



**AUM**

**American University Of The Middle East**

**CVL203: Principles and  
Practice of Geomatics**

**Lectures 18:  
Mapping**

- Introduction
- Availability of Maps and Related Information
- Accuracy Standards for Mapping
- Map Design
- Map Layout
- Contour Intervals
- Plotting contours
- Lettering
- Cartographic Map Elements
- Sources of Errors in Mapping
- Mistakes in Mapping

- Maps have traditionally been produced in *graphic*, or “hardcopy,” form, that is, printed on paper or a stable-base plastic material.
- However, today most mapping data are collected in digital form and are then processed using *Computer Aided Drafting and Design* (CADD) systems to develop “softcopy” maps.
- Softcopy maps are stored within a computer, can be analyzed, modified, enlarged or reduced in scale, and have their contour intervals changed while being viewed on the monitors of CADD systems.
- Different types or “layers” of information can also be extracted from digital maps to be represented and analyzed separately, and softcopy maps can be transferred instantaneously to other offices or remote locations electronically. They can also be printed in hardcopy form if desired.
- Softcopy maps are indispensable in the development and operation of modern Land Information Systems (LISs) and Geographic Information Systems (GISs).

- Maps have had a profound impact on human activities and today the demand for them is perhaps greater than ever.
- They are important in engineering, resource management, urban and regional planning, management of the environment, construction, conservation, geology, agriculture, and many other fields.
- Maps show various features: topography, property boundaries, transportation routes, soil types, vegetation, land ownership, and mineral and resource locations.
- Maps are especially important in engineering for planning project locations, designing facilities, and estimating contract quantities.
- Cartography, the term applied to the overall process of map production, includes map design, preparing or compiling manuscripts, final drafting, and reproduction. These processes, which apply whether the maps are graphic or digital, are described in this chapter.

- Maps for a variety of different purposes, prepared at scales varying from large to small, and in both graphic and digital form, are prepared by private surveying and engineering companies, industries, public utilities, cities, counties, states, and agencies of the federal government.
- With such a wide range in organizations and agencies involved, some duplication of effort has occurred because mapping activities generally have not been coordinated. Also, the existence of available maps and related information is often unknown to potential users.
- The U.S. Geological Survey (USGS) now coordinates all mapping activities at the federal level. They offer nationwide information and sales service for map products and Earth science publications. The USGS provides information about *topographic, land use, geologic and hydrologic maps, books and reports; Earth science and map data in digital format and related applications software; aerial, satellite, and radar images and related products; and geodetic data.*
- Several states have established state cartographers' offices. One of their functions is the dissemination of local maps and related products and information to surveyors, engineers, cartographers, and the general public

# Accuracy Standards for Mapping

- United States Bureau of the Budget developed the *National Map Accuracy Standards* (NMAS).
- These standards provide specifications governing both the horizontal and vertical accuracy with which features are depicted on maps.
- To meet the NMAS **horizontal position specification**, *for maps produced at scales larger than 1:20,000, not more than 10% of well-defined points tested shall be in error by more than 1/30 in. (0.8 mm).*
- Accordingly, *on a map plotted to a scale of 1 in. = 100 ft., point positions would have to be correctly portrayed to within  $\pm 3.3$  ft. to meet this specification.*
- *On smaller scale maps, the limit of horizontal error is 1/50 in. (0.5 mm), or approximately  $\pm 40$  ft. on the ground at a map scale of 1:24,000.* These limits of accuracy apply to positions of well-defined points only, such as monuments, benchmarks, highway intersections, and building corners.

# Accuracy Standards for Mapping

- The NMAS **vertical accuracy requirements** specify that not more than 10% of elevations tested shall be in error by more than one half the contour interval, and none can exceed the interval. To meet this requirement, contours may be shifted by distances up to the horizontal positional tolerance, if necessary.
- The accuracy of any map can be tested by comparing the positions of points whose locations or elevations are shown on it with corresponding positions determined by surveys of a higher order of accuracy.
- Plotted horizontal positions of objects are checked by running an independent traverse or other survey to points selected by the person or organization for which the map was made.
- To check vertical accuracy, elevations obtained from field profile surveys are compared with elevations taken from profiles made from plotted contours.
- These procedures provide a check on both fieldwork and map drafting.

# Accuracy Standards for Mapping

- With the evolution of *Soft Maps*, the *Federal Geographic Data Committee* (FGDC) drafted a more current set of accuracy standards called the *Geospatial Positioning Accuracy Standards*.
- The new *Geospatial Positioning Accuracy Standards* document specifies accuracies in separate horizontal and vertical components.
- Unlike NMAS, accuracies are specified in terms of coordinates of points, ground distances, and elevations at the 95% confidence level.
- These new standards are applicable to all types and scales of maps, including those in digital form.
- The test for maps intended to meet this standard involves checking a set of at least 20 well-defined points against information obtained from an independent source of higher accuracy.
  
- The *American Society of Civil Engineers* (ASCE) has also developed a set of standards for topographic mapping that are aimed primarily at large-scale engineering maps.
- In addition to suggesting accuracies for various map scales, they also provide standards for contouring, map symbols, abbreviations, lettering, and other factors important in mapping.

Before beginning the design of a map, the following two basic questions should be answered:

**1) What is the purpose of the map?**

- the information that the map must convey

**2) Who is the map intended to serve?**

- achieving the design that best meets its objectives and conveys the necessary information clearly to its users

**To achieve maximum effectiveness in map design, the following elements or factors should be considered:**

Clarity

Order

Balance

Contrast

Unity

Harmony

## Clarity

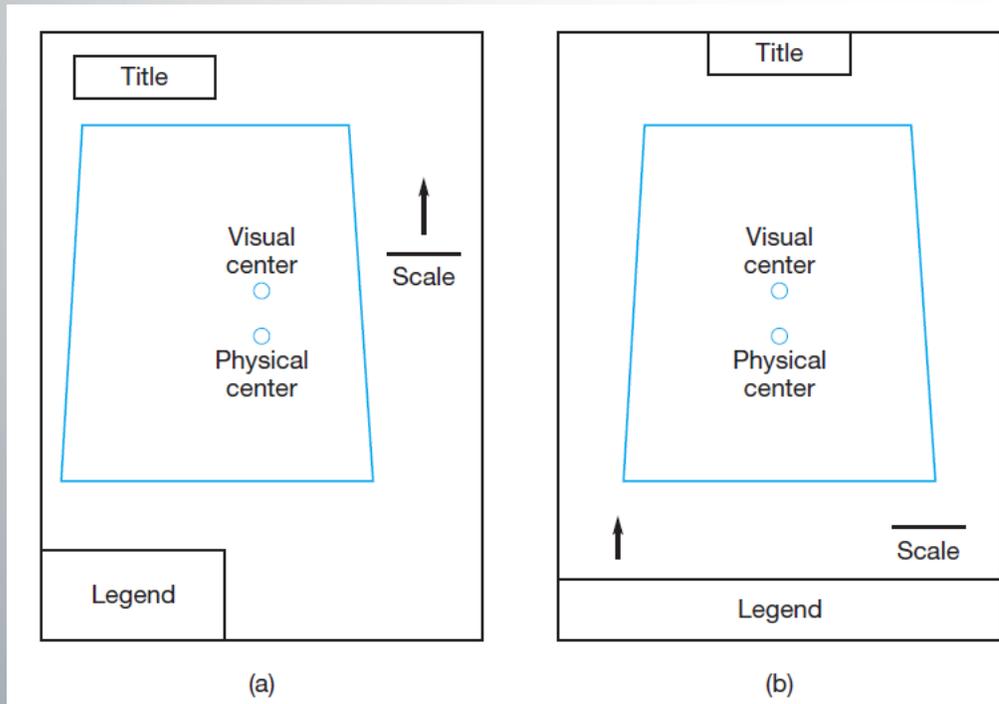
- Ability of a map to convey its intended information completely and unambiguously.
- Fully examining the objectives of the map and then emphasizing the features necessary to carry out those objectives.
- Maps should not be overloaded with details, as this can cause congestion and confusion.

## Order

- It refers to the logic of a map, and relates to the path that a user's eye would follow when looking at one.
- A design should be adopted that first draws the user's attention to the subject area of the map, then the map title, and then to any notes.
- A common mistake made by beginners is to make bar scales and north arrows so large and bold that they attract attention away from the subject of the map.

## Balance

- All elements on a map have weight, and they should be distributed uniformly around the “visual center” of the map.
- The weight of an element is affected by factors such as size, color, font, position, and line width.
- Map elements that appear at the center have less weight than those on the edges. Elements in the top or right half of the map will appear to have more weight than those in the bottom or left half of the map.



In (a), the map appears to be too heavily weighted to the left, and thus has poor overall balance. A redistribution of the map features, as shown in (b), produces a more visually balanced product.

## Contrast

- Use of different line weights and fonts of varying sizes. Contrast can be used to enhance balance, order, and clarity.
- For example, the title of the map should be displayed in a larger font than the other textual elements. This will attract the viewer's attention, thereby enhancing the order and clarity of the map.

## Unity

- Interrelationships between the backgrounds, shading, and colors on a map.
- These items can enhance clarity, balance, and contrast. They can also detract from these same items.
- For example, yellow lettering on a white background is difficult to see and often overlooked by the reader. However, this same yellow lettering on a black background will stand out and appear emphasized.
- A map with good unity is visualized as a unit and not as an assemblage of individual elements.

## Harmony

- Interrelationships between all elements on the map.
  - If a map has good harmony, the elements work together.
  - Common errors are the use of too many fonts, a north arrow that is too fancy or large, or a bar scale that is too large.
- 
- In designing maps, it is important to remember that different audiences may require different maps.
  - For example, it would be difficult for a layperson to read and understand a map produced for an engineering project. Accordingly, maps that are developed for design professionals are not generally suitable for public hearings.
  - Because laypeople often have no training in map reading, it may be best to develop specialized three-dimensional maps or models that depict relief, boundaries, proposed buildings, landscaping, and so on.

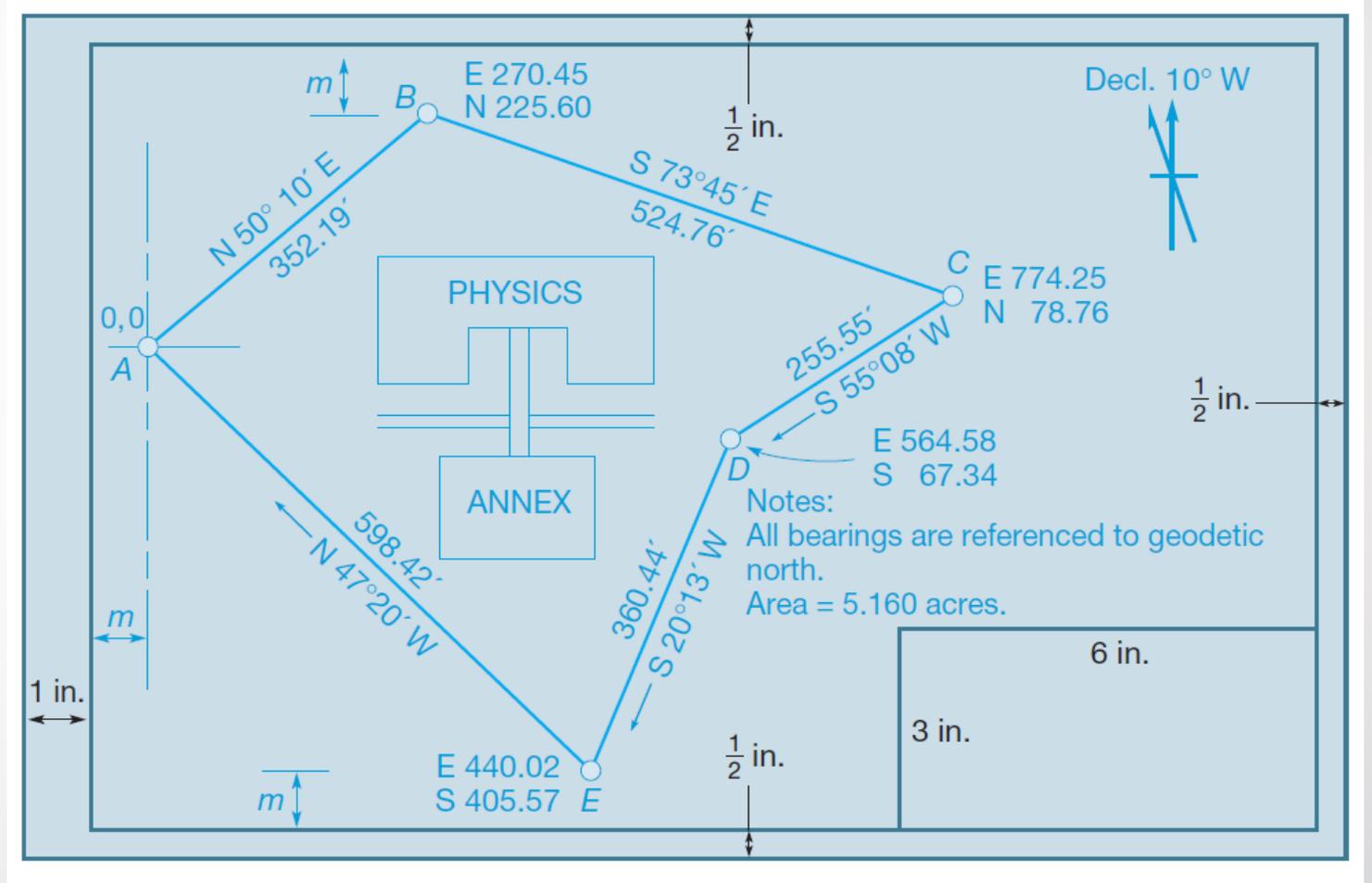
- The subject area of the map should be plotted at the largest scale that will enable it to fit neatly within its borders without producing overcrowding.
- It should also be centered on the map sheet and, if possible, should be aligned so that the edges of the map sheet coincide with the cardinal directions. If this is not done, users may experience some confusion when viewing the map.
- Accordingly, the size and shape of the map sheet, the size and shape of the area to be mapped, the orientation of the subject area on the map sheet, and map scale, must be jointly considered in map layout.

# Map Layout

**Example: a simple traverse from a planimetric survey.**

Before any plotting is done, the proper scale for a sheet of given size must be selected. Assume in this example that an 18- by 24-in. sheet will be used, with a 1-in. border on the left (for possible binding) and 1/2-in. borders on the other three sides.

A borderline somewhat heavier than all other lines can be drawn to outline this area.

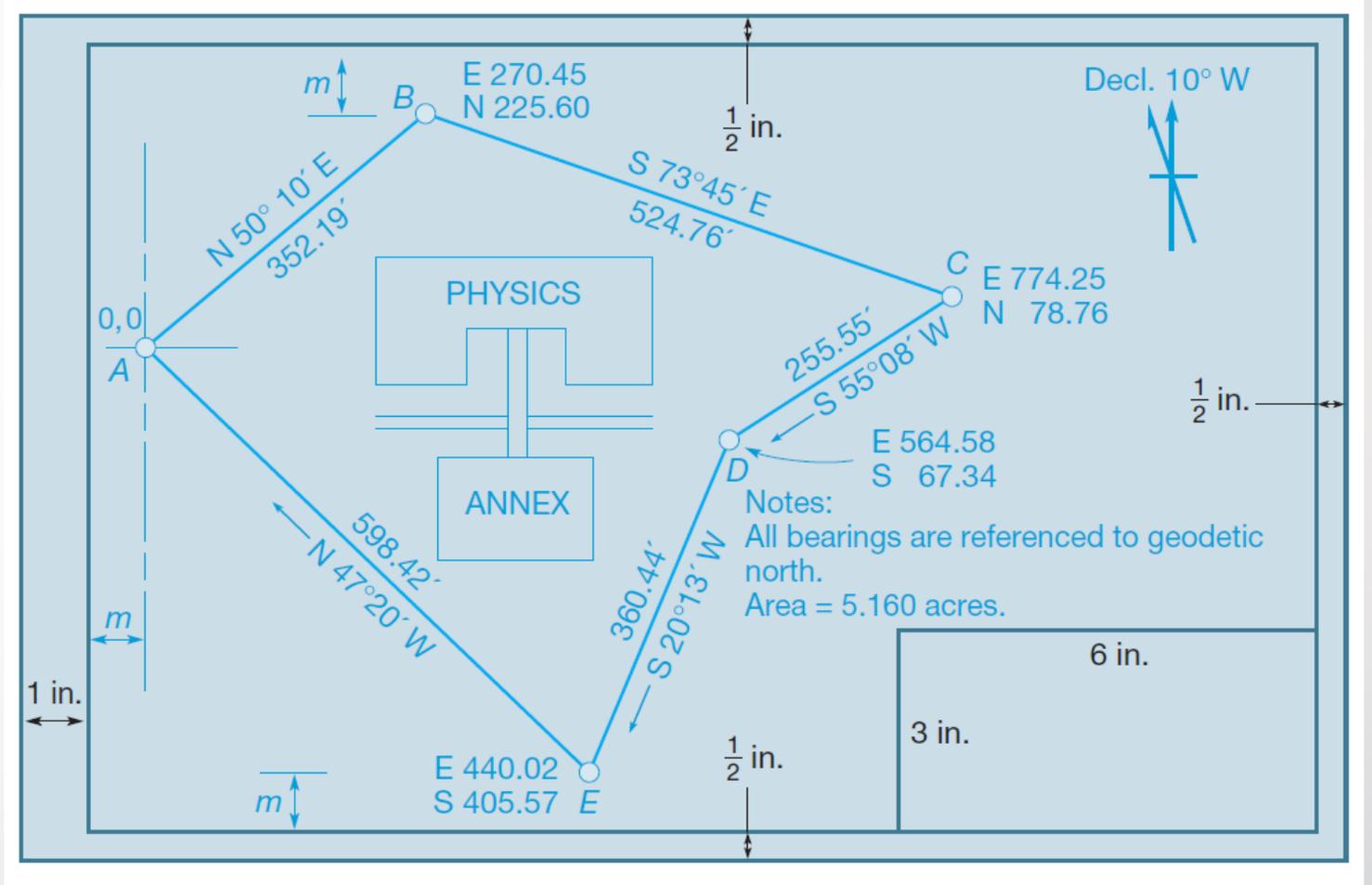


# Map Layout

**Example: a simple traverse from a planimetric survey.**

If the most westerly station (A in the example) has been chosen as the origin of coordinates, then divide the total departure to the most easterly point C by the number of inches available for plotting in the eastwest direction. The maximum scale possible is 774.25 divided by 22.5, or 1 in. = 34 ft. **The nearest standard scale that will fit is 1 in. = 40 ft.**

This scale must be checked in the Y direction by dividing the total difference in Y coordinates (631.17) by 40 ft., giving 15.8 in. required in the north-south direction. Since 17 in. are usable, a scale of 1 in. = 40 ft. is satisfactory.

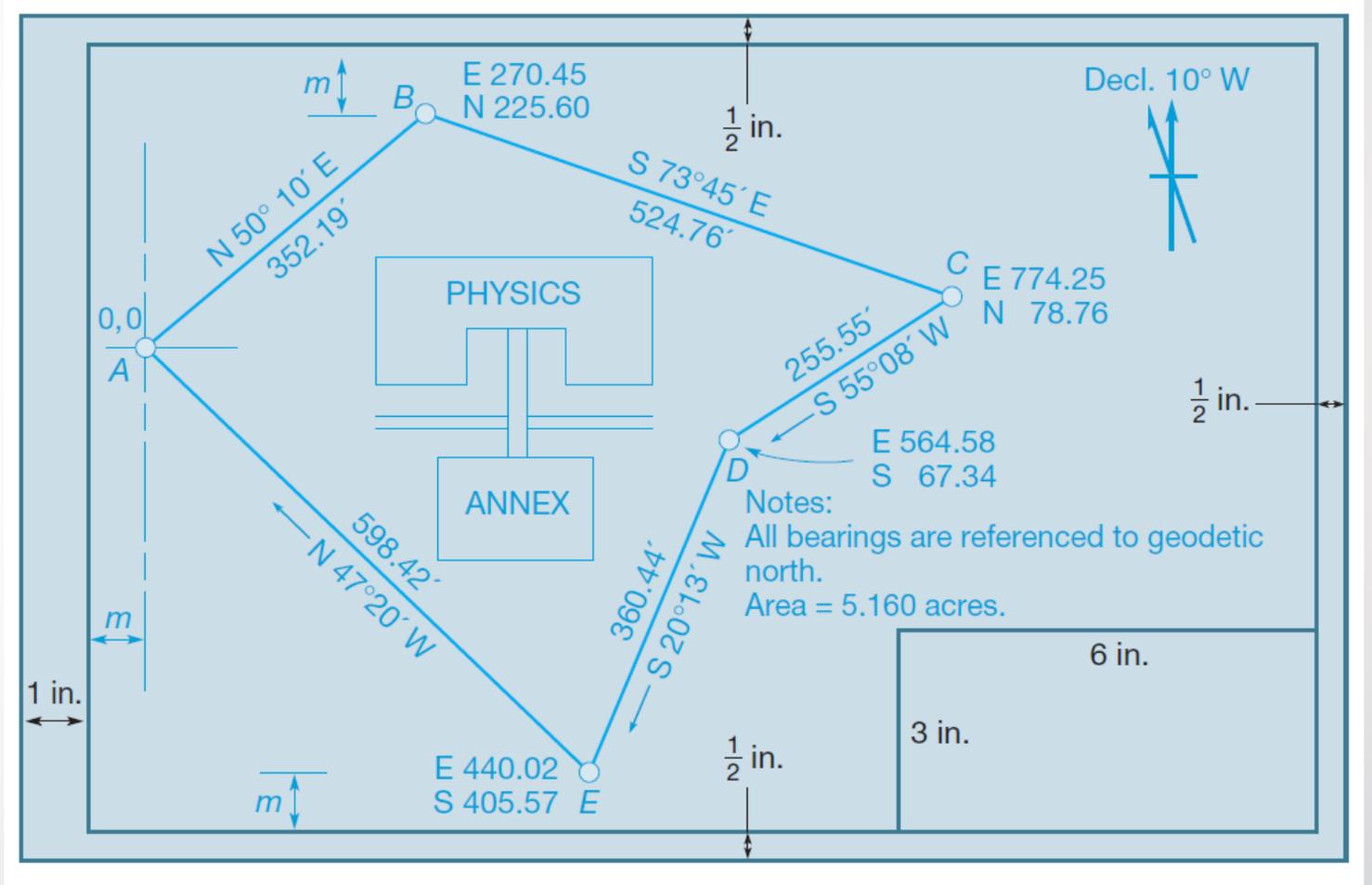


# Map Layout

## Example: a simple traverse from a planimetric survey.

The traverse is centered between the borderlines in the  $Y$  direction by making each distance  $m$  equal to  $\frac{1}{2}(17-631.17/40)$ , or 0.61 in. The same 0.61 in. can be used for the left side.

Weights of the title, notes, and north arrow compensate for the traverse being to the left of the sheet centre and leave ample space for including the necessary auxiliary elements of the map



- The choice of contour interval to be used on a topographic map depends on the map's intended use, required accuracy, type of terrain, and scale.
- If, according to National Map Accuracy Standards, elevations can be interpolated from a map to within one half the contour interval, then if elevations taken from the map must be accurate to within  $\pm 1$  ft., a 2-ft maximum interval is necessary. However, if only 10-ft accuracy is required, a 20-ft contour interval will suffice.

**Terrain type and map scale combine to regulate the contour interval needed to produce a suitable density (spacing) of contours:**

- 1) Rugged terrain requires a larger contour interval than gently rolling country and flat ground mandates a relatively small one to portray the surface adequately.
- 2) If the map scale is reduced, the contour interval must be increased; otherwise, lines are crowded, confuse the user, and possibly obscure other important details.

English System		Metric System	
Scale (ft/in.)	Contour Interval (ft)	Scale	Contour Interval (m)
50	1	1:500	0.5
100	2	1:1000	1
200	5	1:2000	2
500	10	1:5000	5
1000	20	1:10,000	10

In plotting contours, points used in locating them are first plotted on the map following special techniques:

- Contours found by the direct method are sketched through the plotted points.
- Interpolation between plotted points is necessary for the indirect method.

Contours are drawn only for elevations evenly divisible by the contour interval:

- For a 20-ft interval, elevations of 800, 820, and 840 are shown, but 810, 830, and 850 are not.
- To improve legibility, every fifth line (those evenly divisible by five times the contour interval) is made heavier: for a 20-ft interval, the 800, 900, and 1000 lines would be heavier.

An important part of the contents of any map is its textual information.



The title and all feature names, coordinate values, contour elevations, and other items must be clearly identified.



To produce a professional looking drawing and one that clearly conveys the intended information, a suitable style of lettering must be selected.



That style should be used consistently throughout the map, but the size varied in accordance with the importance of each particular item identified.

Lettering that is too big or bold should not be used, but the letters must be large enough to be readable without difficulty.

Lettering should be carefully placed so that it is clearly associated with the item it identifies and so that letters do not interfere with other features being portrayed.

Typically, the best balance results if names are centered in the objects being identified.

Also both appearance and clarity are generally improved by aligning letters parallel with linear objects that run obliquely.

For ease in map reading, letters should be placed so that the map can be read from either the bottom or its right side.

Text should take precedence over line work.

If necessary, lines should be broken where text is placed, as this improves clarity.

It is best to select straight, or nearly straight, sections of contours for labeling.

Contours should not be labeled around tight turns since this will remove valuable topographic information expressed by the contours.

When using automated drafting techniques, manuscripts must be carefully examined to make sure that the text and lines do not overwrite each other and any observed overwrites corrected

## Essential cartographic elements included on maps:

Notes

Legends

Bar scales

Meridian arrows

Title blocks

# Cartographic Map Elements

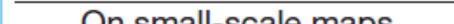
## Notes

- Notes cover special features pertaining specifically to a particular map:
  - *Datum for elevations is the NAVD88.*
  - *Area by calculation is X acres (or hectares).*

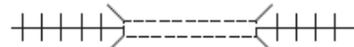
## Legend

- Cartographic symbols and different line types are commonly used to represent and portray different topographic features on maps.
- Legends are employed to explain the meaning of those symbols and lines.

### Topographic symbols

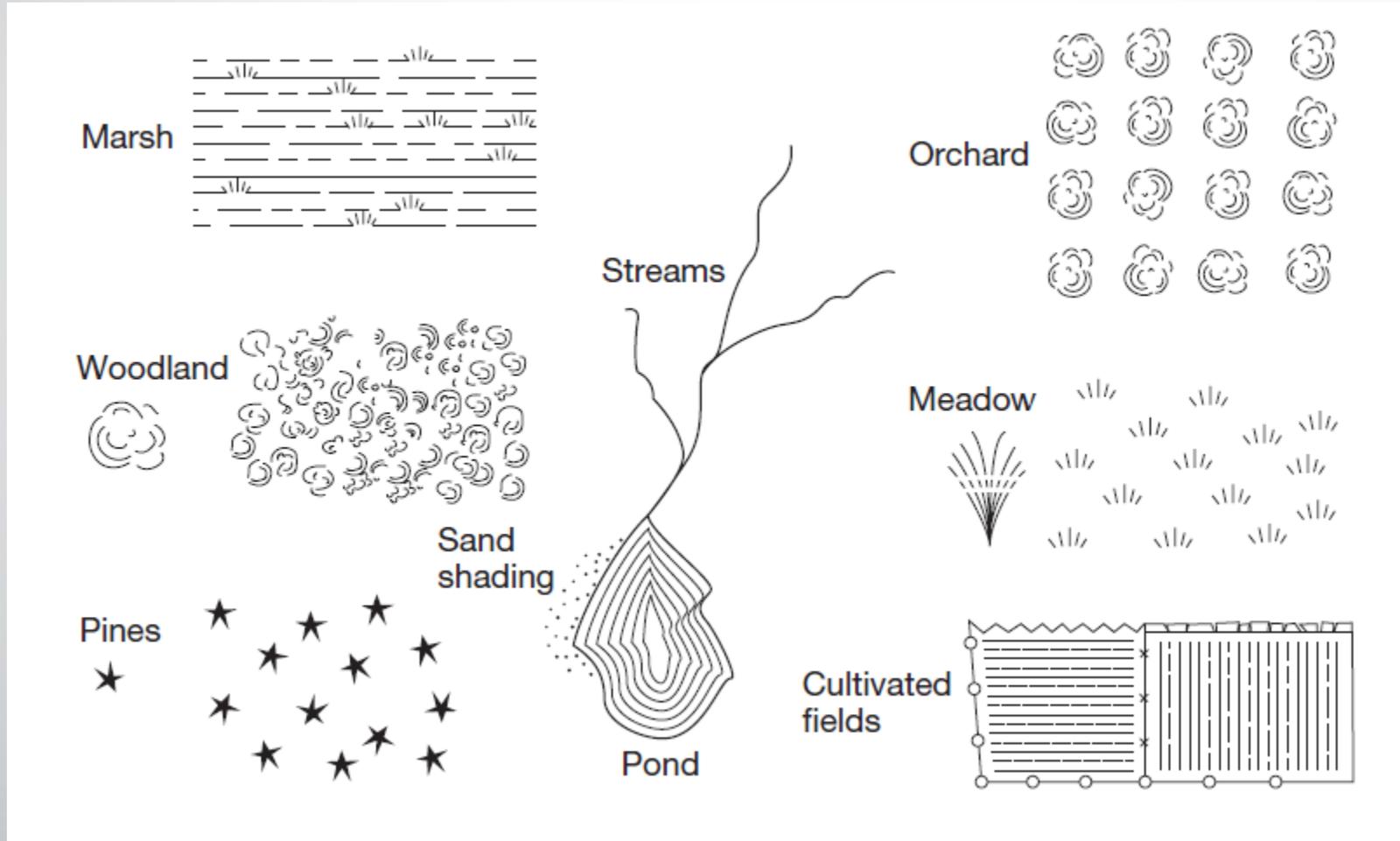
Roads		Good motor
		Poor motor or private
		On small-scale maps
Trails		Good pack
		Poor pack or foot

Railroads		Single track
		Double track
		In road or street

Tunnel	
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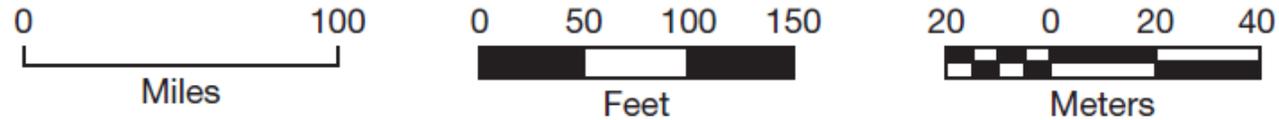
Buildings	
Triangulation or 1st-order traverse station	
Iron pipe	
Permanent BM (and elev)	BM x 863.12
Intermediate BM (and elev)	x 876.42

## Topographic symbols



## Scale

- The scale of the map should preferably be presented as both a representative fraction and a graphical element.



## Meridian Arrow

- Every map must display a meridian arrow for orientation purposes.
- However, the arrow should not be so large or elaborate that it becomes the focal point of a sheet.

## Title Block

- The title block should state the type of map, name of property or project and its owner or user, location or area, date completed, scale, contour interval, horizontal and vertical reference systems (datum) used, and for property surveys, the name of the surveyor with his or her license number.

## Sources of error in mapping include:

1. Errors in the data used in plotting.
2. Errors in the scales used for laying out lengths and coordinate values.
3. Errors in laying out grids for plotting by coordinates.
4. Using a soft pencil, or one with a blunt point, for plotting.
5. Variations in the dimensions of map sheets due to temperature and moisture.

## Some common mistakes in mapping are:

1. Selecting an inappropriate scale or contour interval for the map.
2. Using the wrong edge of an engineer's scale.
3. Making the north arrow too large or too complex.
4. Neglecting to identify the meridian of reference, that is, geodetic, grid, magnetic, etc.
5. Omitting the scale or necessary notes.
6. Failing to balance the sheet by making a preliminary sketch.
7. Drafting the map on a poor-quality medium.
8. Failing to realize that errors are also magnified when maps are enlarged electronically or photographically.

# End of Lecture 18: Mapping