

Watersheds

4

"The study of rivers is not a matter of rivers, but of the human heart."

— Tanaka Shozo

All land on earth is a **watershed**. Humans and their activities play an important and essential role in watersheds, yet few people understand them. Still fewer know how a watershed works or can describe the boundaries of the ones in which they live.

A watershed is often called a drainage basin. It is the land area drained by a network of channels, called **tributaries**, that increase in size as the amount of water, sediment, and dissolved materials they must carry increases. Each watershed is an interconnected land-water system that conveys water to its outlet—a larger stream, an inland lake, a wetland, an estuary, or the ocean.

A watershed may be the drainage area surrounding a lake that has no surface outlet, such as Malheur and Harney Lakes in southeast Oregon

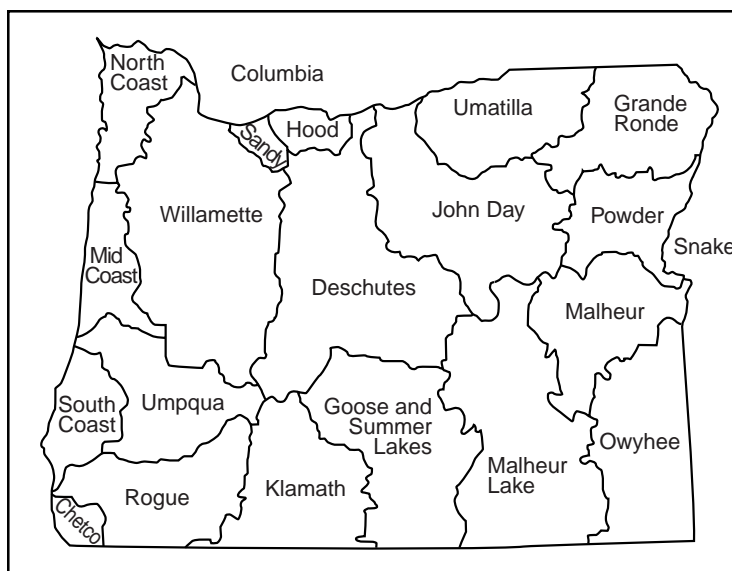
or a river basin as large as that of the Columbia River. A puddle even has its own watershed.

Within a large watershed tributaries form smaller watersheds called **sub-basins**. Each tributary contributes to overall streamflow for the entire basin. Oregon has 20 major river basins (see Figure 4.)

All watersheds have an aquatic (or water) area, a riparian area, and an upland area. Aquatic areas include standing waters like ponds, lakes, wetlands, bogs and running surface waters such as streams and rivers. The corridor of vegetation next to and influencing the aquatic area is called the **riparian area**.

The point where two watersheds meet is called a **divide**. Connecting the divide with the valley or lowland areas below are the hill slopes or **uplands**. Events in the uplands ultimately

Figure 4. Oregon River Basins



Vocabulary

aquifers	perennial
baseflow	plant associations
climate	radial drainage
dendritic drainage	residual soils
deposition	riparian area
divide	streamflow hydrograph
ephemeral	sub-basins
erosion	sublimation
first-order streams	transported soils
forage	trellis drainage
gradient	tributaries
intermittent	uplands
leaching	water equivalent
parallel drainage	watershed

affect the capture of water on the surface of the land, storage and movement of water below the surface, and release of water to riparian and aquatic areas.

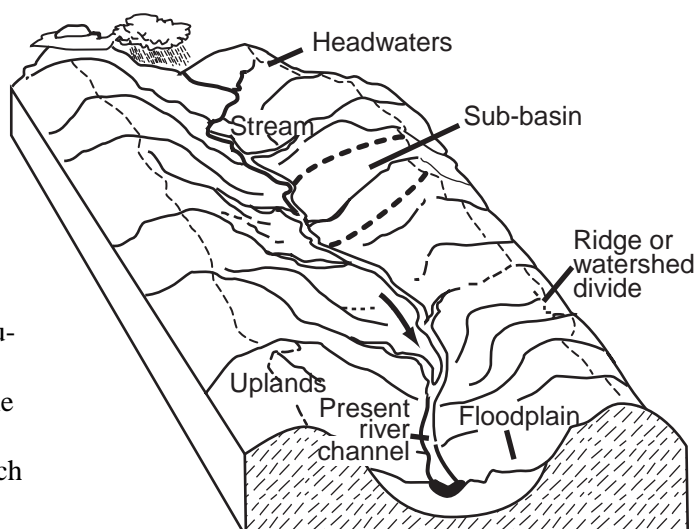
Each stream in a watershed is an ever-changing open-water system. It carves through valleys, collects water and sediments, and conveys the surface runoff generated by rainfall, snowmelt, or groundwater discharge to the estuaries and oceans. The shape and pattern of a stream is a result of the land it is cutting and the sediment it must carry.

Each of us has a “watershed address,” which describes our basic relationship with a watershed. One part of our address is our location. We all live in topographic watersheds—areas drained by a common stream. When a raindrop falls on the roof of our house, where is it going? What creeks or rivers will carry it toward the sea?

Some people also live in engineered watersheds, which may not follow topographic lines. When we turn on the faucet in the kitchen sink, what watershed did that water come from? When the water runs down the drain, what watershed is it going to? For example, while rainwater in much of the Portland Metro area flows into the Willamette River, much of Portland’s domestic water supply is piped from the nearby Bull Run Watershed, a watershed that flows toward the Columbia River. In this way, one watershed is artificially connected to several other watersheds at once. The watershed of surface flow, the watershed where domestic water originates, and the watershed where wastewater goes are all connected. This means Portland residents live in one watershed and drink water from another, while their wastewater may affect their “home watershed” and others.

Physical features of a watershed

Rain, snow, wind, ice, and temperature variations are all agents of erosion in a watershed. The erosional effects of surface water create stream channels. As streams carve their way through a watershed, they are responsible for most of the “topographic identity” of a watershed.



A watershed is almost like a domicile, a mini-biosphere, with halls of hills and mountains, a floor of river or lake, and a roof of rain clouds. Adapted from Co-Evolution Quarterly, Winter 1976/77.

Area

The area of a watershed affects the amount of water that flows from the river or stream that drains it. Generally, with similar climates large watersheds receive more precipitation than small ones. Greater precipitation and runoff may occur on a smaller watershed in a moist climate than on a large watershed in an arid climate.

Shape and slope

Shape and slope of a watershed and its drainage pattern influence surface runoff and seepage in streams draining the watershed. The steeper the slope, the greater the possibility for rapid runoff and erosion. Plant cover is more difficult to establish and infiltration of surface water is reduced on steep slopes.

Orientation

Orientation of a watershed in relation to the direction that storms move across it also affects runoff and peak flows. A rainstorm moving up a watershed from the mouth releases water in such a way that runoff from the lower section has passed its peak before runoff from the higher sections has arrived. A storm starting at the top

and moving down a watershed can reverse the process.

Orientation of a watershed relative to sun position affects temperature, evaporation, and transpiration. Soil moisture is more rapidly lost by evaporation and transpiration on steep slopes facing the sun. Watersheds sloping away from the sun are cooler, and evaporation and transpiration are less. Slopes exposed to the sun usually support different plants than those facing away from the sun. Orientation to prevailing winds has similar effects.

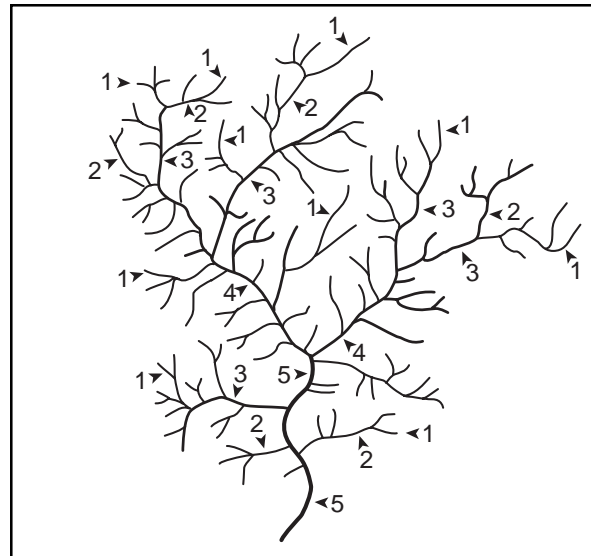
Drainage patterns

Viewed from above, the tributaries of each river system create a distinct pattern. Geology, topography, and climate are responsible for this pattern. Regions with parallel valleys formed by the folding of the earth's surface have a **parallel drainage** pattern. Where the geology is sedimentary rock, fault lines may create a drainage pattern where streams flow parallel to each other and tributaries join at nearly right angles in a **trellis drainage** pattern.

In the Pacific Northwest two of the most common patterns are **radial drainage** and **dendritic** (treelike) **drainage**. When streams drain a central high point, such as a mountain top, they create a pattern similar to the spokes on a wheel radiating out from the central hub. This is radial drainage.

The branching tributaries of a river may also create a pattern similar to the branches of a tree. This is dendritic drainage. Both types may occur within the same watershed. For example, the radial pattern of streams that drain Mount Hood are all within the Columbia Basin, but the drain-

Figure 5. Stream Orders



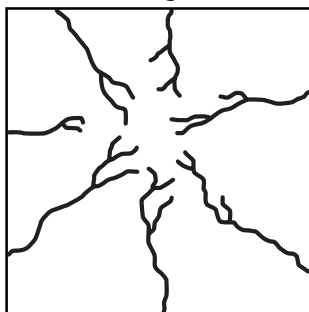
age pattern of the individual sub-basins formed by these streams have a dendritic pattern.

Stream orders

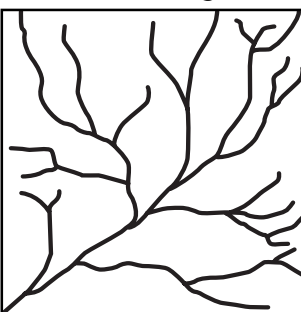
In most cases, a watershed system is almost entirely hillsides, called uplands. Only about one percent of a watershed is stream channels. The smallest channels in a watershed have no tributaries and are called **first-order streams**. When two first-order streams join, they form a second-order stream. When two second-order channels join, a third-order stream is formed, and so on (Figure 5). First- and second-order channels are often small, steep, or **intermittent**. Orders six or greater are larger rivers.

Channels change by **erosion** and **deposition**. Natural channels of rivers increase in size downstream as tributaries enter and add to the flow.

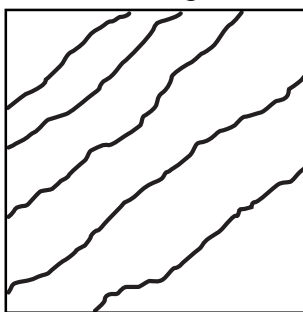
Radial Drainage



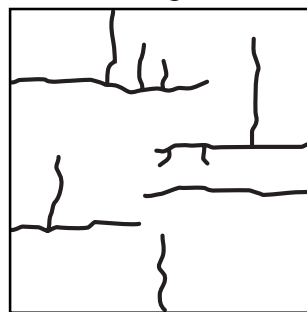
Dendritic Drainage



Parallel Drainage



Trellis Drainage



A channel is neither straight nor uniform, yet its average size changes in a regular and progressive fashion. In upstream reaches, the channel tends to be steeper. **Gradient** decreases downstream as width and depth increase. The size of sediments tends to decrease, often from boulders in the hilly or mountainous upstream portions, to cobbles or gravels in middle reaches. More sand or silt are found downstream. In some cases, large floods cause new channels to form, leaving once-productive streams dry and barren.

Streamflow types

Besides the ordering system previously described, streams may be classified by how much of the year they have flowing water.

- **Perennial** flow indicates a nearly year-round flow (90 percent or more) in a well-defined channel. Most higher order streams are perennial.
- **Intermittent** flow generally occurs only during the wet season (50 percent of the time or less).
- **Ephemeral** flow generally occurs during and shortly after extreme precipitation or snowmelt conditions. Ephemeral channels are not well defined and are usually head-water or low order (1-2) streams.

Factors affecting watersheds

Climate

Land and water are linked directly by the water cycle. Solar energy drives this and other cycles in the watershed. **Climate**—the type of weather a region has over a long period—is the source of water. Water comes to the watershed in seasonal cycles, principally as rain or snow. In some areas, condensation and fog-drip contribute water. The seasonal pattern of precipitation and temperature variation control streamflow and water production.

Some precipitation infiltrates the soil and percolates through porous rock into groundwater storage, which recharges areas called **aquifers**. Natural groundwater discharge, called **baseflow**,

is the main contributor to streamflow during dry summer and fall months. Without baseflow, many streams would dry up.

Pumping water from an aquifer for industrial, irrigation, or domestic use reduces the aquifer's volume. Unless withdrawals are modified or recharge increased, the aquifer will eventually be depleted. A drained aquifer can collapse from the settling of the overlying lands.

Collapsed underground aquifers no longer have as much capacity to accept and hold water. Recharge is difficult, volume is less, and yields

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directly by the water cycle.*

are considerably reduced. Springs once fed from the water table also dry up.

Climate affects water loss from a watershed as well as provides water. In hot, dry, or windy weather, evaporation loss from bare soil and from water surfaces is high.

The same climatic influences that increase evaporation also increase transpiration from plants. Transpiration draws on soil moisture from a greater depth than evaporation because plant roots may reach into an available moisture supply. Transpiration is greatest during the growing season and least during cold weather when most plants are relatively dormant.

Wind also causes erosion, controls the accumulation of snow in sheltered places, and may be a significant factor in snowpack melting. Wind erosion can occur wherever wind is strong and



constant, or where soil is unprotected by sufficient plant cover.

Soils and geology

Soil, a thin layer of the earth's crust, could be called the "skin" of a watershed. It is composed of mineral particles of all sizes and varying amounts of organic materials. It is formed from the breakdown of parent rocks into fine mineral particles. This occurs by:

- freezing and thawing in winter,
- heating expansion and cooling contraction in summer,
- wind and water erosion,
- the grinding action of ice, and
- action of lichens and other plants.

Soils are of two types. **Residual** soils are those developed in place from underlying rock formations and surface plant cover. **Transported** soils include those transported by gravity, wind or water.

Climate, particularly precipitation and temperature, strongly affects soil formation. Rainfall causes **leaching**—movement of dissolved particles through soil by water. Temperature affects both mechanical breakdown of rocks and breakdown of organic material. Soil bacteria, insects, and burrowing animals also play a part in the breakdown and mixing of soil components.

Soil often determines which plants grow in a watershed, which in turn establish a protective vegetative cover. Plants also modify and develop soil. Plant roots create soil spaces and extract water and minerals in solution from their roots. Plant litter adds organic matter to soil. It also slows surface runoff and protects the soil surface from rainfall's beating and puddling effects. Soil depths and moisture-holding capacities are usually less on steep slopes, and plant growth rates are often slower.

Forage, timber, and water are all renewable resources. Water is renewed by cycles of climate. Forage and timber are renewed by growth in seasonal cycles. The availability of these watershed resources is dependent upon soil. Soil is, except over long periods, a nonrenewable

resource. It may take more than a century to produce a centimeter of soil and thousands of years to produce enough soil to support a high-yield, high-quality forest, range, or agricultural crop. Soil is the basic watershed resource. Careful management and protection is necessary to preserve its function and productivity.

Vegetation

The variety of plant species and their growth and distribution patterns within a watershed are the result of differences in soil type, light, temperature, moisture, nutrient availability, and human activity. For example, temperatures on the north and south slopes of the same hill may vary considerably. Different light intensities may account for the temperature variation on either side of the hill. Temperature differences in turn affect the moisture levels on each of the slopes. Generally south-facing slopes are warmer and drier than north-facing slopes in the northern hemisphere.

The plant species that are present directly affect the ability of a watershed to capture, store, and release water within that particular habitat. Branches of large conifers effectively intercept snow and rain. Some of the moisture in the precipitation will evaporate before it has a chance to reach the ground but the rest is slowed

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and release water.*

in its descent, lessening the impact to the soil's surface. Sagebrush and other arid land shrubs, on the other hand, are not as effective in slowing snow or rain. Yet in areas with less precipitation, this adaptation provides the greatest opportunity for moisture to infiltrate. Watersheds covered with dense grass cover help the soil capture water much more effectively than watersheds with sparse vegetation.

Groups of plants that have evolved together over time are called **plant associations (or communities)**. Plant associations share specific adaptations to certain watershed conditions—climate, soil type, light and temperature requirements, moisture, and nutrient availability as described above. Knowing the basic plant associations found in a particular watershed can tell you a lot about the health of that watershed.

Fish and wildlife

Each watershed has a diverse mix of wildlife species—mammals, birds, reptiles, amphibians, and invertebrates. Plant communities influence which species are found in a particular watershed. Plants, in some form or another, meet the basic habitat needs of food, water, shelter, or space for most all forms of wildlife. And, all wildlife species, large or small, become part of the interrelationships found within a watershed.

Some wildlife never leave their watershed residence while others move among several adjoining watersheds or even migrate hundreds or thousands of miles to live in a completely different watershed during different times of the year. Wildlife populations within a watershed may vary seasonally and annually. Migration, predation, wildlife management (like hunting seasons), or watershed management decisions (development, timber harvest, mining, recreation, agriculture) can all affect wildlife populations.

Wildlife perform a variety of functions within a watershed. Less commonly known but very important contributions include burrowing activities of animals like worms and mice. Their burrows allow moisture to penetrate deep into the soil, aiding the water storage capabilities of the watershed. Small rodents also collect and store nuts and seeds, many of which sprout and grow to provide more food and ground cover. Rodents are also an important part of many watershed food chains. Birds also help transport seeds. Dams built by beavers help increase water storage in the soil and their activities are often responsible for channel changes within a stream system.

Limited exclusively to the aquatic habitats found within a watershed, fish occupy a unique

niche. Fish are part of complex aquatic food chains and, along with the aquatic organisms on which they feed, are indicators of water quality.

A number of factors within the watershed control a stream's ability to produce fish food. When producers such as algae and diatoms are plentiful, the aquatic insects that feed upon them also thrive. They in turn are food for other

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aquatic invertebrates and fish. Overhanging streamside vegetation also contributes insects to the aquatic dinner plate.

Studies in recent years show considerable evidence that stream systems with migrating populations of salmon and trout are highly dependent on the nutrients provided by the decaying carcasses that remain after spawning.

Fish populations vary with the quantity and the quality of available water within a watershed. Streams that flow cold and clean throughout the year generally provide the conditions that salmon and trout need to be healthy and productive. Human management activities can affect the quantity and quality of water in streams.

Management objectives in a watershed

A key watershed management objective is to maintain effective vegetative cover and soil characteristics that sustain high quality water supplies. Meeting this objective enhances the usefulness and productivity of the land for other purposes. If the soil is protected and maintained in good condition, then other renewable

resources that depend on this most basic form of productivity can be supported.

Timber, forage, minerals, food, and wildlife represent important watershed management considerations. Problems arise when development and use of these resources conflict with the primary objectives of maintaining and protecting high quality water supplies and promoting watershed integrity.

Land ownership is the principal institutional control of a watershed. A private individual or public management agency may be free to apply whatever measures they believe necessary or desirable on their own land. They may regulate

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access and prevent use and development of associated resources.

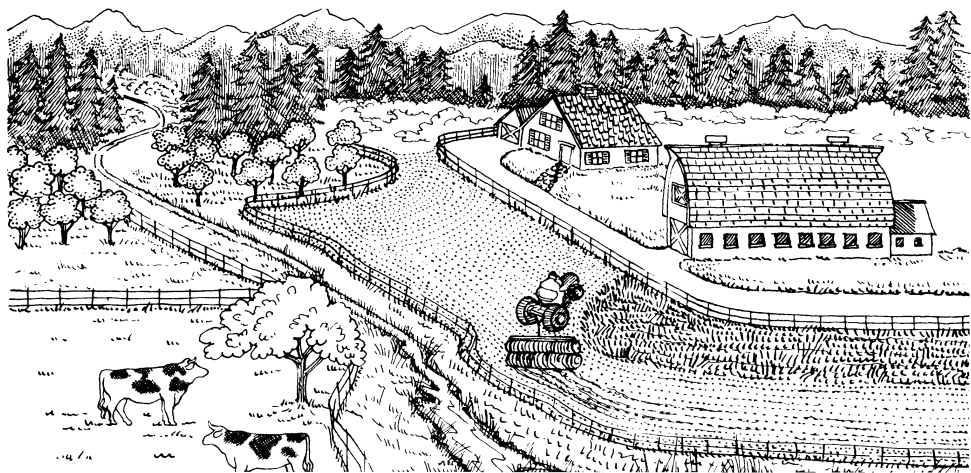
Many watersheds are in public or state ownership. Unless protected by specific legislation or agreement, most are used and developed to take advantage of all resources available for the general public benefit. It is in these multiple-use watersheds that management may face the most serious conflicts and challenges. Protecting the water resources of some of these watersheds may require limiting and balancing development to provide the greatest possible benefits with the least significant disruption of the water resource.

Legislation and government edicts also provide controls that can aid water resource management. These laws may include:

- land use planning,
- zoning,
- permitted and prohibited land uses or types of development,
- restrictions on water use,
- limitations on water development,
- pollution control, or
- fill and removal restrictions.

All watershed users should know that private actions have public consequences on water quality and quantity.

In Oregon, and the Pacific Northwest, watershed councils are a growing voice in guiding the management of local watersheds. These councils are voluntary local advisory groups formed around interest in a particular watershed. Watershed councils use consensus-based decision making (depending on the support of all council members rather than a majority) to foster coordination and cooperation in managing their local watershed. As advisory groups their determinations do not have the force of law, but inform management agencies about the concerns and wishes of those most closely affected by watershed management decisions. In many cases these councils also plan and implement projects for



Adapted from original artwork by Sandra Noel, *Adopting A Stream A Northwest Handbook*, Adopt-A-Stream Foundation, 1988.

watershed protection, improvement, and education.

Watershed councils also play an important role in the Oregon Plan for Salmon and Watersheds. The Oregon Plan establishes local networks and partnerships between citizen groups, communities, local governments, state agencies and others to allow citizens to be proactive and address watershed problems. Currently the Oregon Plan has two parts. The Oregon Coastal Salmon Restoration Initiative, often called the Oregon Salmon Plan, seeks to develop programs to preserve and restore native coho salmon populations in coastal basins. The Healthy Streams Partnership is the second component. Its purpose is to create networks and partnerships to improve water quality throughout the state to meet the federal Clean Water Act standards.

Summary

Rivers, upland areas, mountaintops, and flood-formed bottomlands with their associated riparian areas are all part of one system. All are integrated with each other. Hillside shape controls the rate of water flow. All living elements in the watershed interact with and modify the energy flow through the system. The unique combination of climatic conditions, soil types, topography, vegetative cover, and drainage system define the specific character of each watershed.

Rivers do not stop at state lines or national boundaries. The effects of natural and human processes in a watershed are focused at its outlet, wherever it may be, even if a watershed crosses another state or country's borders. Each watershed is a part of a larger watershed whose downstream portion is affected by upstream influences.

Everyone depends on the resources watersheds provide. As the human population continues to grow, the demand on those resources intensifies. Human uses of land and water re-

sources affect the ecological dynamics of a functioning watershed system, altering natural habitats as well as the quantity and quality of its water supplies. Some changes are improvements. Others are not. It is up to the public at all local, regional, state, and national levels to meet the challenges of balanced, productive watershed management.

Extensions

1. "Where Does Water Run?" *Aquatic Project WILD*, pp. 21. Grades 6-12.
2. "Watershed," *Aquatic Project WILD*, pp. 132. Grades 4-12.
3. "To Dam or Not to Dam," *Aquatic Project WILD*, pp. 170.
4. "Identifying Your Watershed," *Watershed Uplands Scene*, pp. 17-36. Grades 9-12.
5. "Weather and Climate Investigation," *Watershed Uplands Scene*, pp. 89-108. Grades 9-12.
6. "Branching Out," *Project WET*, pp. 129-132. Grades K-2 and 6-8.
7. "A-Maze-ing Water," *Project WET*, pp. 219-222. Grades 3-8.
8. "Color Me a Watershed," *Project WET*, pp. 223-227. Grades 9-12.
9. "Common Water," *Project WET*, pp. 232-237. Grades K-8.
10. "Dilemma Derby," *Project WET*, pp. 377-381. Grades 6-12.
11. "Get the Ground Water Picture," *Project WET*, pp. 136-143. Grades 6-12.
12. "Irrigation Interpretation," *Project WET*, pp. 254-259. Grades K-8.
13. "A Grave Mistake," *Project WET*, pp. 311-315. Grades 6-12.

Adapted from W.E. Bullard, "Watershed Management Short Course," Oct. 1975, and used with permission.

14. "The Pucker Effect," *Project WET*, pp. 338-343. Grades 6-12.
15. "Surface Water," *The Comprehensive Water Education Book*, pp. 141-143. Grades 4-6.
16. "Floods and Erosion," *The Comprehensive Water Education Book*, pp. 144-145. Grades 3-6.
17. "Lakes," *The Comprehensive Water Education Book*, pp. 146-147. Grades 4-6.
18. "Watersheds," *The Comprehensive Water Education Book*, pp. 151-152. Grades K-6.
19. To make a simple watershed model crumple up a large piece of butcher paper and put it on the floor. Imagine that the paper is the surface of the land, the edges the shoreline, and the floor the sea. Use a permanent marker to trace the ridgelines separating one watershed from another. Then trace the river systems with a various colors of water soluble markers. Spray water on the watershed. Each river system will have its own color, but all colors mix in the estuaries and sea.
20. Since everyone lives in one, a first step in understanding watersheds is to explore your own local watershed by outlining its boundaries. Check with your local library for topographic maps if you cannot determine the boundaries visually.
 - a. On a map, trace the lines along the high points that separate your creek or river from the next.
 - b. Map the land use in your watershed (e.g., streets, forests, farms, yards, etc.)
 - c. List all possible places rain goes in your watershed.
 - d. Go outside the school building. What happens to the rain when it falls on the school roof? Does any of it get to a stream or river? How?
 - e. Are you ever anywhere that is not in a watershed?
- f. Collect newspaper clippings on watershed management problems in your area.
- g. In small groups have students design their own watershed. Each design should include the location, climate, uses of, abuses to, human impact on, and group perceptions of what a watershed should and should not be. After preparing visuals to depict their watershed, groups present their design to the class. (Contributed by Mary Roberts, 1989)
21. Have students develop an oral history of their watershed. Students should first develop a list of questions they want to research about their watershed, then set up interviews with people in the community. Questions should include past watershed events, both human-caused and natural, how it looked fifty or more years ago, and more. Students can then summarize their research into a written report or verbal presentation or both.

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A sense of place: your ecological address

Activity Education Standards: Note alignment with Oregon Academic Content Standards beginning on p. 483.

Objectives

Students will (1) define watershed, (2) determine boundaries of a watershed on a map, (3) draw a map of their own watershed, (4) identify potential effects of human and natural events on a watershed, (5) calculate the number of miles of streams and rivers in their watershed, and (6) identify potential effects of intermittent streams in the watershed.

Method

Students will brainstorm, create, and illustrate a definition of a watershed, outline watershed boundaries on maps, draw a map of their own watershed, and answer questions about watersheds.

For younger students

1. Consult extension activities at the end of each chapter to address the needs of younger students.
2. Read activity background information aloud to younger students or modify for your students' reading level.

This activity is an adaptation of the original *Stream Scene* activity "Does The Earth Wear A Raincoat" and "Finding Your Ecological Address" from *The Fish Hatchery Next Door* by Bill Hastie, et al., Oregon Department of Fish and Wildlife, 1996. The material was also published in "Ecological Address: At Home In Your Watershed," National Science and Technology Week, 1992-93 Packet, National Science Foundation, Washington, D.C.

3. A three dimensional model, perhaps of modeling clay, may help younger students visualize a watershed. Then, use the Umatilla Drainage Basin and Mid-Coast Drainage Basin maps (or substitute a map of a local watershed) as overheads along with a teacher-led discussion and inquiry to answer all questions.

Materials

For each pair of students

- copies of student sheets pp. 53-58
- copies of Oregon watershed maps (mid-coast drainage basin and Umatilla drainage basin) or a local watershed drainage basin map (see Chapter 14.4 for source of Oregon drainage basin maps.
- paper for illustrating a watershed "definition" and drawing a watershed "map"
- colored pencils or markers
- string or yarn (about one foot per student)

Notes to the teacher:

To set the stage and work through all the parts of this activity may take two or three class periods. You can also choose the parts that are appropriate for your students or that will fit your classroom schedule.

In the procedures that follow, an "ecological address" includes the name of the watershed in which students live as well as each successively larger stream and watershed—up to and including the major river from which the largest watershed usually takes its name. This system also includes the large lakes or the ocean into which that river feeds. Use the Columbia River basin watershed

Vocabulary

divide
intermittent stream
sub-basin
watershed

as an overhead transparency to demonstrate this concept.

Help students understand their “sense of place.” Each of us has a place we want to become part of, care about, and want to protect or enhance. Understanding this concept and the responsibilities that go along with it are part of watershed education. When people have a greater understanding of their watershed, they gain awareness of how their personal actions, local laws and regulations, and everyday practices affect the integrity and stability of their ecological address and the larger biological community.

Depending on age level, students will need varying degrees of background information before proceeding with the “brainstorming and definition of a watershed” part of the activity. The activity’s background section is appropriate as is a student reading developed from the chapter content.

A simple demonstration may also help students understand the concept of watershed. Trace the outline of your hand, wrist, and part of your arm on the chalkboard. Color in the space between your fingers and label your arm “Muddy River.” Tell the students this outline is a model for a watershed area. Your fingers represent streams that feed into the larger river (your arm). The colored space between your fingers is land, where people live. Let students know that a watershed’s name is usually taken from the

stream or river that serves as the main collector of all the water in the watershed. Ask students what the watershed you just drew would be called (Muddy River Watershed). Write the name on the board. Create names for the finger tributaries and write those on the board, too. Ask students how large they think watersheds can be, then how small they can be. They should recall this from their background reading. Impress upon the students that large watersheds include many small watersheds.

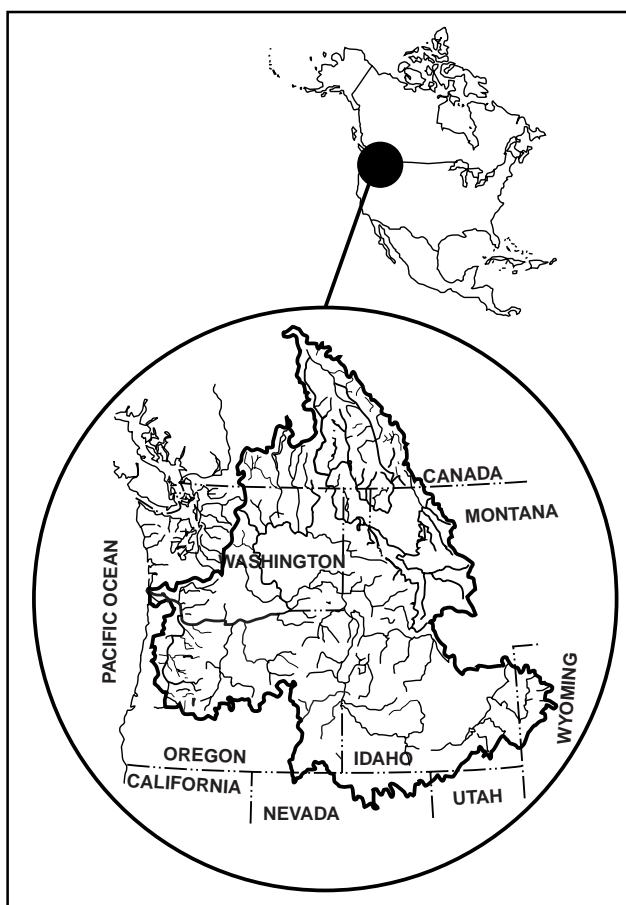
Use maps that parallel the local watershed situation as closely as possible. Substituting local maps for the mid-coast and Umatilla drainage basin maps where appropriate will help students associate more closely with their own watershed

and develop their own “sense of place.”

Modify the procedures to work with the local map. In urban areas a city map may be needed to determine the exact watershed in which a student’s home or school might be found. Depending on the proximity of waterways, the watershed named should reflect that students’ ecological addresses can have several components, from the smallest watershed they can observe to a larger watershed of which the smaller one is a part.

It is not necessary for the “map” created in Step 7 to be to scale, but it should represent the watershed(s) in which the students live. Use the Five Rivers water-

Columbia River Basin



Based on: Ed Chaney, *A Question of Balance: Water/Energy—Salmon and Steelhead Production in the Upper Columbia River Basin, Summary Report*, Nov. 1978. NW Resource Information Center, Inc.

shed map as an example. As an alternative or additional activity, have the entire class make a larger map of the watershed on large sheets of paper.

Background

Do you know ...

Water runs downhill. We all know that. The instant that a drop of rain hits the earth, it begins its journey to the ocean. If it falls as snow, it has to wait until it melts! Of course, not all water drops make it to the ocean. Some are taken up by plant roots and are transpired into the air through the plant's leaves. Some evaporate in puddles or other areas that hold water. Some filter down into underground areas, moving slowly downhill. But most water drops end up as runoff, the water that finds its way into creeks, streams, and rivers.

This long or short journey to the ocean takes place within a watershed. If you stand in a streambed and look upstream at all the land the stream drains, you are looking at the stream's **watershed**. Almost all the area of a watershed is land—not water! And, almost everything that drains it happens on that land. In other words, all land on earth is in a watershed.

Every body of water, stream, lake, pond, or river, has a watershed. Even a mud puddle has a watershed! Watersheds can be big or small. A mud puddle has a watershed of only a few square feet, while the Columbia River watershed has 258,000 square miles! The biggest watershed in the country is the Mississippi River, which drains all the land between the Rocky Mountains and the Appalachian Mountains.

A raindrop, no matter where it falls in the Columbia River watershed (unless it evaporates), will end up at the mouth of the Columbia River at Astoria. Most large watersheds are made up of many smaller watersheds called **sub-basins**. For instance, the Columbia watershed includes the Snake, John Day, Deschutes, Umatilla, and Willamette watersheds plus many others.

Watersheds are separated by ridges, called **divides**. The Continental Divide of the United

States, for example, is in the Rocky Mountains. All the rain and snow falling on the west side of the divide flows into the Pacific Ocean. All the rain and snow falling on the east side of the divide, sooner or later, ends up in the Atlantic Ocean.

Procedure

Now it's your turn . . .

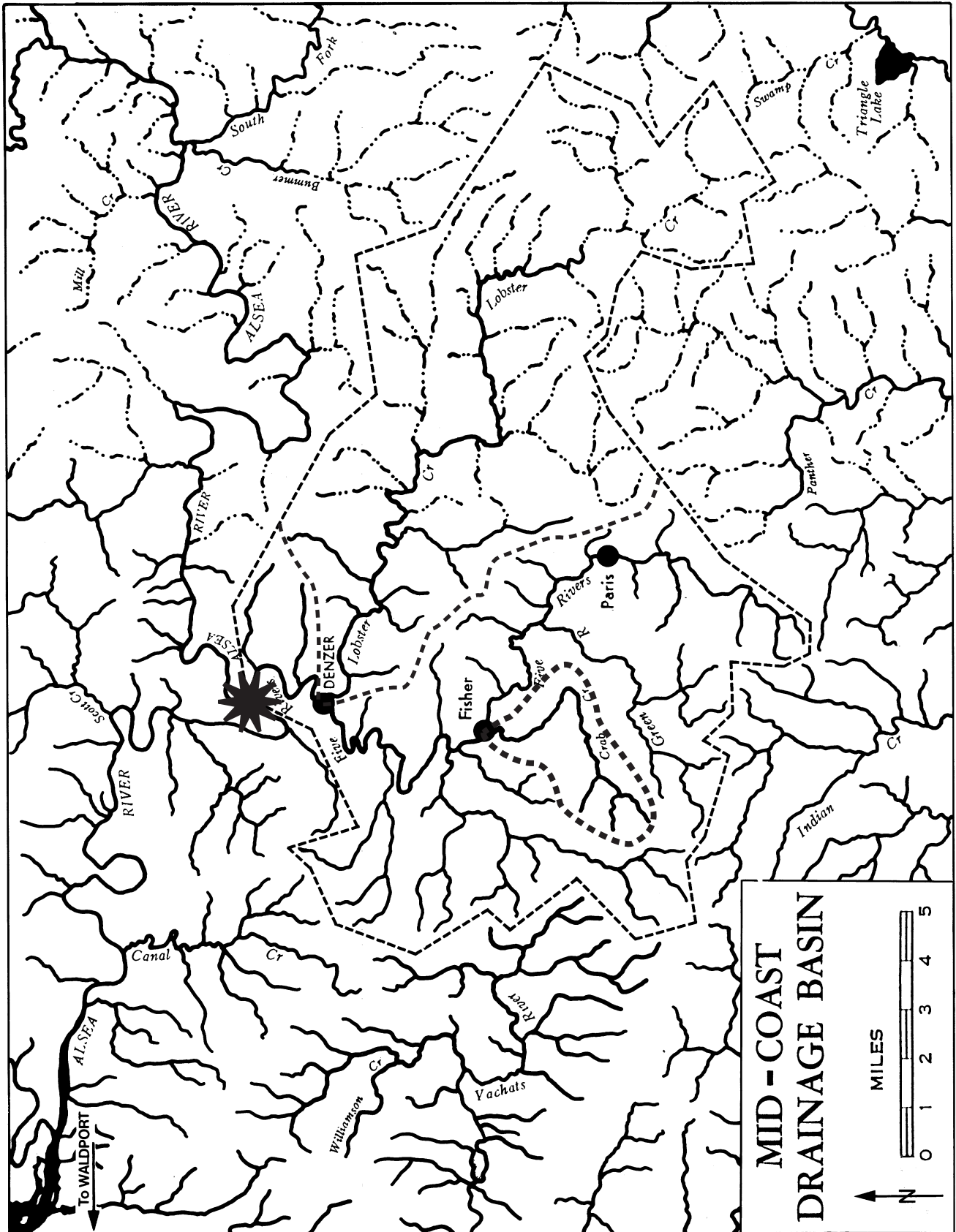
1. What is your home mailing or street address? What are the addresses of several other students in your class? These postal addresses have been devised by society—in other words, they are “social” addresses. Social addresses are important because people need to be located within their community by family, friends, and services such as the mail, police, fire, or ambulance.
2. You have another kind of address, called an “ecological address.” Ecological refers to the relationship between an organism and its environment. Just as a postal address tells people one way they are connected to the community, the ecological address tells people how they are connected to the land on which they live. In this activity, your “ecological address” is based on an ecological feature you are just now learning about—a watershed.
3. With your partner, brainstorm words or ideas that make you think of a watershed. Write down your thoughts. Using your ideas as a starting point, create a watershed definition. Write your definition in the space provided for Question 1 on the student worksheet. Now, using a piece of paper and markers, draw and color a picture of the watershed you just defined. When all the groups are finished share your definition and drawing with the rest of the class. Post your drawing on the wall. As a class discuss all of the group's definitions and decide on the definition that best states the meaning of a watershed. You may have to combine several

group's definitions to come up with the best answer.

4. Look at your copy of the Mid-Coast Drainage Basin map. Locate a stream called Five Rivers (Five Rivers runs through the communities of Denzer, Fisher, and Paris). Mark the point where Five Rivers runs into the Alsea River. Where does the Alsea River go? **(Pacific Ocean.)**
5. Locate the Crab Creek watershed by drawing a line around it with a colored pencil or marker. Then, locate the Lobster Creek watershed in the same way with another color. With a third color, draw a line around the entire Five Rivers watershed. Check with your teacher to see if you have correctly identified the watersheds. Answer Questions 2, 3, and 4 on the student worksheet from the mid-coast drainage basin map.
6. Now, look at your copy of the Umatilla drainage basin map. The Umatilla River watershed is in Northeastern Oregon. Locate a stream called Willow Creek (Willow Creek runs through the communities of Heppner, Jordan, and Ione). Locate the Spring Hollow watershed by drawing a line around it with a colored pencil or marker. Then, locate the Rhea Creek watershed in the same way with another color. With a third color, draw a line around as much of the Willow Creek watershed as possible. Answer Questions 5 through 10 on the student worksheet.
7. Using an Oregon state map or local map that shows streams and rivers, name the watershed in which you live. This watershed is your "ecological address." It describes how you are connected to the land and water system that drains it. Share your ecological address while other students follow along on their own map.
8. On the second piece of paper make a "map" of your ecological address. Refer to the Five Rivers or Umatilla drainage basin maps as examples. Label the communities and other important features in your watershed. Share

your watershed map with the rest of the class.

9. Brainstorm a list of what you think can happen to water as it moves through a watershed. Use a check to mark the ones caused by human activities. If some items on your list include substances that can get into the water in your watershed, use a marker to trace the path these substances would follow on your watershed map until it empties into larger watershed areas. Repeat this process with another color to mark the effects of non-human influences on watersheds, such as heavy rains, wind, and other natural events. Compare the two lines. Which of the two, human-caused or non-human would have the greatest effect on your watershed? Record your answer has Question 11 on the student worksheet.
10. How many miles of stream and river are in your watershed? Use the "scale of miles" on the published map to determine how many miles are represented by a certain length, usually one or two inches. Use a string to measure that length, then apply the string, following the curves on your map, to measure the distance. Multiply the number of "string lengths" times the map scale to obtain the number of stream miles. Record the number of miles for this step under Question 12 on the worksheet. How many miles of stream were affected by the human-caused events in Step 9? How many miles of stream were affected by non-human events in Step 9? Record your answers on the student worksheet and answer the remaining question.



Questions

1. Describe a watershed in your own words.

Answers will vary, but should approximate all the land area that drains into a particular body of water.

2. If you lived two miles south of the town of Fisher, in which watershed (or sheds) would you live?

You would actually live in the Crab Creek watershed which is part of the larger Five Rivers watershed. Remind students that a large watershed is made up of many smaller watersheds, and that both Crab Creek or Five Rivers would be correct answers to the question.

3. If you lived in Paris, in which watershed would you live?

Five Rivers

4. Using the mid-coast drainage basin map as a guide, explain in your own words why the following statement is true. "Everyone lives in a watershed."

All land has waterways running through it that drain into larger waterways. This is also true in urban areas where rainwater feeds into storm drains. The drains then feed into nearby streams or rivers.

5. The watersheds on these two maps are similar in size. Compare the two watersheds. What other similarities and differences did you note when outlining the watershed boundaries?

Each watershed is composed of several smaller watersheds. The Willow Creek watershed has more sub-basins than Five Rivers. The shape of the watersheds depends on the drainage patterns of the streams. It is much harder to outline the watersheds with intermittent streams than it is to outline streams that have year-round water.

6. In which watershed (or sheds) is the community of Jordan found?

Jordan is located at the mouth of the Rhea Creek watershed which is part of the Willow Creek watershed.

7. If a stream does not have a name on the map does that mean it is not a watershed? Explain your answer.

No, stream names are only a convenient way to designate different sub-basins within a watershed. Any land areas through which water drains to a larger body of water is a watershed.

8. An **intermittent stream** is a stream that does not flow year-round. These streams are shown on maps as lines separated by dots. List as many reasons as you can why streams do not flow year-round.

Lack of rainfall, lack of snowmelt, removal of vegetation that holds back moisture (reducing rapid runoff), the topography (flat or steep), the soil type, etc.

9. How would fish be affected by intermittent flow?

Fish would be forced downstream to where the stream was flowing or would be stranded in small pools where they would eventually die as the stream dried up.

10. How would wildlife living near the stream be affected by intermittent flow?

Food, cover and drinking water would be absent from the area, forcing wildlife to go elsewhere.

11. Based on the colored lines on your own watershed map, which of the two, human-caused or non-human influences, would have the greatest effect on your watershed? Why?

Human-caused effects would have the most influence because they are normally carried further throughout the watershed than natural events. Natural events are usually more localized.

12. How many miles of streams and rivers are found on your watershed map? How many miles of stream were affected by the human-caused events in Step 9? How many miles of stream were affected by non-human events in Step 9?

Answers will vary.

13. What have you learned about your watershed, an ecological address, and a sense of place in this activity?

Answers will vary.

Going Further

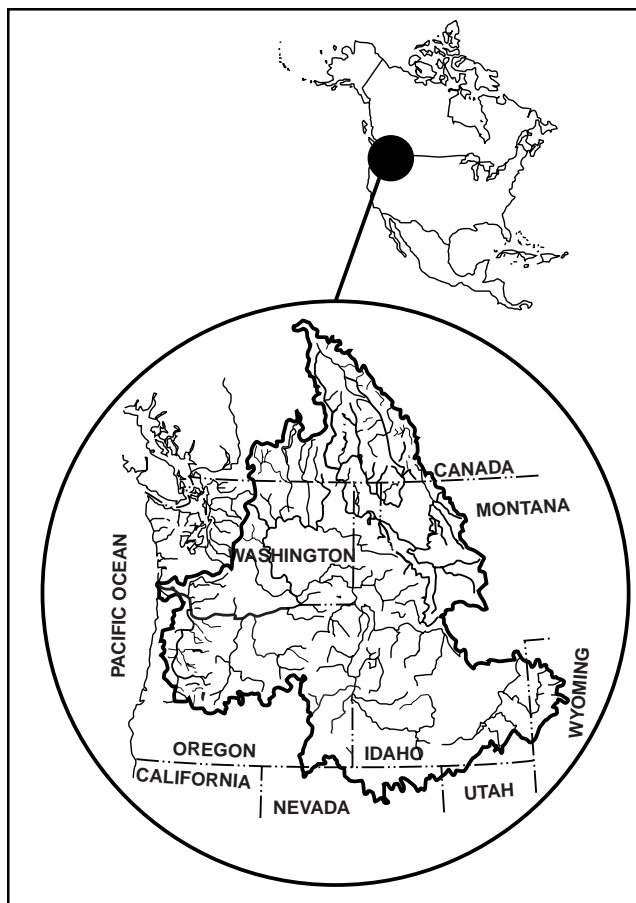
1. Using a topographic map as a reference, build a model of your local drainage basin. (See “What a Relief” activity in this unit.) Design a way to use this or other models of your local watershed to show someone the key features (rock types, soils, rainfall amounts, slope, and other characteristics) of your watershed.
2. Design an experiment to monitor the daily weather patterns in your watershed for several weeks or even months. Develop graphs, displays, and a presentation to share the results of your investigation.
3. Add five structures or features (dams, irrigation canals, industry, vegetation, etc.—it is even better if these are real) that would affect the flow of water on your watershed map. Develop hypotheses about how each of these structures will affect your watershed. How could you test your hypotheses?
4. Build a list of who and what uses your watershed—from people to fish to wildlife. Research the effects each has on the watershed.

A sense of place: your ecological address

Do you know ...

Water runs downhill. We all know that. The instant that a drop of rain hits the earth, it begins its journey to the ocean. If it falls as snow, it has to wait until it melts! Of course, not all water drops make it to the ocean. Some are taken up by plant roots and are transpired into the air through

Columbia River Basin



Based on: Ed Chaney, *A Question of Balance: Water/Energy—Salmon and Steelhead Production in the Upper Columbia River Basin*, Summary Report, Nov. 1978. NW Resource Information Center, Inc.

the plant's leaves.

Some evaporate in puddles or other areas that hold water. Some filter down into underground areas, moving slowly downhill. But

most water drops end up as runoff, the water that finds its way into creeks, streams, and rivers.

This long or short journey to the ocean takes place within a watershed. If you stand in a streambed and look upstream at all the land the stream drains, you are looking at the stream's **watershed**. Almost all the area of a watershed is land—not water! And, almost everything that drains it happens on that land. In other words, all land on earth is in a watershed.

Every body of water, stream, lake, pond, or river, has a watershed. Even a mud puddle has a watershed! Watersheds can be big or small. A mud puddle has a watershed of only a few square feet, while the Columbia River watershed has 258,000 square miles! The biggest watershed in the country is the Mississippi River, which drains all the land between the Rocky Mountains and the Appalachian Mountains.

A raindrop, no matter where it falls in the Columbia River watershed (unless it evaporates), will end up at the mouth of the Columbia River at Astoria. Most large watersheds are made up of many smaller watersheds called **sub-basins**. For instance, the Columbia watershed includes the

Vocabulary

divide
intermittent stream
sub-basin
watershed

This activity is an adaptation of the original *Stream Scene* activity "Does The Earth Wear A Raincoat" and "Finding Your Ecological Address" from *The Fish Hatchery Next Door* by Bill Hastie, et al., Oregon Department of Fish and Wildlife, 1996. The material was also published in "Ecological Address: At Home In Your Watershed," National Science and Technology Week, 1992-93 Packet, National Science Foundation, Washington, D.C.

Student sheet

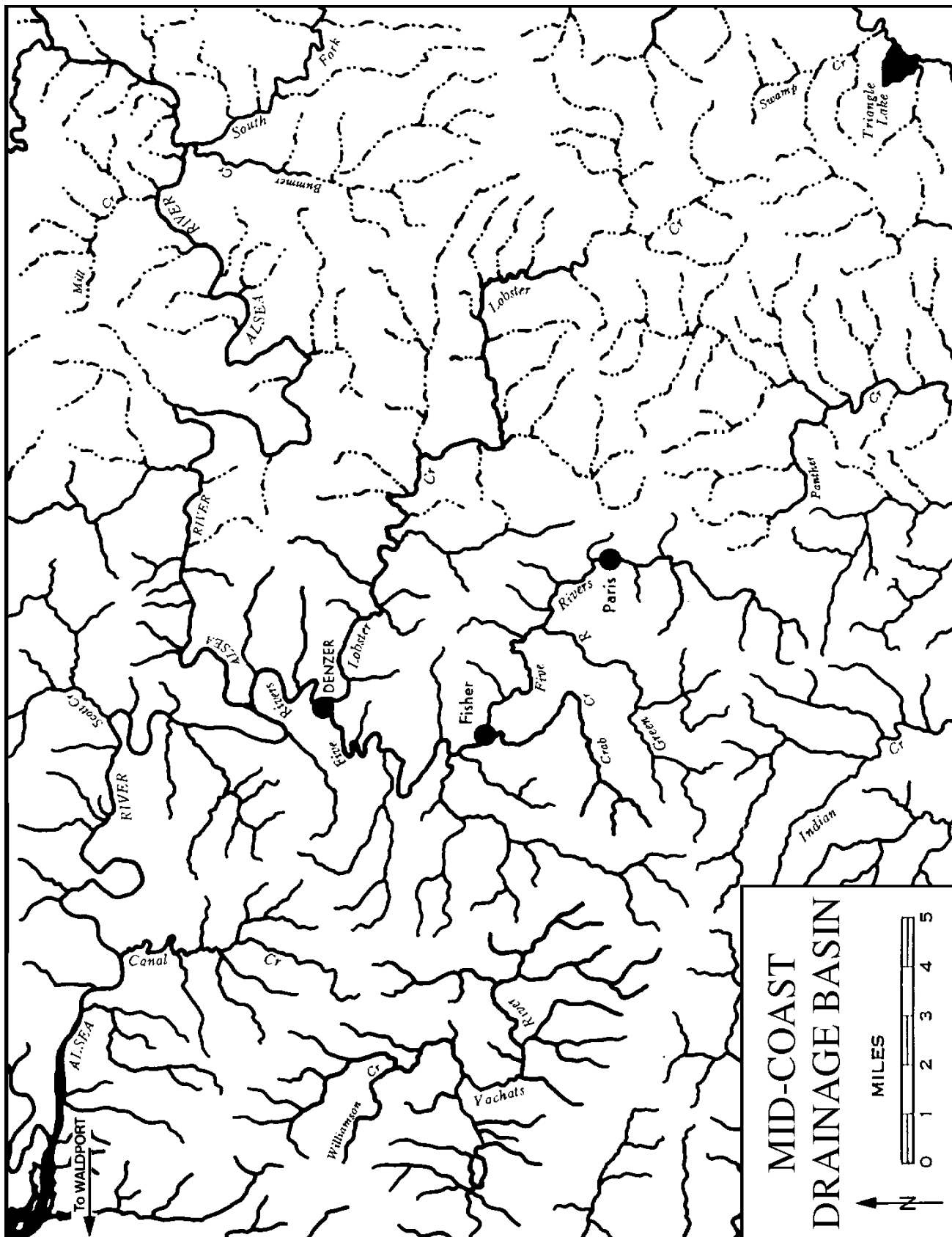
SNAKE, JOHN DAY, DESCHUTES, UMATILLA, and Willamette watersheds plus many others.

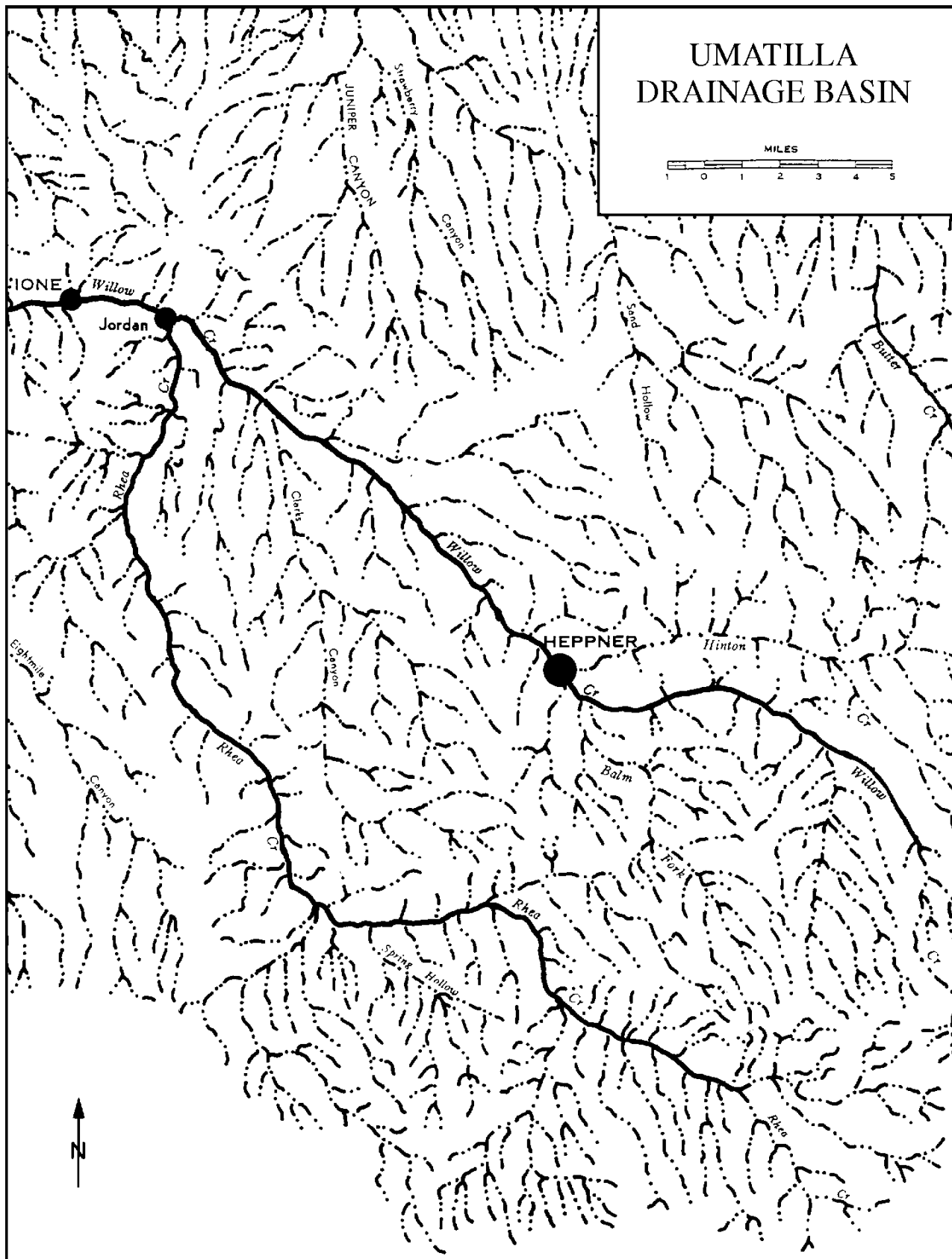
Watersheds are separated by ridges, called **divides**. The Continental Divide of the United States, for example, is in the Rocky Mountains. All the rain and snow falling on the west side of the divide flows into the Pacific Ocean. All the rain and snow falling on the east side of the divide, sooner or later, ends up in the Atlantic Ocean.

Now it's your turn . . .

1. What is your home mailing or street address? What are the addresses of several other students in your class? These postal addresses have been devised by society—in other words, they are “social” addresses. Social addresses are important because people need to be located within their community by family, friends, and services such as the mail, police, fire, or ambulance.
2. You have another kind of address, called an “ecological address.” Ecological refers to the relationship between an organism and its environment. Just as a postal address tells people one way they are connected to the community, the ecological address tells people how they are connected to the land on which they live. In this activity, your “ecological address” is based on an ecological feature you are just now learning about—a watershed.
3. With your partner, brainstorm words or ideas that make you think of a watershed. Write down your thoughts. Using your ideas as a starting point, create a watershed definition. Write your definition in the space provided for Question 1 on the student worksheet. Now, using a piece of paper and markers, draw and color a picture of the watershed you just defined. When all the groups are finished share your definition and drawing with the rest of the class. Post your drawing on the wall. As a class discuss all of the group’s definitions and decide on the definition that best states the meaning of a watershed. You may have to combine several group’s definitions to come up with the best answer.
4. Look at your copy of the Mid-Coast Drainage Basin map. Locate a stream called Five Rivers (Five Rivers runs through the communities of Denzer, Fisher, and Paris). Mark the point where Five Rivers runs into the Alsea River. Where does the Alsea River go?
5. Locate the Crab Creek watershed by drawing a line around it with a colored pencil or marker. Then, locate the Lobster Creek watershed in the same way with another color. With a third color, draw a line around the entire Five Rivers watershed. Check with your teacher to see if you have correctly identified the watersheds. Answer Questions 2, 3, and 4 on the student worksheet from the mid-coast drainage basin map.
6. Now, look at your copy of the Umatilla drainage basin map. The Umatilla River watershed is in Northeastern Oregon. Locate a stream called Willow Creek (Willow Creek runs through the communities of Heppner, Jordan, and Ione). Locate the Spring Hollow watershed by drawing a line around it with a colored pencil or marker. Then, locate the Rhea Creek watershed in the same way with another color. With a third color, draw a line around as much of the Willow Creek watershed as possible. Answer Questions 5 through 10 on the student worksheet.
7. Using an Oregon state map or local map that shows streams and rivers, name the watershed in which you live. This watershed is your “ecological address.” It describes how you are connected to the land and water system that drains it. Share your ecological address while other students follow along on their own map.
8. On the second piece of paper make a “map” of your ecological address. Refer to the Five Rivers or Umatilla drainage basin maps as examples. Label the communities and other

Student sheet





Student sheet

important features in your watershed. Share your watershed map with the rest of the class.

9. Brainstorm a list of what you think can happen to water as it moves through a watershed. Use a check to mark the ones caused by human activities. If some items on your list include substances that can get into the water in your watershed, use a marker to trace the path these substances would follow on your watershed map until it empties into larger watershed areas. Repeat this process with another color to mark the effects of non-human influences on watersheds, such as heavy rains, wind, and other natural events. Compare the two lines. Which of the two, human-caused or non-human would have the greatest effect on your watershed? Record your answer for Question 11 on the student worksheet.
10. How many miles of stream and river are in your watershed? Use the “scale of miles” on the published map to determine how many miles are represented by a certain length, usually one or two inches. Use a string to measure that length, then apply the string, following the curves on your map, to measure the distance. Multiply the number of “string lengths” times the map scale to obtain the number of stream miles. Record the number of miles for this step under Question 12 on the worksheet. How many miles of stream were affected by the human-caused events in Step 9? How many miles of stream were affected by non-human events in Step 9? Record your answers on the student worksheet and answer the remaining question.

Questions

1. Describe a watershed in your own words.
2. If you lived two miles south of the town of Fisher, in which watershed (or sheds) would you live?
3. If you lived in Paris, in which watershed would you live?
4. Using the mid-coast drainage basin map as a guide, explain in your own words why the following statement is true. “Everyone lives in a watershed.”
5. The watersheds on these two maps are similar in size. Compare the two watersheds. What other similarities and differences did you note when outlining the watershed boundaries?

6. In which watershed (sheds) is the community of Jordan found?
7. If a stream does not have a name on the map does that mean it is not a watershed? Explain your answer.
8. An intermittent stream is a stream that does not flow year-round. These streams are shown on maps as lines separated by dots. List as many reasons as you can why streams do not flow year-round.
9. How would fish be affected by intermittent flow?
10. How would wildlife living near the stream be affected by intermittent flow?
11. Based on the colored lines on your own watershed map, which of the two, human-caused or non-human influences, would have the greatest effect on your watershed? Why?
12. How many miles of streams and rivers are found on your watershed map? How many miles of stream were affected by the human-caused events in Step 9? How many miles of stream were affected by non-human events in Step 9?
13. What have you learned about your watershed, an ecological address, and a sense of place in this activity?

Student sheet

Tour of a topo

Activity Education Standards: Note alignment with Oregon Academic Content Standards beginning on p. 483.

Objectives

The student will demonstrate how to use the information on a topographic map to (1) determine the name; location, and source of a quadrangle map; (2) determine the names of adjacent maps in the series; (3) describe the differences in roads using the map's legend; (4) determine the map's scale; (5) describe and define contour lines and how to find an index contour; (6) describe the difference between True North and magnetic north and how to find the map's declination; (7) determine latitude, longitude, and universal transverse mercator (UTM) coordinates on a map; and (8) describe how to use the Public Lands Survey System to find a specific location on a topographic map.

Method

Using the “Tour of a Topo” descriptions, the student will learn about the information available on a topographic map and will apply this information to answer questions about specific locations on a map.

For younger students

1. Read activity background information aloud to younger students or modify for your students' reading level.
2. Use the “Tour of a Topo” map as an overhead transparency. Work through the tour stops as a class, while students follow along on their copies of a real topographic map. Eliminate the details that are too difficult for younger students to absorb.

3. Modify the list of questions to meet the needs of younger students. Call specific attention to familiar landmarks.

Materials

- copy of “Tour of a Topo” map guide for each student
- local topographic map for each pair of students

Notes to teacher

A topographic map of your local watershed works best for this exercise as students relate well to familiar landmarks and place names.

Vocabulary

base line	meridian
contour	minutes
contour lines	orientation
contour interval	prime meridian
declination	Public Land System
degree of latitude	quadrangle
degree of longitude	range
equator	relief
geographic north	representative fraction
Global Positioning System (GPS)	scale (graphic or verbal)
hachure	seconds
index contour	section
latitude	topographic map
legend	township
longitude	true north
magnetic north	universal transverse mercator (UTM)
map	
map series	

Tour of a Topo was developed by Michael Goodrich, Director, GeoQuest Publications, PO Box 1665, Lake Oswego, OR 97035, and is used with permission.

Local topographic maps are available from the U.S. Geological Survey (USGS) at 1-800-USA-Maps. An index of Oregon topographic maps is also available from the USGS. The index can help you quickly decide which maps are available for your area. You can also get topographic maps from local sporting good outlets and map stores. Expect to pay \$6.00 to \$7.00 per map (1999 prices).

Laminate the maps to extend their use. If students are to mark on the laminated maps, use water-based felt marker pens. Maps are easily wiped clean with damp paper towels and are quickly available for the next class' use.

Map symbols used on most topographic maps are not discussed in this activity. The USGS also produces a chart of symbols that is helpful for students involved in map work. Ask for a symbol chart when requesting maps from USGS. Earth-Science textbooks often have USGS topographic map legends in their appendices.

The questions at the end of this activity can be used as a worksheet as students work through the exercise or it can serve as a measure of understanding (or quiz) following the activity.

Background

Do you know . . .

... how to use a map? Do you know how to give a legal description of your school's location or maybe your mom or dad's favorite fishing hole? Do you know how to get the elevation of your favorite ski slope or how to determine the scale of distance a map covers?

A map gives you a lot of information. With a little practice you can use this information to find out all kinds of things about your local watershed. You can learn a lot by looking at the information outside of your map's boundaries as well as inside.

The first important step in getting to know your watershed is to get a map of it. But, a map isn't a lot of help if you don't know how to use it.

Maps are the "common ground" among all the players in a watershed study. They are important communication tools if working with other groups in the same watershed. Each group needs a copy of the same map, so everyone can talk the same language and keep the same reference points.

Maps are a permanent record of your watershed. You can mark your study sites, important reference points, restoration work sites, land-use designations, pollution sources, historical sites, or other important locations that are part of your watershed study.

Procedure



Now it's your turn . . .

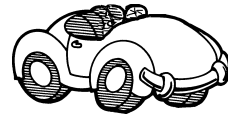
Just what can you learn from a map? Join us for a "tour of a topo" and find out.

Use your "Tour of a Topo" tour guide and a local topographic map. Work in pairs and explore the parts of a map and your watershed. Our "tour" begins in the upper right-hand corner of the topographic map. First we will travel around the outside of the map (clockwise) and then go to the inside. We will stop where there is a number on the tour guide. Answer the questions at the end when you are done.

Stop 1: Name, Location, Series

The map we'll be touring is called a **quadrangle** map. It is usually named after a prominent feature in the area—a town, city, mountain or a lake. It is called a quadrangle because it has four (quad is the word prefix that means four) equal sides, each with an equal number of **degrees** of **latitude** and **longitude**. The length of a degree of latitude is about the same throughout the world. Latitude lines are parallel to the equator, run east-west, and are measured in degrees north and south of the equator. The length of a degree of longitude varies with distance from the **equator**. Longitude lines come together at the poles, run north-south, and are measured east and west of the prime meridian, which runs through Greenwich, England (see the globe and chart on p. 62).

9



Start Tour
Here

1

United States
Department of the Interior
Geologic Survey

Name of Quadrangle
Location of Map
Topographic Map Series

Latitude			Longitude		Longitude
UTM Grid #s					
Latitude					
UTM Grid #s					
Latitude					
UTM Grid #s					

8

10

2

4

7

6

5

3

Magnetic
Declination

Scale
1 0 1 mile
0'
100'
Contour Interval

Road Legend
Name of Quadrangle
Edition Date
Revision

Looking at your map, however, you'll notice that the map *length* is different than its *width*. That's because the earth is a three-dimensional globe but the map is a flat, two-dimensional picture of a small piece of the earth. A topographic map for land straddling the equator (for example, Ecuador or Indonesia) would be almost square. As you move away from the equator, the map begins to look like a rectangle.

On a map, a degree is a measure of distance. There are 360 degrees in a circle. A line of latitude or longitude circles the earth. A degree of latitude or longitude, then, is $1/360^{\text{th}}$ of the total length of that line. Each degree can be divided into 60 smaller pieces called minutes. Each minute can be divided further into 60 smaller pieces called seconds. There are special symbols for degree, minute, and second. Seventy degrees is written 70° . Thirty minutes is written $30'$. Twenty-two seconds is written $22''$. Minutes and seconds are a measure of distance, just as

Latitude	*Length (miles) of °Longitude	** Length (miles) of °Latitude	
0 (equator)	69.17	68.71	very close
15	66.83	68.75	↓
30	59.95	68.88	
45	48.99	69.05	
60	34.67	69.23	
75	17.96	69.36	
90 (poles)	0.00	69.40	not close

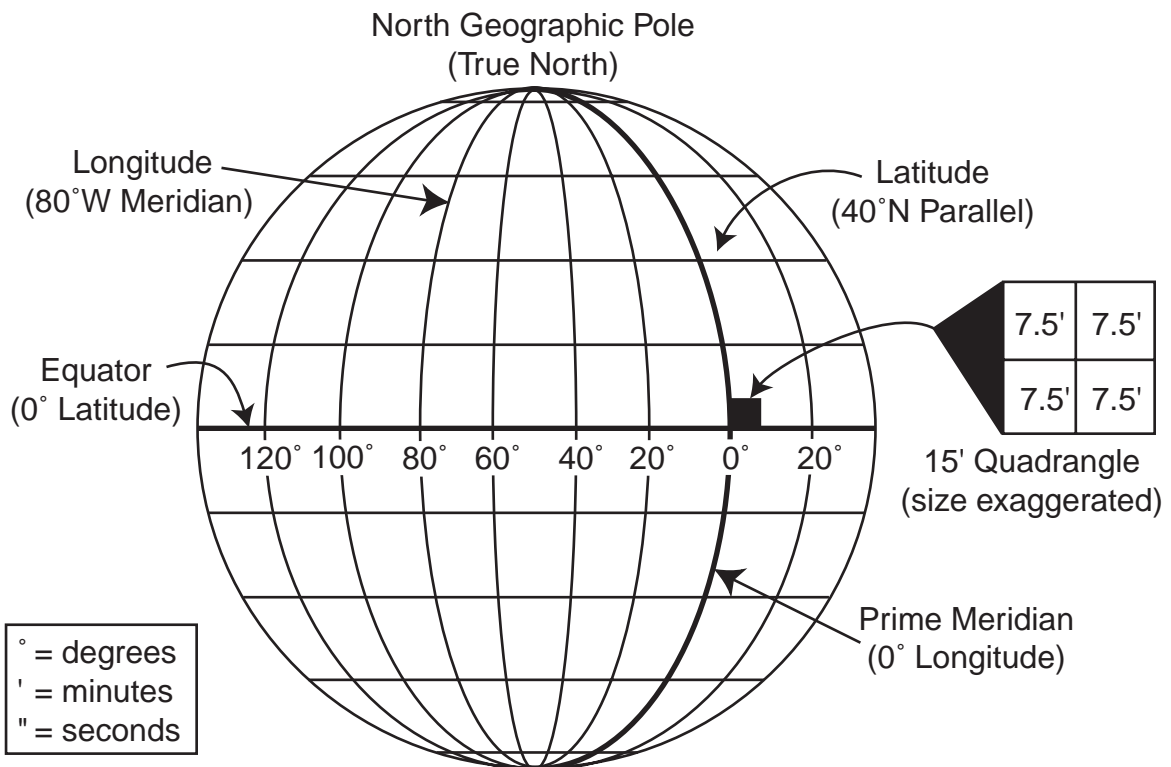
*Length of a degree of arc along the latitude named.

**Length of a degree of arc centered on the latitude named.

(Table based on the National Geodetic Survey 1980 ellipsoid.)

degrees are. If 1° is equal to approximately 70 miles of latitude, then $30'$ (half of a degree) is equal to 35 miles, and $30''$ (half of a minute or one-fourth of a degree) is equal to 15 miles.

We normally think of minutes and seconds as measurements of time. When working with a map, minutes and seconds become fractions of a degree. Therefore, a fraction of a degree is also a measure of distance. If 1° is equal to approxi-



mately 70 miles of latitude, then 30' (half of a degree) is equal to 35 miles.

The *location* of the map gives the state and county where the quadrangle is located. Quadrangle maps are published in several sizes, but the two most common are 15' quadrangle maps and 7.5' quadrangle maps. A 15' quadrangle represents an area bounded by 15 minutes of latitude (one-fourth of a degree) and 15 minutes of longitude (one-fourth of a degree). Each 15' map can be divided into four 7.5' maps. Most of the United States is mapped using the 7.5' series.

If you have any questions about Stop 1, a detour to the bibliography or glossary might be in order. Proceed to Stop 2.



Stop 2: Adjacent maps

What if you wanted to go beyond the borders of your map? The maps that border yours are called adjacent maps. Stop 2 is where you will find information about an adjacent map. There are typically eight maps that border any topographic quadrangle map. Looking below, we see our map in the middle. If the adjacent map to the east (Gladstone #5) is not in parenthesis along the boundary of the map, then the information is included at the bottom of the map.

1	2	3
4	Our Map	5
6	7	8

Adjacent Quadrangles

1. Linnton
2. Portland
3. Mt. Tabor
4. Beaverton
5. Gladstone
6. Sherwood
7. Canby
8. Oregon City

Stop 3: Legend

The symbols used for roads are part of the map's **legend**. Below the legend is the name of the quadrangle and the year the map was made.

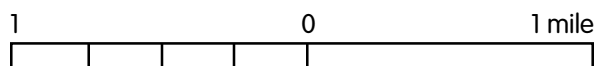
Because maps cannot be updated yearly (a Coast Range quadrangle in Oregon has not been revised since 1949), there is often a date for when the map was revised. You can tell if a map has a partial revision because the revised portion is shown in a different color.

Let's move on to Stop 4.

Stop 4: Scale

Maps are scale models. To make a model of anything, you must first decide what the scale of the model is going to be. **Scale** is the relationship between distance on the map to distance on the ground. A map scale is given in the form of a **graphic scale** or bar scale, a **representative fraction**, or a **verbal scale**.

The *graphic scale* or bar scale below represents a *total* of two miles. Remember, half the line is one mile. The graphic scale can also be given in kilometers or feet.



Representative fractions, such as $1/24000$, are a way of comparing the size of the map to the size of the area the map represents. The "1" could be anything you wish to use as a measuring tool. For example, one of your thumbs on the map would equal 24,000 of your thumbs outside on the ground. Or one inch on the map would equal 24,000 inches outside. This would be inconvenient because no one measures big distances in inches. If your map has a scale stated as a fraction ($1/24000$), it would mean that the portion of the earth represented has been reduced to $1/24000$ of its actual size on the map. These scales are fractions, so remember the larger the number on the bottom, the smaller the scale of the map ($1/100^{\text{th}}$ is less than $1/10^{\text{th}}$). The smaller the scale, the less detail is shown. LARGE is small!

Verbal scales are simply ways of writing out what the scale means. Some common scales and their verbal equivalents are:



<i>Fraction</i>	<i>Verbal</i>
1:24,000	1 inch = 0.379 miles
1:62,500	1 inch = 0.986 miles
1:250,000	1 inch = 4.0 miles
1:500,000	1 inch = 7.891 miles

Stop 5: Contours and elevation

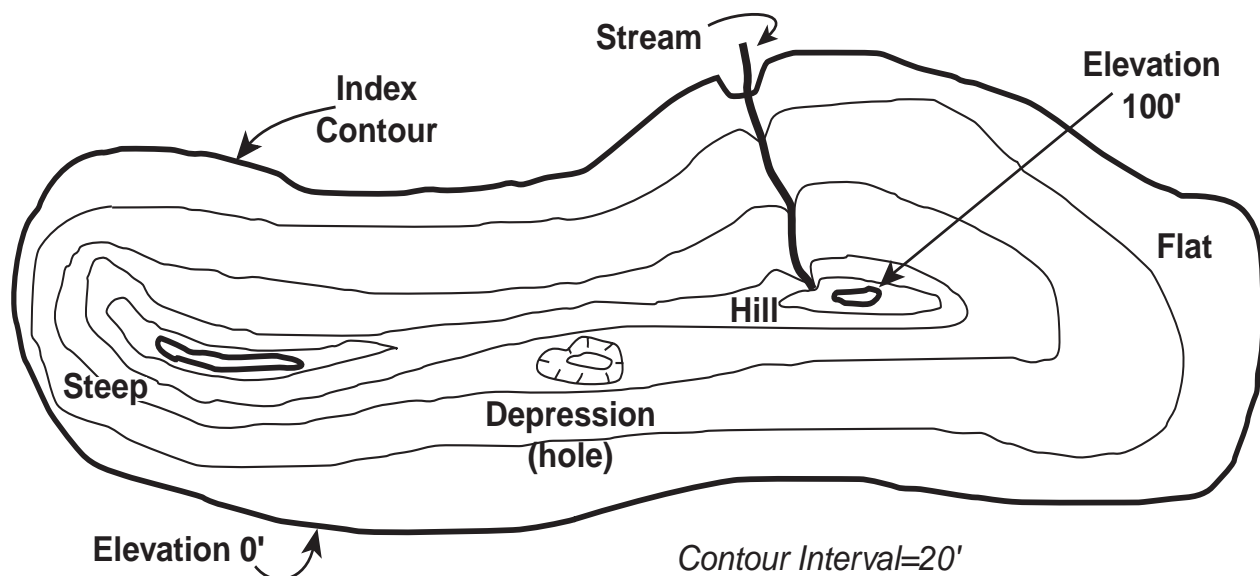
Topographic maps are scaled-down models of the Earth's three-dimensional surface, printed on a two-dimensional piece of paper. You have seen how the two-dimensional map of length and width can be reduced from the real world to a piece of paper. The third dimension—elevation—is shown on a map using **contour lines**.

A contour line connects map points of the same elevation above sea level. If you were driving along the contour, you would stay at the same elevation above sea level. Different elevations are shown by different contour lines. Every fifth contour line is thicker and is called an **index contour**. Index contours are often marked with an elevation.

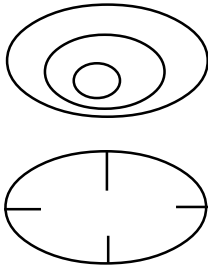
A map's **contour interval** is the vertical distance (height) between two adjacent contour lines. The amount of error in a map's elevation can be no more than half of the map's contour interval. If the contour interval on the map is 10 feet, then the elevations have a margin of error plus (+) or minus (–) 5 feet.

Relief is the difference in elevation between two points on a map. Maps with small contour intervals (10 feet) are generally of low relief. Topographic maps of mountainous areas have large contour intervals (50 feet). If a map has both low relief and high relief within the topographic quadrangle, there are two contour intervals on the map. By finding the closest contour line marked with an elevation label and then counting lines, you can figure out the elevation of a point. Here are some rules to help you interpret the contour lines on a map.

1. The closer together the contour lines, the steeper the slope.
2. When contour lines cross a stream, they form a “V” that points upstream.
3. Contour lines do not cross unless there is an overhanging cliff.
4. The thicker contour lines are called index contours.
5. All contour lines are multiples of the contour interval.
6. Every point along a contour line has exactly the same elevation.
7. Contour lines can merge to form a vertical cliff.



8. A concentric series of contour lines represent a hill.
9. Depression contours have **hachure** marks on the downhill side that represent a depression (hole).
10. There is no beginning or end to a contour line. It is a closed loop with an irregular shape.

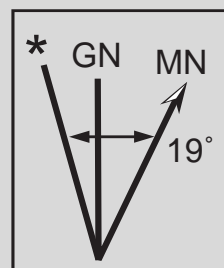


The 19° east line shown below shows that the magnetic north is slightly east of geographic north. This defines the amount of **declination** (turning away from magnetic north) in your area. Local declination can be affected by materials within the earth. Iron in rock can affect your magnetic declination. This information is used when you want to set your compass and orient your map. Since the magnetic field of the earth changes, maps are periodically revised.

Stop 6: Declination

The earth has two norths: a **magnetic north** (MN) and a **geographic north** (GN). A compass points to the Earth's magnetic north, which is created by the planet's magnetic core. This magnetic north is not fixed because this point moves with changes in the Earth's magnetic core. In contrast, geographic (true) north is a fixed point at the end of the axis on which the earth spins.

Because magnetic north slowly wobbles about somewhere to the west of Baffin Island, Canada, topographic maps use the fixed geographic north to designate direction. Because the compass points to magnetic north and a map uses geographic north, topographic maps often show compass direction with a diagram or sometimes with a written description. This diagram shows the local difference between magnetic north and true north.



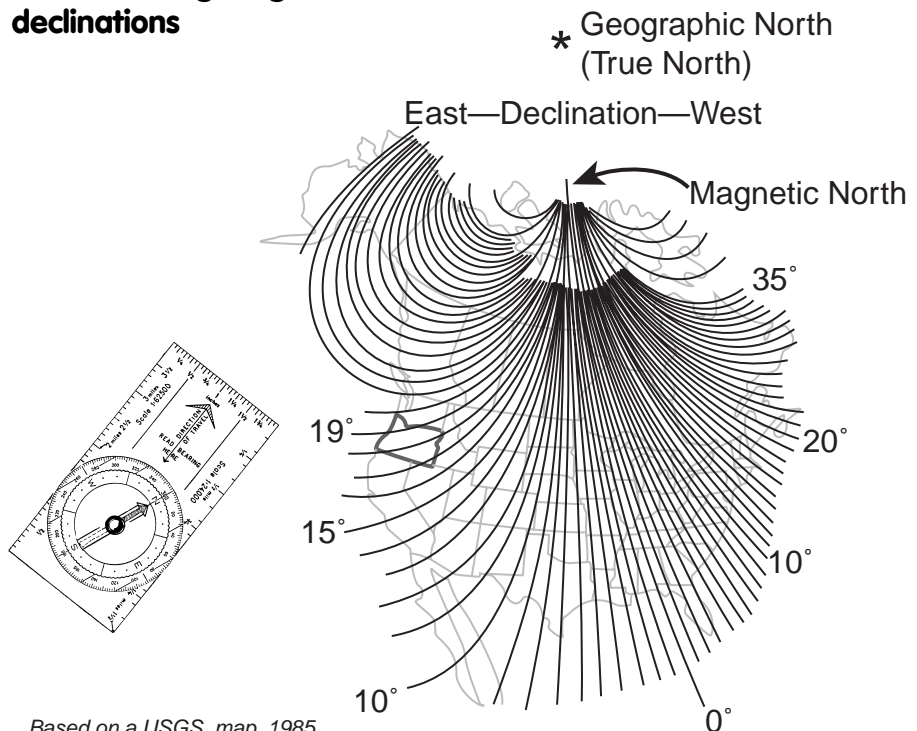
* = direction of geographic north

GN = direction of grid north
(Universal Transverse Mercator System)

MN = direction of magnetic north

The magnetic declination for the map is 19°

Chart showing magnetic declinations



Based on a USGS map, 1985

Stop 7: Latitude and longitude coordinates

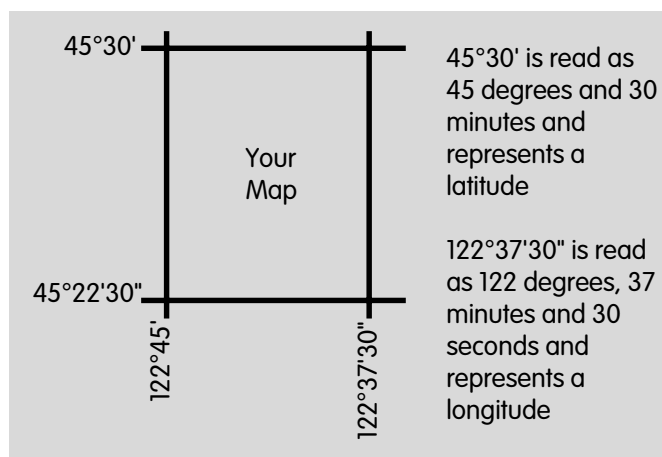
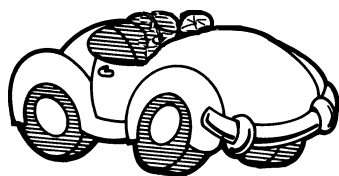
In the four corners of the topographic map you will find the degrees longitude and latitude that are used to define the borders of the quadrangle.

Remember from Stop 1 that there are 360 degrees in a circle, 60 minutes in a degree, and 60 seconds in a minute. Also remember that on a map, degree is a measure of distance and, therefore, a fraction of a degree is also a measure of distance.

The **series** of the map explained at Stop 1 can also be determined by subtracting one latitude from the other (see above right).

$$\begin{array}{r} 45^{\circ}30' \quad \text{latitude} \\ - 45^{\circ}22'30'' \text{ latitude} \\ \hline 7'30'' \text{ or } 7.5 \text{ minutes} \end{array}$$

Look at the data table at Stop 1 (p. 62) for 45° latitude. You can work out the number of miles from the top of your map to the bottom of your map with reasonable accuracy. According to the table, at 45° north of the equator, each degree of latitude equals 69.05 miles. There are 60 minutes in a degree. Therefore 30 minutes is half a degree, 15 minutes is one-quarter of a degree, and 7.5 minutes is equal to one-eighth (0.125) of a degree. So 0.125 times 69.05 miles is equal to 8.63 miles. This number (8.63) gives you the total distance in miles from the top of the map to the bottom of the map. You could check the results by using the graphic scale at Stop 4.



Stop 8: UTM grid

The fine blue lines along the borders of the map are the Universal Transverse Mercator (UTM) grid “ticks.” These are part of an international reference system. Each tick is separated by one kilometer (1,000 meters) or about five-eighths of a mile, making it a handy scale.

UTM coordinates are commonly used by agencies to locate sampling sites on streams or note locations of culverts or other important parts of the stream. A Global Positioning System (GPS) device helps determine UTM coordinates and can tell you latitude and longitude positions.

If you are interested in the UTM or GPS system, a detour to the bibliography may be in order.

Stop 9: Map source

The United States Department of the Interior’s Geological Survey (USGS) produced the topographic map. An index of Oregon topographic maps is available from the USGS. The index can help you quickly decide which maps are available for your area. You can call the USGS at 1-800-USA-MAPS.

This was a short stop! Let’s travel to the interior of the map.

Stop 10: Public land survey system

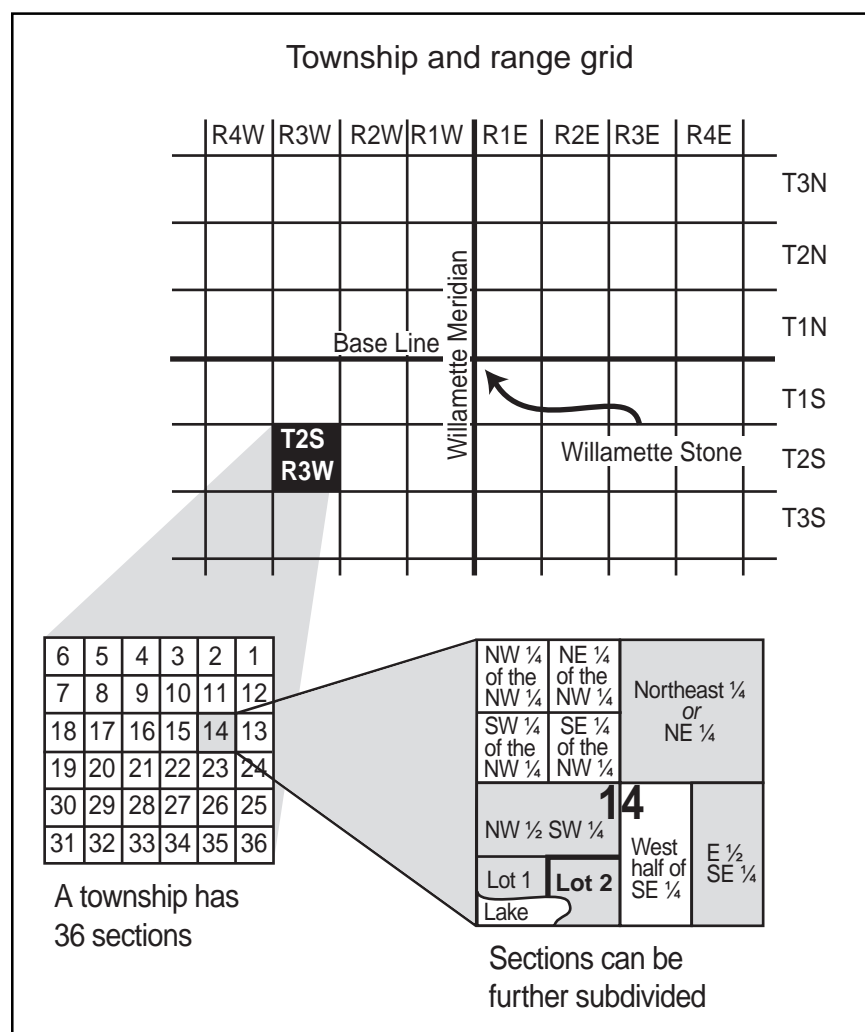
The U.S. **Public Land Survey System** divides a region into a **township** and **range** grid. The diagram on this page explains this system. The starting points are the Willamette Meridian of longitude and a **base line** that is surveyed perpendicular to it. The Willamette Stone, located in the West Hills of Portland, Oregon, is at the junction of the Willamette Meridian and the base line. Township strips of land run parallel to the base line and are numbered north and south of it (T1N, T1S, etc.). Range strips of land run parallel to the Willamette Meridian and are numbered east and west of it (R1E, R1W, etc.). Each inter-

section of a township strip with a range strip forms a square, called a township.

Use the following statements to help you understand the Public Land Survey System.

1. Townships are numbered north and south of the base line and are labeled along the right and left margins of the map.
2. In Oregon, ranges are numbered east and west of the Willamette Meridian and are labeled along the top and bottom of the map.
3. Each township is 6 miles square and is divided into 36 sections. Note that the section numbers begin in the upper right hand corner of the township and end at the lower right hand corner of the township.
4. Each section is 1 mile square.

Public land survey map



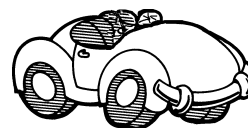
5. A section contains 640 acres that can be subdivided into smaller tracts.
6. A section can also be subdivided into sixteen 40-acre tracts that can be designated by compass directions (for example, SE, NW, etc.)
7. A legal description of the parcel of 40 acres (labeled Lot #2) would read:

SE 1/4, SW 1/4, Section 14, T2S, R3W

Note: Begin the legal description with the smallest designation.



Our tour has ended. Good luck with your watershed explorations. Happy touring!



Glossary

contour: imaginary line on the ground, all points of which are the same elevation above or below a specific datum. A datum is a reference point used in surveying.

contour interval: difference in elevation between two adjacent contours.

declination: angular difference between magnetic north and true (geographic) north at the point of observation; it is not constant but varies with time because of the “wandering” of the magnetic north pole.

hachure: any series of lines used on a map to indicate the general direction and steepness of slopes; these lines are often used to denote a depression (hole) in the land.

latitude: angular distance in degrees, minutes, and seconds, of a point north or south of the equator.

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

map: any concrete or abstract representation of the distributions of features that occur on or near the surface of the earth or other celestial bodies.

map, topographic: map that presents the horizontal and vertical positions of the features represented.

meridian: great circle of the surface of the earth passing through the geographical poles and any given point on the earth’s surface. All points on a given meridian have the same longitude.

orientation: establishing the correct relationship in direction with reference to points of the compass; the state of being in correct relationship in direction with reference to the points of the compass.

prime meridian: meridian of longitude 0 degrees, used as the origin of measurements of longitude; the meridian of Greenwich, England, is the internationally accepted prime meridian on most charts.

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

quadrangle: four-sided area, bounded by parallels of latitude and meridians of longitude used as an area unit in mapping.

relief: elevations and depressions of the land or sea bottom.

scale: relationship existing between a distance on a map, chart, or photograph and the corresponding distance on the earth.

section: one thirty-sixth of a township.

township: a six square-mile segment of land, the basic unit of the Public Land System Survey.

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Haslam, Andrew. *Make It Work! MAPS*. Chicago, IL: World Book, 1996.

Seidman, David. *The Essential Wilderness Navigator*. Camden, MN: Ragged Mountain Press, 1995.

Silva. *Teaching Orienteering*. Binghamton, NY: Johnson Worldwide Assoc., Inc., 1991.

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Questions:

1. What is the name of your quadrangle map? Where do you find this information on your map?
Answers will vary. The name of the map is found in the upper right corner and in the lower right corner. Both of these locations are outside of the map's boundaries.
2. How are quadrangle maps named?
Quadrangle maps are named for some prominent feature within the area of the map.
3. _____ or meridian lines run north and south and are measured in degrees east and west around the earth from Greenwich, England.
Longitude
4. _____ or parallel lines run east and west and are measured in degrees north and south from the equator to the poles.
Latitude
5. Why are longitude lines more variable in length than latitude lines?
Because longitude lines converge at the poles. The arc of their distance varies with the distance from the equator.
6. What does it mean when we say that a topographic map is a 7.5 minute map?
A 7.5 minute map represents an area bounded by 7.5 minutes of latitude (one-eighth of a degree) and 7.5 minutes of longitude (one-eighth of a degree).
7. Which map shows the most detail—a 7.5' or a 15' map?
A 7.5' map shows more detail even though it covers less surface area than a 15' map.
8. If a location is just outside the boundaries of your topographic map, how would you find out the next map to use?
Use the adjacent quadrangle map key located at the bottom of the map or look at the adjoining map's name listed in parenthesis along the sides or top and bottom of older quadrangle maps.
9. When was your map produced? If it was revised, when was it revised?
Answers will vary.
10. What is the scale of your topographic map? What does this mean?
Most topographic maps are at a scale of 1:24,000, which means that for every 1 unit of measurement on the map, the equivalent distance on land is 24,000 times that amount—one inch to 24,000 inches, or 1 meter to 24,000 meters, etc.
11. What is a contour line?
A contour line is a line that connects map points at the same elevation above sea level.
12. What is an index contour?
An index contour is a heavier line on a map that occurs at every fifth contour line.
13. What is contour interval?
The contour interval is the vertical distance between two contour lines—for example, 20 feet, 40 feet, or 80 feet.
14. What is the contour interval of your map ?

Answers will vary. Some maps may have more than one contour interval; for example, 20 feet in areas of high relief and 40 feet in areas of low relief.

15. What is meant about the topography if the contour lines are very close together on a map?
The landform in that area is very steep.
16. How do you know which direction a stream is flowing?
When contour lines cross a stream, they form a "v" that points upstream.
17. What is the difference between "magnetic north" and "true north"? Which should you use to find the most accurate direction?
"Magnetic north" is the compass direction influenced by the earth's magnetic core. It is not fixed and varies somewhat over time. "True north" or geographic north is the fixed point of the earth as it spins on its axis. Use "true north" as the most accurate direction.
18. Where do you find the declination distance on your map so you can adjust your compass to the most accurate direction?
Declination information is usually located in the bottom left hand corner of the map.
19. What are the latitude and longitude coordinates in the top left corner of your map?
Answers will vary.
20. What are the Universal Transverse Mercator (UTM) tick mark designations in the upper left hand corner of your map?
Answers will vary.
21. What is the total distance in miles from the top to the bottom of your map at 45° latitude? What is the total distance in miles from side to side on your map at the same latitude?
8.63 miles from top to bottom and 6.12 miles from side to side.
22. What is the Willamette Meridian? Why is it important?
The Willamette Meridian is the degree of longitude that runs through the Willamette Stone in the West Hills of Portland, Oregon. All of Oregon's range and township lines are measured from this point.
23. Describe the relationship of townships, ranges, and sections in the Public Land Survey System?
In Oregon, all ranges are measured east or west of the Willamette Meridian. All townships are measured north and south of the Willamette Stone base line. Each township is 6 miles square and contains 36 sections. Each section is one mile square and consists of 640 acres.
24. What is the legal description at the mouth of the main stream closest to your community?
Answers will vary, but should begin with the smallest designation (quarter section first) and end with township and range designations (for example, SE ¼, SW 1¼, Section 14, T2S, R3W).

Going further

1. Design a set of questions (with an answer key) that could be asked about your local topographic map. Design your questions so that the person answering the questions will have a better understanding of your watershed.
2. A landfill is planned for a site within the boundaries of your local topographic map. As a consultant for the city, give evidence that would support your choice for the placement of that landfill.

Tour of a topo

Do you know . . .

... how to use a map? Do you know how to give a legal description of your school's location or maybe your mom or dad's favorite fishing hole? Do you know how to get the elevation of your favorite ski slope or how to determine the scale of distance a map covers?

A map gives you a lot of information. With a little practice you can use this information to find out all kinds of things about your local watershed. You can learn a lot by looking at the information outside of your map's boundaries as well as inside.

The first important step in getting to know your watershed is to get a map of it. But, a map isn't a lot of help if you don't know how to use it.

Maps are the "common ground" among all the players in a watershed study. They are important communication tools if working with other groups in the same watershed. Each group needs a copy of the same map, so everyone can talk the same language and keep the same reference points.

Maps are a permanent record of your watershed. You can mark your study sites, important reference points, restoration work sites, land-use designations, pollution sources, historical sites, or other important locations that are part of your watershed study.

Now it's your turn . . .

Just what can you learn from a map? Join us for a "tour of a topo" and find out.

Use your "Tour of a Topo" tour guide and a local topographic map. Work in pairs and explore the parts of a map and your watershed. Our "tour" begins in the upper right-hand corner of the topographic map. First we will travel around the outside of the map (clockwise) and then go to

the inside. We will stop where there is a number on the tour guide. Answer the questions at the end when you are done.

Stop 1: Name, Location, Series

The map we'll be touring is called a **quadrangle** map. It is usually named after a prominent feature in the area—a town, city, mountain or a lake. It is called a quadrangle because it has four (quad is the word prefix that means four) equal sides, each with an equal number of **degrees of latitude** and **longitude**. The length of a degree of latitude is about the same throughout the world. Latitude lines are parallel to the equator, run east-west, and are measured in degrees north and

Vocabulary

base line	meridian
contour	minutes
contour lines	orientation
contour interval	prime meridian
declination	Public Land System
degree of latitude	quadrangle
degree of longitude	range
equator	relief
geographic north	representative fraction
Global Positioning System (GPS)	scale (graphic or verbal)
hachure	seconds
index contour	section
latitude	topographic map
legend	township
longitude	true north
magnetic north	universal transverse mercator (UTM)
map	
map series	

Tour of a Topo was developed by Michael Goodrich, Director, GeoQuest Publications, PO Box 1665, Lake Oswego, OR 97035, and is used with permission.

Oregon Department of Fish & Wildlife

south of the equator. The length of a degree of longitude varies with distance from the **equator**. Longitude lines come together at the poles, run north-south, and are measured east and west of the prime meridian, which runs through Greenwich, England (see the globe and chart on p. 62).

Looking at your map, however, you'll notice that the map *length* is different than its *width*. That's because the earth is a three-dimensional globe but the map is a flat, two-dimensional picture of a small piece of the earth. A topographic map for land straddling the equator (for example, Ecuador or Indonesia) would be almost square. As you move away from the equator, the map begins to look like a rectangle.

On a map, a degree is a measure of distance. There are 360 degrees in a circle. A line of latitude or longitude circles the earth. A degree of latitude or longitude, then, is 1/360th of the total length of that line. Each degree can be divided

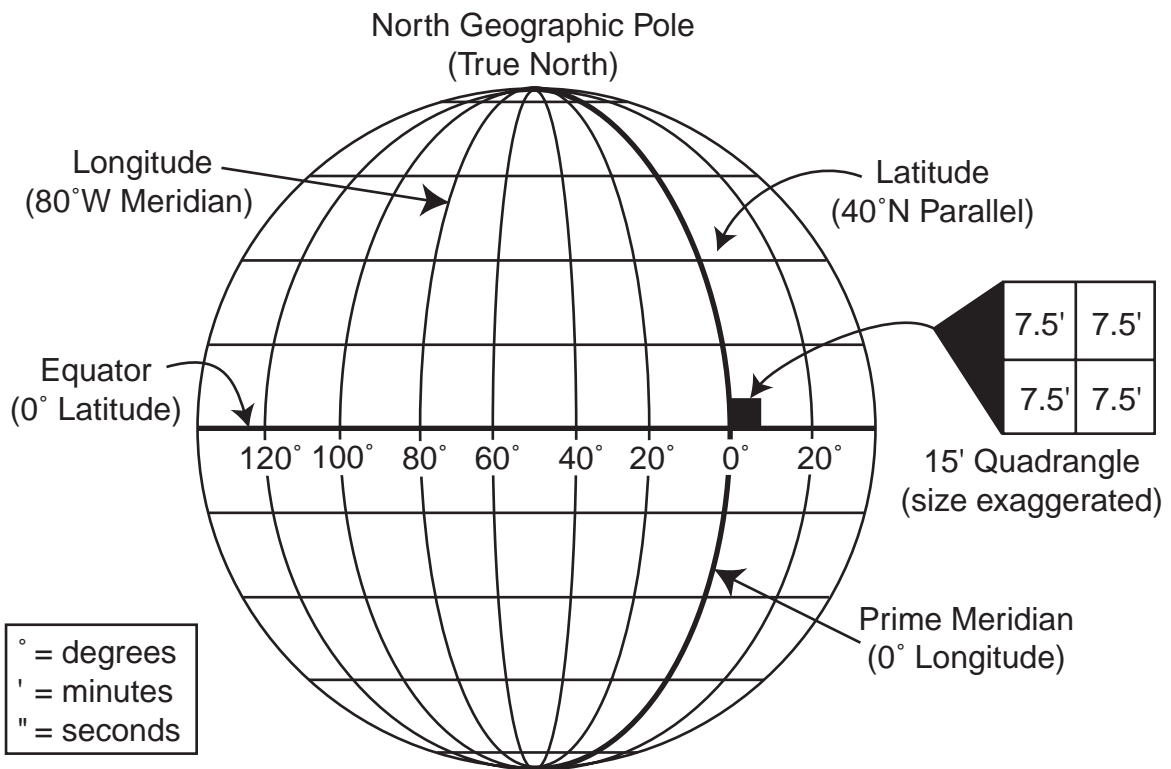
into 60 smaller pieces called minutes. Each minute can be divided further into 60 smaller pieces called seconds. There are special symbols for degree, minute, and second. Seventy degrees is written 70°. Thirty minutes is written 30'. Twenty-two seconds is written 22". Minutes and seconds are a measure of distance, just as degrees are. If 1° is equal to approximately 70 miles of latitude, then 30' (half of a degree) is equal to 35

Latitude	*Length (miles) of °Longitude	** Length (miles) of °Latitude	
0 (equator)	69.17	68.71	very close
15	66.83	68.75	↓
30	59.95	68.88	
45	48.99	69.05	
60	34.67	69.23	
75	17.96	69.36	
90 (poles)	0.00	69.40	not close

*Length of a degree of arc along the latitude named.

**Length of a degree of arc centered on the latitude named.

(Table based on the National Geodetic Survey 1980 ellipsoid.)



miles, and 30" (half of a minute or one-fourth of a degree) is equal to 15 miles.

We normally think of minutes and seconds as measurements of time. When working with a map, minutes and seconds become fractions of a degree. Therefore, a fraction of a degree is also a measure of distance. If 1° is equal to approximately 70 miles of latitude, then 30' (half of a degree) is equal to 35 miles.

The *location* of the map gives the state and county where the quadrangle is located. Quadrangle maps are published in several sizes, but the two most common are 15' quadrangle maps and 7.5' quadrangle maps. A 15' quadrangle represents an area bounded by 15 minutes of latitude (one-fourth of a degree) and 15 minutes of longitude (one-fourth of a degree). Each 15' map can be divided into four 7.5' maps. Most of the United States is mapped using the 7.5' series.

If you have any questions about Stop 1, a detour to the bibliography or glossary might be in order. Proceed to Stop 2.



Stop 2: Adjacent maps

What if you wanted to go beyond the borders of your map? The maps that border yours are called adjacent maps. Stop 2 is where you will find information about an adjacent map. There are typically eight maps that border any topographic quadrangle map. Looking below, we see our map in the middle. If the adjacent map to the east (Gladstone #5) is not in parenthesis along the

1	2	3
4	Our Map	5
6	7	8

Adjacent Quadrangles

1. Linnton
2. Portland
3. Mt. Tabor
4. Beaverton
5. Gladstone
6. Sherwood
7. Canby
8. Oregon City

boundary of the map, then the information is included at the bottom of the map.

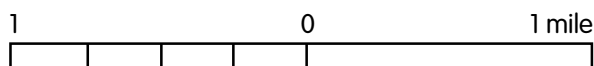
Stop 3: Legend

The symbols used for roads are part of the map's **legend**. Below the legend is the name of the quadrangle and the year the map was made. Because maps cannot be updated yearly (a Coast Range quadrangle in Oregon has not been revised since 1949), there is often a date for when the map was revised. You can tell if a map has a partial revision because the revised portion is shown in a different color.

Let's move on to Stop 4.

Stop 4: Scale

Maps are scale models. To make a model of anything, you must first decide what the scale of the model is going to be. **Scale** is the relationship between distance on the map to distance on the ground. A map scale is given in the form of a **graphic scale** or bar scale, a **representative fraction**, or a **verbal scale**.



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Student sheet

scales are fractions, so remember the larger the number on the bottom, the smaller the scale of the map ($1/100^{\text{th}}$ is less than $1/10^{\text{th}}$). The smaller the scale, the less detail is shown. LARGE is small!

Verbal scales are simply ways of writing out what the scale means. Some common scales and their verbal equivalents are:

Fraction	Verbal
1:24,000	1 inch = 0.379 miles
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Stop 5: Contours and elevation

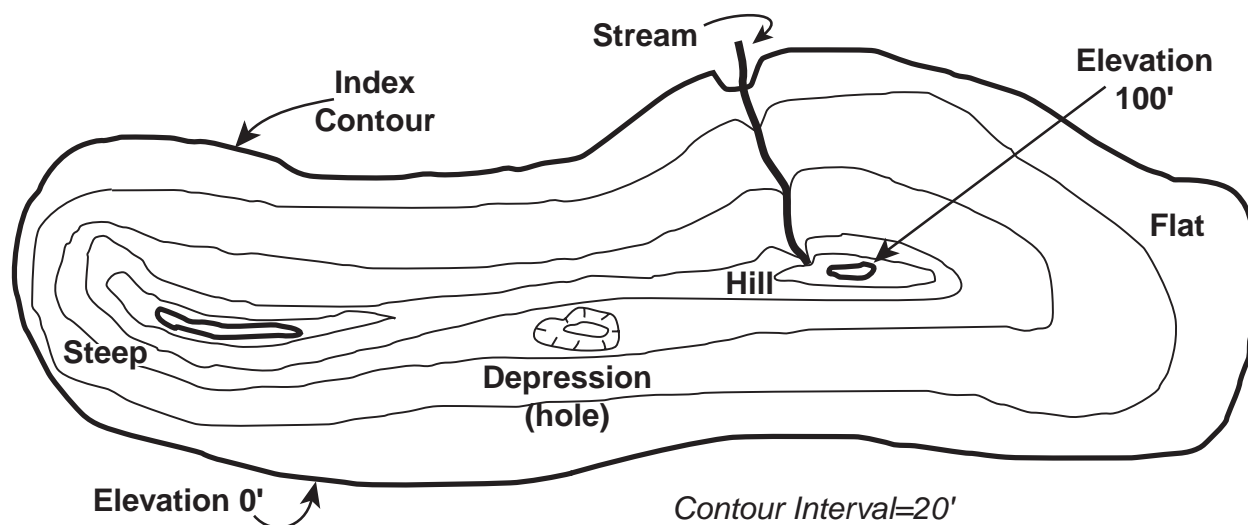
Topographic maps are scaled-down models of the Earth's three-dimensional surface, printed on a two-dimensional piece of paper. You have seen how the two-dimensional map of length and width can be reduced from the real world to a piece of paper. The third dimension—elevation—is shown on a map using **contour lines**.

A contour line connects map points of the same elevation above sea level. If you were driving along the contour, you would stay at the same elevation above sea level. Different elevations are shown by different contour lines. Every fifth contour line is thicker and is called an **index contour**. Index contours are often marked with an elevation.

A map's **contour interval** is the vertical distance (height) between two adjacent contour lines. The amount of error in a map's elevation can be no more than half of the map's contour interval. If the contour interval on the map is 10 feet, then the elevations have a margin of error plus (+) or minus (–) 5 feet.

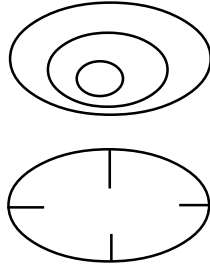
Relief is the difference in elevation between two points on a map. Maps with small contour intervals (10 feet) are generally of low relief. Topographic maps of mountainous areas have large contour intervals (50 feet). If a map has both low relief and high relief within the topographic quadrangle, there are two contour intervals on the map. By finding the closest contour line marked with an elevation label and then counting lines, you can figure out the elevation of a point. Here are some rules to help you interpret the contour lines on a map.

1. The closer together the contour lines, the steeper the slope.
2. When contour lines cross a stream, they form a “V” that points upstream.
3. Contour lines do not cross unless there is an overhanging cliff.
4. The thicker contour lines are called index contours.
5. All contour lines are multiples of the contour interval.



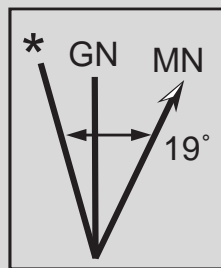
Student sheet

6. Every point along a contour line has exactly the same elevation.
7. Contour lines can merge to form a vertical cliff.
8. A concentric series of contour lines represent a hill.
9. Depression contours have **hachure** marks on the downhill side that represent a depression (hole).
10. There is no beginning or end to a contour line. It is a closed loop with an irregular shape.



topographic maps often show compass direction with a diagram or sometimes with a written description. This diagram shows the local difference between magnetic north and true north.

The 19° east line shown below shows that the magnetic north is slightly east of geographic north. This defines the amount of **declination** (turning away from magnetic north) in your area. Local declination can be affected by materials within the earth. Iron in rock can affect your magnetic declination. This information is used



* = direction of geographic north

GN = direction of grid north
(Universal Transverse Mercator System)

MN = direction of magnetic north

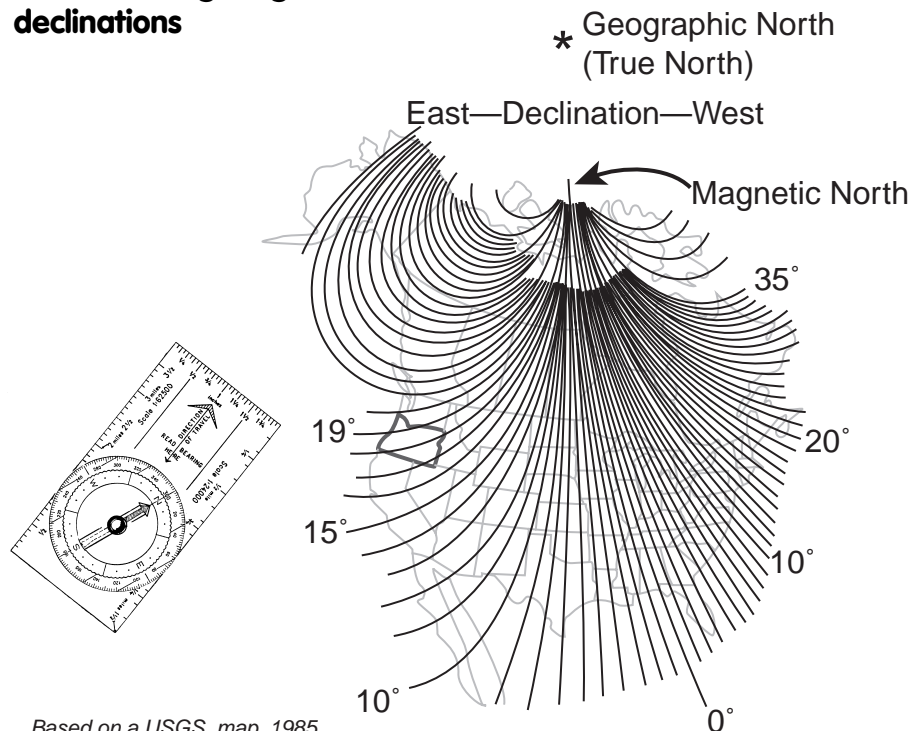
The magnetic declination for the map is 19°

Stop 6: Declination

The earth has two norths: a **magnetic north** (MN) and a **geographic north** (GN). A compass points to the Earth's magnetic north, which is created by the planet's magnetic core. This magnetic north is not fixed because this point moves with changes in the Earth's magnetic core. In contrast, geographic (true) north is a fixed point at the end of the axis on which the earth spins.

Because magnetic north slowly wobbles about somewhere to the west of Baffin Island, Canada, topographic maps use the fixed geographic north to designate direction. Because the compass points to magnetic north and a map uses geographic north,

Chart showing magnetic declinations



Based on a USGS map, 1985

Student sheet

when you want to set your compass and orient your map. Since the magnetic field of the earth changes, maps are periodically revised.

Stop 7: Latitude and longitude coordinates

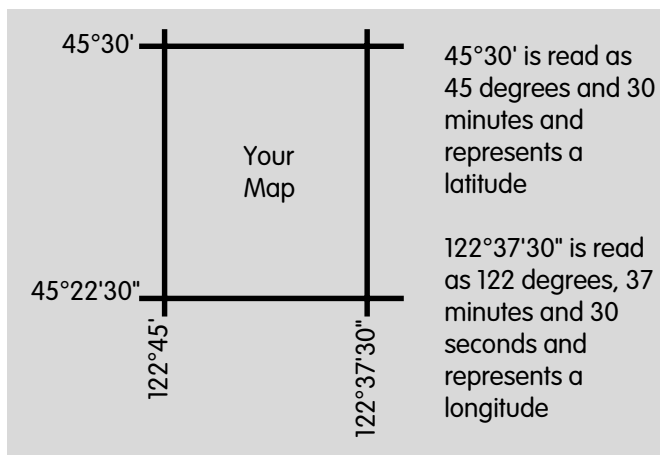
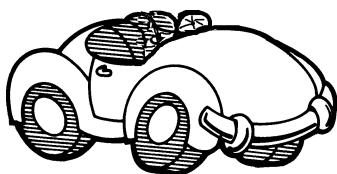
In the four corners of the topographic map you will find the degrees longitude and latitude that are used to define the borders of the quadrangle.

Remember from Stop 1 that there are 360 degrees in a circle, 60 minutes in a degree, and 60 seconds in a minute. Also remember that on a map, degree is a measure of distance and, therefore, a fraction of a degree is also a measure of distance.

The **series** of the map explained at Stop 1 can also be determined by subtracting one latitude from the other (see above right).

$$\begin{array}{r} 45^{\circ}30' \quad \text{latitude} \\ - 45^{\circ}22'30'' \text{ latitude} \\ \hline 7'30'' \text{ or } 7.5 \text{ minutes} \end{array}$$

Look at the data table at Stop 1 (p. 62) for 45° latitude. You can work out the number of miles from the top of your map to the bottom of your map with reasonable accuracy. According to the table, at 45° north of the equator, each degree of latitude equals 69.05 miles. There are 60 minutes in a degree. Therefore 30 minutes is half a degree, 15 minutes is one-quarter of a degree, and 7.5 minutes is equal to one-eighth (0.125) of a degree. So 0.125 times 69.05 miles is equal to 8.63 miles. This number (8.63) gives you the total distance in miles from the top of the map to the bottom of the map. You could check the results by using the graphic scale at Stop 4.



Stop 8: UTM grid

The fine blue lines along the borders of the map are the Universal Transverse Mercator (UTM) grid “ticks.” These are part of an international reference system. Each tick is separated by one kilometer (1,000 meters) or about five-eighths of a mile, making it a handy scale.

UTM coordinates are commonly used by agencies to locate sampling sites on streams or note locations of culverts or other important parts of the stream. A Global Positioning System (GPS) device helps determine UTM coordinates and can tell you latitude and longitude positions.

If you are interested in the UTM or GPS system, a detour to the bibliography may be in order.

Stop 9: Map source

The United States Department of the Interior’s Geological Survey (USGS) produced the topographic map. An index of Oregon topographic maps is available from the USGS. The index can help you quickly decide which maps are available for your area. You can call the USGS at 1-800-USA-MAPS.

This was a short stop! Let’s travel to the interior of the map.

Stop 10: Public land survey system

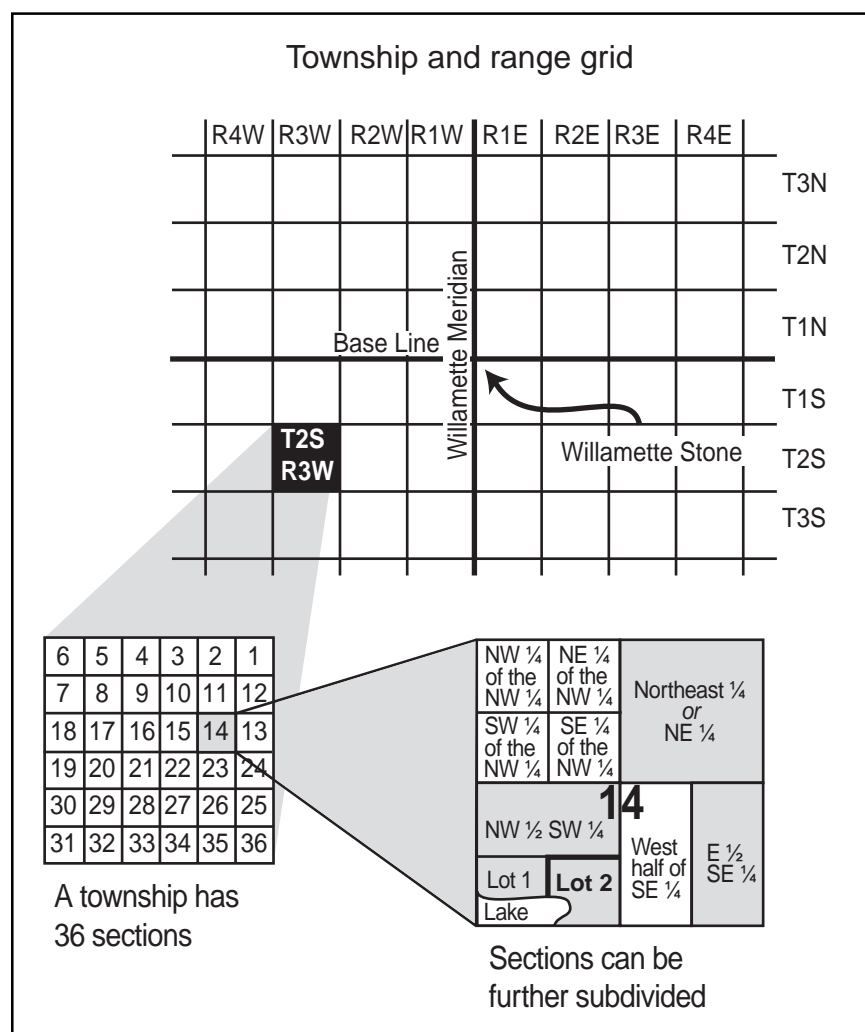
The U.S. **Public Land Survey System** divides a region into a **township** and **range** grid. The diagram on this page explains this system. The starting points are the Willamette Meridian of longitude and a **base line** that is surveyed perpendicular to it. The Willamette Stone, located in the West Hills of Portland, Oregon, is at the junction of the Willamette Meridian and the base line. Township strips of land run parallel to the base line and are numbered north and south of it (T1N, T1S, etc.). Range strips of land run parallel to the Willamette Meridian and are numbered east and west of it (R1E, R1W, etc.). Each inter-

section of a township strip with a range strip forms a square, called a township.

Use the following statements to help you understand the Public Land Survey System.

1. Townships are numbered north and south of the base line and are labeled along the right and left margins of the map.
2. In Oregon, ranges are numbered east and west of the Willamette Meridian and are labeled along the top and bottom of the map.
3. Each township is 6 miles square and is divided into 36 sections. Note that the section numbers begin in the upper right hand corner of the township and end at the lower right hand corner of the township.
4. Each section is 1 mile square.

Public land survey map



5. A section contains 640 acres that can be subdivided into smaller tracts.
6. A section can also be subdivided into sixteen 40-acre tracts that can be designated by compass directions (for example, SE, NW, etc.)
7. A legal description of the parcel of 40 acres (labeled Lot #2) would read:

SE ¼, SW ¼, Section 14, T2S, R3W

Note: Begin the legal description with the smallest designation.



Our tour has ended. Good luck with your watershed explorations. Happy touring!



Student sheet

Glossary

contour: imaginary line on the ground, all points of which are the same elevation above or below a specific datum. A datum is a reference point used in surveying.

contour interval: difference in elevation between two adjacent contours.

declination: angular difference between magnetic north and true (geographic) north at the point of observation; it is not constant but varies with time because of the “wandering” of the magnetic north pole.

hachure: any series of lines used on a map to indicate the general direction and steepness of slopes; these lines are often used to denote a depression (hole) in the land.

latitude: angular distance in degrees, minutes, and seconds, of a point north or south of the equator.

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

map: any concrete or abstract representation of the distributions of features that occur on or near the surface of the earth or other celestial bodies.

map, topographic: map that presents the horizontal and vertical positions of the features represented.

meridian: great circle of the surface of the earth passing through the geographical poles and any given point on the earth’s surface. All points on a given meridian have the same longitude.

orientation: establishing the correct relationship in direction with reference to points of the compass; the state of being in correct relationship in direction with reference to the points of the compass.

prime meridian: meridian of longitude 0 degrees, used as the origin of measurements of longitude; the meridian of Greenwich, England, is the internationally accepted prime meridian on most charts.

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

quadrangle: four-sided area, bounded by parallels of latitude and meridians of longitude used as an area unit in mapping.

relief: elevations and depressions of the land or sea bottom.

scale: relationship existing between a distance on a map, chart, or photograph and the corresponding distance on the earth.

section: one thirty-sixth of a township.

township: a six square-mile segment of land, the basic unit of the Public Land System Survey.

Questions:

1. What is the name of your quadrangle map? Where do you find this information on your map?
2. How are quadrangle maps named?
3. _____ or meridian lines run north and south and are measured in degrees east and west around the earth from Greenwich, England.
4. _____ or parallel lines run east and west and are measured in degrees north and south from the equator to the poles.
5. Why are longitude lines more variable in length than latitude lines?
6. What does it mean when we say that a topographic map is a 7.5 minute map?
7. Which map shows the most detail—a 7.5' or a 15' map?
8. If a location is just outside the boundaries of your topographic map, how would you find out the next map to use?
9. When was your map produced? If it was revised, when was it revised?
10. What is the scale of your topographic map? What does this mean?
11. What is a contour line?
12. What is an index contour?

Student sheet

13. What is contour interval?
14. What is the contour interval of your map?
15. What is meant about the topography if the contour lines are very close together on a map?
16. How do you know which direction a stream is flowing?
17. What is the difference between “magnetic north” and “true north”? Which should you use to find the most accurate direction?
18. Where do you find the declination distance on your map so you can adjust your compass to the most accurate direction?
19. What are the latitude and longitude coordinates in the top left corner of your map?
20. What are the Universal Transverse Mercator (UTM) tick mark designations in the upper left hand corner of your map?
21. What is the total distance in miles from the top to the bottom of your map at 45° latitude? What is the total distance in miles from side to side on your map at the same latitude?
22. What is the Willamette Meridian? Why is it important?
23. Describe the relationship of townships, ranges, and sections in the Public Land Survey System?
24. What is the legal description at the mouth of the main stream closest to your community?

Student sheet

What a relief!

Activity Education Standards: Note alignment with Oregon Academic Content Standards beginning on p. 483.

Objectives

Students will (1) choose a stream segment to investigate, (2) define the word *relief*, (3) use a topographic map to construct a three-dimensional model of a watershed, (4) explain and demonstrate how contour lines on a topographic map are related to features on a three-dimensional map, and (5) determine what kinds of information are best displayed using the topographic relief model.

Method

Students will construct a three-dimensional relief model of a local watershed and answer questions about the use and effectiveness of the model.

For younger students

1. Read activity background information aloud to younger students or modify for your students' reading level. Use props to demonstrate the key concepts.
2. Try "Branching Out," Project WET, pp. 129-132. This activity eliminates safety concerns associated with younger students using X-Acto knives.

What a Relief was developed by Michael Goodrich, Director, GeoQuest Publications, PO Box 1665, Lake Oswego, OR 97035, and is used with permission.

Materials

- copies of student sheets
- scissors
- white paste (such as Elmer's)
- ¼" foamboard or cardboard
- 7.5 minute topographic map
- dot grids (from engineering or forestry supply company)
- pencil
- X-Acto knife or utility knife
- paint or colored pencils

Background

Do you know . . .

... how to use a **topographic map**? Maps are flat, but the areas they show can have mountains, valleys, hills, or plains. Topographic maps show the shape and elevation of land forms with **contour lines**. All points along any one contour line are at the same **elevation**. The lines allow **cartographers** to show what the land looks like in three dimensions (3-D). This is important. It gives us clues about the slope of the land and suggestions about the geological history of the area. It is also necessary information for managing watersheds.

Some maps and globes are made with raised surfaces. This helps us read maps because things

Vocabulary

cartographer	scale
contour/contour lines	topographic map
declination	USGS
index contour	watershed
reach, stream	wetlands
relief	

like mountains and valleys are more easily recognized when the relief of the area is raised and highlighted. **Relief** is the difference in elevation between the high and low points on land.

On computer screens it is possible to make a 3-D picture of a landscape. These pictures can be moved around. You can look at them from close up or from far away and from ground level or from above, like in a plane.

A stream does not exist apart from the land that surrounds it. When studying watersheds, you must look at the entire watershed. Rock and soil types, vegetation, slope, and human-made structures all affect watersheds and their streams. Making topographic 3-D models can help you better understand all parts of your watershed.

Procedure

Now it's your turn . . .

How do you create a 3-D topographic model of a watershed? First, do some careful planning *before* you begin this project.

- Use a topographic map published by the United States Geological Survey (USGS).
- Different scales of topographic maps cover different sized areas of the earth's surface. The most detailed maps from the USGS are part of the 7.5 minute series. A map from this series has a scale of 1:24,000 (one inch on the map equals 24,000 inches on the ground). The area of a 7.5 minute map is approximately 7 miles long and 7 miles wide.
- Choose the watershed your class will study, preferably one that is close to your school.
- Determine the watershed boundaries. (See the activity "A Sense of Place: Your Ecological Address" in the watershed chapter, pages 43-52.)
- Determine the area of the watershed. The dot grid method for determining the area of a watershed is a simple technique and does not require expensive equipment. Dot grids are

sheets of acetate or Mylar that have a series of dots (about the size of a period at the end of a sentence) printed on them. They are available from engineering and forestry supply companies. Ask for the grid that fits the scale of your map. Place a dot grid on the map over the area you want to measure. Count the dots that fall within the area of the watershed and then multiply by the conversion factor noted on the grid sheet to determine the area.

- Determine the stream order for your stream. See page 35 in the Watershed chapter.
- Determine where any political boundaries (county, city, or state) cross your watershed. USGS topographic maps indicate these boundaries with a system of lines. See the legend on your map.
- Note any water surface features such as lakes, **wetlands**, **springs**, and **seeps**.
- Check with local authorities to see if the houses near the stream are on septic tanks or sewers.
- Ultimately, where does the water in your stream end up?
- Are there any issues past or present that may affect the stream you are about to study?
- Establish a climate base for your watershed by collecting temperature and precipitation data for the past few years. State climatologists archive this information. The following Web site offers addresses, phone numbers, and Internet sites for the state climatologists: http://www.people.virginia.edu/~climate/state_climatologists.htm.

Next, decide which specific stream section or tributary to research. When choosing a stream section, consider access and safety. Within that section, which **stream reach** will you study? A reach is a length of stream defined by some common characteristic. A reach may simply be the section surveyed. More frequently, reaches are defined by the distances between named tributaries, by major changes in valley and channel form, vegetation, or by changes in land

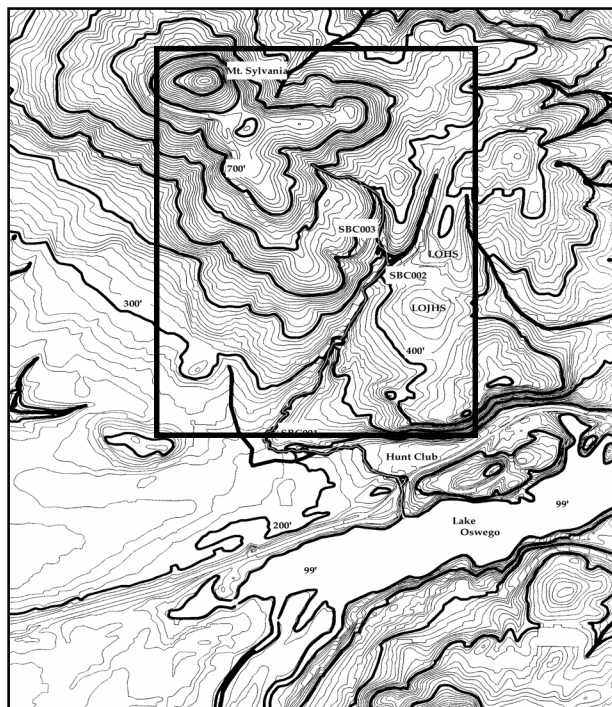
use ownership. Locate your reach by longitude and latitude. Use your topographic map and the exercise “A Sense of Place,” pages 43-52, or a GPS Satellite Navigator.

You are now ready to construct a 3-D topographic model.

Watershed site selection

1. Photocopy and enlarge the watershed map.
2. Copy the scale along with the map. The scale on the map to the right is shown graphically as a line: 0' ————— 2,000'.
3. Record or copy the magnetic declination noted on the map. This is shown graphically: $\swarrow 20^\circ$, or as part of the text.
4. Next trace the river system with a dark pencil.
5. Decide which reach you will study in more detail.

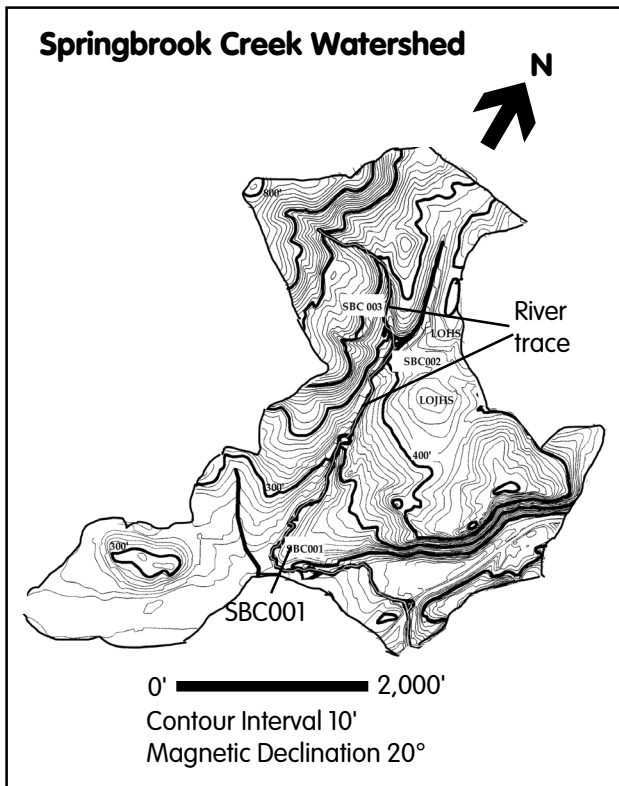
Finding the cutting edge



0' ————— 2,000'
Contour Interval 10'
Magnetic Declination 20°



Watershed site selection

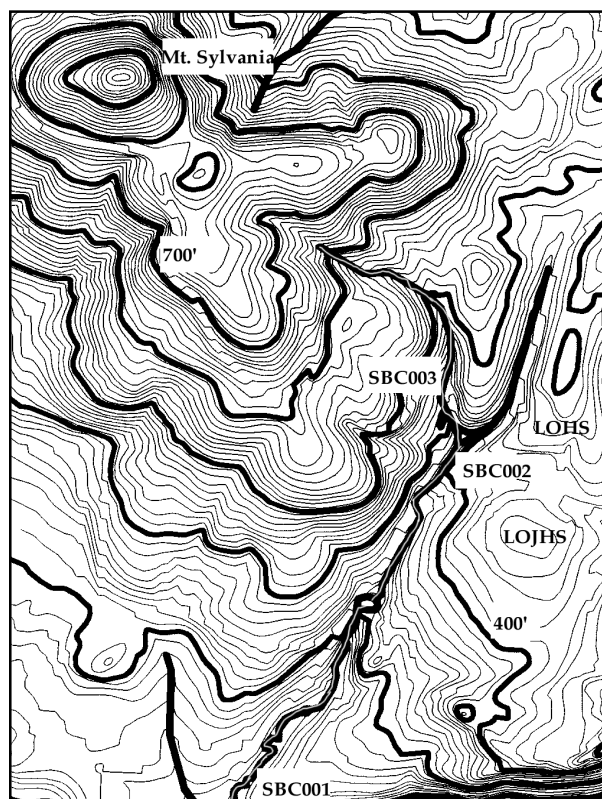


6. Mark the reach on the map and give it a number. On the example, SBC 001 stands for Springbrook Creek Reach number 1.
7. Include upstream areas in the 3-D model as those areas can affect your reach.

Finding the cutting edge

8. The area to be included in the 3-D model is outlined on the example map to the left.
9. Place the map with the selected area outlined in a photocopy machine. Enlarge it to a suitable size ($8\frac{1}{2}'' \times 11''$). The example on these pages was enlarged three times. Make several copies.
10. Cut out the enlarged outlined area and set it aside. It will become your 3-D model.
11. Cut out the scale and any other pertinent data and set it aside.

Enlargement of study area



Contours: getting elevated

12. The enlarged map area (see above) is used for the model.
13. Choose either foamboard or cardboard for the 3-D model. Foam board comes in a variety of thicknesses and is easy to cut with an X-Acto knife.
14. In areas with less relief, consider exaggerating the elevation of your 3-D model so the changes in elevation will show better. Using $\frac{1}{4}$ " foamboard with a 7.5 minute topographic map results in no vertical exaggeration. Using $\frac{1}{2}$ " foamboard, provides an exaggeration of two times (2X).

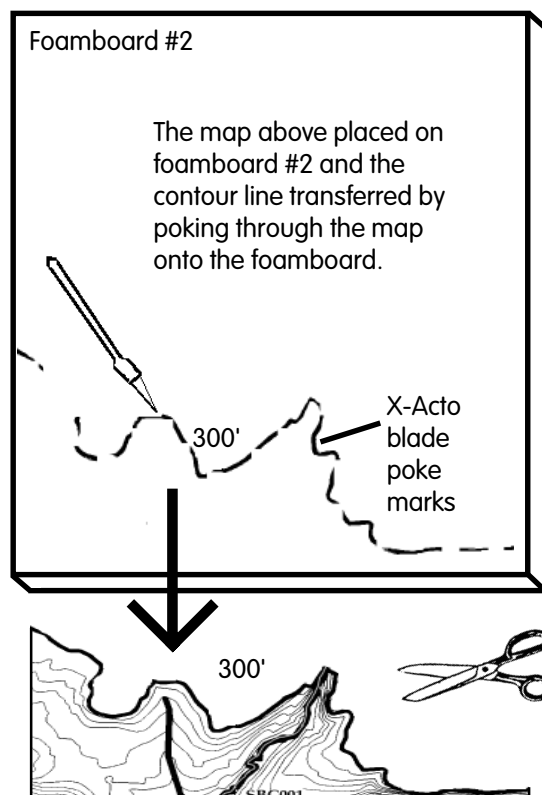
Contours: cutting up

15. Count how many index contour lines are on your map. On the example map, the indexed contours lines (the heavier lines) are 300', 400', 500', 600', 700', 800', and 900'. On this example there are seven index contour lines.

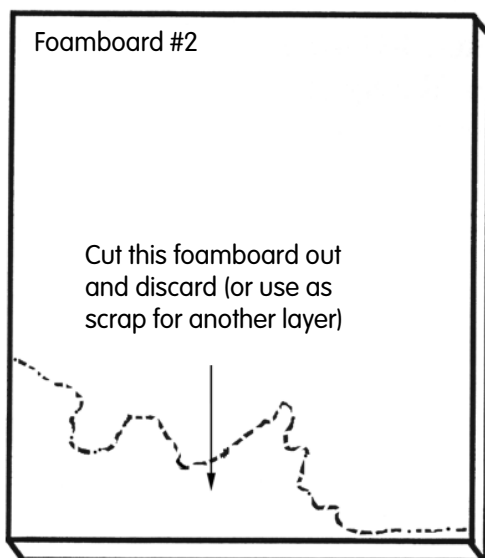
Using a utility knife with a razor blade or an X-Acto knife, cut foamboard pieces to the size of your enlarged area (the example map is $8\frac{1}{2}" \times 11"$). But cut foamboard pieces for only half the number of index contours on the map. For the example map, we would cut four foamboards measuring $8\frac{1}{2}" \times 11"$. Cutting only half the number of index contour lines allows you to use as much of the foamboard as possible. **One of the foamboards will become layer #1—your base—and will not be cut.**

16. Set the map on one of the foamboards (#2). Using your X-Acto knife, poke into the foamboard along the contour line that represents the lowest elevation on the map. Be careful with the X-Acto knife! Check to

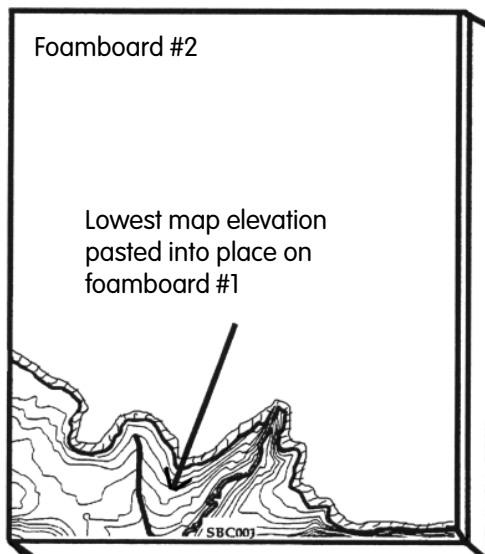
Steps 16-17



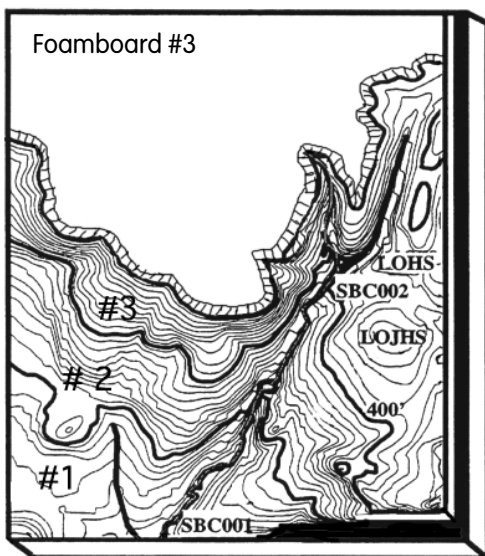
Step 18



Steps 19-20



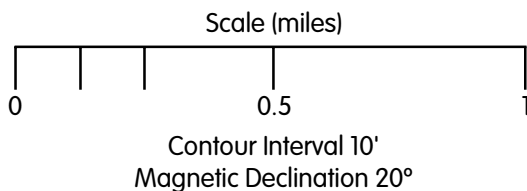
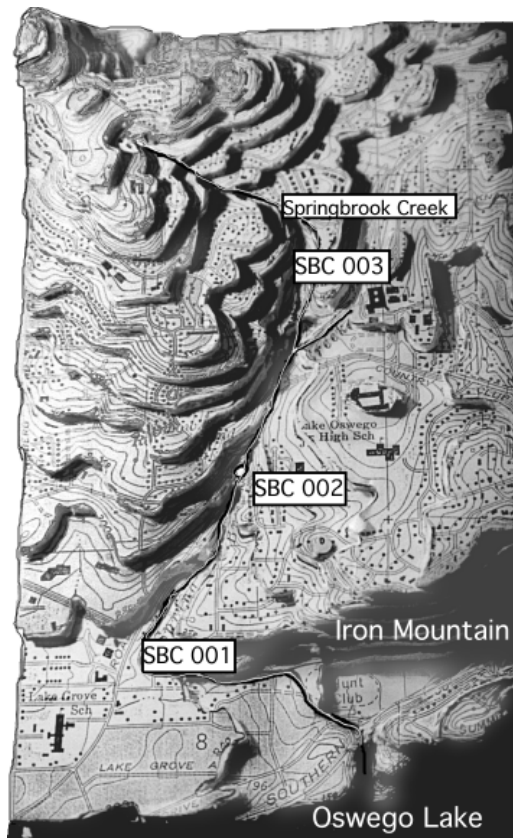
Step 21



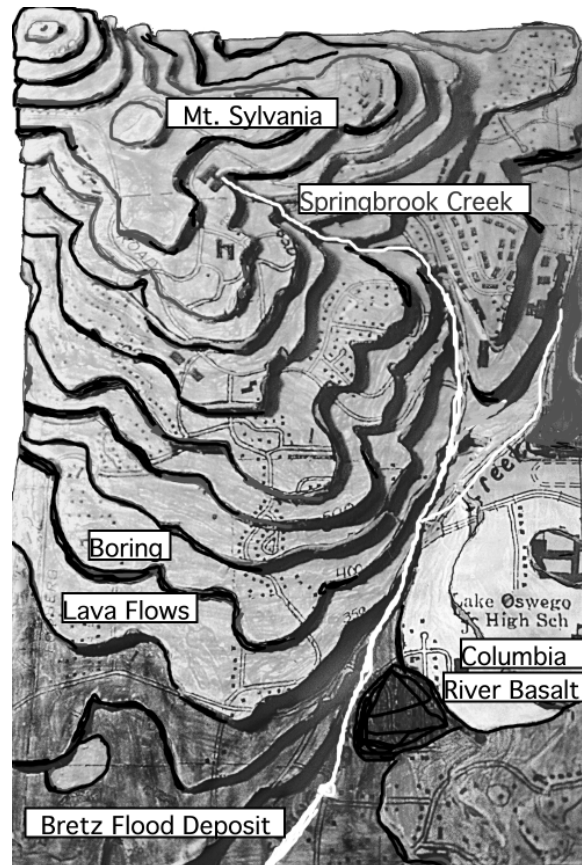
see if there is more than one contour line on the map that has that same elevation (there may be two or more contour lines of equal elevation on different parts of the map indicating the lowest places on the map). If this occurs, poke into the foamboard along both contours.

17. Using scissors cut out the lowest contour(s) on the map. The lowest elevation on this example map (300') occurs only once.
18. Cut out the dotted area on the foamboard with your X-Acto knife and discard or use as a scrap piece for another layer.
19. Place foamboard #2 on top of foamboard #1 (the base). Glue the two boards together with white paste.
20. Take the *map* piece you just cut out (lowest elevation) and paste it on foamboard #1 (base) in the space left for it.
21. Repeat this procedure for each contour elevation. The bottom diagram shows three layers completed.
22. When you have completed the entire model and have glued down each layer, attach the magnetic declination, scale and contour interval. Add your name to the model and indicate when the model was built. See page 88 for an example of a completed model.
23. By coloring the appropriate sections in different colors, you can use the model to show the slope of the land, the rock units in the area, or the soil types. All this information helps us understand our watersheds. If you plan to include all three of the above, make three separate models. On page 88 is an example of a 3-D topographic map that includes rock units.
24. To protect your map, spread some white paste over the surface. The paste will dry clear.

Completed 3-D Topographic Model of the Springbrook Watershed



Rock Units in the Springbrook Watershed



Questions

1. What have you learned about maps during the construction of your model?

Answers will vary.

2. How could you use your model to show someone the features of your watershed?

Answers will vary, but should include some discussion of how "relief" shows high and low points and different ways map models are used to show certain features, i.e. rock types, land use, slope, and others.

Going further

1. Using a geologic map, soils map, and topographic map as a reference, construct a series of 3-D models that reflect (a) the slope of the land, (b) the rock units and faults, (c) the soil types, and (d) the dominant vegetation. Using your models, discuss the effect the landscape has on the "built environment" and the "integrity of the stream."
2. A 3-D model of the earth's surface has some advantages over the use of a topographic map when studying a watershed. What are some of the advantages and how might these advantages be used to better understand your watershed?

Glossary

cartographer: a person who makes maps.

contour/contour lines: lines on maps that pass through points of the same elevation.

declination: the angular difference between true north and magnetic north.

elevation: distance above or below sea level.

index contour: the thicker brown lines on a topographic map; these lines usually have an associated number that indicates the elevation along the line.

reach, stream: a length of stream defined by some common characteristic.

relief: the difference in elevation between the highest points and lowest points on a map; the configuration of the earth's surface.

scale: relationship between the distance on a map and the distance it represents on the earth (1:24000 or 1" to 24,000").

topographic map: a map that uses contour lines and symbols to represent the human-created and natural features of a mapped area.

USGS: the United States Geological Survey is a branch of the federal government's Department of the Interior responsible for creating many types of maps.

watershed: the land area from which water flows toward a common stream in a natural basin.

wetlands: lands where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities—sloughs, ponds, marshes.

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What a relief!

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- Choose the watershed your class will study, preferably one that is close to your school.
- Determine the watershed boundaries. (See the activity "A Sense of Place: Your Ecological Address" in the watershed chapter, pages 53-58.)
- Determine the area of the watershed. The dot grid method for determining the area of a watershed is a simple technique and does not require expensive equipment. Dot grids are sheets of acetate or Mylar that have a series of dots (about the size of a period at the end of a sentence) printed on them. They are available from engineering and forestry supply companies. Ask for the grid that fits the scale of your

Vocabulary

cartographer	relief
contour lines	scale
declination	topographic map
elevation	USGS
index contour	watershed
reach, stream	wetlands

map. Place a dot grid on the map over the area you want to measure. Count the dots that fall within the area of the watershed and then multiply by the conversion factor noted on the grid sheet to determine the area.

- Determine the stream order for your stream. See page 35 in the watershed chapter.
- Determine where any political boundaries (county, city, or state) cross your watershed. USGS topographic maps indicate these boundaries with a system of lines. See the legend on your map.
- Note any water surface features such as lakes, **wetlands**, **springs**, and **seeps**.
- Check with local authorities to see if the houses near the stream are on septic tanks or sewers.
- Ultimately, where does the water in your stream end up?
- Are there any issues past or present that may affect the stream you are about to study?
- Establish a climate base for your watershed by collecting temperature and precipitation data for the past few years. State climatologists archive this information. The following Web site offers addresses, phone numbers, and Internet sites for the state climatologists: http://www.people.virginia.edu/~climate/state_climatologists.htm.

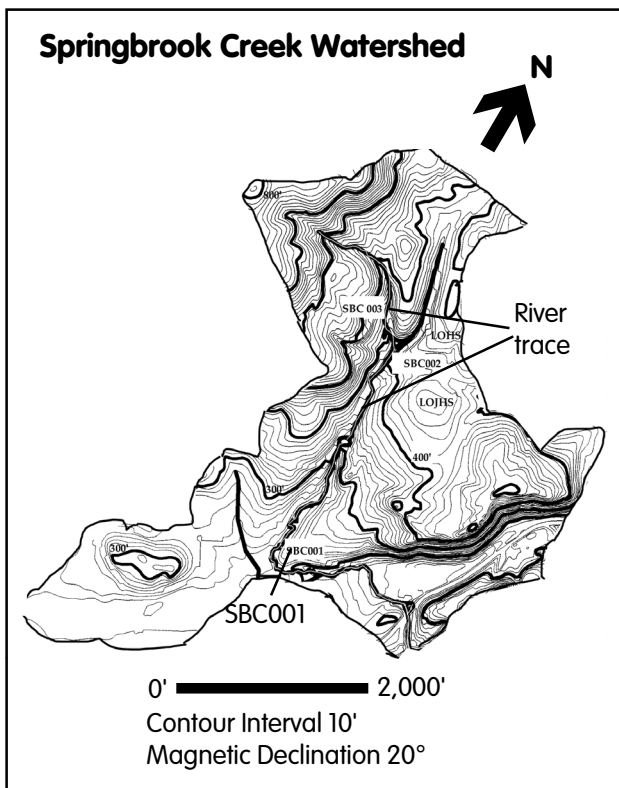
Next, decide which specific stream section or tributary to research. When choosing a stream section, consider access and safety. Within that section, which **stream reach** will you study? A reach is a length of stream defined by some common characteristic. A reach may simply be the section surveyed. More frequently, reaches are defined by the distances between named tributaries, by major changes in valley and channel form, vegetation, or by changes in land use ownership. Locate your reach by longitude and latitude. Use your topographic map and the exercise “A Sense of Place,” pages 53-58 or a GPS Satellite Navigator.

You are now ready to construct a 3-D topographic model.

Watershed site selection

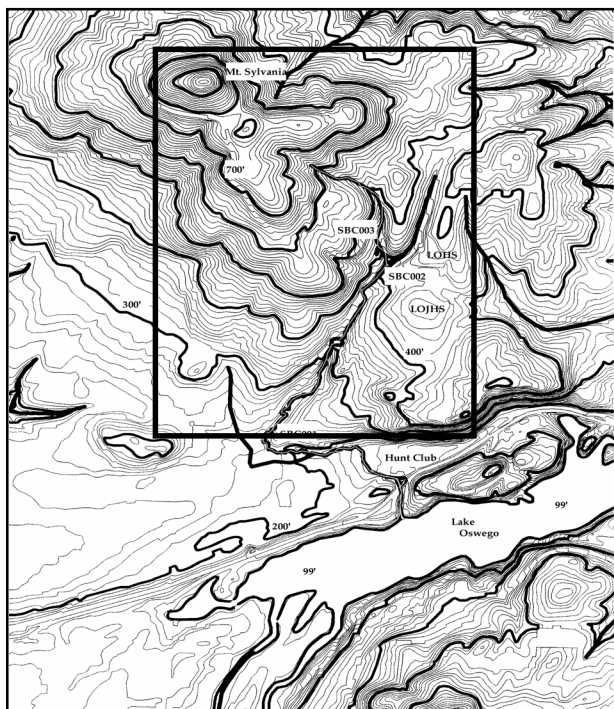
1. Photocopy and enlarge the watershed map.
2. Copy the scale along with the map. The scale on the map to the right is shown graphically as a line: 0' ————— 2,000'.
3. Record or copy the magnetic declination noted on the map. This is shown graphically: $\swarrow 20^\circ$, or as part of the text.
4. Next trace the river system with a dark pencil.
5. Decide which reach you will study in more detail.
6. Mark the reach on the map and give it a number. On the example, SBC 001 stands for Springbrook Creek Reach number 1.
7. Include upstream areas in the 3-D model as those areas can affect your reach.

Watershed site selection



Student sheet

Finding the cutting edge



0' ————— 2,000'

Contour Interval 10'

Magnetic Declination 20°



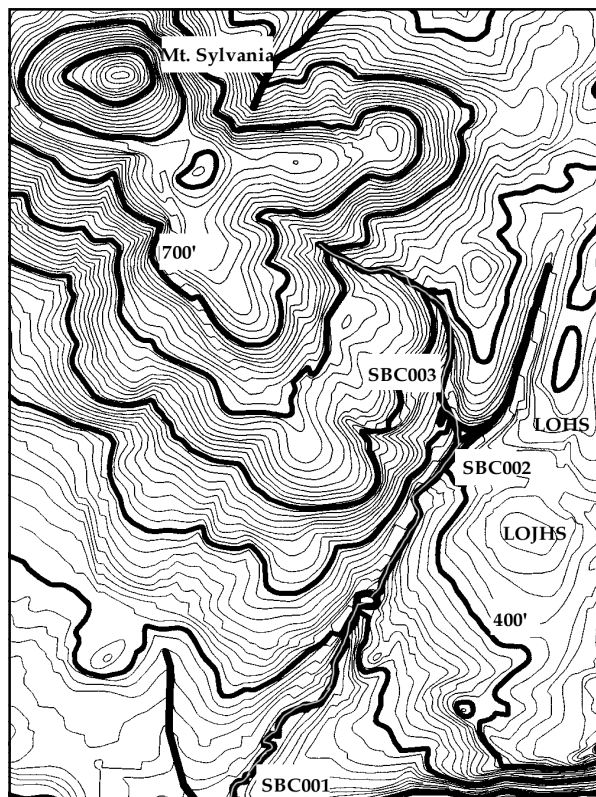
Finding the cutting edge

8. The area to be included in the 3-D model is outlined on the example map to the left.
9. Place the map with the selected area outlined in a photocopy machine. Enlarge it to a suitable size (8½"×11"). The example on these pages was enlarged three times. Make several copies.
10. Cut out the enlarged outlined area and set it aside. It will become your 3-D model.
11. Cut out the scale and any other pertinent data and set it aside.

Contours: getting elevated

12. The enlarged map area to above is used for the model.
13. Choose either foamboard or cardboard for the 3-D model. Foam board comes in a variety of thicknesses and is easy to cut with an X-Acto knife.
14. In areas with less relief, consider exaggerating the elevation of your 3-D model so the changes in elevation show better. Using ¼" foamboard with a 7.5 minute topographic map results in no vertical exaggeration. Using ½" foamboard, provides an exaggeration of two times (2×).

Enlargement of study area



0' ————— 2,000'

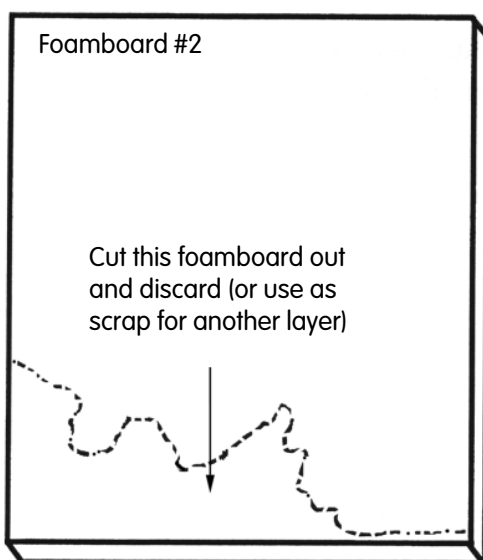
Contour Interval 10'

Magnetic Declination 20°

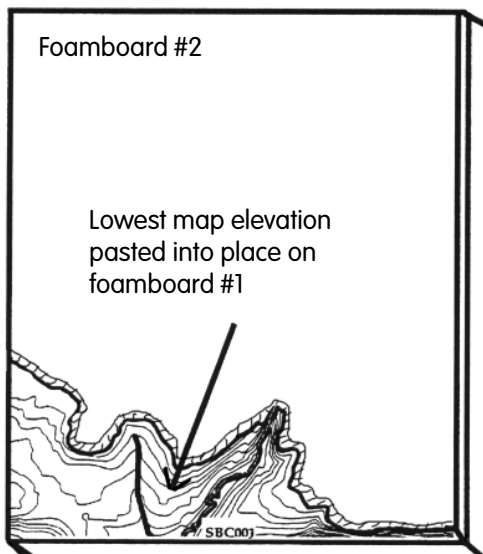


Student sheet

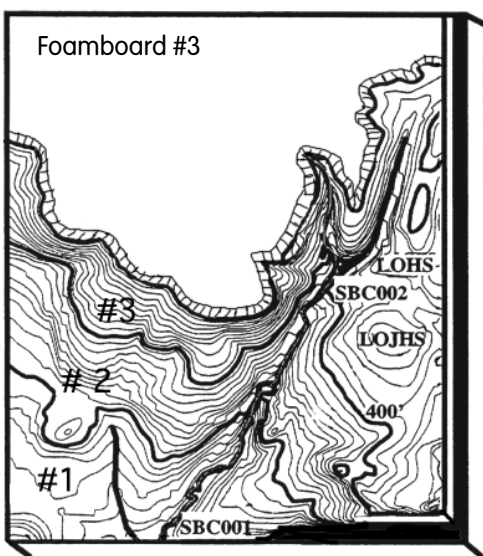
Step 18



Steps 19-20



Step 21



Contours: cutting up

- Count how many index contour lines are on your map. On the example map, the indexed contours lines (the heavier lines) are 300', 400', 500', 600', 700', 800', and 900'. On this example there are seven index contour lines.

Using a utility knife with a razor blade or an X-Acto knife, cut foamboard pieces to the size of your enlarged area (the example map is 8½"×11"). But cut foamboard pieces for only half the number of index contours on the map. For the example map, we would cut four foamboards measuring 8½"×11".

Cutting out half the number of index contour lines allows you to use as much of the foamboard as possible. **One of the foamboards will become layer #1—your base—and will not be cut.**

- Set the map on one of the foamboards (#2). Using your X-Acto knife, poke into the foamboard along the contour line that represents the lowest elevation on the map. Be careful with the X-Acto knife! Check to see if there is more than one contour line on the map that has that same elevation (there may be two contour lines of equal elevation on different parts of the map indicating the lowest places on the map). If this occurs, poke into the foamboard along both contours.
- Using scissors cut out the lowest contour(s) on the map. The lowest elevation on this example map (300') occurs only once.
- Cut out the dotted area on the foamboard with your X-Acto knife and discard or use as scrap piece for another layer.
- Place foamboard #2 on top of foamboard #1 (the base). Glue the two boards together with white paste.
- Take the *map* piece you just cut out (lowest elevation) and paste it on foamboard #1 (base) in the space left for it.

Student sheet

21. Repeat this procedure for each contour elevation. The bottom diagram shows three layers completed.
22. When you have completed the entire model and have glued down each layer, attach the magnetic declination, scale and contour interval. Add your name to the model and indicate when the model was built. See below for an example of a completed model.
23. By coloring the appropriate sections in different colors, you can use the model to show the slope of the land, the rock units in the area, or the soil types. All this information helps us to understand our watersheds. If

you plan to include all three of the above, make three separate models. An example of a complete 3-D topographic map that includes rock units is shown below.

24. To protect your map, spread some white paste over the surface. The paste will dry clear.

Glossary

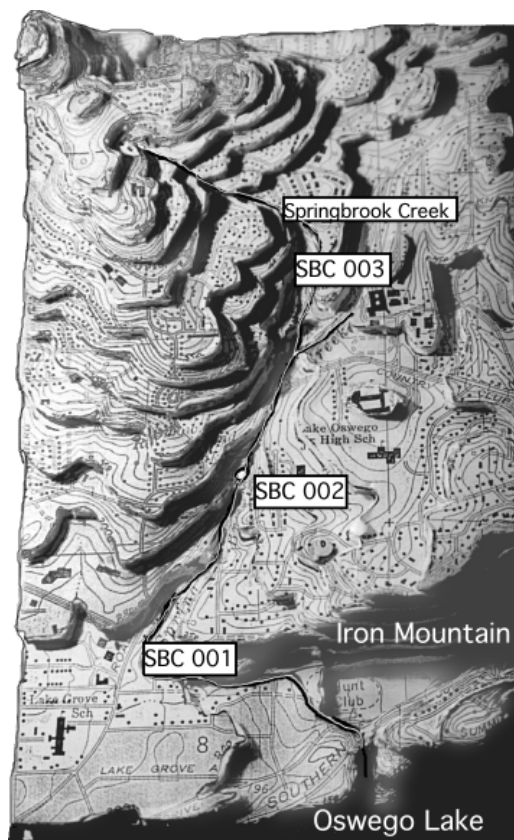
cartographer: a person who makes maps.

contour/contour lines: lines on maps that pass through points of the same elevation.

declination: the angular difference between true north and magnetic north.

elevation: distance above or below sea level.

Completed 3-D Topographic Model of the Springbrook Watershed



Scale (miles)
0 0.5 1
Contour Interval 10'
Magnetic Declination 20°

Rock Units in the Springbrook Watershed



Student sheet

index contour: the thicker brown lines on a topographic map; these lines usually have an associated number that indicates the elevation along the line.

reach, stream: a length of stream defined by some common characteristic.

relief: the difference in elevation between the highest points and lowest points on a map; the configuration of the earth's surface.

scale: relationship between the distance on a map and the distance it represents on the earth (1:24000 or 1" to 24,000").

topographic map: a map that uses contour lines and symbols to represent the features (human created and natural) of the mapped area.

topographic profile: a side view of the land along a specific line; a profile of a stream would show the stream's slope.

topographic cross section: a side view of the land along a specific line; a cross section would show you the profile of the valley that the stream passes through.

USGS: the United States Geological Survey is a branch of the federal government's Department of the Interior responsible for creating many types of maps.

watershed: the land area from which water flows toward a common stream in a natural basin.

wetlands: lands where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities—sloughs, ponds, marshes.

Questions

1. What have you learned about maps during the construction of your model?
2. How could you use your model to show someone the features of your watershed?

Snow way!

Activity Education Standards: Note alignment with Oregon Academic Content Standards beginning on p. 483.

Objectives

Students will (1) graph the annual rainfall for a basin, (2) graph annual snowpack for the same basin, (3) graph streamflow during the same period, and (4) analyze and describe the response of the stream to various types of precipitation.

Method

Students will graph rainfall, snowpack, and streamflow data for Silver Creek near Silver Lake in Lake County, Oregon. Students will then draw conclusions about the response of a watershed to various types of precipitation.

For younger students

1. This activity can also be done as a group.
2. Younger students may need graphing practice prior to this activity.

Materials

- copies of student sheets (pp. 101-104)

Notes to the teacher

Ask the students to describe the direct correlations shown on the graph. For example, peak snowpack is in February and March. At this time, streamflows are at their lowest. Then, as snow-melt occurs, streamflows increase as shown when lines cross and go in opposite directions. When streamflows are highest, precipitation is lowest. Notice that the streamflow peaks in September but continues to provide good flows

throughout the warmest months of the year because of baseflow (groundwater recharge).

Background

Do you know . . .

. . . in many places snow is an important part of the total precipitation of a watershed? It is the main source of water for streams in the mountainous West. Melting snow may affect streamflow long after it falls as precipitation. Snow may melt slowly, creating streamflow throughout the otherwise dry summer. Or it may melt rapidly, creating floods.

During the spring and fall, temperature fluctuations can cause recent snowfall to melt. When this happens it creates runoff and streamflow affects similar to rainstorms. During the winter, snow may stay on the ground for long periods. This stores the water in snow until later in the year. Streams fed by melting snow often flow for much longer periods than streams fed only by rain.

Mountain snowpacks are measured to predict how much water will be available when it melts later in the year. To evaluate how much water is in snow it is important to measure not only its depth, but its **water equivalent**. This is the amount of water that would be released if all of the snow melted.

Snow disappears in other ways besides melting. In a process known as **sublimation** snow can pass directly from frozen form to vapor. Wind blowing directly across snow evaporates it. Blowing snow is especially prone to sublimation.

Vocabulary

water equivalent

sublimation

streamflow hydrograph

Procedure

Now it's your turn . . .

The information in the following table shows annual precipitation and snowpack amounts and streamflow for a basin in southeastern Oregon. The data for precipitation includes snowfall. Even though it falls as precipitation, snow may not affect streamflow until later in the year. When temperatures are below freezing, snow is stored in the watershed rather than being captured in, or stored by, soils. The data given for snowpack shows the accumulated amounts over a season.

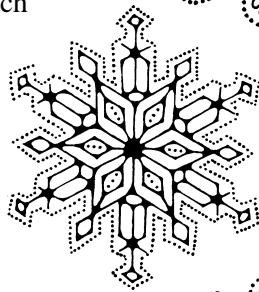
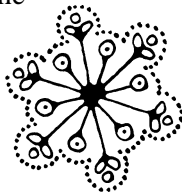
Snowpack was measured near the top of the Silver Creek watershed. Precipitation and streamflow were measured near the mouth of Silver Creek.

On the graph provided, create a line graph by plotting the annual precipitation and snowpack of the Silver Creek basin near Silver Lake in Lake County. Repeat the process for the streamflow data. This graph is called a **streamflow hydrograph**.

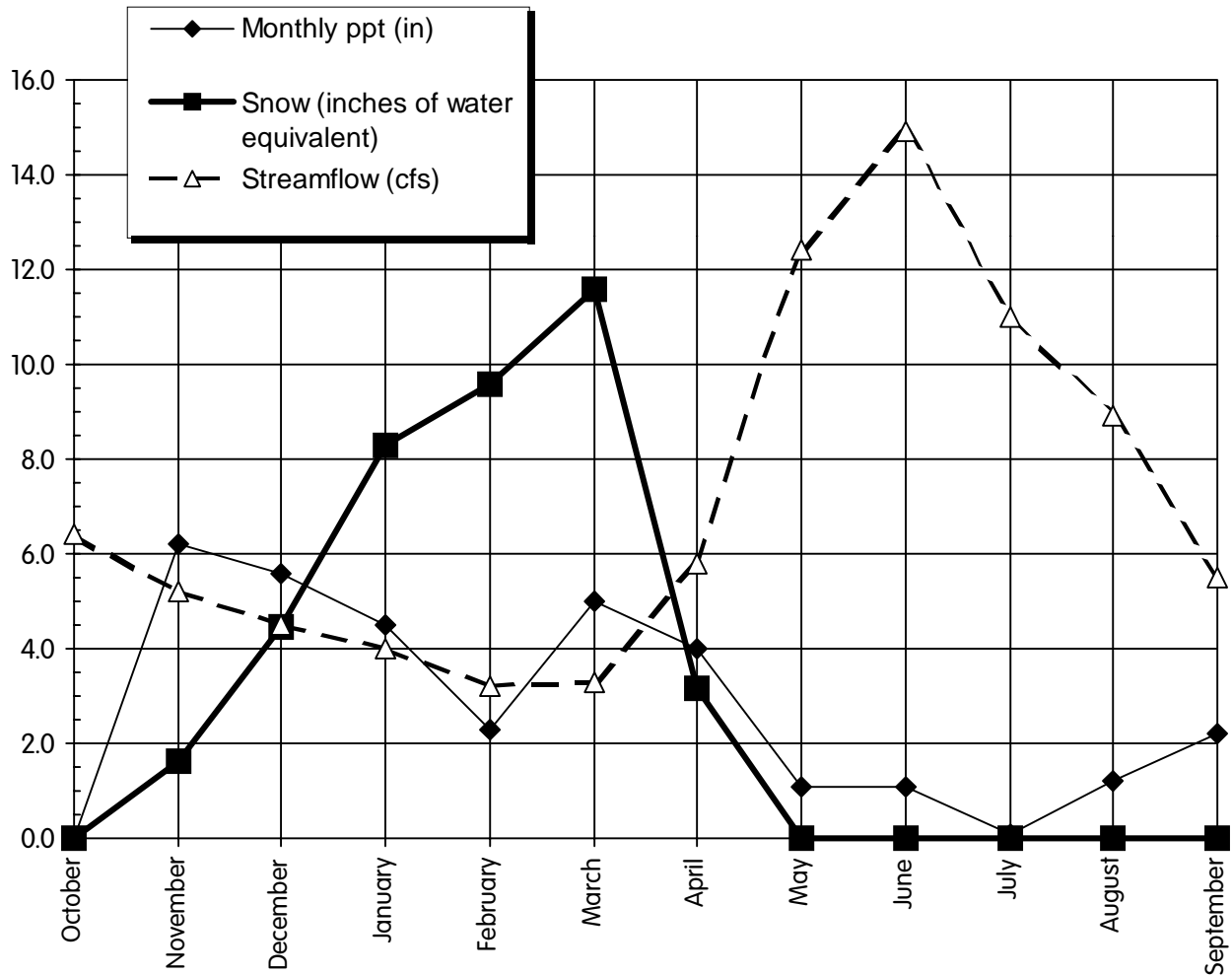
Use a different color for each line. Be sure to mark a legend with the color representing each line.

Silver Creek is a tributary of Silver Lake, in Lake County, Oregon. The drainage area of Silver Creek is 180 square miles.

1989	Monthly ppt (in)	Snow (inches of water equivalent)	Streamflow (cfs)
October	0.0	0.00	6.4
November	6.2	1.63	5.2
December	5.6	4.47	4.5
January	4.5	8.31	4.0
February	2.3	9.60	3.2
March	5.0	11.59	3.3
April	4.0	3.15	5.8
May	1.1	0.00	12.4
June	1.1	0.00	14.9
July	0.1	0.00	11.0
August	1.2	0.00	8.9
September	2.2	0.00	5.5



Silver Creek Streamflow Hydrograph



Questions

1. Which month had the greatest precipitation? The most water stored as snow? The highest streamflow?

Precipitation was highest in November. The peak snowpack was in March. June was the month with the highest streamflow.

2. How long was it from the precipitation peak to the streamflow peak.

The period between the precipitation peak and streamflow peak is November to June, or about 7 months.

3. How long was it from the peak storage of snow to the streamflow peak.

The period between the snow storage peak and streamflow peak is March to June, or about 3 months

4. Which has a greater influence on the peak streamflow of Silver Creek, total precipitation or snow storage? Why?

Snow storage has a greater effect on the flow of Silver Creek. The amount of water stored as snow may be relatively small compared to the total precipitation in the watershed, but it's rapid melt moves it into the stream relatively quickly.

5. Use the concepts of “capture, store, and safe release” to explain where the water from the melting snow was between the time it melted and when it reached to stream?

Snow on the uplands was “captured” when it melted and infiltrated into the soil. It was then stored there for several days while it percolated downhill to the stream. When it reached the stream it was released as streamflow.

Going further

1. Design an experiment that will determine the water equivalent of snow. Collect information about snow water equivalence, monthly precipitation, and streamflow data for your own watershed. Develop a streamflow hydrograph for your own stream, based on your research.
2. What relationship exists between “stream order” and the lag time for the stream to reflect a sudden snow-melt event in the spring?
3. The activity “Winter Watersheds!” (pp. 131-152) can be used as an extension of this activity.

Snow way!

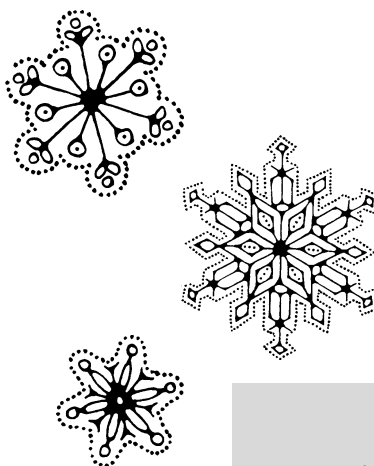
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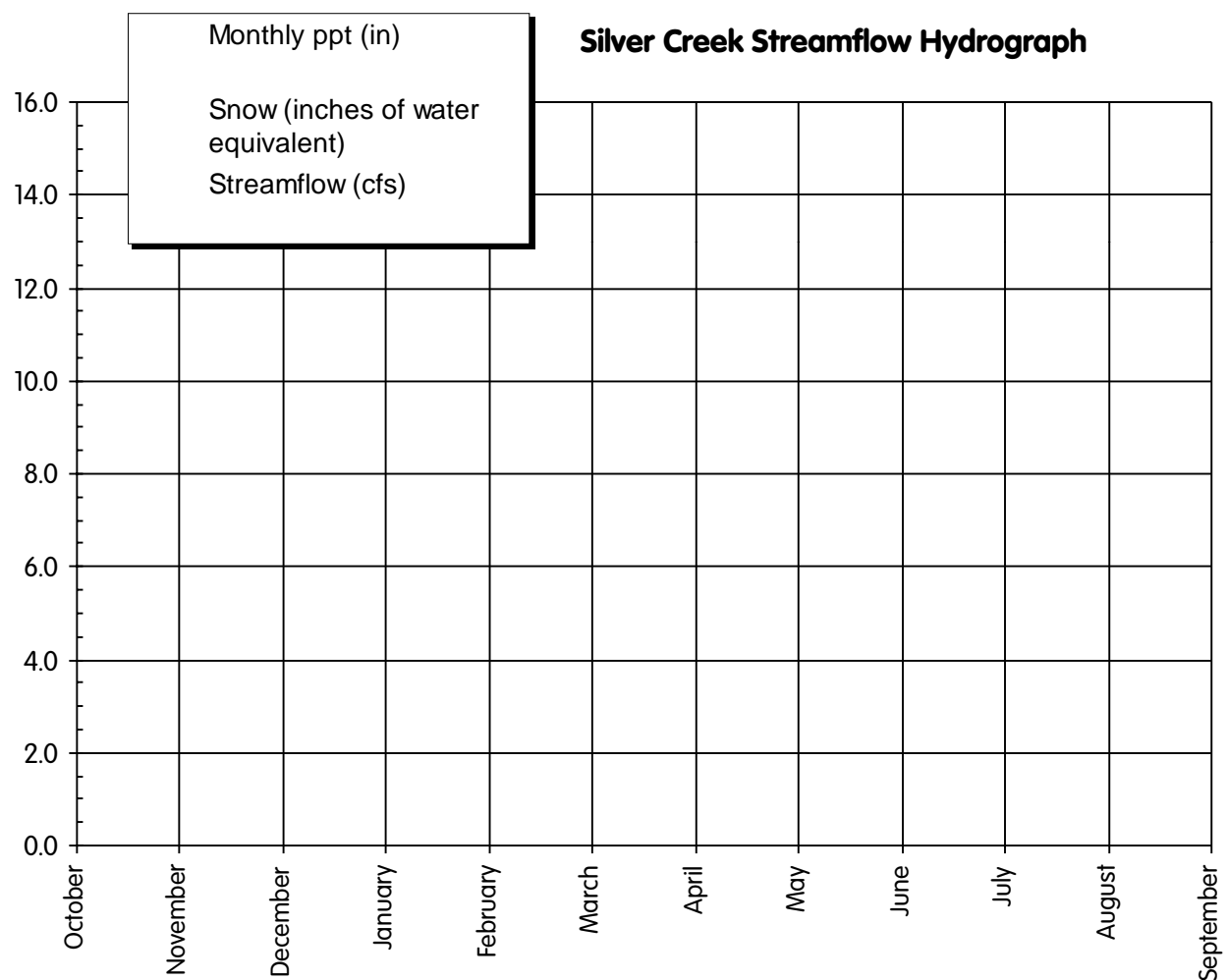
Vocabulary

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Student sheet

Questions

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Student sheet
