CHAPTER

1

Introduction to Civil Drafting Technology

Learning Objectives

After completing this chapter, you will be able to:

- Define civil engineering and civil drafting.
- Identify civil drafting employment opportunities.
- Describe the education and qualifications required to be a civil drafter.
- Identify professional civil engineering and civil drafting organizations.
- Define terms and elements related to maps and civil drafting.
- Identify a variety of map types.
- Describe the design and drafting process.
- Explain the purpose and provide examples of drafting standards.
- Discuss workplace ethics.

Key Terms

Civil engineering
Surveying
Civil drafting
Two-dimensional (2-D)
Three-dimensional (3-D)
Geomatics
Consulting engineering
Computer-aided design and drafting (CADD)
Geographic information systems (GIS)
Professional engineer (PE)
Manual drawing
Map
Charts
Elevation
Cartography
Cartographer
Border
Title block
Legend
Key
Scale
Physical map
Political map
Thematic map
Photogrammetric map
Photogrammetry
Aerial photographs
Topographic map
Contour line

(*continued*)

Key Terms (*continued*)

Quadrangle map
Geologic map
Military map
Terrain
Milliradian
Mil
Cadastral map
Hydrographic map
Engineering map
Site plan
Plot plan
Plot
Plat
Subdivision
Infrastructure
Planning map
Zoning map
Nautical chart
Aeronautical chart
Digital elevation model (DEM)
Digital surface model (DSM)
Remote sensing
Digital terrain model (DTM)
Surveyors
Plan view
Plan
Vicinity map
Cross section view
Cross section
Profile
Cutting-plane line
Typical cross section
Detail drawing
Detail
As-built survey
As-built drawing
As-built
Standards
Code
Client
Specification
Standards checking
Ethics
Code of ethics
Intellectual property

This textbook focuses on fundamental design and drafting theory and applications associated with common civil engineering projects. This chapter is an introduction to civil drafting technology and describes civil drafting employment opportunities, education, qualifications, and professional organizations. You will also learn about maps, the design and drafting process, drafting standards, and workplace ethics.

Civil Engineering

Civil engineering is the branch of engineering related to the planning, design, construction, and maintenance of structures. Civil engineers probably designed the construction site upon which your house or apartment, and school or office is built. The road on which you drive and the water supply system from which you drink also require civil engineering. Civil engineering is the second oldest form of engineering known, after military engineering. It is a broad discipline, and civil engineers are often involved in all phases of a construction project. Architecture, building construction and management, environmental health, material science, surveying, and transportation are a few of the many civil engineering subdisciplines. **Surveying** is the science of measuring distances, angles, and directions of characteristics of the Earth's surface.

Civil drafting is drafting performed for civil engineering. Civil drafters work with civil engineers and other industry professionals to prepare models and drawings for civil engineering projects. Examples of civil engineering projects are bridges, building sites, canals, dams, harbors, roadways, railroads, pipelines, public utility systems, and waterworks. Civil drafters create maps, plans, cross sections, profiles, and detail drawings. Projects are designed in two-dimensional (2-D) and/or three-dimensional (3-D) formats. **2-D** refers to a view displaying only width and height, width and length, or height and length. **3-D** refers to a view displaying width, height, and depth. Civil drafters may also calculate excavation and fill volumes, and prepare graphs and diagrams used in earthmoving operations. Civil drafters can accompany survey crews in the field to collect data required to prepare or revise construction drawings.

Note: Surveying, mapping, civil engineering, and civil drafting are a few of the disciplines associated with the broad field of geomatics. **Geomatics** is the whole method of collecting, storing, managing, and presenting geographic or spatial data.

Employment Opportunities

Civil drafters are employed by consulting engineering companies; local, state, and federal government agencies; manufactures of products and providers of services associated with civil engineering projects; and the military. **Consulting engineering** is an independent service that provides licensed and certified engineering for construction and related projects. Civil drafting job opportunities are available around the world; from rural communities to large cities.

Civil engineering is an extensive field. Therefore, civil drafters often create many different types of drawings for a variety of projects. Some civil engineering companies or agencies, especially consulting engineers, offer expertise in several areas. Other civil engineering firms specialize in certain aspects of civil engineering. The following is a list of some of the specialties in which civil engineering companies and agencies are involved:

- Agribusiness
- Construction observation
- Environmental studies
- Flood control
- Foundation work and soil analysis
- Hydrologic studies
- Irrigation and drainage
- Land and construction surveys
- Land planning and subdivision
- Map-making
- Municipal improvements
- Power plants
- Refuse disposal
- Sewage and water treatment
- Transportation

Drafting employment opportunities fluctuate with national and local economies. Employment for civil drafters is often linked with demands for construction and related industries. A national increase or decrease in construction affects the number of available drafting jobs. The economic effect on drafting job opportunities also occurs locally and within specific subdisciplines. For example, construction can be stronger in one part of the country than another, or one city or state may have more funding to apply toward municipal improvements than another. The demand for civil drafters is accordingly higher in areas where the economy is stronger, and lower in areas where the economy is weaker. A growing number of drafters are finding employment on a temporary or contract basis as more companies and agencies turn to employment services to meet their changing needs.

Salaries for civil drafters are usually competitive with those in other professions with equal educational requirements. Working conditions vary but are usually excellent. Employment benefits differ according to each employer. However, most employers offer vacation and health insurance coverage, and some include dental, life, and disability insurance. Check your local and state employment offices and online employment resources for information about specific employment opportunities, salary ranges, and benefits.

Education and Qualifications

High schools, technical institutes, community colleges, and some four-year colleges and universities throughout North America offer drafting courses or programs. A school often focuses curriculum on the needs of industry in the immediate area. Many schools with a drafting program provide a general education with courses in a variety of drafting disciplines so that graduates have versatile employment opportunities. Some schools offer a specific civil drafting education, especially if necessary to fill the employment needs of local civil engineering companies and agencies. Identify the school and program that will best serve your specific goals. Research the curriculum and placement potential for graduates. Talk to representatives of local industries to help evaluate a school's drafting curriculum.

Students who desire to work as civil drafters should complete a one-year certificate or a two-year associate of science degree with studies in computer-aided design and drafting (CADD), civil drafting theory, and geographic information systems (GISs). **CADD** is the process of using a computer with CADD software to design and produce drawings and models according to specific industry and company standards. A **GIS** is a computerized database system used to manage, analyze, and display spatial data. Employers in the drafting industry typically prefer applicants who have at least two years of postsecondary training in a drafting program that provides strong technical skills and considerable CADD training. If you are interested in civil drafting as a career, your schooling should include math at least through basic trigonometry; application of CADD software programs; sketching techniques and skills; and the civil drafting theory, standards, and practices explained throughout this textbook.

After completing a two-year associate degree program, graduates can obtain jobs as drafters or continue education in a related field at a four-year college. A student wanting to become a civil engineer must complete four or five years of college and graduate with a bachelor of engineering or bachelor of science degree. Students can specialize in one of the wide variety of engineering subdisciplines in the final years of study. A **professional engineer (PE)** is an engineer who has a four-year degree in engineering from an accredited engineering program, has passed the Fundamentals of Engineering (FE) exam, has completed four years of progressive engineering experience under a PE, and has passed the Principles and Practice of Engineering (PE) exam.

> **Note:** **Manual drawing** is drafting done using traditional tools to create drawings by hand with pencil or ink on paper or other media. The need for precise hand line work, inking skills, and lettering has almost disappeared from the workplace, though occasionally the need to modify old, archived drawings does arise. However, technical sketching and CADD are the focus rather than the use of manual drafting equipment.

Professional Organizations

There are many professional organizations that offer a great deal of information and resources for engineers and drafters. Joining a professional design and drafting or related organization is a good way to further your career and expand your knowledge. Associations promote many different events and activities that can help you reach your professional goals by connecting with peers, volunteering, and sharing ideas. Most associations provide access to books, journals, magazines, articles, and other materials that are useful for learning about new concepts and practices. Some associations offer career resources such as job listings, and techniques for searching for and obtaining a job. The following information briefly explains a few of the professional associations related to civil drafting technology.

American Design Drafting Association/American Digital Design Association (ADDA)

The American Design Drafting Association/American Digital Design Association (ADDA) is a professional organization dedicated to the advancement of design and drafting and the graphics professions. The ADDA offers leadership opportunities, local professional councils, and student chapters. The ADDA also approves products based on quality, durability, usability, and value; and publications based on content relative to the design and drafting industry.

The ADDA holds the Annual Technical and Educational Conference and sponsors the Annual Design Drafting Week, Annual Poster Contest, and Annual Design Drafting Contest. Examples of other ADDA benefits are publication and product discounts, networking, members only forum, and access to publications and documents such as the ***Drafting Examination Review Guides***. The following information highlights a few prominent ADDA programs for you to consider. For more information about the ADDA, go to www.adda.org.

Professional Certification Programs The ADDA professional certification exams are international certification programs that allow apprentice drafters, drafters, designers, design drafters, design technicians, engineering and architectural technicians, digital imaging technicians, and other graphic professionals to indicate their knowledge in professional concepts and internationally recognized standards and practices. The ADDA developed these exams to elevate an individual's comprehension of the professional standards related to the design drafting and graphics professions.

Certification allows drafters to demonstrate professional capabilities and helps employers to identify quality employees. The tests do not cover specific CADD software or graphic production. The ADDA Drafter Certification Examination is open to all individuals, regardless of experience and formal education. An ADDA membership is not required to take the test or to become certified. Becoming a Certified Drafter reflects your proven knowledge of drafting. Certification enhances your credibility as a professional, improves your opportunities for promotion and pay increases, and gives you a competitive edge in a highly technical job market.

When employers hire an ADDA Certified Drafter, they know that the new employee meets certification criteria and has demonstrated initiative and pride in the profession by becoming certified. Therefore, certification can serve as one criterion for differentiating among candidates in the selection process. Certification also serves educators as a supplementary measurement of a student's performance on a recognized national level.

Employment Center The ADDA Employment Center is available to help connect ADDA members with employment opportunities. Post your résumé online if you are seeking work. Access the newest jobs available by employers to professionals seeking employment.

Instructor and Curriculum Certification Programs The ADDA Instructor Certification Program is designed to provide professional recognition to instructors, teachers, and educational professionals. Instructors must be engaged in a design drafting and graphics training program within an approved educational setting on an annual schedule with an end result of a trade or craft certificate or diploma. The ADDA Certified Curriculum Program approves curriculum that meets or exceeds industry standards.

American Council of Engineering Companies (ACEC)

The American Council of Engineering Companies (ACEC) is a national organization devoted to the business and support of engineering companies. The ACEC mission is to contribute to America's prosperity and welfare by advancing the business interests of member firms. Members range from PEs and professional land surveyors (PLSs) to consulting engineering companies and large corporations.

The ACEC advocates for, and takes political action to support, the business interests of engineering companies. The ACEC offers educational webinars, seminars, workshops, and meetings. ACEC publications include the ***Engineering Inc.*** magazine, ***Last Word*** newsletter, and ***ACEC Engineering Business Index*** survey. The ACEC holds two conferences per year and presents a variety of awards and scholarships. For more information about the ACEC, go to www.acec.org.

American Society for Engineering Education (ASEE)

The American Society for Engineering Education (ASEE) is a non-profit association dedicated to promoting and improving engineering and technology education. The ASEE mission focuses on developing policies and programs that enhance professional opportunities for engineering faculty members and promote activities that support increased student enrollments in engineering and engineering technology colleges and universities. Members include engineering firms, government agencies, and educational institutions.

ASEE publications include the ***Prism*** and ***eGFI*** magazines, ***Journal of Engineering Education*** and ***Advances in Engineering Education*** journals, and ***Profiles of Engineering and Technology Colleges*** directory. The ACEC offers educational workshops, meetings, and conferences, including the ASEE Annual Conference and Exposition. The ASEE offers fellowship programs and presents a variety of awards. For more information about the ASEE, go to www.asee.org.

American Society of Civil Engineers (ASCE)

The American Society of Civil Engineers (ASCE) is a professional organization that provides value to members, member careers, partners, and the public by developing leadership, advancing technology, advocating lifelong learning, and promoting the civil engineering profession. The ASCE publishes numerous civil engineering products including books, manuals, journals, and standards. Examples of ASCE journals are ***Journal of Bridge Engineering***, ***Journal of Environmental Engineering***, ***Journal of Transportation Engineering***, and ***Journal of Water Resources Planning and Management***. ***Civil Engineering*** is the monthly ASCE magazine.

The ASCE offers educational webinars, seminars, workshops, and meetings. Education and continuing education courses and programs are available to help PEs meet competency requirements. The ASCE holds several conferences per year, including an annual conference. The ASCE also offers professional certification and presents a variety of awards. For more information about the ASCE, go to www.asce.org.

Map Fundamentals

A **map** is a graphic representation of part or all of the Earth's surface, drawn to scale on a plane surface. Some maps, such as aeronautical and nautical maps, are more commonly referred to as **charts**. Maps use lines, symbols, colors, and labels to display natural features such as mountains and rivers, and areas with constructed features such as buildings and roads. Maps have many different purposes, depending on their intended use. A map can accurately provide distances, locations, elevations, best routes, land features, and much more. **Elevation** is the height of a geographic location above or below a theoretically exact reference point, axis, or plane.

Cartography

Cartography is the art of making maps and charts. A **cartographer** is a highly skilled professional who designs and draws maps. Cartographers use a variety of graphic media, computer software, and artistic illustration to create maps. Civil drafting and cartography are similar in that both professions deal with making maps. However, civil drafting is generally concerned with drawings for civil engineering projects. Cartographers often use more graphic skills in the preparation of documents and maps. A cartographer typically has completed four years of education with emphasis on cartography, civil engineering, digital imaging, geodesy, geography, navigation, and optics.

Map Elements

A map typically includes several basic elements such as a border, title, legend, information about scale and direction, and additional written labels and notes (see Figure 1–1). A **border** consists of lines that create the format margins of the sheet. Maps may or may not display a border, while civil engineering drawings usually include a border. The map title names the map. A title block often contains the title of a civil engineering drawing. A **title block** is a sheet block that

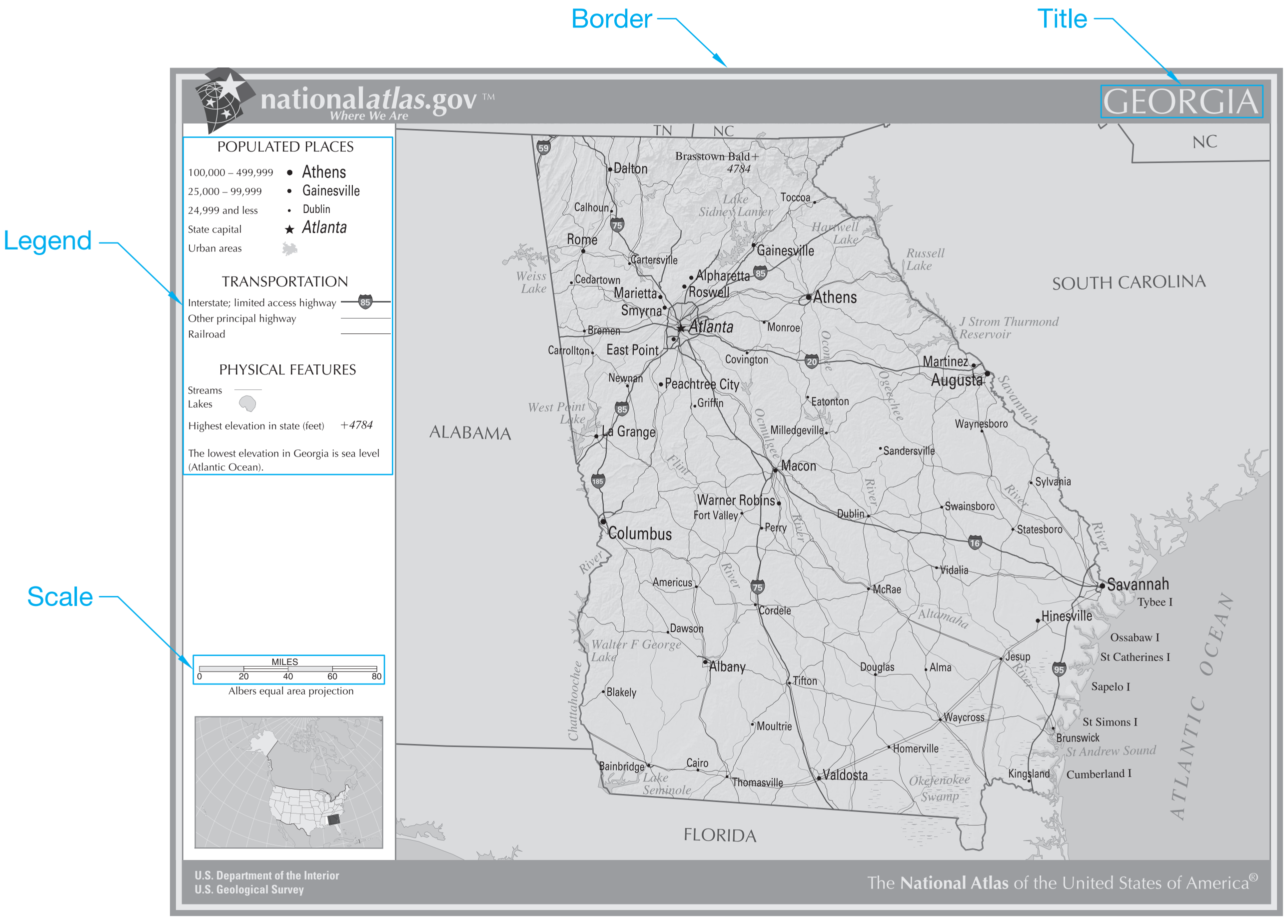


Figure 1–1. A general reference map of the State of Georgia. This map includes common map elements such as a border, title, legend, and scale.
(Courtesy of the U.S. Geological Survey)

provides a variety of information about a drawing, such as the title, sheet size, and predominant scale. Figure 1–2 shows an example of a title block. The title and information in a title block tell you immediately if you have the correct map or drawing.

Figure 1–2. A title block found on drawing for a residential construction project.

A map **legend**, or **key**, explains the symbols, colors, and labels that make up the map or drawing data. A legend is necessary in order to understand the information presented on a map. The legend shown in Figure 1–1, for example, keys population, transportation, and physical land and water feature symbols to the map. A **scale** is an instrument with a system of ordered marks at fixed intervals used for measurement. For example, use the scale shown in Figure 1–1 to approximate the number of miles between two cities. A scale establishes a proportion used to determine the dimensional relationship of an actual object to the representation of the same object on a drawing. Scale also refers to the ratio of measuring units expressing a proportional relationship between a drawing and the full-size items the drawing represents. For example, the map of the large area shown in Figure 1–1 must be scaled down to fit on a sheet. Chapter 3 explains map scales in detail. A map may include a north arrow in order to specify orientation, especially if the map is not north-oriented. North is assumed to be facing the top of the sheet in the map shown in Figure 1–1. Therefore, the north arrow is omitted. Chapter 7 explains angles and directions in detail.

Types of Maps

There are hundreds of different types of maps. Some maps show the geography of the world, while other maps display construction sites for new homes or commercial projects. Civil engineering companies primarily prepare maps associated with the planning, design, construction, and maintenance of structures; such as construction site and roadway plans. The following information describes several of the most common types of maps. This textbook focuses on maps related to the Earth.

Physical Maps

A **physical map** displays the physical features of an area such as differences in elevation and bodies of water. Physical maps commonly display color and relief-shading that provide a descriptive representation of a portion of the Earth's surface (see Figure 1–3). Physical maps are usually prepared at a small scale and show large areas.

Political Maps

A **political map** shows the boundaries of governments such as countries, states, and counties. Political maps may identify major cities and often shows large bodies of water (see Figure 1–4). Political maps are usually prepared at a small scale and show large areas.

Thematic Maps

A **thematic map** provides information about specific topics or themes such as the amount of vegetation on the surface of the Earth, observing the effects of wildfires, or plotting human population patterns.

Figure 1–3. A physical map of the contiguous United States.
(Courtesy of the U.S. Geological Survey)

Figure 1–5 shows an example of a thematic map generated using images taken by a satellite. This particular map shows the distribution of permafrost across the mainland State of Alaska. The map provides information that can be used to model the decrease in permafrost, which has implications for many issues such as land-use planning and environmental calculations.

Photogrammetric Maps

A **photogrammetric map** is a map created from photographs, typically aerial photographs, using photogrammetry. **Photogrammetry** is the method of measuring the distance between points on photographs. **Aerial photographs** are photos taken at various altitudes and controlled by base stations at known distances on the ground to check for accuracy. Many overlapping photos are typically required to create an accurate map. Aerial photographs can be used to create orthophotos through a process known as rectification, which combines multiple overlapping images and projects the images onto a plane. Figure 1–6 shows an example of an aerial photograph. Aerial photos are accurately scaled and converted to maps using special stereoscopic instruments and computer software.

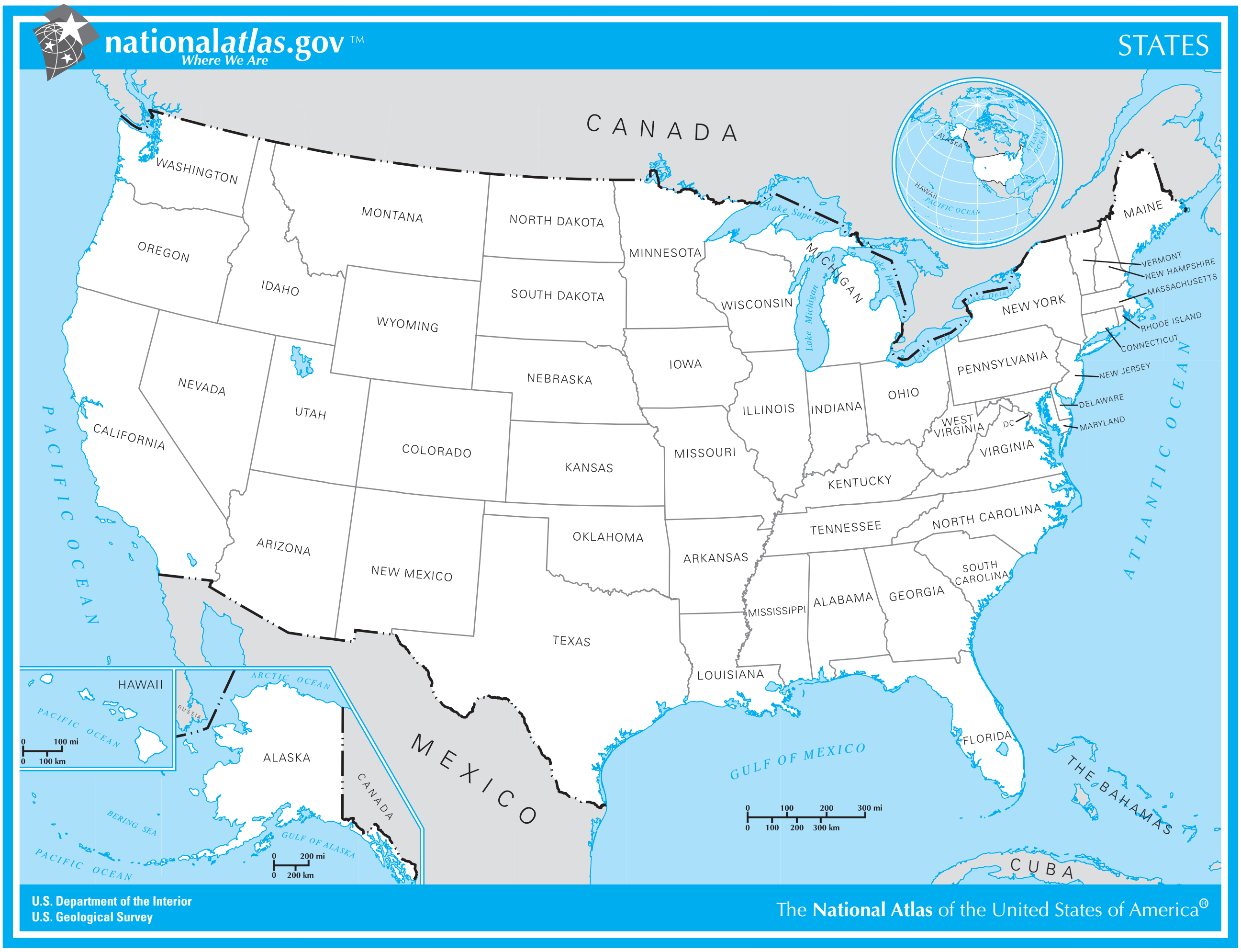


Figure 1–4. A basic political map of the United States.
(Courtesy of the U.S. Geological Survey)

Topographic Maps

A **topographic map** accurately shows the shape of the Earth using contour lines (see Figure 1–7). A **contour line** is a line that connects points of equal elevation. The spacing of contour lines is determined by the grade, or slope, of the land. On very steep terrain, contour lines are close together because changes in elevation occur quickly. On terrain that slopes gradually, contour lines are farther apart because it takes longer to reach a change in elevation. Contour lines are drawn at equal changes in elevation, such as every 2, 5, or 10 ft. Elevation is usually labeled at least every fifth contour. Many of the maps described in this chapter include contour lines. Chapter 8 explains contour lines in detail.

Quadrangle Maps

A **quadrangle map** is a map of an area of the Earth's surface with a grid showing geographic location. Figure 1–8 displays an example of a ***US Topo*** quadrangle map published by the U.S. Geological Survey (USGS). Quadrangle maps are typically drawn using colors

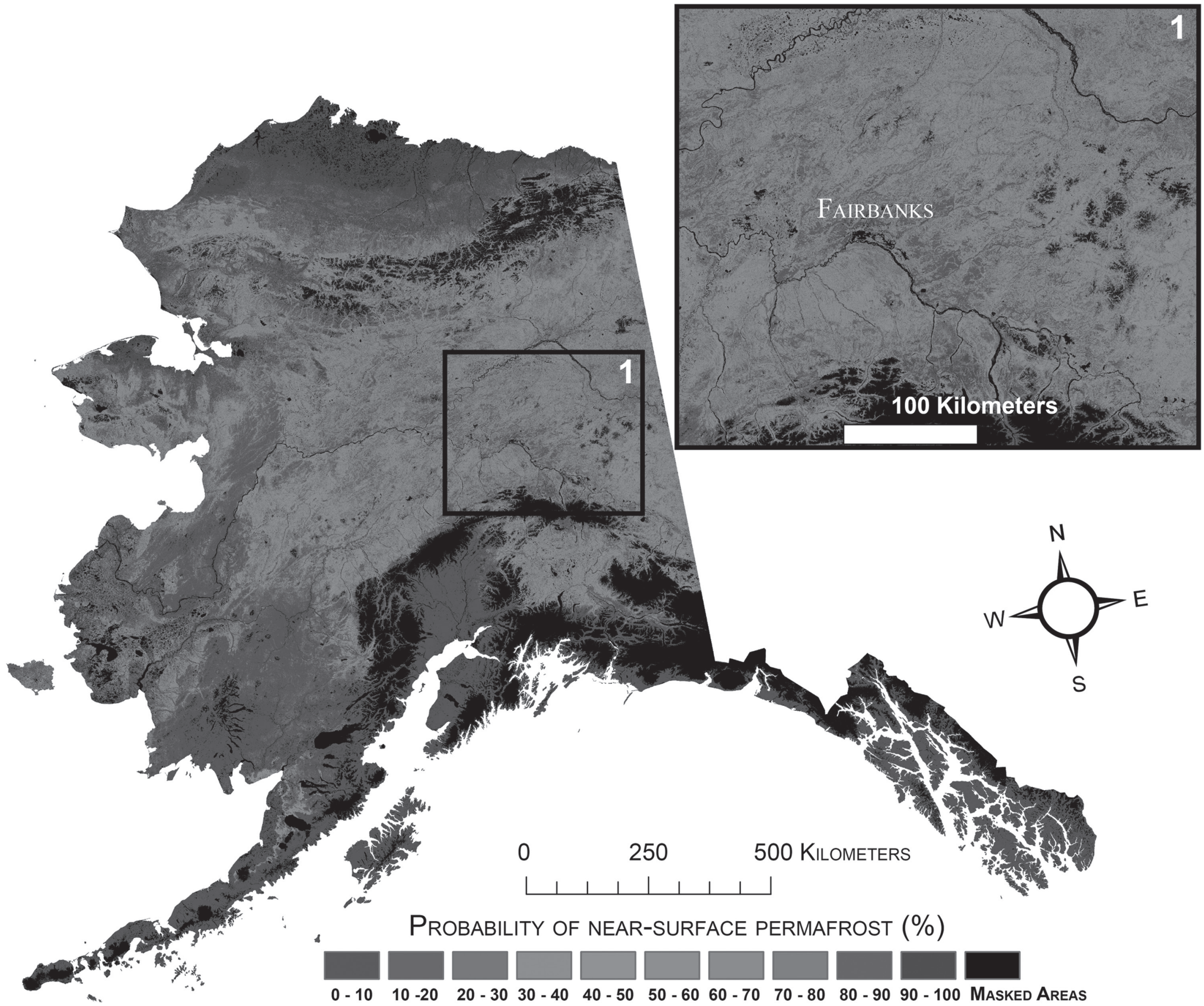


Figure 1–5. A permafrost distribution thematic map of mainland State of Alaska created using satellite images.
(Courtesy of the U.S. Geological Survey)

that represent different map features. Contour lines are often brown, while streams, lakes, and rivers are blue. Woodland features are green, and structures, such as buildings and roads, are usually black. Some quadrangle maps also indicate boundaries of the Public Land Survey System (PLSS) explained in Chapter 9.

Geologic Maps

A **geologic map** describes the location, type, and extent of geologic features such as rock formations and edges of earth movement (see Figure 1–9). A geologic map is usually created by adding geologic information to an existing map, typically, a topographic map. Geologic maps contain a variety of lines, shapes, symbols, and colors. Each color on a geologic map represents a different type and age of rock. Scientists and engineers use geologic maps for many different purposes. The following are some of the data geologic maps help provide:

Figure 1–6. This aerial photograph of the District of Columbia can be used to create a photogrammetric map.
(Courtesy of the U.S. Geological Survey)

- Locations of acceptable building sites or agricultural areas.
- Identification of areas prone to earthquakes, volcanoes, floods, and other dangers.
- Locations of beneficial natural resources such as natural gas, oil, groundwater, precious minerals, and gravel; or dangerous elements such as asbestos.

Military Maps

A **military map** displays information of military importance or that serve a military use. A military map can be used by a soldier in the field and can have information about terrain, concealment, and cover. **Terrain** is the shape and lay of the land. A military map can show a large geographic area useful for military planning. Military maps often display special military symbols that signify military activity. For example, blue symbols represent friendly forces, while red symbols represent enemy forces. Distance on military maps is measured in meters, and angle is measured in mils. A **milliradian**, or **mil**, is a unit of angular measurement approximately equal to 1/6,400 of the circumference of a circle. Military artillery and gun sight settings are expressed in mils. Military maps are also designed to be read in the dark using a red light. Figure 1–10 shows a portion of a military map.

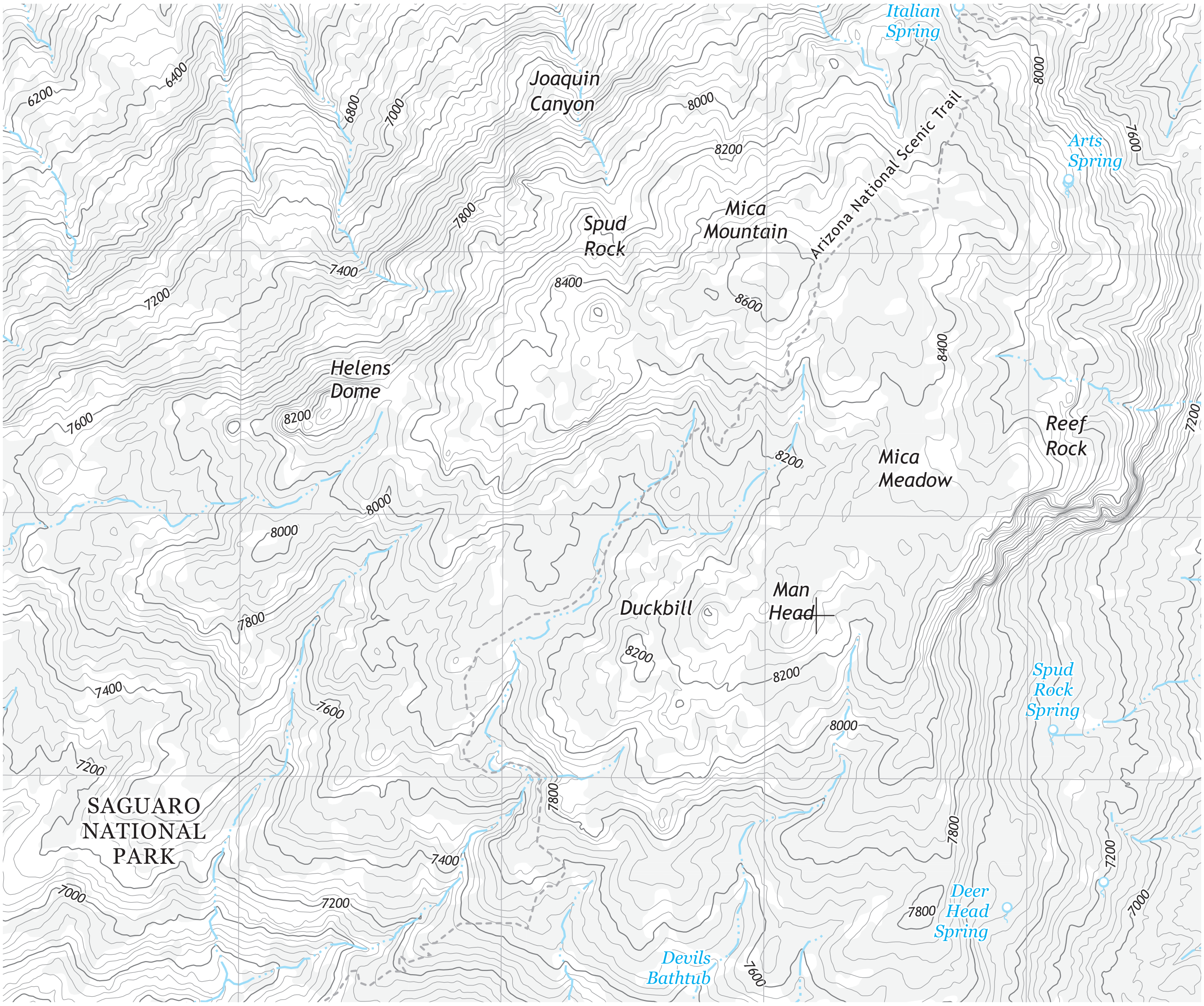


Figure 1–7. A portion of the Mica Mountain, Arizona topographic map.
(Courtesy of the U.S. Geological Survey)

Cadastral Maps

A **cadastral map** is a large-scale map that accurately shows property boundaries and public lands. Cadastral maps are often used for city and county development, operation, and taxation. Figure 1–11 shows an example of a cadastral map.

Hydrographic Maps

A **hydrographic map** accurately shows the boundaries and characteristics of surface waters, or hydrography. Hydrographic maps are used for water and land resource planning, and often include information about drainage, culture, and conditions. Hydrographic maps are typically printed in color. Figure 1–12 provides a sample of a hydrographic map.

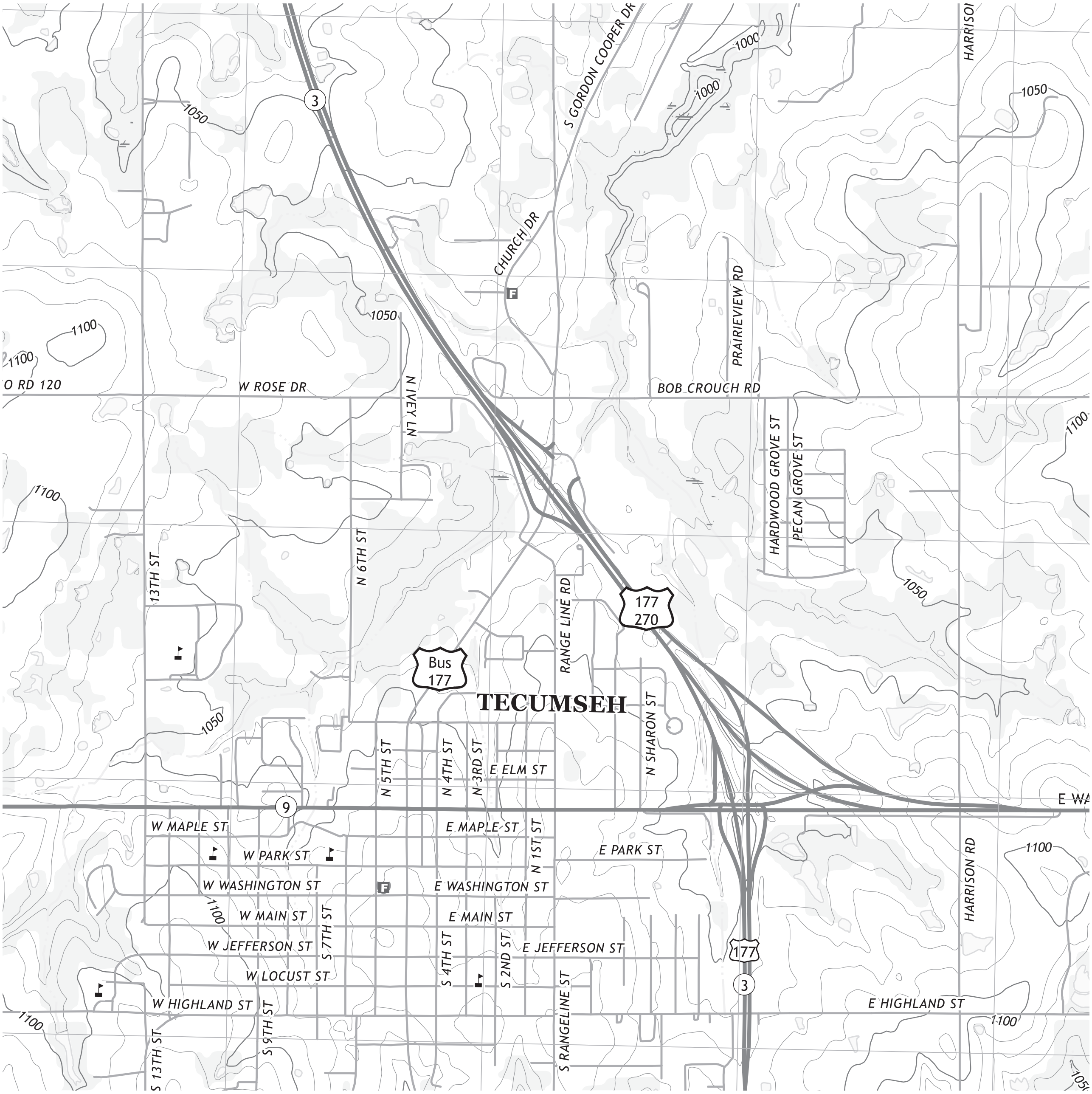


Figure 1–8. A portion of the Shawnee quadrangle map near Tecumseh, Oklahoma. (Courtesy of the U.S. Geological Survey)

Engineering Maps

An **engineering map** details the layout of an engineering project such as a building construction project. Figure 1–13 shows an example of an environmental engineering map. Engineering maps are unique to each project and application. The following items are regularly found on a variety of engineering maps:

- Contour lines
- Drainage ways
- Existing and proposed structures

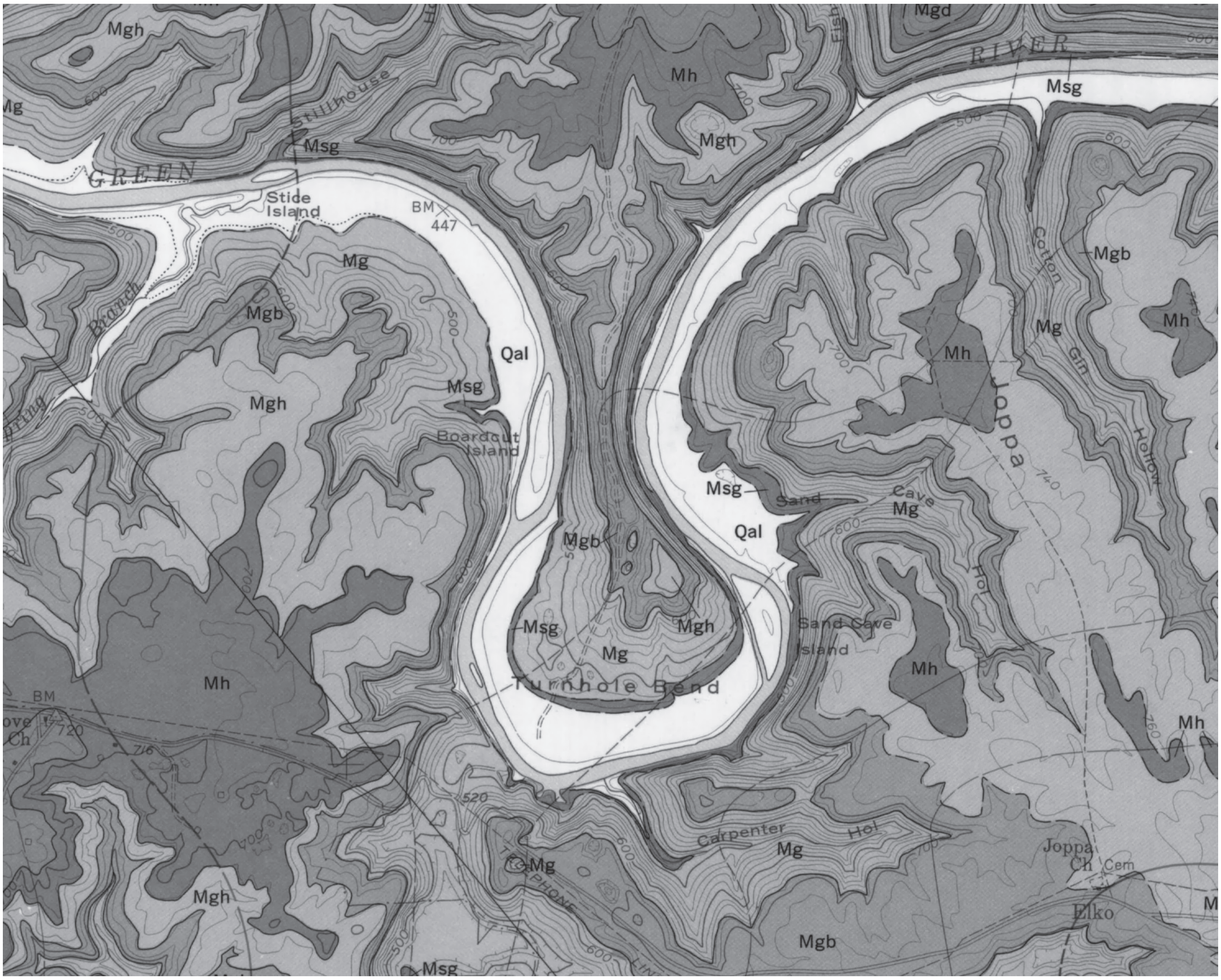


Figure 1–9. Part of the Rhoda, Kentucky quadrangle geologic map.
(Courtesy of the U.S. Geological Survey)

- Landscaping
- Location and size dimensions
- Parking areas
- Property lines and boundaries
- Roads
- Specifications
- Utilities such as water, sewer, electrical power, and natural gas

A site plan is an example of a common engineering map. A **site plan**, also known as a **plot plan**, **plot**, or **plat**, is a drawing that shows an accurate layout of a piece of land. Engineers and developers use site plans to map construction projects. The term plat can refer one or more pieces of land, but is commonly associated with a group of individual sites. Figure 1–14 shows an example of a subdivision plat. A **subdivision** is a tract of land divided into lots. Figure 1–15 shows an example of a residential site plan. Chapter 9 explains site plans in detail.

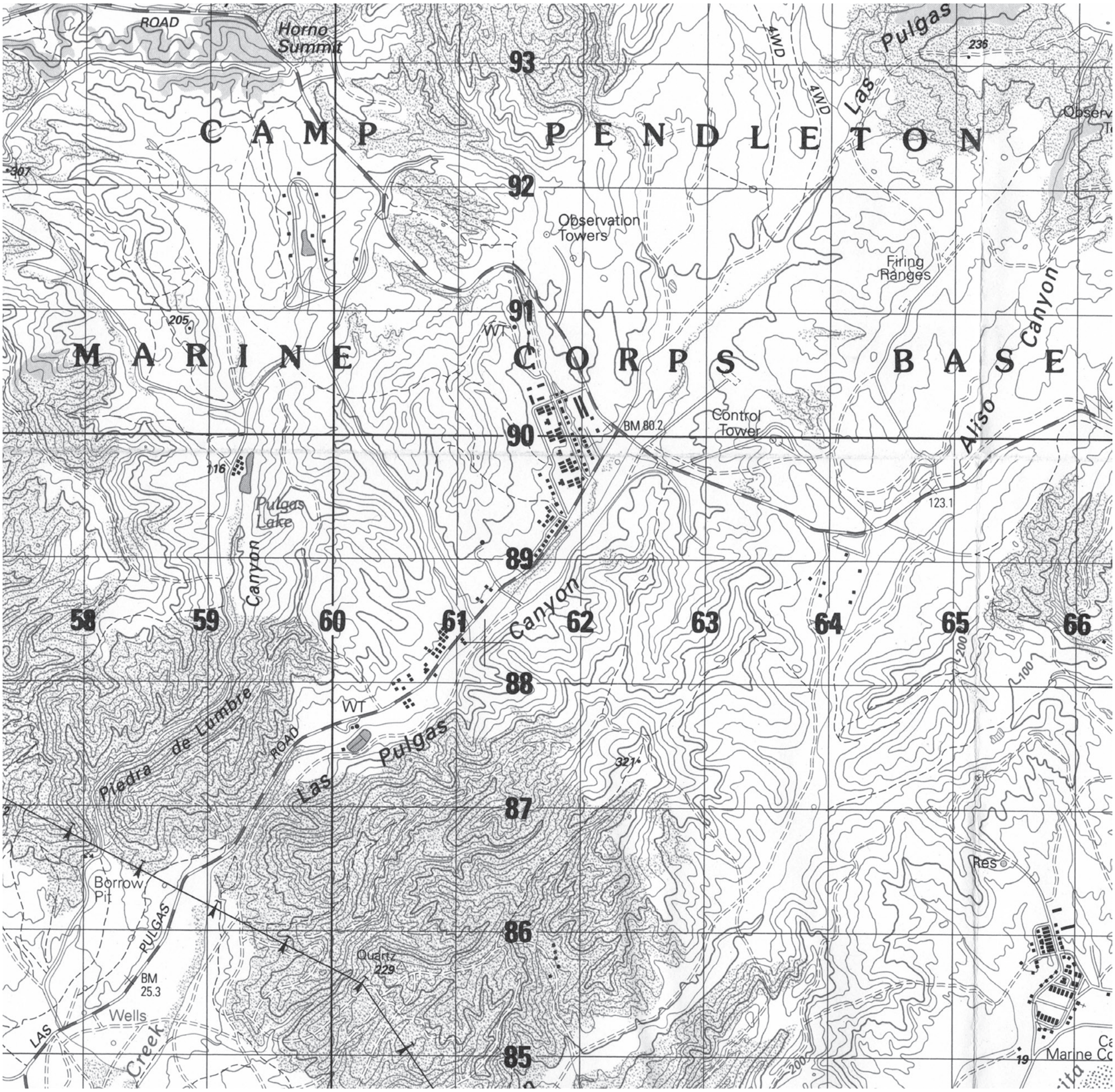


Figure 1–10. A military map looks very similar to a quadrangle map, but uses different units and displays military significant information, symbols, and colors.
(Courtesy of the U.S. Geological Survey)

Planning Maps

Engineers, developers, and urban and city planners use many different types of maps when designing and maintaining community land use projects and infrastructure. **Infrastructure** is the structures, facilities, and services required for an economy to function such as buildings, roads and bridges, water supply and sewer systems, and power supply and telecommunication systems. All of the maps explained in this chapter can be useful for planning purposes depending on the application. A **planning map** depicts the layout and characteristics of an area for municipal planning purposes. A planning map may have a photogrammetric or topographic base map overlaid with appropriate

Figure 1–11. A portion of a Portland, Oregon cadastral map.
(Courtesy of the City of Portland, Oregon)

information such as zoning boundaries, urban growth boundaries, or population density. A planning map can be combined with hydrographic maps or engineering maps, for example, to show existing conditions and to plan for improvements. Depending on the specific need, planning maps are often produced in color and may be either large or small scale.

Many planning maps, such as the portion of a zoning map shown in Figure 1–16, are generated using GIS technology. A **zoning map** is typically used to layout and categorize districts within a town, city, or state. Chapter 14 is an introduction to GIS.

Nautical Charts

A **nautical chart** is a map used to aid to water navigation (see Figure 1–17). Nautical charts provide information such as water depths, bridge clearances, and the location of overhead cables. Nautical charts also show navigation lanes, lighthouses, beacons, and buoys.

Figure 1–12. A hydrographic map of the contiguous United States.
(Courtesy of the U.S. Geological Survey)

Aeronautical Charts

An **aeronautical chart** is a map used to aid air travel (see Figure 1–18). Aeronautical charts indicate important features of land such as mountains and outstanding landmarks in a format similar to a detailed physical map. Contour lines are regularly provided with 200–1,000-ft. intervals. Aeronautical charts provide comprehensive information regarding air routes, airport locations, types of air traffic, radio aids to navigation, and maximum elevation of features.

Digital Models

A **digital elevation model (DEM)** typically refers to a raster image model created from a collection of 3-D points showing bare surfaces of land, without natural vegetation and built structures. Figure 1–19 shows a 3-D DEM of Mount St. Helens in Washington State before and after the May 18, 1980, eruption. A **digital surface model (DSM)** typically refers to a raster image model that shows land with natural and built surface features such as vegetation and structures. DEM and DSM data points can be collected using ground surveying; though remote sensing, typically from aircraft or satellites, is most often associated with DEM and DSM data collection. **Remote sensing** refers to the detection of information about an object or experience, without actually contacting the object or experience. Chapter 5 includes additional information about remote sensing.

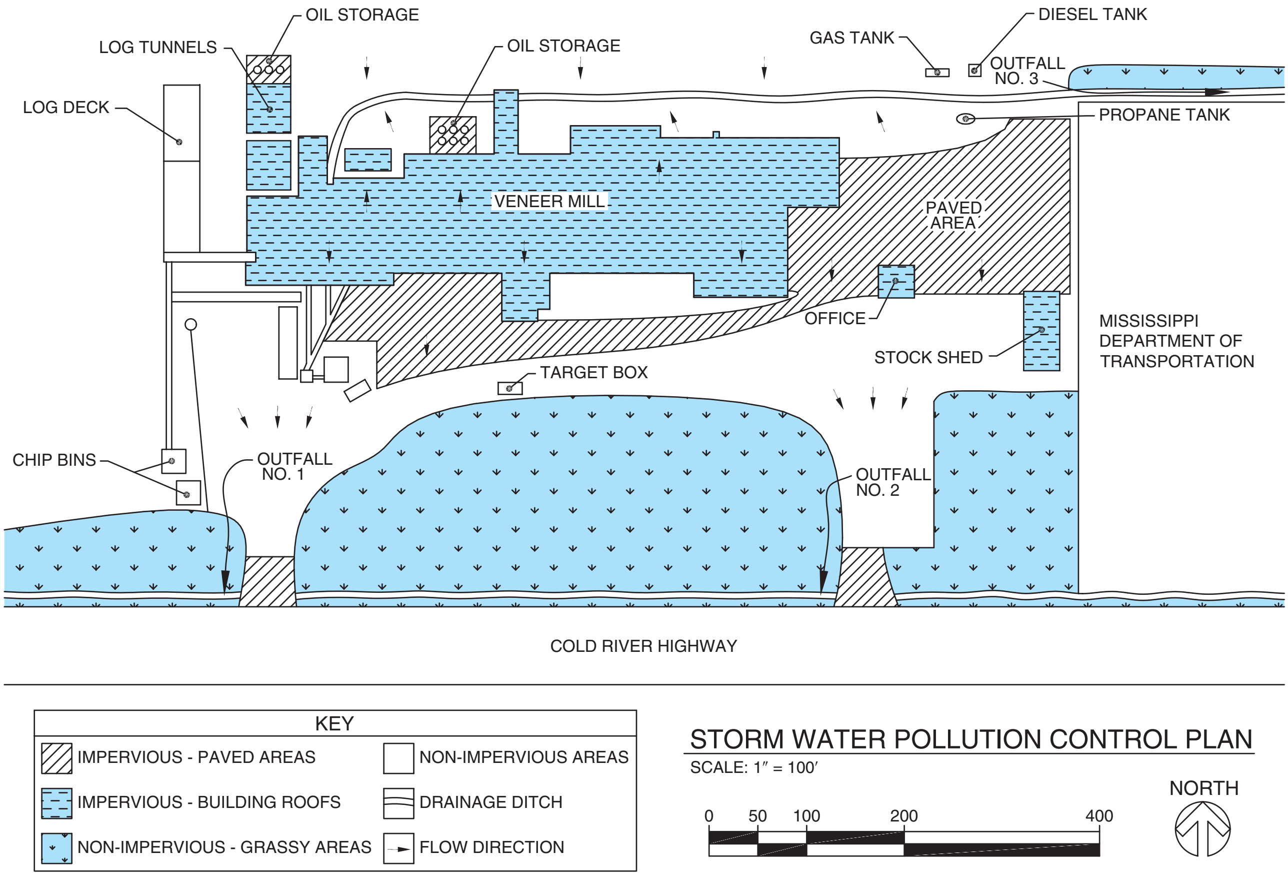


Figure 1–13. A storm water pollution control site plan showing impervious and non-impervious surfaces, and the mapping of the location and direction of storm water flow.

DEM and DSM data can be used to produce a variety of realistic and easily understandable maps and images, such as the thematic map shown in Figure 1–5. Different viewpoints of a site can be observed with the use of specialized computer software, and the vertical scale can be magnified to display elevation changes at sites that are relatively flat. Additional information and graphics can be applied to digital models including photorealistic rendering and topographic map overlays (see Figure 1–20). DEMs are helpful for a variety of applications such as slope analysis and determining hydrographic boundaries; and planning of highways, subdivisions, and underground utilities that rely on gravity flow. Engineers analyze DEMs to find flaws or problem areas during the design of, and before building, a project.

Though sometimes used as a synonym for DEM, a **digital terrain model (DTM)** typically refers to a vector graphic model created from a collection of 3-D points showing terrain and features that define a change in slope such as a stream or ridge, or the edge of a wall or road. A DTM is generally described as a model of the existing terrain that is developed from elevation data collected in reference to a coordinate system. As explained later in this textbook, data points collected during a conventional ground survey can be imported into a CADD system to create a DTM for civil engineering design and analysis.

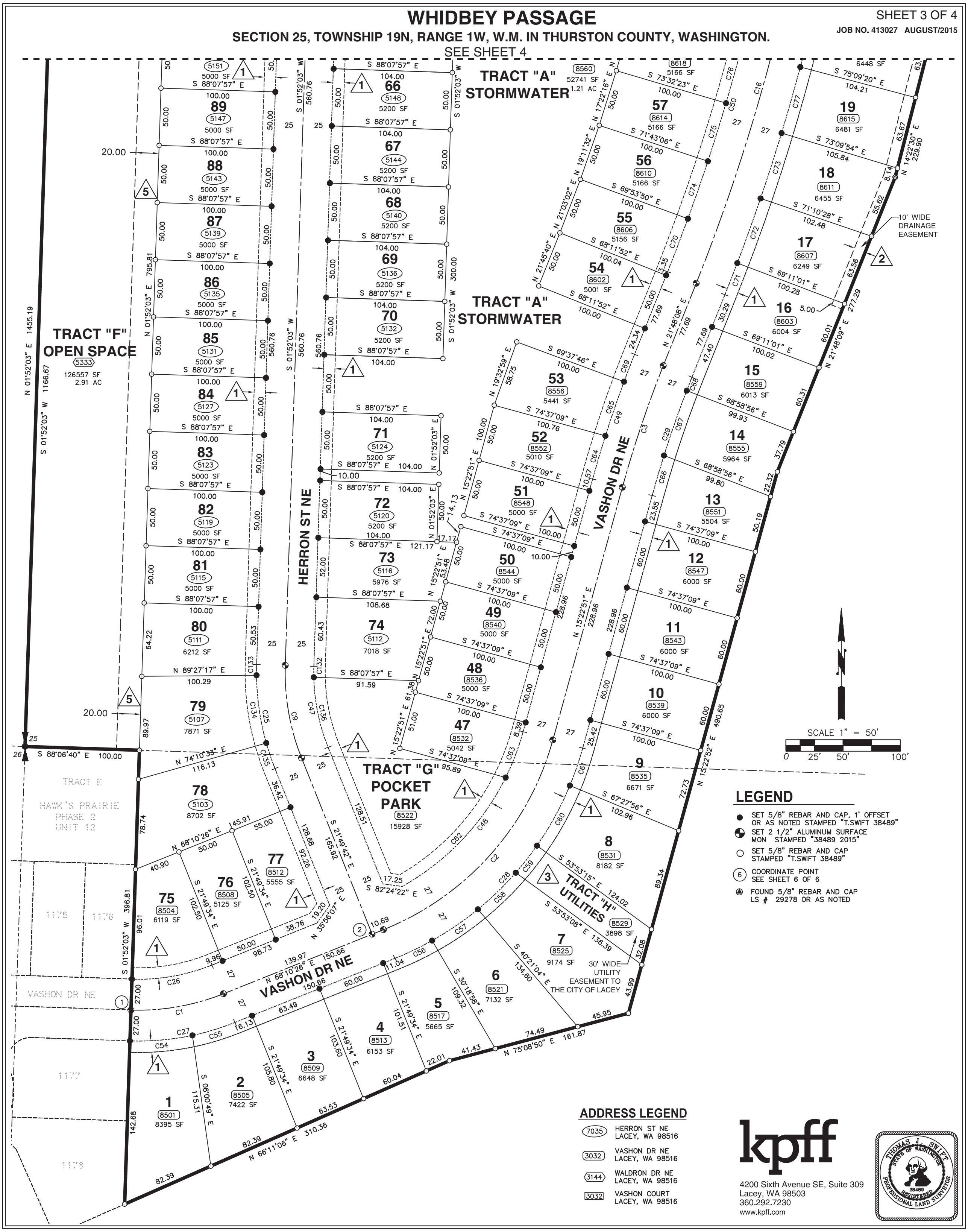


Figure 1–14. A subdivision plat required for the development of a residential housing subdivision. (Courtesy of KPFF Consulting Engineers)

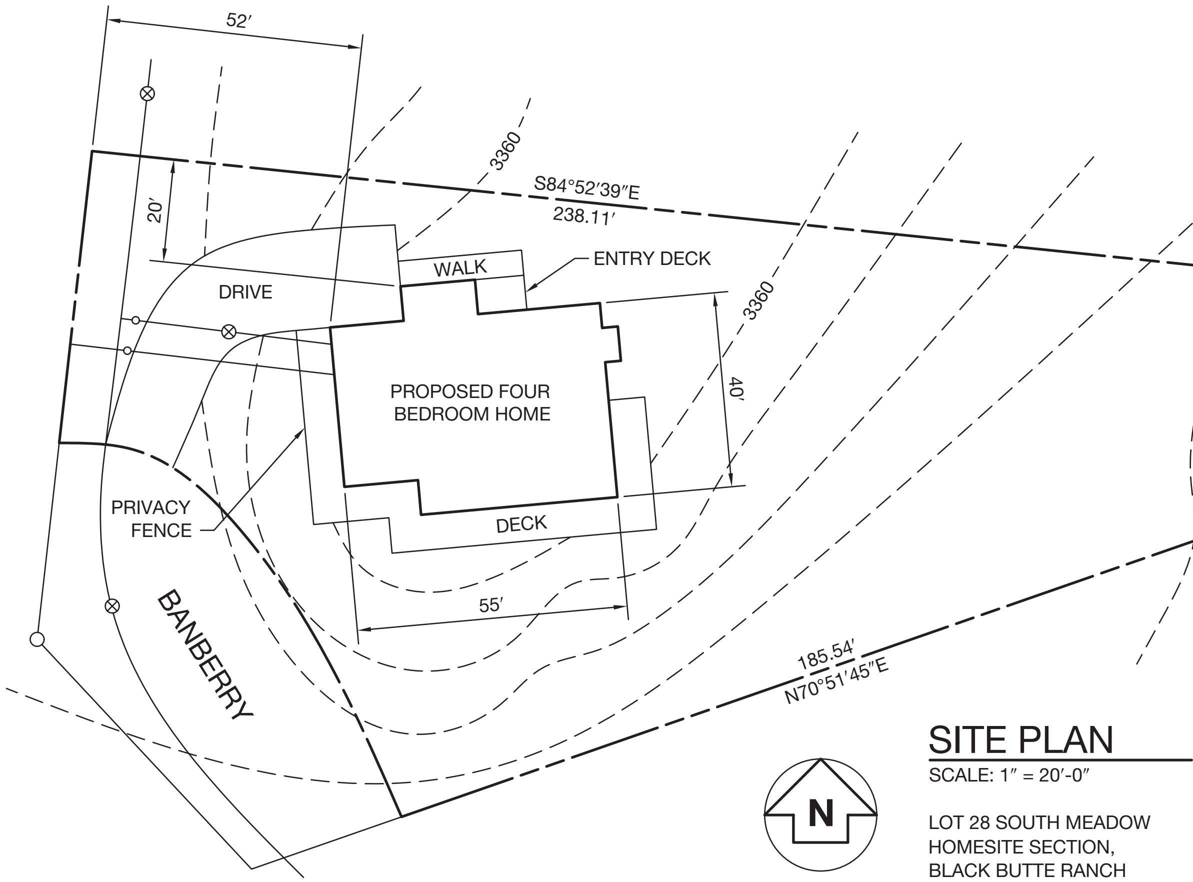


Figure 1–15. A residential building site plan.

The Design and Drafting Process

Civil engineering companies and agencies are often involved in all phases of a construction project, especially the design and drafting necessary to document the project. Depending on the size and capabilities of the company or agency and the scope of the project, civil engineering firms create drawings internally or contract with other firms that specialize in certain aspects of the project. The civil engineering design and drafting process involves several stages, from determining the general extents of the project to completing the design.

Surveying is an early phase of the civil engineering design process, and often continues throughout a project. Surveying is often contracted to licensed surveyors. **Surveyors** provide a map file of the job site from which civil designers and drafters develop drawings. Chapter 5 explains more about surveying. Departments within the civil engineering firm then work on site preparation, street and parking layout, earthwork grading and drainage, and foundation and structural work. Architectural design and drawings might be handled by the civil engineering firm or contracted to an architectural company. Architects may be given appropriate base drawings from which to work such as site plans, contour maps, road layouts, and structural drawings.

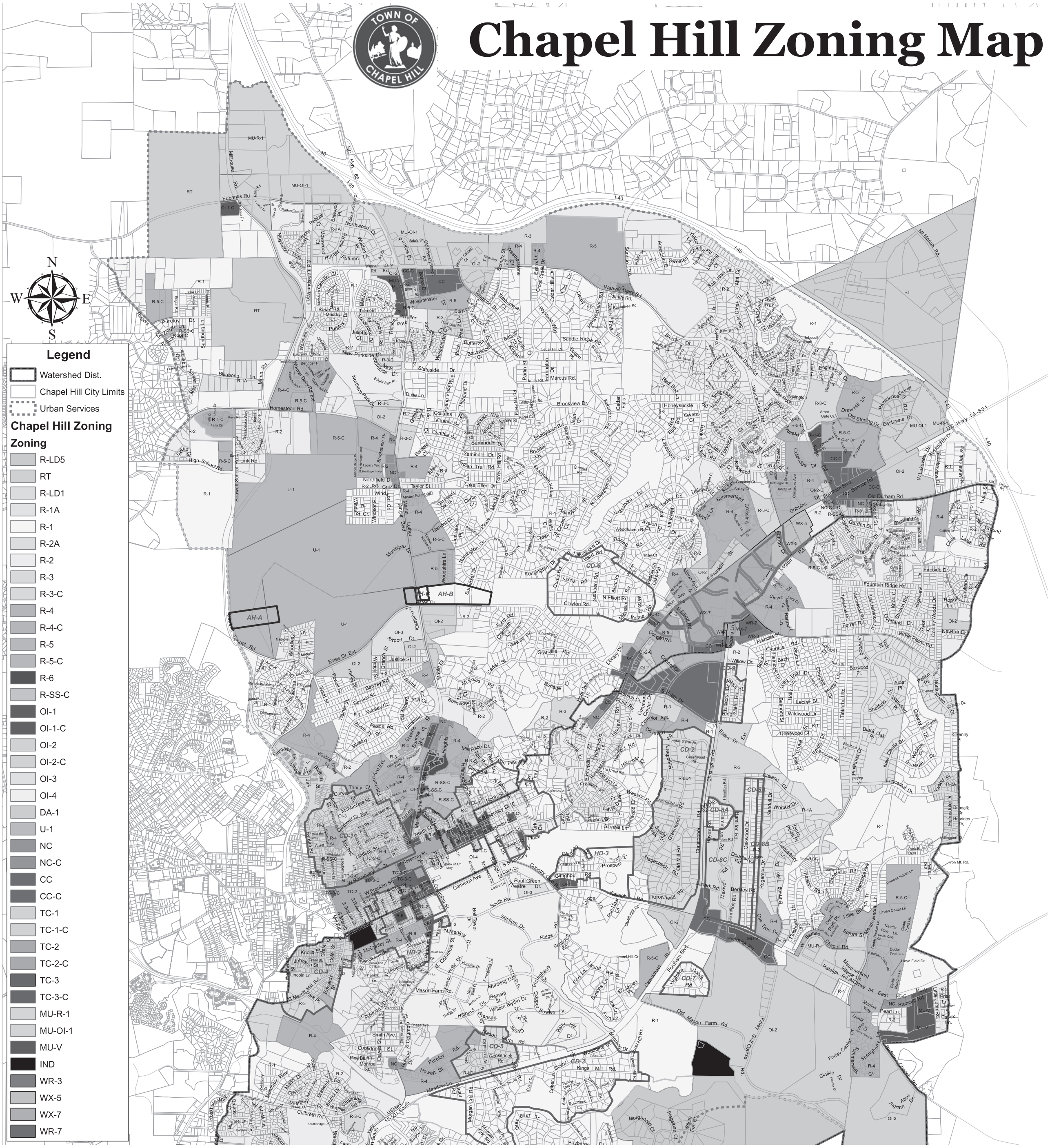


Figure 1–16. A portion of a Chapel Hill, North Carolina zoning map. A zoning map is an example of a common planning map.
(Courtesy of the Town of Chapel Hill, North Carolina)

Projects involving mechanical, piping, and electrical work such as waterworks, sewage treatment, and power generation may require specialized design and engineering. These aspects of a project might be contracted to engineering companies that focus in these

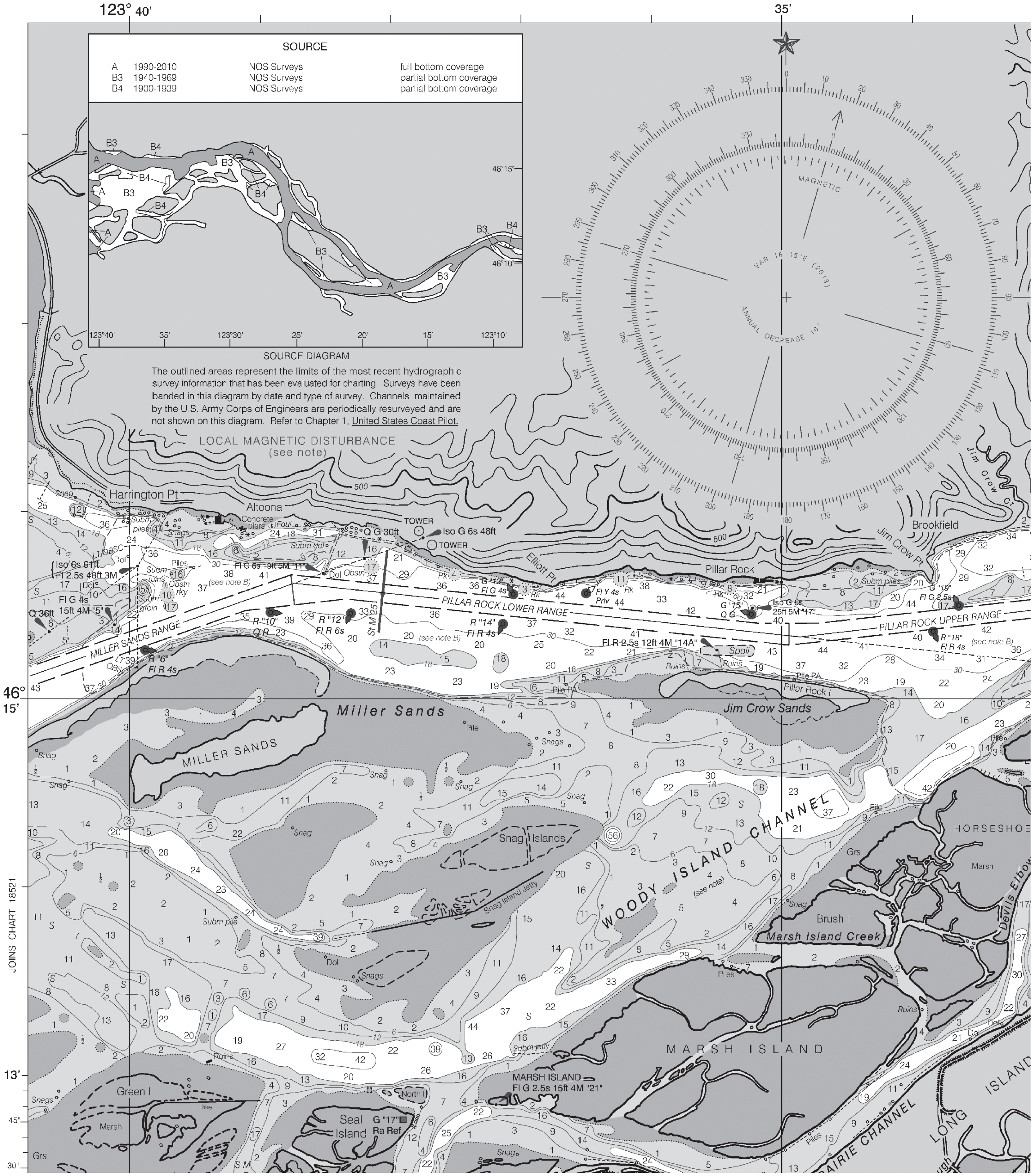


Figure 1–17. A part of the Columbia River nautical chart.
(Courtesy of the Office of Coast Survey, National Oceanic and Atmospheric Administration)

disciplines. Final stages of a project may involve finished site preparation and landscape design. This aspect of a project may be contracted to landscape architects. Each stage of the civil engineering design and drafting process results in specific plan, cross section, profile, and/or detail drawings.

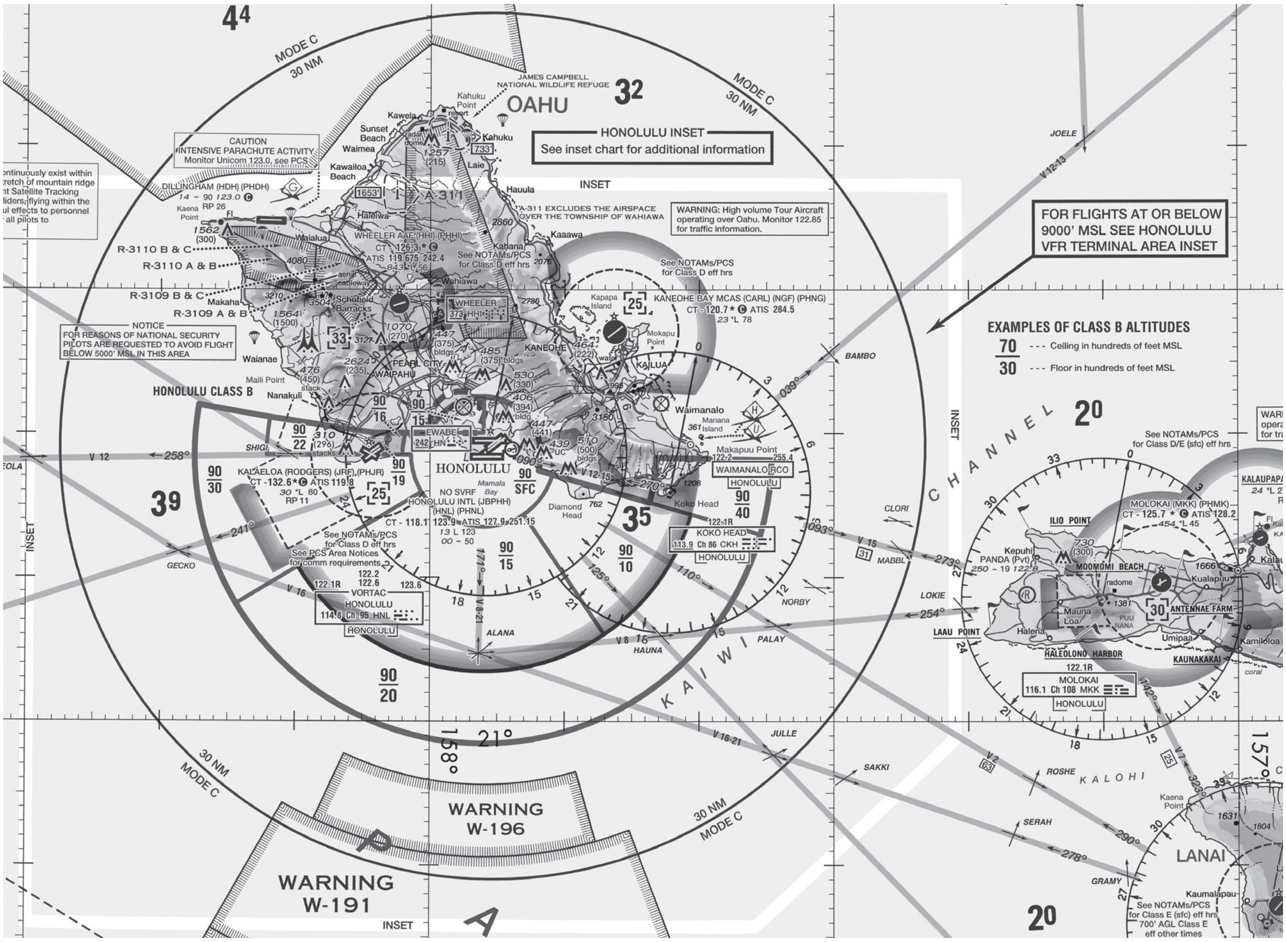


Figure 1–18. A part of the Hawaiian Islands aeronautical chart.
(Courtesy of the National Aeronautical Charting Office, Federal Aviation Administration)

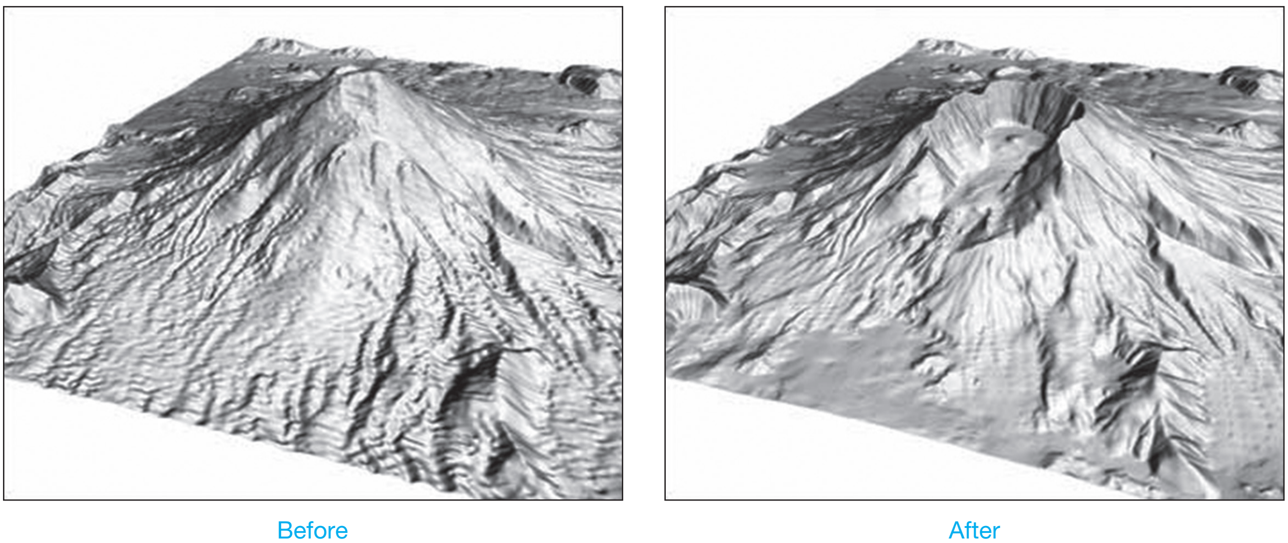


Figure 1–19. A 3-D DEM of Mt. St. Helens in Washington State before and after the May 18, 1980, eruption.
(Courtesy of the U.S. Geological Survey)

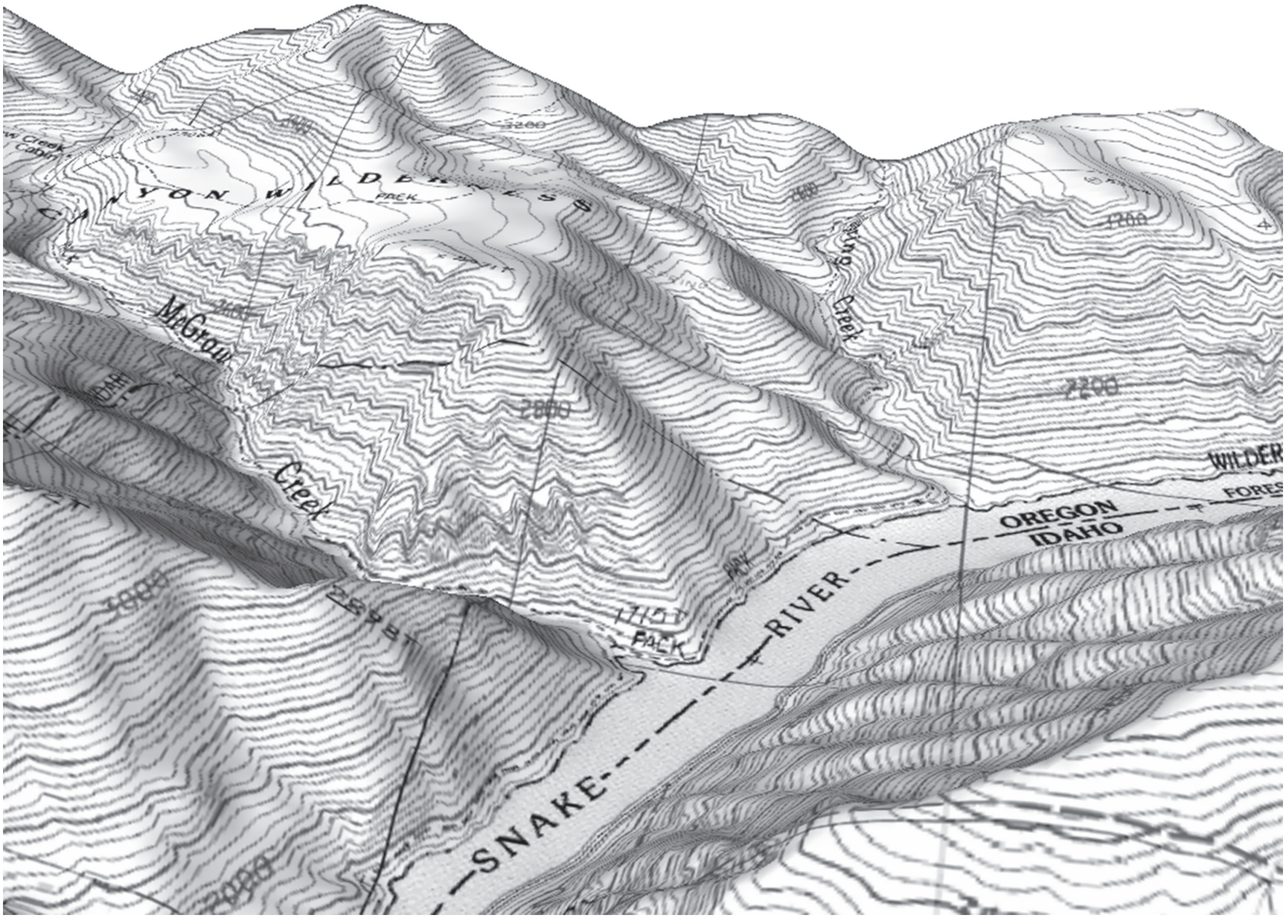


Figure 1–20. A 3-D DEM of a portion of the Snake River between the states of Oregon and Idaho. This DEM includes a topographic map overlay.
(Courtesy of the U.S. Geological Survey)

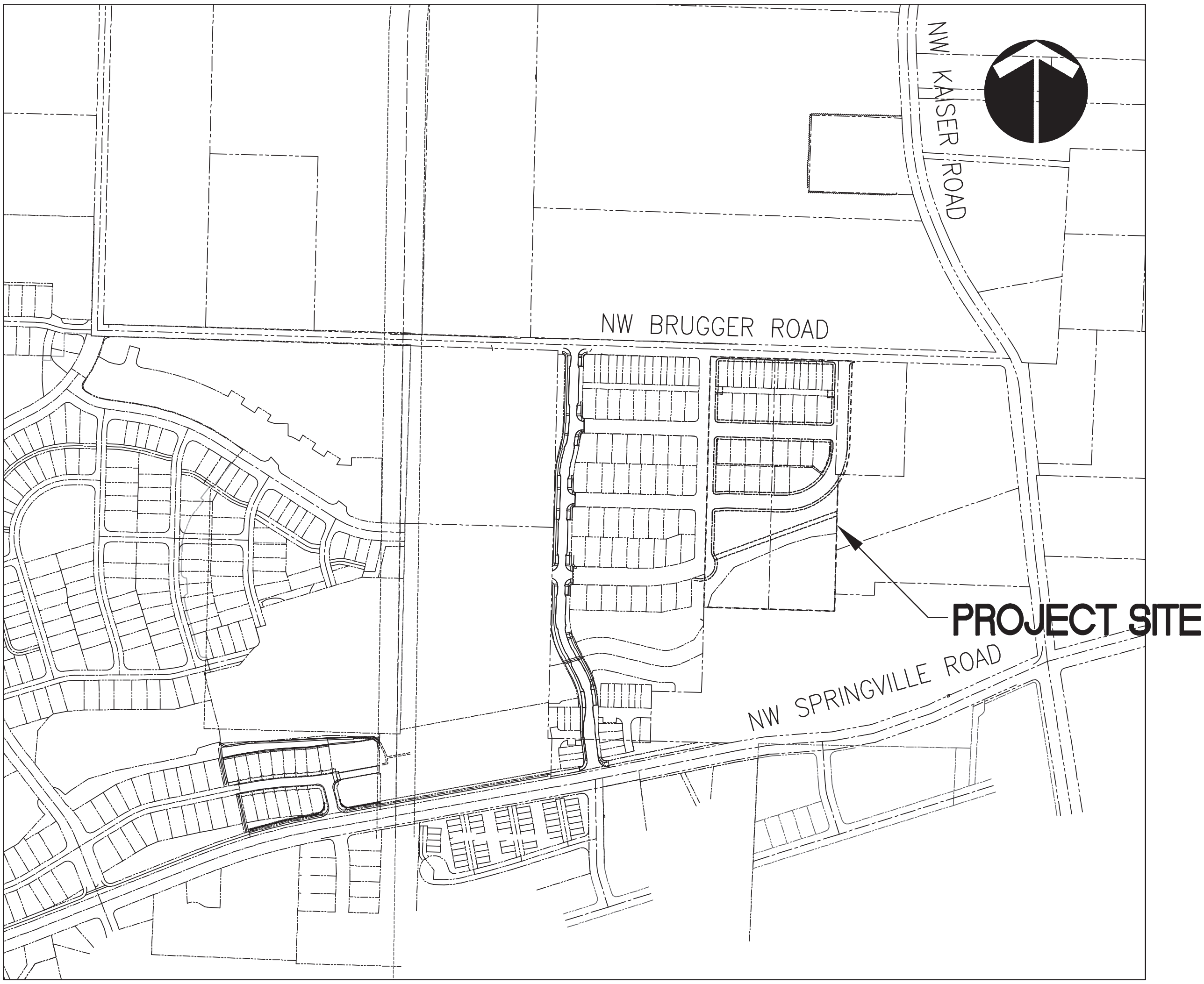
Plan Drawings

A **plan view**, or **plan**, is a view of an area looking down on the area as projected onto a horizontal plane. Plan views illustrate aspects of a project such as property lines, roads, structures, utilities, and landscaping. A variety of plan drawings may be created depending on the size and complexity of a project. Maps and site plans are some of the first drawings created for a project.

A **vicinity map** places a project site within a large area, such as several square miles, and provides an overview of the site relative to the surrounding area (see Figure 1–21). A site plan is drawn at a larger scale than the vicinity map, and depicts the overall scope of the project. Several site plans may be included in a set of drawings, each illustrating a specific element of the design. Figure 1–22 shows an example of a site plan for a subdivision.

Cross Section and Profile Drawings

Once plan drawings are available, cross section and profile drawings are created to show the side view, or elevation, of plan view features. A **cross section view**, or **cross section**, is a view that cuts through



VICINITY MAP

N.T.S.

Figure 1–21. A vicinity map places a project site within a large area and provides an overview of the site relative to the surrounding area.
(Courtesy of Otak, Inc.)

an area to show detail that cannot be clearly identified in plan view. The terms cross section and section are often used interchangeably. Technically, a cross section cuts completely across a feature, while a section cuts through a feature partially or completely. A **profile** is a cross section of a portion of land, or along the length of a linear feature such as a road, sewer line, power line, or stream. A profile normally has horizontal and vertical scales that are different (see Figure 1–23). Chapter 11 describes profiles in detail.

A **cutting-plane line** is a line drawn on a plan view to show the location of a cross section cut. A cutting-plane line usually terminates with arrowheads or other symbols that point toward the cutting plane, indicating the line of sight when looking at the cross section. Cutting-plane lines often include information to help key the plan view to the cross section in a set of drawings. Figure 1–24 displays a portion of the site plan shown in Figure 1–22. The letter

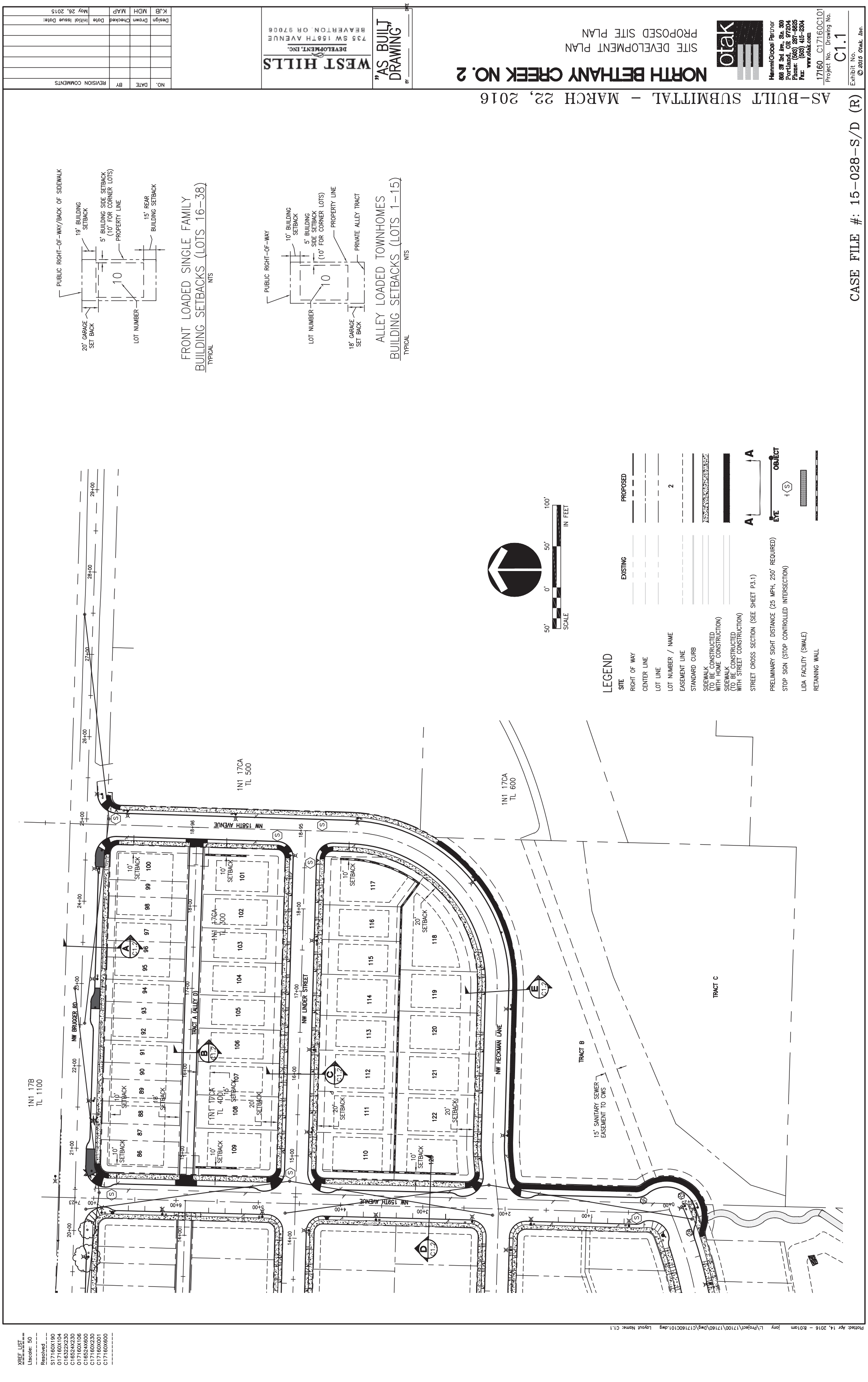


Figure 1–22. A subdivision site plan shows the layout of the project on the land.
(Courtesy of Otak, Inc.)

in the top half of the cutting-plane line symbol is the identification for the section, and the information in the lower half of the symbol indicates the sheet on which the section is shown. The sheets in a set of drawings for a project are numbered sequentially. To find section A-A in Figure 1–24, go to sheet C1.2 of the drawing set. Figure 1–25 shows section A-A.

A **typical cross section** is common to any location along the feature such as the street shown in Figure 1–26. Therefore, a cutting-plane line for the section is not shown on the plan drawing. Specific cross sections may be shown if features such as drains and underground utilities are required. A section will have a certain scale, or may be indicated as not to scale (NTS) as shown in Figure 1–26. Chapter 12 explains cross sections in detail.

Detail Drawings

A **detail drawing**, or **detail**, is typically an enlarged view created to describe features not shown on other drawings. Details can be created for any construction feature. Details normally specify standards that govern the project, and are used to guide construction. Most civil engineering companies and agencies have large libraries of standard

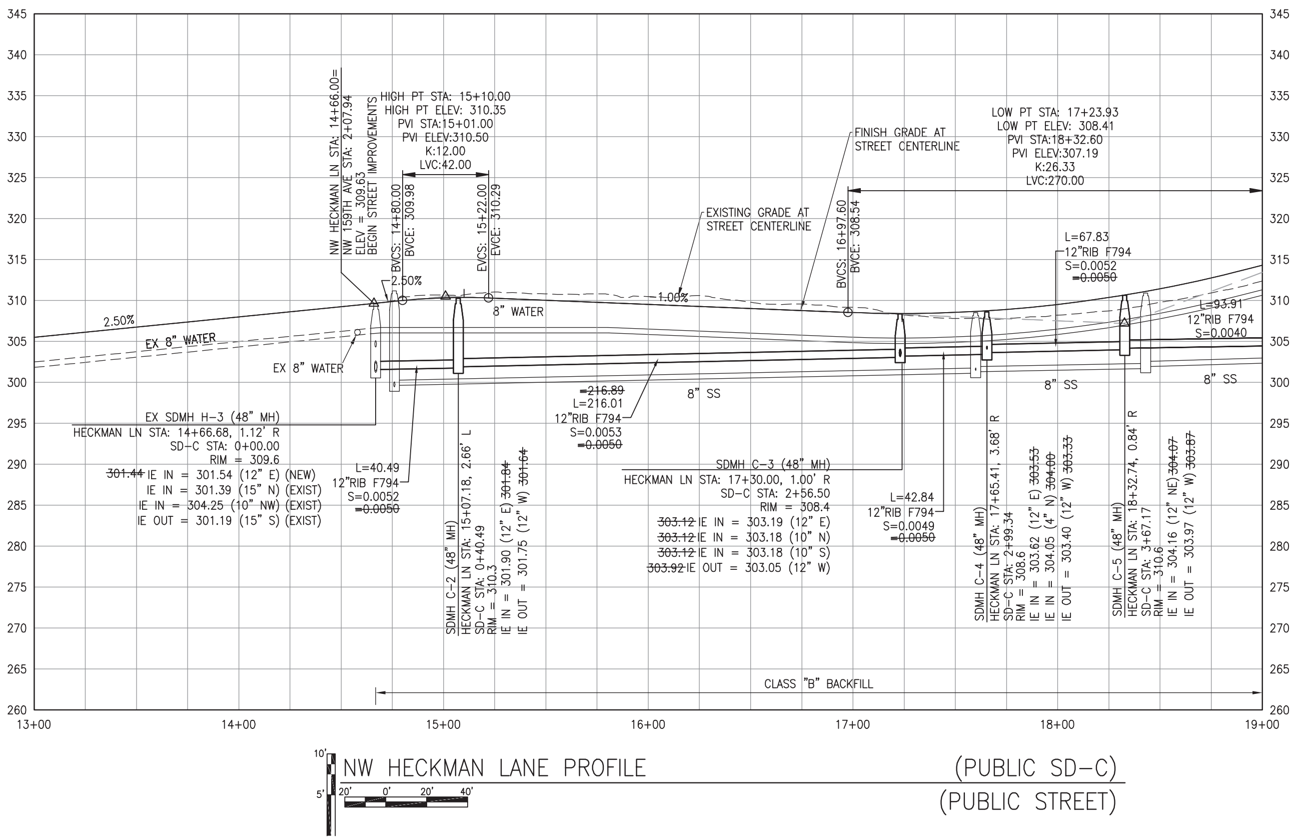


Figure 1–23. A profile is a section that is cut along the length of a linear feature, such as this street, and normally has different horizontal and vertical scales.
(Courtesy of Otak, Inc.)

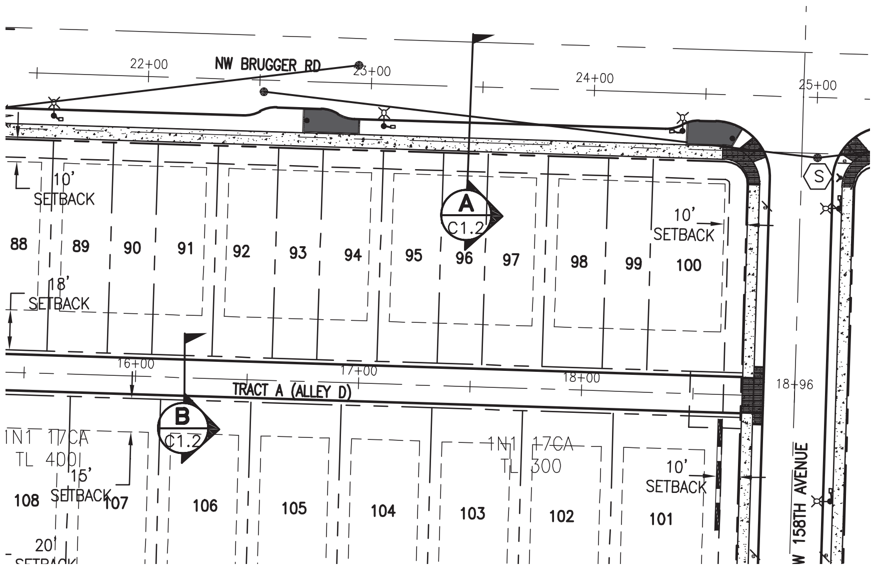


Figure 1–24. Cutting-plane line symbols shown on a plan view. Sections A-A and B-B are shown on sheet C1.2, and the views are to the right.
(Courtesy of Otak, Inc.)

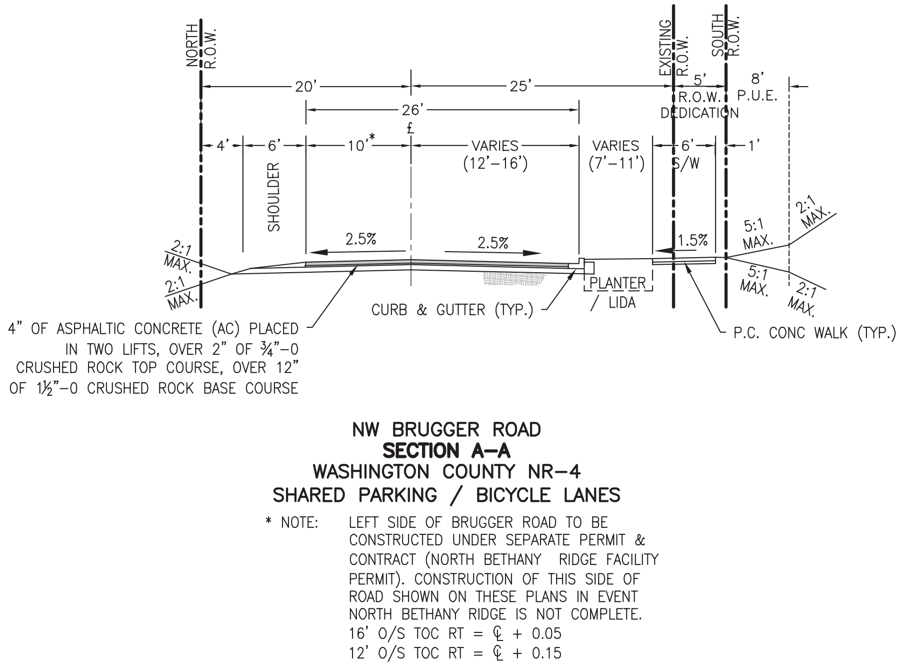


Figure 1–25. This is section A-A, cut on sheet C1.1 and shown on sheet C1.2.
(Courtesy of Otak, Inc.)

details. Details may be shown on one of the plan sheets if they are common features and the subject of a specific plan. If a detail is not a typical construction standard, it may be shown on plan sheets, cross sections, or with other details. Figure 1–27 shows an example of a detail drawing.

As-Built Drawings

An **as-built survey** is preformed after a construction project is finished to identify final construction, including improvements and structures created during construction. As-built surveys provide the data required to create as-built drawings. An **as-built drawing**, also known as an **as-built**, is drawn after a construction project is finished to document final construction. As-builts can reveal changes made during construction that differ from the design shown in the construction documents. As-built drawings are also referenced for maintenance and operations, and future alterations to a structure. As-built changes are often drawn by the contractor, and shown in red.

Drafting Standards

Most industries have established standards. **Standards** are a set of technical definitions and guidelines that specify requirements, techniques, and operating procedures. Standards promote safety, reliability, productivity, and efficiency. A **code** is a standard that one or more governmental bodies adopts and has the force of law. Standards are considered voluntary because they serve as guidelines. However, successful engineering companies and agencies implement and strictly adhere to nationally and internationally recognized drafting standards. Standards become mandatory when incorporated into a business contract or regulations.

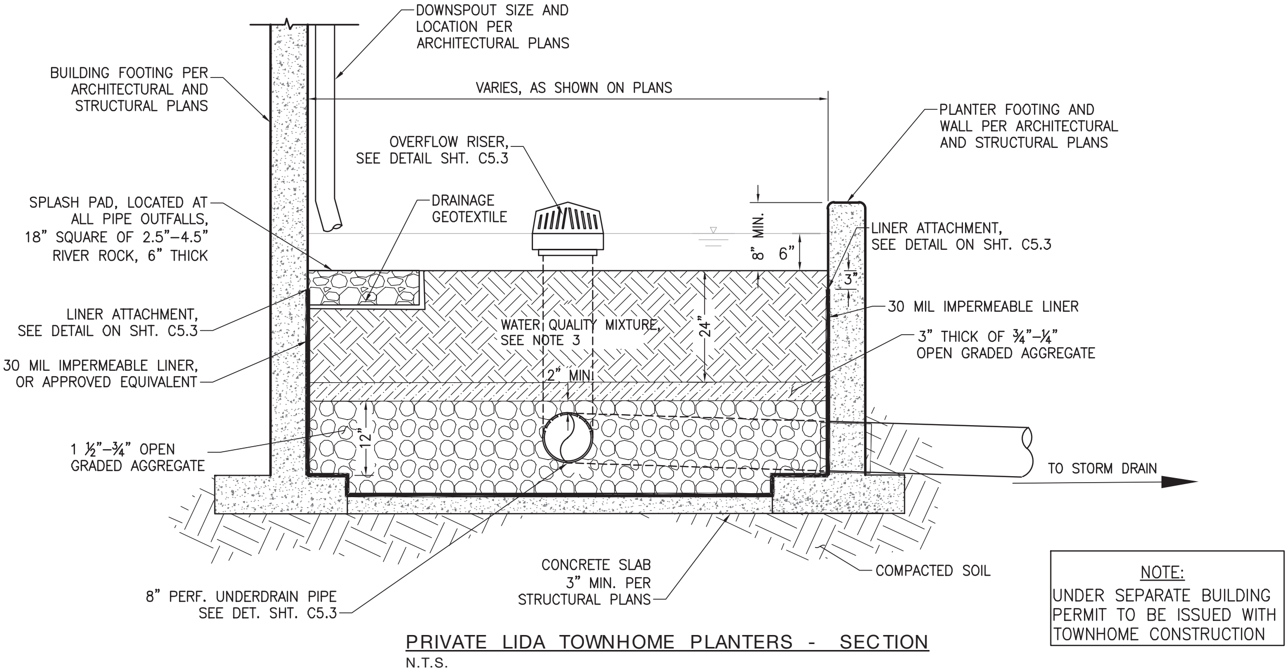
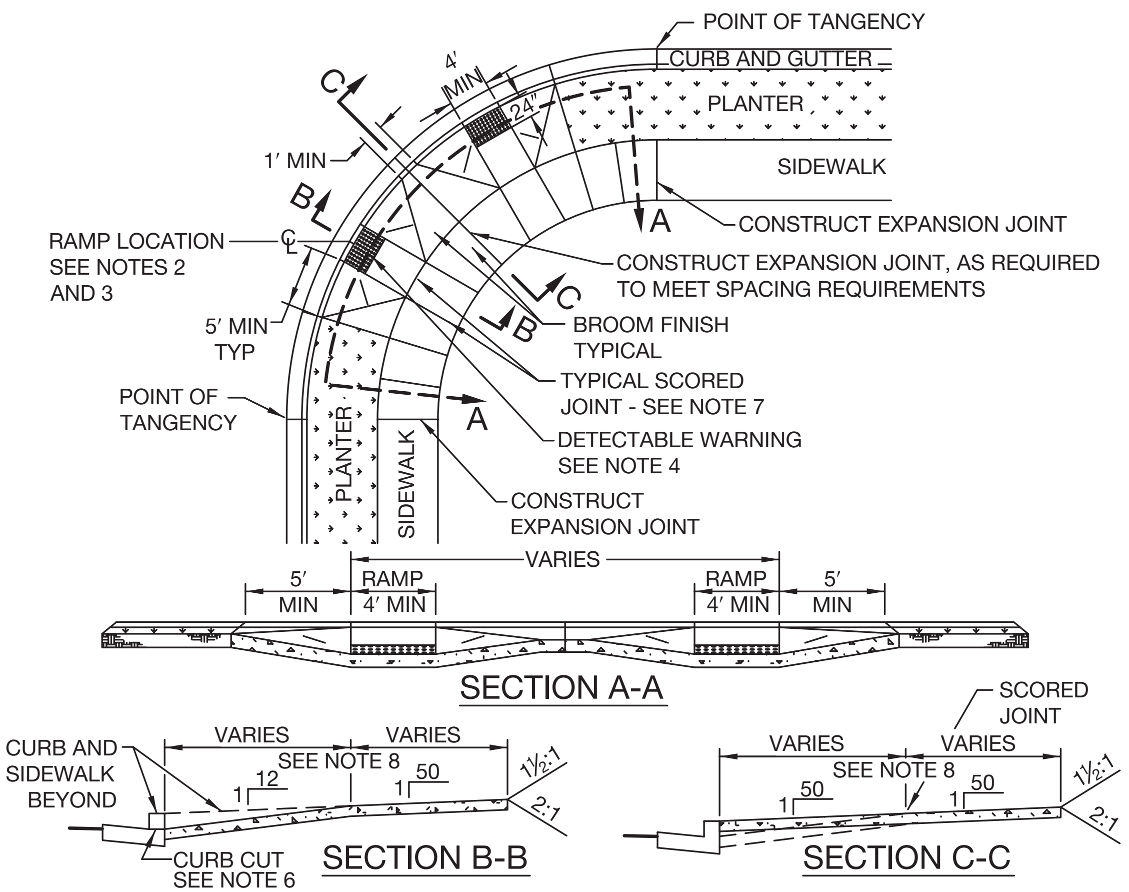


Figure 1–26. A typical cross section common to any townhome built in the subdivision. This section shows the construction of a low impact development approach (LIDA) storm water pollution control system.
(Courtesy of Otak, Inc.)



NOTES:

1. Sidewalk ramp shall meet *ADA Standards*.
2. Engineer shall prepare a site-specific drawing for each ramp, accepting full responsibility for correcting all unacceptable ramp construction resulting from applying this drawing "*as is*."
3. Each ramp shall be located relative to crosswalk or stop line.
4. Detectable warning shall be 24 inches long in the direction of travel and full width of the ramp, made of concrete imbedded yellow tiles, that have truncated domes aligned on a square grid with its gridlines parallel and perpendicular to the centerline of the ramp, from the approved list in the *Engineering Design Manual, Sec* 210.10.
5. Concrete shall have a compressive strength of 4,000 psi at 28 days.
6. Bevel the curb cut from gutter to back of curb at 8.33% (1:12).
7. Score at grade changes, surface texture changes and at other points shown. Edges shall be shined.
8. For sidewalk and planter strip widths and sidewalk panel dimensions, see *Beaverton Standard Dwg* 215.
9. Curb inlet or catch basin shall not be allowed in front of sidewalk ramp.
10. A single ramp may be used at "T" intersections at the locations shown in the diagram in the *Engineering Design Manual, Sec* 210.10.

STANDARD SIDEWALK RAMPS
WITH PLANTER STRIP

Figure 1–27. This detail illustrates the construction standards for sidewalk ramps with a planter strip to be used in the subdivision street system.
(Courtesy of PACE Engineers, Inc.)

One of the most important concepts for a new drafter to understand is the role that standards play in the design and drafting process. Standards are important for engineering communication because they serve as a common language. Standardized procedures result in lower costs, fewer errors, and simplified training. The cleaner and more accurate drawings are when sent out for bids, permitting, and construction, the greater the potential is for saving time and money.

Drawing standards apply to most settings and procedures, from the name assigned to a CADD file to the appearance of symbols and text on a drawing. Though standards vary in content, the most important point is that standards exist and are understood and used by all design and drafting personnel. When you follow drawing standards, drawings are consistent, you become more productive, and projects function more efficiently. Standards are generally defined by professional organizations, companies, clients, government agencies, and projects.

Professional Organization Standards

Members of professional associations, such as those identified in this chapter, develop or have a strong influence on national and international design and drafting standards and practices. The American Society of Mechanical Engineers (ASME) is an accredited standards developing organization that meets American National Standards Institute (ANSI) requirements. Codes and standards developed under an accredited program can be designated as American National Standards. Many ASME drafting standards apply to drawings prepared in the manufacturing industry or specialized engineering disciplines. However, several ASME standards, such as ***ASME Y14.2 Line Conventions and Lettering***, provide general drafting standards that can be adapted to any field. For more information about ASME standards, go to www.asme.org.

The International Organization for Standardization (ISO) develops and maintains an extensive list of internationally recognized standards and related documents. ISO standards are based on the opinions of experts in ISO technical committees. Many ISO drafting standards apply to a specific discipline. The ***93: Civil engineering*** series are civil engineering standards. The ***01.100.30: Construction drawings*** standards are construction, including civil engineering, drawing standards. Several ISO standards, such as many of the standards found in the ***01.100: Technical drawings*** series, offer fundamental drafting principles that can be applied to any field. For more information about ISO standards, go to www.iso.org.

The United States National CAD Standard (NCS) is a set of standards intended to simplify and increase the efficiency and accuracy of CADD data exchange. The NCS was developed by several national organizations, and focuses on architecture, engineering, and construction (AEC) projects. The American Institute of Architects (AIA), Construction Specifications Institute (CSI), and the National Institute of Building Sciences (NIBS) contribute to the NCS. The NCS includes four major components:

- AIA CAD Layer Guidelines
- Uniform Drawing System (UDS)
- BIM Implementation
- Plotting Guidelines

Chapter 2 explains more about the NCS. For additional information about the NCS, go to www.nationalcadstandard.org or www.nibs.org.

The National Council for Advanced Manufacturing (NACFAM) publishes the ***National Skill Standards for Computer-Aided Drafting and Design***. This publication provides the skills needed for beginner CADD users. While this standard is not related specifically to civil drafting, it contains valuable content for new CADD drafters, professionals, and educators. For more information about NACFAM, go to www.nacfam.org.

Company Standards

Engineering firms adopt standards published by professional organizations, and/or apply client, government, and project standards. Companies also create their own standards as an element of the business process, and in an attempt to save time and expense. Examples of company standards are methods of saving and storing CADD data; plotting procedures; systems for transferring files to vendors; and libraries of symbols, cross sections, and details. Company standards are often proprietary and may or may not be created based on nationally or internationally recognized standards.

Client Standards

Company standards often reflect the clients with which the company works. The **client** is the individual or organization for which a project is developed. A client can be a private interest, such as a landowner or developer, or a government municipality. Client standards are often reflected in detail drawings representing methods of layout, design, and construction.

Government Standards

City, county, state, and federal codes and details typically apply to many aspects of a civil engineering project. Government codes and details must be adhered to even if professional organization and company drafting standards are available. Government standards apply when required to all projects, even if the government is not the client. Municipalities and government agencies usually have libraries of symbols, details, cross sections, and other drawing files that are used directly in a set of drawings for a project. A CADD drafter must be able to locate and use these files properly.

Project Standards

Project standards may include a combination of professional organization, company, client, and government standards. Project standards are the final documents that are used to design and build a project. Depending on the size and scope of the project, a document with a title such as ***Project Specifications*** may be printed and made available for reference. A **specification** is an exact statement describing the characteristics of a particular aspect of a project.

Checking Drawing Standards

Prior to the release of drawings for bids and/or construction permitting, it is important that drawings go through a final check for adherence to applicable standards. **Standards checking** is a procedure by which drawings are checked against a base standards drawing that contains up-to-date drawing, design, and construction standards for a specific discipline or trade. CADD software often includes routines that allow the user to put any drawing or set of drawings through a standards check before the drawings are sent on to the next project phase. Software-based standards checking usually involves opening the drawing to be checked and opening the standards drawings to be used in the checking process. The software may automatically change items not up to standard or mark them for change by the CADD user.

Workplace Ethics

Ethics are rules and principles that define right and wrong conduct. A **code of ethics** is a formal document that states an organization's values and the rules and principles that employees are expected to follow. In general, a code of ethics contains the following main elements:

- Be dependable
- Obey the laws
- Be honest
- Have integrity
- Treat others with respect
- Build teamwork through trust
- Be a good citizen
- Have good customer relations

Intellectual Property Rights

The success of a company often relies on the integrity of its employees. Products are often the result of years of research, engineering, and development. This is referred to as the **intellectual property** of the company. Protection of intellectual property can be critical to the success of the company in a competitive economy. This is one reason why it is very important for employees to help protect design ideas and trade secrets. You will often find proprietary notes on drawings that inform employees and communicate to the outside world that the information contained in the drawings is the property of the company and cannot be used by others without permission.

CHAPTER REVIEW

Answer the following questions using the information presented in this chapter.

Part 1

Define the following terms.

1–1 Civil engineering

1–2 Civil drafting

1–3 Map

1–4 Cartography

1–5 Legend

1–6 Scale

1–7 Political map

1–8 Photogrammetry

1–9 Contour line

1–10 Terrain

1–11 Cadastral map

1–12 Site plan

1–13 Digital elevation model (DEM)

1–14 Plan view

1–15 Cross section

1–16 Profile

1–17 Detail drawing

1–18 Standards

1–19 Code

1–20 Ethics

Part 2

Choose the response that best describes each statement.

1–21 An instrument with a system of ordered marks at fixed intervals used for measurement is called a:

a. Title block
b. Scale
c. Legend
d. Digital terrain model (DTM)

1–22 Small-scale maps that display the physical features of an area such as differences in elevation and bodies of water are called:

a. Political maps
b. Cadastral maps
c. Geologic maps
d. Physical maps

1–23 Arial photos taken at certain intervals and controlled by base stations on the Earth's surface are used to create:

- **a.** Contour lines
- **b.** Cutting-plane lines
- **c.** Photogrammetric maps
- **d.** Detail drawings

1–24 Maps that accurately show the shape of the Earth using contour lines are called:

- **a.** Photogrammetric maps
- **b.** Topographic maps
- **c.** Digital terrain models
- **d.** Geographic maps

1–25 Maps that describe the location, type, and extent of geologic features such as rock formations and edges of earth movement, are called:

- **a.** Charts
- **b.** Geographical maps
- **c.** Geologic maps
- **d.** Topographic maps

1–26 Maps that show the boundaries and characteristics of surface waters, or hydrography, are called:

- **a.** Environmental maps
- **b.** Nautical charts
- **c.** Cadastral maps
- **d.** Hydrographic maps

1–27 Maps that detail the layout of a construction project are called:

- **a.** Thematic maps
- **b.** Cadastral maps
- **c.** Engineering maps
- **d.** Topographic maps

1–28 A view of an area looking down on the area as projected onto a horizontal plane is called a:

- **a.** Detail view
- **b.** Vicinity map
- **c.** Profile
- **d.** Plan view

1–29 A cross section of a portion of land, or along the length of a linear feature such as a road, sewer line, power line, or stream is called a:

a. Geologic map
b. Profile
c. Digital elevation model (DEM)
d. Cutting-plane line

1–30 A standard that one or more governmental bodies adopts and has the force of law is called a:

a. Code
b. Client standard
c. CADD standard
d. Detail

PROBLEMS

Follow the specific instructions to complete each problem.

P1–1 Describe five examples of civil engineering projects.

P1–2 Describe five programs and activities sponsored by the American Design Drafting Association/American Digital Design Association (ADDA).

P1–3 Classify the type of map shown in Figure P1–3. Describe how you came to your conclusion.

Figure P1–3.
(Courtesy of the U.S. Geological Survey)

P1–4 Classify the type of map shown Figure P1–4. Describe how you came to your conclusion.

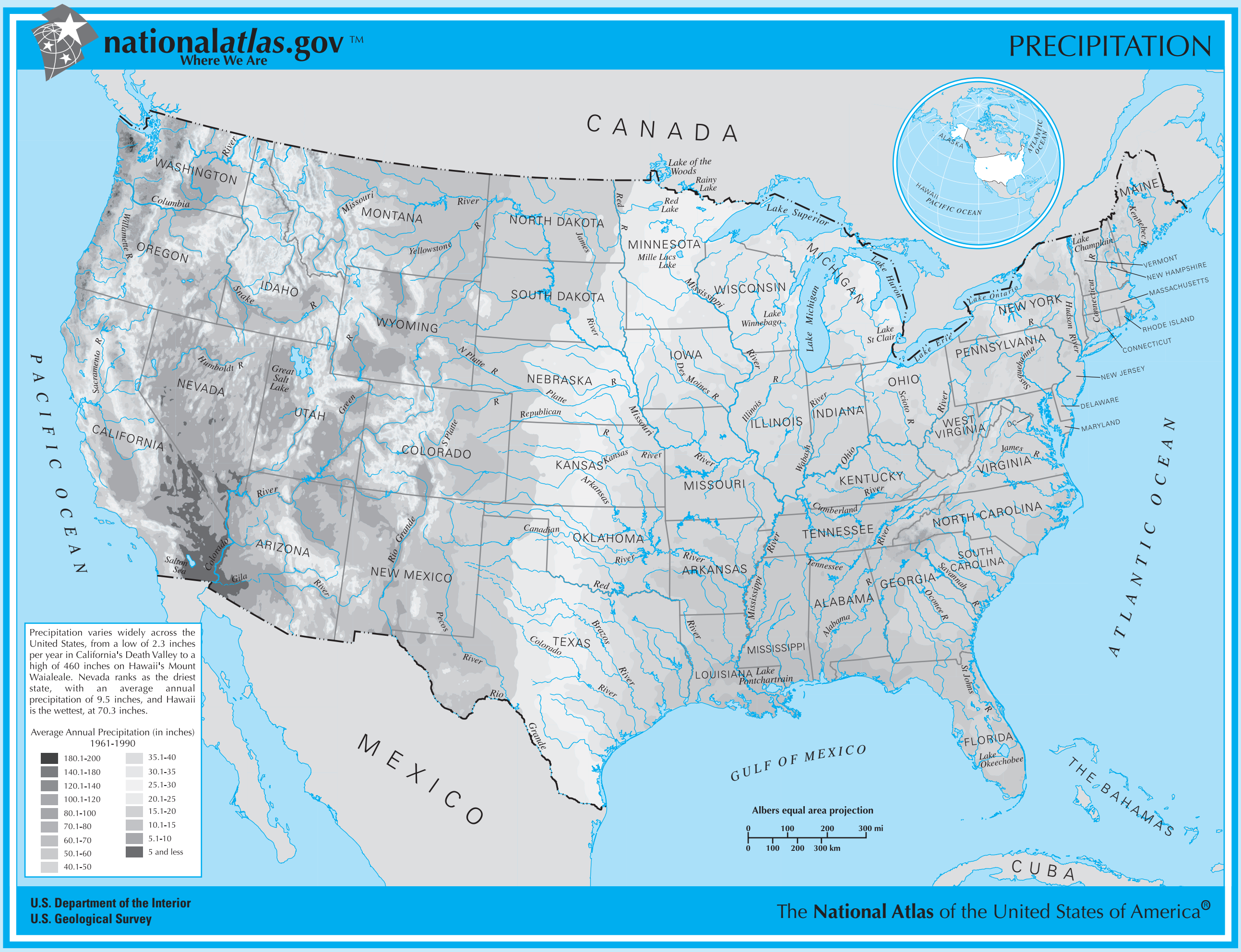


Figure P1–4

(Courtesy of the U.S. Geological Survey)

P1–5 Classify the type of map shown in Figure P1–5. Describe how you came to your conclusion.

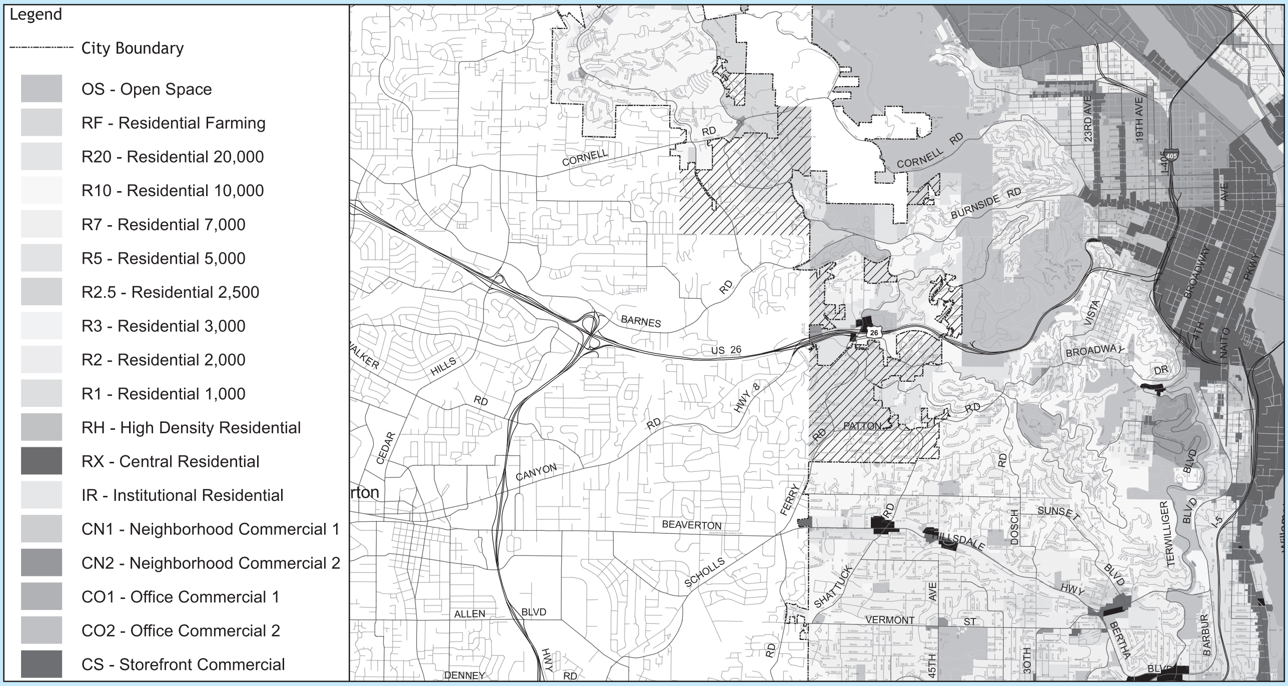


Figure P1–5.
(Courtesy of the City of Portland, Oregon)

P1–6 Interview your drafting instructor or supervisor to determine what type of drawing standards exist at your school or company. Write the standards down and keep them with you as you learn civil drafting technology. Make notes as you progress through this textbook on how you use these standards. Note how you could change the standards to reduce costs and improve productivity.

P1–7 Research and write a report of approximately 250 words describing the employment opportunities for civil drafters in the city and state in which you live.

P1–8 Research and write a report of approximately 250 words covering the American Society of Mechanical Engineers (ASME) standards accredited by the American National Standards Institute (ANSI). Prepare a PowerPoint presentation of your research and present the slide show to your class or office.

P1–9 Research and write a report of approximately 250 words covering the International Standards Organization (ISO) drafting standards. Prepare a PowerPoint presentation of your research and present the slide show to your class or office.

P1–10 Research and write a report of approximately 250 words covering workplace ethics, especially as it applies to civil engineering design and drafting applications and CADD-related software. Prepare a PowerPoint presentation of your research and present the slide show to your class or office.