UNIT 5A. WATERSHEDS

ACTIVITIES	TIME	LEVEL
Watershed Reading & Discussion	30-45 minutes	Advanced
Bird's Eye View of a Watershed	60-90 minutes	All
Creating a Watershed Model	2-4 class periods	Introductory

BENCHMARKS	
Next Generation Science Standards	MS-ESS2-4 MS-LS2.C MS-ESS2.C HS-ESS2.E HS-ESS3.A
Common Core-State Standards-ELA/Literacy	CCRA.R.1 CCRA.R.4
Common Core-State Standards-Speaking&Listening	CCRA.SL.1
Science & Engineering Practices	-Asking questions and defining problems. -Developing and using models. -Engaging in argument from evidence. -Obtaining, evaluating & communicating information.
OR Social Sciences Academic Content Standards	HS.63

INTRODUCTION

We are all familiar with our own neighborhood. We know the homes and their inhabitants. We become less familiar as we consider what lies outside the neighborhood. Neighborhoods are part of a larger structure: city, county, and region. Watersheds, large and small, and their connections, are the salmon's cities, counties and regions. Just as our larger civic bodies provide our neighborhoods' needs, watersheds provide a salmon's needs. The watershed provides the water at the site; what happens upstream affects this water; what happens at the site affects water downstream.

In this section, we learn what watersheds are, the different kinds, the effects upon them, and how they are managed. Students read about watersheds, then explore them using aerial photographs and maps, engaging in a discussion of watersheds and their place in providing for the needs of organisms who live in or depend upon the stream.

OBJECTIVES:

- Students will gain a full understanding of the physical features and functions of watersheds, with salmon as the key indicator of watershed health.

KEY QUESTIONS

- ➔ What is the difference between a stream and a watershed?
- ➔ How do watersheds fit into the life of a salmon?
- ➔ What are a salmon's habitat needs and how does land uses affect them?

VOCABULARY (Brief definitions of vocabulary terms are found in the Glossary.):

watershed	precipitation	contour
stream flow	in situ	topographic
stream channel	channel area	run off
channel movement	ecological	watershed management
channel gradient	temperature	

ACTIVITIES:

WATERSHED READING AND DISCUSSION

MATERIALS:

- Reference material
- STUDENT HANDOUT 5A-1: Watersheds, Stream Scene

PROCEDURE:

1. Assign STUDENT HANDOUT 5A-1: Watersheds, Stream Scene, which describes the types of watersheds.

2. Engage the class in a discussion about their own watershed.
    - What is it?
    - Can they find it on a map?
    - How can we tell that what we see on a map is our watershed?
    - Where do your students get their drinking water?
    - Where does water and sewage go when they flush their toilet?

Note: Oregon Dept. of Environmental Quality Water Laboratories has water quality reports on file for many watersheds in the state. These reports are available for classroom use. They contain measurement records for a number of water quality parameters. Use these in the classroom to learn more about your own watershed. Obtaining these reports makes a good student project.
(503-229-5696; http://www.oregon.gov/DEQ/WQ/Pages/default.aspx)

BIRD'S EYE VIEW OF THE WATERSHED

(This activity was developed by Paula Minear, Oregon State University)

MATERIALS:

- Aerial photos of your site:
  - Recent low elevation
  - Within last 10 years at higher elevation
- Historical maps of your site:
  - Recent of site
  - Pre-World War II
  - Original survey maps (1800)
- Overhead pens

Note: aerial photos can be borrowed from resource agencies and city/county governments or university map libraries.

PROCEDURE:

1. Introduce the bird's eye view activity by talking with the students about how they observe tiny little things, then larger and larger objects. How do they see things differently as they pull away and look from a distance? Ask them what their classroom might look like if they were looking down from the ceiling. You might have them sketch an aerial view of their home or neighborhood or of their school and grounds. Depending upon the readiness of your students, you may want to introduce the idea of different scales (micro to mega; not metric versus English).

2. Present each team with the first aerial photograph. You might explain that aerial photos may be taken from a variety of aircraft, including ultralights and spy planes, and have many uses. Aerial photos were first used extensively in the 1930s. Natural resource agencies like B.L.M. and the Forest Service use them to spot landslides, identify diseased trees, map roads, and measure vegetation, among other things. Private timber companies like Weyerhauser will also use aerial photos to keep track of their lands.

3. Ask them to pick out a major feature of your choice, perhaps the river or the school. Have each student put their finger on the object you have asked them to identify, so you are sure they are with you. Now have each team orient themselves and their aerial photo with the real world, holding it flat in front of them as they turn appropriately. Check them for comprehension. Can they point to objects on the ground that they have identified in the photo?

4. Give each team 5 minutes to identify other features in the photo, by discussing it within their teams. You may wish to point out that conifer trees show up somewhat darker green and pointy at the top, while deciduous trees are lighter green and fluffier-looking in the color aerial photos. If you wish, you could have the students actually label the features on the aerial photo using the overhead pens (non-permanent). At the end of the time have each team show one interesting thing they see in the photo. Does this new view of the world give them an interesting perspective they didn't have before?

5. During the analysis of this aerial photo, make sure the students have discussed conditions of special importance to salmon, for example: Where is the nearest stream? (Have them put their finger on it to check.) Does it have a riparian area? Are there places where the riparian vegetation is missing? (Review the importance of riparian vegetation to stream conditions.) Can they identify bridges, houses, and roads near the stream? What other land uses are nearby?

6. Now give them the second photo, taken at a higher altitude, and again have them orient themselves, identify major features, and then discuss in their teams and present additional features they have found and differences they have seen from the first photo. What has been gained by taking the picture from a higher altitude? What has been lost? If the photo was taken several years previously, they may also notice differences in buildings, roads, and vegetation.

7. What major land uses do they notice in this aerial photo (#2)? If you are at your Salmon Watch site, you may see agriculture, forestry, and roads. In an urban setting, you may notice that the stream disappears into culverts, has been forced to bend around buildings, etc. Talk about how each of these land uses has a potential impact upon salmon or their habitat. Alternatively, you may give each team one land use to discuss and have them share with the class how they think that land use would affect salmon. Also point out that land uses upstream of the stream will affect salmon habitat downstream. Have them show you some examples of upstream land uses on the photos.

8. Let them keep the original photos for comparison, and hand them the last aerial photo, the one taken a long time ago. It will probably be black and white, so help the students make the adjustment from seeing vegetation and features in color to black and white. Again, give them time in their groups to discuss similarities and differences and then share with the class. How have conditions in this watershed changed over time? Is the riparian area wider or narrower? Rather than tell them what year the photo was taken, have them guess first. You will be reminded that their understanding of the concept "old" is different from yours!

Time is another important scale. (You may want to include a full discussion of this concept). It is critical to evaluate how watershed land uses have changed over time in order to understand the decline in our salmon populations.

9. What would it look like if someone could have taken an aerial photo back before the settlers and trappers came to this area? Perhaps the students would like to draw what they imagine it would have looked like. You may wish to use students' knowledge of early pioneers to discuss how settlers changed the landscape (clearing and burning land for fields, clearing rivers for navigation, cutting riparian timber and creating splash dams to float logs to market, damming and diverting water for irrigation, building roads, etc.) Native Americans were known to have set fires in the valleys to reinvigorate the grasslands. How would a fire pattern look different from a cultivated field?

10. If you have located old maps, show them to the students, help them orient to the maps, and have them point out features as they did with the aerial photos. Maps are somewhat more abstract than aerial photos, so it is possible that not all students will comprehend the meaning of the symbols on the maps. You may be able to go back as far as the 1850s with the original plat maps, drawn after the survey that divided the land into sections, ranges and townships. This survey established the major north-south; east-west grid pattern that we see imposed upon the landscape in the aerial photos and in the land ownership. Have the students observe or measure the difference in plot size between present times and the original survey. These plat maps show major river channels, land ownership, towns, sections, and describe vegetation, Students may recognize names that have persisted locally since the 1800s.

CREATING A WATERSHED MODEL

OBJECTIVES:
Students will be able to:
- explain and demonstrate how contour lines on a topo map are related to the features on the three dimensional map
- show the following on a model: the boundary of a watershed
- the course that water takes over the land
- the stream(s) and/or river that watershed drains into
- identify, in general, how the land within a watershed is used and how those uses may effect water quality in a stream.

MATERIALS:
- Topographic map of a watershed (your own if possible)
- Sheets of ¼ or ½ inch Styrofoam (4x8 feet is a standard size, they may be cut to the size you need)
- Butcher paper
- Pencils and marking pens
- Burnishing instrument
- Serrated butter knives
- Masking tape
- Rulers
- Overhead projector
- Paper mache
- Paints and paint brushes
- Push pins
- Pitchers and buckets

BACKGROUND INFORMATION TO RELATE TO STUDENTS:
A watershed is a place, which receives and stores water. It is made up of rock, soil, leaves, grasses, trees, brush and many other forms of life. Acting much the same as a sponge, it absorbs water and releases it slowly. The key to a healthy watershed is topsoil. Topsoil is more than dirt; in nature it does not exist separate from vegetation, which builds it, nor from animals, which live in it and refine it. The watershed's contributions to life forms are oxygen, a mellowing influence on climate, plentiful food and shelter, pleasant scenery and water.

PREP:
Make a transparency of the watershed from the topo map or use an opaque projector to enlarge it. If you are in a hilly area, you will probably not trace every contour line. You should trace at intervals so that the scale is about 2-" units vertical to one unit horizontal.

It may be easiest to blow up the map until the contour lines are big enough that they could be cut out into the Styrofoam. Look for little fingers of the land that may cause problems. Now figure out what the new scale is. If it was 1 inch = 1 mile, and you have increased the size by five, then 5 inches = 1 mile. (Horizontal)

PROCEDURE:

1. CUT THE STYROFOAM SHEETS. Begin at the lowest elevation. This will be the innermost contour line on the map, and will have the least amount cut out of the Styrofoam. This section will be placed on a base sheet. Continue to trace and cut each level. The Styrofoam will break, so warn students to be careful when they are cutting around fingers of land or other narrow pieces.

2. STACK THE LAYERS AND GLUE. As you cut out each elevation level, put in on top of the one below it. When you are done, look at the slope to see if it looks reasonable. It is still not too late to make adjustments, such as adding or taking out a few sheets to give the proper scale. When it looks right, glue the sheets together. Begin at the bottom. You will need plenty of glue, and several workers for this task!

The glue will take a couple of days to dry. Put heavy books or boards on the top of the model to assure good contact between all surfaces.

3. ROUND OFF SHARP EDGES. Once the model has dried, you should round off the edges of the Styrofoam layers, so the land doesn't look like staircases. Usually, landforms are more sloping, but his will depend on the geology in your area. Use a knife to shave off the sharp corners.

4. FINAL TOUCHES. Once the basic model is a complete, challenge student to use their creativity to make the watershed a comprehensive model. Use any number and kinds of materials as symbols representing and designating vegetation, land use, etc. Soil, sticks, leaves, legos, matchsticks, etc. make great symbolic materials. Discuss the kinds of activities that occur in this watershed and relate them to the condition of the streams. Label all geographic features and parts of the watershed. Place materials in the stream or river like gravel, sand, root wads, woody debris, etc.

5. WATERSHED IN ACTION. Place a bucket at one end of the watershed model. Have a student slowly pour water down a several sides of the watershed. Lead a discussion about how the watershed functions and problems that can occur like flooding. How do roads, development, etc. affect the watershed? How should the watershed be managed?

EXTENSION ACTIVITIES:

- As a homework exercise, you might have students check out the aerial photos or maps to show to long time residents and report back their findings. Students could research aspects of area history they have discovered in the photos/maps.

- Each team could compile and present a report on a particular land use in the watershed, how this land use affects salmon habitat, when it first started, how widespread it is, whether it is expected to increase or decrease in the future, and what could or should be done about it.

- Have your students study pre-settlement conditions in their watershed. Create a pre-settlement map or representation of an aerial photo. How do they think the land and river looked in the 1700s? Be sure they consider natural processes such as floods and fire in their representation.

- Create a salmon timeline, marking off the major events from the first salmon ancestors to the use by Native Americans, the coming of the settlers, major canning operations, extensive log drives on the rivers, construction of hydroelectric dams, first listings of endangered salmon runs, etc. Have your students reflect on the length of time salmon have existed, the conditions to which they adapted during that time, and the relative length of time humans have impacted those conditions.

- If you have access to a satellite image of your watershed, have students find major landmarks, then compare relative amounts of each kind of vegetation (depending upon what information is available with the image). Talk about the use of satellite imagery in monitoring the environment (or invite a guest speaker). What is gained or lost in using this new scale for observation of your watershed?

- Pass out worksheets from Stream Scene, Does the earth wear a raincoat? pp. 37-40 to the class. Students then use the worksheet to analyze the Umatilla Watershed. After they have finished, discuss the concept of watersheds with the class.

- Find a map with local rivers and streams and have your students find a stream near their house. Then, ask them to find streams that drain into it. What happens if someone pollutes the stream or if the student pollutes? Use this approach to adapt the Stream Scene watershed curriculum to your class. As the year progresses, encourage your students to pin out events on the map. Keep track of rainfall, and ask your students to contribute their observations about their stream during periods of high or low rainfall. They can make turbidity observations once a week, and add them to the rainfall data. If you do this on a large poster, students will begin to see relationships between the weather and events near their home.

EXTENSION CURRICULUM:

A. Watershed, Project Wild Aquatic, pp. 132-139, involves an activity in which students measure the area of a small watershed using a local site approximately 100 ft x 100 ft. They calculate the amount of water received by this area each year, and then explore the role watersheds play in human and wildlife habitat. This can be done in any schoolyard.

B. California's Salmon and Steelhead, Our Valuable Natural Heritage, pp. 116-117, uses an outline of a river and drawings of physical and biotic stream components to teach how to make a river map. Pp. 124-126 teaches how to interpret graphs of data. Pp. 127-132 contain reading, map-making and modeling activities to teach about watersheds.

C. INTERDISCIPLINARY INTEGRATION IDEA: Have a math teacher help students learn how to calculate irregular areas. Then, they can apply this to the measurement of watersheds, slopes, etc. Locate and do this for your school ground watershed. Review this section with the math teacher and provide as much information as you can about the watershed of your field site. Coordinate this lesson with a social studies unit on early settlers, the Homestead Act, or Native Americans.

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.

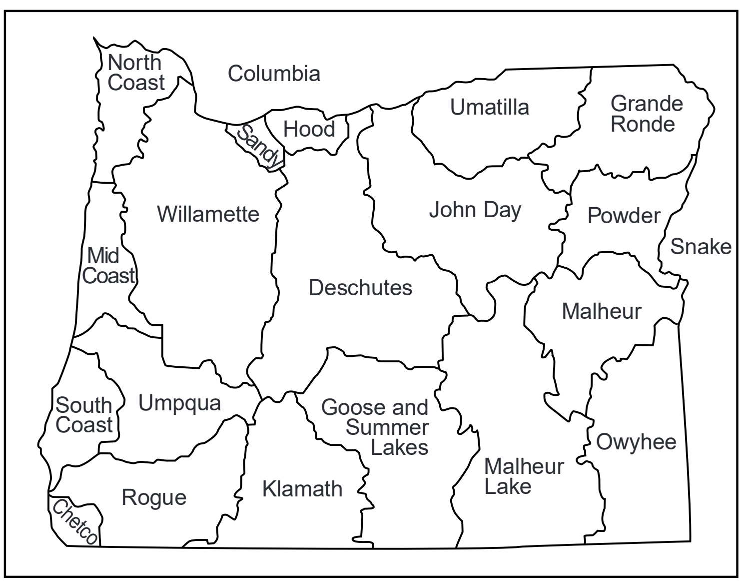
A watershed may be the drainage area surrounding a lake that has no surface outlet, such as Malheur and Harney Lakes in southeast Oregon or a river basin as large as that of the Columbia River. A puddle even has its own watershed.

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.

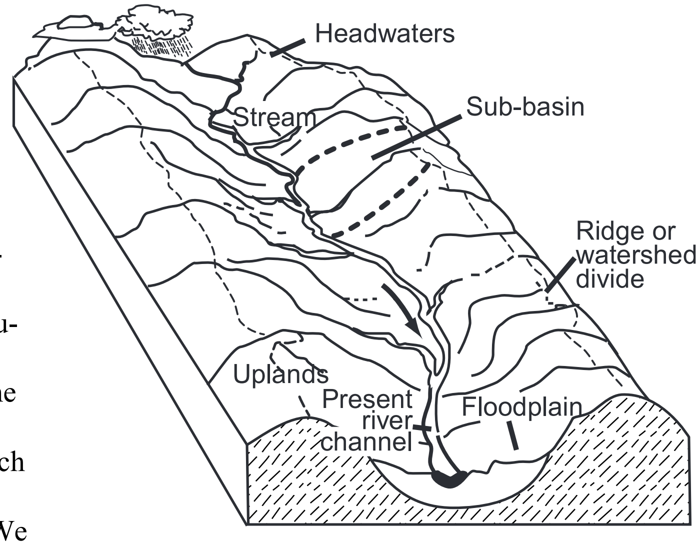
Each stream in a watershed is an ever-changing open-water system. It carves through valleys, collects water and sediments, and conveys the surface runoff generated by rainfall, snowmelt, or groundwater discharge to the estuaries and oceans. The shape and pattern of a stream is a result of the land it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

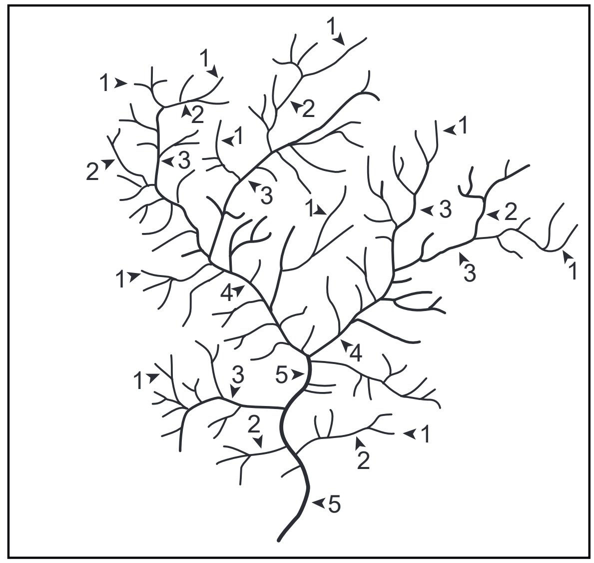
Drainage patterns

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

Figure 5. Stream Orders

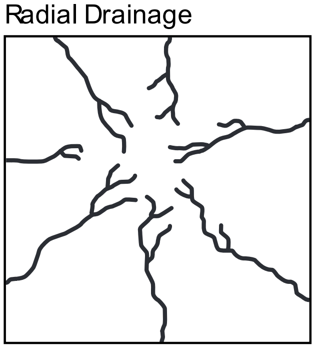


Stream orders

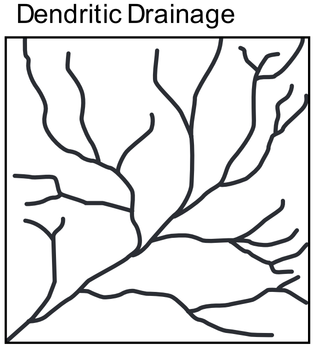
In most cases, a watershed system is almost entirely hillsides, called uplands. Only about one percent of a watershed is stream channels. The smallest channels in a watershed have no tributaries and are called **first-order streams**. When two first-order streams join, they form a second-order stream. 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.

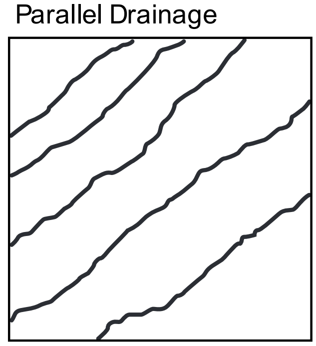
Radial Drainage



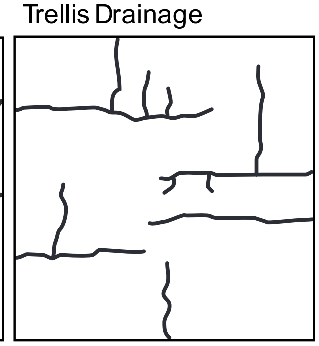
Dendritic Drainage



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

Land and water are linked directly by the water cycle.

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 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.

Plants directly affect the ability of a watershed to capture, store, and release water.

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

Plants, in some form or another, meet the basic habitat needs of food, water, shelter, or space for most all forms of wildlife.

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 access and prevent use and development of associated resources.

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

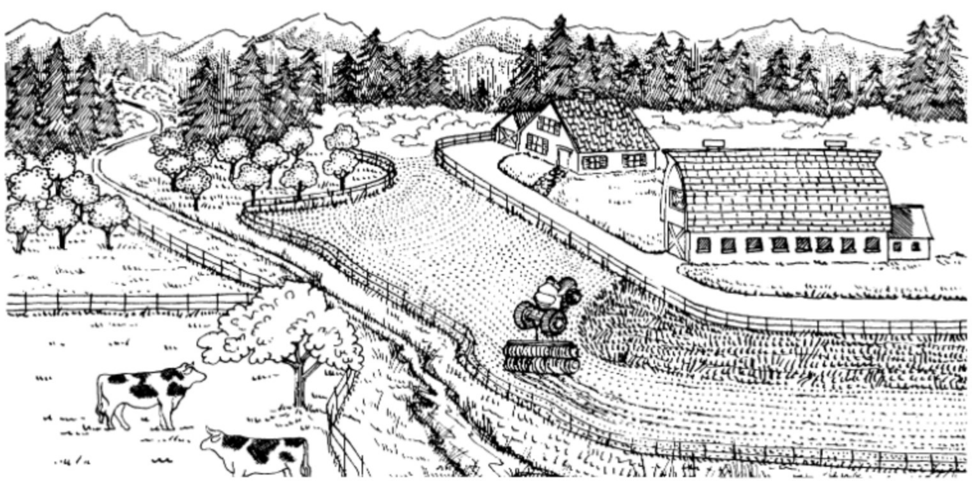
Many watersheds are in public or state ownership. Unless protected by specific legislation or agreement, most are used and developed to take advantage of all resources available for the general public benefit. It is in these multiple-use watersheds that management may face the most serious conflicts 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 resources 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.

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

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.

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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