CHAPTER 38

TYPES OF DRAWINGS USED IN LAND DEVELOPMENT

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INTRODUCTION
There are numerous types of maps and drawings, each with its own characteristics with regard to scale, orientation and purpose. With practice and exposure, one can recognize many of these characteristics by inspection and be able to read and create drawings effectively. For example, to the uninitiated a site plan may seem messy, unorganized and difficult to read. However, as one gains experience, reading the site plan becomes as simple as reading a newspaper.

Project design is an evolution of ideas presented in the form of maps and drawings. Design begins with worksheet drawings—a compilation of existing information amassed from other maps and drawings. The project evolves from generalized ideas scribbled on the worksheets into the high-detail, final-design drawings when project ideas are formalized. More specifically maps, drawings and specifications are the tools that:

- Help insure a viable design
- Show where and how a project will be built
- Show where and how a project was built
- Are used for estimating costs and materials
- Show whether the project conforms to ordinances and codes
- Become legal documents for the project

Maps and drawings can be as simple or as complex as necessary; it depends on what information needs to be conveyed and who is reading them. A well-developed drawing is neat and readable, but more importantly it is accurate and clear. Some inaccuracies are caused by the transfer of data, distortion, and paper stretch. This need not be magnified by carelessness or laziness during design. Often during design, a scaled measurement is used to further the design. Any inaccuracy in the drawing is then carried over to other design areas and can become critical during construction. In addition, the adequacy, accuracy, and clarity of the drawings avert arguments and possibly legal conflicts during the course of the project.

Maps and drawings use symbols, abbreviations and jargon specific to the industry. People associated with land development projects must be familiar with reading civil site drawings, structural drawings, architectural drawings and survey maps. Each of these has numerous variations of plan sheets and detail drawings. By being familiar with the types of drawings, the user can identify quickly the type of drawing that has the needed information. A construction drawing set for civil site work could have 20 to 30 sheets. The architect’s set of drawings for the same project will likewise have as many sheets. Add this to the numerous mechanical and structural drawings associated with the project and the finding of specific information or cross checking of dimensions could become an ordeal to the uninitiated.

MAPS
According to Manual No. 34 by the American Society of Civil Engineers, a map is "a representation on a plane sur-
face, at an established scale, of the physical features (natural, artificial or both) or a part or the whole of the earth’s surface by the use of signs and symbols, and with the method of orientation indicated.” Maps depict the real world of three dimensions on two-dimensional media. Features shown on a map originate from data collected and compiled in various ways. This data has been simplified, manipulated, enhanced and even distorted so that the map is able to present the features in a usable manner. The accuracy of a map is determined by comparing the actual position of an object from field measurements to its position as shown on the map. This relative accuracy presumes there is no error in the field measurement. Several agencies and organizations have set standards for map accuracy: the Office of Management and Budget, The Reference Guide Outline, and American Congress for Surveying and Mapping (ACSM), to cite a few.

Maps are of two basic varieties: planimetric and topographic. A planimetric map shows horizontal positions of various features at the surface such as roads, buildings, trees, lakes, and rivers. Planimetric maps show only the features that are essential to the purpose of the map. Familiar examples of planimetric maps are street maps, political boundary maps and zoning maps. Maps with contour lines, referred to as topographic maps, show spatial variations as well as essential surface features. Vertical spatial variations appear as contour lines or as relief. The types of topographic maps used in the design process include the topographic maps from local public agencies or USGS quadrangle maps, as well as those created by surveys of the project site itself. Figure 38.1 compares a planimetric with a topographic map of the same vicinity.

Creating a Map

The making of a map begins with smoothing out the shape of the Earth, and approximating the true irregular shape of the Earth with a mathematical model does this. Most often, this approximation is a sphere, spheroid, or ellipsoid. The approximated shape is reduced in scale and then transformed onto a flat surface. Three common methods for making this transformation, as shown in Figure 38.2, are by projecting the features of the globe onto a cylinder, cone, or surfaces. These surfaces are then unrolled, or developed, to make the flat, two-dimensional map.

The transformation results in the distortion of the features, such as landforms and continents. The transformation requires that either shape or size of the feature be maintained. Maps where the shape of the feature on the developable surface have the same area as the shape on the globe are known as equal-area maps. In maintaining equal areas, the shapes of the features are changed. For example, a circle on the globe might appear as an ellipse on the developable surface. Those maps where shape is maintained at the expense of size are conformal maps. A circle on the globe appears as a circle on the developable surface; however, there is no resemblance between the areas of the two shapes. For example, the area of Greenland is about 1/6th the area of South America. However, on many conformal maps the two appear nearly equal in size.

Lambert and Transverse Mercator Projections

Two types of map projections specifically related to land development projects are those used to develop state plane coordinate systems. These two projections are the Lambert conformal conic projection and the transverse Mercator projection.

Most state plane coordinate systems divide the state into zones—north-south zones or east-west zones depending on whether the state is elongated in the north-south or east-west direction. Those states elongated in the east-west direction use the Lambert conformal conic projection. This type of map projection, shown in Figure 38.3, wraps a conic section around the Earth’s surface, which intersects the sphere at two specific locations. The circles within the sphere created at the intersection locations represent parallels of latitude, referred to as standard parallels. Along these parallels the scale is exact. Between the two standard parallels the scale is less than true. Outside the standard parallels the scale is greater than true scale.

The transverse Mercator projection of Figure 38.4 wraps a cylinder around the Earth such that the cylinder’s axis lies in the plane of the equator. Along the two locations where the cylinder cuts the sphere, the scale is exact. Distortion between these locations causes the scale to be less than true scale. Outside the locations the scale is greater than true.

Map projections are created by mathematically projecting points from the sphere along radial lines from the Earth’s center onto the projection surface of the imaginary cone or cylinder. The distortions in scale between or outside the parallel circles are evident from Figure 38.5. Outside the parallel circles lines ab and ef are longer than the actual surface represented by a’b and e’f’ illustrating why the scale is greater than true in these sections. Similarly, line cd on the projection surface is shorter than line c’d’ on the sphere of the Earth. Distortion can be kept within tolerable limits by proper selection of the location of the intersection of the sphere and projection surface.

LEGENDS AND SCALE

Maps and drawings use combinations of symbols and variations in lines to represent specific features and data. The meaning of the symbols and line variations is provided on the map in the legend. It is helpful if the legend is located on the map itself, usually near a corner of the sheet. However, in a map or drawing set containing more than one sheet, the legend is usually shown on the first sheet.

Bar Scales

The relationship between distances on the map and corresponding distance at the Earth’s surface is the scale. Map
scales are either graphic or numerical. The most common graphic method is the bar scale—a line with calibrated marks at intervals that represent distances on the map. For example, Figure 38.6 shows bar scales that might appear on a map for miles, feet, and kilometers. Although a bar scale is needed for each system of units, the advantage is evident when the map is reduced or enlarged. Although the map scale changes during reproduction, the bar scale shrinks or enlarges proportionally to the drawing.

The numerical representation of a map scale is given as a ratio or representative fraction. The ratio represents a unit distance on the map to the corresponding number of equivalent units on the Earth’s surface. For example, a ratio given as 1:30,000 means that one map unit represents 30,000 units on the Earth’s surface. Therefore, a distance that measures 2 in. on the map is actually 60,000 in. (5000 ft) on the Earth’s surface. Since the scale ratio is dimensionless, it applies to any system of units. This method is somewhat cumbersome in that a conversion is necessary to change the larger dimension into something usable.

**Engineering and Architectural Scales**

The conversion is avoided by the use of another method for depicting scale. This method, perhaps the most popular for design drawings, associates a unit measurement on the drawing to a usable measurement at the Earth’s surface. An example for this method shows scales as 1 in. = 50 ft or ¼ in. = 1 ft. The first example is used typically on engineering drawings and is convenient for the type of tool used to measure distances. The 1 in. = 50 ft means that a measured distance of 1 in. on the plan represents 50 ft as measured on the Earth’s surface. The latter, ¼ in. = 1 ft example is typical of architectural drawings because of the way the architect’s measuring tool is calibrated. Here a measured ¼ in on the drawing represents 1 ft on the surface of the Earth.
Another definition of scale is the tool that measures map distances, analogous to the 12 in. rule. The engineer’s scale divides an actual inch into fractional parts representing feet and decimals of a foot. For example, the 30 scale divides an inch into 30 uniform divisions—each division representing \( \frac{1}{30} \) of an inch. This translates to each division representing one foot when distances are measured on a scale drawing of 1 in. = 30 ft. The 30 scale also conveniently measures distances on drawings with scales of 1 in. = 3 ft, 1 in. = 300 ft, 1 in. = 3000 ft... etc. In which case each \( \frac{1}{30} \) division represents 0.1, 10, 100 ft, ... etc., respectively. Engineers’ scales commonly available are 10, 20, 25, 30, 40, 50 and 60. Each of these scales are appropriately subdivided to measure dimensions in decimals.

The architect’s scale is based on customary units of inches and feet to be consistent with the system used by the building materials industry. A major portion of the scale is divided into one-foot increments with the ends of the scale outside the zero mark further graduated into inches and fractions of an inch. Each face of the scale has two different scales. One scale is read left to right and the other is read right to left. A number at each end identifies the appropriate scale. The number of subdivisions outside the zero mark depend on the space available for legible markings. The space available depends on the scale; therefore, the subdivisions for each scale represent different fractions of a inch. For example, the \( \frac{1}{8} \) scale has 6 markings each mark representing 2 in. The \( \frac{3}{8} \) scale has 24 markings, each mark representing \( \frac{1}{2} \) in. Typical architectural scales are available at \( \frac{1}{32}, \frac{1}{16}, \frac{1}{8}, \frac{1}{4}, \frac{3}{8}, \frac{1}{2}, \frac{3}{4}, 1 \), and \( 1\frac{1}{2} \) in. A comparison of the two scales showing 4.5 ft is given in Figure 38.7.

The scale of a drawing is inversely proportional to its size. For the same coverage of area, increasing the scale decreases the size. For instance, a square 50-acre tract of land at a scale of 1 in. = 100 ft requires a approximately a 15 x 15-in. area. A larger scale drawing of this tract of
land, say a scale of 1 in. = 30 ft, requires a minimum sheet size of 50 in. square. Decreasing the scale number enlarges the scale, and consequently the size of the drawing increases. An increase of the scale is actually a decrease in the size of the drawing but an increase of the scale number.

It is important in design that the features be drawn precisely to the scale selected for the drawing. Design drawings are used to estimate material quantities and earthwork. During some aspects of design, scaled distances from a plan are used as parameters for other aspects of design. Therefore, it is unequivocally imperative that precision in scale on a drawing be maintained.

Selection of Scale

The scale selected for a drawing depends on the type of drawing, the size of the drawing, the size of the sheet of paper and the desired level of detail. Many public agencies require minimum sheet sizes and scales for particular drawings. For design and analysis purposes, however, worksheet drawings and scales are selected for convenience of the task. Eventually, worksheet drawings are transformed into final drawings. Therefore the scale selected for the worksheets should be the same scale as that of the final drawings. This reduces design time and cost and lessens the chance of error in transferring information from the worksheets to the final drawings. This is the general practice for manual drafting. However, this practice is of little consequence if drawings are produced by digitized drafting methods.

The scale is selected such that the size of the drawing occupies nearly the full sheet, to provide as much clarity as possible. For example, a 5-acre parcel at 100 scale is roughly 5 in. square. This scale is too small for a 24 × 36-in sheet of paper. A more appropriate scale might be 1 in. = 30 ft. On the other hand, a drawing should not be unreasonably enlarged just for the purpose of occupying a whole sheet. Several drawings can be shown on one sheet for those times when the scale is sufficient for the drawing and there is additional room on the sheet. For example, an adequate scale of 1⁄2 in. = 1 ft for a detail drawing of a foundation footing may require an area of 10 in. square. The additional area on a 24 × 36-in. sheet could be used for notes, other detail drawings or calculation charts. It is imperative to label clearly the drawing and the scale of each drawing in such circumstances. Some drawings (e.g. profile drawings—discussed later), use different scales for the horizontal and vertical directions. It is advisable to maintain consistent scales throughout a set of drawings to the extent possible. This can eliminate mistakes and confusion, especially when the drawings are taken to the jobsite where the luxuries of desk/layout space and drafting equipment may be scarce.

DRAWINGS

Project acceptance by the community and approval by public agencies can depend on an accurate graphical and pictorial presentation of the project. Surrounding residents of a project frequently perceive development as an intrusion and disruption to the status quo. The numerous questions by the concerned community generated by new development projects and the resulting anxiety can be addressed
TYPES OF DRAWINGS USED IN LAND DEVELOPMENT

**Figure 38.5** Distortions on projection surface.

**Figure 38.6** Bar scales.
FIGURE 38.7  
Engineers Scale and Architects Scale.
by using various types of drawings to show the effects of the project. Additionally, sufficiently detailed and accurate drawings (and specifications) helps insure that construction proceeds without delays, cost overruns, or legal actions.

The numerous types of drawings used throughout the design process of a land development project include free-hand sketches, three-dimensional perspectives, and various types of projection drawings. During the various phases of design, these various types of drawings assist and record the progression of the project and illustrate the end product. The typical design process includes conceptual drawings, preliminary drawings, construction drawings and others.

Most of the drawings generated throughout the design are parallel-projection type drawings. Of the four types of projection drawings—multi-view, axonometric, oblique, and perspective—multi-view projection drawings are used most frequently for the civil site and some architectural drawings. Multi-view projection drawings, sometimes referred to as orthographic projection, do not have foreshortening or distortion of linear or angular measurement. The other three types of drawings, more frequently used by architects, landscape architects, and occasionally planners, distort the image in order to provide a more realistic picture.

**Orthographic Drawings (Multi-view Projection)**

An orthographic projection shows the details of an object on a plane passed through or in front of one of the faces of the object. The details project onto the plane by extending lines perpendicular to plane from the object to the plane. Orientation of the object to the plane is completely arbitrary and is determined by what or how the specific features should be shown. Any orthographic projection is only two dimensional. The simplicity of these types of drawings is the limiting of detail of only one face; the problem is that many people have difficulty conceptualizing the three-dimensional object from collectively observing the separate views.

Specifically there are six views (in a rectangular coordinate system) of an object (see Figure 38.8). Each view represents the face of a cube. The six views are labeled: front, rear, top, bottom, left side, and right side. There is a correlation between these fundamental views and the common views of construction drawings. A plan view is analogous to the top view, a profile view compares to a front (or rear) view and the cross-section view compares to the left or right-side views. A plan view identifies spatial relationships in the horizontal plane by presenting the object as viewed from overhead. Profile views show the object longitudinally. They detail features of items where the length is greater than the width (e.g., streets, water mains, sanitary lines, and storm-sewer lines). Cross-section views, on the other hand, are oriented at right angles to the longitudinal direction. Street sections, channel/ditch sections, stream valleys and foundations are items frequently shown in section views.

These three views—plan, profile, and cross-section—are those used for most civil site drawings. The counterparts to these in the architectural profession are plan and elevation drawings. Figure 38.9 illustrates this comparison.

The profile and cross-section views are the result from passing a vertical plane through an object or feature. In

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**Figure 38.8** Six views of an orthographic scale.

**Figure 38.9** Orthographic views for engineering and architecture.
practice the vertical planes do not have to be straight. They can be angular or curvilinear if the situation warrants. The objects or features do not have to be cut by the vertical plane in order for them to appear in the view. Often the features lie behind the vertical plane and are projected onto the view. The location of the feature, whether it lies on or behind the vertical plane in one view, can be determined from observing that feature in other views.

**Plan Views.** These show the pertinent data as it would appear if viewed from directly overhead. As with any type of drawing, line weights and styles (e.g., dashed) help categorize similar elements and emphasize the important elements. For example, all proposed buildings might be shown with a thick heavy line. Tangible objects such as curb and gutter and buildings are shown, as well as intangible elements such as property lines, easement lines and, when appropriate, contour lines. The horizontal arrangement of the elements is shown to the correct scale.

Typically, a design phase of the project begins by drawing the plan view of base information. These initial sheets are referred to as base sheets. The information includes any existing features and elements that need to be shown and are pertinent to the design (e.g., property lines, existing roads and buildings, existing easements and utilities, and streams). Since this base information is what the design evolves from, it is highly imperative that this information be drawn accurately from reliable field information.

**Profile Views.** To establish the profile view, a base line or reference line is established in the plan view. The reference line might be the centerline of a road or the centerline of pipe for a water main, sanitary line, or storm-sewer line. In other cases the reference line might be edge of pavement, top of curb, or any other established reference line where the vertical relationships need to be examined. A reference system (e.g. stationing) along the reference line is shown in both plan and profile views. This helps in correlating a position on the reference line in the plan view with the profile view. Note that horizontal scale is different from the vertical scale in most profile drawings.

The horizontal axis of the profile view represents the selected-reference line. Although the reference line may curve and meander in the plan view, it appears straight in the profile view. The vertical axis of the profile view represents elevations. For example, existing and proposed ground elevations are plotted in the profile by locating the reference-line station in the plan view where contour lines cross the reference line. This elevation is then plotted at the appropriate station in the profile view. After the ground-elevation points are plotted in the profile view, they are connected by dashed lines to depict existing grade and solid lines for proposed grade. Additionally, underground utilities and other existing features that cross the reference line, or come very close to it, should be plotted and identified in the profile view. Such items will affect the design. Figure 38.10 shows how the profile is developed from the plan view. However, the two views are not necessarily aligned such that the viewer can project elements directly from one view to the other as is the case in Figure 38.10.

**Cross-Section Views.** Often in the design of roads, large conveyance channels, and floodplain studies, cross sections become a necessary part of the design drawing set, either by ordinance requirement for approval or to facilitate the engineering design itself. Similar to profiles, cross sections also show vertical relationships of existing and design features except that they are oriented perpendicular (or nearly perpendicular) to the reference line. Their purpose is to show the vertical relationships of objects and design details that cannot be shown effectively in other views.

Cross-section views (see Figure 38.11) are plotted in a manner similar to profile views. The location of each section is determined in the plan view. Cross-section lines typically intersect the reference line at right angles. However, the situation does arise in which features can be better illustrated if the cross-section line is skewed with the reference line. At appropriate scales, the sections are plotted with the horizontal axis representing the perpendicular distance relative to the reference line and the vertical axis as elevations. The reference-line location is identified on each section by the stationing. From the plan view, the distances from the reference line to points of known elevations on the section line are determined. This same distance is measured from the reference line in the section, and the elevation is plotted. After all elevations are plotted, the points are connected and the lines appropriately labeled as existing or proposed when required for clarity.
A common pitfall when plotting or reading sections is the location on the section relative to the reference line. Positions left or right of the reference line depend on which direction of the reference line one is facing. If the reference line runs north-south, for instance, and the stationing increases going north, then the left side of the reference line is west. This is typical for road and highway sections. The left side is the side as determined from facing the direction of increasing stationing. Although the selection left or right vis-a-vis ahead or behind stationing is purely arbitrary, the cross sections must be consistent, and indication must be given on the plans to alert the reader to the orientation.

When several cross sections appear on the same sheet, the reference line of each section should be aligned with the preceding section. As shown in Figure 38.12, this enhances the appearance of the design sheet and helps in visualizing the continuity of the sections.

Spacing of cross sections depends on their purpose. Typically in road design, cross sections are spaced every 50 or 100 ft. Channel and stream-valley cross sections are located where there is significant change in the topography to warrant a cross section, although there is usually a prescribed maximum distance set by local agencies.

The purpose of profile and section views is to show the vertical relationship of objects. Because the longitudinal distance for the object is so long, the vertical relationship cannot be shown effectively if the same scale is used in the vertical and longitudinal direction. Very often, profile views and cross section-views use a larger scale in the vertical direction to exaggerate and accentuate these vertical relationships. As a result, take-off quantities may be better served from cross-section views rather than profile views. A comparison of an unexaggerated profile view with the exaggerated view is shown in Figure 38.13.

**Pictorial Projection Drawings**

A pictorial drawing shows the object in three-dimensional form. This type of drawing conveys design concepts in a non-technical manner. Three types of pictorial projection drawings are: perspective, axonometric and oblique. Each type differs on how the object is projected onto the projection plane. Figure 38.14 shows the projection plane for the three types of projection drawings and the multi-view drawing.

**Perspective.** Of the three types of pictorial drawings, the perspective drawing is the most realistic in that it shows the object as perceived by the human eye and eliminates optical distortion produced by other pictorial-projection drawings. Parallel lines converge to vanishing points (V.P.) in the drawing as they recede from the observer. This gives the illusion of depth. Perspective drawings may have one or several vanishing point (see Figure 38.15).

**Axonometric.** The axonometric drawing is a projection drawing where the projection lines are parallel to each other and perpendicular to the projection plane. The axonometric drawing is a view of the object such that it is turned and slightly inclined to the projection plane. The drawing is transferred to the projection plane with parallel projection lines perpendicular to the projection plane. The three edges of the object that meet at the corner nearest the observer are the axonometric axes. Axonometric drawings are classified as: isometric if the angles of the axonometric axes are equal; diametric if two angles are equal; and trimetric if the three angles are unequal. Figure 38.16 illustrates these different types of axonometric drawings. Scale can be determined along each of the three axonometric axes. All lines parallel to each axis will be to the scale of that axis.

**Oblique.** The reference axes for an oblique drawing are horizontal, vertical and depth, similar to the axonometric drawing. For elevation obliques, the object is oriented with one of the faces parallel to the projection plane. This makes the angle between the horizontal and vertical reference axes 90°. The other two angles are arbitrarily selected at the convenience of the drawing. Typically, the angle between the horizontal axes and the depth axes is 30°, 45° or 60°, the standard angles of drafting triangles. Plan obliques are depicted with a high angle of view, with either a horizontal or vertical plane receiving more emphasis than other planes.

The projection lines from the object are all parallel but make an oblique angle with the projection plane. Oblique drawings that use full size height, width and depth are known as cavalier oblique drawings. These drawings portray the object as having an exaggerated depth. To give the object a visually-correct appearance, the cabinet oblique...
drawing shortens the depth dimension to 1⁄2 of the width and height dimension (see Figure 38.17).

**Microcomputer Graphics**

The microcomputer has revolutionized design and drafting. Solutions to design problems and creation design drawings are done almost concurrently with the aid of microcomputers and software application programs. Producing drawings at various scales, viewing the designed product from any perspective in three dimensions and color design drawings essentially can be had at the touch of a button. Revisions to the design and to the drawings can be performed very quickly and efficiently. One distinct advantage of using a computer for design is the ability to generate customized drawings. For example, a drawing showing only proposed roads and existing topography at one scale can be generated, and in a short time another drawing can be generated showing lot lines, sanitary sewer and waterline at a different scale—that is, once the data has been entered into the drawing file.

Microcomputer graphics can be used to link information among the various disciplines. For example, surveying field data can be downloaded to a microcomputer file, which can then be accessed for engineering-design purposes. Conversely, data generated from engineering design can be transferred to surveying equipment to make for easier field measurements. The sharing of information translates to savings throughout the design process.
The design and the drawing is only as good as the person who operates the machine, the available input data, as well as the limitations of the software program. Despite the dramatic effects of the microcomputer, one realization frequently overlooked is the over-emphasis placed on the reliability of the output. For the most part, the output from most software programs is accurate and reliable. However, the designer should not blindly accept output design just because a computer generated the solution. A familiarity with the software and its limitations is essential to produce a good design. When a designer’s intuition results in a suspicious feeling about a computer-generated design, it is best to follow that intuition and investigate the solution until an acceptable comfort level is attained. Don’t be reluctant to challenge the output from a computer. Computers have not changed the nature of the design process, only the efficiency and productivity.

**TYPES OF DRAWINGS USED IN LAND DESIGN**

**Project Planning**

During initial stages of the design process, a small-scale plan view of the project area with the property lines, existing features and topography is used as the base to begin planning the project. The location and identification of the features are taken from existing records rather than field-run surveys. At the very early planning stages, initial layout of the site is a broad-brush generalization that “roughs-in” the major streets, residential areas, commercial areas, recreational areas, open space areas and other major ideas about the design. Residential and commercial areas are located with only free-hand circles, streets have no geometric smoothness, and ideas for proposed land use are labeled in the general vicinity of their impact. Such an abstract and symbolic drawing is commonly referred to as a bubble diagram or blob diagram (see Figure 38.18).

As the project evolves, the bubble diagram is further refined to what is referred to as the concept plan or concept diagram. The identified residential areas and commercial areas show building location, entrances, parking areas, open space areas, ponds and other amenities. Major roads are refined to a reasonable geometric relationship. Realizing that the building has, in all likelihood, not been designed at this stage, the building footprints shown on the conceptual diagram are only representations of potential building configurations. Parking areas are drawn to within a reasonable area that accounts for the estimated number of re-
required parking spaces. On large projects, the conceptual plan shows the project broken down into different phases and the order the phases will be developed. Figure 38.19 is the concept plan for the bubble diagram of Figure 38.18.

The conceptual plan is then modified into separate site-analysis diagrams that illustrate specific concepts about the site. Such diagrams may show views from different directions away from the site, solar orientation, hydrologic and hydraulic issues, or how the site appears from the road or entrance during various stages of completion. Some site-analysis diagrams are sometimes prepared before the concept plan is started. These diagrams evaluate the site for specific existing conditions.

Preliminary-layout drawings typically follow as the next design phase begins. These drawings take the conceptual diagrams to the next level of detail. Lot lines are drawn such that each lot size and configuration conforms to zoning regulations, streets are drawn with proper geometric characteristics that conform to design speed and traffic loads (e.g., minimum widths and minimum radii), preliminary grades for design are indicated by spot elevations, etc.

During early stages of the project, members of the design team frequently meet with civic groups, neighborhood citizens, staff of local planning agencies, environmentalists and other people not adept at reading technical drawings. In order to relay project-design ideas, they prepare various types of presentation drawings. These drawings are enhanced versions of the plan view or three-dimensional perspective drawings sometimes shaded and colored to convey project ideas more clearly. Occasionally they are enlarged for presentation purposes.

An illustrative plan is a plan view of the project that is colored or shaded to depict open space, parking, streams, lakes and other site characteristics. Buildings, trees, lot lines, and other physical features are illustrated to embellish

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\[ \Delta a = \Delta b = \Delta c \quad \text{Isometric} \]

\[ \Delta a \approx \Delta b = \Delta c \quad \text{Dimetric} \]

\[ \Delta a \approx \Delta b \approx \Delta c \quad \text{Trimetric} \]
**FIGURE 38.17** Cavalier and cabinet oblique drawings.

**FIGURE 38.18** Bubble diagram.
the drawing. Perspective drawings of the site, colored and shaded (i.e., renderings), also help the uninitiated visualize the project. Often, one type of drawing may serve several purposes. Figure 38.19 is also an illustrative-type drawing.

Civil Site Drawings

The civil site drawings are the technical drawings created by engineers that show site improvements such as building location and grading, road design, utilities and storm-sewer network. Many of these drawings become the construction drawings when sealed by the engineer and approved by the appropriate public agencies. Typically, the civil site drawings use orthographic-type drawings to show the site as it exists and the finished project. In rare circumstances, the civil site drawings may include a pictorial type of drawing. On complex projects, drawings may be included to show intermediate stages of the project. For example, on a site where massive earthwork is required there may be several grading plans showing the grading at intermediate stages.

Location of existing and proposed structures such as buildings, streets, and utilities, size and type of materials, existing and proposed grades, appropriate details and computation analysis are all common elements in the full drawing set. Although the drawings' main purpose is to direct the construction, they are also used for quantity take-offs and bidding purposes. Submission of the completed set to various public agencies is mandatory in most localities. Public agencies such as department of transportation, department of public works, water authority and utility companies, fire marshall’s office, and others all must approve the design of their respective disciplines. Until such complete approval is obtained, site-construction activities cannot begin. The review and approval by these public agencies is necessary to insure the design conforms to applicable codes and standards. (See Chapter 19, The Plan Submittal, Review and Approval Process, for further discussions.)

A typical construction-drawing set includes:

1. A cover sheet—this contains general notes regarding general site/project conditions, vicinity map, sheet index, legend for symbols used in the plan set, block areas for public agency approval stamps and signatures, the name and address of client/developer, and name of the project manager.

2. Grading plan/site plan—this is a plan view showing horizontal location of the existing and proposed buildings, roads, utilities, parking areas, storm-sewer network, and existing and proposed contours.

3. Plan and profile sheets—these are drawing sheets with part of the sheet showing a plan view and part showing a profile view of the road, utility, storm-drain section etc. Depending on the nature of the project, a plan and profile view could show several facilities on the same sheet. For example, a length of street with water, sanitary, and storm sewer could all be shown on the same plan and profile view. In other cases, such as a sanitary-sewer outfall running through tracts of land, the plan and profile sheets would show only the sanitary line. Various examples of a plan and profile drawing can be seen throughout the book.

4. Sediment and erosion-control plan—this identifies the size, location, and types of various structural and vegetative measures that are used throughout the duration of the project to control erosion and sediment. Typically, this sheet contains a narrative. Drainage divides are depicted on this sheet to support the erosion and sediment-design decisions.

5. Calculation sheet—these sheets show the storm-sewer design calculations relating to inlet and pipe sizing. Calculation sheets also show stage-storage and stage-discharge curves for storm-water management facilities or other calculations for the benefit of the review process and to be used by other design professionals.

6. Various detail sheets—most designs use local and national standards for construction. Occasionally no standard exists or the specifics of the site preclude the use of an existing standard. In such cases, the engineer composes his own detail drawings.

7. Landscaping plan and detail sheet—these drawings locate and identify the types of trees, shrubs, and other vegetation for the project.

8. Record plats/easement plats—although these drawings are not typically thought of as part of the construction set, they may be a required part of the submission set to the public agencies. These plats show the subdivision of the original tract, right-of-way acquisitions and dedications, and the granting of certain property rights (e.g., easements).

The number of drawing sheets in a construction set varies according to the size of the project, the scales selected for the drawings and the requirements of the public agencies. The foregoing sheets are the more common sheets; other drawing sheets are included as the particular project warrants. The project engineer is responsible to see that the set contains all sheets necessary for communicating proper information to the contractors and public agencies. Insufficient or inadequate drawings will delay the approval process and cause headaches for the builder, and this occasionally results in backcharges to the engineer.

Survey Drawings

Frequently, survey drawings and maps are referred to as plats. Boundary plats, easement plats and subdivision plats are a few types of survey drawings encountered in land development projects. Additionally, surveyors are responsible for topographic maps and as-built plans, sometimes called record drawings. Most survey drawings are a form of a plan view.
Boundary lines, lot lines, easements, etc. at the subdivision level are identified with bearings and distances. In the public-land system, a lot in a subdivision is referenced eventually to the township in which it is located. The public-land system partitions land according to latitudes and longitudes of the Earth. Base latitudes and longitude lines were established. From there, land was blocked off into 6-mile square rectangles. Each township was further divided into 1-mile square rectangles called sections. Sections were divided into halves, quarters, and quarter sections. The intent of establishing this system was to provide a simple method for real property identification to facilitate the apportionment of government lands to private ownership beginning in the early nineteenth century. Thirty-two states used the public-land survey system. The remaining 20 states rely on metes and bounds, lot and block for land descriptions. With the public-land system, any lot can be traced backwards to the township.

Early property boundaries in the “metes and bounds states” were identified by referencing physical features of the property. That is, the property lines were identified as “from the fence post to the oak tree to the pine tree stump to the edge of the swamp.” A surveyor surveyed the property, and, based on the metes and bounds description, established property lines with bearings and distances.

Boundary plats (see Figure 38.20) establish the property lines for the project. The plat shows the monuments set and found, and the bearings and distances for each line. Existing easements or the potential for existing easements is shown. Although the boundary is essential for planning design, often the planning design begins using only plotted-deed descriptions to expedite the design process. When the boundary survey is complete, the design worksheets are updated to the newly-established boundary. For the purposes of conceptual and preliminary site analysis, a plotted-deed boundary is usually adequate as long as the worksheet boundary is revised to reflect currently-established property lines.

Topographical maps are also critical to preliminary design. Again because of timing and the nature of the land development process, topographical surveys are completed later in the process after some of the planning phase has already begun. During preliminary design, topography maps from existing sources suffice. During final design, more accurate topographic information is an absolute necessity.

The subdivision plat (see Figure 38.21) delineates the lot lines with bearings and distances and areas for each lot. Street dedications, rights-of-way, and easements are included on the subdivision plat. This plat is eventually recorded in the land records of the municipality.

Easement plats typically are required for all permanent off-site easements. On some projects, utilities must be extended to the project site by traversing through private property. The success of the project is determined by the acquisition of the necessary easements to access the existing utilities. The easements permit access by appropriate personnel for construction and maintenance.

Construction drawings typically use dashed lines for existing features on the site and solid lines for proposed features. Different line weights (i.e., thicknesses) depict different categories of the features to make the drawings more readable. Survey plats do not follow this practice. Dashed lines on survey plats are indicative of existing features as well as other items. For example, dashed lines are frequently used for easements (existing and proposed).

**Shop Drawings**

Inevitably, design drawings cannot cover all construction details. In circumstances where site-specific details are necessary, the contractor supplements the design drawings with shop drawings (sometimes referred to as detail drawings). These drawings convey details necessary to manufacture specific components for the project or detail construction techniques for a site-specific purpose. These shop drawings may have to be approved by the local municipal agency and/or the project engineer. In most cases, the engineer’s approval is only to insure the drawings meet contract specifications. The engineer assumes no responsibility for their accuracy; unless the contract states otherwise.

**Architectural Drawings**

Architectural drawings are used extensively in the land development industry. They basically show the interior and exterior design specific to the building. Planners and engineers coordinate with the architect in order to merge the site design with the building design. Confirmation by the planner/engineer is recommended as to the architect’s intentions for grades and elevations of the site and location of the buildings. Site grades, building location and orientation as visualized by the architect may not work because of constraints relating to street and utility location and grades, as well as land acquisition for easements and rights-of-way.

Because of the nature of the design process, plans and drawings change quite frequently. An open communication line between the architect and planner/engineer is essential to minimize conflicts between the architectural design and site design. A change of even 1 ft in elevation on a building or the addition of a window or door changes the site grading scheme and could severely affect the site design. Therefore, when obtaining information from architectural plans (or from any plans outside the site engineer’s office), it is prudent to verify that the information is current.²

Architectural drawings for residential dwellings include the following types of drawings: floor plans, framing plans, etc.

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² Some architectural/engineering design firms are so dispersed that it is wise to verify plans when everything has been designed in-house.
FIGURE 38.20 Boundary plat. Reprinted by permission of Uniwest Construction, Inc.

roof-framing plans, heating and cooling plans, plumbing plans, electrical plans and pictorial presentations. Floor plans are section views that depict items of interest such as the location and dimensions of exterior walls, windows, doors, garages, walks, decks, stoops and patios. Other features shown and dimensioned on the floor plans include interior walls, mechanical equipment and plumbing fixtures. As shown in Figure 38.22, the floor plan is a horizontal sectional view. A floor plan showing typical details and dimensions is shown in Figure 38.23. Typically, there is a floor plan for each floor of the building.

Elevation views (Figure 39.24) show exterior features of one side of the building. The elevation shows the finished appearance of the building with vertical dimensions. Grade lines, windows, doors, and exterior materials are evident from the elevation views. When establishing the grading plan, floor plans and elevation views are referenced frequently for information. An example of a wall section is shown in Figure 38.25.

Another architectural drawing helpful in site design is wall sections. Wall sections, a type of detail view, shows floor to floor dimensions, exterior grades, foundations, footings, and overhangs, and other features that impact site design.

In commercial projects, other professionals design many of the plans. For example, mechanical engineers and electrical engineers perform the heating and cooling plans and electrical design. During the site-design process, the planners and engineers refer to these plan sets to locate utility service connections and dimensions for construction stakeout surveys.

MAPS FREQUENTLY USED IN LAND DEVELOPMENT PROJECTS

There are numerous sources for obtaining maps that provide useful information for a project. It is good practice to obtain many of the maps at the outset of the project. They will be invaluable during the course of the project. Additionally, these maps can be kept on file to serve future projects.

The United States Geologic Survey (USGS) is a major source of various maps. The USGS publishes a series of...
topographic quadrangle maps, which cover the United States, its territories and possessions. These maps, The National Topographic Map Series, are available in various scales, depending on the area of coverage. Areas bounded by 7.5′ of latitude and 7.5′ of longitude (referred to as 7.5-minute maps), 15′ maps, and 1 degree maps are available for most areas of the U.S.

Other types of maps available from the USGS include geologic maps, mineral resource maps, water resource maps, land use and land cover maps, and both high and
FIGURE 38.23  Typical floor plan.
FIGURE 38.24 Architectural Elevations.
Figure 38.25 Wall section.
low-altitude photographic maps. The topographic and geologic-map coverages are identified on state indexes. Other map coverages are outlined in U.S. indexes.

For example, each state index to the topographic maps shows the quadrangle areas by reference code, map name and scale. The more comprehensive catalog, the “State catalog”, lists alphabetically, grouped by map type and scale, the names, dates and prices of all available maps. The list includes topographic maps, orthophoto quadrangles, state maps, satellite-image maps and others.

The “Indexes to Geologic Mapping in the United States” comprise a map of each state showing areas for which geologic maps have been published. Each sheet has a color code to identify the scale, along with a text that gives the source of publication, scale, date, and author of each geologic map and a list of USGS reports on the state.

Other small-scale topographic maps are produced by the Army Map Service and the United States Coast and Geodetic Survey (US&GS). The US&GS mainly publishes aeronautical and coastline charts.

Large-scale topographic maps with 5-ft contour intervals are available from the local municipality. These maps provide information usable at the land development level but not all municipalities have these. Large-scale topographic maps may also be accessible from aerial survey firms. Additionally, these firms may have low-altitude aerial photographic maps if the local municipality does not have them either.

Soil surveys, performed by the U.S. Dept. of Agriculture's Soil Conservation Service since the early 1900s, identify soils according to county. This information is presented in map form and text form. The text describes the areal extent, physiography, relief, drainage patterns, climate and vegetation along with the soil deposits of the area. The soils are described and mapped by the pedologic method. Some of the newer versions of the SCS maps include engineering characteristics of the soils also. Other localized soil maps and reports may be available through local municipal divisions.

Other maps that assist in the planning and design of a land development project include the comprehensive plan map, zoning/land-use maps, political-boundary maps, utility maps, watershed maps, special district maps, and many others that are readily available from the municipality.

REFERENCES
American Society of Photogrammetry, Manual of Photogrammetry, American Society of Photogrammetry, Falls Church, Va., 1980.