30, 1979, and September 30, 1980, respectively, as may be necessary for grants under section 315(2), to remain available until expended; and

"(8) such sums, not to exceed $5,000,000 for each of the fiscal years ending September 30, 1977, September 30, 1978, September 30, 1979, and September 30, 1980, respectively, as may be necessary for administrative expenses incident to the administration of this title.

"(b) There are authorized to be appropriated until October 1, 1986, to the Fund, such sums, not to exceed $800,000,000, for the purposes of

Ante, p. 1017.

carrying out the provisions of section 308, other than subsection (b), of which not to exceed $50,000,000 shall be for purposes of subsections (c) and (d)(4) of such section.

"(c) Federal funds received from other sources shall not be used to pay a coastal state's share of costs under section 305, 306, 309, or 310.".

Ante, p. 1015, 1017, 1028, 1029.

SEC. 15. ADMINISTRATION.

15 USC 1511a.

(a) There shall be in the National Oceanic and Atmospheric Administration an Associate Administrator for Coastal Zone Management, who shall be appointed by the President, by and with the advice and consent of the Senate. Such Associate Administrator shall be an individual who is, by reason of background and experience, especially qualified to direct the implementation and administration of the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.). Such Associate Administrator shall be compensated at the rate now or hereafter provided for level V of the Executive Schedule Pay Rates (5 U.S.C. 5316).

(b) Section 5316 of title 5, United States Code, is amended by adding at the end thereof the following new paragraph:

"(140) Associate Administrator for Coastal Zone Management, National Oceanic and Atmospheric Administration.".

15 USC 1511a note.

(c) The Secretary may, to carry out the provisions of the amendments made by this Act, establish, and fix the compensation for, four new positions without regard to the provision of chapter 51 of title 5, United States Code, at rates not in excess of the maximum rate for GS-18 of the General Schedule under section 5332 of such title. Any such appointment may, at the discretion of the Secretary, be made without regard to the provisions of such title 5 governing appointments in the competitive service.

5 USC 5332 note.

SEC. 16. SHELLFISH SANITATION REGULATIONS.

16 USC 1462 note.

(a) The Secretary of Commerce shall—

(1) undertake a comprehensive review of all aspects of the molluscan shellfish industry, including, but not limited to, the harvesting, processing, and transportation of such shellfish; and

(2) evaluate the impact of Federal law concerning water quality on the molluscan shellfish industry.

Report to Congress.

The Secretary of Commerce shall, not later than April 30, 1977, submit a report to the Congress of the findings, comments, and recommendations (if any) which result from such review and evaluation.

(b) The Secretary of Health, Education, and Welfare shall not promulgate final regulations concerning the national shellfish safety program before June 30, 1977. At least 60 days prior to the promulgation of any such regulations, the Secretary of Health, Education, and Welfare, in consultation with the Secretary of Commerce, shall publish an analysis (1) of the economic impact of such regulations on the domestic shellfish industry, and (2) the cost of such national shellfish safety program relative to the benefits that it is expected to achieve. Analysis, publication.

Approved July 26, 1976.

LEGISLATIVE HISTORY:

HOUSE REPORTS: No. 94-878 accompanying H. R. 3981 (Comm. on Merchant Marine and Fisheries) and No. 94-1298 (Comm. of Conference).
SENATE REPORTS: No. 94-277 (Comm. on Commerce) and No. 94-987 (Comm. of Conference).
CONGRESSIONAL RECORD:
Vol. 121 (1975): July 16, considered and passed Senate.
Vol. 122 (1976): Mar. 11, considered and passed House, amended, in lieu of H. R. 3981.
June 29, Senate agreed to conference report.
June 30, House agreed to conference report.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS:
Vol. 12, No. 31 (1976): July 26, Presidential statement.

Appendix 6

Accuracy Standards

I. United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. *Horizontal accuracy.*—For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 in [0.846 mm] measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 in [0.508 mm]. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markets, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will also be determined by what is plottable on the scale of the map within 1/100 in [0.254 mm]. Thus while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 in [0.254 mm]. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.

2. *Vertical accuracy,* as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

3. The accuracy of any map may be tested by comparing the positions of point whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.

4. Published maps meeting these accuracy requirements shall note this fact on their legends, as follows: "This map complies with National Map Accuracy Standards."

5. Published maps whose errors exceed those aforestated shall omit from their legends all mention of standard accuracy.

6. When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."

7. To facilitate ready interchange and use of basic information for map construction among all Federal mapmaking agencies, manuscript maps and published maps, where economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes, of latitude and longitude, or 7.5 minutes, or 3 3/4 minutes in size.

U.S. Bureau of the Budget
Issued June 10, 1941
Revised April 26, 1943
Revised June 17, 1947

II. Accuracy standards recommended for hydrographic surveys

A. General Standards

1. Scale of survey

a. The scale adopted for a survey of a particular area should not be smaller than the scale of the existing or proposed chart of the area and preferably should be at least twice as large as that of the largest scale of the published or proposed chart of the area.

b. Ports, harbors, channels, and pilotage waters should be surveyed on a scale of 1:10,000 or larger.

c. Other waters used by shipping with possible shoals or other dangers to navigation should be sounded on a scale of 1:20,000 or larger.

d. Surveys of coastal and harbor approach areas to a depth of at least 20 m (11 fm) should be conducted on a scale of 1:50,000 or larger.

e. Offshore hydrographic surveys in depths greater than 20 m (11 fm) may be plotted on a scale smaller than 1:50,000 dependent on the importance of the area covered, the depth, and bottom configuration. The scale of the offshore plotting sheet should not be smaller than is necessary to provide a sheet of convenient size that will extend a short distance beyond the offshore limit of the survey and will, where feasible, include the stations necessary for control of the survey.

2. Interval of sounding lines at the scale of the survey

a. Spacing of principal sounding lines:

1.0 cm (0.4 in) or less, as may be needed to thoroughly develop the area at the scale of the survey, except where depth and character of the bottom will permit wider spacing.

b. Spacing of cross-check lines:

7.5 cm (3.0 in) or less.

3. Interval of plotted soundings

Frequency along sounding lines:

Spacing should be less than the interval with peak and deep soundings shown, but this interval may be increased in areas of even bottom, and where the soundings are recorded on an echogram.

4. Sampling of bottom characteristics

In general, sufficient sampling should be done to demarcate the limits where one general type of bottom changes to another.

In waters that may be used for anchoring, samples should be taken at regular intervals not to exceed 5 cm (2 in) at the scale of the survey. In other areas, shoaler or deeper, a spacing of 8 cm (3 in) is sufficient depending on the regularity of the bottom. Deep-water bottom samples, over 100 m (55 fm), are classed as oceanographic observations requiring special equipment and samples will be taken as required.

5. Spacing of position fixes

The spacing of position fixes on the survey sheets shall be from 2 to 4 cm (1–1.5 in).

6. Current observations

When velocity is expected to exceed 0.2 kn, both velocity and direction of currents shall be observed at entrances to harbors or channels, at any change in direction of channels, in anchorages, and adjacent to a pier or wharf area. It is also desirable to measure coastal and offshore currents when they are of sufficient strength to affect shipping. (Editor's note: Current observations for a circulating survey by NOS are made under more rigid and exacting specifications).

B. Specific Standards

1. Horizontal control

a. Primary shore stations

The location of primary shore control stations and electronic positioning stations shall be within the limits of accuracy for third-order control when the geodetic survey extends no more than 50 km (31 mi) from the point of origin or from stations of a geodetic net of higher order used as the origin. When the extent of the geodetic survey is in excess of 50 km the use of second-order control methods is desirable, and if the stations of an electronic positioning system are separated by distances in excess of 200 km (124 mi) ties shall be made to basic first-order control whenever possible.

b. Hydrographic signals

The error in location of hydrographic signals used for visual fixing, with relation to the primary shore control should not exceed 1 mm (0.04 in) at the scale of the survey.

c. Position fixes and floating aids

(1) The indicated repeatability of a fix (accuracy of location referred to shore control) in the operating area, whether observed by visual or electronic methods, combined with the plotting error, shall seldom exceed 1.5 mm (0.06 in) at the scale of the survey.

(2) Ocean surveys for nautical charts (shoal searches, investigation of doubtful soundings, etc.): acceptable error when fixing a reference beacon by astronomic or electronic means: 1 km (0.6 mi).

d. Aids to navigation

(1) Fixed aids to navigation shall be located within the same limits of accuracy as primary shore stations stated in paragraph 1.

(2) Floating aids to navigation shall be located within the same limits of accuracy as position fixes stated in paragraph 3.

e. Offshore installations dangerous to navigation. Location of offshore installations, dangerous to navigation should, when feasible, meet the requirements for third-order control.

2. Vertical control

a. Measurements of depth

Allowable errors:

(1) 0–20 m (0–11 fm): 0.3 m (1.0 ft)

(2) 20–100 m (11–55 fm): 1.0 m (0.5 fm)

(3) Deeper than 100 m (55 fm): 1 percent of depth

Normally, a disagreement of cross-check lines with principal sounding lines of three times or more the allowable error stated above indicates error in either position, depth, or both, and should be further investigated.

b. Sweeping over wrecks, obstructions, and shoals

The same accuracy as that specified for the measurement of depths (art. B.2.a.) to a depth of 30 m (16 fm). In depths greater than 30 m (16 fm) the same accuracies as for measurement of depth (art. B.2.a.) where the depth and equipment available permit these accuraries.

c. Reference of sounding to vertical datum

Location and duration of tidal observations to be such that each sounding can be referred to the sounding datum with an error no greater than one-half that specified in art. B.2.a., above. Tidal reductions are not usually applied to oceanic soundings over 200 m (109 fm).

3. Current measurements

The velocity of the current at each station should be determined to the nearest 0.1 kn and the direction of the current to the nearest 10°.

APPENDIX 7

On the following pages are samples of cartographic data provided by NOAA, USGS, and other Federal agencies. As most of the maps are at publication scale, only a portion of each published map is shown. Colors may vary from the original maps because of printing restrictions.

Not all products or agencies are represented here, but the samples represent many of the products available from the Federal Government.

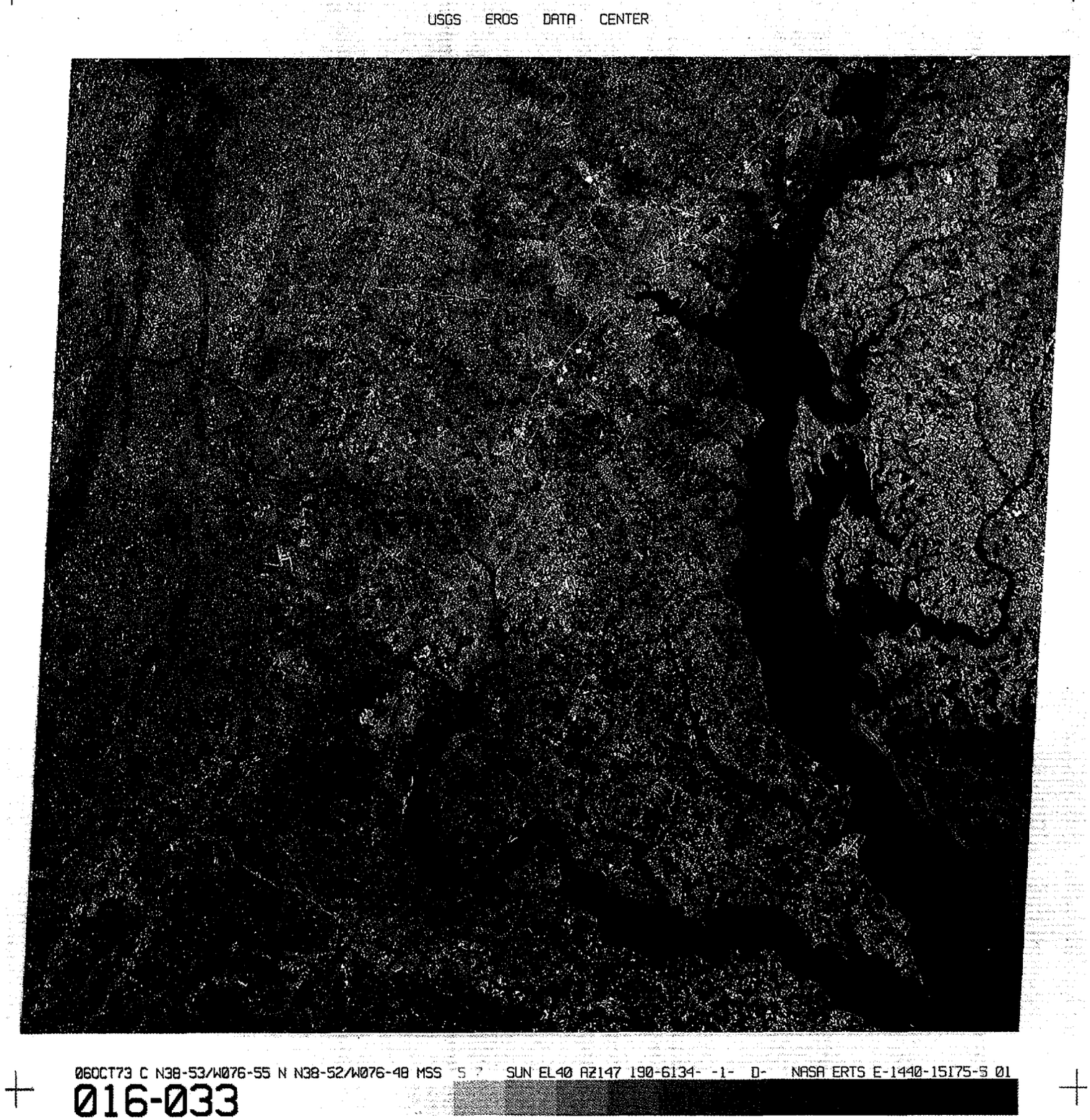


FIGURE 1.—Upper Chesapeake Bay, approximately 1:990,000 scale. This NASA Landsat scene is a color composite of three simultaneously recorded spectral bands; color response is similar to that of color infrared film. Black-and-white copies of Landsat scenes are available for the entire coastal zone, and color composites are available for selected areas.

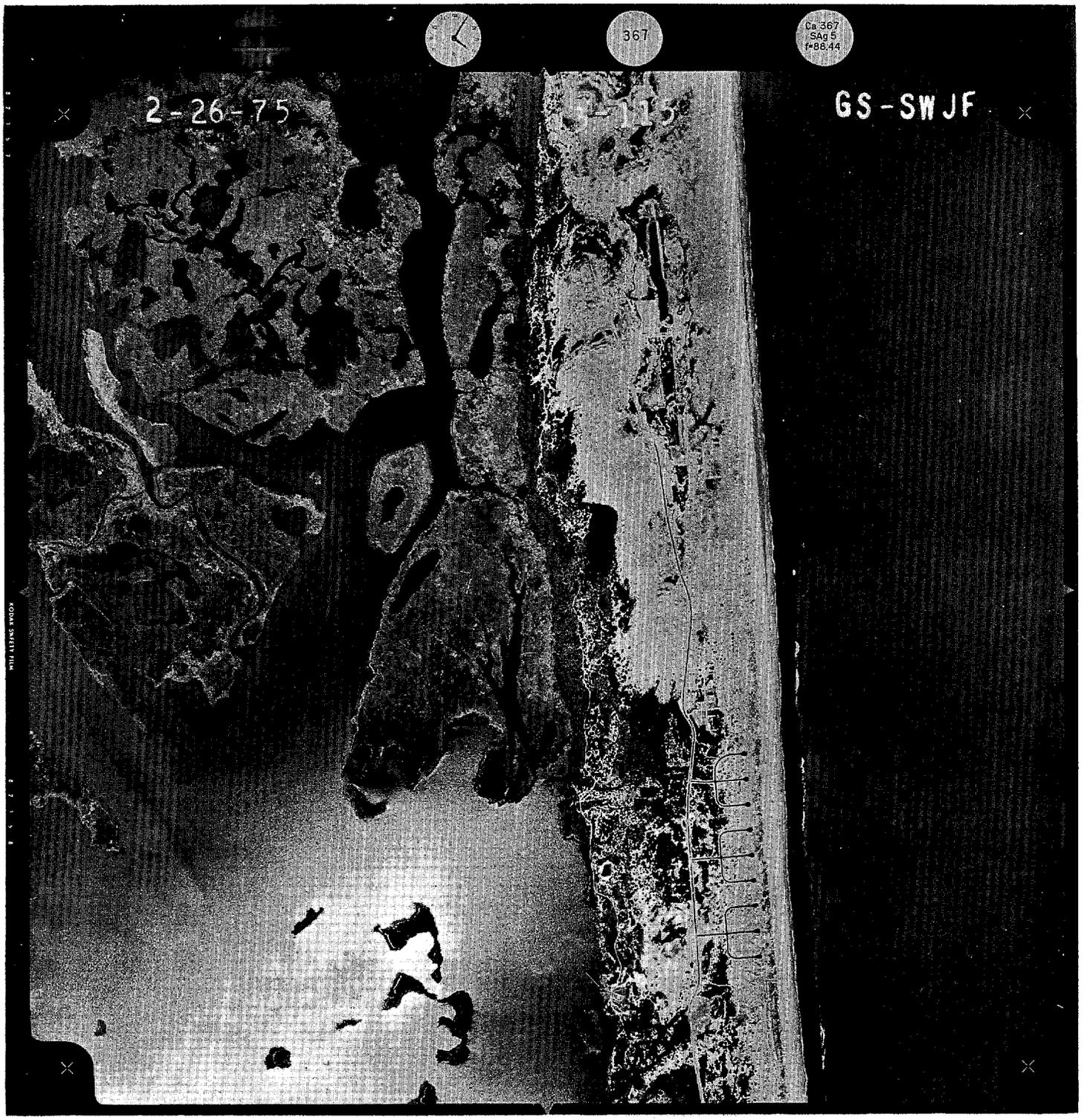


FIGURE 2.—Aerial photograph, approximately 1:21,000 scale, of part of the coast of North Carolina. A typical black-and-white large-scale mapping photograph, taken at a flight height of 1,830 m with a Wild RC 9 camera, 88-mm super-wide-angle lens. Specifications and equipment for photography vary with the project area and conditions.

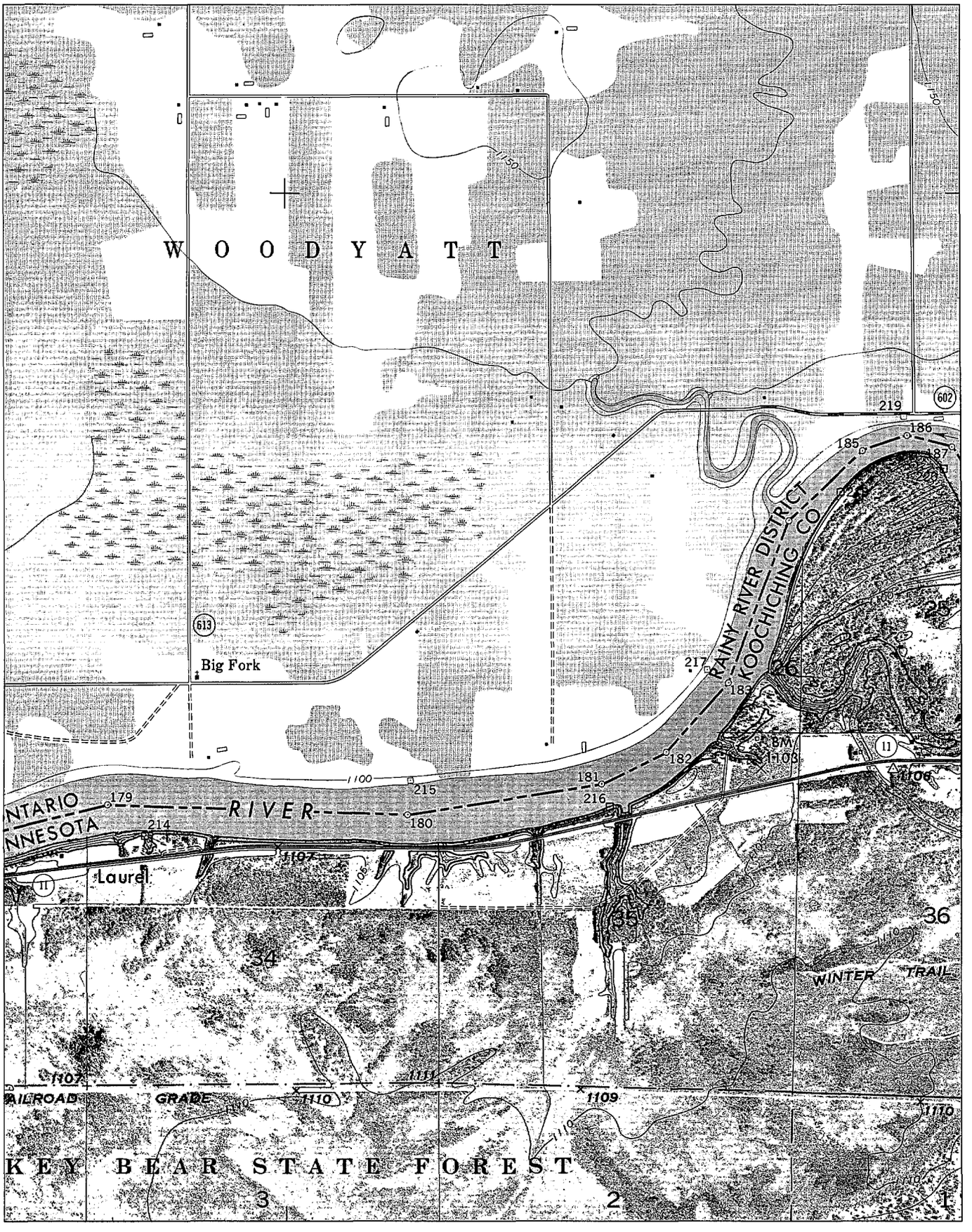


FIGURE 3.—Devlin, Minn.–Ont., 1:24,000-scale orthophotomap/line map, showing the standard line map (Canadian portion) and the orthophotomap (U.S. portion) on a single sheet. The orthophotomap/line map combination is not standard.

FIGURE 4.—Upper Matecumbe Key, Fla., 1:24,000-scale orthophotomap. This type of map is available for selected coastal areas. It shows excellent underwater detail in areas like the Florida Keys.

FIGURE 5.—Sterling, Va.–Md., 1:24,000-scale orthophotoquad, showing the same area as appendix figure 6; it is a photographic base with limited cartographic enhancement.

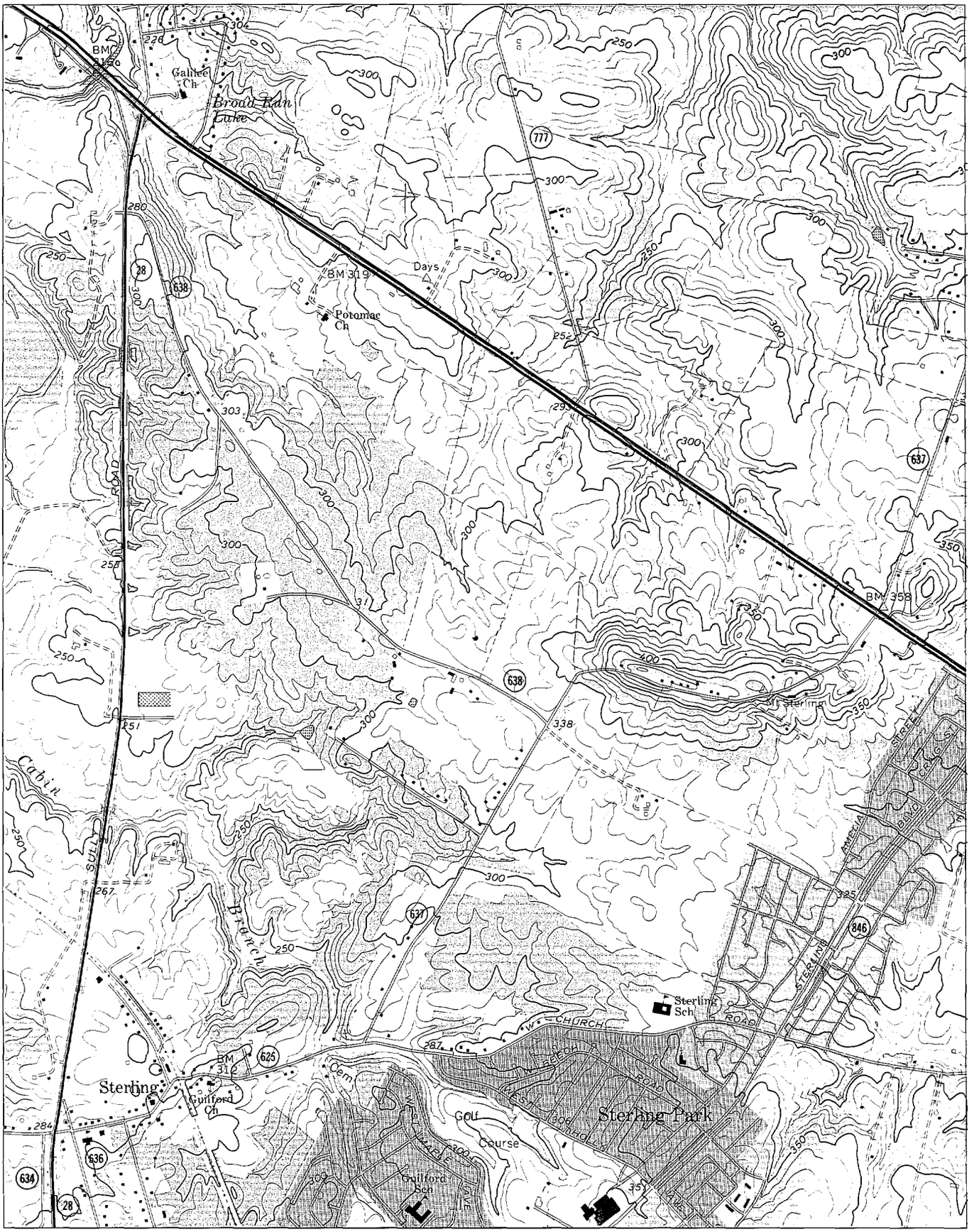


FIGURE 6.—Sterling, Va.–Md., 1:24,000-scale, 7.5-min topographic quadrangle map, showing the same area as appendix figure 5. Maps in this USGS series (either line or orthophoto) will be available for the entire coastal zone.

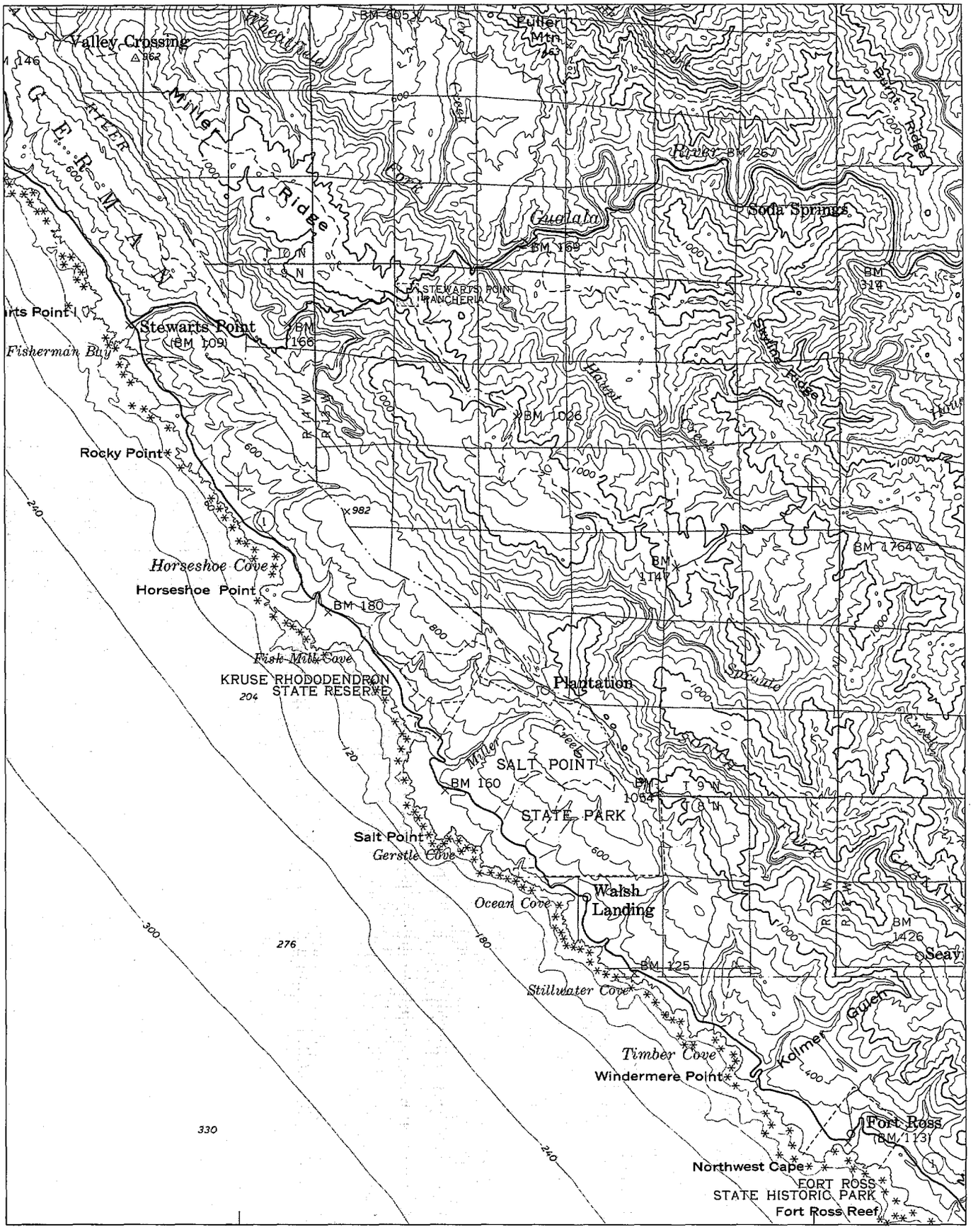


FIGURE 7.—Sonoma County, Calif., 1:100,000-scale topographic map, one of the first in a new USGS county series at scales of 1:100,000 or 1:50,000. The maps are formatted on county boundaries rather than parallels and meridians.

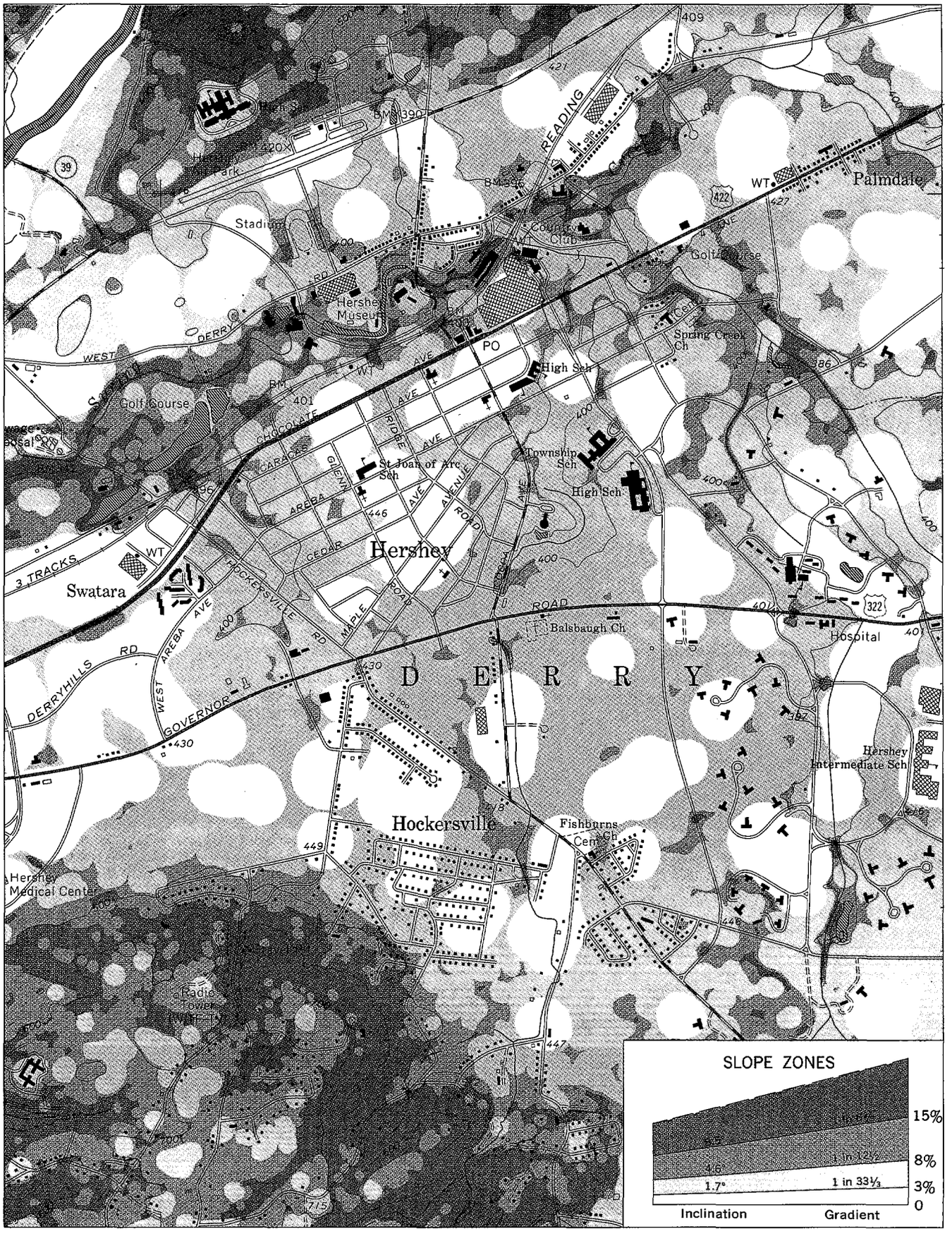


FIGURE 8.—Hershey, Pa., 1:24,000-scale slope map. Slope maps are available for selected areas. Ranges of slope percentage are shown by various shades of gray. Some USGS slope maps are available with slope zone ranges distinguished by different colors.

FIGURE 9.—Hyannis, Mass., 1:24,000-scale geologic quadrangle, a type available for many parts of the coastal zone. These USGS maps show the structure and composition of the Earth's crust and include text describing the geologic history of the area.

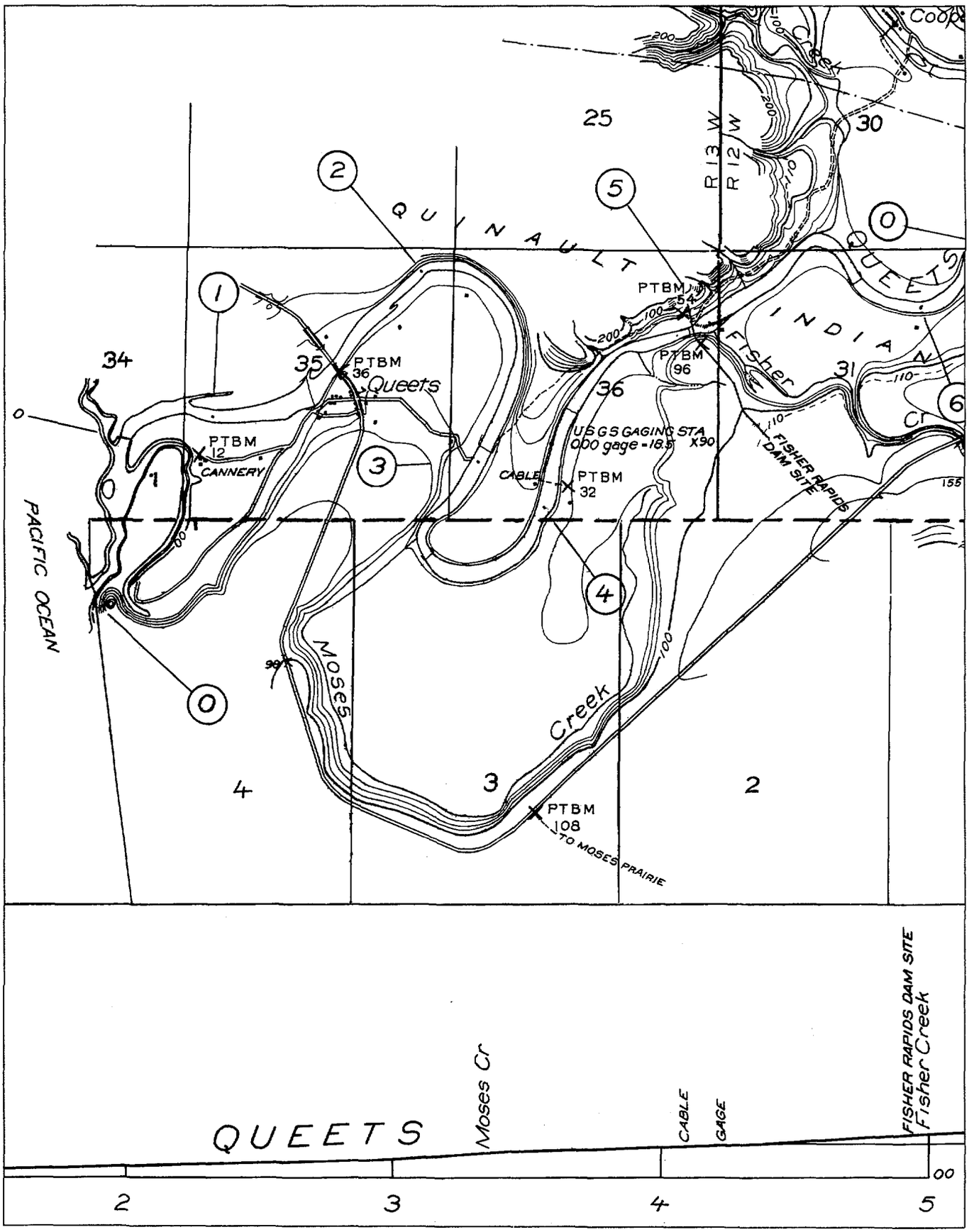


FIGURE 10.—Queets River, Wash., 1:31,680-scale plan and profile. USGS river surveys, available for selected streams, consist of a topographic map, a centerline profile, and special damsite insets (app. fig. 11). On the published map, contours are brown.

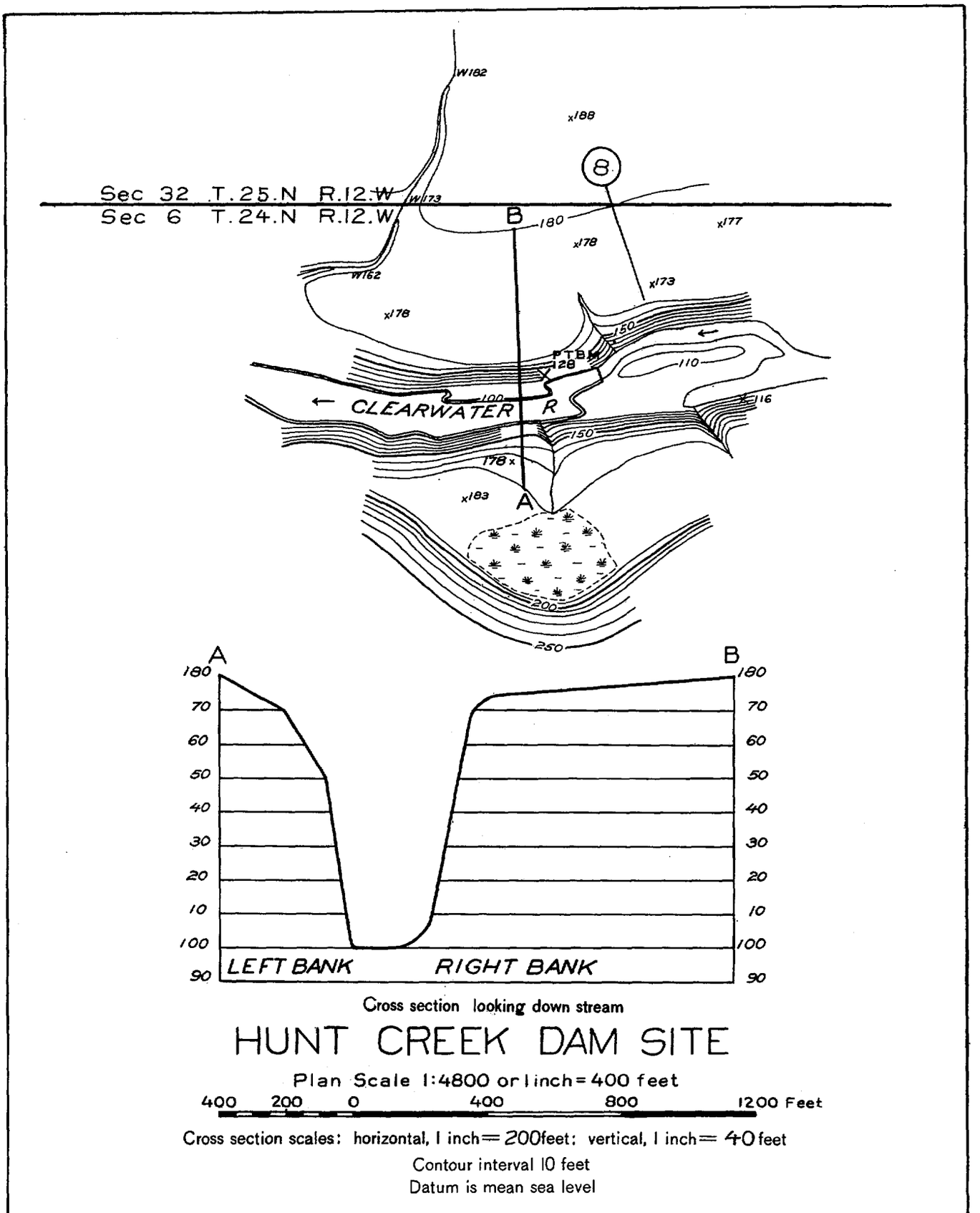


FIGURE 11.—Hunt Creek Dam Site, Wash., 1:4,800-scale topographic map and cross-sectional profile; an inset from the USGS Queets River, Wash., plan and profile (app. fig. 10). On the published map, contours are brown.

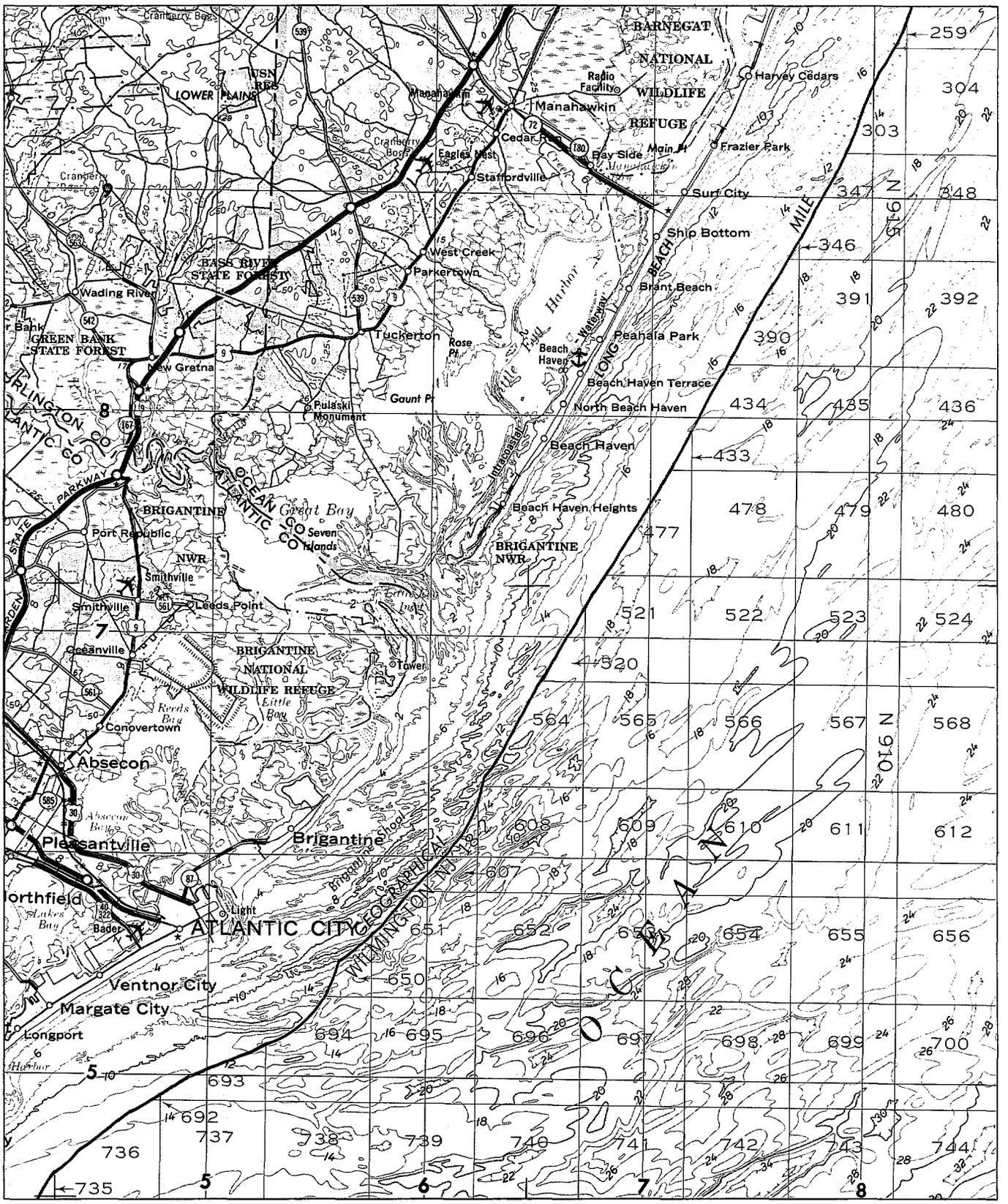


FIGURE 12.—Wilmington, Del.–N.J.–Pa.–Md., 1:250,000-scale topographic map. The red lines beyond the 3-mi limit show areas designated on BLM Outer Continental Shelf Protraction Diagrams. These lines and bathymetric data are being added to the 1:250,000-scale maps during revision.

FIGURE 13.—Fort Pierce, Fla., 1:24,000-scale orthophotoquad. This is a standard USGS orthophotoquad with bathymetric contours added from data furnished by NOS. The same area is shown in appendix figures 14 and 15 and partly in appendix figure 16.

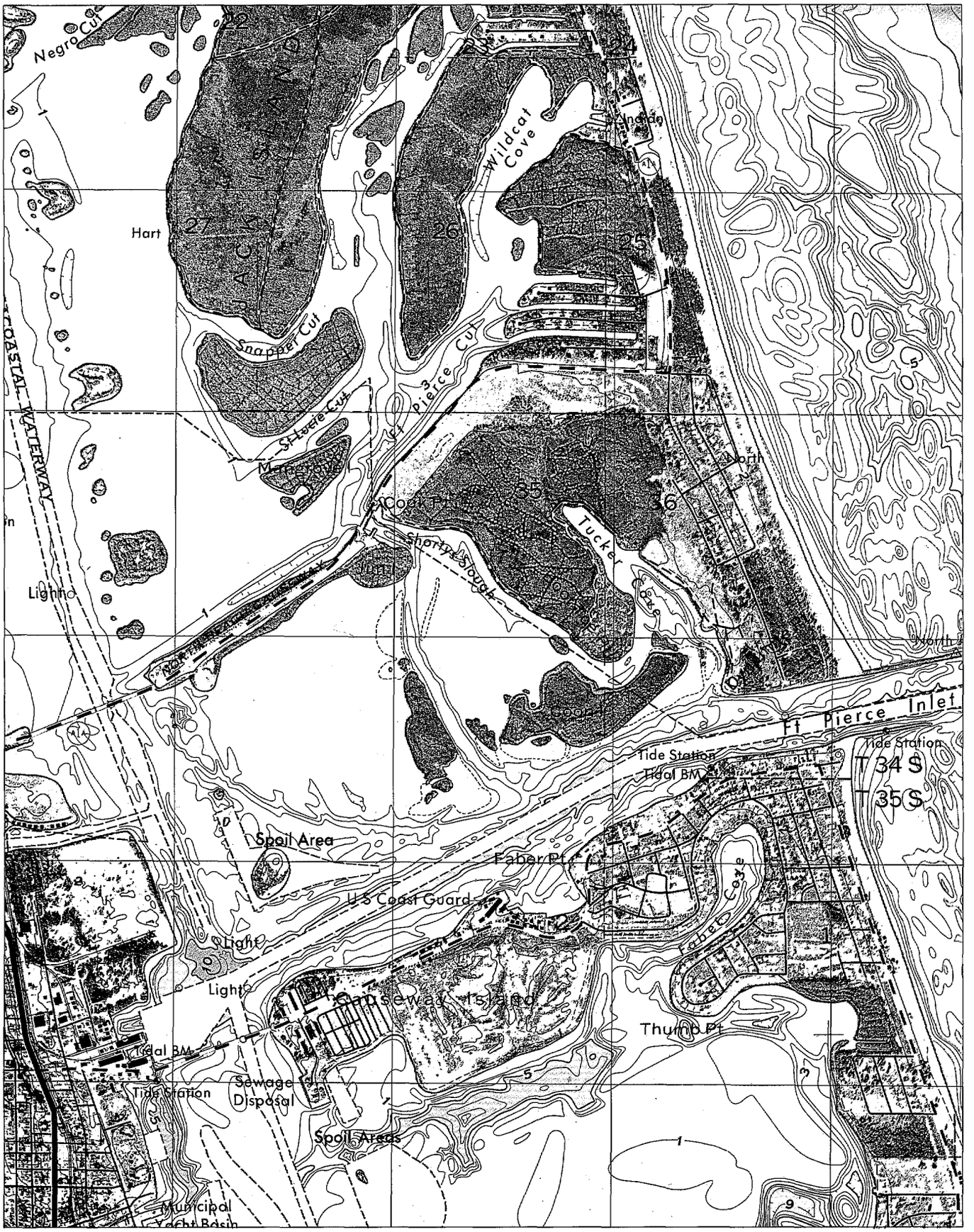


FIGURE 14.—Fort Pierce, Fla., 1:24,000-scale orthophotomap. This is a standard USGS orthophotomap with bathymetric contours added from data furnished by NOS. The same area is shown in appendix figures 13 and 15 and partly in appendix figure 16.

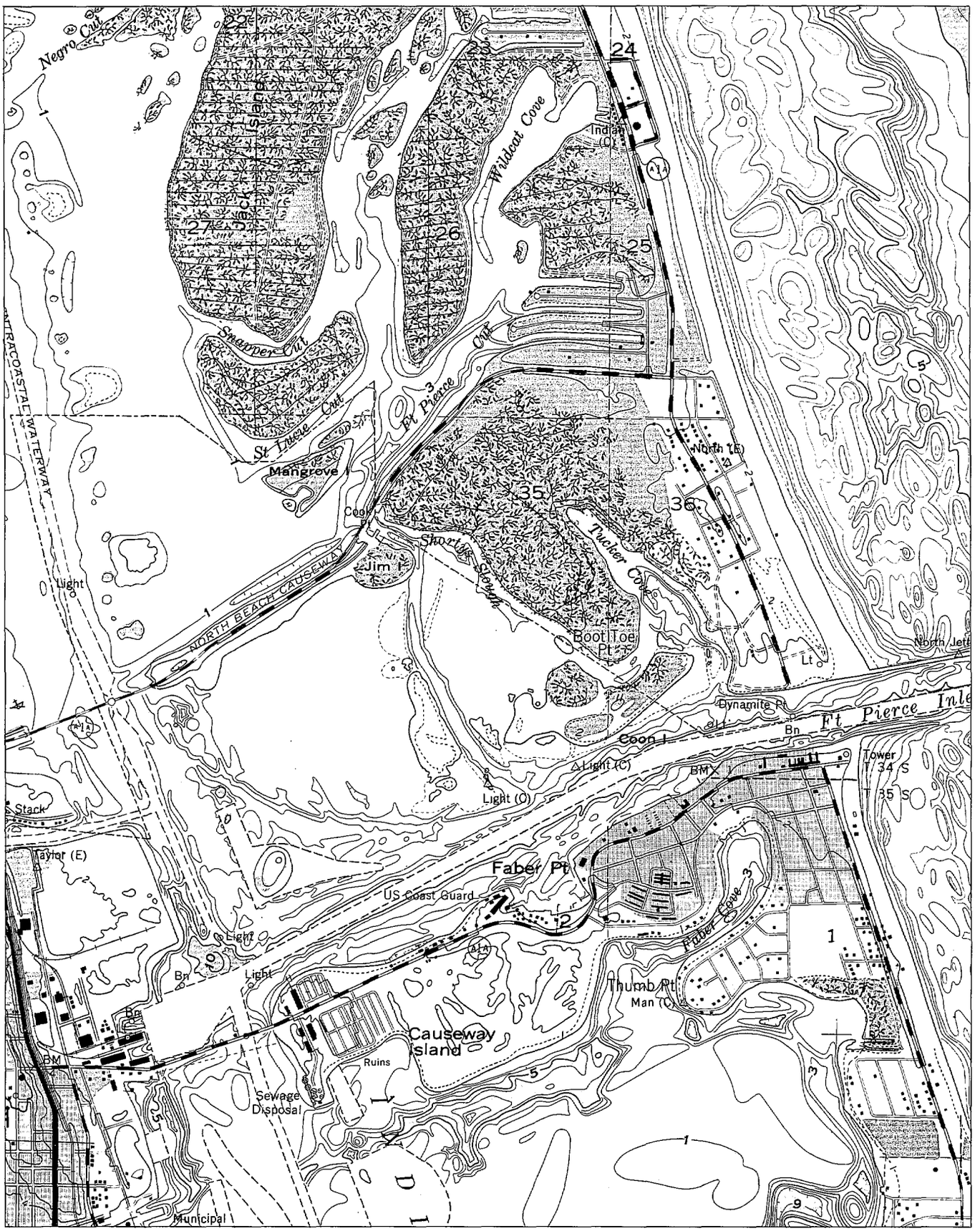


FIGURE 15.—Fort Pierce, Fla., 1:24,000-scale topographic map. This is a standard USGS 7.5-min quadrangle with bathymetric contours added from data furnished by NOS. The same area is shown in appendix figures 13 and 14 and partly in appendix figure 16.

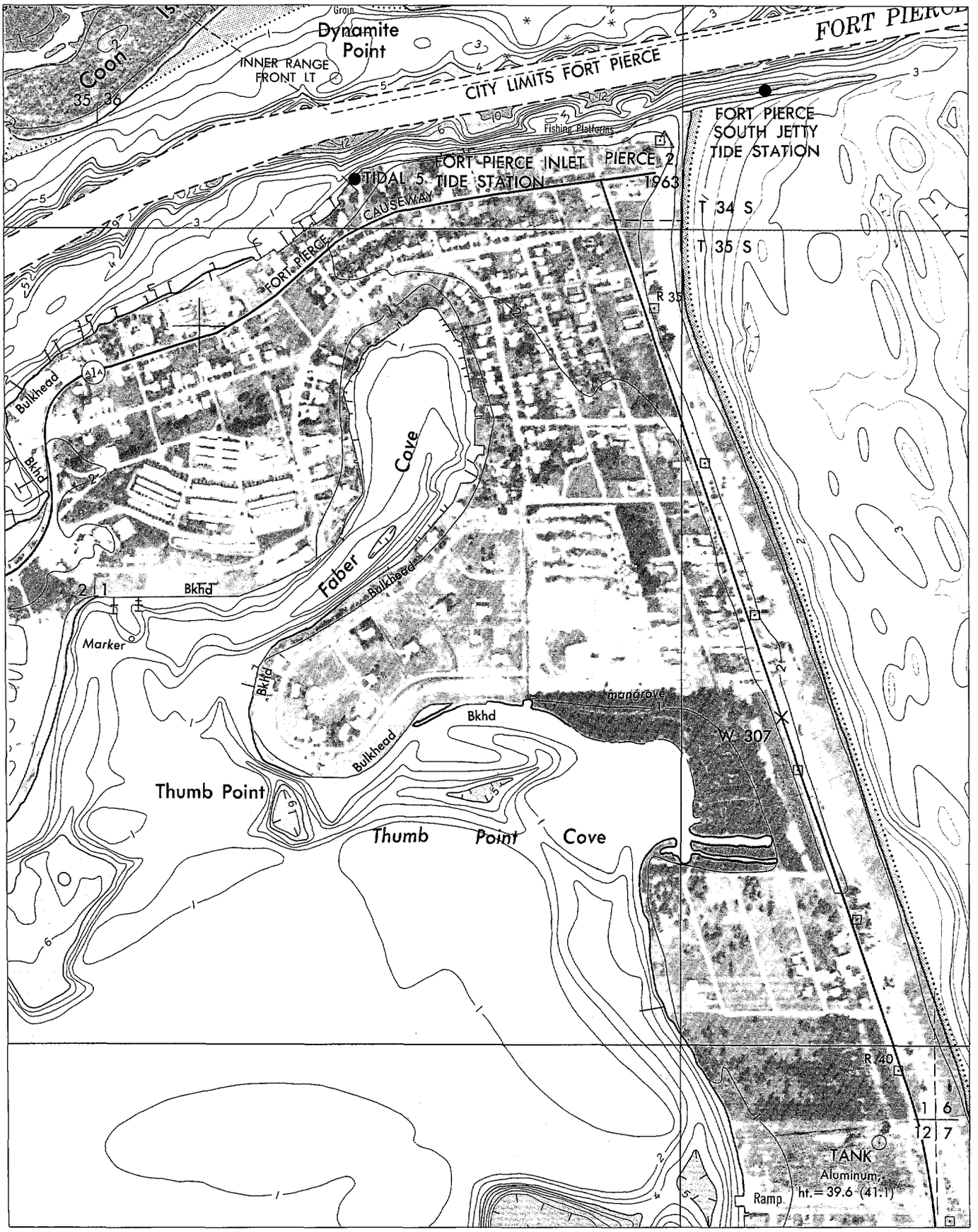


FIGURE 16.—Fort Pierce, Fla., 1:10,000-scale prototype coastal zone map. This NOS map includes the mean low and mean high waterlines and bathymetric detail. Land areas are enhanced by an orthophotographic image. The same area is shown at 1:24,000 scale in appendix figures 13, 14, and 15.

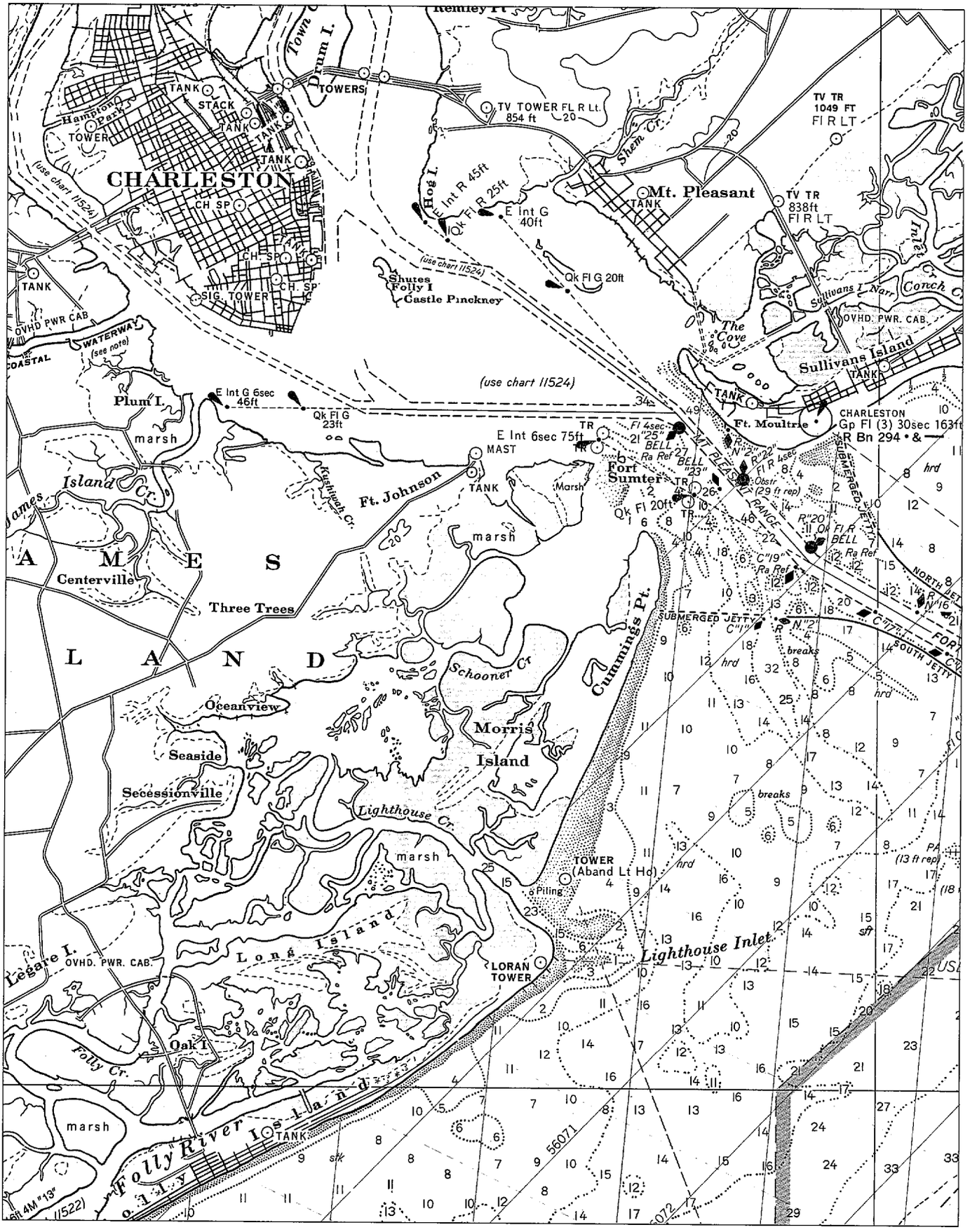


FIGURE 17.—Charleston Harbor and Approaches, S.C., (Chart 11521), 1:80,000-scale nautical chart. NOS nautical charts range in scale from 1:2,500 to 1:3,121,170. This chart is used by vessels approaching the coastline. This general area is also shown in appendix figures 18, 19, 21, 30, and 34.

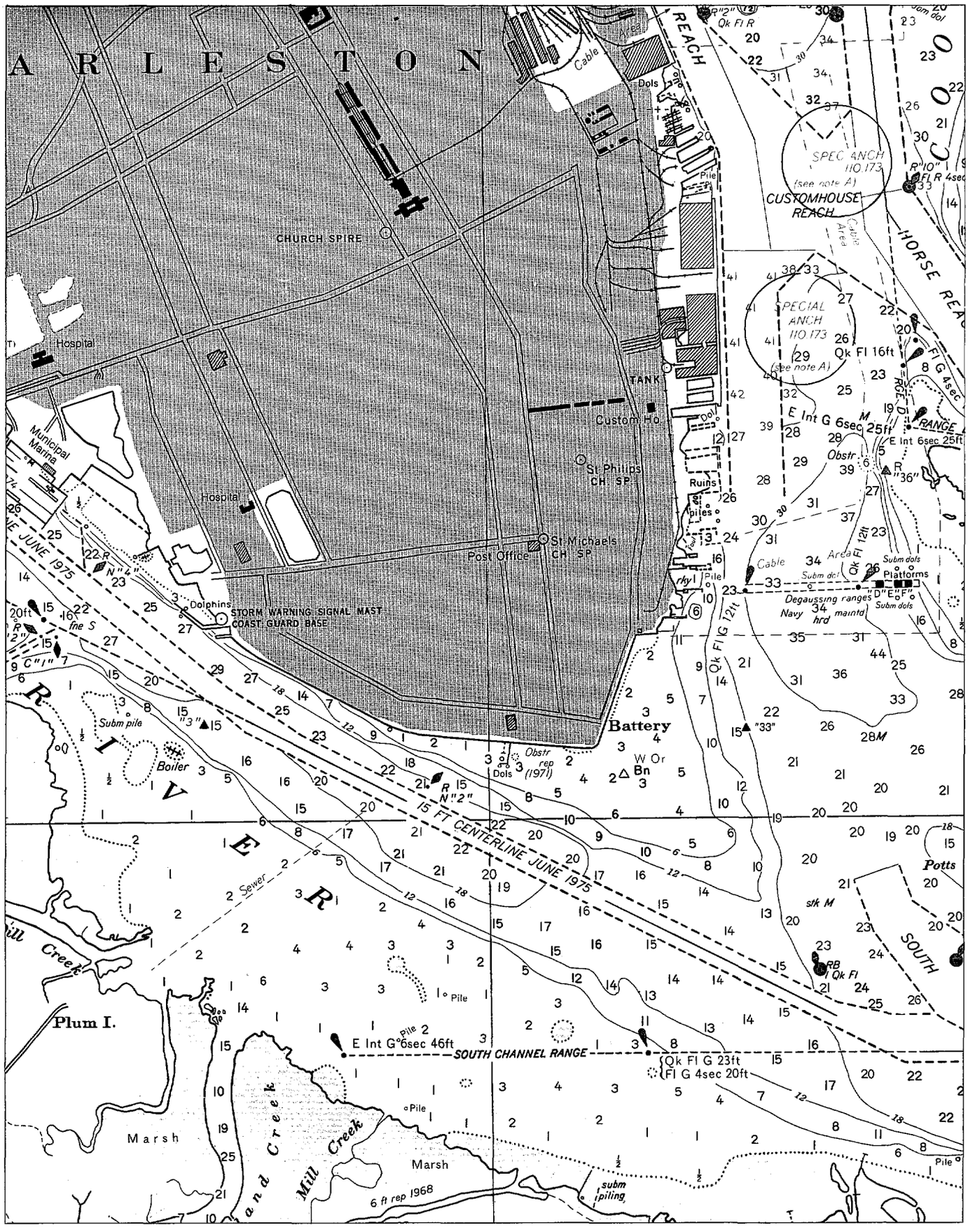


FIGURE 18.—Charleston Harbor, S.C., (Chart 11524), 1:20,000-scale harbor chart. This NOS chart is published specifically for harbor piloting. Generally harbor charts are at 1:10,000 scale; a few include an orthophotographic image. This general area is also shown in appendix figures 17, 19, 21, 30, and 34.

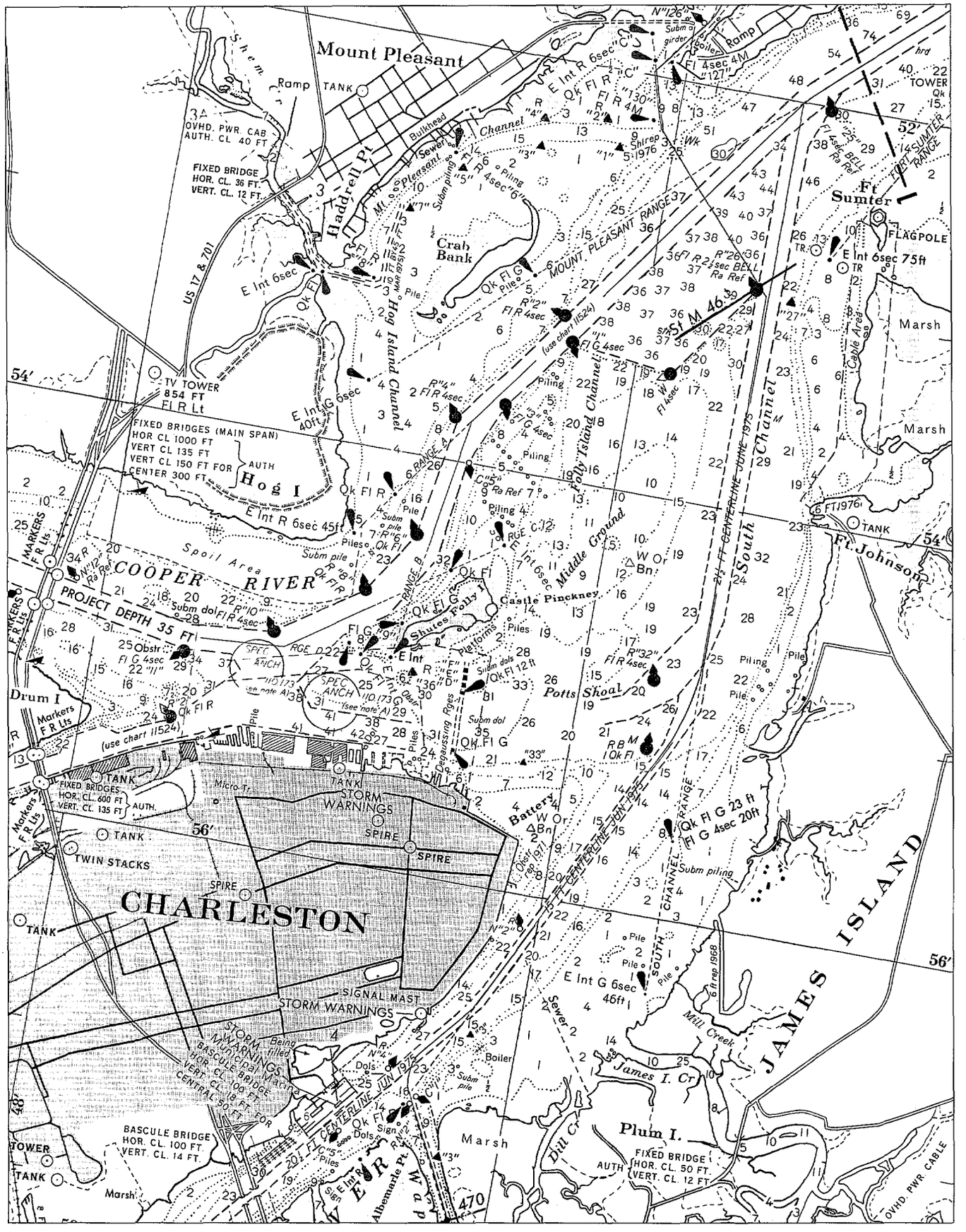


FIGURE 19.—Casino Creek to Beaufort River, S.C., (Chart 11518), 1:40,000-scale Intracoastal Waterway chart. These NOS small-craft charts range in scale from 1:10,000 to 1:80,000 and cover areas where recreational small-craft boating is popular. This general area is also shown in appendix figures 17, 18, 21, 30, and 34.

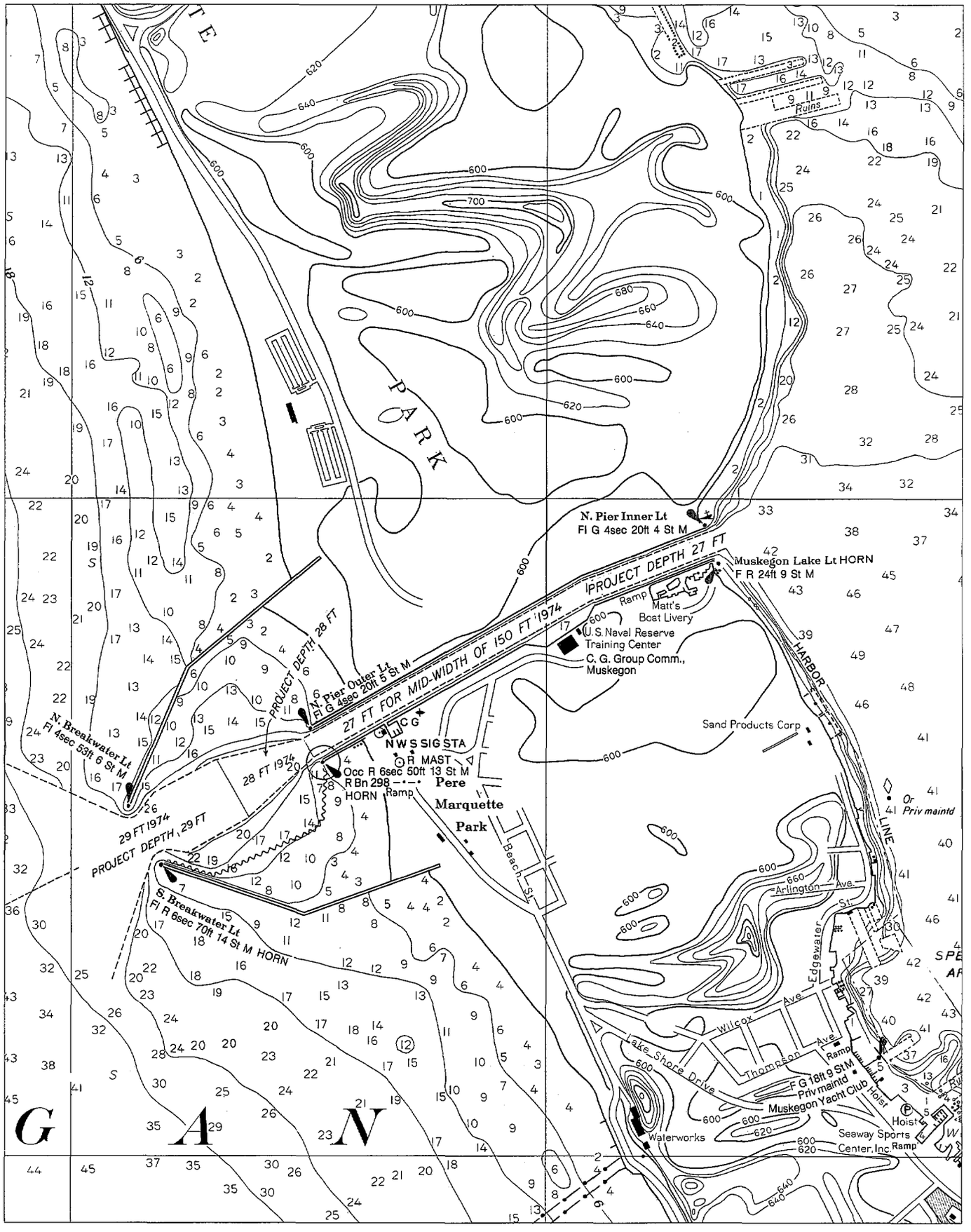


FIGURE 20.—Muskegon Lake, Mich., (Chart 14934), 1:15,000-scale lake chart. This is a typical NOS lake chart available for the Great Lakes coastal zone. There is a complete set of lake charts ranging in scale from 1:5,000 to 1:1,200,000.

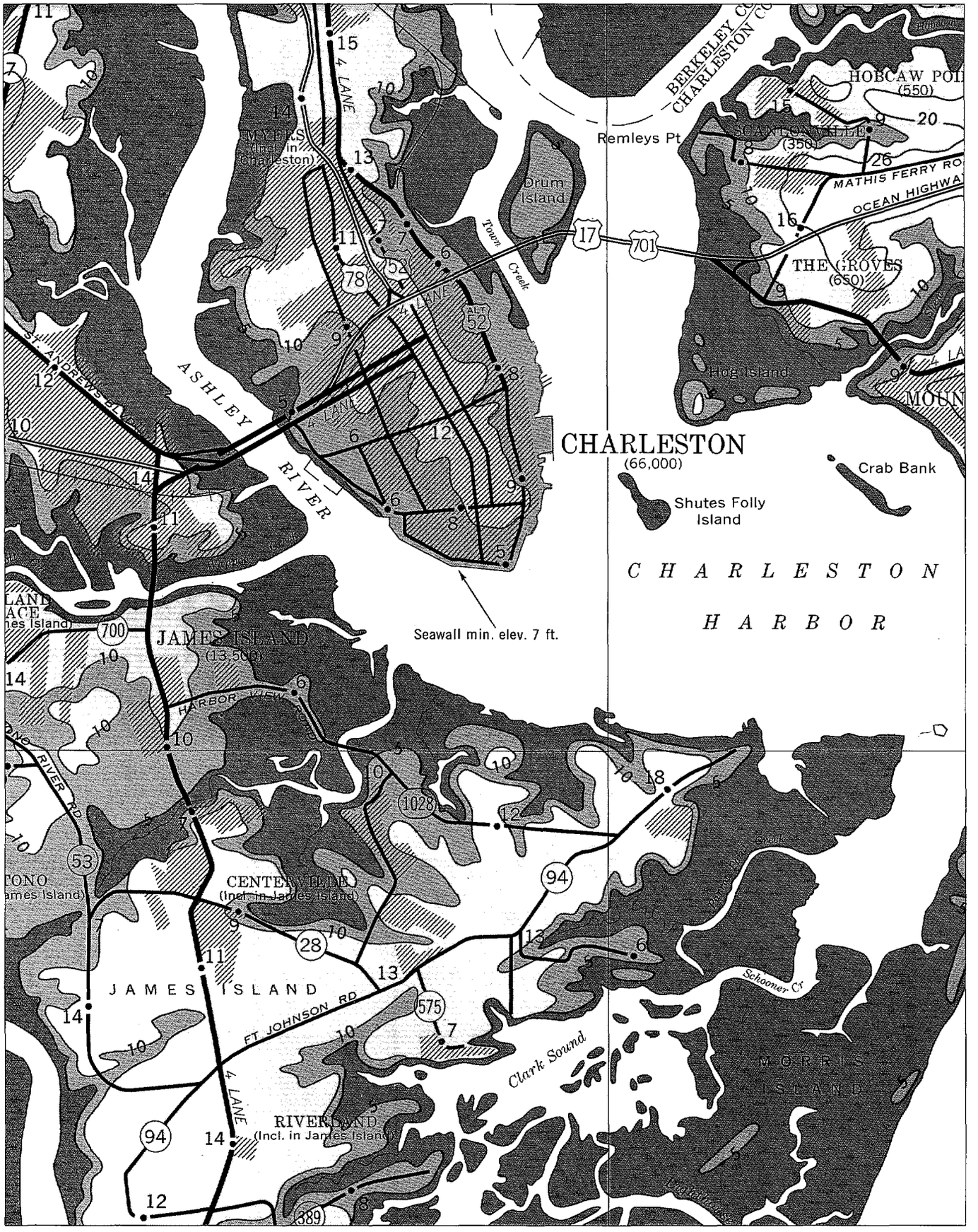


FIGURE 21.—Charleston, S.C., 1:62,500-scale storm evacuation map. This type of map is prepared by NOS from USGS base maps. They are designed to aid evacuation due to flooding and show only enough planimetric detail for that purpose. This general area is also shown in appendix figures 17, 18, 19, 30, and 34.

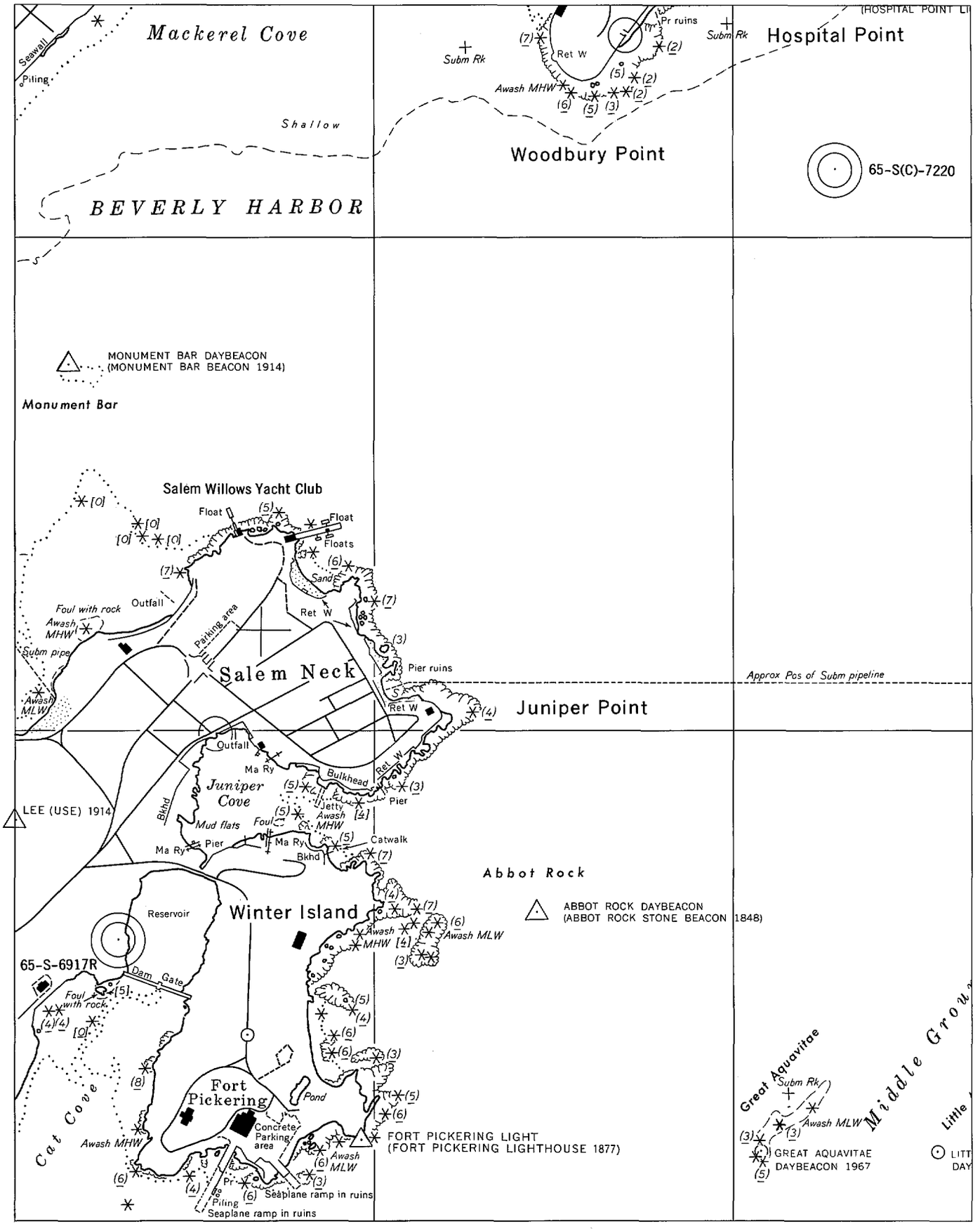


FIGURE 22.—Marblehead Harbor, Mass., 1:10,000-scale shoreline map. These NOS maps show precisely determined high and low waterlines and limited planimetry and are used in chart construction. Scales range from 1:5,000 to 1:20,000. Part of this area is shown in appendix figure 23.

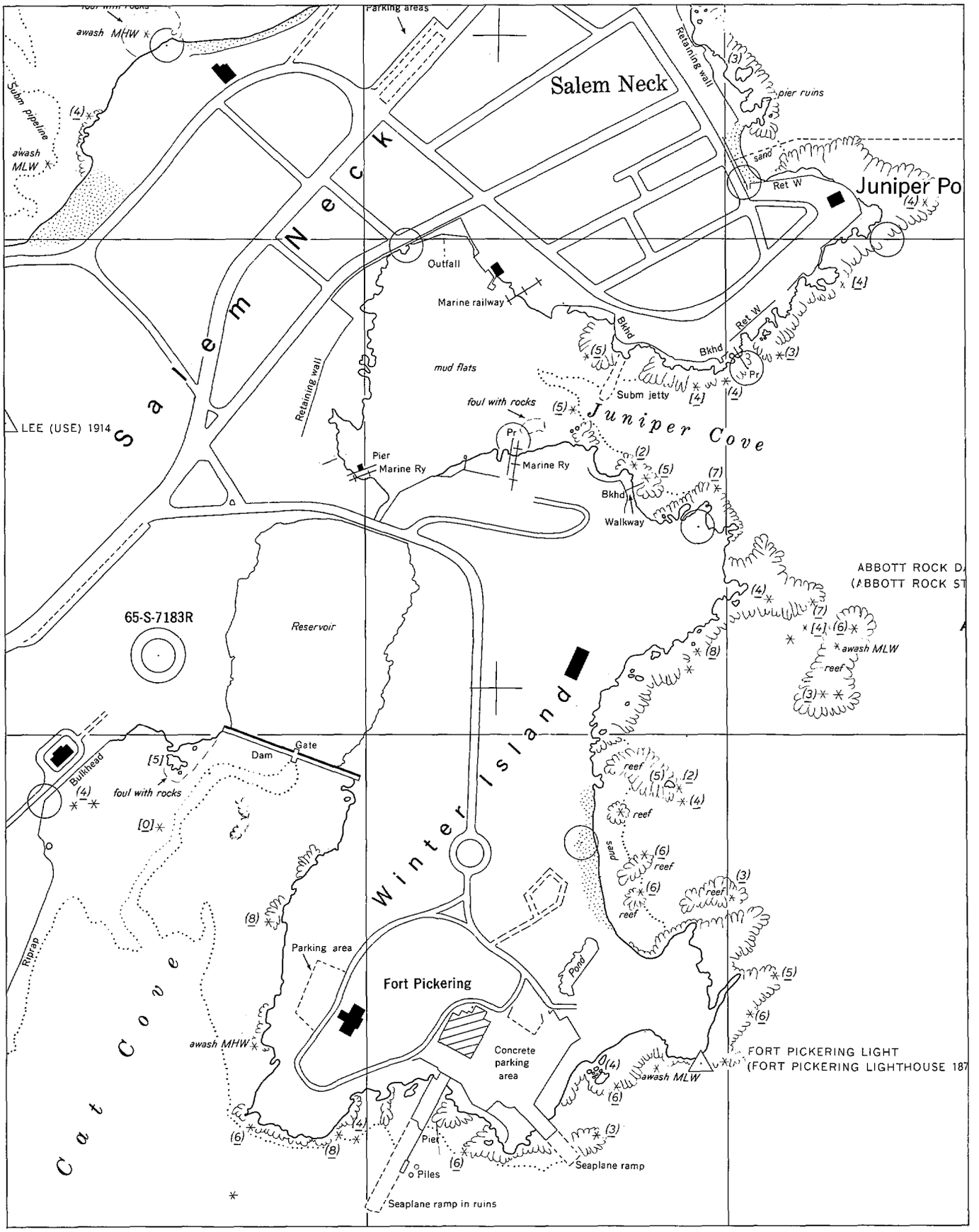


FIGURE 23.—Beverly Cove, Mass., 1:5,000-scale shoreline map. These NOS maps are stored on film, and diazo copies are reproduced on request. Shoreline maps dating from the early 19th century are available. This area is included in appendix figure 22.

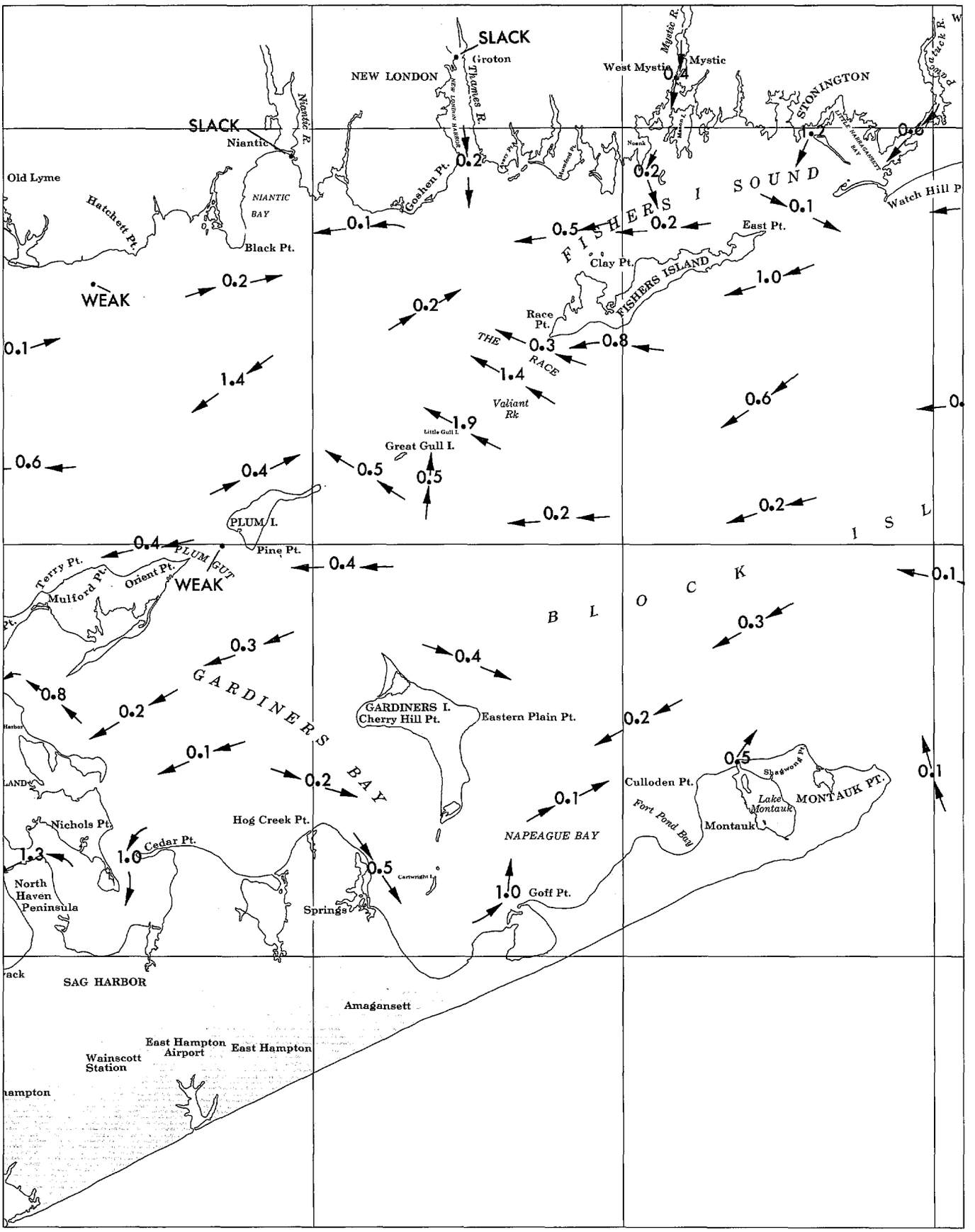


FIGURE 24.—Block Island Sound and Eastern Long Island Sound, N.Y.–Conn.–N.J., 1:210,000-scale tidal current chart. This NOS chart shows current direction and spring speed in knots. Data are based on predicted times and velocities at a selected location. The charts are available for major harbors.

CHARLESTON HARBOR (OFF FT. SUMTER), S.C., 1977

F-FLOOD, DIR. 335° TRUE E-EBB, DIR. 120° TRUE

NOVEMBER

DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
1		0222	1.9E
TU	0541	0819	1.8F
	1146	1451	2.0E
	1832	2048	1.4F
	2354		
2		0307	1.7E
W	0629	0908	1.7F
	1232	1543	1.9E
	1924	2137	1.3F
3	0047	0402	1.6E
TH	0724	0959	1.6F
	1326	1638	1.8E
	2018	2233	1.3F
4	0150	0459	1.6E
F	0825	1056	1.5F
	1426	1735	1.8E
	2113	2332	1.3F
5	0256	0601	1.7E
SA	0927	1155	1.6F
	1526	1834	1.9E
	2206		
6		0029	1.5F
SU	0358	0700	1.9E
	1026	1255	1.7F
	1623	1928	2.1E
	2255		
7		0124	1.8F
M	0454	0756	2.2E
	1121	1349	1.9F
	1715	2021	2.4E
	2342		
8		0220	2.2F
TU	0547	0847	2.6E
	1213	1443	2.2F
	1805	2109	2.7E
9	0028	0309	2.6F
W	0636	0940	2.9E
	1303	1534	2.4F
	1852	2155	2.9E
10	0113	0358	2.9F
TH	0724	1029	3.2E
	1352	1624	2.6F
	1939	2242	3.1E
11	0159	0445	3.1F
F	0813	1117	3.4E
	1441	1713	2.7F
	2027	2330	3.2E
12	0246	0536	3.3F
SA	0902	1206	3.4E
	1532	1804	2.7F
	2116		
13		0021	3.2E
SU	0335	0625	3.3F
	0953	1258	3.4E
	1624	1853	2.6F
	2208		
14		0112	3.1E
M	0427	0715	3.1F
	1046	1350	3.3E
	1718	1948	2.4F
	2304		
15		0207	2.9E
TU	0523	0810	2.9F
	1142	1445	3.0E
	1816	2042	2.2F
16	0004	0304	2.6E
W	0623	0907	2.6F
	1242	1546	2.8E
	1916	2143	2.0F
17	0109	0409	2.4E
TH	0728	1009	2.2F
	1345	1654	2.5E
	2019	2251	1.8F
18	0217	0522	2.2E
F	0837	1119	1.9F
	1449	1804	2.4E
	2121		
19		0009	1.8F
SA	0325	0637	2.2E
	0944	1242	1.8F
	1552	1911	2.3E
	2220		
20		0130	1.8F
SU	0428	0745	2.3E
	1049	1358	1.7F
	1650	2012	2.3E
	2314		
21		0231	1.9F
M	0525	0844	2.4E
	1147	1457	1.7F
	1743	2100	2.3E
22	0002	0316	2.0F
TU	0616	0935	2.4E
	1239	1542	1.7F
	1831	2147	2.3E
23	0046	0358	2.1F
W	0701	1016	2.5E
	1325	1623	1.7F
	1913	2224	2.3E
24	0127	0425	2.1F
TH	0742	1057	2.5E
	1407	1648	1.7F
	1952	2257	2.3E
25	0205	0452	2.1F
F	0820	1128	2.5E
	1446	1714	1.6F
	2028	2328	2.2E
26	0241	0522	2.1F
SA	0856	1201	2.4E
	1523	1743	1.6F
	2102		
27		0001	2.2E
SU	0317	0555	2.2F
	0930	1230	2.4E
	1601	1818	1.6F
	2135		
28		0033	2.1E
M	0353	0632	2.1F
	1004	1305	2.3E
	1638	1855	1.6F
	2208		
29		0112	2.1E
TU	0430	0711	2.1F
	1039	1344	2.2E
	1718	1934	1.6F
	2244		
30		0155	2.0E
W	0510	0754	2.0F
	1115	1423	2.1E
	1800	2020	1.5F
	2323		

DECEMBER

DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
1		0236	1.9E
TH	0555	0835	1.9F
	1155	1512	2.1E
	1845	2107	1.5F
2	0010	0327	1.8E
F	0645	0926	1.8F
	1241	1559	2.0E
	1933	2156	1.5F
3	0106	0421	1.8E
SA	0742	1018	1.7F
	1334	1654	2.0E
	2025	2253	1.6F
4	0209	0518	1.9E
SU	0844	1115	1.7F
	1433	1750	2.1E
	2118	2348	1.8F
5	0315	0621	2.0E
M	0947	1214	1.7F
	1534	1845	2.2E
	2212		
6		0046	2.0F
TU	0417	0721	2.3E
	1048	1313	1.9F
	1633	1942	2.4E
	2304		
7		0145	2.3F
W	0516	0818	2.6E
	1145	1412	2.1F
	1730	2037	2.7E
	2356		
8		0240	2.7F
TH	0612	0916	2.9E
	1241	1510	2.3F
	1825	2129	2.9E
9	0047	0335	3.0F
F	0705	1010	3.2E
	1334	1604	2.5F
	1918	2222	3.1E
10	0137	0427	3.2F
SA	0757	1101	3.4E
	1425	1656	2.6F
	2010	2314	3.2E
11	0228	0518	3.3F
SU	0848	1153	3.5E
	1517	1749	2.6F
	2103		
12		0006	3.2E
M	0320	0611	3.3F
	0940	1243	3.5E
	1609	1841	2.6F
	2156		
13		0057	3.2E
TU	0413	0702	3.2F
	1032	1337	3.3E
	1702	1932	2.5F
	2251		
14		0151	3.0E
W	0508	0755	2.9F
	1125	1429	3.1E
	1756	2029	2.3F
	2348		
15		0249	2.7E
TH	0606	0851	2.6F
	1221	1525	2.8E
	1852	2124	2.1F
16	0049	0349	2.5E
F	0707	0949	2.2F
	1318	1626	2.6E
	1949	2225	1.9F
17	0152	0457	2.3E
SA	0811	1048	1.9F
	1417	1727	2.3E
	2048	2334	1.8F
18	0256	0607	2.1E
SU	0917	1202	1.6F
	1518	1834	2.2E
	2145		
19		0045	1.7F
M	0359	0716	2.1E
	1021	1321	1.4F
	1616	1938	2.1E
	2240		
20		0155	1.7F
TU	0457	0821	2.1E
	1121	1430	1.4F
	1711	2031	2.1E
	2331		
21		0254	1.8F
W	0550	0913	2.2E
	1215	1523	1.4F
	1801	2118	2.1E
22	0018	0335	1.9F
TH	0637	0958	2.2E
	1303	1559	1.4F
	1846	2201	2.1E
23	0101	0404	1.9F
F	0720	1039	2.3E
	1345	1630	1.4F
	1927	2234	2.1E
24	0140	0433	2.0F
SA	0759	1112	2.3E
	1425	1653	1.5F
	2005	2307	2.1E
25	0218	0501	2.1F
SU	0835	1141	2.3E
	1502	1721	1.6F
	2040	2339	2.2E
26	0255	0534	2.1F
M	0910	1212	2.4E
	1538	1756	1.6F
	2114		
27		0013	2.2E
TU	0331	0609	2.2F
	0943	1244	2.4E
	1614	1833	1.7F
	2147		
28		0050	2.2E
W	0407	0646	2.2F
	1015	1319	2.4E
	1650	1912	1.8F
	2221		
29		0129	2.2E
TH	0446	0729	2.2F
	1049	1400	2.3E
	1728	1951	1.8F
	2258		
30		0210	2.1E
F	0527	0811	2.1F
	1125	1439	2.3E
	1807	2036	1.8F
	2341		
31		0257	2.1E
SA	0614	0858	2.0F
	1205	1525	2.3E
	1852	2125	1.9F

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.

FIGURE 25.—Charleston Harbor, S.C., tidal current predictions from NOS.

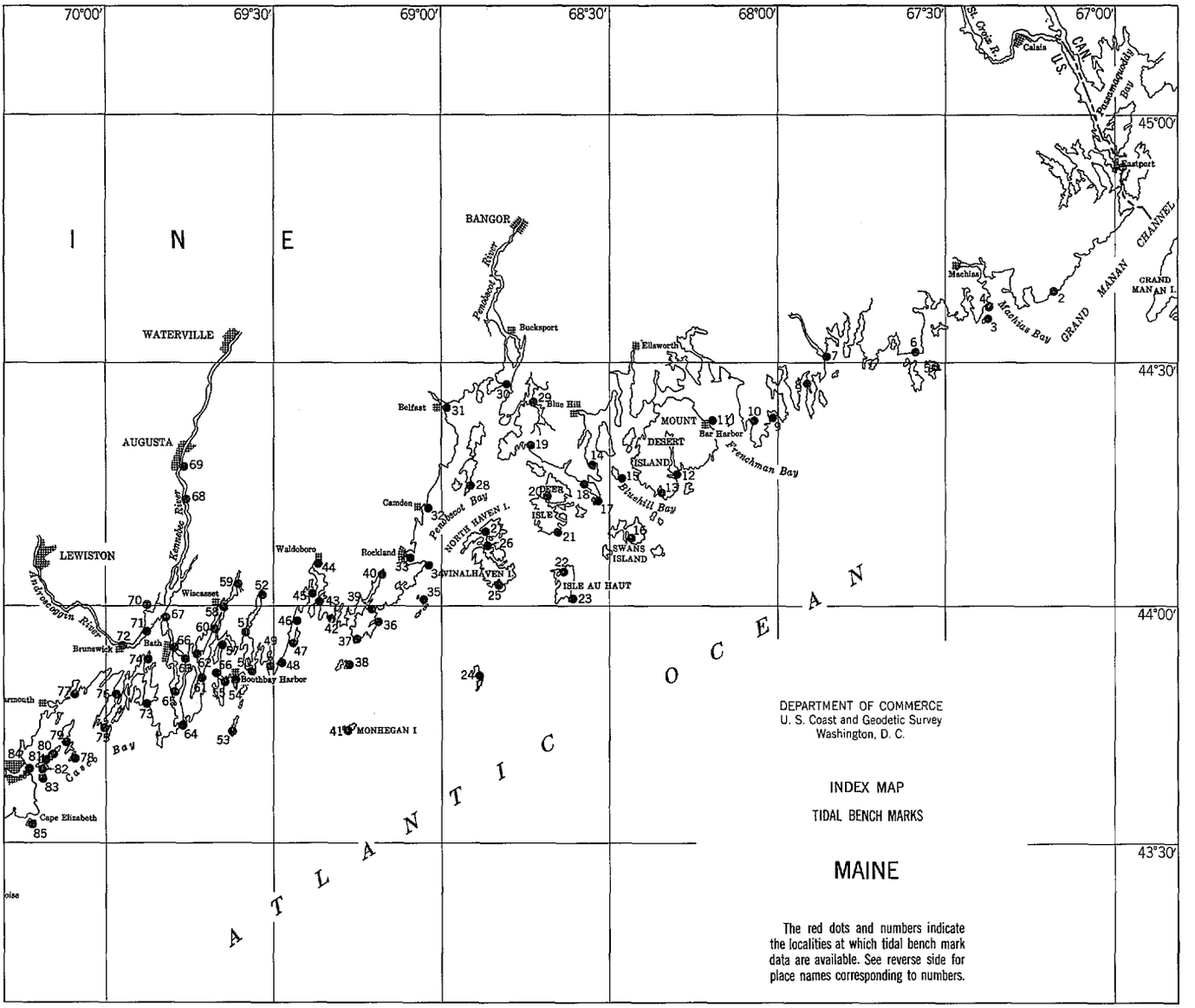


FIGURE 26.—NOS index map of tidal bench marks for the State of Maine. Indexes are available for other coastal States.

2/18/76

SOUTH CAROLINA

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY

The difference between the National Geodetic Vertical Datum (NGVD) 1929 (formerly Sea Level Datum 1929) and the mean low water (MLW) for each location where the tidal bench marks and the geodetic bench marks of the National Geodetic Network have been connected by differential levels is given below.

Bench mark elevations above the National Geodetic Vertical Datum (1929) may be obtained by applying the tabular difference to the published elevations above mean low water, subtracting the difference when positive and adding the difference when negative.

Index Map Number	Locality	NGVD-MLW Feet
3A	Myrtle Beach (Ocean)	2.21
9	Georgetown, Sampit River Entrance	1.03
39A	Fort Johnson, South Channel, Charleston Harbor	2.22
40	Charleston (Custonhouse Wharf), Cooper River Entrance	2.65**
42	Cainhoy, Wando River	2.81
46	Port Terminal, Cooper River	2.16
52	Ashley River, Highway Bridge, Charleston	2.50
53	Virginia-Carolina Chemical Company Wharf, Ashley River.	2.45
54	Bees Ferry Bridge (Atlantic Coast Line Railroad Bridge), Ashley River	2.47
74	Seabrook, Fenwick Island	2.68
77	Field Point, Combahee River	2.78
79	Summerhouse Point, Bull River	3.19
84	Ladies Island, Junction of Morgan River and Lucy Point Creek	3.21
84A	Harbor River Entrance, St. Helena Sound	3.06
90	Marine Training Station, Parris Island, Beaufort River.	3.51
91	Distant Island, Beaufort River	3.42
92	Beaufort, Beaufort River	3.63

** Above Charleston Low-Water Datum

FIGURE 27.—Charleston, S.C., NGVD-MLW correlation table from NOS.

3/17/71

SOUTH CAROLINA - 40-2

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY

TIDAL BENCH MARKS

Charleston (Customhouse Wharf), Cooper River Entrance
Lat. 32°46'.9; Long. 79°55'.5

BENCH MARK 1 (U.S.E.) is a chiseled cross in the top and near north end of bottom step of east entrance of customhouse at intersection of Market and Conrad Streets. Elevation: 11.95 feet above Charleston low-water datum.

BENCH MARK 5 = 9 (U.S.G.S.) (1918) is a standard disk, stamped "9.311 1918," set in top and near north end of bottom step at east entrance of customhouse. It is 1/2 foot south of Bench Mark 1 (U.S.E.). Elevation: 11.97 feet above Charleston low-water datum.

BENCH MARK 7 (1921) is a standard disk, stamped "7 1921 ELEV. 13.612 FT," set in top of east end of ledge of second basement window west of southeast corner of east wing of customhouse, and about 5 feet above ground. Elevation: 16.28 feet above Charleston low-water datum.

Elevations of other tide planes referred to *Charleston low-water datum are based on 19 years of records, 1941-1959 and are as follows:

	Feet
Highest tide observed (Aug. 11, 1940)	10.7
Mean high water	5.51
Mean tide level	2.91
Mean low water	0.31
Charleston low-water datum	0.00
Lowest tide observed (Nov. 30, 1963)	-3.3

*CHARLESTON LOW-WATER DATUM. This datum has been in use by the National Ocean Survey since 1905. It was officially adopted by the Corps of Engineers, U.S. Army and the U.S.Coast and Geodetic Survey in May 1929, and is defined as being 11.95 feet below Bench Mark 1 (U.S.E.) at the Customhouse Wharf at Charleston.

FIGURE 28.—Charleston, S.C., tidal bench mark descriptions. Descriptions are available for NOS tide gages shown on State indexes (app. fig. 26).

CHARLESTON, S.C., 1976

TIMES AND HEIGHTS OF HIGH AND LOW WATERS

DAY	OCTOBER TIME H.M.	OCTOBER HT. FT.	DAY	OCTOBER TIME H.M.	OCTOBER HT. FT.	DAY	NOVEMBER TIME H.M.	NOVEMBER HT. FT.	DAY	NOVEMBER TIME H.M.	NOVEMBER HT. FT.	DAY	DECEMBER TIME H.M.	DECEMBER HT. FT.	DAY	DECEMBER TIME H.M.	DECEMBER HT. FT.
1	0155	5.1	16	0041	4.6	1	0331	5.2	16	0224	5.1	1	0350	5.1	16	0305	5.4
F	0801	0.6	SA	0702	1.0	M	0939	0.8	TU	0842	0.6	W	1000	0.7	TH	0926	0.1
	1438	5.9		1313	5.4		1601	5.4		1443	5.4		1611	4.8		1518	4.9
	2049	0.7		1946	1.2		2206	0.5		2111	0.2		2215	0.2		2142	-0.4
2	0300	5.1	17	0148	4.8	2	0426	5.4	17	0329	5.5	2	0438	5.2	17	0409	5.7
SA	0905	0.6	SU	0807	0.9	TU	1032	0.7	W	0947	0.3	TH	1051	0.6	F	1030	-0.1
	1538	5.8		1417	5.5		1650	5.4		1544	5.4		1659	4.7		1622	5.0
	2147	0.7		2049	1.0		2253	0.3		2210	-0.1		2301	0.1		2241	-0.7
3	0400	5.3	18	0253	5.0	3	0513	5.6	18	0430	6.0	3	0525	5.4	18	0510	6.1
SU	1006	0.6	M	0912	0.7	W	1122	0.6	TH	1048	0.0	F	1137	0.5	SA	1130	-0.4
	1633	5.8		1518	5.6		1736	5.4		1645	5.6		1744	4.7		1725	5.1
	2238	0.5		2147	0.6		2336	0.2		2305	-0.4		2345	0.0		2339	-0.9
4	0452	5.5	19	0355	5.5	4	0557	5.8	19	0528	6.4	4	0607	5.5	19	0610	6.3
M	1059	0.5	TU	1014	0.4	TH	1206	0.5	F	1146	-0.3	SA	1221	0.3	SU	1226	-0.6
	1722	5.8		1617	5.8		1818	5.3		1744	5.7		1826	4.7		1823	5.2
	2325	0.3		2240	0.2												
5	0541	5.7	20	0454	5.9	5	0018	0.1	20	0000	-0.7	5	0026	-0.1	20	0034	-1.1
TU	1147	0.4	W	1112	0.1	F	0636	5.9	SA	0624	6.7	SU	0647	5.6	M	0705	6.5
	1808	5.8		1712	6.0		1248	0.4		1242	-0.5		1303	0.2		1319	-0.8
				2333	-0.2		1855	5.3		1839	5.7		1906	4.7		1919	5.3
6	0009	0.2	21	0549	6.4	6	0057	0.1	21	0052	-0.9	6	0107	-0.2	21	0126	-1.2
W	0626	5.8	TH	1206	-0.2	SA	0715	5.9	SU	0719	6.9	M	0727	5.7	TU	0759	6.5
	1231	0.3		1807	6.1		1327	0.4		1335	-0.7		1344	0.2		1410	-0.9
	1850	5.8					1934	5.2		1935	5.7		1944	4.7		2013	5.3
7	0050	0.1	22	0024	-0.5	7	0135	0.1	22	0143	-1.0	7	0146	-0.2	22	0217	-1.1
TH	0705	5.9	F	0643	6.7	SU	0752	5.9	M	0813	6.9	TU	0803	5.7	W	0850	6.4
	1313	0.3		1300	-0.5		1406	0.4		1427	-0.7		1423	0.2		1459	-0.8
	1927	5.7		1900	6.2		2009	5.1		2028	5.7		2021	4.6		2106	5.3
8	0127	0.1	23	0114	-0.7	8	0212	0.1	23	0234	-0.9	8	0226	-0.2	23	0307	-0.9
F	0743	6.0	SA	0735	7.0	M	0827	5.9	TU	0906	6.8	W	0840	5.7	TH	0940	6.2
	1352	0.4		1351	-0.6		1444	0.5		1518	-0.6		1501	0.2		1546	-0.7
	2003	5.5		1951	6.2		2043	4.9		2123	5.5		2056	4.6		2157	5.2
9	0204	0.2	24	0203	-0.8	9	0249	0.2	24	0325	-0.7	9	0303	-0.1	24	0357	-0.6
SA	0819	6.0	SU	0829	7.1	TU	0901	5.8	W	0959	6.6	TH	0916	5.6	F	1027	5.9
	1429	0.5		1443	-0.5		1523	0.6		1610	-0.4		1540	0.2		1634	-0.5
	2038	5.4		2045	6.0		2117	4.8		2218	5.4		2133	4.6		2247	5.0
10	0240	0.3	25	0253	-0.7	10	0325	0.3	25	0418	-0.4	10	0344	0.0	25	0447	-0.3
SU	0853	5.9	M	0922	7.0	W	0936	5.7	TH	1052	6.3	F	0953	5.6	SA	1116	5.5
	1508	0.6		1535	-0.4		1602	0.7		1700	-0.2		1618	0.2		1721	-0.3
	2109	5.2		2138	5.8		2151	4.7		2313	5.2		2213	4.6		2336	4.9
11	0316	0.4	26	0344	-0.5	11	0404	0.4	26	0512	0.0	11	0426	0.1	26	0536	0.0
M	0927	5.8	TU	1017	6.8	TH	1014	5.6	F	1147	5.9	SA	1035	5.4	SU	1204	5.1
	1545	0.8		1629	-0.1		1642	0.8		1753	0.1		1703	0.2		1808	-0.1
	2141	5.0		2234	5.6		2229	4.6					2258	4.7			
12	0354	0.5	27	0439	-0.2	12	0446	0.6	27	0009	5.0	12	0514	0.2	27	0027	4.7
TU	1002	5.7	W	1114	6.5	F	1055	5.5	SA	0606	0.3	SU	1121	5.3	M	0628	0.4
	1622	1.0		1724	0.2		1726	0.8		1241	5.5		1748	0.2		1254	4.7
	2215	4.8		2332	5.3		2319	4.6		1847	0.2		2353	4.8		1859	0.1
13	0431	0.7	28	0535	0.2	13	0535	0.7	28	0106	4.9	13	0609	0.3	28	0120	4.6
W	1040	5.6	TH	1212	6.2	SA	1143	5.4	SU	0705	0.6	M	1212	5.2	TU	0725	0.6
	1706	1.1		1822	0.4		1814	0.8		1334	5.2		1841	0.1		1342	4.5
	2255	4.7								1942	0.4					1949	0.2
14	0514	0.8	29	0033	5.2	14	0014	4.7	29	0202	4.9	14	0056	4.9	29	0213	4.6
TH	1125	5.5	F	0635	0.5	SU	0633	0.7	M	0806	0.7	TU	0712	0.3	W	0821	0.7
	1753	1.2		1313	5.9		1239	5.4		1428	5.0		1310	5.0		1435	4.3
	2343	4.6		1920	0.6		1910	0.7		2034	0.4		1937	0.0		2041	0.2
15	0604	0.9	30	0136	5.1	15	0119	4.9	30	0257	4.9	15	0159	5.1	30	0307	4.7
F	1216	5.4	SA	0736	0.7	M	0737	0.7	TU	0905	0.8	W	0818	0.3	TH	0918	0.7
	1848	1.3		1412	5.7		1341	5.3		1521	4.8		1414	5.0		1527	4.2
				2020	0.6		2011	0.5		2125	0.3		2040	-0.2		2134	0.2
			31	0236	5.1										31	0358	4.8
			SU	0840	0.8										F	1013	0.6
				1507	5.5											1619	4.2
				2113	0.6											2224	0.0

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.
HEIGHTS ARE RECKONED FROM THE DATUM OF SOUNDINGS ON CHARTS OF THE LOCALITY WHICH IS MEAN LOW WATER.

FIGURE 29.—Charleston, S.C., times and heights of high and low waters. This table is taken from the Tide Tables published annually by NOS.

3/17/71

SOUTH CAROLINA - 40-2

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY

TIDAL BENCH MARKS

Charleston (Customhouse Wharf), Cooper River Entrance
Lat. 32°46'.9; Long. 79°55'.5

BENCH MARK 1 (U.S.E.) is a chiseled cross in the top and near north end of bottom step of east entrance of customhouse at intersection of Market and Conrad Streets. Elevation: 11.95 feet above Charleston low-water datum.

BENCH MARK 5 = 9 (U.S.G.S.) (1918) is a standard disk, stamped "9.311 1918," set in top and near north end of bottom step at east entrance of customhouse. It is 1/2 foot south of Bench Mark 1 (U.S.E.). Elevation: 11.97 feet above Charleston low-water datum.

BENCH MARK 7 (1921) is a standard disk, stamped "7 1921 ELEV. 13.612 FT," set in top of east end of ledge of second basement window west of southeast corner of east wing of customhouse, and about 5 feet above ground. Elevation: 16.28 feet above Charleston low-water datum.

Elevations of other tide planes referred to *Charleston low-water datum are based on 19 years of records, 1941-1959 and are as follows:

	Feet
Highest tide observed (Aug. 11, 1940)	10.7
Mean high water	5.51
Mean tide level	2.91
Mean low water	0.31
Charleston low-water datum	0.00
Lowest tide observed (Nov. 30, 1963)	-3.3

*CHARLESTON LOW-WATER DATUM. This datum has been in use by the National Ocean Survey since 1905. It was officially adopted by the Corps of Engineers, U.S. Army and the U.S.Coast and Geodetic Survey in May 1929, and is defined as being 11.95 feet below Bench Mark 1 (U.S.E.) at the Customhouse Wharf at Charleston.

FIGURE 28.—Charleston, S.C., tidal bench mark descriptions. Descriptions are available for NOS tide gages shown on State indexes (app. fig. 26).

CHARLESTON, S.C., 1976

TIMES AND HEIGHTS OF HIGH AND LOW WATERS

DAY	OCTOBER TIME H.M.	OCTOBER HT. FT.	DAY	OCTOBER TIME H.M.	OCTOBER HT. FT.	DAY	NOVEMBER TIME H.M.	NOVEMBER HT. FT.	DAY	NOVEMBER TIME H.M.	NOVEMBER HT. FT.	DAY	DECEMBER TIME H.M.	DECEMBER HT. FT.	DAY	DECEMBER TIME H.M.	DECEMBER HT. FT.
1	0155	5.1	16	0041	4.6	1	0331	5.2	16	0224	5.1	1	0350	5.1	16	0305	5.4
F	0801	0.6	SA	0702	1.0	M	0939	0.8	TU	0842	0.6	W	1000	0.7	TH	0926	0.1
	1438	5.9		1313	5.4		1601	5.4		1443	5.4		1611	4.8		1518	4.9
	2049	0.7		1946	1.2		2206	0.5		2111	0.2		2215	0.2		2142	-0.4
2	0300	5.1	17	0148	4.8	2	0426	5.4	17	0329	5.5	2	0438	5.2	17	0409	5.7
SA	0905	0.6	SU	0807	0.9	TU	1032	0.7	W	0947	0.3	TH	1051	0.6	F	1030	-0.1
	1538	5.8		1417	5.5		1650	5.4		1544	5.4		1659	4.7		1622	5.0
	2147	0.7		2049	1.0		2253	0.3		2210	-0.1		2301	0.1		2241	-0.7
3	0400	5.3	18	0253	5.0	3	0513	5.6	18	0430	6.0	3	0525	5.4	18	0510	6.1
SU	1006	0.6	M	0912	0.7	W	1122	0.6	TH	1048	0.0	F	1137	0.5	SA	1130	-0.4
	1633	5.8		1518	5.6		1736	5.4		1645	5.6		1744	4.7		1725	5.1
	2238	0.5		2147	0.6		2336	0.2		2305	-0.4		2345	0.0		2339	-0.9
4	0452	5.5	19	0355	5.5	4	0557	5.8	19	0528	6.4	4	0607	5.5	19	0610	6.3
M	1059	0.5	TU	1014	0.4	TH	1206	0.5	F	1146	-0.3	SA	1221	0.3	SU	1226	-0.6
	1722	5.8		1617	5.8		1818	5.3		1744	5.7		1826	4.7		1823	5.2
	2325	0.3		2240	0.2												
5	0541	5.7	20	0454	5.9	5	0018	0.1	20	0000	-0.7	5	0026	-0.1	20	0034	-1.1
TU	1147	0.4	W	1112	0.1	F	0636	5.9	SA	0624	6.7	SU	0647	5.6	M	0705	6.5
	1808	5.8		1712	6.0		1248	0.4		1242	-0.5		1303	0.2		1319	-0.8
				2333	-0.2		1855	5.3		1839	5.7		1906	4.7		1919	5.3
6	0009	0.2	21	0549	6.4	6	0057	0.1	21	0052	-0.9	6	0107	-0.2	21	0126	-1.2
W	0626	5.8	TH	1206	-0.2	SA	0715	5.9	SU	0719	6.9	M	0727	5.7	TU	0759	6.5
	1231	0.3		1807	6.1		1327	0.4		1335	-0.7		1344	0.2		1410	-0.9
	1850	5.8					1934	5.2		1935	5.7		1944	4.7		2013	5.3
7	0050	0.1	22	0024	-0.5	7	0135	0.1	22	0143	-1.0	7	0146	-0.2	22	0217	-1.1
TH	0705	5.9	F	0643	6.7	SU	0752	5.9	M	0813	6.9	TU	0803	5.7	W	0850	6.4
	1313	0.3		1300	-0.5		1406	0.4		1427	-0.7		1423	0.2		1459	-0.8
	1927	5.7		1900	6.2		2009	5.1		2028	5.7		2021	4.6		2106	5.3
8	0127	0.1	23	0114	-0.7	8	0212	0.1	23	0234	-0.9	8	0226	-0.2	23	0307	-0.9
F	0743	6.0	SA	0735	7.0	M	0827	5.9	TU	0906	6.8	W	0840	5.7	TH	0940	6.2
	1352	0.4		1351	-0.6		1444	0.5		1518	-0.6		1501	0.2		1546	-0.7
	2003	5.5		1951	6.2		2043	4.9		2123	5.5		2056	4.6		2157	5.2
9	0204	0.2	24	0203	-0.8	9	0249	0.2	24	0325	-0.7	9	0303	-0.1	24	0357	-0.6
SA	0819	6.0	SU	0829	7.1	TU	0901	5.8	W	0959	6.6	TH	0916	5.6	F	1027	5.9
	1429	0.5		1443	-0.5		1523	0.6		1610	-0.4		1540	0.2		1634	-0.5
	2038	5.4		2045	6.0		2117	4.8		2218	5.4		2133	4.6		2247	5.0
10	0240	0.3	25	0253	-0.7	10	0325	0.3	25	0418	-0.4	10	0344	0.0	25	0447	-0.3
SU	0853	5.9	M	0922	7.0	W	0936	5.7	TH	1052	6.3	F	0953	5.6	SA	1116	5.5
	1508	0.6		1535	-0.4		1602	0.7		1700	-0.2		1618	0.2		1721	-0.3
	2109	5.2		2138	5.8		2151	4.7		2313	5.2		2213	4.6		2336	4.9
11	0316	0.4	26	0344	-0.5	11	0404	0.4	26	0512	0.0	11	0426	0.1	26	0536	0.0
M	0927	5.8	TU	1017	6.8	TH	1014	5.6	F	1147	5.9	SA	1035	5.4	SU	1204	5.1
	1545	0.8		1629	-0.1		1642	0.8		1753	0.1		1703	0.2		1808	-0.1
	2141	5.0		2234	5.6		2229	4.6					2258	4.7			
12	0354	0.5	27	0439	-0.2	12	0446	0.6	27	0009	5.0	12	0514	0.2	27	0027	4.7
TU	1002	5.7	W	1114	6.5	F	1055	5.5	SA	0606	0.3	SU	1121	5.3	M	0628	0.4
	1622	1.0		1724	0.2		1726	0.8		1241	5.5		1748	0.2		1254	4.7
	2215	4.8		2332	5.3		2319	4.6		1847	0.2		2353	4.8		1859	0.1
13	0431	0.7	28	0535	0.2	13	0535	0.7	28	0106	4.9	13	0609	0.3	28	0120	4.6
W	1040	5.6	TH	1212	6.2	SA	1143	5.4	SU	0705	0.6	M	1212	5.2	TU	0725	0.6
	1706	1.1		1822	0.4		1814	0.8		1334	5.2		1841	0.1		1342	4.5
	2255	4.7								1942	0.4					1949	0.2
14	0514	0.8	29	0033	5.2	14	0014	4.7	29	0202	4.9	14	0056	4.9	29	0213	4.6
TH	1125	5.5	F	0635	0.5	SU	0633	0.7	M	0806	0.7	TU	0712	0.3	W	0821	0.7
	1753	1.2		1313	5.9		1239	5.4		1428	5.0		1310	5.0		1435	4.3
	2343	4.6		1920	0.6		1910	0.7		2034	0.4		1937	0.0		2041	0.2
15	0604	0.9	30	0136	5.1	15	0119	4.9	30	0257	4.9	15	0159	5.1	30	0307	4.7
F	1216	5.4	SA	0736	0.7	M	0737	0.7	TU	0905	0.8	W	0818	0.3	TH	0918	0.7
	1848	1.3		1412	5.7		1341	5.3		1521	4.8		1414	5.0		1527	4.2
				2020	0.6		2011	0.5		2125	0.3		2040	-0.2		2134	0.2
			31	0236	5.1										31	0358	4.8
			SU	0840	0.8										F	1013	0.6
				1507	5.5											1619	4.2
				2113	0.6											2224	0.0

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.
HEIGHTS ARE RECKONED FROM THE DATUM OF SOUNDINGS ON CHARTS OF THE LOCALITY WHICH IS MEAN LOW WATER.

FIGURE 29.—Charleston, S.C., times and heights of high and low waters. This table is taken from the Tide Tables published annually by NOS.

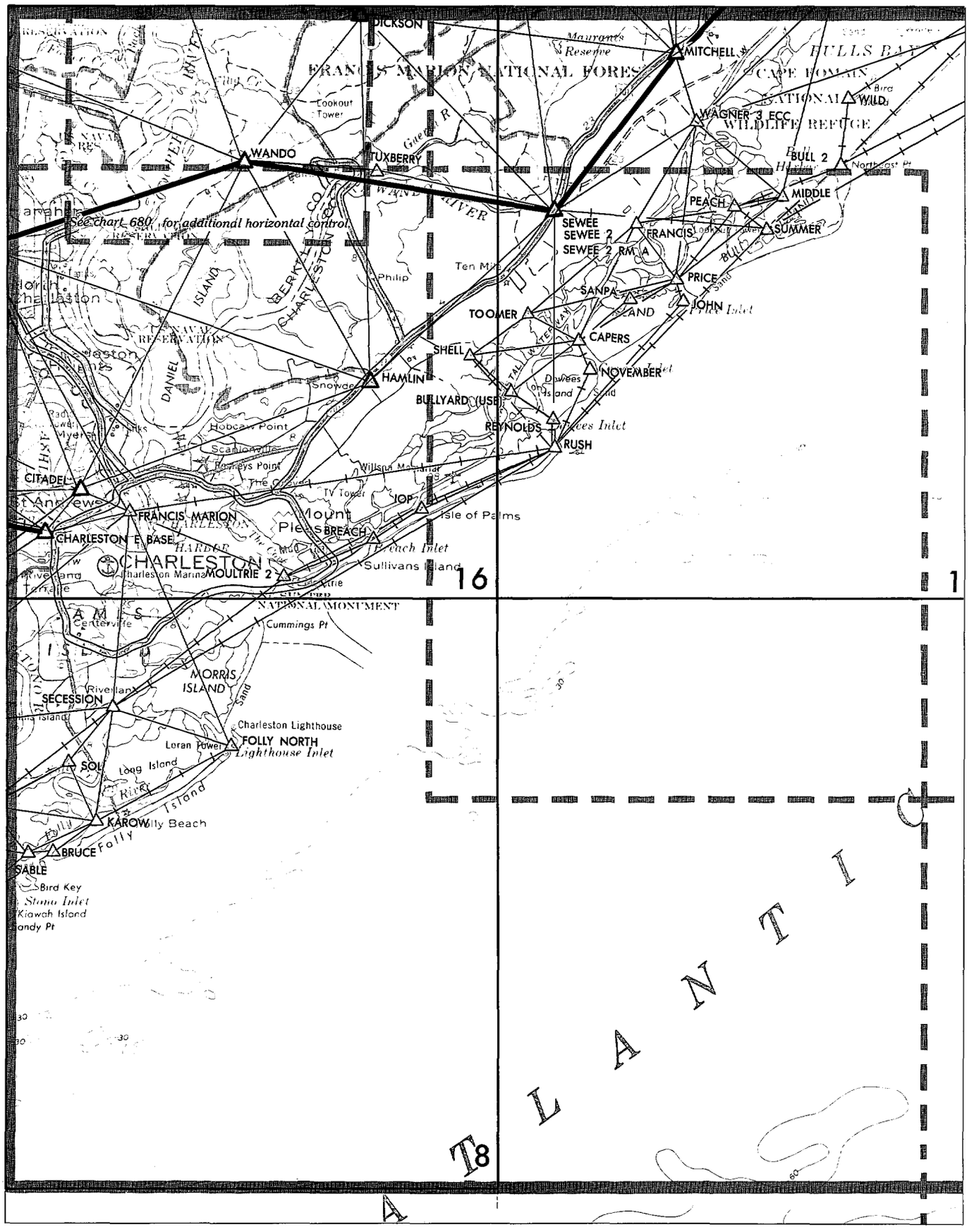


FIGURE 30.—James Island, S.C., 1:250,000-scale geodetic control diagram. These NOS/NGS diagrams are drawn on USGS base maps. They show horizontal control lines and monuments established by NGS and USGS. This general area is also shown in appendix figures 17, 18, 19, 21, and 34.

JUL 1976
U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY
National Geodetic Survey

HORIZONTAL CONTROL DATA

by the
National Ocean Survey
NORTH AMERICAN 1927 DATUM

QUAD 320794 STATION 1022
SC
LATITUDE 32° 30′ TO 33° 00′
LONGITUDE 79° 30′ TO 80° 00′
DIAGRAM NI 17-12 JAMES ISLAND

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 526
2d, July, 1950

DESCRIPTION OF TRIANGULATION STATION

NAME OF STATION: BOG
CHIEF OF PARTY: G. D. Cowie
Surface-station mark, Note,* 1 b
Underground-station mark, Note,* 7 a
Reference mark, No. 1 Note,* 11 b
Reference mark, No. 2 Note,* 11 b
Witness mark, Note,*
Witness mark, Note,*
Height of signal above station mark —— meters.
Height of telescope above station mark 1.7 meters.

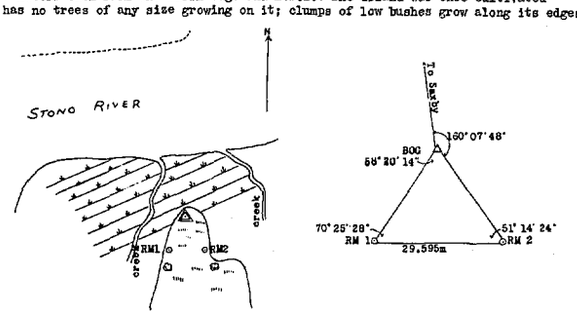
STATE: South Carolina COUNTY: Charleston
YEAR: 1933 LOCALITY: James Island— Stono River

DISTANCES AND DIRECTIONS TO REFERENCE MARKS AND PROMINENT OBJECTS

OBJECT	DISTANCE	DIRECTION	AZIMUTH
SAXBY		00° 00′ 00″	° ′ ″
R. M. # 2	32.758 m	160-07-48	
R. M. # 1	27.115 m	218-28-02	

Detailed description:

On a small island in the first prominent point of marsh on the East bank of the Stono River after passing Legareville and proceeding up the river. The river makes a sharp turn to the East around this point and the island is the first one near the river after rounding the point. It is about 70 meters back in the marsh from the L. W. L. The station is on the N W edge of the islands northernmost tip and 2 meters back from the marsh edge and H.W.L.. The island was once cultivated and has no trees of any size growing on it; clumps of low bushes grow along its edges.



BOG (Charleston County,S.C.,G.D.C.,1933;I.R.R.,1956)

The station mark and reference marks 1 and 2 were recovered in good condition. The distances to the reference marks were verified. The published description is adequate with the following additions:

The station mark is 29.2 ft. NW of the largest and center one of three oak trees, and 6.5 ft. SE of the marsh. It is a standard disk, stamped "BOG 1933" and set in the top of a 10-in. square concrete monument which is flush with the ground.

Reference mark 1 is 64.7 ft. SW of the largest and center one of three oak trees, and 8.0 ft. SE of the marsh. It is a standard disk, stamped "BOG NO 1 1933" and set in the top of a 10-in. round concrete monument which is flush with the ground.

Reference mark 2 is 81.3 ft. SE of the largest and center one of three oak trees, and 11.8 ft. W of the E edge of the high ground. It is a standard disk, stamped "BOG NO 2 1933" and set in the top of an 8-in. round concrete monument which is flush with the ground.

FORM 526
(11-8-55)

U.S. DEPARTMENT OF COMMERCE - COAST AND GEODETIC SURVEY
RECOVERY NOTE, TRIANGULATION STATION

R

NAME OF STATION: BOG
ESTABLISHED BY: G.D.C. YEAR: 1933 STATE: South Carolina
RECOVERED BY:* J.K.W. YEAR: 1964 COUNTY: Charleston

Detailed statement as to the fitness of the original description; including marks found, stampings, changes made, and other pertinent facts:

The station was recovered as described

ADJUSTED HORIZONTAL CONTROL DATA

NAME OF STATION: BOG
STATE: SOUTH CAROLINA YEAR: 1933 THIRD -ORDER
LOCALITY:
SOURCE: G- 1922 FIELD SKETCH:

GEODETIC LATITUDE:	32°41′08.″424	ELEVATION:	2 METERS
GEODETIC LONGITUDE:	79 59 38.562	SCALED	FEET

STATE COORDINATES (Feet)

STATE & ZONE	CODE	X	Y	θ (OR Δ α) ANGLE*
SC S	3902	2,309,505.06	311,572.59	+ 0° 32′ 52″

* PLANE AZIMUTH HAS BEEN COMPUTED BY THE θ (OR Δ α) FORMULA NEGLECTING THE SECOND TERM.

TO STATION OR OBJECT	GEODETIC AZIMUTH (From south) ° ′ ″	PLANE AZIMUTH* (From south) ° ′ ″	CODE
SAXBY	181 22 53.9	180 50 02	3902

BP 026

FIGURE 31.—Quadrangle 320794, S.C., NOS/NGS triangulation station descriptions.

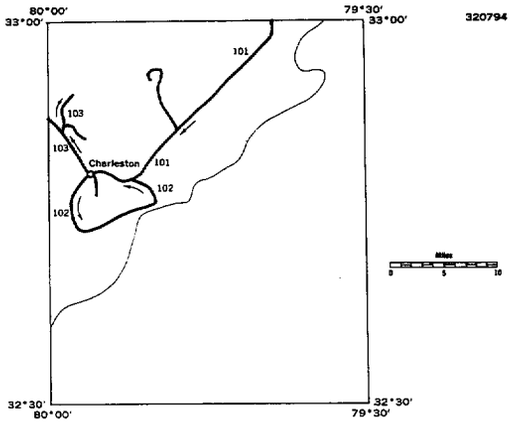
OCTOBER 1964

PUBLISHED AND PRINTED BY:
U.S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON D.C.

VERTICAL CONTROL DATA
by the
Coast and Geodetic Survey
SEA-LEVEL DATUM OF 1929

] 1

QUAD 320794 PAGE NO.
S.C.
LATITUDE 32°30' to 33°00'
LONGITUDE 79°30' to 80°00'
DIAGRAM NI 17-12 JAMES ISLAND



LINE 101

FORM 685A (1-8-58) U.S. DEPARTMENT OF COMMERCE COAST AND GEODETIC SURVEY

RECOVERY NOTE, BENCH MARK R

Designation K 16 State South Carolina County Charleston
Nearest town Mount Pleasant County Charleston Chief of Party R. Gerrish
Distance and direction from nearest town 22.4 miles northeast Recovery Date 12-62
Character of mark A C&GS bench mark disk Stamping
Established by C&GS
Present condition Not Recovered
Detailed report A thorough search was made for this mark but it was not recovered this date.

22.4 miles north along U.S. Highway 701 from Mount Pleasant, Charleston County, 0.5 mile south of Awendaw Creek, 255 feet north of highway station 1270, between the highway and a county road, opposite a shallow borrow pit, 29 feet west of the centerline of the county road, 22 feet east of the east edge of the highway, and level with the highway. A standard disk, stamped "19.062 K 16 1933" and set in the top of a concrete post projecting 9 inches above ground.

FORM 685A (1-8-58) U.S. DEPARTMENT OF COMMERCE COAST AND GEODETIC SURVEY

RECOVERY NOTE, BENCH MARK R

Designation D (S.C.H.D.) State South Carolina County Charleston
Nearest town Mount Pleasant County Charleston Chief of Party R. Gerrish
Distance and direction from nearest town 20.3 miles northeast Recovery Date 12-62
Character of mark A 2 inch pipe filled with lead Stamping
Established by South Carolina Highway Dept.
Present condition Not Recovered
Detailed report A thorough search was made for this mark but it was not recovered this date.

20.3 miles north along U.S. Highway 701 from Mount Pleasant, Charleston County, 120 feet south of highway station 1170, 290 feet north of the intersection of Seewee Road, 38 feet east of the centerline of the highway, and level with the highway. A 2-inch galvanized-iron pipe filled with lead, and set in a concrete base, marked by a post painted "SCHD STA 1168 + 75 PROJ 120-B-REOP."

FORM 685A (1-8-58) U.S. DEPARTMENT OF COMMERCE COAST AND GEODETIC SURVEY

RECOVERY NOTE, BENCH MARK R

Designation 21 (U.S.G.S.) State South Carolina County Charleston
Nearest town Mount Pleasant County Charleston Chief of Party R. Gerrish
Distance and direction from nearest town 19.9 miles northeast Recovery Date 12-62
Character of mark A U.S.G.S. standard cap Stamping
Established by U.S.G.S.
Present condition Not Recovered
Detailed report A thorough search was made for this mark but it was not recovered this date. The measurements would place the mark in the highway ditch.

19.9 miles north along U.S. Highway 701 from Mount Pleasant, Charleston County, 0.2 mile east of the highway, 160 feet east of milepost "Mt. P. 21-McC. 15," 130 feet northwest of the Awendaw Public School, at the northwest corner of the schoolyard, 30 feet east of the centerline of Seewee Road, 10 feet north of the centerline of an east-and-west road, and level with the grade. A United States Geological Survey standard cap, stamped "21.306" and riveted on the top of a 3-1/2-inch iron pipe projecting 4 inches above ground.

DESCRIPTION OF BENCH MARK

Designation U 125 State South Carolina County Charleston
Nearest town Awendaw County Charleston Chief of party R. Gerrish
Distance and direction from nearest town 3.6 miles southwest Leveling date 12-62
Character of mark A C&GS BM disk on a steel rod Stamping U 125 1962
Established by C&GS
Detailed description 3.6 miles southwest along U.S. Highways 17 and 701 from the Post Office at Awendaw, at the junction of a black top road No. S 10-432 leading southeast, 55 feet southeast of the center line of the highway, 145 feet south of the center line of the junction of the black top road, 76 feet southwest of the southwest corner of Fenders grocery store, 2.5 feet northwest of a fence, 1.5 feet northeast of a creosote witness post, 3 feet below the level of the highway, and is a disk on a copper coated steel rod, flush, and protected by a 6 inch tile which projects 2 inches. The rod was driven to a depth of 56 feet.

FIGURE 32.—Quadrangle 320794, S.C., NOS/NGS geodetic bench mark descriptions.

OCTOBER 1964

PUBLISHED AND PRINTED BY:
U.S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON D.C.

VERTICAL CONTROL DATA

by the
Coast and Geodetic Survey
SEA-LEVEL DATUM OF 1929

QUAD 320794
S.C.
LATITUDE 32°30' to 33°00'
LONGITUDE 79°30' to 80°00'
DIAGRAM NI 17-12 JAMES ISLAND

LINE 102
(Continued)

Bench Mark	Adjusted Elevation (Meters)	(Feet)
M 69	Not recovered	
E 126	4.964	16.286
* L 69	5.550	18.209
K 69	6.192	20.315
MICHEL	6.549	21.486
MICHEL RM NO 1	6.554	21.503
Tidal FT JOHNSON 5	4.001	13.127
Tidal FT JOHNSON 4	2.999	9.839
Tidal FT JOHNSON 1	2.811	9.222
Tidal FT JOHNSON 2	2.024	6.640
Tidal FT JOHNSON 3	2.013	6.604
* Tidal 6	2.592	8.504
JOHNSON (USE) RM 2 = Tidal 9	2.955	9.695
* JOHNSON (USE) RM 1 = Tidal 8	2.628	8.622
JOHNSON (USE) = Tidal 7	2.749	9.019
* NO 9 RESET 1958	6.994	22.946
* FORT SUMTER BATTERY RM NO 3	7.249	23.783
* FORT SUMTER BATTERY RM NO 4	6.957	22.825
FORT SUMTER BATTERY REFERENCE 2	Not leveled over	
* NO 11 RESET	6.366	20.886
* Tidal 3	2.469	8.100
15.709 (USE)	Not recovered	
* Tidal 2	4.009	13.153
* Tidal 1	4.241	13.914
MOULTRIE RM NO 3	2.905	9.531
MOULTRIE	2.983	9.787
* U 70	6.684	21.929
* V 70	2.491	8.173
* 10.237 (USE)	2.333	7.654
C 126	3.546	11.634
W 70	Not recovered	
* X 70	8.353	27.405
* PLEASANT RM NO 2	1.885	6.184
* PLEASANT	1.915	6.283
* PLEASANT RM NO 1	1.955	6.414
EFS 10	2.620	8.596
Mount Pleasant (SCHD)	Destroyed	

LINE 103
(First-order)

The original field work (L-679) was done in March 1933 by a party supervised by W. M. Gibson. The line was releveled (L-14254) and extended in the winter of 1952 by a party supervised by Clarence Symns, Jr. Releveling (L-18261) was done in the vicinity of N. Charleston in 1961 by a party supervised by S. J. Diez. The line was again releveled (L-19048) from November 1962 to March 1963 by a party supervised by R. R. Gerrish.

The 1952 elevations are based on a supplementary adjustment of 1952. The 1962-63 elevations are based on a supplementary adjustment of 1964.

Bench Mark	Adjusted Elevation (Meters)	(Feet)
* T 69	3.755	12.320
12.6 (USGS)	3.805	12.484
* W 16	4.737	15.541
* U 69	4.697	15.410
15 (USGS)	Destroyed	
SPUR LINE TO TIDAL BENCH MARK		
* Z 70	4.589	15.056
* Y 70	4.621	15.161
* Tidal 3 (1934)	2.434	7.986
END OF SPUR LINE		
V 69	4.961	16.276
SPUR LINE TO TIDAL BENCH MARK		
* Tidal 4 (1951)	3.522	11.555
* Tidal 3 (1933)	3.747	12.293
* Tidal 1 (1933)	3.409	11.184
* RP 4 A (CHLAR)	2.759	9.052
* Tidal 2 (1933)	3.344	10.971
* Tidal 5 (1951)	3.846	12.618
END OF SPUR LINE		

LINE 103
(Continued)

Bench Mark	Adjusted Elevation (Meters)	(Feet)
* X 16	6.722	22.054
Z 125	8.520	27.953
SPUR LINE NORTHWEST		
* F 71	8.804	28.884
W 123	8.832	28.976
Z 123	9.777	32.077
* Y 16	7.690	25.230
* PTS 15 (USGS)	7.674	25.177
* F 67	7.044	23.110
ø A 67	8.526	27.972
* R 26	7.155	23.474
END OF SPUR LINE		
W 69	7.256	23.806
D 70	6.160	20.210
SPUR LINE TO CHARLESTON NAVAL SHIPYARD		
E 71	3.232	10.604
4 (USN)	1.778	5.833
D 71 RESET 1963		8.739
C 71	2.698	8.852
B 71	2.674	8.773
A 71	2.758	9.049
END OF SPUR LINE		
C 70	6.540	21.457
B 70	2.641	8.665
A 70	10.159	33.330
Z 69	9.110	29.888
Y 69	2.032	6.667
X 69	4.120	13.517
Tidal 8 (1951)	2.856	9.370
Tidal 6 (1951)	2.831	9.288
Tidal 7 (1951)	3.095	10.154
Tidal 4 (1942)	2.856	9.370
Tidal 5 (1942)	2.851	9.354

* Changed elevation
ø 1961 elevation

FIGURE 33.—Quadrangle 320794, S.C., NOS/NGS geodetic bench mark elevations.

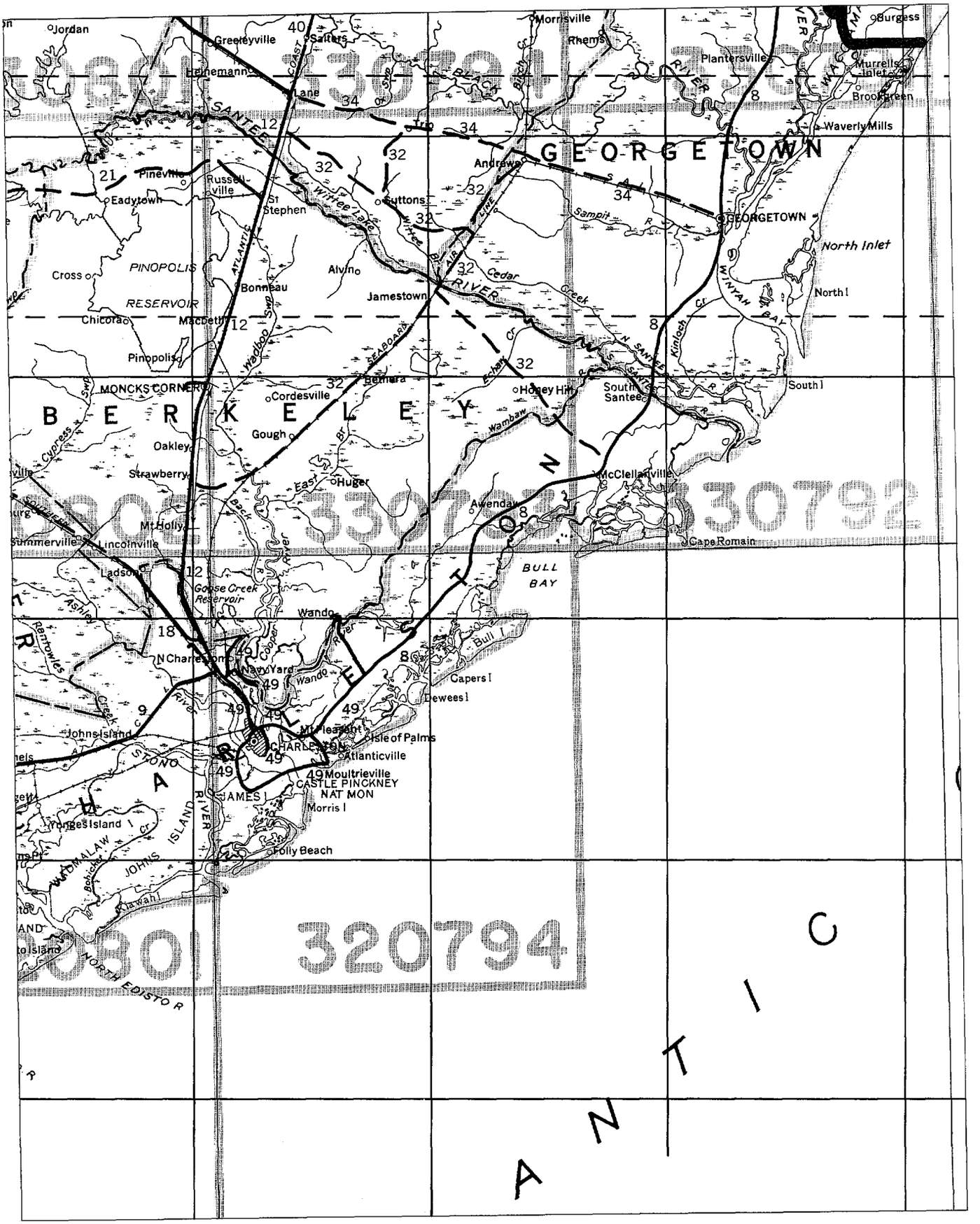


FIGURE 34.—South Carolina, approximately 1:650,000-scale vertical control diagram. This NOS/NGS index is drawn on a USGS State base map. NGS first- and second-order level lines are shown. This general area is shown in appendix figures 17, 18, 19, 21, and 30.

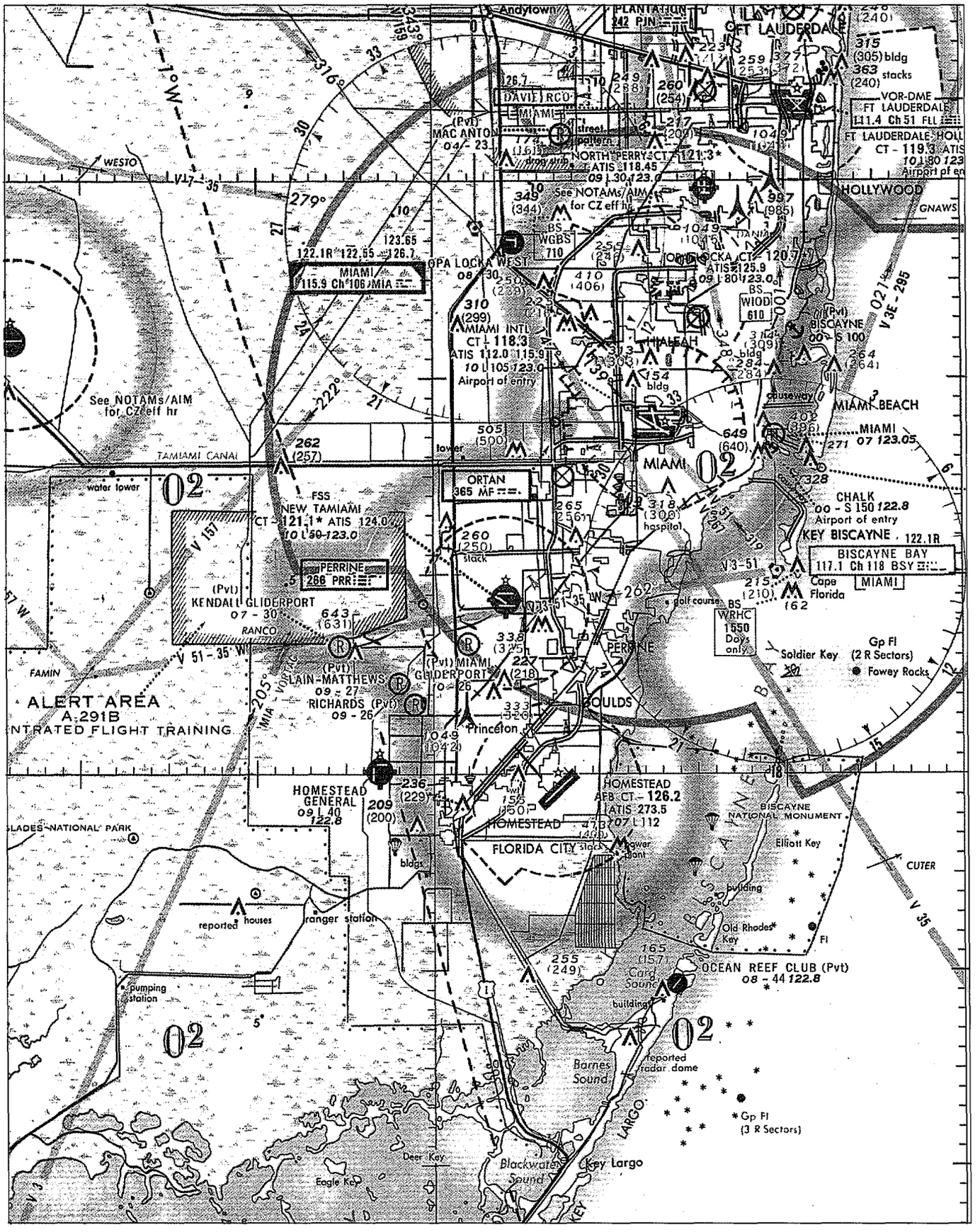


FIGURE 35.—Miami, Fla., 1:500,000-scale sectional aeronautical chart. NOS aeronautical charts range in scale from 1:250,000 to 1:1,000,000. They show navigational facilities and aids as well as generalized planimetric information.

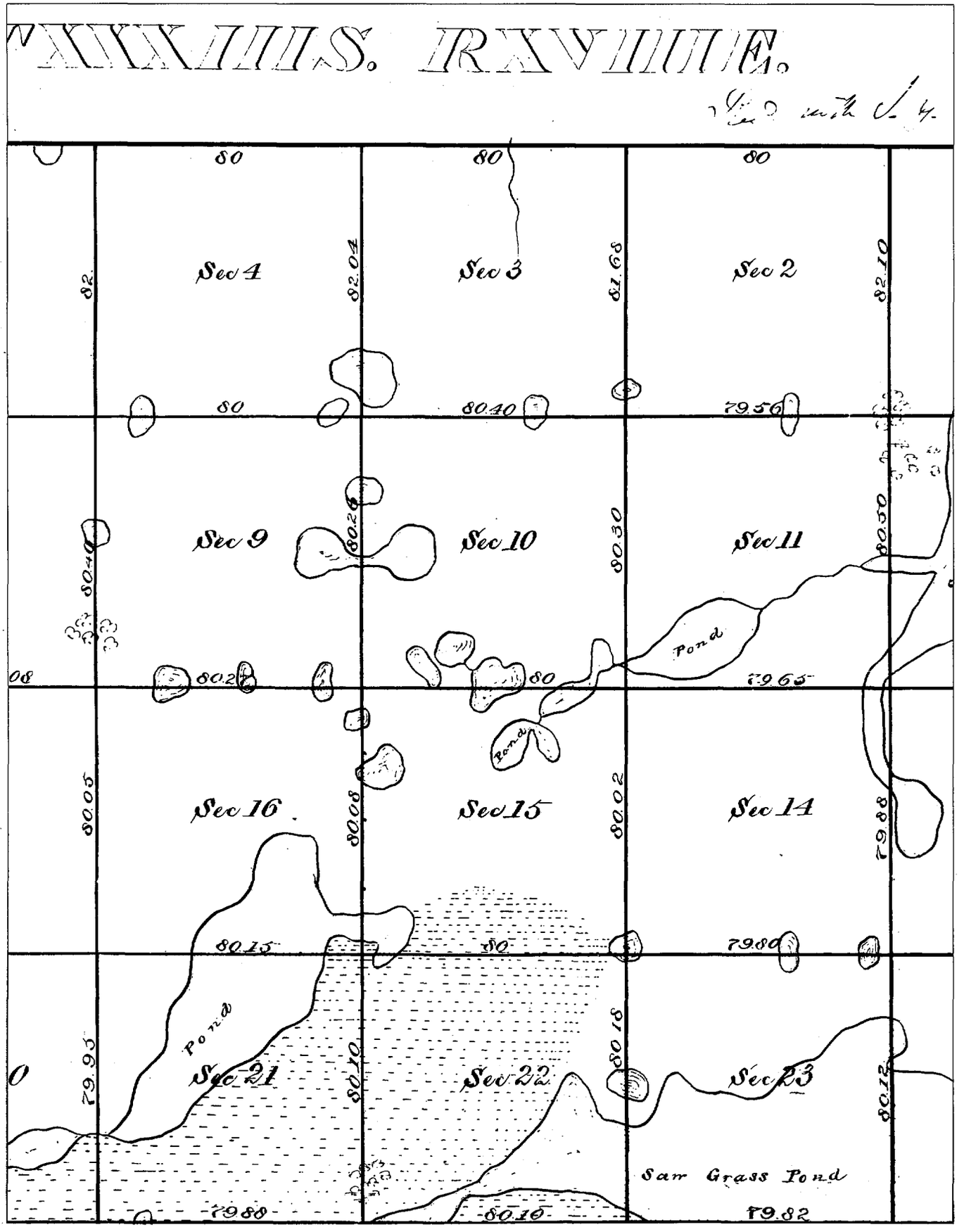


FIGURE 36.—T33S, R18E, Mich., 1:31,680-scale plat. This BLM plat of Township 33 South, Range 18 East is a typical land plat of the Public Land Survey. Sections are numbered (usually 1 through 36) and their dimensions are given in chains (1 chain = 66 ft = 1/80 mi).

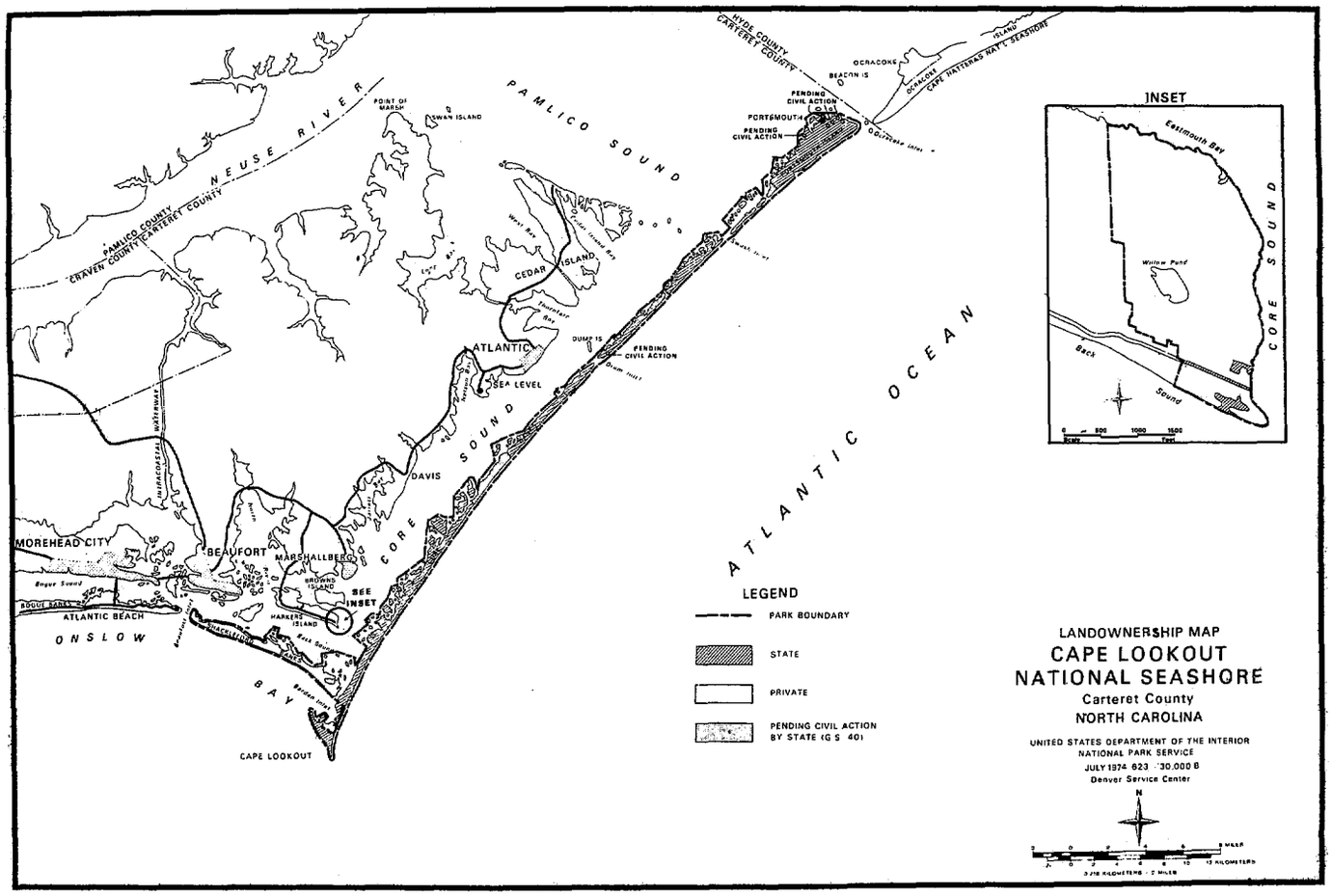


FIGURE 37.—Cape Lookout National Seashore, N.C., land ownership map at scale 1:620,000, reduced from the original scale, 1:430,000. This NPS map shows the reservation boundary and land ownership.

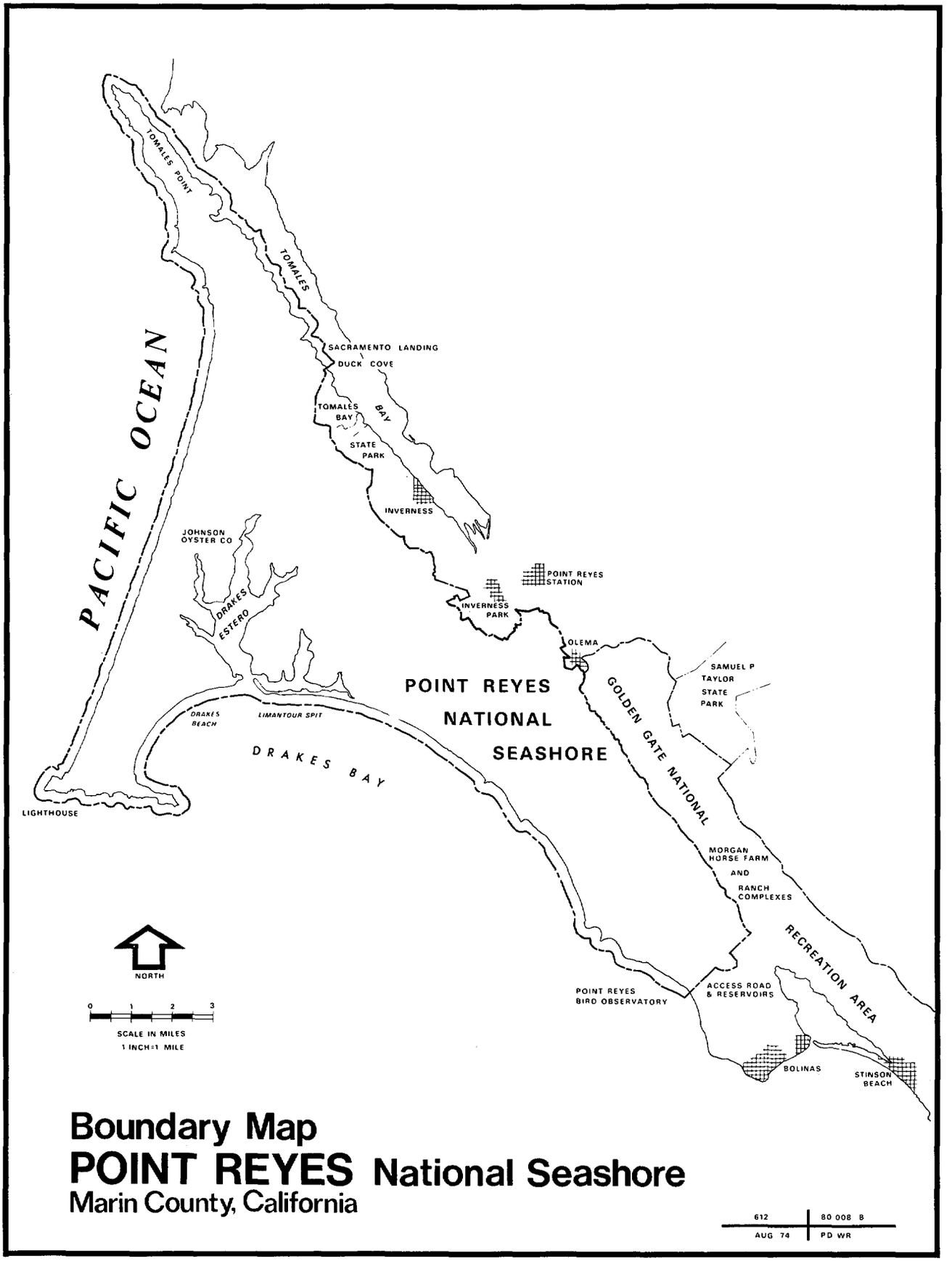


FIGURE 38.—Point Reyes National Seashore, Calif., boundary map at scale 1:210,000, reduced from original scale, 1:63,360. This NPS map shows the reservation boundary.

FIGURE 39.—Clarendon County, S.C., 1:20,000-scale soil survey map. This is one of several SCS soil maps from a bound volume of maps and text describing soils found in Clarendon County. Soil surveys are available for counties throughout the coastal zone.

FIGURE 40.—Hiawatha National Forest, Mich., 1:253,440-scale property map. This USFS map shows the area within the National Forest proclamation boundary. USFS land is green; private land, white. These maps are sold to the public, but smaller scale copies (recreation folders) are distributed free.

INDEX

Page

Accuracy ---- 60, 61, 96, 97
Accuracy Standards, National Map ---- 3, 4, 9, 60, 61, 155
Advice, sources of ---- 10
Aeronautical charts ---- 60, 61
Aerial photographs-2, 5, 6, 7, 8, 10, 14, 43
Aerial surveys ---- 7
Aerotriangulation ---- 9, 42, 43, 44, 99
  Analog ---- 44
  Analytical ---- 46
  Semianalytical ---- 44
Agreements, cooperative ---- 15
Airport obstruction charts ---- 60, 61
Alabama, cooperative agreement ---- 94
Alaska, Aleutian Islands ---- 40
  Coastal area defined ---- 2
  Control network ---- 33
  Grid system ---- 40
  Pipeline ---- 99
Aleutian Islands ---- 40
Altitude, effect on remote sensors ---- 96
Amazon Basin ---- 99
Analog aerotriangulation ---- 44
Analytical aerotriangulation ---- 44, 46
Appendixes ---- 115
Area data, digitized ---- 99
Assistance, sources of ---- 10
Atlas maps ---- 2
Atlas, wetland ---- 7
Automation ---- 66, 98
Azimuth ---- 29, 35

Baltimore Harbor ---- 14
Base map ---- 4, 7, 8, 9, 13, 54
Bathymetric maps ---- 5, 6, 16, 31, 54
Bench marks ---- 31
  Tidal ---- 33
Blanket ---- 53
Boundaries, cadastral ---- 1, 4
  Contiguous zone ---- 6
  Legal ---- 2
  Territorial sea ---- 6
  Vegetative ---- 1
Bureau of Coastal Zone Planning ---- 8
Bureau of Land Management ---- 54
Bureau of the Census ---- 13

Cadastral boundaries ---- 1, 4
Cadastral map ---- 54
Cadastral survey ---- 1
California ---- 7, 15
  Coastal Preservation and Recreation Plan ---- 7
  Comprehensive Ocean Area Plan ---- 7
Cathode-ray tube ---- 40
Central meridian ---- 36
C-factor ---- 43
Charting activities ---- 16
Charts ---- 60
  Aeronautical ---- 60, 61
  Airport obstruction ---- 60, 61
  Coastal ---- 2, 60
  Harbor ---- 60
  Isogonic ---- 60, 62
  Isopach ---- 60
  Nautical ---- 14, 31, 61, 62
  Obstruction ---- 15
  Sailing ---- 60
  Sectional aeronautical ---- 36, 60, 61
  Selecting ---- 5
  Small-craft ---- 14, 60
  Terminal Control Area ---- 60, 61
  Tidal current ---- 60, 61
  World aeronautical ---- 36, 60, 61
Choropleth map ---- 54
Panchromatic film ---- 4
Clarke Spheroid of 1866 ---- 29
Coastal charts ---- 2, 60
Coastal-flooding maps ---- 7
Coastal Mapping Division, NOS ---- 14
Coastal maps ---- 2
Coastal wetlands, mapping ---- 4
Coastal Zone, cooperating agencies ---- 117
  Delimiting ---- 1
  Management Act ---- 1, 123
  Program managers ---- 120

Page

Coastal Zone, State mapping advisory committees ---- 119
Coastal Zone Planning, Bureau of ---- 8
Color gradients ---- 54
Color infrared film ---- 2, 4, 44
Color infrared photographs-5, 9, 10, 14, 96
Color separation ---- 50, 51, 64
Conformal projections ---- 35
Conic projections ---- 35
Connecticut ---- 15
Contact printing ---- 50, 51, 53
Continental Shelf ---- 2
Contour interval ---- 8, 42, 43, 45, 56
Contour lines ---- 15, 46, 48, 50, 54
Control ---- 15, 33, 42, 55
  Horizontal ---- 33
  Surveys ---- 33
  Vertical ---- 33
Cooperating agencies ---- 117
Cooperative agreements ---- 15
Cooperative programs ---- 16
Coordinate system, plane rectangular ---- 2
Coordinatograph ---- 46, 66
Culture ---- 56
Cylindrical projections ---- 35

Data bank ---- 66
Data extraction techniques ---- 64
Data sources ---- 19
Datums ---- 2, 29, 32
  Lake-level ---- 6
  Tidal ---- 6, 7, 14, 15, 29, 31
Deepwater Ports Act, 1974 ---- 12
Defense Mapping Agency Topographic Center ---- 12
Delaware ---- 8
  State Planning Office ---- 8
Diapositives ---- 46
Digital map data ---- 99
Digital maps ---- 55
Distribution maps ---- 54
Distribution offices ---- 19
Diurnal tides ---- 33
Drainage ---- 56
Earth Resources Observation Systems program ---- 12
Eastings ---- 40
Electromagnetic spectrum ---- 40
Ellipsoid, reference ---- 29
Engineering maps ---- 54
Endlap ---- 7
Environmental Data Service ---- 10, 12
Equal-area projections ---- 35
EROS Data Center ---- 10, 12
Etching ---- 48, 50
Eulerian current ---- 48

Feature separation ---- 50, 64, 66
Federal Aviation Administration-13, 15, 43
Federal mapping and charting programs ---- 12
Field classification ---- 48
Field completion ---- 48
Field editing ---- 48
Film ---- 44
  Color infrared ---- 2, 44
  Panchromatic ---- 4, 9, 40, 44
  Processing ---- 44
Final drafting and review ---- 48
Five-color press ---- 53
Flood-control maps ---- 54
Florida ---- 8, 15, 40, 90, 94
  Coastal Zone Management Atlas ---- 8
Florida Keys, Coastal Zone Management Study ---- 8
Focal length ---- 43, 96
Forestry maps ---- 55
Format ---- 55, 61
Form lines ---- 54

Gaging stations ---- 9
Gauss-Kruger projection ---- 38
Geographic maps ---- 54
Geography Program ---- 13
Geologic maps ---- 55
Geometric projections ---- 36
Georgia ---- 15, 94
Glossary ---- 103

Page

Glow tube ---- 40
Graticule ---- 2, 35, 38, 46
Great Lakes ---- 6, 15
Grid lines ---- 55
Grids ---- 2, 35, 38, 46
  State plane coordinate ---- 37, 38
Ground cover ---- 43
Gruber, Otto von ---- 46
Guam ---- 38

Hachures ---- 54
Half-tide ---- 31
Harbor charts ---- 60
Hassler, Ferdinand ---- 36
Hawaii ---- 13, 14, 33
Hipparchus ---- 35
Historical maps ---- 55
Horizontal control ---- 33
Hydrologic unit maps ---- 13
Hypsographic map ---- 54
Hypsometric map ---- 54

Illinois ---- 32
Image generation ---- 96
Imagery, space ---- 5
Information centers ---- 10
Inking ---- 48
Interim revisions ---- 14
International Great Lakes Datum ---- 31
International Hydrographic Bureau ---- 56
International Hydrographic Organization ---- 60
Isogonic charts ---- 60
Isopach charts ---- 60
Isopleth maps ---- 54

Kramer, Gerhard ---- 37

Lagrangian current ---- 48
Lake level ---- 15, 32
Lake-level datum ---- 6
Lake Michigan ---- 32
Lambert conformal conic projection ---- 36
Lambert, Johann Heinrich ---- 36
Land cover ---- 66, 67, 94, 95
Land Information and Analysis Office, USGS ---- 12, 13
Land Inventory and Monitoring Division, SCS ---- 89
Land Management, Bureau of ---- 54
Landsat ---- 12, 41
Landscape map ---- 54
Land use ---- 4, 5, 9, 13, 66, 67, 88, 94, 95, 96, 99
  Data and analysis ---- 62
  Definition ---- 67
Land use maps ---- 7, 55
Land use unit ---- 96
Latitude ---- 29, 56
Legal boundaries ---- 2
Legend ---- 3
Line data ---- 99
Line map ---- 4, 55
Line route map ---- 54
Long-bar bridging ---- 44
Longitude ---- 29, 56
Louisiana ---- 15, 94

Maine ---- 15
Management Act, 1972, Coastal Zone ---- 1
Mangrove ---- 1
Mapping activities ---- 16
Mapping and charting programs ---- 16
Mapping techniques, photogrammetric ---- 41
Mapping the coastal wetlands ---- 4
Map projections and grid systems ---- 35
Map reproduction ---- 51
Maps ---- 54
  Atlas ---- 2
  Base ---- 4, 7, 8, 9, 13, 54
  Bathymetric ---- 5, 6, 16, 31, 54
  Cadastral ---- 54
  Choropleth ---- 54
  Coastal-flooding ---- 7
  Compilation ---- 43, 46
  Digital ---- 55
  Distribution ---- 54
  Engineering ---- 54
  Flood control ---- 54

Page

Forestry ---- 55
Maps, Geographic ---- 54
Geologic ---- 55
Historical ---- 55
Hydrologic unit ---- 13
Hypsographic ---- 54
Hypsometric ---- 54
Isopleth ---- 54
Landscape ---- 54
Land use ---- 7, 55
Line ---- 4, 55
Line route ---- 54
Outline ---- 54
Pictorial ---- 2
Planimetric ---- 5, 33, 54
Quadrangle ---- 13
Revision ---- 60
Road ---- 2
Sample ---- 157
Selecting ---- 5
Slope ---- 55
Soil ---- 55
Special-purpose ---- 54
Storm evacuation ---- 54
Tax ---- 9
Thematic ---- 5, 54
Topographic ---- 5, 8, 12, 13, 15, 16, 54
Topographic-bathymetric ---- 16
Marginal information ---- 55
Marine Chart Division, NOS ---- 14
Mathematically transformed projections 36
Mean high water ---- 1, 2, 14, 31, 32, 61
Mean lower low water ---- 6, 14, 31
Mean low water ---- 6, 14, 31, 32, 61
Mean sea level ---- 9, 31, 32
Mercator projection ---- 37
Meridians ---- 2, 35, 55
Central ---- 36
Metonic cycle ---- 33
Metrication ---- 100
Microwave energy ---- 40
Mississippi River Commission ---- 12
Mixed tide ---- 33
Multispectral scanner ---- 41

National Cartographic Information Center, USGS ---- 10, 11
National Geodetic Network ---- 100
National Geodetic Survey Information Center, NOS ---- 10, 11
National Geodetic Vertical Datum ---- 31, 32
National Horizontal Control Network ---- 33
National Map Accuracy Standards ---- 3, 4, 9, 60, 61, 155
National Tidal Datum Epoch ---- 33
National Vertical Control Network ---- 32, 33
Nautical Charts ---- 14, 31, 61
Neatline ---- 55
New Jersey ---- 8, 15
Wetlands Act, 1970 ---- 9
New York ---- 15, 40
Harbor ---- 14
North American Datum of 1927 ---- 29
Northings ---- 40
NOS cooperative programs ---- 15

Obstruction charts ---- 15
Office of Management and Budget ---- 13
Offset printing ---- 51
Open-window negatives ---- 51
Optical-mechanical scanning radiometers ---- 40
Oregon ---- 15
Ordinary high water ---- 32

Page

Orthophoto ---- 4, 55, 96
Orthophotomaps ---- 3, 5, 46, 55
Orthophotomosaic ---- 55
Orthophotoquad ---- 14, 55
Orthophotoscope ---- 55
Outline map ---- 54
Overlays ---- 3, 4, 9, 13, 62, 64
Overprints ---- 3, 62, 64

Panchromatic film ---- 4, 40, 44
Paneling ---- 42
Pantographs ---- 56
Parallels ---- 2, 35, 55
Standard ---- 35
Peelcoat ---- 50
Pennsylvania ---- 94
Photogrammetry ---- 41, 42
Photographs, aerial ---- 2, 5, 6, 7, 8, 10, 14, 43
Color infrared ---- 5, 9, 14, 96
Photoindex ---- 48
Photomap ---- 55
Photomosaic ---- 44
Pictorial maps ---- 2
Pixel ---- 99
Plane rectangular coordinate system ---- 2, 46
Planimetric features ---- 15, 48
Planimetric maps ---- 5, 33, 54
Plat ---- 54
Point data ---- 99
Polyconic projection ---- 37
Pressplate ---- 51, 53, 64
Product sources ---- 19
Programs, cooperative ---- 16
Major Federal mapping and charting ---- 12
Mapping and charting ---- 16
State coastal mapping ---- 7
Projection lines ---- 55
Projections ---- 36
Conformal ---- 35
Conic ---- 35
Cylindrical ---- 35
Equal-area ---- 35
Gauss-Kruger ---- 38
Geometric ---- 36
Lambert conformal conic ---- 36
Mathematically transformed ---- 36
Mercator ---- 37
Polyconic ---- 37
Transverse Mercator ---- 38
Public land system ---- 56
Puerto Rico ---- 14, 33, 38

Quadrangle maps ---- 13

Radial line plotting ---- 44
Ratio, base-height ---- 43
Width-height ---- 43
Rectification ---- 9, 55
Reference ellipsoid ---- 29
Reference mark ---- 48
Reflectance ---- 40
Register ---- 51, 53
Relief ---- 56
Remote sensing ---- 14, 40, 96
Remote sensors ---- 40, 67
Return beam vidicon ---- 41
Rhumb lines ---- 38
Right-reading ---- 48, 51
Riparian lands ---- 9
River flows ---- 15
Road maps ---- 2

Sailing chart ---- 60

Page

Satellite geodesy ---- 99
Scale ---- 2, 42, 56, 61, 96
Scribecoat ---- 48
Sea Level Datum of 1929 ---- 32
Seas, territorial ---- 2
Sectional aeronautical charts ---- 36, 60, 61
Selected references ---- 100
Semianalytical aerotriangulation ---- 44
Semidiurnal tides ---- 33
Separation guides, color ---- 50, 51, 64
Feature ---- 50, 64, 66
Shaded-relief ---- 12, 13
Shading ---- 54
Shoreline ---- 61, 62
Skylab ---- 12
Slope maps ---- 55
Small-craft charts ---- 14, 60
Smooth sheet ---- 5
Soil Conservation Service ---- 89
Soil maps ---- 55
Sounding lines ---- 56
Soundings ---- 31
Special-purpose maps ---- 54
Standard Land Use Coding Manual ---- 93
Standard Metropolitan Statistical Areas 13
Standard parallels ---- 35
State coastal mapping programs ---- 7
State plane coordinate grid ---- 37, 38, 56
Stereomodel ---- 46, 48
Stereoplotters ---- 48
Stereoscopic effect ---- 46
Stereoscopic pairs ---- 10
Stereotemplets ---- 44
Storm evacuation map ---- 54
Stripping ---- 50
Sun angle ---- 43
Sunspots ---- 7
Surveys, aerial ---- 7
Cadastral ---- 1
Symbolization ---- 4

Tax maps ---- 9
Technical assistance ---- 16
Tennessee Valley Authority ---- 12
Terminal Control Area charts ---- 60, 61
Territorial seas ---- 2, 6
Texas ---- 9
Thematic maps ---- 5
Tidal bench marks ---- 33
Tidal current charts ---- 60, 61
Tidal datums ---- 6, 7, 14, 15, 29, 31
Tides ---- 1, 15, 33
Tide stage ---- 7
Topographic—bathymetric maps ---- 13, 16
Topographic maps ---- 5, 8, 12, 13, 15, 16, 54
Topographic sheets ---- 5
Transverse Mercator projection ---- 38

Ultraviolet ---- 40
Universal Transverse Mercator grid ---- 56
Universal Transverse Mercator projection ---- 38, 40
U.S. Army Corps of Engineers ---- 33
U.S. Coast and Geodetic Survey ---- 36
USGS cooperative programs ---- 15

Vegetative boundaries ---- 1
Vertical control ---- 33
Virgin Islands ---- 33, 38

Wetland atlas ---- 7
Wisconsin ---- 32
Woodland ---- 48
World aeronautical charts ---- 36, 61
Wrong-reading ---- 48, 51

☆ U.S. GOVERNMENT PRINTING OFFICE : 1978 O - 253-905