UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

LARGE-SCALE MAPPING GUIDELINES

Open File Report 86-005

Reston, Virginia
1986

PREFACE

The purpose of Large-Scale Mapping Guidelines is to aid local, State, and Federal agencies and private developers, corporations, and individuals in preparing specifications and acquiring large-scale maps for a wide variety of uses.

The U.S. Geological Survey, U.S. Department of the Interior, is charged with conducting the National Mapping Program, which includes the mapping of the 50 states at a variety of map scales. Commonly used scales in the program are 1:250,000, 1:100,000, 1:50,000; and the largest scale maps produced for the entire United States are at 1:24,000 scale (1:63,360 and a few 1:24,000 and 1:25,000 in Alaska). The Survey, although not involved with mapping at scales larger than 1:24,000, has long recognized the need for larger scale mapping as a result of continually receiving requests for technical and/or financial assistance on specific mapping requirements from other Federal agencies, State, county, and city governments, private engineers, planners and developers, and others. With the need for a consistent and economical large-scale mapping program throughout the country being clearly established and also in response to recommendations in a 1973 report prepared by the Federal Task Force on Mapping, Charting, Geodesy, and Surveying under the direction of the Office of Management and Budget, the Geological Survey undertook a pilot program of urban mapping projects at 1:2,400 scale in five representative cities. The projects, all carried out by private mapping firms under contract, were monitored and evaluated by members of the Geological Survey technical staff in close association with the appropriate officials of the five cities. The results of the projects, together with results from parallel investigations of several other large-scale mapping projects funded by other agencies, led to the preparation of these general guidelines and sample specifications, with the cooperation and assistance of the American Society of Photogrammetry.

The lines of demarcation between scales is not precisely defined. For instance, the Geological Survey considers 1:9,600 a large scale, whereas a highway engineer working on a detailed expressway design may consider 1:960 or 1:480 a large scale. In these guidelines, "large scale" ranges from 1:9,600 to 1:120, with most mapping undertaken at scales of 1:2,400, 1:1,200, and 1:600 or 1:480.

All measurements in the guidelines are expressed in customary inch-foot units. A table of metric equivalents for customary linear and areal measurements is given on page vi. The Geological Survey is committed to the goals of the Metric Conversion Act of 1975 and many of its own products are now published with metric units. In planning large-scale mapping projects, it is therefore suggested that consideration be given to using metric units instead of customary units. For example, a project planned for a scale of 1:9,600 using customary units might be undertaken at the nearly equivalent scale of 1:10,000 using metric units; or a project at 1:4,800 scale using customary units might be undertaken at 1:5,000 scale using metric units. Contour interval conversions present similar considerations, although conversion of intervals of less than 10 feet are more complicated.

The guidelines are divided into three parts: Part I, Uses of Large-Scale Maps; Part II, Contracting for Mapping Services; and Part III, Sample Contract Specifications. A general outline of the mapping process is given, but the details of the various techniques involved are not. The intent is to provide a guide by which an organization or individual needing large-scale maps can determine a desired end product, specify it precisely, and obtain it under fair, reasonable, and uniform contracting procedures. The specification samples in Part III are written in precise terms, but they should not be considered inflexible. Varying circumstances and requirements will certainly justify modifications, deletions, or additions. Parts I and II should be studied before any of the sample specifications in Part III are considered.

The Geological Survey wishes to acknowledge the many useful comments and suggestions from individuals in the private sector and officials of community, State, and Federal agencies who reviewed the drafts of the guidelines. Many of their suggestions have been incorporated into this publication. The Survey especially wishes to acknowledge the high level of cooperation and assistance afforded by the officers and staff of the American Society of Photogrammetry.

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U.S. units		Metric equivalents	
LINEAR MEASURES			
inch (in)	=	25.4	millimeters (mm)
foot (ft)	=	0.3048	meter (m)
yard (yd)	=	0.9144	meter (m)
mile (mi)	=	1.609	kilometer (km)
mile, nautical (nmi)	=	1.852	kilometer (km)
AREAL MEASURES			
$foot^2$ $(ft)^2$	=	0.09290	$meter^2$ $(m)^2$
$yards^2$ $(yd)^2$	=	0.8361	$meter^2$ $(m)^2$
acre	=	4,047	$meters^2$ $(m)^2$
$mile^2$ $(mi)^2$	=	2.590	$kilometers^2$ $(km)^2$

PART I
USES OF LARGE-SCALE MAPS

Large-scale maps, particularly of an urban area, can serve many purposes if made available to potential users. Users may range from an engineer who bases multi-million-dollar construction designs on the maps, to a local bank selecting a location for a new branch, to a city planning commission considering urban renewal. These users are looking at large-scale maps for different purposes and for different information, yet a properly designed and prepared set of maps can serve all equally well.

In the following discussion, a variety of uses of large-scale maps are described and suggestions for scale, contour interval, and content are offered.

Highway and Street Engineering

For large cities, a map scale of 1:24,000 is convenient for master plan transportation studies; but for small towns and communities, map scales might range from 1:1,200 to 1:9,600. For preliminary location work, a topographic map at 1:2,400 scale with a contour interval of 5 feet is usually adequate. However, for final street design, a scale of 1:1,200 or even 1:480 in heavily urbanized areas and a contour interval of 1 or 2 feet are usually required.

All significant ground detail and the precise location and depth of all underground utilities should be shown on the maps. Since the exact mapping of utilities can be expensive, a practical method for preliminary location is to show all utilities in the area from record information only. Thus, the highway or street engineer will have the approximate location of all utilities for his preliminary work. Later, when the specific alinement of a particular transportation corridor or a highway interchange has been determined, the horizontal and vertical positions of the utility lines can be surveyed precisely in the limited area to be affected. For some areas, the utility record information is precise and no detailed field investigation is needed. However, without prior knowledge, the engineer must never assume such a favorable situation; he is responsible for adequately checking the record data.

Property maps at 1:4,800 scale for generalized studies and 1:480 scale for more detailed site studies are useful for surveys involving property acquisition for public access, such as highway rights-of-way, parking complexes, and road ramps to limited-access routes.

The engineering department of a community is usually the primary user of local maps. Consequently, that department should keep a set of reproducibles of the maps for quick reproduction of inexpensive prints to use as work copies as needed.

Water Supply

Map requirements of a municipal water-supply office are generally similar to those of a highway engineering department with regard to scale and contour interval. However, depending on the source of the water supply, the office may need map coverage far beyond municipal limits. Many communities have distant reservoirs and thus need strip maps to construct and maintain pipelines or aqueducts from the reservoirs to treatment plants. Geological Survey quadrangle maps at 1:24,000 scale are usually adequate for determining the extent of the watershed area and the quantity of runoff for any planned reservoir. A transparent overlay of population distribution greatly facilitates coordinating water information with growth trends in a metropolitan area.

Storm and Sanitary Sewer Engineering

Map requirements for storm and sanitary sewer engineering are similar to those for highway engineering; that is, a topographic map will provide the information vital to a project.

One significant additional factor, however, is that in designing a storm drainage system, a much larger watershed area must be considered to make allowance for all runoff that can affect the system. The proper disposal of storm water usually requires downstream terrain information and therefore larger areas of topographic map coverage.

Maps of outlying areas can usually be at a smaller scale than basic municipal maps. For example, if city maps are at 1:2,400 scale with 2-foot contours, adequate runoff information outside the city can normally be obtained from 1:4,800-scale maps with 5-foot contours. In flood-plain areas, 2- to 5-foot contours on 1:4,800-scale maps may be needed to adequately delineate the flood plain for insurance purposes under the nationwide program of the Federal Emergency Management Agency. These maps are also invaluable in managing the flood plains once the areas have been precisely delineated and classified.

Traffic Engineering

For generalized studies, area maps at 1:9,600 and even 1:24,000 scale may be suitable. Information on traffic flow, accidents, street widths, street jogs, street grades, and grade separations can be presented. Traffic engineers concerned with corridors, expressways, signalization, offstreet parking, and street widenings throughout a metropolitan area need detailed map coverage at 1:2,400 or 1:1,200 scale for planning and engineering. For some problem locations, such as heavily congested intersections involving signals, signs, and safety zones, unusually large-scale maps at 1:480 or 1:240 scale may be needed. These special-purpose maps can usually be satisfactorily enlarged from the 1:2,400- or 1:1,200-scale maps. Maps in the traffic engineering category include those for parking surveys, with scale depending on area of coverage. The maps can show offstreet parking areas, curb parking, potential parking sites and vacant lands.

Street Lighting

The map requirements for street lighting are generally similar to those for traffic engineering.

Planning

In a typical urban area, planning is carried out at many levels and by many offices such as county planning commissions, city planning departments, redevelopment commissions, community development and planning departments, regional planning commissions, and urban renewal offices. Because comprehensive planning requires interrelating local details with areawide systems, it would be impractical to recommend a single map scale to meet the needs of all planners. Regional planners might find 1:9,600-scale maps adequate, whereas an office preparing detailed plans for urban renewal of one or two city blocks might require a map at a scale as large as 1:120. Generally, however, most planning requirements can be met with basic area coverage at 1:2,400 scale, supplemented by maps reduced or enlarged from the basic maps. For studies where topography is important, as in engineering improvements and extensive public land projects, a topographic map with contours at appropriate intervals provides a good base for information.

Planners traditionally use great quantities of maps for work bases and meeting presentations. Therefore, the planning office should retain a set of reproducibles of the base maps for convenient reproduction of work prints.

Tax Assessment

Tax assessment and collection are a county responsibility in some localities and a city or town responsibility in others. In either case, the assessor's office may be the only office in the community that has a coordinated set of maps of the entire jurisdiction. The maps may vary widely in scale, age, accuracy, reliability, and content; but they should be considered in designing a new set of maps of the community since they may contain much usable data.

A tax map is highly specialized; its prime feature is the accuracy and completeness of property lines. Details normally shown on a large-scale topographic map, such as contours, wooded areas, bridges, hydrants, and lamp-posts, are of little use to tax assessors; but such information as fences, walls, buildings, and other details that can aid in the precise location of property lines are highly important. The locations of railroads, highways, streets, and alleys are also necessary in preparing a good tax map. In planning a new set of large-scale maps, the production of new tax maps from the base maps, before contours and other details extraneous to tax mapping are added to the base, should be considered.

It is fairly common for tax maps to vary in scale over jurisdictional areas. For example, rural areas may be mapped at 1:4,800 scale, suburban areas at 1:2,400 or 1:1,200, and intensely developed areas at 1:480.

Utilities Location and Management

Both municipal and private utility companies or departments are prime users of areawide maps, and often private utility companies are willing to financially support coordinated mapping programs for common areas of interest. Utility companies require high accuracy in the base maps, and some detailed fieldwork is usually needed to produce an adequate map with the individual utility lines shown in their proper horizontal and vertical positions. Large scales comparable to those for street engineering, such as 1:480, are required for mapping utilities. Some savings in field-survey costs can be achieved by targeting utility features (such as manholes) prior to aerial photography, compiling the locations of these features, and using record information plus minimum field-survey verification to accurately locate the underground utilities.

City Surveys

The city surveyor's office benefits greatly from a set of accurate topographic maps. The city surveyor's office, which is usually responsible for a wide variety of field surveys for many purposes, often finds that work is substantially reduced by the availability of accurate maps. The office can use the largest scale and smallest contour interval available, but usually the base-map scales and intervals suggested for highway and street engineering are adequate.

Parks and Recreation

Map requirements for parks and recreational purposes are usually met by a combination of small-scale area-wide maps and specific site maps at scales of 1:2,400 to 1:1,200 with 2-foot contours.

Emergency Services

Police and fire departments need maps showing all street and address-numbering systems. The map sheets should be small enough for them to be handled in a confined space, such as a squad car. Depending on the size of the community, the workable scale may be 1:24,000, 1:9,600, or 1:4,800. These departments can also use larger scale maps for the delineation of rooftop detail, alleyways, and other emergency access routes.

School Administration

School administration systems need maps to delineate the districts served by various schools, practical busing routes, and the precise areas served by buses. School administration maps are usually tailored to show each school district on a single sheet. Adequate maps can usually be prepared by reducing and compositing the larger scale maps produced under an areawide mapping program. Street addresses and names of property owners are often useful to school administrators if the information is available from tax or utility sources.

Private Engineers, Surveyors, Developers, and Builders

As a public service, communities with mapping programs often provide prints of base maps at nominal cost. Most communities require that subdivision plans and other proposed construction projects be laid out and filed on accurate base maps. Having a complete set of community base maps available obviously saves builders and developers considerable time and money. Because engineers, surveyors, developers, and other professionals are major users of community maps, they should be well informed about the availability of the maps so that they and the general public, in turn, can derive maximum benefit from a community asset.

Other

Municipal Programs

Communities have a wide variety of agencies, organizations, and individuals that use maps. Moreover, a wide variety of programs affecting the community require the support of adequate maps to be effective. Funds for the programs may come from local, State, or Federal sources or a combination of sources. A set of community maps that are properly designed can satisfy all these needs, and they can be produced at far less cost than would be incurred if each map-using agency or program tried to satisfy its own needs without reference to other community interests.

One effective approach to producing a multi-purpose set of community maps is through map preparation using feature and/or thematic separates. For example: separates comprising the community map could be composed in the following sequence to show:

Separate 1 - Streets, drainage, boundaries, rights-of-way, and names data

Separate 2 - Hypsographic information in the form of contour lines and vegetative information

Separate 3 - Buildings

Separate 4 - Surface and underground service and utility lines, with added field survey data

Separate 5 - Property lines, and lot and block data

Separate 6 - Property data and street addresses

Maps showing this level of detail would normally be at a large scale such as 1:1,200, 1:600, or 1:480.

The separates could be used individually or combined in a number of different ways. For example:

- Separate 1 could be the base for the official community map
- Separates 1 + 2 + 3 could be the base for conventional topographic maps

- Separates 1 + 2 + 3 + 4 could be the base for engineering design maps
- Separates 1 + 4 could serve as a utility map
- Separates 1 + 3 + 5 could serve as a land use base and an urban rehabilitation planning base
- Separates 1 + 5 + 6 could serve as an assessment map

There are many possibilities as long as the basic map data is in the form of separates 1 through 3. Other separates could be added as required.

Digital Mapping

The problems of growth and economic expansion faced by city planners and managers today and the corresponding need for rapid access to map data have led to the development of digitally integrated cartographic systems. In these systems, spatially oriented data relating to municipal services such as water and gas systems, storm and sanitary sewer lines, street and freeway centerlines, and boundary lines are keyed to digitized planimetric map data that may be combined into a single composite data base.

A typical digital data collection system consists of a work station at which an operator digitizes map detail with a cursor. These data are stored and can be recalled for graphic display. The planimetric data can be divided into categories, allowing the recall of separate information types such as roadways, railroads, drainage, sidewalks, driveways, fences, parking lots and buildings. The work stations can be interfaced with a minicomputer which in turn controls a high-speed plotter where plots can be generated for editing.

Because the data are available on an instant-access basis through graphic display, the systems provide users with an effective tool for information management. They can access the elements of the data base, display them on a screen in various combinations, or make hard copy. The systems enable users to arrive at decisions quickly and to provide vital information to the public.

There are numerous other uses and users, such as flood control, census, civil defense, health work, demographic studies, and zoning. In planning areawide large-scale map coverage, it is important to identify as many potential users as possible and to consider their particular requirements. See the Appendix for representative examples of large-scale maps.

PART II
CONTRACTING FOR MAPPING SERVICES

An understanding of the mapping process and some of the sophisticated equipment involved is needed in order to use the sample contract specifications in Part III effectively.

Mapping Operations and Products

Photogrammetry, the science of making reliable measurements from photographs, especially aerial photographs, is the basis for preparing virtually all topographic maps today. Maps of small land areas, such as a few acres, are still best prepared by ground survey methods; but the efficiency and economy of photogrammetry dictates its use in mapping areas of any appreciable size.

The mapping procedure using photogrammetry usually consists of four distinct phases. The first phase is the planning and acquisition of the aerial photographs. This phase is crucial to the success of a mapping project even though it is usually a small percentage of the total mapping cost. The photographs must be taken with a calibrated precision mapping camera and must meet the specifications for scale, overlap, tilt, time of day, and other requirements.

The second mapping phase is ground control surveys. To compile an accurate topographic map, the aerial photographs must be related to established horizontal and vertical datums. Ground surveys are performed to establish coordinate positions and elevations for selected ground features clearly visible and identifiable on the aerial photographs. The surveys should start from horizontal and vertical monuments established by Federal or State agencies and should be tied into the national network.

The network of available survey control stations in many areas is dense enough for most communities in the United States to use as a base for local surveys. There are about 195,000 points making up the national network of horizontal control of the National Geodetic Survey, National Oceanic and Atmospheric Administration. Elevations are available for many of these monumented stations. Geodetic control data are readily available to everyone.

The sample contract specifications in Part III provide for the control network to be extended and additional monuments set during new surveys. Additional monumentation is valuable to a wide variety of local users, and the cost of establishing the monuments is justified by their continuing usefulness.

In the third phase, photogrammetric compilation, the ground survey points, and additional supplemental control or pass-points established by the process of aerotriangulation, are plotted on the base map sheets. The pass points are used for controlling individual stereomodels formed from the aerial photographs. This process accurately correlates the aerial photographs to the map.

Different compilation procedures may be followed, depending on the map product desired. For a conventional line map (fig. 1), a skilled operator compiles the manuscript with a stereoplotting instrument. The operator delineates all specified planimetric detail such as roads, streets, alleys, railroads; drainage features such as rivers, streams, and lakes; and buildings, wooded areas, transmission lines, major walls, and recreational facilities. If contours are required, they are plotted at specified intervals. Where the requirement can be met by an image base, another approach is to prepare an orthophotographic base (fig. 2) rather than a line map.

An orthophotograph is prepared by a rectification process that removes tilt and relief displacements in the aerial photograph. Whereas the unrectified photograph is a central projection, the rectified image in an orthophotograph is an equivalent orthographic projection that has the accuracy of a photogrammetrically compiled line map and still retains all the image detail of the aerial photograph. Contours, if required, are stereoscopically plotted and then photographically superimposed onto the orthophotographic base or shown by overlay.

Still another approach is to prepare an orthophotographic base and a companion line map by simply tracing onto the line map the desired detail from the orthophotographic base. One problem with this approach is that it is difficult to maintain accuracy with the procedure.

There are advantages and disadvantages to be considered in selecting the type of map base:

- An orthophotographic base costs less than a photogrammetrically compiled line map because the line map requires a considerable amount of time in manually plotting planimetric detail. A saving should be realized in the total cost of preparing the orthophotographic base.

- Ground detail shown in an aerial photograph is present in an orthophotograph, resulting in a requirement that the user be somewhat skilled in photointerpretation. They must interpret for themselves what certain ground objects really are. For example, is a visible object a building or a tennis court? On the line map, however, a highly skilled compiler, observing a magnified, three-dimensional stereomodel has already interpreted the feature and delineated it clearly.

- A line map is generally more suitable for overlaying additional information, such as water, gas, or electric lines.

A good compromise solution, which incorporates the advantages of both line maps and photoimages, is to obtain the line maps with their inherent accuracy and clarity, along with a set of photographic enlargements (not orthophotographs) at the nominal scale of the line maps. The cost of a set of enlargements is relatively small; and although they possess displacements due to tilt and relief, they provide users with the full detail of the aerial photographs and they can be used most effectively in combination with the line maps. An ideal solution might be to have both line maps and orthophotographs.

The fourth phase of the mapping procedure is map finishing by scribing or drafting. Scribing is a procedure in which specially designed instruments are used to cut lines and symbols through an opaque coating on a stable plastic base to make a negative. Positive prints can be made on sensitized transparent or white opaque sheets or on

Figure 1. —Conventional large-scale line map.

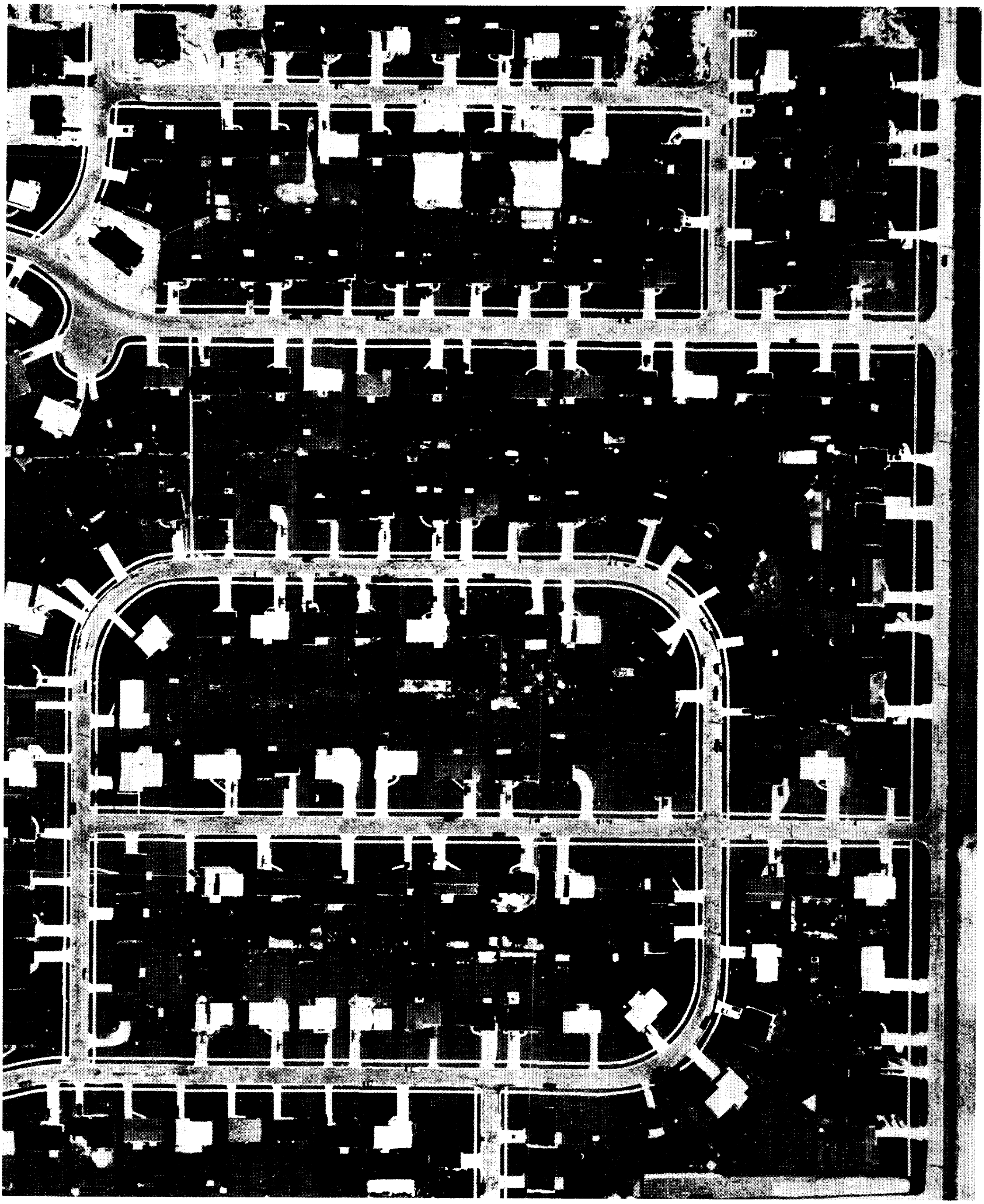

Figure 2.--Orthophotographic base map.

lithographic pressplates. Most map sheets today are prepared by scribing, but some organizations still utilize pencil or ink drafting procedures. By whatever method, the quality of the final maps should be virtually the same. Unless many copies are needed, the final product is a set of black-line positives on polyester sheets which are suitable for making inexpensive paper prints by a diazo process, such as Ozalid.

If map compilation by feature separate is provided for in a contract, it is a relatively simple matter to prepare intermediate or special-purpose editions of the map sheets during the scribing or drafting process. For example, if the final product is to be a topographic map showing the usual physical features and contours, certain users (for instance, tax assessors) have no need for contours and do not want them. For these users it is relatively easy and inexpensive to make polyester duplicates from the scribed or inked sheets before the contours are added. The cost of obtaining an additional set or sets of special-purpose maps in this way is nominal. However, the need for special editions must be considered at the planning stage and separates provided for in the contract because if all the detail is scribed or drafted on the original base sheets, there is no economical way to provide special editions.

Contracting

In contracting for cartographic services, as with most professional services, selecting a contractor is of great importance. The sample contract specifications in Part III are primarily end-product specifications rather than detailed procedural specifications, and are deliberately written to take advantage of the best technology available without excluding any qualified firm from consideration simply on the basis of its size or equipment. Map compilation/preparation using the photogrammetric process encompasses the use of a wide variety of equipment and procedures, and therefore overly restrictive and detailed specifications are usually not in the best interest of the contracting entity.

Proposal Evaluation

Of the several factors that affect the quality of the delivered products, there are two that should receive particular attention when evaluating contract proposals photogrammetric plotting equipment and proposed plan of performance. A proposed plan of performance requires a high level of technical competence to evaluate; and if expertise is not readily available, consultants should be retained to assist in this effort.

1. Photogrammetric Plotting Equipment--While stereoscopic plotting instruments vary in cost from a few thousand dollars to more than a hundred thousand dollars, the precision of these instruments may not be directly proportional to their cost. Under the proper operating conditions, adequate maps can generally be produced with most currently used photogrammetric equipment. One generally accepted practice is to relate an empirical number called the C-factor to plotting instruments. The C-factor assigned to a plotting instrument is defined as the ratio of the flying height to the contour interval. Thus the C-factor is a practical guide in planning aerial

photography as it can be used to determine the flight height required for a specified contour interval. For example, if a certain plotter has an operational C-factor of 1,200, and a 5-foot contour interval has been specified, the flight height must not exceed 5 x 1,200 or 6,000 feet. For an instrument of higher C-factor, such as 1,500, the maximum flight height would be 7,500 feet. As the flight height increases, the number of aerial photographs for a project decreases, as well as the time required for field surveys and stereoplotting. The savings in time, however, may be offset to some extent by the higher cost of the more precise and expensive instrument.

2. Plan of performance--The precision of the available stereoscopic plotting equipment is only one factor to be considered in evaluating a prospective contractor's proposal. Other considerations include ability to perform field surveys, aerotriangulation, map finishing, and orthophotograph production. Many different combinations of procedures and instruments can produce a satisfactory set of maps. Thus, the plan of performance of prospective contractors should include the following items:

    a. A tabulation of full-time employees of the firm available to work on the specified project, with brief professional resumes of key employees. A statement of the number and experience level of technical personnel in each operating department, such as flight, photolab, stereoplotting, drafting, and field surveys. (The caliber of the work force can obviously be an important factor in a firm's ability to produce acceptable map products.)

    b. Identification of the aerial camera, including the date of the latest calibration and acceptance from the Federal camera calibration laboratory run by the Geological Survey. The type of aerial film should also be identified (if not specified in the contract).

    c. A listing and description of the in-house photogrammetric instruments (including orthophotography equipment, if applicable) to be used on the project.

    d. A listing and description of the equipment, procedures, and computer programs to be used for aerotriangulation.

    e. A listing and description of other support equipment, such as negative processing equipment, printers, and copy cameras.

    f. The photographic and compilation scales.

    g. A description of the methods and equipment to be used for horizontal and vertical control surveys, including the number and location of permanent horizontal and vertical control monuments to be established.

    h. Materials for map manuscripts, finished maps, and reproductions of finished maps.

i. A schedule for accomplishing the work, including the time required for completion of each phase. The schedule must consider the effect of other work already undertaken by the firm.

j. Exact listing and description of any work to be subcontracted. The equipment to be used and the qualifications of the subcontracting firm and its employees must also be clearly described. (The ability of a subcontracting firm to perform satisfactorily is just as important as the ability of the prime contractor.)

k. A listing of projects completed by the firm especially those indicating experience related to the project under consideration.

l. Professional, business, and financial references.

Contract Negotiation

In a situation where solicitation of competitive bids is not required, the following procedure has been used successfully in contracting for mapping services:

1. Select three to five firms, furnish them with general specifications, define the area to be covered, list the products needed, and request a technical proposal or plan of performance. (In selecting the firms, consider such factors as location of the firm, size of the firm in relation to the size of the mapping project, equipment owned, and the general reputation of the firm.)

2. Evaluate the technical proposals carefully and rank the firms in order of preference.

3. Call in the highest ranked firm and negotiate a price.

4. If an agreeable price is negotiated, enter into a contract with the firm. If not, continue the process with each successively lower-ranked firm until a price is agreed on and a contract executed.

In situations where competitive bidding is required, it is suggested that bid documents clearly establish minimum acceptable standards regarding corporate experience, personnel qualifications, and equipment available, in order to provide a basis for eliminating unqualified bidders.

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PART III
SAMPLE CONTRACT SPECIFICATIONS

Sample Specifications	Comments
AERIAL PHOTOGRAPHY	
1. <u>Project area</u>	
The location and size of the project area are indicated on the attached map.	Considerable care should be taken in defining the area to be mapped because some problems do not stop at the city limits. For example, drainage from outside the area of primary interest can have so great an effect that coverage should be extended to include the sources of drainage. Moreover, aerial photographs are valuable and highly useful in themselves; and it may be desirable to extend the coverage well beyond the area that will actually be mapped. The additional cost of extra coverage is usually nominal.
2. <u>Conditions</u>	
The contractor shall take vertical aerial photographs, free of clouds, cloud shadows, and atmospheric haze, between 10 a.m. and 2 p.m. during the specified season. When urban areas are photographed, the sun angle must not be less than 30°.	The best time to take aerial photographs is in the spring (usually March or April, or earlier in southern areas) after snow has left the ground and before leaves appear. The next best time is in the fall before snow appears and after the leaves are off the trees, although this photographic season is much shorter than the spring season and the sun angle may be less desirable. If at all possible, a contract should be awarded in January or February so that the contractor can take advantage of the best photographic period and also avoid delay in other work on the project.

Sample Specifications	Comments
3. Aerial camera	
Only precision aerial cameras and magazines which have been calibrated by the U.S. Geological Survey camera calibration laboratory and currently approved for U.S. Geological Survey projects are to be used. The calibration of the camera shall include the magazine matched to it and only that combination of camera cone and magazine shall be used to take the photographs.	The simplest and best way to assure obtaining high-quality photographs is to specify a camera that has been tested and is currently approved for mapping by the U.S. Geological Survey, which maintains the only official civilian camera calibration laboratory in the Federal Government.
4. Film	
The film must be scale-stable, such as the Cronar or Estar-based films, must not have passed the suggested expiration date, and must have been stored in accordance with the manufacturer's instructions. An emulsion such as Kodak type 2402 is acceptable for black-and-white photography.	The use of color aerial photographs for large-scale mapping is increasing and should be encouraged if compatible with the contractor's equipment and operations. It is particularly desirable for mapping which requires the location of undergound utilities, as such appurtenances as manholes and catch basins show up more clearly in color.
5. Flight plan	
With any proposal, the contractor shall submit a plan showing proposed flight lines designed to acquire the photographic coverage specified herein.	
6. Spacing of photographs	
Overlapping photographs in each flight line shall provide full stereoscopic coverage of the area to be mapped. Endlap (in the line of flight) shall not be less than 55 percent, nor more than 65 percent, and shall average approximately 60 percent. Sidelap shall not be less than 20 percent, no more than 40 percent, and shall average approximately 30 percent. Crab in excess of 3° may be cause for rejection of a flight line or any portion thereof in which the crab occurs.	

Sample Specifications	Comments

7. Tilt

Tilt of the camera from verticality at the instant of exposure shall not exceed 3° nor shall it exceed 5° between successive exposure stations. Average tilt over the project shall not exceed 1°.

8. Boundaries

All flight lines shall extend one full photograph beyond each end boundary, and all side boundaries shall be covered by a minimum of 25 percent of the photoimage format, if practical.

9. Flight height

The contractor shall propose the flight height or negative scale and stereoplotting equipment to be used. The technical officer for the contract shall have the right to reject the proposed scale if, in his opinion, the scale is not suitable for meeting the required accuracy with the particular stereoplotting equipment stipulated in the proposal. Deviation from designed flight height shall not exceed 5 percent low or 5 percent high.

10. Reflights

Unacceptable coverage resulting from deviation from the flight plan shall be corrected at the contractor's expense, with reflight coverage overlapping accepted coverage by two stereomodels. The same camera and magazine used on the original flights shall be used on the reflights.

Sample Specifications	Comments

11. Image quality

Maximum shutter speed, considering aperture and film speed, shall be used to minimize image motion. The film shall be free of scratches, electrostatic marks, and other blemishes. It shall be exposed and processed with a density range of 1.0 ± 0.2 as measured in the neat model areas of each roll, with minimum densities of 0.40 ± 0.1 above base fog. Density measurements shall be made on a calibrated densitometer with a 0–3.0 range. Base fog shall not exceed 0.15. All negative and fiducial-mark images shall be clear and sharp.

12. Film labeling

Each negative shall be clearly labeled on the north edge for north-south flights and one the west edge for eastwest flights. The labels shall include the date at the left, the roll and frame numbers in the center, and a project symbol or identifying name at the right. All negatives shall be numbered consecutively. Final frames on each flight line shall show the time of exposure, the camera focal length, and the flying height above mean ground level.

Comment: Details of film labeling can, of course, be tailored to the specific project.

13. Photoindex

The contractor shall prepare a photoindex by stapling together an assembly of contact prints, trimmed to the image. The prints shall be placed so that corresponding images overlap and all photograph numbers are visible. The assembly shall be photocopied at a specified scale on a sheet tailored to the size and shape of the area. The index shall include title information identifying the area, name of contractor, name of contracting authority, photographic scale, index scale, focal length of the aerial camera, flight height, date of photography, north arrow,

Comment: Although the photoindex primarily facilitates correlation and use of individual photographs, it can serve many other purposes because it is a rough photomosaic of a large area. The scale of the photoindex is usually one-third that of the photographs-- for example, 1:18,000 if the photographs are 1:6,000. The 1-to-3 scale ratio can be changed if the index is needed at a particular scale.

Sample Specifications	Comments
bar scale, and the names of principal planimetric features. The contractor shall deliver one negative of each photo-index sheet and three sets of prints on double-weight semi-matte photographic paper.	
14. Contact prints of the aerial photographs	
The contractor shall deliver _____ contact prints of each frame, trimmed to image edges, on double-weight semi-matte paper.	
15. Disposition of aerial negatives	
Aerial negatives shall be forwarded to the contracting officer after he has accepted all delivery materials specified in Specifications A.13 and A.14.	It may be desirable to permit the contractor to retain the aerial negatives for a specified length of time to allow for rapid preparation of any additional photographic products.
B. GROUND CONTROL SURVEYS	
1. Purpose	
The contractor shall establish sufficient ground control points for controlling individual models or for aerotriangulation.	There are many advantages in having a recoverable network of control available for future needs.
2. Use of existing data	
Horizontal and vertical control has been established, but the condition and recoverability of the marks are uncertain. The contractor shall recover enough stations, or establish new ones, to produce maps that meet the specified map accuracy standards. When practical control points to be used for aerotriangulation should be pretargeted in the field. Established horizontal control monuments are first- or second-order stations adjusted to the North American Datum of 1927	Usually enough data on the location of established horizontal and vertical control are available in the office of the city engineer or other comparable office. In some areas with a great amount of planimetric detail, it may not be necessary to pre-target control points to be used for aerotriangulation. The North American Datum is presently being readjusted with completion scheduled for 1986. It will be referred to as the North American Datum of 1983.

Sample Specifications	Comments
(or 1983 if appropriate). Vertical monuments shown are third-order bench marks or better, adjusted to the National Geodetic Vertical Datum of 1929. The contracting authority will furnish survey markers which are appropriate for new stations established by the contractor.	
3. <u>Horizontal control</u>	
Horizontal control established by the contractor shall conform to second-order Class II standards as stated in the publication "Standards and Specifications for Geodetic Control Networks," National Oceanic and Atmospheric Administration, Federal Geodetic Control Committee, September 1984.	The number and location of new horizontal and vertical control points should be carefully considered. It is important to select locations that can be readily included in the contractor's control survey lines.
At least _____ ground control points shall be established and marked around the perimeter of the project area. All other horizontal control points used for making the maps shall be indicated by a recoverable ground marker. All marked points established by the contractor shall be given "to-reach" descriptions referenced to landmarks and identified by field-survey ties to two or more discrete photoimage points in the immediate vicinity. The location of each marked control point shall be symbolized on the face of the appropriate photograph by a triangle and annotated on the back.	

Sample Specifications	Comments
11. Accuracy test	
The technical officer for the contract may, at his option, check the accuracy and adequacy of the field survey work before the map compilation work is begun.	An accuracy test of the basic field survey work is usually not necessary, but it is advisable to retain the right to make such a test if there is reason to question the accuracy of the work.

C. PROJECT DESIGN

1. Project area

The boundaries of the project area will be specifically defined, and the number and type of map sheets required to cover the area will be stated.

2. Scale

Sample Specifications	Comments
The map scale will be specified. Typical scales are:	Typical metric scales would be:

1:240	1 inch =	20 feet
1:480	1 inch =	40 feet
1:600	1 inch =	50 feet
1:960	1 inch =	80 feet
1:1,200	1 inch =	100 feet
1:2,400	1 inch =	200 feet
1:4,800	1 inch =	400 feet
1:9,600	1 inch =	800 feet
1:12,000	1 inch =	1,000 feet

Typical metric scales:

1:250
1:500
1:1,000
1:2,000
1:2,500
1:5,000
1:10,000

3. Contour interval

The contour interval will be specified. For economy, the largest interval that meets user requirements should be selected.

4. Sheet size and orientation

Sample Specifications	Comments
Maximum sheet size shall be 30 by 36 inches. Maximum format should not exceed 25 by 30 inches to provide a minimum margin of 2 1/2 inches. The basis for the map projection will be the proper state plane coordinate system, with the Universal Transverse Mercator projection as an alternative.	The sheet and format sizes indicated are practical and workable, but they can be altered to fit the specific requirements of a community.

Sample Specifications	Comments
5. <u>Map content</u>	
a. Coordinate grid	
A grid shall be shown at multiples of 5 inches at map scale.	
b. Marginal data	
The following data shall be included in the margin of each map.	These items constitute the minimum information to be shown in the margins. Additional information can be added as desired and as space permits.

Items common to all maps:

- Title block
- Project name
- Project location
- Contracting authority
- Contract number
- Sheet name
- Map scale
- Map type
- Credit notes
- North arrow
- Bar scale
- Accuracy note
- Map location diagram

Items that must be specifically tailored to each map:

- Position in map location diagram
- Adjoining sheet designations
- Geographic coordinates
- Preparation date and photo date
- Road classification
- Route symbols and other special symbols (poles, manholes, culverts, underground utilities).
- Datum
- Required signatures
  - Contracting offical
  - Professional engineer/surveyor
- Revision block

Sample Specifications	Comments
4. <u>Basic vertical control</u>	
Vertical control established by the contractor shall conform to second-order, Class II standards as stated in the publication "Standards and Specifications for Geodetic Control Networks," National Oceanic and Atmospheric Administration, Federal Geodetic Control Committee, September 1984. Permanent monuments shall be established at 1-mile intervals along leveling routes, given "to-reach" descriptions referenced by distance measurements to well-defined image points, and sketched on the backs of relevant photographs.	Types of permanent monuments considered in the spacing requirements can be a rock outcrop or suitable structure, a 4-foot (or longer) aluminum or copper-rod type bench mark with base plate, or a pipe mark with base plate. A permanent magnet in the identifying cap will assist in locating non-ferrous monuments in the future.
5. <u>Reference ties</u>	
Field ties from reference monuments to distinct images (including targets) may be established by a single course from a horizontal control point. Two sets of direct/reverse measurements are required; distances shall be double-taped and limited to 200 feet or measured with an EDM instrument and checked. Control field notes shall comply with these requirements and include a sketch for each identification showing the occupied station, directions or azimuths to adjoining stations, directions and identifications of the images (targets), and a reference to north.	
6. <u>Supplemental vertical control</u>	
Supplemental vertical control may be extended by fly levels to control images if circuit distance or ties between higher order control do not exceed 1 mile. Errors of closure shall not exceed one-tenth contour interval.	

Sample Specifications

7. Control adjustment

The contractor shall adjust all horizontal control to the North American Datum of 1927 (or 1983 if appropriate) and all vertical control to the National Geodetic Vertical Datum of 1929.

8. Records

All field survey records, control descriptions, computations, and related materials shall be delivered by the contractor as specified in the contract.

9. Technical reference

Field survey procedures are defined in the publications "Standards and Specifications for Geodetic Control Networks," National Oceanic and Atmospheric Administration, Federal Geodetic Control Committee, September 1984.

10. Control identification

Control may be identified either before or after compilation photographs are taken, with either natural images or artificial targets.

Comments

The locations of section corners, property corners, etc., may be identified by targeting prior to taking compilation photographs.

Control-station identification is defined as the identification on a photograph, usually an aerial photograph, of the image of a ground point of known horizontal position and (or) elevation.

Sample Specifications	Comments
c. Planimetry	
The maps shall show planimetric features identifiable on or interpretable from the aerial photographs, including such features as buildings; canals, ditches, and reservoirs; trails, roads, highways, sidewalks, and alleys; railroads; ferry slips; fords; quarries and borrow pits; cemeteries; orchards and wooded areas; large lone trees; visible traces of utility lines and their poles and towers; undergound cables; pipelines and sewers; billboards; and fences and walls. Such structures as bridges, trestles, tunnels, piers, retaining walls, dams, power plants, transformers, transportation terminals, airfields, and tanks shall also be shown. Such drainage features as rivers, streams, lakes, ponds, and swamps shall be shown as well as such recreational facilities as parks, golf courses, and athletic fields.	The planimetric features stated are those generally depicted on large-scale urban maps. If a community does not need to have some of these features shown, they can be omitted from the specifications; conversely, additional features can be added to the specifications. In adding features, however, planners should take care not to increase costs unduly. Features that can be identified and plotted in stereocompilation are no problem, but those that must be identified and positioned by field inspection and/or survey significantly increase the cost of mapping.
In addition, such features as curbs, sidewalks, parking strips, driveways, hydrants, manholes, and lampposts shall be shown on maps at scales of 1:600 or larger.	
Buildings and similar dimensionable objects shall be accurately outlined on the maps to actual scale, except that building dimensions smaller than 1/20 inch at map scale shall be symbolized at 1/20 inch; and minor irregularities in building outlines not representable by 1/40 inch at map scale shall be ignored.	
Political boundaries and township, range, and section lines (if any) shall be mapped using the best available sources.	

Sample Specifications	Comments
Monumented horizontal control stations and bench marks used in making the maps shall be shown. In addition, other permanent control marks recovered during the course of the project shall also be shown, the objective being to present an even distribution of control on the published maps.	
All mapped information shall be shown in accordance with the symbols, style, and lineweights shown in the Appendix, exhibit 4.	
d. <u>Contours and spot elevations</u>	
Contours shall be shown at a vertical interval of ____ feet, and every fifth contour line (or the fourth contour line in the case of, for example, a 2.5-meter contour interval which makes the 10-meter contour line the logical index contour) shall be an index contour and shall be shown with a lineweight heavier than that of the intermediate contours. (See symbol chart for contour lineweights.) Contours shall be shown as solid lines except in areas where the ground is completely obscured by heavy brush or tree cover; in such areas, the contours shall be shown as dashed lines and shall be plotted as accurately as possible from the stereoscopic model, with particular reference to spot elevations measured photogrammetrically in places where the ground is visible.	Dashed contours may not meet standard accuracy. Therefore, the dashed-contour provision may be omitted from the specifications if standard accuracy must be met, regardless of ground conditions, as is often the case when detailed designs for construction work are to be based on maps. But before omitting, consideration should be given to the high cost difference between actual field contouring and photogrammetric contouring.
Spot elevations determined photogrammetrically shall be shown on the maps in proper position at water level on lakes, reservoirs, and ponds; on hilltops; in saddles; at bottoms of depressions; at intersections of principal streets and highways; and at ends of bridges. In areas where the contours are more than 2 inches apart, additional spot elevations shall be plotted to provide additional topographic information; and the horizontal distance between elevations or	

Sample Specifications

between elevations and contours shall not exceed 1 inch. In areas of uniform slope, at scales 1:1,200 or larger, spot elevations need only be 4 inches apart to locate significant breaks in grade.

e. Names and labels

The maps shall show significant names data. The following are examples of categories of named features in an urban area:

Corporate, locality, and boundary names

Parks, public squares, monuments, and cemeteries

Linear and hydrographic features

Universities, colleges, public schools, and large private schools

Historic, landmark, and unusually important churches

Shopping centers

Main and secondary streets, railroads, transit lines

The selected names data shall be included in the interior of the map in styles and sizes as shown on the style sheet.

The city name is not shown in the map interior except where more than one city appears on the sheet. Suburb, subdivision, and area names are centered within the area if no boundary or limiting line is shown and legibility is not impaired.

Comments

The scale of the map usually determines the density of names data. In maps at a scale of 1:200 or larger, all roads, streets, and alleys are named; all public and major private buildings are named, all churches housed in single-purpose structures are named. In the largest scale maps (1:600, 1:240), dimensional information may be added to water, sewer and storm drainage lines; inverts added to drainage structures; control points named with coordinates and (or) elevations annotated; street addresses added, etc., depending on the intended uses of the map.

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Streets and roads are named and spelled in accordance with local usage. Numbered streets are either spelled out or shown numerically in accordance with official designation. For easy identification, names are repeated on long streets or on streets that make abrupt changes in direction. The generic part of the name (street, avenue, etc.) is spelled out in full, if space permits. Names are positioned within the casings of the streets where space permits.

Important and prominent buildings are named or identified. Normally, individual buildings within a complex are not named or identified.

6. <u>Finished scribing or drafting</u>

a. Final maps shall be scribed or drafted on stable polyester with a minimum thickness of 0.004 inch.

If the same map is intended to be used for other purposes at a different scale--for example, a 1:2,400 street engineering map (planimetric version) reduced to a 1:9,600 regional planning map--consideration should be given to increasing the lineweights and symbol sizes to permit production of a dual-purpose map without sacrificing accuracy or legibility at either scale.

b. Symbols, style, and lineweights shall be as shown on the symbol chart. Professional standards of workmanship shall be maintained throughout the scribing or inking of all maps. Each line shall conform to the specified width and remain uniform throughout. The inked or scribed symbols, lines, letters, and numbers shall be clear and legible. If ink is used, it shall be a waterproof, durable ink that will not chip or flake with normal use.

Sample Specifications	Comments
c. Map reproductions are usually specified as one of the following forms: Reproducible copies of stable polyester with a minimum thickness of 0.004 inch Paper reproductions (either blue- or black-line positives).	As insurance against loss or damage, at least one extra set of polyester reproducibles should be obtained from the contractor and stored at a location different from the place where the original or master set is stored and used. It may be advantageous for the contractor to make and retain an extra set of reproducibles and furnish paper prints, as needed, at prices fixed by agreement. If the contractor is not conveniently located, a similar arrangement could be made with a local reproduction firm. Because paper prints are the usual work medium, it is important that a supplier be readily available.

7. Manuscripts

Map manuscripts shall be drawn on stable polyester with a minimum thickness of 0.004 inch at a scale equal to or larger than the final map scale. If the compilation scale is larger than the publication scale, the manuscript shall be reduced photographically and printed on 0.004-inch polyester material for subsequent contact printing of the final bases.

8. Map accuracy

Sample Specifications	Comments
a. Coordinate grid lines and horizontal control points shall be plotted within 1/100 inch of true position. b. At least 90 percent of all well-defined planimetric features shall be plotted within 1/40 inch of true position, and the remaining features shall be plotted within 1/20 inch of true position.	The accuracy requirements are from the Reference Guide Outline - Specifications for Aerial Surveys and Mapping by Photogrammetric Methods for Highways prepared by the American Society of Photogrammetry and published by the U.S. Department of Transportation in 1968 except that the RGO specifications call for grid lines and horizontal control points to be plotted within 1/100-inch of true position rather than 1/200-inch. Another widely referenced set of accuracy standards, usually used for smaller scale mapping, is the United States National Map Accuracy Standards,

Sample Specifications	Comments
	U.S. Bureau of the Budget, issued June 10, 1941, revised April 26, 1943 and June 17, 1947. These standards specify horizontally, not more than 10 percent of all points tested shall be in error by more than 1/30-inch on maps published at scales larger than 1:20,000 or 1/50-inch on maps published at scales of 1:20,000 and smaller. Vertically, the standards specify that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval.

c. At least 90 percent of all elevations determined from solid-line contours shall be accurate within one-half the contour interval, and the remaining 10 percent shall be accurate within one contour interval. Any contour that could be brought within this accuracy tolerance by shifting its location 1/40 inch (the allowable horizontal error) will be considered to be acceptable.

d. At least 90 percent of spot elevations shown on the maps shall be accurate within one-fourth the contour interval, and the remaining 10 percent shall be accurate within one-half the contour interval.

9. Aerotriangulation

Analytical aerotriangulation or semi-analytical aerotriangulation may be used to establish supplemental horizontal and vertical control for stereoscopic models, provided that the procedures and equipment (both the aerial camera, the comparator, and the stereoplotter) are approved in advance by the technical officer for the contract.

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10. Map testing and inspection

The technical officer for the contract may inspect the work either in the field or in the contractor's plant at any time. He will check finished maps for completeness by comparison with aerial photographs, field inspection, or both, and will check horizontal and vertical accuracy by running field traverses and profiles. Inspection shall be completed within 60 days after receipt of the maps by the technical officer. The contractor shall be responsible for completing and correcting maps rejected because of incompleteness or inaccuracy.

11. Orthophotographic maps

Specifications concerning area to be covered, scale, contour interval (if applicable), sheet size and orientation, coordinate grid, marginal data, contours and spot elevations (if applicable), map accuracy, aerotriangulation, and map testing and inspection shall be as stated in Specifications C.1, 2, 3, 4, 5a, 5b, 8, 9, and 10.

Applicable only if it has been decided to produce an orthophotographic base rather than a photogrammetrically compiled line base.

12. Orthophotograph preparation

Orthophotographs may be prepared by either simple rectification or differential rectification, depending on the relief difference in a specific aerial photograph. Simple rectification is adequate for photographs containing no more relief than a percentage of the denominator of the final map scale expressed as a representative fraction, as indicated below for different focal length cameras:

Nominal focal length (inches)	Percentage of denominator of map scale
3 1/2	0.2
6	0.3
8 1/4	0.5
12	0.7

For areas with comparatively little relief, simple rectification compensates for displacement in the photographic image caused by tilt of the aerial camera at the instant of exposure. The rectification procedure requires relatively inexpensive equipment and is an economical way to make an orthophotograph. However, for areas of higher relief, displacement is present in the photographic image due to the relief itself, in addition to any displacement due to tilt of the camera. Consequently, a more sophisticated procedure--differential rectification--is needed to produce a true orthophotograph. This procedure requires more expensive equipment and is more

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Comments

costly than simple rectification, but standard accuracy cannot be attained by any other procedure when the amount of relief exceeds the stated limits.

The percentage assures that displacement in the photographic image due to relief will not exceed the limits specified. For example, differential rectification is required if relief exceeds 7.2 feet for an orthophotographic map at the scale of 1:2,400 made from photographs taken with a 6-inch focal-length camera.

The final orthophotographic map shall not contain scale lines and mismatched imagery that interfere with the interpretability of ground features or that are esthetically objectionable. Mis-matches exceeding 0.04 inch are generally unacceptable and may be cause for rejection. Other defects that could cause rejection include out-of-focus imagery, dust marks, scratches, and inconsistencies in tone and density between individual orthophotos and (or) adjacent map sheets.

13. Contour overlays (if desired)

Contours and spot elevations are to be shown on a transparent overlay, compiled as stated in Specification C.5d. The contracting officer may include, as a delivery item, a set or sets of orthophotographic maps with the contour and spot elevation data overprinted photographically. The contour overlay must be a clear stable polyester with a minimum thickness of 0.004 inch, registered precisely to the orthophotographic map.

If the contours are to be photographically combined into the orthophotographic maps, a choice must be made between black or white lines. This is usually a matter of selecting the version that will have the most contrast considering the predominant tone of the area. Either black or white contour lines can be provided, but the contractor should be informed before beginning work.

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14. Reproduction materials

Requirement for orthophotographic map reproductions can usually be satisfied in one of the four following forms: (1) stable-base opaque prints on a coated polyester material such as Cronapaque; (2) prints on standard photographic paper, either single or double weight and either semimatte or glossy surface; (3) reproducible, halftone screened (a minimum of 120 lines per inch) positives on polyester base with a minimum thickness of 0.004 inch (for composite photographic and contour reproducibles, only the photographic image should be halftone screened); and (4) paper diazo reproduction made from the screened positives.

Comments

Maximum clarity of detail is presented when the orthophotographic maps are printed on photographic paper or on an opaque polyester material, such as Cronapaque. As these prints are expensive compared to diazo paper prints, a set of screened reproducibles should be obtained so that inexpensive work copies can be made in quantity.

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GLOSSARY

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 - Process designed to minimize inconsistencies in measured or computed quantities by applying derived corrections to compensate for random or accidental errors.

aerotriangulation (or bridging) - The process of developing a network of horizontal and (or) vertical positions from a group of known positions utilizing direct or indirect measurements from aerial photographs and mathematical computations.

azimuth - Horizontal direction reckoned clockwise from the meridian plane.

bench mark - Relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known.

cartography - Science and art of making maps and charts. The term may be taken broadly as comprising all the steps needed to produce a map: planning, aerial photography, field surveys, photogrammetry, editing, color separation, and multicolor printing.

C-factor - Empirical ratio between flight height and contour interval used to indicate the capability of photogrammetric systems. (C-factor multiplied by contour interval desired equals flight height of aerial photography.) C-factor, unless otherwise indicated, is based on the use of 6-inch focal length lenses with a 9- by 9-inch film format.

color separation - Process of preparing a separate drawing, engraving, or negative for each color required in the printing production of a map or chart.

compilation - Preparation of a new or revised map or chart, or portion thereof, from existing maps, aerial photographs, field surveys, and other sources.

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, mapping - Points of established position or elevation, or both, which are used as fixed references in positioning and correlating map features. Fundamental control is provided by stations in the national networks of triangulation and traverse (horizontal control) and leveling (vertical control). Usually it is necessary to extend geodetic surveys, based on the fundamental stations, over the area to be mapped, to provide a suitable density and distribution of control points.

Supplemental control points are those needed to relate the aerial photographs used for mapping with the system of ground control. These points must be positively photoidentified; that is, the points on the ground must be positively correlated with their images on the photographs.

control station - Point on the ground whose position (horizontal or vertical) is known and can be used as a base for additional survey work.

coordinates - Linear and (or) angular quantities that designate the position of a point in relation to a given reference frame.

coordinates, origin of - Point in a system of coordinates which serves as a zero point in computing the systems elements or in prescribing its use.

crab (aerial photography) - The condition caused by failure to orient the camera with respect to the track of the airplane. In vertical photography, crab is indicated by the edges of the photographs not being parallel to the intended ground track of the aircraft.

culture - Features constructed by man that are under, on, or above the ground which are delineated on a map. These include roads, trails, buildings, canals, and sewer systems. In a broad sense, the term also applies to all names, other identification, and legends on a map.

datum (Pl. datums) - In surveying, a reference system for computing or correlating the results of surveys. There are two principal types of datums: vertical and horizontal. A vertical datum is a level surface to which heights are referred. In the United States, the generally adopted vertical datum for leveling operations is the National Geodetic Vertical Datum of 1929. The horizontal datum, used as a reference for position, is defined by: the latitude and longitude of an initial point, the direction of a line between this point and a specified second point, and two dimensions which define the spheroid.

datum, national geodetic vertical - See National Geodetic Vertical Datum of 1929.

diazo process - Rapid and inexpensive method for reproducing documents.

displacement - Any shift in the position of an image on a photograph due to tilt during photography, scale changes in the photographs, and relief of the area photographed.

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 roundtrip 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.

engineering map – See map, engineering.

feature separation – Process of preparing a separate drawing, engraving, or negative for selected types of data in the preparation of a map or chart.

flood control map – See map, flood control.

flood plain – Belt of low flat ground bordering a stream channel that is flooded when runoff exceeds the capacity of the stream channel.

fly leveling – Leveling in which some of the restrictions of precise leveling, such as limiting length of sight, balancing backsights and foresights, etc., are relaxed to obtain elevations of moderate accuracy more rapidly.

focal length – A general term for the distance between the rear node of a lens and the point where the image of an infinitely distant object comes into critical focus.

fog (photographic) – The visual density reducing light transmission caused by the base material (usually polyester) and the emulsion of the photographic medium.

geodesy – Science concerned with the measurement and mathematical description of the size and shape of the Earth and its gravitational field. Geodesy also includes the large–scale extended surveys for determining positions and elevations of points, in which the size and shape of the Earth must be taken into account.

graticule – Network of parallels and meridians on a map or chart.

grid – Network of uniformly spaced parallel straight lines intersecting at right angles. When superimposed on a map, it usually carries the name of the projection used for the map––that is, Lambert grid, transverse Mercator grid, universal transverse Mercator grid. However, care must be taken not to confuse a projection grid with the underlying network of geographic meridians and parallels generated by the projection.

halftone – A picture in which the gradations of light are obtained by the relative darkness and density of tiny dots produced by photographing the subject through a fine screen.

hypsographic map – See map, hypsographic.

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 photographic emulsion (directly as in a camera or indirectly after being first recorded on magnetic tape as an electrical signal) or on magnetic tape for subsequent conversion and display on a cathode ray tube.

land use map – See map, land use.

latitude – Angular distance, in degrees, minutes, and seconds, of a point north or south of the Equator.

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.

leveling - Surveying operation in which elevations of objects and points are determined relative to a specified datum.

line copy (line drawing) - Map copy suitable for reproduction without the use of a screen; a drawing composed of lines as distinguished from continuous-tone copy.

line map - See map, line.

longitude - Angular distance, in degrees, minutes, and seconds, of a point east or west of the Greenwich meridian.

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, 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 flood control projects in areas subject to flooding.

map, hypsographic - Map showing relief with elevations referred to the National Geodetic Vertical Datum of 1929.

map, land use - Map showing the various purposes for which parcels of land are being used.

map, line - Map composed of lines as distinguished from photographic imagery maps.

map, orthphotographic - Map produced by assembling orthophotographs at a specified uniform scale in a map format.

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 features usually shown on a planimetric map include rivers, lakes, and seas; mountains, valleys, and plains; forest and 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 essential to the purpose to be served.

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 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. For maps of the Earth, a projection consists of (1) a graticule of lines representing parallels of latitude and meridians of longitude or (2) a grid.

map series – Family of maps conforming generally to the same specifications and designed to cover an area or a country in a systematic pattern.

meridian – Great circle on the surface of the Earth passing through the geographical poles and any given point on the Earth's surface. All points on a given meridian have the same longitude.

metes and bounds – Method of describing land by measure of length (metes) of the boundary lines (bounds).

metric system – Decimal system of weights and measures based on the meter as a unit length and the kilogram as a unit mass.

monument (surveying) – Permanent physical structure marking the location of a survey point. Common types of monuments are inscribed metal tablets set in concrete posts, solid rock, or parts of buildings; distinctive stone posts; and metal rods driven in the ground.

National Geodetic Vertical Datum of 1929 – Reference surface established by the U.S. Coast and Geodetic Survey in 1929 as the datum to which relief features and elevation data are referenced in the conterminous United States; formerly called "mean sea level of 1929."

neatline – Line separating the body of a map from the map margin. On a standard U.S. Geological Survey quadrangle map, the neatlines are the meridians and parallels delimiting the quadrangle.

Origin of coordinates – Point in a system of coordinates that serves as a zero point in computing the system's elements or in prescribing its use.

orthophotograph – Photograph having the properties of an orthographic projection. It is derived from a conventional perspective photograph by simple or differential rectification so that image displacements and scale differences caused by camera tilt and terrain relief are removed.

orthophotographic map – Map produced by assembling orthophotographs at a specified uniform scale in a map format.

orthophotomap – Orthophotographic map with contours and cartographic treatment, presented in a standard format, and related to standard reference systems.

orthophotomosaic – Assembly of orthophotographs forming a uniform-scale mosaic.

overlap – The amount by which one photograph overlaps another, customarily expressed as a percentage. The overlap between aerial photographs in the same flightline is called the endlap, and the overlap between photographs in adjacent parallel flightlines is called the sidelap.

overlay - Printing or drawing on a transparent or translucent medium intended to be placed in register on a map or other graphic which depicts information which does not appear on the base material or which requires special emphasis.

overprint - New material printed on a map or chart to show data of importance or special use, in addition to those data originally printed.

pass point - A point whose horizontal and (or) vertical position is determined from photographs by photogrammetric methods and which is intended for use as a control point in the orientation of the photographs.

photogrammetry - Science or art of obtaining reliable measurements or information from photographs or other sensing systems.

photoindex - An assembly of photographs in their proper relative positions, generally annotated and copied at a reduced scale.

photomap (photographic map) - Map made by adding marginal information, descriptive data, and a reference system to a photograph or assembly of photographs.

planimetric map - See map, planimetric.

planimetry - Plan details of a map--those having no indications of relief or contour.

public land survey system - Public lands are subdivided by a rectangular system of surveys established and regulated by the Bureau of Land Management. The standard format for subdivision is by townships measuring 6 miles (480 chains) on a side. Townships are further subdivided into 36 numbered sections of 1 square mile (640 acres) 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).

rectification, differential - The process of scanning and reprojecting a photograph onto a plane in differential elements to remove displacements due to tilt and relief. The process may be accomplished by any one of a number of instruments developed specifically for the purpose.

rectification, simple - The process of projecting a photograph onto a horizontal plane by means of a rectifier to remove displacements due to tilt of the camera.

relief - Elevation variations of the land or sea bottom.

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.

scale - Relationship existing between a distance on a map, chart, or photograph and the corresponding distance on the Earth.

scribing - Removal of portions of a photographically opaque coating from a transparent base with engraving tools.

section – Unit of subdivision of a township; normally a quadrangle 1 mile square with boundaries conforming to meridians and parallels within established limits, and containing 640 acres as nearly as practicable.

sidelap – See overlap.

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, on a selective basis, 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.

state plane coordinate systems – Coordinate systems established by the U.S. Coast and Geodetic Survey (now the National Ocean Service), usually one for each State.

stereocompilation – Production of a map or chart manuscript from aerial photographs and geodetic control data by means of photogrammetric instruments.

stereoplotter – Instrument for plotting a map by observation of stereomodels formed by pairs of photographs.

stereoscopic – Pertaining to the use of binocular vision for observation of a pair of overlapping photographs or other perspective views, giving the impression of depth.

target – The distinctive marking or instrumentation of a ground point to aid in its identification on a photograph. A target is so arranged and placed as to form a distinctive image 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.

thematic map – See map, thematic.

topographic map – See map, topographic.

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.

township – Unit of survey of the public lands of the United States, normally a square area approximately 6 miles on a side with boundaries conforming to meridians and parallels within established limits, containing 36 sections. Also, in certain parts of the country, the term designates a minor governmental subdivision.

traverse – Sequence of lengths and directions of lines connecting a series of stations, obtained from field measurements, and used in determining positions of the stations.

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.

Universal Transverse Mercator (UTM) 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.

APPENDIX

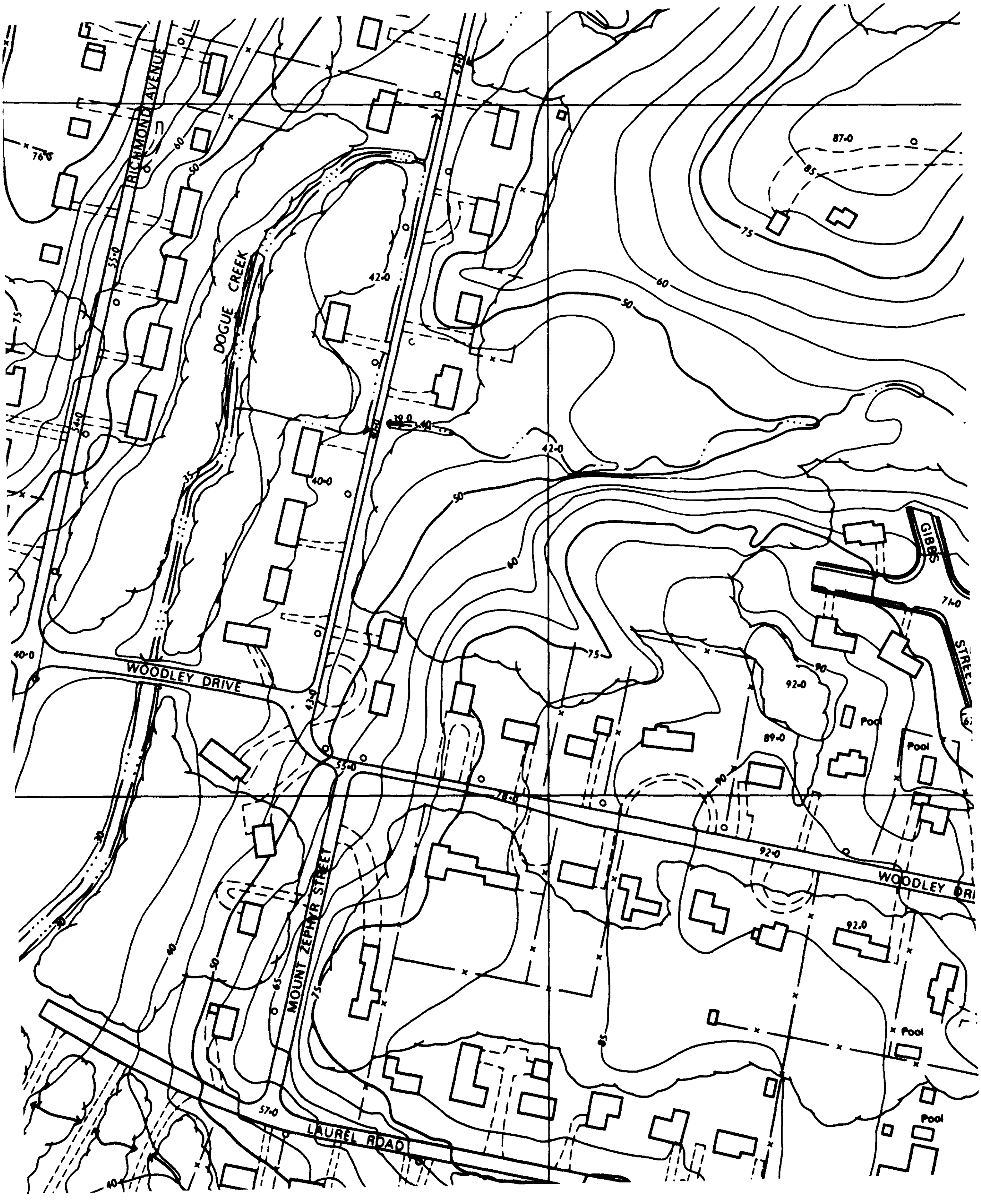

Exhibit 1.--Map scale: 1:2,400 (1 inch = 200 feet) with 5 foot contours.

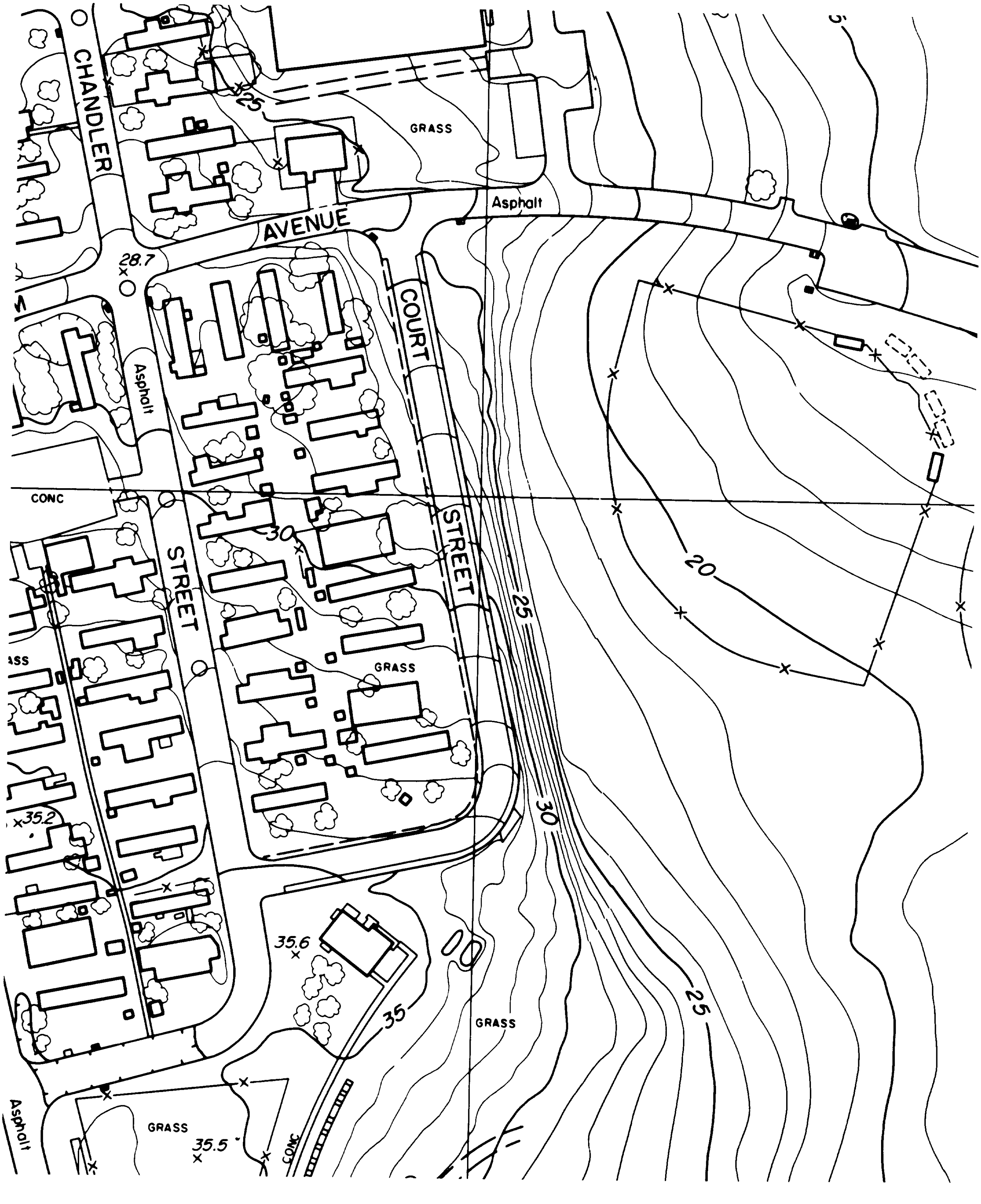

Exhibit 2.– Map scale: 1:1,200 (1 inch = 100 feet) with 1 foot contours.

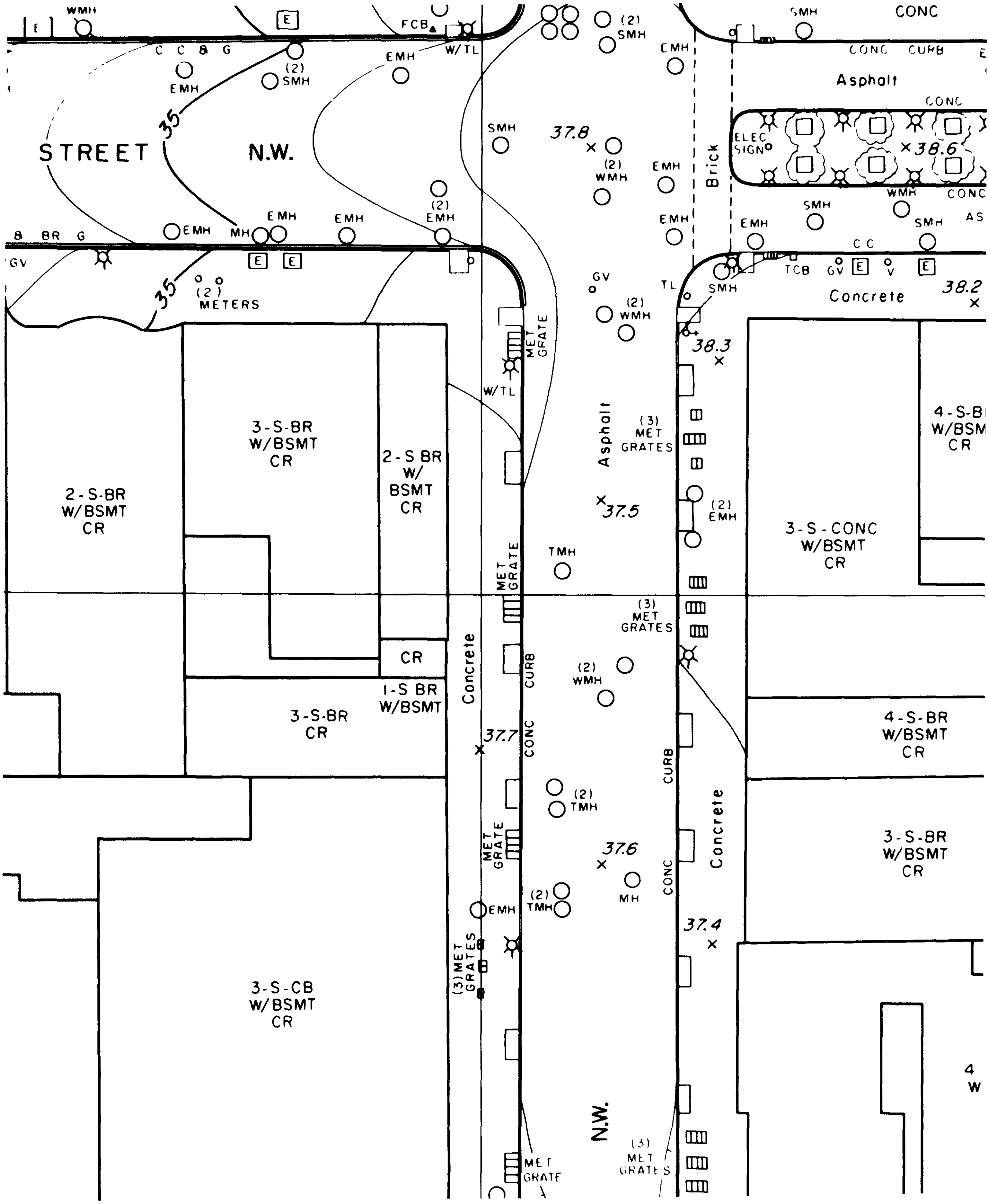

Exhibit 3.—Map scale: 1:480 (1 inch = 40 feet) with 1 foot contours.

LEGEND

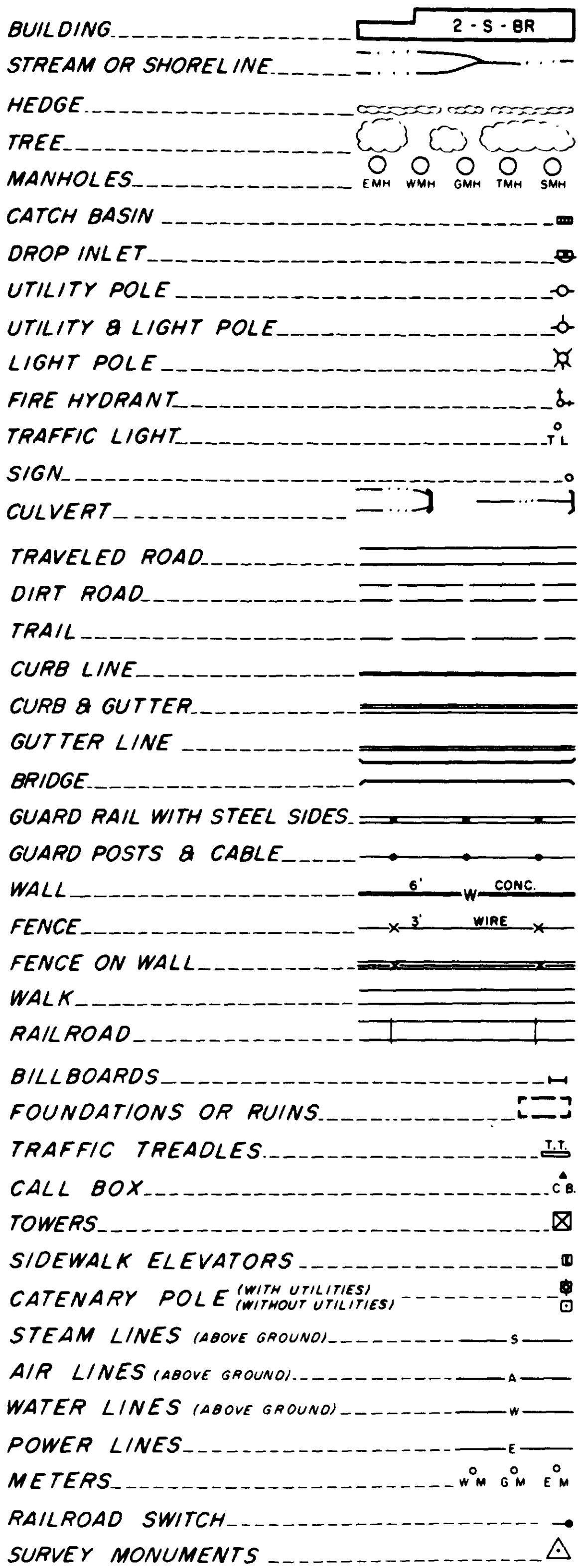

Exhibit 4.—Sample lengend for large-scale topographic maps.

*U.S. GOVERNMENT PRINTING OFFICE: 1986-491-405:40022