Raising Your Water IQ:
A Water Conservation Curriculum

Developed by the

Texas Water Development Board

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Contents

Introduction

"When the well's dry, we know the worth of water."
- Benjamin Franklin

Water is our most precious natural resource. Without water, nothing else is possible.

In this curriculum, water conservation messages and concepts stem from core academic standards detailed in the Texas Essential Knowledge and Skills (TEKS). These hands-on activities engage student interest in learning through our natural affinity for water.

The goals of the curriculum are to:

- enhance a student's ability to make sound environmental decisions based on an understanding of science;
- foster student awareness of the need for water conservation;
- help students discover and practice water conservation strategies;
- increase a sense of stewardship for local water resources; and
- establish patterns of responsible water consumption.

This curriculum is designed to be flexible, scaffolded and interdisciplinary. Math, science, technology, and social sciences combine to give students the knowledge, skills, and dispositions to be more engaged and informed environmental decision makers.

The activities in this curriculum engage both hands and minds, are inquiry-based, and offer community-based service learning opportunities. As students learn about water, they learn about themselves and their communities.

An important component of this curriculum is a series of visually engaging interactive resources designed to introduce broad concepts and the Big Ideas of water conservation to students. Visit www.twdb.texas.gov/conservation to view these "Educational Resources."

Hands-on activities align with the TEKS and include brief, straightforward background information for students that articulate the Big Ideas, as well as assessments to help teachers check for understanding. The activities explore concepts that Texas teachers identified in focus groups as particularly difficult to teach and/or learn.

The curriculum includes activities that explore very basic concepts of the water cycle, the relationship between surface water and groundwater, how human activity has shaped natural systems, and how the natural world has shaped human culture.

Once students have explored these concepts, investigations move them out into their communities to discover how these concepts are applied in their neighborhoods. There are projects that engage students through in-depth analyses of their own environmental behaviors and service learning opportunities that give students a voice in shaping their environment.

Take your students on a journey of discovery through the entire curriculum, or select only those activities that fit your specific needs. Materials needed for hands-on activities are easy to obtain and inexpensive.

This teacher's guide is provided via the internet and is also included on a TWDB conservation education resource CD. This CD contains numerous additional resources that are referenced in the text of this guide. If you downloaded this teacher's guide from the internet or obtained it in some other way and would like copies of these additional resources, please contact us at the phone number or email address listed below.

In all ways, we have tried to make this curriculum fit the needs and capacities of Texas classrooms. If you have any questions or suggestions regarding the curriculum, please let us know by contacting the Texas Water Development Board conservation education staff at 512-463-7955 or consedu@twdb.texas.gov.

Water Conservation Glossary

Acid rain rain that has a pH below 5.6 due to water combining with pollutants in the air, such as oxides of sulfur and nitrogen

Aeration mixing air and water to increase the amount of oxygen in the water

Agriculture the cultivation of animals and plants for food, fiber, and other products

Aquifer an underground geologic formation that contains water

Bacteria very small, single-celled life forms that can reproduce quickly

Bioremediation using bacteria and enzymes to "eat" the pollutants in wastewater

Coagulation using chemicals to make suspended solids gather or group together into small clots called "flocs"

Chlorination a method of water treatment where chlorine is added to disinfect

Commercial related to business or business activity

Commercial customer individual or group of people engaged in a business activity

Condensation the process of a gas or vapor changing to a liquid form

Confluence where a stream enters another, larger stream

Conservation the care, preservation, protection, and wise use of natural resources

Contamination the entry of undesirable organisms into some material or object reducing the quality

Delineation the process of determining a boundary

Desalination removal of dissolved salts from water

Disinfection elimination of bacteria in a water supply or distribution system

Drainage divide the highest ridge-line or elevated area between stream channels that divides watersheds

Drains pipes that carry away water

Drought a climatic condition where evaporation exceeds precipitation

Dumping depositing garbage, sewage, or environmentally harmful materials in unregulated or uncontrolled areas

Ecosystem a community of interdependent organisms living together in an environment

Erosion the washing away of the soil and land surface by the action of water, wind, or ice

Evaporation the change in state of water from a liquid to a gas

Fertilizer a substance that improves the ability of soil to produce crops

Filtration a process for removing solids from water by passing them through a filter, or filtering materials like sand or gravel

Flood an excess of water that overflows the boundaries of a stream, river, or other body of water onto normally dry land

Floodplain the land alongside a body of water that is subject to flooding

Groundwater water naturally stored below the surface of the earth, supplying wells and springs

Groundwater contamination the pollution of groundwater and associated springs and wells

Headwaters the source of a stream; the upper portion of a stream's drainage system

Hydrologic cycle the constant movement of water between the atmosphere and the earth through precipitation, runoff, infiltration, percolation, storage, evaporation, and transpiration

Impermeable any material that does not allow water to pass through it

Industrial customer an individual or group of businesses that are engaged in a particular kind of commercial enterprise

Industrial use the use or activity performed by an industrial customer

Industrial waste any waste produced as a by-product of any industrial process or operation other than domestic sewage

Infiltration the downward movement of water through another substance

Irrigation applying water to plants to supplement insufficient rainfall

Landfills land disposal sites for solid waste

Landscape an expanse of scenery; the highs and lows of the environment

Livestock animals raised for human use

Manufacturing the process of turning raw materials into finished products

Microorganisms animals and plants that are too small to be seen clearly with the naked eye

Mouth where a stream enters a lake, reservoir, sea, or ocean

Municipal anything related to a city or town

Municipal use anything that is related to use by a city or domestic consumption

Nonpoint source pollution pollution that occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water

Nutrient substance that helps plants and animals grow

Organism a living thing; human, plant, animal, bacterium, or other life form

Pathogen a biological substance that causes diseases or illness

Particle a very small piece of something bigger

Permeability any material that allows water to pass between particles or cracks

Pesticide poison used to control undesirable organisms

Point source pollution pollution originating from a single point such as a pipe, ditch, well, vessel, or container

Pollutant a waste material that contaminates air, soil, or water. Sediment, nutrients, and toxic chemicals are considered the major groups of pollutants

Pollution the introduction of any substance that leads to undesirable effects on the natural environment

Population the collection of members of a single species living in a habitat

Pore space the space found between particles of rock and soil

Porosity percentage of empty spaces in a volume of soil or rock

Precious something that is of high value, worth, or cost

Precipitation water in various forms that falls to the earth as part of weather events; rain, snow, sleet, fog, or hail

Purify to remove all contaminants from a substance

Radiant energy energy from the sun that comes to earth as light and heat energy

Resource anything obtained from the environment that can be used

River a natural channel of water larger than a creek

Runoff excess water that flows across the land to streams and rivers

Saturation the point at which soil, sediments, or rock is completely full of water

Sedimentation the process by which suspended particles settle to the bottom

Septic tank tank used underground to store domestic wastes where a municipal sewer line is not available

Sewage human-generated wastewater that flows from homes, businesses, and industries

Shortage having less of something than you need

Soil the layer of unconsolidated (loose) materials at the earth's surface consisting of mineral particles, organic matter, air space, and water

Source the place where something begins

Storm drain a pipeline that carries away excess rain or surface water runoff

Surface water water in a stream, river, lake, or reservoir on the Earth's surface

Topographic map map that shows land elevation above or below sea level using contour lines; also called contour map

Toxic contaminant poisonous substance that can harm the health of organisms

Transpiration the process by which plants lose water through small openings on leaves

Tributary a stream that contributes its water to another stream or body of water

Vapor the gaseous form of any substance

Wastewater water that carries wastes from homes, businesses, and industries

Water conservation the care, preservation, protection, and wise use of water

Water cycle the constant movement of water (in various states of matter) between the atmosphere and the earth

Water table the top surface of groundwater; below the water table, the soil or rock is saturated

Water treatment a method of cleaning water so it can be used again for a specific purpose such as human consumption or discharge to a stream

Watershed the specific land area that drains water into a river system or other body of water

Waterway path for water to travel across the land such as a canal, channel, lake, stream, river or sea

Wetland area of land covered with water either permanently or seasonally

Chapter 1 **What is a Watershed?**

GRADE LEVEL 6th–8th

Objectives

- Students will use a model to predict and observe the relationship between tributaries and the main stem of rivers as they drain to form watersheds.
- Students will investigate erosion in a watershed.
- Students will investigate point source and nonpoint source pollution in a watershed.

Introduction

In this activity students create and observe a simple model of a landform to learn about watershed systems, river flow, erosion, and sources of pollution. This activity can help students understand the concept of "systems."

Critical concepts related to systems are listed below:

- Most things are made of parts.
- Something may not work if some of its parts are missing.
- When parts are put together, they can do things that they couldn't do by themselves.
- In something that consists of many parts, the parts usually influence one another.
- Something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched, or misconnected.
- A system can include processes as well as things.
- Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.
- Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

(From Benchmarks for Science Literacy, by the American Association for the Advancement of Science, Project 2061)

Time

Flexible, 30–45 minutes, with extensions

Materials

Large flat pans (at least 11 x 17 — disposable roasting pans will work)

Small cups of water with tight-fitting lids. Poke a large number of small holes in the lids to make "watering cups."

Water supply

Plastic sheet (a trash bag will work)

Newspapers

3–4 cups of soil

1–2 cups of colored drink mix

Paper towels for spills

Large watershed map —

Sources include:

- www.twdb.texas.gov/
- www.epa.gov/surf

All of these concepts can be explored as you work with students on this activity.

This activity will also help students investigate the associated concepts of erosion and nonpoint source pollution. There are four major types of nonpoint source pollution:

- Sediments — soil particles washed off the land
- Nutrients — fertilizers and animal waste
- Toxic substances — pesticides, motor oil, and other hazardous materials
- Pathogens — such as bacteria from septic systems

Vocabulary

Confluence — where a stream enters another, larger stream

Drainage divide — the highest ridge-line or elevated area between stream channels that divides watersheds

Erosion — the washing away of the soil and land surface by the action of water, wind, or ice. This process can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or logging.

Floodplain — the land alongside a body of water that is subject to flooding

Headwaters — the source of a stream; the upper portion of a stream's drainage system

Landscape — an expanse of scenery; the highs and lows of the environment

Mouth — where a stream enters a lake, reservoir, sea, or ocean

Nonpoint source pollution — pollution that cannot be traced to a single point because it comes from many places or a widespread area. Examples include agricultural runoff or urban runoff from streets, yards, and parking lots. Nonpoint source pollution is the direct result of our everyday land use activities.

Pathogen — a biological substance that causes diseases or illness

Point source pollution — pollution that can be traced to a single point such as a pipe. Examples include an industrial plant pumping waste into a lake or an inefficient wastewater treatment plant discharging its waste into a river.

Pollutant — a waste material that contaminates air, soil, or water. Sediment, nutrients, and toxic chemicals are considered the major groups of pollutants.

River — a natural channel of water larger than a creek

Tributary — a stream that contributes its water to another stream or body of water

Watershed — the specific land area that drains water into a river system or other body of water

Background

- Water flows downhill with the pull of gravity. We call a large channel of flowing water a river.
- A watershed is the area drained by one river and its tributaries. A high ridge of land (drainage divide) separates one watershed from another. On one side of the ridge, rainfall would drain to *this* river water while rain falling on the other side of the ridge would flow to *that* river.
- Other names for a watershed include river basin, drainage basin, and catchment.
- A large watershed (like the Brazos River watershed) contains many smaller watersheds (like the San Gabriel River or the Bosque River 'sub-basins').
- A stream that flows into a larger stream or a river drains the smaller watershed. The smaller body of water that contributes to the larger river is called a tributary. For example, the Bosque River is a tributary of the Brazos River.
- The EPA's "Surf Your Watershed" site (www.epa.gov/surf) allows you to search for your watershed.

Method

Divide the class into small groups of 3–4 students. Give each group a large pan, several sheets of newspaper, a large sheet of plastic, a small amount of soil, a small amount of colored drink mix, and a watering cup full of water.

Have students crumple several sheets of newspaper into tight bundles and stack them loosely in the large pan. Cover the newspaper with the plastic sheet.

Now you have a rugged landscape before you. Ask students to identify and/or predict the following:

- Identify drainage divides. Where is the ridge with the highest elevation?
- Where are other high points such as mountains?
- Where will the water go when it rains on the mountaintops?
- Where will small streams form?
- Where will streams join together?
- Where will large rivers be located? Identify the headwaters and other key features (confluence, mouth, and floodplain).
- Where will ponds, lakes, or oceans form?
- Can students find smaller watersheds within larger watersheds?
- Identify the largest watershed on this model.

You may wish to do the activity more than once for students to make increasingly detailed observations. Review new vocabulary words.

Ask students in each group to make it "rain" on their landscape, and then check their predictions against what actually happened.

Erosion

Have students sprinkle a fine layer of soil onto their landscape. Ask them to predict where the soil will go when it "rains" on their landscape. When they have made their predictions, ask them to pour more water across the landscape to observe the "erosion."

Nonpoint Source Pollution

When fertilizers and herbicides are overused, or when oil, antifreeze, and other automotive liquids spill onto the ground, they get carried away by rainfall and runoff into waterways as nonpoint source pollution.

Have students sprinkle a fine layer of colored drink mix onto their landscape. This will act as a pollutant on the landscape. Ask them to predict where the pollutant will go when it "rains" on their landscape. When they have made their predictions, ask them to pour more water across the landscape to observe the nonpoint source pollution.

Assessment

Ask students to write a short paragraph answering one or more of these questions:

- What is a watershed? Do you live in a watershed?
- What are the parts of the watershed system?
- What is erosion, and what causes it?
- What is nonpoint source pollution, and what are some common pollutants?
- What natural features should we consider before we build houses and communities?
- What are the principal limitations of this watershed model?

Extensions

Looking at the Land: Ask students to examine the surrounding landscape in the park or school grounds near where you are located.

- Where is the highest elevation?
- Are there signs of erosion? Where? When it rains where does the water go?
- Create structures to control or direct water flow across their landscape. (Gutters, drains, dams, etc.)
- Where will the water flow? (If there is time, create a simple map of their table-top landscape using arrows to show the direction of water flow.)
- If the river they created on their landscape were to flood, what land will be covered first?
- Discuss floodplains, the flat land along the river that is formed from sediments deposited by periodic flooding of the river. Has your community used the floodplain for a park, for housing, or for business development?

Student Name______________________________ Date ______________________

What Is a Watershed?

A watershed is an area of land that drains to a body of water. Each watershed contains a set of streams and rivers that all drain to a single larger body of water, such as a larger river, a lake, a reservoir, or an ocean. In Texas, most large rivers flow in a general southeastern direction, emptying into the Gulf of Mexico. Watersheds can be small, covering only a few acres, or very large, spanning thousands of square miles.

A watershed includes more than just the water. Watersheds are complex systems with many smaller parts. All surface water, groundwater, soils, plants, animals, and human activities are part of a watershed. Everything that happens in a watershed has an impact on the health of the whole system.

As the population in Texas grows, demand of available water supplies in Texas also grows. We all need to think and learn about how to protect our water resources. Conservation is an especially important strategy to make sure Texas has enough water today and in the future.

1. What are the important parts of a watershed?

2. Why is it important to protect the health of watersheds?

3. What is water conservation?

4. Write a question you have about this article.

Grade Level	**TEKS**
Grade 6 Science	Scientific Investigations and Reasoning 1. B 2. A, B, E Matter and Energy 5. C
Grade 7 Science	Scientific Investigations and Reasoning 1. B 2. A, B, E 3. A Earth and Space 8. C
Grade 8 Science	Scientific Investigations and Reasoning 3. A Organisms and Environments 11. C

Overview

Solutions to water quality issues begin at home. In this service-learning project, students will map the immediate neighborhood around their school, identify features that contribute to nonpoint source pollution, identify a site for making improvements in the landscape, and present the plan to an authentic audience of planners or community members.

Service learning is an effective strategy for engaging students in solving real problems as they learn core academic content and practice the essential skills of learning. The more local the service project, the more meaningful it can be to students.

A critical element of effective service learning is student voice: the degree to which a student makes decisions and directs their own learning. Seldom do we invite young people to reimagine their environment. Giving students permission to take a lead in neighborhood improvements empowers them to become a more active, positive force in their community.

In this project, students have the opportunity to identify the site they want to reimagine and create a new vision for that site.

Time

This project can vary in length of time depending on your schedule, size of the class, and scope of your project. Figure on at least five class periods (these can be non-consecutive) with students doing homework and research between class periods.

Note: This activity requires a field investigation in your neighborhood.

Materials

- Neighborhood map for each student
- Topographical maps for each team of 3–5 students
- Map Symbols Guide for each team of students

Neighborhood maps of adequate quality are available through several free online mapping sites (Google, Yahoo, Bing). Type in your school's address, enlarge or shrink the map to meet your needs, and select the printer-friendly version to print.

Topographical maps can often be obtained from those same mapping sites (view "Terrain") or can be obtained from other online sites. They can also be purchased through agencies such as the Texas Natural Resources Information System www.tnris.org or the U.S. Geological Survey store.usgs.gov/

Consider giving a student or a group of students the responsibility of obtaining the necessary maps.

Background

Nonpoint source (NPS) pollution can come from many sources in urban and rural areas. Unlike point source pollution from industrial and wastewater treatment plants, NPS is caused by all of us. We all share in the causes of this type of water pollution, and we can all be part of the solution to pollution.

The primary cause of NPS pollution is runoff from rainfall or snowmelt that picks up natural and human-made pollutants from land surfaces and then carries them into streams, rivers, lakes, wetlands, and even groundwater. Impervious surfaces and construction sites in urban areas and farmland and barnyards in rural areas also contribute to NPS.

There are four major types of NPS pollution:

- Sediments — soil particles washed off the land
- Nutrients — fertilizers and animal waste
- Toxic substances — pesticides, motor oil, and other hazardous materials
- Pathogens — such as bacteria from septic systems

Some common sources of NPS pollution are

- roads and streets (storm water runoff);
- agriculture;
- logging;
- mining;
- construction and land development sites;
- eroding stream banks and other habitat modifications;
- septic tanks;
- animal feeding operations;
- lawns, parks, and golf courses; and
- boating and marine activities.,

Getting Started: Preparation

Divide your class into study groups of 3–5 students. Students will work in these groups throughout the project.

Reflecting – Reflection is a critical element of service learning. Ask students to keep a daily journal of their service-learning experience. Give them daily questions to which they can respond. Collect journals periodically to check in on student progress and thinking.

Formative reflection questions might include the following:

- What is working well, and what needs to be improved?
- What surprised me in my work today?
- What is the biggest challenge I faced today?
- What is hard for me to understand about the work I did today?
- What do I need to do next?
- Why is this work important to me and my community?
- What am I learning about myself through this project?

Summative reflection questions might include the following:

- What will I do differently next time?
- Why should my community care about nonpoint source pollution?
- Tell a story about your service-learning experience that is meaningful to you.
- What did you learn about your community during this project?
- How did my service project affect my community?
- What did you learn about yourself during this project?

Outline the Study, Identify the Area

Acquire a map of the neighborhood around your school and outline the boundaries of the area students will explore. Limiting the area of study gives you an important measure of control over the scope and size of the project. Constrain the area to make your project something you and the students can reasonably manage.

Consider using online mapping sites or free programs such as Google Earth to present an overview of the study area and identify key locations or features. Make sure the printed map is large enough for students to mark local features on it.

Day One: Introducing the Project

If your students have no experience with service learning, begin by discussing the idea with them. You may want to have them talk in small groups about their neighborhood and the concerns they have.

- What works in their neighborhoods, and what do they see that could be improved? Is there litter on the streets?
- Is there a lot of automobile traffic?
- Are there enough trees to shade the buildings?
- Are there enough natural areas?
- Are there oil spots on the pavement where cars park?
- Do people sweep their yard clippings into a storm drain?

Distribute copies of the neighborhood map, the Map Symbols Guide, and the student overview to small groups of students. Every student in each group should read the student overview. Ask students to discuss the following questions in their groups:

- Why is nonpoint source pollution an important issue in their neighborhood?
- What kinds of nonpoint pollution sources do they predict they will find in their study area?
- What are their goals for the project? These might include cleaning up their neighborhood, making a difference in their community, working to solve a real problem, etc.
- Who else in the community might be interested in hearing about this service project and what students have discovered?

Share the results of student discussions in the large group. Gather students' ideas into one comprehensive list.

Discuss the audience to whom your students will present their findings: neighbors, planners, or other policy makers. Remind students that they will need to take their study seriously if they want their audience to take their findings and recommendations seriously.

Discuss the students' goals for the project. Narrow the list of goals to a reasonable number. Don't try to do too much.

Consider how you and your students will assess how well they did on the project. How will they know if they succeeded? Ask them to think about how to evaluate their project. There are assessment ideas included with this activity.

See also the "Improvement Plan Rubric" and "Oral Presentation Rubric."

Day Two: Survey the Area

Each team will walk the boundaries of the study area and mark on the map likely sources of nonpoint source pollution and the types of pollution generated.

These might include

- sediments — soil particles washed off the land;
- nutrients — fertilizers and animal waste;
- toxic substances — pesticides, motor oil, and other hazardous materials; or
- pathogens — such as bacteria from septic systems.

Possible sources of NPS pollution are

- parking lots, driveways, roads and streets (storm water runoff);
- agriculture;
- logging;
- mining;
- construction and land development sites;
- eroding stream banks and other habitat modifications;
- septic tanks;
- animal feeding operations;
- lawns, parks, and golf courses; and
- boating and marine activities.

For each likely source that teams mark on their map, they should also include

- measurements of the site, where appropriate (for paved areas, lawns, etc.);
- observations and descriptions of the source—a gas station might have spilled oil or solvents on the ground, streets may have litter, etc.; and
- any appropriate information about the ownership of the site, including contact information.

Student teams should also make note of the natural areas, habitats, gardens, and other places that make their community a greener place to live.

Students may not have a second chance to survey the neighborhood in their group, so make the most of this survey. Each student in the group should take notes, make observations, offer ideas, and record information.

Days Three through Five: Identify Your Site, Identify Your Strategy

After students have surveyed the neighborhood, ask them to make two pie charts showing

- the different categories of contributing sources of pollution, and
- the number of examples of each of the major categories of pollution they found.

Once you have your maps marked with sources of nonpoint source pollution in your neighborhood, the next step is to choose the contributing feature your team will focus on and a strategy for the improvement you will recommend.

Analysis of Survey Maps

Look at the street surveys for two trends:

- The source of the most damaging pollution
- The source of the most easily remedied pollution

Your Strategy: Developing a Plan

Develop an action plan to address the most easily remedied pollution.

The action plan should identify the exact source of the pollution and identify the impact the source is having on the stream. Use a topographical map to determine where the pollutant might enter a waterway, and then do the following:

- Decide what can reasonably be done to remove or reduce the source
- Create all the steps necessary to remove or reduce the pollution
- Decide who will complete each step
- Create a poster to display this information
- Develop an oral presentation to communicate this information

Authentic Audience

Real work deserves a real audience. Who in your community would be interested in hearing about your students' work— a neighborhood group? Who might implement your students' plans? Make contact with local groups that share your interest in neighborhood improvement and ask for time at an upcoming meeting. Have students present their findings.

Many positive changes happen when a group of interested, well-prepared students commit to making a difference.

Soak It Up: Improvement Plan Rubric

	Exceptional 4	**Admirable** 3	**Acceptable** 2	**Amateur** 1	**Score**
Identifying a site for improvement	Students have accurately identified a site and how the improvement plan or service will address the need, including expected outcomes	Students have identified a site, and how the improvement plan will address the need, but outcomes are not clearly defined	Students have not identified an appropriate site. Improvement plan doesn't clearly address issue. Outcomes are not clearly defined.	Students have not identified an appropriate site. Improvement plan doesn't clearly address issue. Outcomes are not defined, or are unlikely.	
Articulating the improvement plan	Improvement plan is clearly defined, practical, and effective. Student capacities are clearly considered and the plan is realistic and practical.	Improvement plan is clearly defined, reasonably practical, and effective. Student capacities may have been over- or underestimated. The plan is reasonable and practical.	Improvement plan is vague or unfocused. Student capacities have been over- or underestimated. The plan is somewhat practical.	Plan is unfocused or ineffective. Student capacities have been over- or underestimated. The plan is not practical.	
Resources of the team	The resources of the team have been accurately identified. Student team members have creatively offered skills and interest areas as contributions to the team effort.	The resources of the team have been identified. Student team members have offered skills and interest areas as contributions to the team effort.	The resources of the team have been identified but not clearly or comprehensively. Team members have offered some skills and interests to the team.	The resources of the team have not been identified. Team members have been reticent to offer skills as a contribution to the group effort.	
Student participation	All students enthusiastically participate	At least three-fourths of students actively participate	At least half the students confer or present ideas	Only one or two persons actively participate	

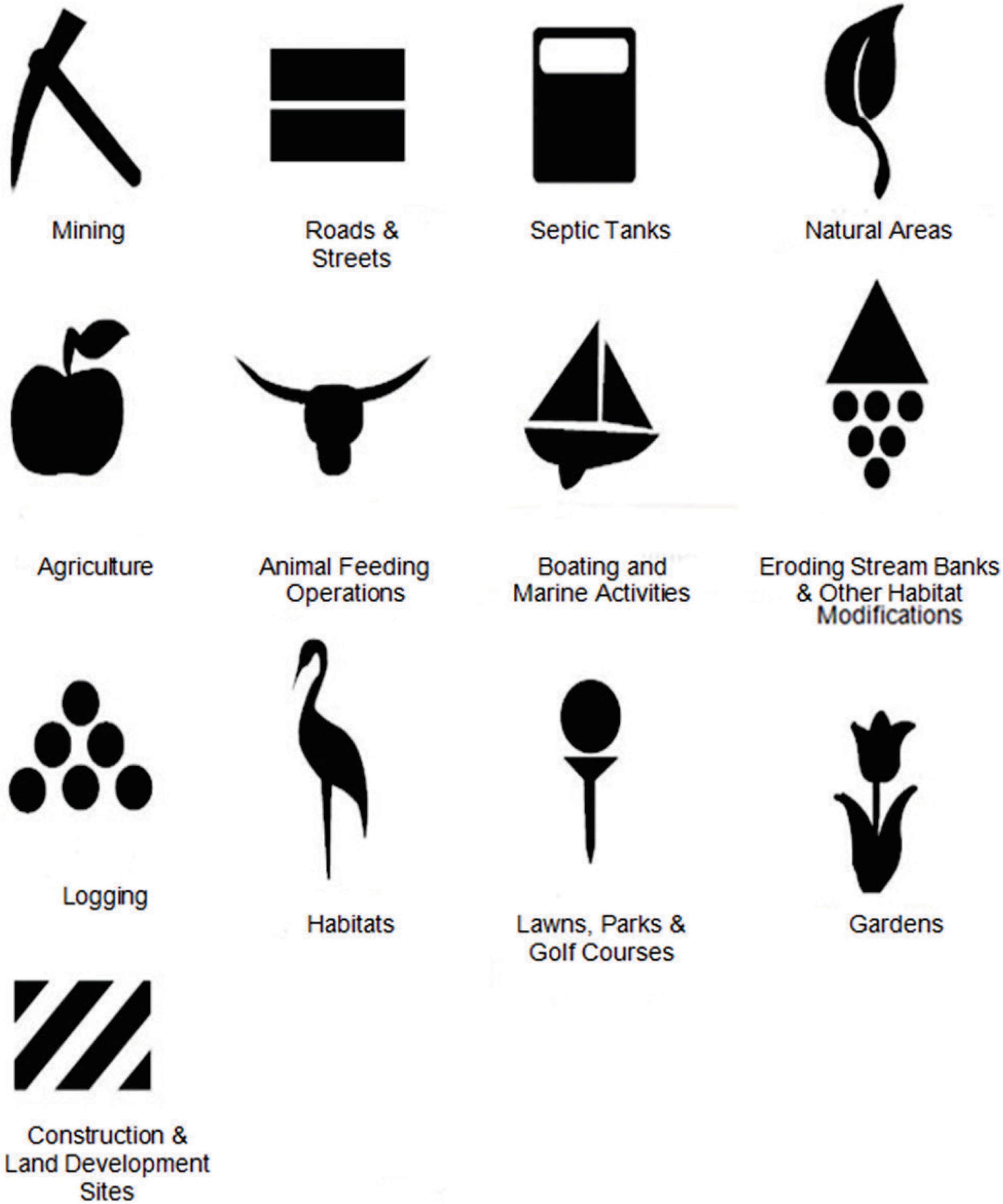
Soak It Up: Improvement Plan Rubric

	Exceptional 4	Admirable 3	Acceptable 2	Amateur 1	Score
Responsibility	Responsibility for task is shared evenly	Responsibility is shared by most group members	Responsibility is shared by half the group members	Exclusive reliance on one person	
Listening and leadership	Excellent listening and leadership skills exhibited; students reflect awareness of others' views and opinions in their discussions	Students show adeptness in interacting; lively discussion centers on the task	Some ability to interact; attentive listening; some evidence of discussion or alternatives	Little interaction; very brief conversations; some students were disinterested or distracted	
Student roles	Each student assigned a clearly defined role; group members perform roles effectively	Each student assigned a role, but roles not clearly defined or consistently adhered to	Students assigned roles, but roles were not consistently adhered to	No effort made to assign roles to group members	
Identifying resources	Other resources have been thoroughly and accurately identified, including information, materials, community members and partnerships, and necessary funding.	Most, but not all, of the other resources have been identified, including information, materials, community members and partnerships, and necessary funding.	Some, but not most, of the other resources have been identified, including information, materials, community members and partnerships, and necessary funding.	Few of the necessary resources available have been identified. Efforts seem perfunctory.	

Soak It Up: Improvement Plan Rubric

	Exceptional 4	Admirable 3	Acceptable 2	Amateur 1	Score
Comparing resources to project needs	Students have thoughtfully compared resources with needs. The results show an exceptional level of understanding of the issues and processes involved.	Students have compared resources with needs. The results show a thorough understanding of the issues and processes involved.	Students have compared resources with needs, but the results show an incomplete understanding of either the issues or processes.	Students have not mastered the concepts needed to compare resources with needs. Results show a lack of understanding of either the issues or the processes.	
Getting resources	Students have precisely identified how to get needed resources. Results demonstrate a thorough familiarity with both their community and their needs.	Students have determined how to get needed resources. Results demonstrate a familiarity with both community and needs.	Students have determined how to get needed resources, but the results show a lack of familiarity with either their community or their needs.	Students have not determined how to get needed resources. Results show a lack of familiarity with both community and needs.	
Flow chart	Flow chart precisely maps the task. Great care and thought is evident in both design and execution.	Flow chart accurately maps the tasks. Care and thought are evident in both design and execution.	Flow chart maps the task, but is unclear or confusing. Some care and thought are evident in either design or execution.	Flow chart does not accurately chart task. Flow is confusing. Little care or thought is evident in either design or execution.	
Plan implementation	Plan was fully implemented. Work was shared equally. All members of the team were fully engaged and responsible.	Plan was fully implemented. Work was shared, but not always equally. Most team members were fully engaged and responsible.	Plan was mostly implemented. Work was not equally shared. Some team members were engaged and responsible.	Plan was not fully implemented. Work was not fully shared. Most team members were not engaged or responsible.	

Soak It Up: Map Icons



Soak It Up: Oral Presentation Rubric

Name:____

	Superior	**Adequate**	**Minimal**	**Inadequate**
Content	The speaker provides a variety of types of content appropriate for the task, such as generalizations, details, examples, and various forms of evidence. The speaker adapts the content in a specific way to the listener and situation. Solutions proposed are creative, reasonable, and well supported by research.	The speaker focuses primarily on relevant content. The speaker sticks to the topic. The speaker adapts the content in a general way to the listener and the situation. Solutions proposed are reasonable and supported by research.	The speaker includes some irrelevant content. The speaker wanders off the topic. The speaker uses words and concepts which are inappropriate for the knowledge and experiences of the listener (e.g., slang, jargon, technical language). Solutions proposed are not reasonable, or are not supported by research.	The speaker says practically nothing. The speaker focuses primarily on irrelevant content. The speaker appears to ignore the listener and the situation. Solutions proposed are not reasonable, and are supported by research.
Delivery	The speaker delivers the message in a confident, poised, enthusiastic fashion. The volume and rate varies to add emphasis and interest. Pronunciation and enunciation are very clear. The speaker pauses very infrequently and has no interruptions, such as 'ahs,' 'uhms,' or 'you knows.'	The volume is not too low or too loud and the rate is not too fast or too slow. The pronunciation and enunciation are clear. The speaker pauses infrequently and has few interruptions, such as 'ahs,' 'uhms,' or 'you knows.	The volume is too low or too loud and the rate is too fast or too slow. The pronunciation and enunciation are unclear. The speaker pauses frequently and has some interruptions, such as 'ahs,' 'uhms,' or 'you knows.' The listener is distracted by problems in the delivery of the message and has difficulty understanding the words in the message.	The volume is so low and the rate is so fast that you cannot understand most of the message. The pronunciation and enunciation are very unclear. The speaker appears uninterested.
Organization	The message is clearly well organized. The speaker helps the listener understand the sequence and relationships of ideas by using organizational aids such as announcing the topic, previewing the organization, using transitions, and summarizing.	The message is organized. The listener has no difficulty understanding the sequence and relationships among the ideas in the message. The ideas in the message can be outlined easily.	The organization of the message is confusing. The listener must make some assumptions about the sequence and relationship of ideas.	The message is so disorganized you cannot understand most of the message.
Creativity	Very original presentation of material; captures the audience's attention.	Some originality apparent; good variety and blending of materials/ media.	Little or no variation; material presented with little originality or interpretation.	Repetitive with little or no variety; insufficient use of materials/ media.
Length of Presentation	Within two minutes of allotted time.	Within four minutes of allotted time.	Within six minutes of allotted time.	Too long or too short; ten or more minutes above or below the allotted time.

Soak It Up:

Grade Level	**TEKS**
Grade 6 Social Studies	Citizenship 12. A Social Studies Skills 19. D 20. A 21. C, E 22
Grade 7 Social Studies	Social Studies Skills 22. B 23
Grade 8 Social Studies	Social Studies Skills 29. B, E 30. C 31

Chapter 2 **Evaporation, Transpiration, and Condensation**

GRADE LEVEL 6th–8th

Time

Two class periods, with a 24-hour waiting period between

Materials

See individual section headings for lists of needed materials.

Background Information

Evaporation, Transpiration, and Condensation are all part of the water cycle. Evaporation from bodies of water accounts for about 90 percent of the water in the atmosphere, and transpiration accounts for most of the remaining 10 percent (with a small amount from sublimation). Condensation occurs when that water vapor changes to a liquid.

Multiple activities are offered in this chapter to explain and demonstrate how radiant energy from the sun drives the water cycle.

Transpiration is the process by which water in plants is transferred as water vapor to the atmosphere. Plant roots take up liquid water from the soil and transpire that water as vapor through openings in their leaves (called stomata). Transpiration is essentially evaporation of water from plant leaves.

Transpiration is often a very difficult concept for students to understand. The concepts of evaporation and transpiration are related and are often discussed together. In fact, the term "evapotranspiration" (the combined processes of evaporation and transpiration) is most often used in scientific communities due to the similarities between the two processes and the difficulties in quantifying each process separately in the real world.

In this activity, students will conduct an experiment that demonstrates how water can be obtained and purified by understanding and taking advantage of

- the evaporation, transpiration, and condensation aspects of the water cycle; and
- radiant energy from the sun or other light/heat source.

To capture water from evaporation, students will make a solar still. A still is a tool used to distill liquids by heating and then cooling. Note: At the end of this chapter, a method for demonstrating transpiration is presented.

Prior Knowledge

If possible, consider completing the Porosity Activity (Chapter 4) with students before doing this one. Students should understand that soils hold moisture in the spaces between particles. Near the surface, this soil moisture can be lost to the atmosphere though evaporation.

Students may use data from the "Water Use Inventory" in the extension activity in Chapter 5.

This activity is offered in two forms: outdoor investigation and indoor investigation.

The Problem

You are lost in the wilderness. Pure water free of contaminants like chemicals and other pollutants is essential for human survival. In fact, all life on earth depends on water.

- Could you make a system to obtain and purify water that would save your life?
- What time of day or night would be the best time to purify water?
- What materials would you need?
- How much water could you produce in a 24-hour period?

Vocabulary

Evaporation — the process by which liquid water is converted into a gas or vapor

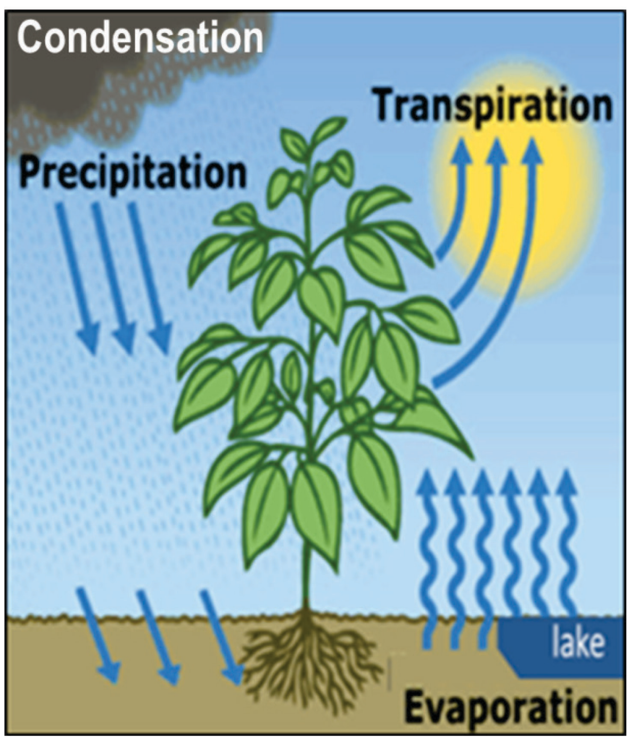
Condensation — change in state of matter from vapor to liquid

Radiant energy — energy from the sun that comes to earth as light and heat energy

Transpiration – the process by which plants lose water through small openings on the leaves

Water cycle – the constant movement of water (in various states of matter) between the atmosphere and the earth

Though an outdoor still can produce liquid both day and night, it will produce about 50 percent more water in the cooler hours between 8 p.m. and 8 a.m. than it does during warmer daylight hours. The rate at which water collects from the indoor still is variable and depends on a number of factors. You could incorporate that uncertainty into the investigation by students.



(Image adapted from salinitymanagement.org)

Teacher Directions: Outdoor Investigation

Divide class into small groups of 2–4 students.

Materials for Outdoor Investigation

CAUTION: You MUST obtain clearance from both the appropriate school officials AND the local utility company prior to digging a hole on campus or anywhere for this activity.

Each group of students should have the following:

- Clean, black plastic garbage bag, cut open fully so it will lay flat
- Small plastic or glass container able to hold up to a liter of water. Beakers work best if you have them.
- A variety of local plant materials—several pounds of leaves, grasses, etc. Have each group of students weigh out and use one pound of plant materials.
- Shovel or other implement to dig a hole (and permission to dig there)
- Thermometer
- Scale

A simple still for collecting water (condensation) can be made from a clean garbage bag, plant materials, and a small collection container.

Dig a hole in the ground in a sunny place. The hole should be about 1 meter across and 1/2 meter deep or deeper if possible. The site should be preferably in moist ground.

When the hole has been dug, line it with a variety of plant materials, and pack them down. Weigh down the plant materials with small, flat stones. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials to measure the air temperature under the black plastic.

Cover the hole with the clean garbage bag. (Make sure to cut the bag open so it lies flat in a single layer.) Use some of the soil scooped from the hole to seal the edges and hold them to the ground.

Place a stone on top and in the center of the plastic garbage bag over the center of the water container to weigh it down. Make sure the plastic garbage bag doesn't touch the collection container. The rock will push the black plastic down in a point aiming at the water collection container.

Moisture in the soil and in the plant materials packed in the hole will transpire as they are heated by the sun and condense on the underside of the plastic.

The condensed moisture will collect into droplets and trickle down the underside of the plastic to the lowest point where they will drop off into the container.

To make the droplets run off more cleanly, roughen the underside of the plastic with a fine abrasive. You can use fine particles of sand or a fine-grained stone to roughen the surface. Be extremely careful not to puncture the plastic while you do this.

Leave the still in place for 24 hours.

Teacher Directions: Indoor Investigation

Divide class into small groups of 2–4 students.

Materials

Each group of students should receive the following:

- A variety of local plant materials—several pounds of leaves, grasses, etc. Have each group of students weigh out and take half a pound of plant materials.
- Large bucket of moist sand
- Large, flat pan
- Small plastic container able to hold up to a liter of water. A beaker is best if you have access to one.
- Small rocks
- Clean, black plastic garbage bag, fully cut open so it will lay flat
- Masking tape
- Thermometer
- Sunny, warm location or a warm light source, such as a lamp

Fill the large, flat pan with the moist sand and dig a deep depression in it. Line the deep depression with a variety of plant materials and pack them down. Weigh down the plant materials with small, flat stones. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials to measure the air temperature under the black plastic.

Cover the depression with the clean garbage bag. Make sure to cut the bag open so it lies flat in a single layer. Use the masking tape to seal the plastic bag around the edges of the pan so the condensed liquid will not leak out.

Place a small stone on top of the plastic garbage bag over the center of the water container to weigh it down. Make sure the plastic garbage bag does not touch the collection container.

Place a light source directly above the solar still so the light shines on the black plastic.

Moisture in the sand and in the plant materials packed in the hole will evaporate as the sun (or other heat/light source) drives the change from liquid to vapor. The water vapor then condenses on the underside of the plastic.

To make the droplets run off more cleanly, roughen the underside of the plastic with a fine abrasive. You can use fine particles of sand or a fine-grained stone to roughen the surface. Be extremely careful not to puncture the plastic while you do this.

Leave the still in place for at least 24 hours.

Data Collection

Remove the stone from the top of the plastic then remove the plastic. Immediately note and record the temperature.

Measure and record the amount of water that has collected in the beaker or container.

Make note of the length of time that has elapsed since you placed the sill and began the experiment.

Discussion

What happened?

- Which part of this activity demonstrated evaporation?
- Which part of this activity demonstrated condensation?
- Where did the water in the collection container come from?
- What caused the transfer of energy that created the water sample in the collection container?
- What part of the day produced the most water? If you don't know, how could you find out?
- What variables could you change to make more water?

Extension

Refer to the data you generated in the *Water Use Inventory* from Chapter 5.

Calculate the percentage of your daily water use that you generated using this still.

Create a graph that shows your calculations.

- What size still would you need in order to generate enough water for your family?

Grade Level	**TEKS**
Grade 6 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. C
Grade 7 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. A
Grade 8 Science	Scientific Investigation and Reasoning 2. A, B 3. A

Student Name______________________ Date _____________________

Evaporation and Transpiration

Background Information

Pure water is essential. In fact, all life on Earth depends on water. More than half of all plants and animals live in water. The human body is two-thirds water. Water is even more important than food. People can survive for many days without food, but will survive only a few days without water.

Plants hold water in their cells. Transpiration is a continuous process in which water taken in from the soil by plant roots evaporates from leaves of plants to the atmosphere.

Transpiration cools plants down (just as evaporation cools our bodies) and enables the plant to take in minerals and nutrients through the root system. This process, part of the water cycle, requires an input of energy from the sun to drive the cycle.

The sun's energy also heats liquid water near the surface of land and water bodies causing evaporation, or the change in state of matter from liquid to vapor. Whether from transpiration or evaporation, the water vapor in the atmosphere will "condense" at some point and fall again as rain to the earth's surface.

Vocabulary

Evaporation — the process by which liquid water is converted into a gas or vapor

Condensation — change in state of matter from vapor to liquid

Radiant energy — energy from the sun that comes to earth as light and heat energy

Transpiration — the process by which plants lose water through small openings on the leaves

Water cycle — the constant movement of water (in various states of matter) between the atmosphere and the earth

How do plants move water from the soil to the atmosphere?

Where does the energy come from to make transpiration happen?

Student Directions: Outdoor Investigation

CAUTION: You MUST obtain clearance from both the appropriate school officials AND the local utility company prior to digging a hole on campus or anywhere for this activity.

1. Dig a hole in the ground in a sunny place. The hole should be about 3 feet across and 1 to 2 feet deep or deeper if possible. The site should be preferably in moist ground.
2. When the hole is complete, line it with one pound of plant materials. Weigh down the plant materials with small, flat stones.
3. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials to measure the air temperature under the black plastic.
4. Cover the hole with the clean garbage bag. Make sure to cut the bag open so it lies flat in a single layer. Use some of the soil scooped from the hole to seal the edges and hold them to the ground.
5. Place a small stone on top of the plastic garbage bag over the center of the water container to weigh it down. Make sure the plastic garbage bag doesn't touch the collection container. The rock will push the black plastic down in a point aiming at the water collection container.
6. Make note of the time.
7. Leave your solar still in place for at least 24 hours.

Data Collection

- Remove the stone from the top of the plastic then remove the plastic. Immediately note and record the temperature.
- Measure and record the amount of water that has collected in the container.
- Make note of the length of time that has elapsed since you placed the sill and began the experiment.

Think about and be prepared to discuss these questions:

- What happened?
- Which part of this activity demonstrated evaporation?
- Which part of this activity demonstrated condensation?
- Where did the water in the collection container come from?
- What caused the transfer of energy that created the water sample in the collection container?
- What part of the day produced the most water? If you don't know, how could you find out?
- What variables could you change to make more water?

Student Directions: Indoor Investigation

1. Fill the large, flat pan with the moist sand, and dig a deep depression in it. Line the deep depression with one pound of plant materials and pack them down.
2. Weigh down the plant materials with small, flat stones.
3. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials to measure the air temperature under the black plastic.
4. Cover the depression with the clean garbage bag. Make sure to cut the bag open so it lies flat in a single layer. Use the masking tape to seal the plastic bag around the edges of the pan so the condensed liquid will not leak out.
5. Place a small stone on top of the plastic garbage bag in the center of the water container to weigh it down. Make sure the plastic garbage bag does not touch the collection container.
6. Place a light source directly above the solar still so the light shines on the black plastic. You can use a lamp or place the still in a sunny location.
7. Make note of the time.
8. Leave the still in place for at least 24 hours.

Data Collection

- Remove the stone from the top of the plastic then remove the plastic. Immediately note and record the temperature.
- Measure and record the amount of water that has collected in the collection container.
- Make note of the length of time that has elapsed since you placed the still and began the experiment.

Think about and be prepared to discuss the following questions:

- What happened?
- Which part of this activity demonstrated evaporation?
- Which part of this activity demonstrated condensation?
- Where did the water in the collection container come from?
- What caused the transfer of energy that created the water sample in the collection container?
- What part of the day produced the most water? If you don't know, how could you find out?
- What variables could you change to make more water?

Evaporation

Overview

Evaporation occurs when water molecules absorb energy and move fast enough to escape their liquid state to become a gas. This transformation is a key part of the water cycle and is one of the simplest concepts of energy transfer.

Applying this concept to the local environment is a powerful way to learn why the transfer of energy is an important concept. Evaporation plays a critical role in water planning in Texas. Every year, large volumes of water held in Texas reservoirs are lost because of evaporation into the atmosphere. Water planners must be able to account for water lost to evaporation. More water lost to evaporation means less water is available to draw upon for various uses such as drinking and bathing.

In this activity, students will investigate evaporation and the factors that influence evaporation rates.

Background

Reservoirs are an essential part of water supply in Texas. Reservoirs stabilize the flow of water in a watershed, slow down and hold back floodwaters, provide a source of water for drinking and other uses, keep streams flowing during dry periods, help generate power, and provide recreational opportunities.

Just like Texans, reservoirs come in all shapes and sizes. Some are wide and shallow, while others are narrow and deep. Texas has approximately 5,700 reservoirs with a surface area of 10 acres or larger. Overall, reservoirs in Texas cover approximately 3,065,600 acres of surface area.

When reservoirs are wide and shallow, they lose more water to evaporation than deeper reservoirs because the energy from the sun reaches a relatively larger "piece" of the reservoir. Energy from the sun does not reach deeper water, so a smaller piece of the reservoir is subject to evaporation.

Evaporation rates vary across the state depending on factors such as temperature, humidity, available water, and wind speed and direction. In the hot, dry Texas summer, evaporation rates can be very high. Refer to the enclosed average annual evaporation map to give students an idea of how much water evaporates in your area. Compare it to other statewide maps on rainfall or maximum summer temperatures to find patterns.

Wide, shallow reservoirs also require more land to be flooded to hold the same amount of water that a narrow, deep reservoir might hold. Which kind of reservoirs exist near you? Are they relatively deep or shallow? Find out information about all of the reservoirs in Texas by visiting the "Water Data for Texas" website.

The surface area of a reservoir is one of three major factors affecting the rate of evaporation. The three major factors that affect the rate of evaporation are

1. water temperature,
2. surface area, and
3. wind.

In this investigation, students will manipulate two of these three variables to see how they affect evaporation rates. The resulting evaporation rates will be expressed as millimeters per hour and will relate directly to surface area.

Please note: Measuring the evaporation from a reservoir in real field conditions is an extremely complex process. Wind, relative humidity, temperature, atmospheric pressure, surface area, water depth, water clarity and other factors make it difficult to accurately measure evaporation rates of lakes and other water bodies.

Procedure

Divide students into groups of four. Each team will set up and track an investigation into two of the factors that influence evaporation rates.

Day One

Each team will complete the following:

- Make two sets of each of the three types of containers needed:
    1. Large, shallow container
    2. Large, shallow container with black plastic
    3. Tall, narrow container
- Number each of the containers based on the descriptions on the Data Sheet.
- Measure out exactly 100 ml of water into a graduated cylinder. Record the temperature of the water and pour it into the first large, shallow container.
- Calculate the surface area of the water in the container. To do that, students will need to measure the length and width of the container at the surface of the water.
- Measure out a second 100 ml of water, record the temperature, and pour it into the tall, narrow container.
- Calculate the surface area of the water in the container as before.
- Measure out a third 100 ml of water, record the temperature, and pour it into the large, shallow pan with the black plastic covering the bottom of the container.
- Calculate the surface area of the water in the container as before. The surface area of this pan should be exactly the same as the other large, shallow pan.
- Put all three containers in a sunny location or under a light source. Record the time and leave at least overnight.
- Repeat these steps, filling a second large, shallow container; a second large, shallow pan lined with black plastic; and a second tall, narrow container. Place this second set of three containers in a cool, dark location. Record the time and leave at least overnight.

Day Two

- Record the number of hours that have passed since students began the experiment. Note that the longer the pans are left alone, the greater the volume lost to evaporation.
- Record the temperature of the water in all six containers. (Be sure to measure the water at the same depth in each container. Why?)
- Remeasure the amount of water left in the containers by pouring it back into the graduated cylinder.
- Calculate the rate of evaporation by subtracting the amount of water left from the original 100 ml in the containers, then dividing it by the number of hours that have passed since they began the experiment. This gives them the rate of water loss in milliliters per hour (ml/hr.).
- Express the rate of evaporation as

$$\frac{(Starting\ volume) - (Ending\ volume)}{(time\ elapsed\ in\ hours)} = \frac{milliliters}{hour}$$

- Data should be recorded by each student on the included data sheet, and questions on the Evaporation Assessment should be answered individually.

Discussion

- Was the water in each set of containers warmer or cooler than when they began the investigation?
- Which set of containers had the biggest change in temperature?
- In which set of containers did students observe the biggest change in volume of water?
- How does surface area relate to evaporation rate?
- What was the source of energy that caused the water to evaporate?
- How could you have altered the experiment by including the third major factor that influences evaporation (wind)? How would that have changed the results?

Evaporation Activity Assessment

1. Write down the equation you used to calculate the rate of evaporation.

2. Which set of containers had the biggest change in temperature?

3. In which set of containers did you observe the biggest change in volume of water?

4. Which **two** of these statements are best supported by the data?

    a. Cooler temperature = more evaporation

    b. Higher surface area = more evaporation

    c. Higher surface area = higher temperature

    d. Taller container = higher temperature

    e. Higher temperature = more evaporation

5. This activity demonstrated a transfer of energy. Explain what happened in this energy transfer. In your explanation, please include the following:

    a. The source of energy

    b. The substance that absorbed the energy

    c. How water evaporates (what happens to the molecules that make up water)

    d. The variable that increased the rate of energy absorption and the result of the exchange of energy

Grade Level	**TEKS**
Grade 6 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. C
Grade 7 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. A
Grade 8 Science	Scientific Investigation and Reasoning 2. A, B 3. A

Name____ Date ____________________

Container Number and Description	Location	Water Temperature		Surface Area	Volume		Evaporation Rate (milliliters/hour)
		Day One	Day Two		Day One	Day Two	
A1. Large, shallow	Sunny						
A2. Large, shallow with black plastic	Sunny						
A3. Tall, narrow	Sunny						
B1. Large, shallow	Cool, dark						
B2. Large, shallow with black plastic	Cool, dark						
B3. Tall, narrow	Cool, dark						

Transpiration

Overview

Evaporation and Transpiration are both a part of the water cycle. Evaporation from bodies of water accounts for about 90 percent of the water in the atmosphere, and transpiration accounts for most of the remaining 10 percent (with a small amount from sublimation).

Transpiration is the process by which water in plants is transferred as water vapor to the atmosphere. Plant roots take up liquid water from the soil and transpire that water as vapor through openings in their leaves. Transpiration is essentially evaporation of water from plant leaves.

Transpiration is often a very difficult concept for students to understand. Transpiration occurs when that moisture is transferred to the atmosphere. Transpiration requires an input of energy—in this case, energy from the sun.

Applying this concept to the local environment is a powerful way to learn how the transfer of energy occurs and why it is an important concept. Evaporation activities in this chapter (such as the collection of condensed water from the solar still) are very similar to the following investigation of transpiration. That is because the processes of evaporation and transpiration are similar: both result in a change from liquid water to water vapor and both contribute that water vapor to the atmosphere.

Essentially, this lesson involves the use of a "transpiration bag" wrapped around a tree branch or the leaves of a potted plant. The leaves transpire water vapor that condenses and collects in a bag in a manner similar to the evaporation activity outlined previously. Even a small house plant with a sandwich bag can be used to demonstrate this concept.

(photos courtesy of dirttime.com and usgs.gov)

Teacher Directions: Indoor / Outdoor Investigation

Divide class into small groups of 2–4 students.

Materials

Each group of students should receive:

- A clean plastic bag without perforations (not a zip lock bag, as they present more of a challenge in creating an airtight seal);
- A piece of string or other means to secure the seal; and
- A live houseplant or tree with leaves.

WARNING: Do not use this technique with poisonous plants.

Plants transpire water vapor through small openings in their leaves. In essence, this investigation shows how the transpired water vapor will condense on the smooth surface of the sealed plastic bag and then drain to the lowest point where it collects. This method can be useful as a survival skill or an inquiry based learning experiment.

Ensure the plant is intact, alive, and growing. Neither a dead plant nor a dormant plant will transpire water vapor. With a severed branch, prospects of collecting water are limited.

1. Cover as many leaves as the bag can accommodate.

2. Secure the opening of the bag around the branch, stem, or trunk.

3. Make certain that the seal is as airtight as possible.

4. Ensure that a portion of the plastic bag is lower than the airtight seal (this is where the water will gather).

5. Ensure the plastic bag and plant can bear the weight of any collected water.

6. Now wait. The amount of water that collects in the bag depends on the type of plant, surface area of the enveloped leaves, location conditions, and the integrity of your airtight seal. If possible, use different types of plants and have students predict which will transpire water at the fastest rate. Or, have students predict how much water will collect based on the number of leaves enclosed in the bag(s). Finally, consider transpiration as part of the global water cycle: how many leaves of plants and trees across the globe transpire water vapor into the atmosphere each day?

GRADE LEVEL 6th–8th

Overview

In this inquiry activity, students will design, construct, and test a model water treatment plant.

Background

Everything that goes down the drain becomes part of our water system. The remains of dinner when you wash the dishes, detergent from the laundry, everything you flush down the toilet (unless you have a septic tank), whatever is ground up in your garbage disposal, it all cycles through—first to the water treatment facility and then back into the water cycle. Wastewater treatment is a critical part of ensuring that Texas has enough water to meet the growing demand. What would happen if we didn't treat wastewater?

In many wastewater treatment plants, there are two stages of treatment. In the primary stage, solids are removed through sedimentation. Water is held in large tanks where the solids settle to the bottom and are pumped out for disposal.

Grease and oil are skimmed off the top of these tanks and removed for disposal or incineration.

Secondary treatment involves aerating the water, or mixing it to increase the volume of oxygen, then adding different types of microorganisms. The microorganisms "eat" the remaining foreign substances in the water. When the microorganisms die, they fall to the bottom of the tank and the resulting sludge is pumped out for disposal.

Time

This activity will take two or three 45–55 minute periods, depending on how you structure the investigation. Begin with a demonstration of how wetland plants absorb pollutants, a discussion of what is in wastewater, and a planning session for teams to investigate materials and begin to design their models. Days two and three offer an opportunity for students to design, test, and refine their model, adding layers of inquiry, discovery, and student engagement.

Materials

Demonstration

- Celery: 2–3 stalks per group
- Food coloring
- Glass jar
- Water

Water Treatment

Note: This materials list is extensive, but the variety of materials is intended to give students a lot of ideas and tools to experiment with as they create their treatment plant. If you don't have every one of these items, use what you can reasonably gather.

- Large, flat pans - one per group (Note: disposable roasting pans will work.)
- Fine sand - at least 2 cups per group
- Fine gravel - at least 2 cups per group
- Gravel - at least 2 cups per group
- Alum (can be found in the spice aisle at grocery stores)
- Filter papers (cone-shaped coffee filters will work.)
- Rubber bands

(continued on next page)

Water is treated with chlorine to kill any remaining bacteria then filtered through carbon filters to reduce the toxicity. In the final step before it is pumped back into waterways, water is treated with sulfur dioxide to reduce the concentration of chlorine. Chlorine helps clean the water of harmful microorganisms, but if it is not reduced it could be harmful to the river and ecosystem.

Wetlands are a naturally occurring part of water treatment. Wetlands act as sponges absorbing and processing many of the nutrients in water. Wetland plants trap sediments in their root systems and slow the flow of nonpoint source pollution to surface water and groundwater.

In this inquiry-based activity, students will watch a demonstration and then investigate methods of treating and cleaning water using a variety of tools and materials.

Materials

Water Treatment *(continued)*

- Empty 2-liter soda bottles - several per group
- Glass jars with lids - one per group (Note: 1-quart canning jars or empty mayonnaise jars work well.)
- Small plastic cups
- Scissors
- Graduated cylinders
- Granulated activated charcoal
- Paper towels
- Duct tape
- Water quality test kits (optional)
- Soil - (Sediments) at least 1 cup per group
- Food coloring (Nutrients)
- Vinegar (alters pH)
- Salad oil - (Toxics) about a cup
- Liquid detergent
- Grass clippings

Method

As you plan for this investigation, you will need to decide in advance if the activity will span two days or three.

Day One

- Read background article
- Wetlands demonstration
- Discuss what is in the water
- Investigate materials
- Plan model

Day Two

- Build and test model
- Demonstrate model or, if over three days, plan modifications

Day Three (if needed)

- Revise and demonstrate model

Day One — Introduction

Ask students to read the background article before the inquiry begins. Begin the inquiry with a demonstration and a discussion.

Explain to students that they will be building a model water treatment plant. They can use any of the materials provided. They can bring additional materials from home if they want.

Each model must meet the following criteria:

- Each model must use only the materials provided, or those brought by students from home.
- Each model must fit into the roasting pan.
- Each model treatment plant must include at least two stages.
- Each treatment plant must remove all of the potential pollutants listed above.

Demonstration

Wetland plants are a vital part of the water system. They clean the water as they absorb pollutants. We can show how that happens in a simple demonstration.

1. Measure out 50 ml of water and pour it into a glass jar.
2. Add 3–4 drops of food coloring (representing a pollutant) to the water.
3. Cut across the large ends of 2–3 stalks of celery. Put the cut ends of the celery stalks into the colored water.
4. Leave the celery and the water undisturbed for 24 hours.

While the celery demonstration is working, begin a discussion with students about substances that might be found in water. In the wetlands demonstration, the food coloring represents a pollutant, but what exactly is it representing?

In small discussion groups, ask them to list substances that they send down the drain.

- Which rooms in the home have sinks or water faucets? For each of these rooms, make a list of things that go down the drain.
- How is water used outside their homes?
- Where does that water go, and what does it carry with it?
- In the school, how many rooms have drains? Make a list of what goes down these drains.
- Where is the closest water treatment plant?

Gather students' lists onto a large chart or whiteboard. Ask students to create categories of substances and organize the lists into categories.

Introduce the materials available to them for constructing their water treatment plant. Discuss the methods of water treatment used by municipal wastewater treatment plants. Talk about which materials they have that will replicate commercial treatment methods.

Discuss how they will determine the quality of the water they have treated. If you have water quality testing kits, consider conducting tests on the water students treat with their model treatment plants. If you do not have water testing kits, other methods could be used such as visual observations and comparisons (Are there chunks? Does it have an oily sheen?), smell tests, turbidity (can be measured with a secchi disk), and so on.

Category	Method	Materials
Physical	**Aeration** — Mixing air and water to increase the amount of oxygen in the water **Sedimentation** — Letting solids settle out of wastewater **Filtration** — A process for removing solids from water by passing them through a filter or filtering materials like sand or gravel	Glass jars Soda bottles, glass jars Filter paper
Chemical	**Coagulation** — Using chemicals to make suspended solids gather or group together into small clots called “flocs” **Disinfection** — A chemical process that kills microorganisms	Alum N/A
Biological	**Bioremediation** — Using bacteria and enzymes to “eat” the pollutants in wastewater	N/A

As a final discussion, give students time in their small groups to begin talking about the **design** of their model. Let them look through the materials and begin thinking about how to construct their water treatment plant.

Day Two — The Model

Begin by checking on the celery stalk experiment. The celery will have pulled water (and food coloring) up into the veins in the stalk. This is a powerful visualization of how effective plants can be in removing and sequestering pollutants from water.

Give each group of students a large roasting pan. Each group of students may select the materials they need for their water treatment model, based on their discussion and design from the previous day.

Give students as much time as possible to design and test their models. Each group will complete a "Water Treatment Reporting Sheet" detailing their model and explaining their treatment methods.

If you are planning to complete the inquiry extension, wait until the end of the third day to have students fill out their reports. Instead, ask students to discuss how their groups could refine their model.

- Which parts of their model work well?
- Which parts of their treatment process need refining?
- How will they change their models?
- What additional materials do they need?

Important — Ask students to save a sample of the water they treated using the first version of their water treatment plant. They will compare this sample to water they treat after refining their model if the activity occurs over three days.

Day Three — Refining the Model

If you plan this investigation to happen over three days, the third day has students refining their models to improve the effectiveness of their water treatment plant model.

Using their assessment of the first model, give students time to change and refine their model and retest water samples.

Ask each group to report their findings and compare treatment methods. Each individual student should fill out a report on their investigation. Use these reports to assess student understanding of the investigation.

Water Treatment Background

According to "The Water Sourcebooks," an educational publication by the U.S. Environmental Protection Agency:

> "Water pollution has increased greatly over the years as the population has grown and development has occurred. Water treatment has also grown. Water is cleaned in nature as it passes through sand and gravel. Drinking water or wastewater treatment plants use metal grating and screens that filter out large debris. Most point sources are treated; nonpoint sources have continued to grow, however. Raw sewage must now be treated before it is allowed to enter our rivers, lakes, and ocean. All water from streams and lakes must be treated or purified again before it can be used as drinking water. The procedures used for treating water in this experiment are similar to the procedures used in water treatment plants." (pages 2–17)

There are many different kinds of pollutants in wastewater, so water treatment plants need to use many processes to clean it up. These processes can be grouped into three categories.

Physical	**Aeration** — Mixing air and water to increase the amount of oxygen in the water. **Sedimentation** — Letting solids settle out of wastewater. **Filtration** — A process for removing solids from water by passing them through a filter or filtering materials like sand or gravel.
Chemical	**Coagulation** — Using chemicals to make suspended solids gather or group together into small clots called "flocs." **Disinfection** — A chemical process that kills microorganisms.
Biological	**Bioremediation** — Using bacteria and enzymes to "eat" the pollutants in wastewater.

In many areas, wetlands are part of the water treatment process. Wetlands act as sponges, absorbing and processing many of the nutrients in water. Wetland plants trap sediments in their root systems. They also slow the flow of nonpoint source pollution to surface and groundwater sources.

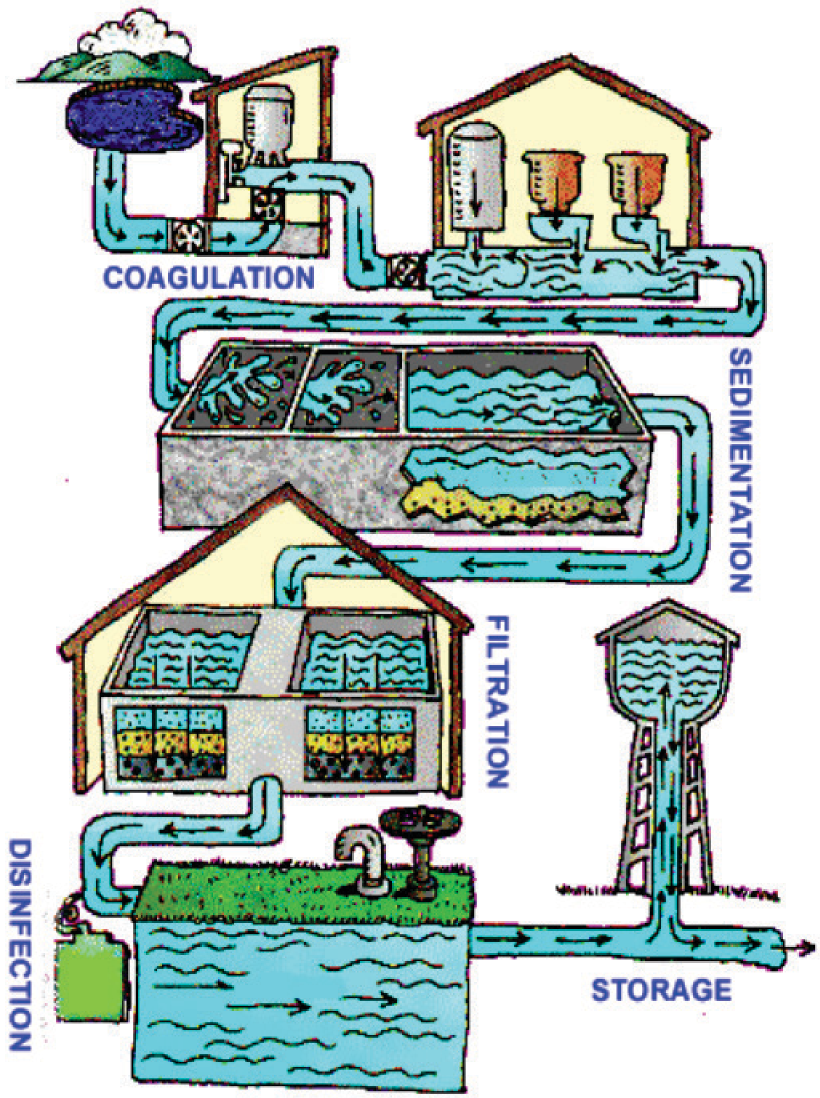
In municipal wastewater treatment plants, there are generally two stages of treatment. In the primary stage, solids are removed through sedimentation. In this process, water is held in large tanks; the solids settle to the bottom and are then pumped out for disposal.

Grease and oil are skimmed off the top of these tanks and removed for disposal or incineration.

Secondary treatment involves aerating the water, or mixing it to increase the volume of oxygen. Then microorganisms are added. The microorganisms "eat" the remaining foreign substances in the water. When the microorganisms die, they fall to the bottom of the tank and are pumped out for disposal.

The water is treated with chlorine to kill any remaining bacteria and then filtered through carbon filters to reduce the toxicity. In the final step before it is pumped back into the waterways, water is treated with sulfur dioxide to reduce the concentration of chlorine. Chlorine helps clean the water of harmful microorganisms, but too much could be harmful to the river ecosystem.

Even after going through all these processes, wastewater might still be polluted. Some chemicals, medicines, and heavy metals like mercury cannot be removed in the wastewater treatment process. In the case of these substances, prevention is the key. Keeping these things out of the water in the first place is the best way to keep water clean.



(Image from www.epa.gov/.)

Student Name______________________ Date _____________________

Water Treatment Reporting Sheet

(Please use complete sentences in your report.)

1. Draw a sketch of your water treatment plant, labeling all parts.

2. Explain how your water treatment plant works. Make sure to include an explanation of both stage one and stage two treatments.

3. What are the most effective parts of your design? What parts could be more effective?

4. What will you do differently next time?

Grade Level	**TEKS**
Grade 6 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. C
Grade 7 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. A
Grade 8 Science	Scientific Investigation and Reasoning 2. A, B 3. A

Chapter 4 **Porosity and Permeability**

GRADE LEVEL 6th–8th

Objectives

- To understand the principles of porosity and permeability as they relate to soils.
- To measure the amount of water stored in the pore space of a soil sample.
- To express porosity in different forms: a fraction, a percentage, and in a graph.

Teacher Background

Soils are made of particles of different types and sizes. The void space between particles is called pore space. That space can be filled with either water or air; therefore, pore space determines the amount of water that a given volume of soil can hold.

Porosity is the percentage of empty spaces in a volume of soil. This concept is important when discussing the capacity of a soil to hold water and relates specifically to discussions of groundwater as well. Porosity differs with soil type. Different textures (fine, medium, coarse) of soil particles affect the porosity and water holding capacity of a soil. Coarse textured soils tend to have larger particles and therefore larger empty spaces between those particles. That equates to a greater percentage of pore spaces (higher porosity).

Permeability refers to a measure of the ability of a material (rock or soil) to allow water to pass through. Permeability and porosity are interrelated concepts: permeability is dependent on the porosity of the soil. The basic soil textures are sand, silt, and clay. Sand is coarse grained (high porosity), and sandy soils have high permeability. Consider how quickly water disappears (passes through) if you pour it onto pure sand. A sandy soil similarly drains very quickly. Clay has very fine particles, very low porosity, and very low permeability, which is why clay pottery is used to hold water. A landfill often has a layer of clay at the bottom to prevent rain from passing through the waste and into the groundwater. Silt particles and silty soils fall somewhere between sand and clay.

Of course every unique soil type has a different porosity and permeability. This concept also dictates how water moves through soil and rock as groundwater. A geologic formation with large pore spaces (like the "Swiss cheese" Edwards Aquifer) easily allows the passage of water (high permeability) compared to a granite formation that has poor or low permeability. (Would you install a granite countertop if water easily soaked into it?)

The Natural Resources Conservation Service is a great resource for information on soils. You can find teacher resources and the Web Soil Survey that allows you to find broad and/or local soil descriptions.

Find other links to soil resources on the TWDB's "Conservation Education" page.

Grade Level	**TEKS**
Grade 6 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. C
Grade 7 Science	Scientific Investigation and Reasoning 2. A, B 3. A Matter and Energy 5. A
Grade 8 Science	Scientific Investigation and Reasoning 2. A, B 3. A

Vocabulary

Soil — the layer of unconsolidated (loose) materials at the earth's surface consisting of mineral particles, organic matter, air, space, and water.

Particle — a very small piece of something bigger

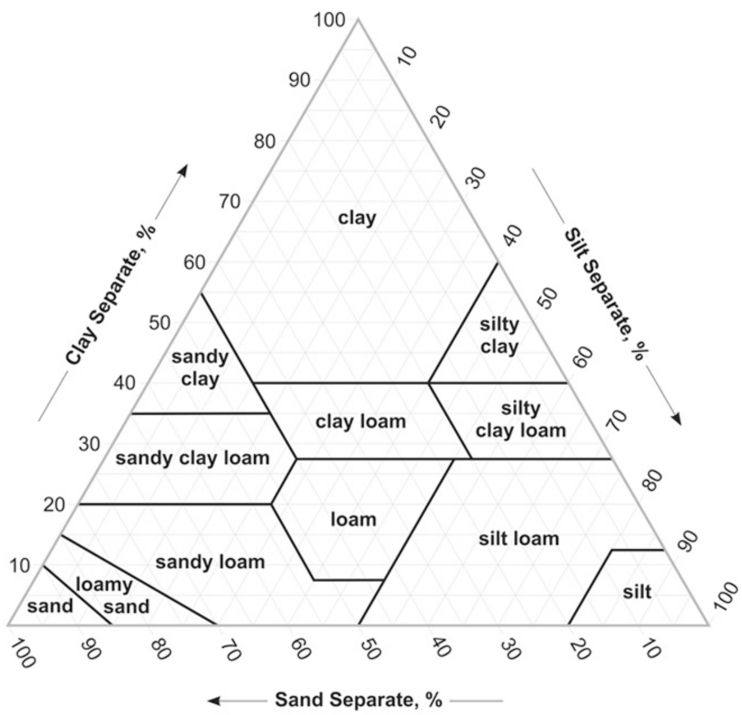
Pore space — the space found between particles of rock and soil

Porosity — percentage of empty spaces in a volume of soil or rock

Saturation — the point at which soil, sediments, or rock is completely full of water

Water table — the top surface of groundwater; below the water table, the soil or rock is saturated

Groundwater — water stored below the surface of the earth that occupies the pore spaces of soil, sediments, or rock



("Soil Texture Triangle" from soils.usda.gov)

Materials

- Dry soil samples representative of what can be found in the local area. Include several kinds to allow students to investigate the porosity of soils with different particle sizes. Gravel and "fish tank rocks" would also work.
- Two 500 ml beakers (or graduated cylinders)
- Water/paper towels to clean up spills

Procedure

This activity can be done either as a guided lab or an inquiry investigation, depending on the teacher's time and comfort level with inquiry-based learning.

For a guided lab, give students the following instructions:

1. Have students read "Thinking about Porosity." The answers can be filled in as either a pre-assessment or after the investigation.
2. Divide class into pairs of students. Distribute the materials.
3. Fill one beaker with 500 milliliters (ml) of your dry soil or sediment sample. Place it on a table or flat workspace.
4. Fill the other beaker with 500 ml of water.
5. Slowly (the slower the better) pour the water from the second beaker into the dry sample. Stop pouring when the water level reaches the top of the soil. The soil has reached saturation and cannot hold any more water.
6. Determine how much water is now held in the pore spaces of the saturated sample. Subtract the volume of the water remaining in the second beaker from the starting volume (500 ml). This is the volume of the pore space.
7. Compute the porosity (the percentage of pore space) of the soil sample using the formula below.
8. Now express the porosity as a fraction. Use graph paper to graph porosity.
9. Answer the questions on "Thinking about Porosity" if not already done.

$$\text{porosity (\%)} = \frac{Volume\ of\ pore\ spaces}{Total\ volume\ of\ the\ dry\ sample} \times 100$$

For an inquiry-based lab, follow these instructions:

1. Have students read "Thinking about Porosity." Do not have them fill out the questions until after the investigation.
2. Divide class into pairs of students. Distribute the materials.
3. Ask students to answer the following questions:
   a. How can you measure the porosity of different soils?
   b. What is the porosity of each soil sample expressed as a percentage of volume, a fraction of volume, and on a graph?
4. Give students a set amount of time to plan and conduct their investigation. On the back of the porosity background information sheet, ask them to record their plan, predictions, observations, and conclusions.
5. When they have completed their investigations, ask students to answer the questions on "Thinking about Porosity."

Student Name____________________ Date _______________________

Thinking about Porosity

Soils are made of particles of different types and sizes. The space between particles is called pore space. Pore space in soils can be filled with either water or air. A dry soil has more air in the pore spaces and very little water. A wet soil has more water in the pore spaces than air. When the soil holds only water (no air), it is saturated.

Porosity is the percentage of the total volume of soil that consists of pore space. Each different type of soil has a different porosity. High porosity soils can hold large amounts of water or air. Low porosity soils have little pore spaces and cannot hold much water or air.

Some underground rock formations also have open pore spaces that can be filled with air or water. Think about an underground cave as a giant pore space. Underground rock formations that are filled with water are said to be saturated, meaning they are holding as much water as they possibly can. We call these formations "aquifers" and the water "groundwater" because it is stored underground. The top surface of that layer of saturated soil or rock is called the water table.

Knowledge of porosity allows us to understand the volume of water stored in the underground aquifers. In parts of Texas where drinking water is pumped from an aquifer, it is essential to know how much water is down there. If you know the porosity of the rock formation, it is possible to know how much water can be pumped from the aquifer in order to plan for the future.

List the important vocabulary words in these paragraphs.

Summarize the main idea in each of the paragraphs.

Why is porosity important to people in Texas who use groundwater for drinking water?

Student Name____________________ Date _______________________

Porosity Activity Chart

Soil Sample Description	**Volume of water held**		
	Volume	Fraction of 500 ml	Percentage of 500 ml

Vocabulary

Soil — the layer of unconsolidated (loose) materials at the earth's surface consisting of mineral particles, organic matter, air, and water.

Particle — a very small piece of something bigger

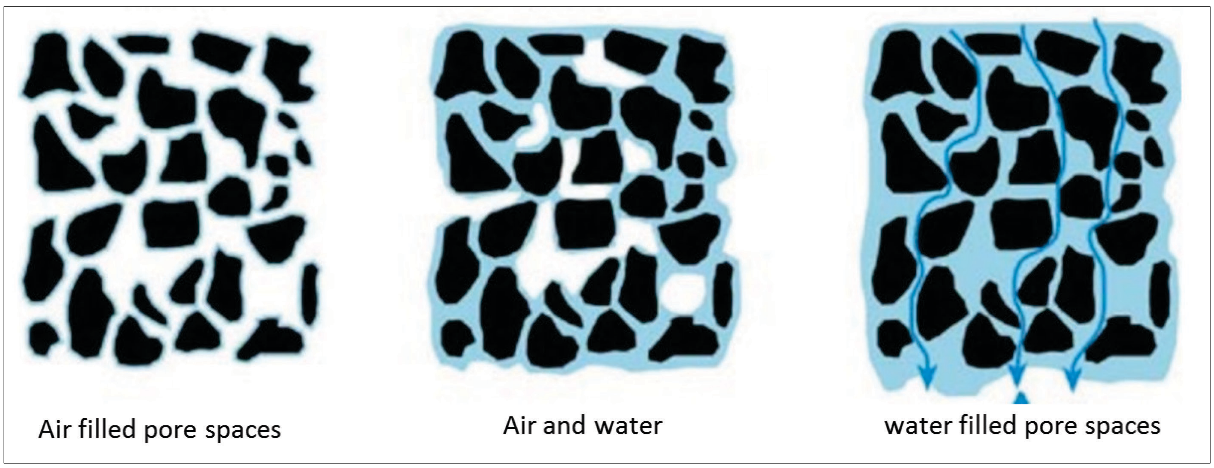
Pore space — the space found between particles of rock and soil

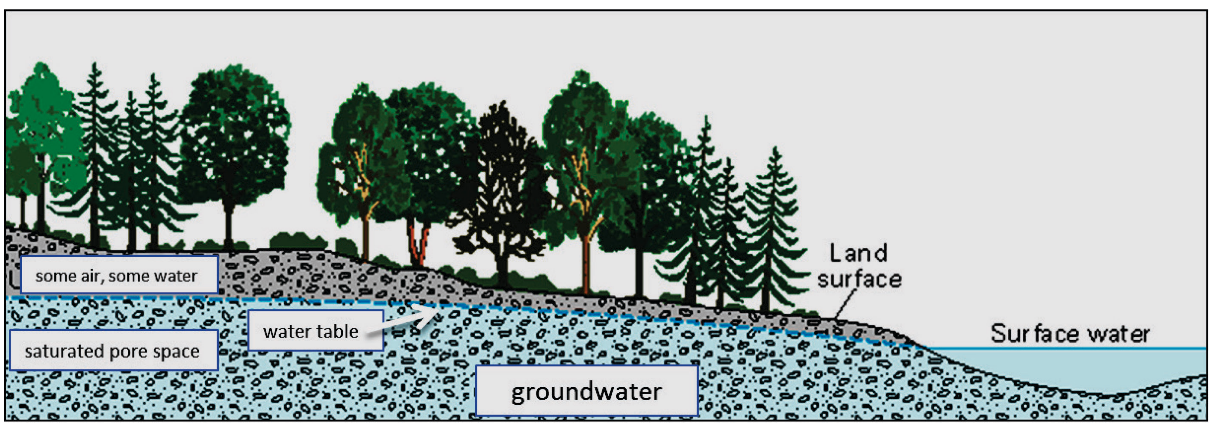
Porosity — percentage of empty spaces in a volume of soil or rock

Saturation — the point at which soil, sediments, or rock is completely full of water

Water table — the top surface of groundwater; below the water table, the soil or rock is saturated

Groundwater — water stored below the surface of the earth that occupies the pore spaces of soil, sediments, or rock





(Adapted from water.usgs.gov)

Permeability —Teacher Background and Instructions

Background

This activity works well when combined with the Porosity Investigation.

Permeability is the ability of a material to allow the passage of a liquid such as water through rocks. Permeable materials, such as gravel and sand, allow water to move quickly through them, whereas impermeable materials, such as clay, don't allow water to flow freely.

Permeability also refers to the degree to which soils and rock are interconnected, depending upon size and shape of pores and the size and shape of their interconnections.

Generally, the coarser (containing more larger particles like sand and gravel) the soil, the more permeable it is. However, if the pore spaces are not well connected, the permeability will be low.

Water will run through more permeable soils at a faster rate than through soils with small particles and/or less connectivity. This concept (along with porosity) is important in understanding how water soaks through the ground (infiltrates) into an aquifer, a key component of the complex relationship between surface water and groundwater.

Time

One 50-minute period

Materials

- Student Data Chart
- Samples of soil, sand, and gravel
- Small plastic bags to hold soil samples (9 per group)
- Spoons (Tbsp.)
- Stop watches or clock with second hand
- 10 ml graduated cylinders (one per group)
- 50–100 ml water containers (one per group)
- Funnels (small)
- Hand lenses
- Plastic bottles or small-mouthed containers
- Filter paper (nine pieces for every group; round, flat coffee filters work)
- Paper towels

Description

Students will determine the relative permeability of several samples (sand, soil, and gravel). This investigation is designed to take students approximately one 50-minute period to complete.

General Instructions to the Teacher

Students will be working in groups of 2 or 3 during this investigation.

See "Permeability Investigation - Student Directions" for detailed instructions on how to conduct this investigation.

Each team of students will need to weigh out a predetermined amount of each sample depending on how much you have available. If time permits, have students weigh the material to get experience using scales. Once the samples have been weighed, they should be stored in a small plastic bag and labeled.

Grade Level	**TEKS**
Grade 6 Science	Scientific Investigations and Reasoning 2. A, E 3. A
Grade 6 Math	Number and Operations 3. D
Grade 7 Science	Scientific Investigations and Reasoning 2. A, E 3. A
Grade 7 Math	Mathematical Process Standards 1. E Number and Operations 3. A
Grade 8 Science	Scientific Investigations and Reasoning 2. A, D, E 3. A

Vocabulary

Permeable — any material that allows water to pass between particles or cracks

Impermeable — any material that does not allow water to pass through it

Permeability — the ability of rocks or soil to allow the passage of water

Particle — a very small piece of something bigger

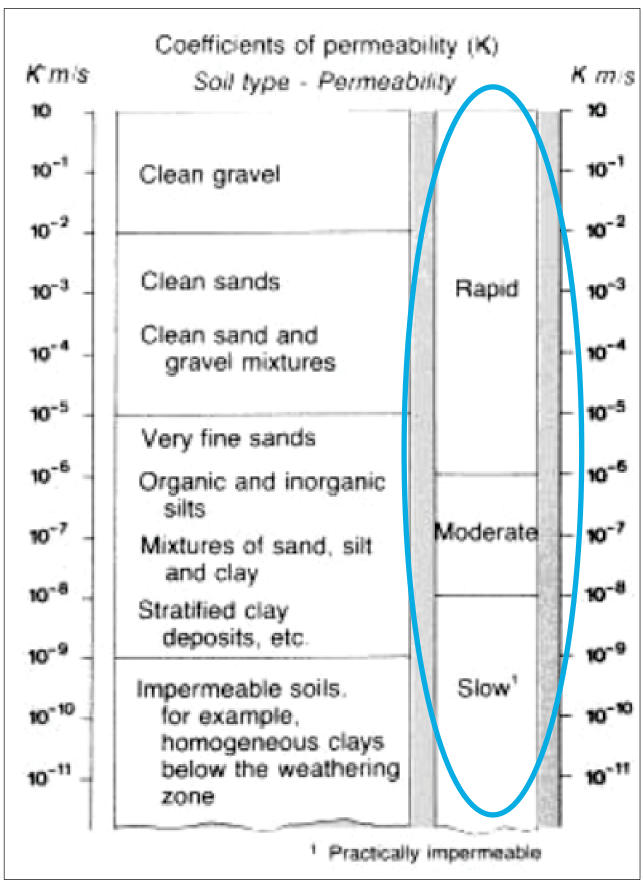
Pores — the spaces found between particles of soil, sand or gravel

Porosity — the percentage of empty spaces in a volume of rock or soil

Infiltration — the downward movement of water through another substance

Assessments

Students will graph the data collected from their investigations on the Permeability Activity Student Data Chart.



Permeability Investigation: Student Directions

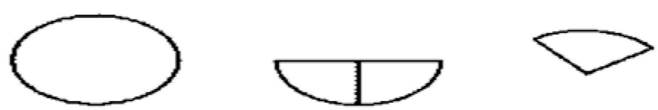
In this investigation, you will be working in groups to determine the relative permeability of different soil samples.

Directions

1. Measure out three samples of each of the three soil types and put them in small plastic bags. Be sure to label the bag with the type of soil and a number. (For example, "Sand #1," Sand #2," "Gravel #3")
2. Observe each sample with the hand lens and record your observations in the data table on the back of this page.
3. Which sample has the largest particles?

   Which sample has the smallest particles?

   Predict which type of soil is the most permeable. Record your observations and predictions in the data table on the back of this page.
4. Fold a piece of filter paper in half, then in half again (see picture below). Then open the folded paper to form a cone with 3 quarters on one side and one quarter on the other side. **Note**: You will need to create 9 cones total.



Materials

- Data Graph (one per group)
- Soil samples (3)
- Sand samples (3)
- Silt samples (3)
- Small plastic bags (9)
- Hand lens
- 10 ml graduated cylinder
- Funnel
- Plastic bottle or small-mouthed container
- Filter paper (9 pieces)
- Spoon
- Paper towels
- Stop watch
- Water container
- Colored pencils

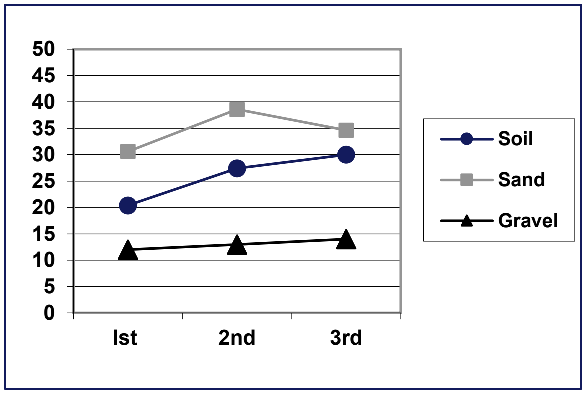
5. Place your filter cone into the funnel. Now place the funnel into the plastic bottle or small-mouthed container.
6. Pour water into the funnel to completely wet the filter paper. Be sure to let all the water drip through the funnel into the bottle then pour that water back into the water container. The filter paper should stick to the sides of the funnel without any air bubbles.
7. Pour one of your pre-measured soil samples into the wet filter paper and gently pack down the sample with the back of the spoon.
8. Measure out 10 ml of water in the graduated cylinder. Choose a group member to be the timer.
9. Slowly pour the 10 ml of water on top of the soil in the funnel and time how long it takes for the 10 ml of water to completely disappear into the soil.

10. Record the time on the data table below.
11. Remove the soil sample and filter cone from the funnel. **Note:** The soil samples can be collected and reused again and again in the future, but the filter paper should be thrown away.
12. Go back to step #5 and repeat steps #5 – 11 with each of the remaining soil samples. You should record your data in the table below for a total of 9 soil samples (3 soil types * 3 samples per each type of soil).

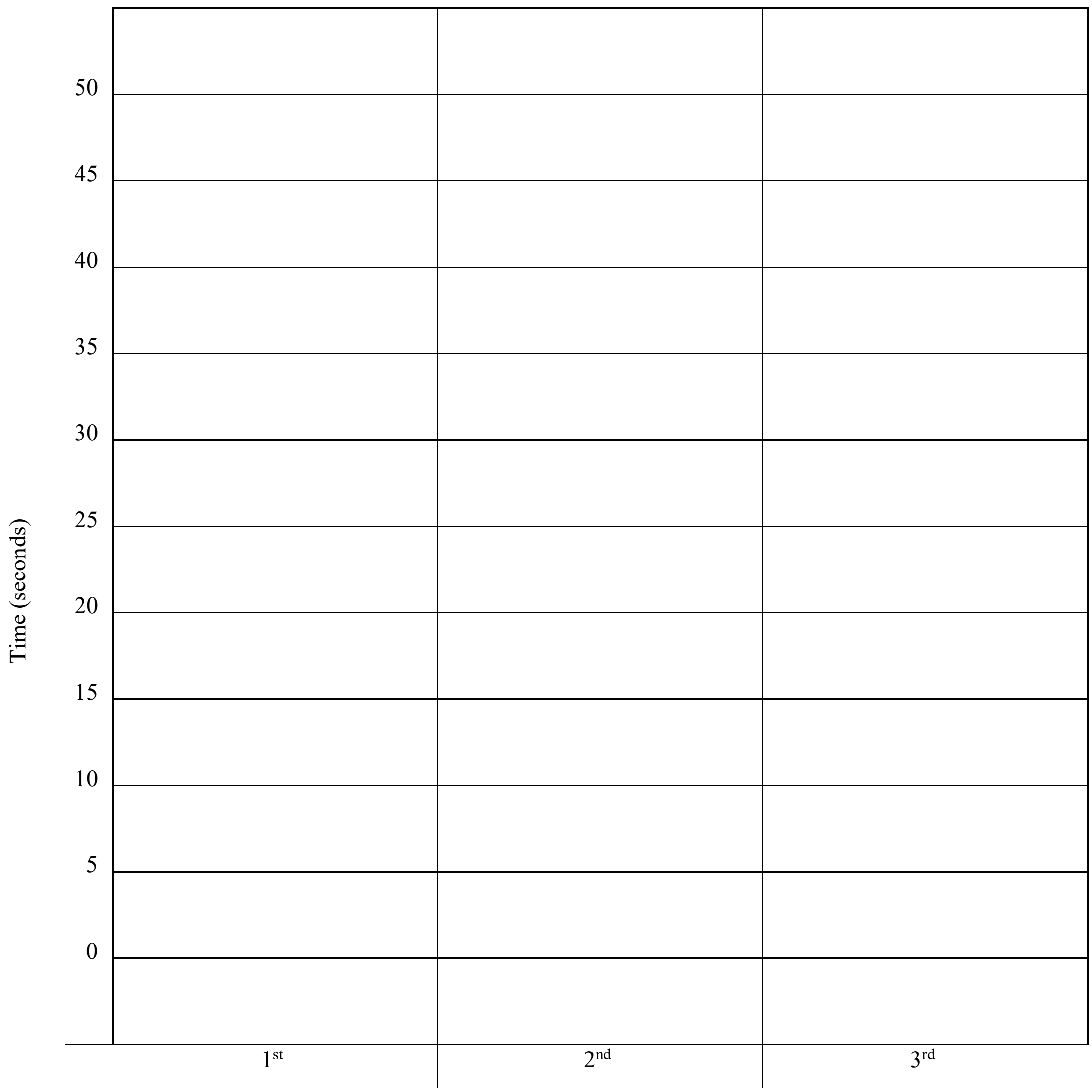
#	Sample Name and Number	Sample Observations	Permeability Prediction	Time
1				
2				
3				
4				
5				
6				
7				
8				
9				

Student Name________________________ Date _______________________

Permeability Data Graph



1. Plot your recorded times for each sample (total of 9) on the graph below.
2. Use a different color and/or symbol for each soil type.
3. Your graph will end up looking something like the plotted data on the left.
4. How does your graph compare to other groups'?



Student Name______________________ Date _____________________

Thinking about Permeability

Permeability is the rate at which water will flow through soil or rocks. Highly permeable materials, such as gravel and sand, allow water to move quickly through them. Materials with low permeability, such as clay, don't allow water to flow through freely. Some materials have no permeability; we call those “impermeable” or “impervious.”

Think about examples in your everyday life. You get stuck waiting for the bus in the rain. Your jeans are permeable (water soaks in), but your raincoat is impermeable (hopefully) so that your upper half is dry. What are some other materials that are permeable?

Permeability also refers to the degree to which soils and rock are interconnected, depending upon size and shape of pore spaces and the size and shape of their interconnections. Generally, the coarser (containing more large particles like sand and gravel) the soil, the more permeable it is. However, if the pore spaces are not well connected, the permeability will be low.

Water will run through more permeable soils at a faster rate than through soils with small particles and/or less connectivity. This concept (along with porosity) is important in understanding how water soaks through the ground (infiltrates) into an aquifer, a key component of the complex relationship between surface water and groundwater.

What are the important vocabulary words in these paragraphs?

What are the main ideas in these paragraphs?

Why is *permeability* important in the relationship between surface water and groundwater?

Background on Permeability

Permeability is the ability of a material to allow the passage of a liquid such as water through rocks. Permeable materials, such as gravel and sand, allow water to move quickly through them, whereas impermeable materials, such as clay, don't allow water to flow freely.

Permeability also refers to the degree to which soils and rock are interconnected, depending upon size and shape of pores and the size and shape of their interconnections. Generally, the coarser (containing more larger particles like sand and gravel) the soil, the more permeable it is. However, if the pore spaces are not well connected, the permeability will be low.

Water will run through more permeable soils at a faster rate than through soils with small particles and/or less connectivity. This concept (along with porosity) is important in understanding how water soaks through the ground (infiltrates) into an aquifer, a key component of the complex relationship between surface water and groundwater.

Vocabulary

Permeable — any material that allows water to pass between particles or cracks

Impermeable — any material that does not allow water to pass through it

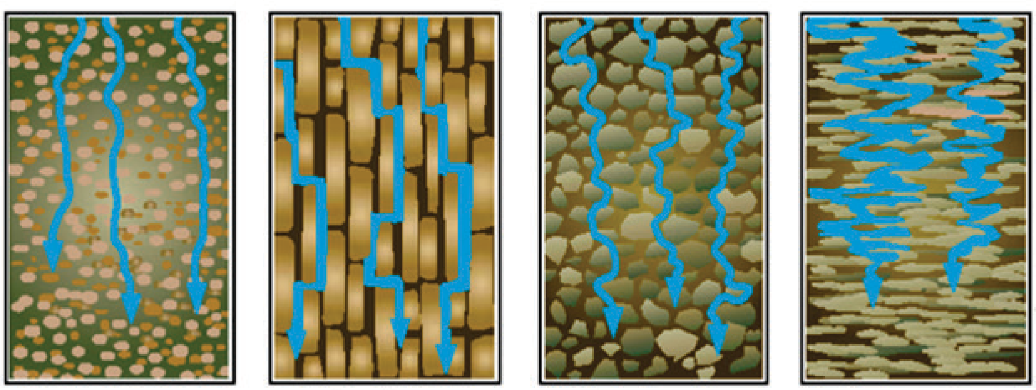
Permeability — the ability of rocks or soil to allow the passage of water

Particle — a very small piece of something bigger

Pores — the spaces found between particles of soil, sand or gravel

Porosity — the percentage of empty spaces in a volume of rock or soil

Infiltration — the downward movement of water through another substance



Water <u>infiltrates</u> soil and rock according to the <u>porosity</u> and <u>permeability</u> of the material.

Groundwater Contamination: Point and Nonpoint Sources

Lesson Introduction: For the Teacher

A serious threat to both humans and wildlife is groundwater contamination. Though the figure will vary from year to year, approximately 63% of the water used in Texas comes from underground.

Polluted groundwater is more difficult to detect than polluted rivers or lakes because the pollutants generally cannot be seen or smelled, and serious contamination problems can occur before they are detected. In this lesson, students will build and experiment with a model aquifer in order to investigate how pollutants get into groundwater. Pollution comes from both point sources and nonpoint sources.

Half of your small groups of students will investigate point source pollution and half will investigate nonpoint source pollution. Plan enough time to allow groups to share and discuss their findings.

This activity is intended to give you a great deal of flexibility and includes opportunities to make the activity more of an inquiry investigation. A synthesis and writing extension helps students practice literacy skills by asking them to write about their investigations.

Completing all three of the activities will give students an opportunity for an in-depth investigation into meaningful and important content areas. Doing all three activities will give you the following assessment data points.

Formative assessments:

- Discussions
- Observations of student investigations
- Data sheets - predictions, observations, and conclusions
- Lists of student-generated questions
- Inquiry investigation planning sheets

Time

Day One

Science experiments – 50 minutes

Day Two

Inquiry extension – 50 minutes

Homework - Assessment Extension Synthesis and Writing

Materials

For the teacher

- Whiteboard and markers OR large chart paper and markers

Science experiments

- Data sheets
- Clear plastic tray (at least 4" deep)
- Dry sand
- Gravel
- Powdered red drink mix
- Small cups
- Paper towels
- 12-inch rulers or similarly sized flat pieces of wood

Inquiry extensions

- Inquiry planning sheets
- Clear plastic tray (at least 4" deep)
- Dry sand
- Gravel
- Powdered red drink mix
- Small cups
- Paper towels
- Aluminum foil
- Clay
- Plastic wrap
- Plant materials (grasses, leaves, twigs, etc.)

Summative assessment:

Groundwater Assessment — Literacy through Science

Preparation

- Divide students into groups of 4.
- Copy data sheets. Distribute one data sheet to each student. Be sure to note the title on the data sheets, which vary slightly depending on whether students will investigate point source or nonpoint source pollution.

Background Information

Pollutants are considered hazardous based on four characteristics:

1. Ignitability - how flammable is the substance. Examples: oil and other petroleum based products.
2. Corrosivity - a function of the pH of a substance; the acidity or alkalinity of the pollutant. Examples: Leaking batteries, solvents like toluene.
3. Reactivity - a measure of how easily the substance reacts with water or air to produce heat or explosion. Examples: Hydrogen and chlorine.
4. Toxicity - a measure of how dangerous the substance is to living things. Examples: Ammonia, benzene.

(For more information, visit www.epa.gov/osw/hazard/wastetypes/characteristic.htm)

Once groundwater has become polluted, it is very difficult and expensive to clean.

In this activity, students will investigate two types of groundwater contamination: point source and nonpoint source. Point source contamination originates directly from identifiable sources of contamination such as a factory discharge pipe, leaking chemicals from storage tanks, septic systems, and landfills. Nonpoint source contamination originates from pollution such as pesticides, fertilizers, or acid precipitation that does not enter the groundwater at any one specific point.

Official definitions from "Watershed Planning Glossary of Terms" by the EPA:

Nonpoint source: Diffuse pollution source; a source without a single point of origin or not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm water. Common nonpoint sources are agriculture, forestry, urban areas, mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Point source: A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution, such as a pipe, ditch, ship, ore pit, or factory smokestack.

Grade Level	**TEKS**
Grade 6 Science	Scientific Investigations and Reasoning 1. B 2. B, D, E
Grade 7 Science	Scientific Investigations and Reasoning 1. B 2. B, D, E
Grade 8 Science	Scientific Investigations and Reasoning 1. B 2. B, D, E

Procedure

Day One

Tap Prior Knowledge

Ask students to think about where things "go" when they go "away."

- Where does litter go?
- When cars leak oil, where does the oil go?
- When you put fertilizer on your lawn and it rains, where does the fertilizer go?
- When leaves fall off the trees, where do they go?
- When you flush the toilet or run water through your washing machine, where does it go?

Share with Neighbor

Ask students to work in their small groups to brainstorm where each of these things go. Have them draw a simple map showing how each of these substances gets to where it is going.

Give students time to share their maps and ideas about where things go with the whole class.

Introduce Vocabulary

Contaminants in our water systems are either point source or nonpoint source pollutants. As you discuss the following concepts with students, ask them to categorize the substances on their maps as either point source or nonpoint source pollution.

Groundwater contamination — the pollution of groundwater and associated springs and wells. Some sources of groundwater contamination include:

- used oils, paint thinners, gasoline, and other petroleum-based products;
- leaking storage tanks (e.g. underground storage tanks, above ground storage tanks, home heating fuel tanks, kerosene tanks);
- overuse of pesticides, herbicides, and fertilizers that may be used on lawns, golf courses, and agricultural fields;
- chemical spills at businesses, farms, and along highways (e.g. solvents, petroleum products);
- illegal dumps and poorly managed landfills; and
- failing septic tanks.

Pollutant — a material that contaminates air, soil, or water. Toxic chemicals and nutrients are considered the major groups of groundwater pollutants.

Aquifer — an underground geologic formation that contains water

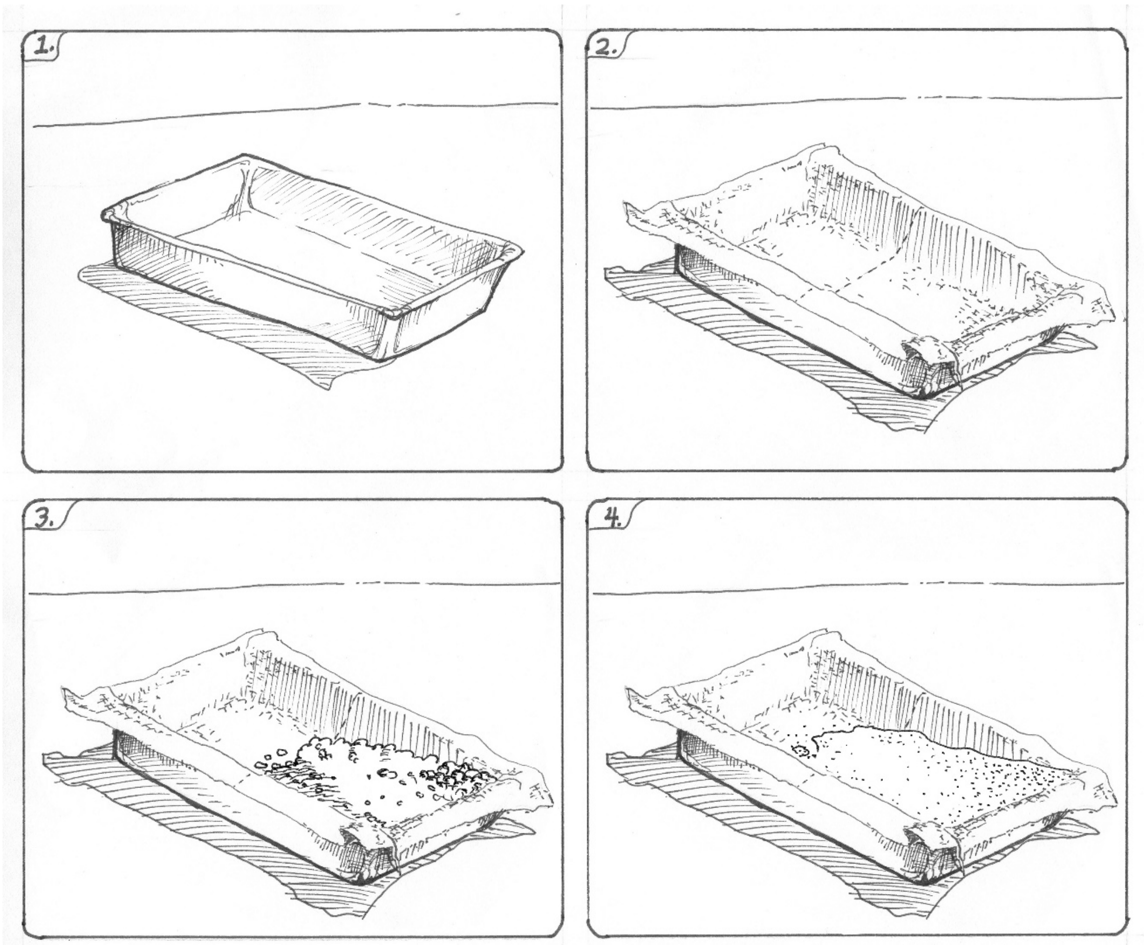
Point source and nonpoint source pollution — *see Background page*

Engage Students in a Hands-on Activity

1. Explain to students that they will create a model to investigate pollution. Split small groups of students into two categories: half of the small groups will investigate **point sources** of pollution and half will investigate **nonpoint** sources.

2. Distribute materials. Begin building the model by putting a paper towel on the bottom of the container. Make sure that several centimeters of the towel are draped over the edge of the container. Place 3 centimeters of gravel on the bottom of the tray atop the paper towel. Create a gradual slope across the surface of the gravel creating an empty space at one edge of the tray representing a lake (see box 3 below).

3. Place a loose, thin layer of sand over the gravel.



Instructions for nonpoint source pollution groups

1. **Nonpoint source pollution groups** will spread 20 grams of powdered drink mix over the sand. The drink mix represents a pollutant such as pesticides or fertilizers. Ask them to think about what will happen to the pollutant when rain falls on the ground. Have them write their predictions on their data sheets.

2. Sprinkle warm water on top. Have students observe and record their observations on their data sheets. Compare the results to their predictions. As the water moves through the sand, it dissolves the drink mix and the color will mix with the water.

3. Observe the paper towel that was placed under the gravel. What has happened to it? How and why do the students think this occurred? Ask students to record all their observations on their data sheets. What does the paper towel represent?

4. Have the groups draw conclusions about what they have observed.

5. Have the groups write down a list of 3–5 questions that they have about what they observed.

Instructions for point source pollution groups

1. **Point source pollution groups** will put 20 grams of powdered drink mix in a small cup and dissolve it with water.

2. Ask them to think about what will happen to the pollutant when it is "discharged" or spilled onto the ground. Students should record their predictions of what will happen when they pour the pollutant on the sand.

3. Place a 12-inch ruler or similarly sized piece of wood across the pan over the sand layer of your landscape. Poke a hole in the bottom of a second plastic cup then balance the cup on the ruler. Pour the dissolved pollutant into the cup perched atop the ruler. The dissolved "pollutant" will spill onto the layer of sand through the hole in the cup. Have students record their observations.

4. Have the groups draw conclusions about what they have observed.

5. Have the groups write down a list of 3-5 questions that they have about what they observed.

Discuss the Scientific Principle

Ask students from each set of groups (point and nonpoint sources) to report the predictions, observations, and conclusions from their investigations. Collect their predictions, observations, and conclusions on a whiteboard or large pieces of chart paper.

Ask students to share the questions they had related to what they observed. Collect their questions on a whiteboard or large piece of chart paper,

Refer students to their experiments and the information they recorded on their data sheets. Pollutants contaminated their aquifer in two ways—through point and nonpoint sources.

The first was nonpoint source pollution from surface water runoff. When they made it "rain" on their landscapes, pollutants (colored drink mix) washed across the surface and carried the pollutants into rivers, lakes, and eventually into the groundwater (aquifer).

The second experiment demonstrated groundwater contamination by a point source. The student saw this when they poked a hole in their cup full of "pollutants" and it spilled onto their landscape.

In each case, they should have observed that the colored drink mix "pollutant" stained the paper towels as it infiltrated the sand and gravel and entered the groundwater. Water drawn from underneath a contaminated source is itself contaminated if the geologic materials are porous and permeable. Drinking water wells can be contaminated even miles away from the source of the pollution.

Relate Activity and Concept

Ask the students how their observations from this model relate back to their lists of things that "go away" made at the beginning of the experiment. Discuss the effects that pollutants such as litter and leaking septic tanks have on water sources.

In preparation for the next day's Inquiry Extension, ask students to work in their small groups to identify from their list of questions the one question they are most interested in investigating further. Distribute an **Inquiry Planning Sheet** to each student. Give them a few minutes to design a plan for the next day's investigation. If their plan involves materials beyond what you will provide, ask them to bring them from home.

Day Two: Inquiry Extension

Begin by asking each group to identify the one question they will investigate. Have each group build a second model using the same steps as day one.

1. Distribute fresh data sheets to each student. Students should record their predictions.
2. As they investigate their question, students should record their observations.
3. Ask students to record their conclusions on their data sheets.
4. Ask students to share their findings. Gather their questions, observations, and conclusions on a whiteboard or large sheets of chart paper.

Groundwater Assessment: Literacy through Science

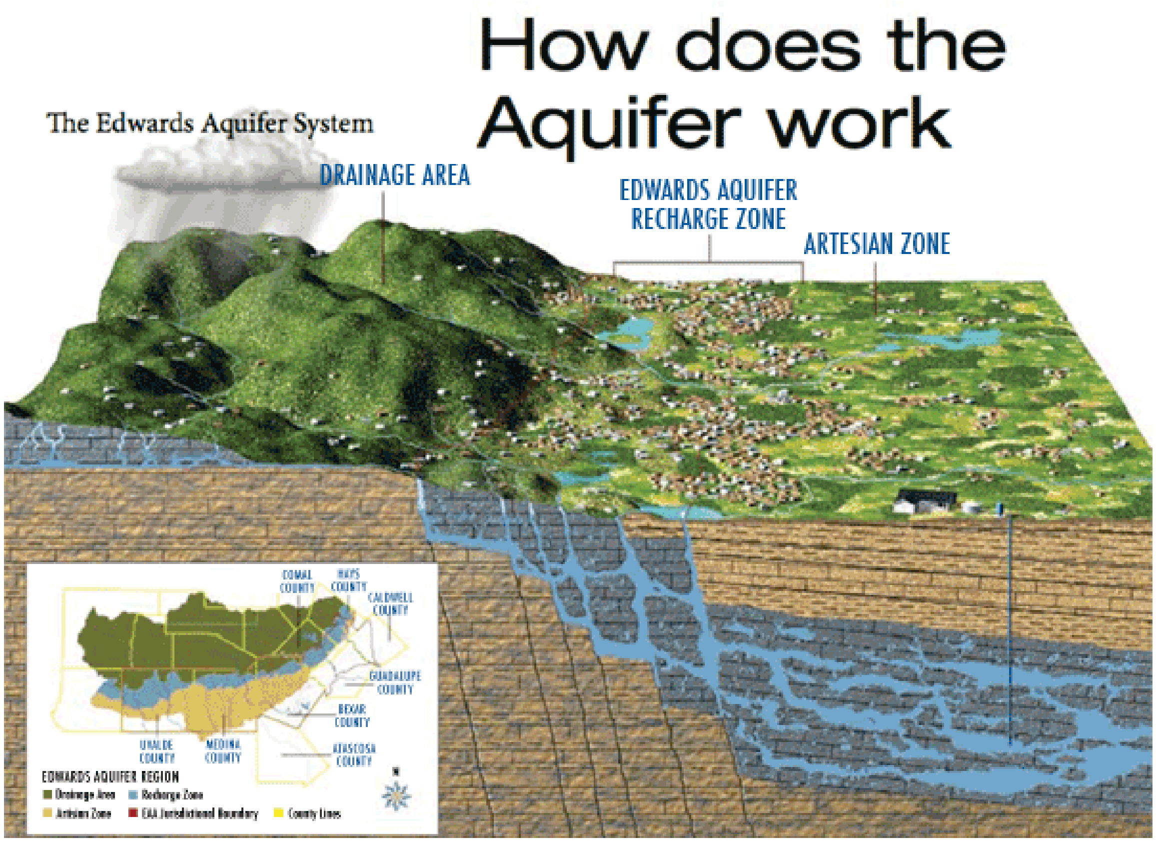
Synthesis and Writing

Distribute the **Background on Groundwater** and Groundwater Contamination sheets to students. Ask them to read the paragraphs and respond to the questions that follow.

Use this assessment to check student understanding of groundwater and pollution and as an opportunity to practice literacy skills as they learn scientific concepts.

For more information about groundwater in Texas and specific information about the type of aquifer located near you, visit the Texas Water Development Board's Groundwater page at www.twdb.texas.gov/groundwater/ or view the "Aquifers of Texas" (TWDB Report 380). For more information on the sources of drinking water near you, visit www.WaterIQ.org .

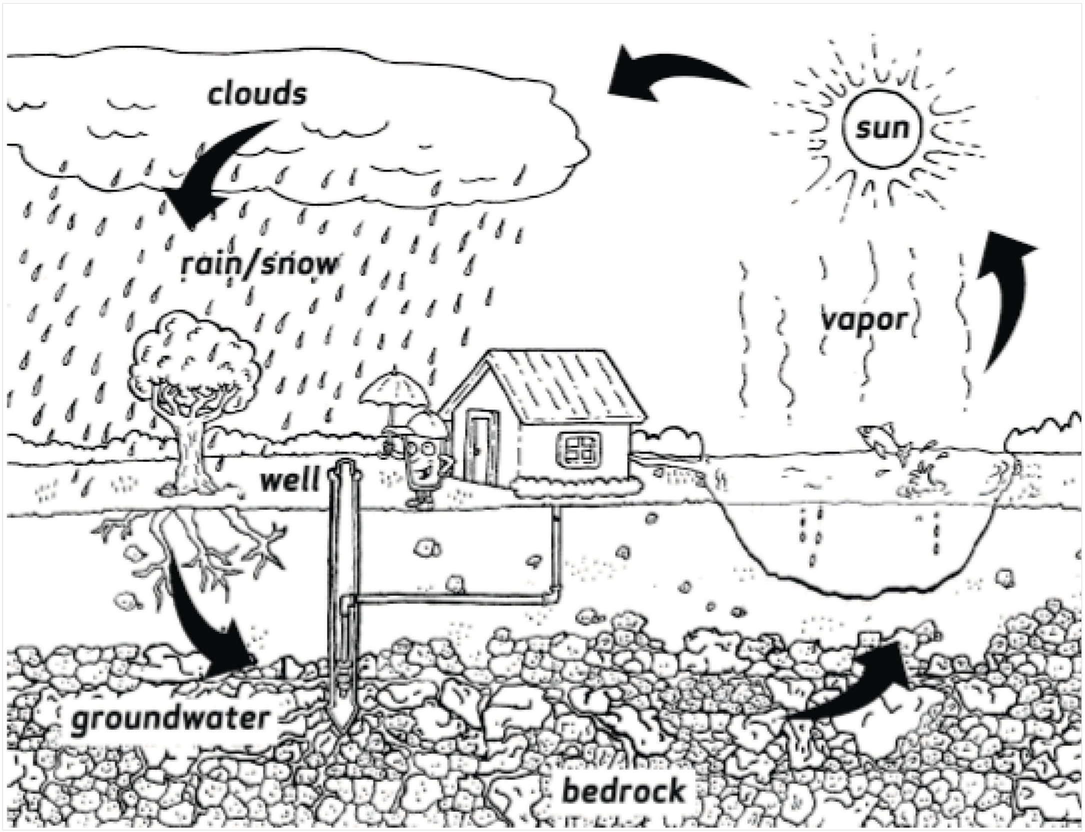
Maps and related files of major and minor aquifers of Texas can be found online.



(from www.edwardsaquifer.org)

Background on Groundwater

Groundwater comes from moisture that soaks into the ground. Moisture can come from rain, snow, sleet, or hail. The water infiltrates, passing between particles of soil, sand, gravel, or rock, due to gravity. This is an essential part of the water cycle.



Vocabulary

Pollutant — a material that contaminates air, soil, or water. Toxic chemicals and nutrients are considered the major groups of groundwater pollutants.

Aquifer — an underground geologic formation that contains water

Groundwater contamination — the pollution of groundwater and associated springs and wells

Nonpoint source pollution — pollution that occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water

Point source pollution — pollution originating from a single point such as pipes, ditches, wells, vessels, and containers

Student Name____ Date _____________

Groundwater Contamination

Groundwater comes from moisture that soaks into the ground. Moisture can come from rain, snow, sleet, or hail. The water infiltrates, passing between particles of soil, sand, gravel, or rock, due to gravity. This is an essential part of the water cycle.

Groundwater can move through the ground and discharge into a lake or stream via springs and seeps. Also, water in a lake can soak down into the ground and become groundwater.

Groundwater is stored in the ground in the tiny spaces, or pores, between particles of gravel or sand. Water can also move through cracks in some rock formations. An area that holds a lot of water underground is called an aquifer. Wells drilled deep into the ground pump groundwater from the aquifer. Pipes deliver the water to cities, houses in the country, or to crops.

Most of the groundwater in Texas is clean and drinkable, but groundwater can become polluted or contaminated. When pollutants leak, spill, or are carelessly dumped on the ground, they can move with water through the soil. As you saw in your investigations, these pollutants can contaminate the groundwater.

List the important vocabulary words in these paragraphs.

How are surface water and groundwater connected?

What is meant when we say: "Pollutants do not 'go away; there is no 'away'"?

What is one thing you can do to prevent groundwater contamination?

Student Name____ Date _____________

Student Data Sheet: Groundwater Contamination – Nonpoint Source Pollution

For this experiment, you will follow the instructions to create a model. Record your predictions, descriptions, observations, and conclusions in the spaces provided.

Prediction — What do you think will happen when you pour water (rain) over your landscape and your pollutant?

Description — Describe the physical properties of each of the soils in your landscape.

Observation — Record what happens when you pour water (rain) over your landscape and your pollutant. Record ONLY what you see happening and be specific. Try to observe EVERYTHING you see happening.

Conclusion — Why do you think this happened? Why are pollutants harmful to groundwater?

Student Name____ Date _____________

Student Data Sheet: Groundwater Contamination – Point Source Pollution

For this experiment, you will follow the instructions to create a model. Record your predictions, descriptions, observations, and conclusions in the spaces provided.

Prediction — What do you think will happen when you pour the water and dissolved drink mix into the perched cup? What does this cup represent?

Description — Describe the physical properties of each of the soils in your landscape.

Observation — Record what happens when you introduce the dissolved pollutant to your landscape. Record ONLY what you see happening and be specific. Try to observe EVERYTHING you see happening.

Conclusion — Why do you think this happened? Why are pollutants harmful to groundwater?

Student Name____ Date _____________

Investigation Question:

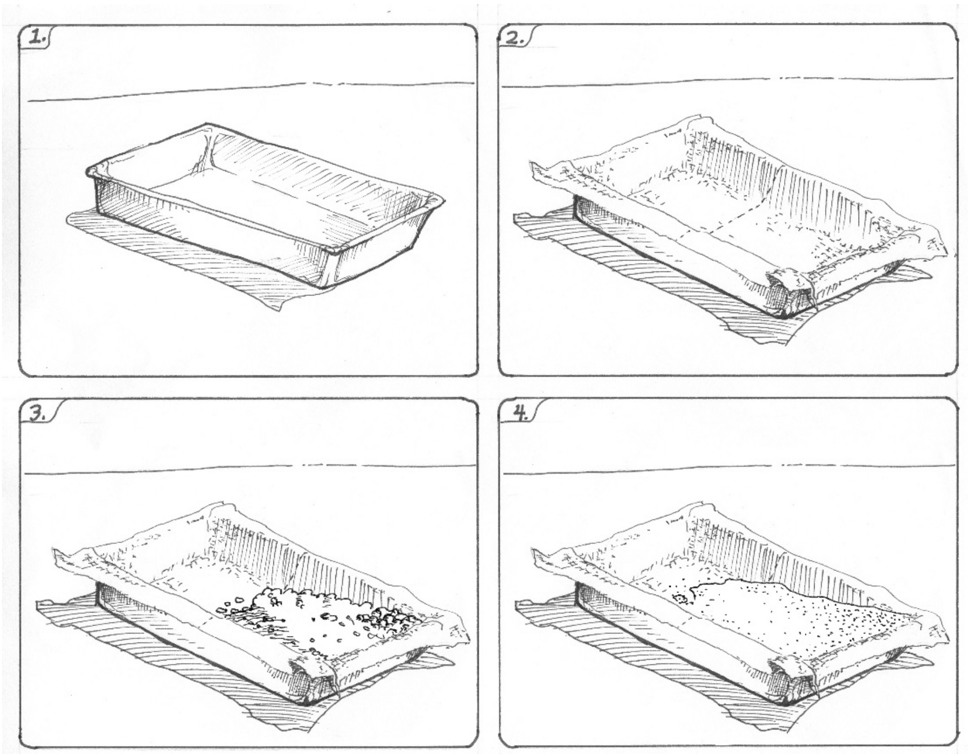
Materials needed for my investigation:

My first step will be to

My next step will be to

Instructions for Nonpoint Source Pollution Groups

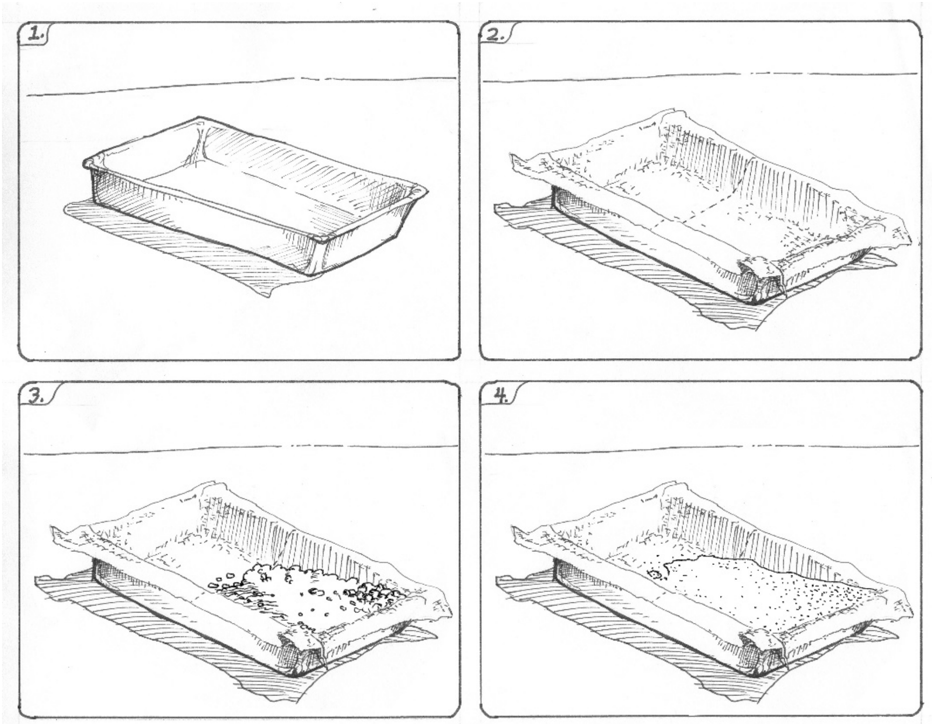
1. Begin building the model by putting a paper towel on the bottom of the container. Make sure that several centimeters of the towel are draped over the edge of the container.
2. Place 3 centimeters of gravel on the bottom of the tray atop the paper towel. Create a gradual slope across the surface of the gravel creating an empty space at one edge of the tray representing a lake (see box 3 below).
3. Place a loose, thin layer of sand over the gravel.



4. Spread 20 grams of powdered drink mix over the sand. The drink mix represents a pollutant such as pesticides or fertilizers.
5. On your data sheet, predict what will happen when rain falls on your landscape.
6. Sprinkle warm water on top of your landscape. Observe and record on your data sheets what happens to the pollutant as the water spreads across and through your landscape. Compare the results to your predictions.
7. Observe the paper towel you placed under the gravel. What happened to it? How and why do you think this occurred? Record your observations and conclusions on your data sheets.
8. As a group, write down a list of 3-5 questions you have about what you observed.

Instructions for Point Source Pollution Groups

1. Begin building the model by putting a paper towel on the bottom of the container. Make sure that several centimeters of the towel are draped over the edge of the container.
2. Place 3 centimeters of gravel on the bottom of the tray atop the paper towel. Create a gradual slope across the surface of the gravel creating an empty space at one edge of the tray representing a lake (see box 3 below).
3. Place a loose, thin layer of sand over the gravel.



4. Put 20 grams of powdered drink mix in a small cup and dissolve it with water. The drink mix represents a pollutant such as from a leaking gas tank.
5. On your data sheet, predict what will happen to the pollutant when it is "discharged" or spilled onto the ground.
6. Place a 12-inch ruler or similar sized piece of wood across the pan over the sand layer of your landscape. Poke a hole in the bottom of a second plastic cup then balance the cup on the ruler.
7. Pour the dissolved pollutant into the cup perched atop the ruler. The dissolved "pollutant" will spill onto the layer of sand through the hole in the cup. Record your observations of what happens on your data sheet. Compare the results to your predictions.
8. Observe the paper towel you placed under the gravel. What happened to it? How and why do you think this occurred? <u>Record</u> your observations and conclusions on your data sheets.
9. As a group, write down a list of 3-5 questions you have about what you observed.

Chapter 5 **Web Quest: Water in Texas**

Where Are We?

GRADE LEVEL 6th–8th

Overview

In this activity, students will use maps to analyze average rainfall, evaporation, and distribution of water resources to discuss how those factors have influenced the distribution of people across Texas.

Materials

Maps

1. Regional Water Planning Areas
2. Major Surface Water Features
3. Major Aquifers
4. Minor Aquifers
5. Precipitation
6. Average Annual Evaporation
7. Natural Regions of Texas
8. Total Population by county
9. Population Density by county
10. Percent Population Change by county

Note: These maps are included here in grayscale. Water-related maps are also available on the TWDB website. Population maps were created using *census.gov* data.

Background

People simply cannot live without water. The availability of water is one of the leading factors impacting historical settlement patterns in Texas and throughout the world. Consider how many major cities are located near a river.

Maps make this fact of life very apparent. By analyzing maps representing different demographic and environmental data, students will see the correlations between the availability of water—an irreplaceable resource—and the patterns in nature and society.

Different methods exist for describing geographic patterns and grouping similar features together. A “region” is defined as some area having similar characteristics.

In Texas, regions could be defined as areas with similar physical characteristics (like “natural regions”), similar population characteristics (urban versus rural or “the Houston area” or “Dallas-Fort Worth”), or more vernacular similarities (“the South,” “West Texas,” or “the Panhandle”). In terms of water, the state can be divided by watershed (the Colorado River Basin) or by Regional Water Planning Areas (see map).

Preparation

Gather the needed materials. All maps are included, some in grayscale and some in color. Each team of students will need one full set of maps.

Procedure

1. Divide the class into small discussion groups of 3–4 students.
2. Distribute maps to each group.
3. Go through each of the maps and give a brief description of the data it displays. Are any patterns evident?
4. Consider discussing the features and resources near your location in addition to highlighting areas in other parts of Texas.
5. Consider allowing students to explore the maps of Texas and come up with their own ways of describing Texas in terms of separate "regions." List these on the board.
6. Ask students to discuss and answer each of the discussion questions.

To make the activity more engaging for different learning styles and to keep the activity moving, consider the following brain-friendly strategy:

- *Write each of the discussion questions on a half-sheet of paper.*
- *Fold each piece of paper in half, and number each piece of paper.*
- *Set the questions on a table or desk at the front of the room.*
- *On your signal, one representative from each group goes to the table, selects a sheet of paper, and runs back to the group. The group will work together to answer the question, and record the answer.*
- *When that question has been answered, a second representative from the group takes the paper back up to the table, drops it off, gets a second question, and returns to the group. Continue until every group has answered every question.*
- *The "relay race" element of this strategy makes the activity engaging, fast-paced and light-hearted.*

Discussion Questions

1. Which regions of Texas experience the greatest rainfall?
2. Which regions of Texas have the most surface water features? Why?
3. Which regions of Texas experience the greatest rates of evaporation?
4. Which regions of Texas have the most groundwater (aquifers)?
5. Which regions of Texas have the highest population per county? Why?
6. Which regions of Texas have the highest population density per county?
7. Why are some regions more densely populated than others?
8. How has water "shaped" Texas and certain counties in Texas?

Individual Reflection Questions

In what ways has water influenced WHERE people live in Texas?

In what ways has water influenced HOW people live in Texas?

What else, besides water, might influence where people live in Texas?

In which 'region' of Texas do you live? What characteristics define your region?

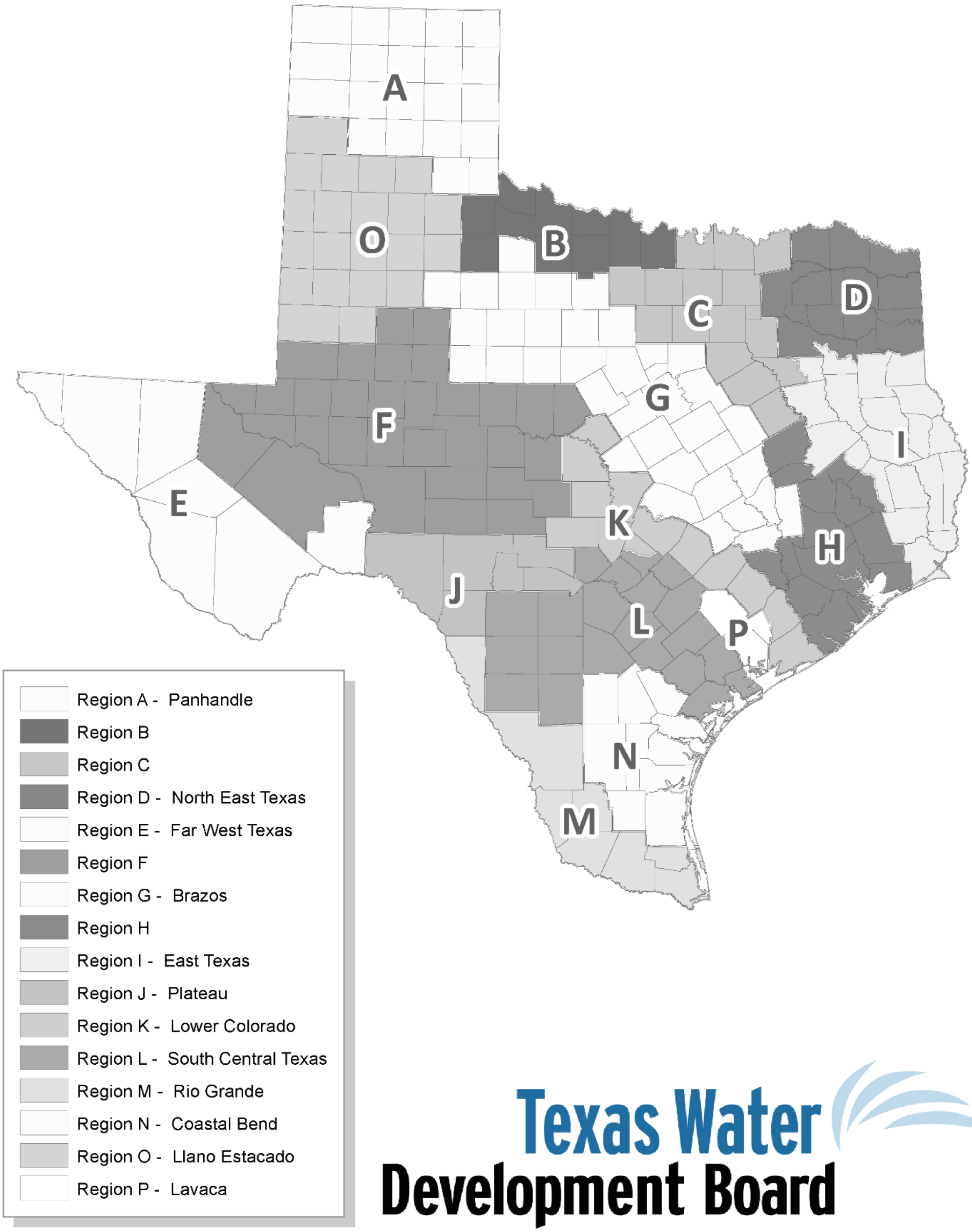
Assessing Understanding

When student groups have answered all the questions, ask each group to report their findings. If groups arrive at different interpretations, ask the groups to defend their reasoning.

Use the individual reflection questions as an individual assessment. Ask students to answer these questions with a short essay that synthesizes the information displayed on the maps with the class discussions and their own experiences.

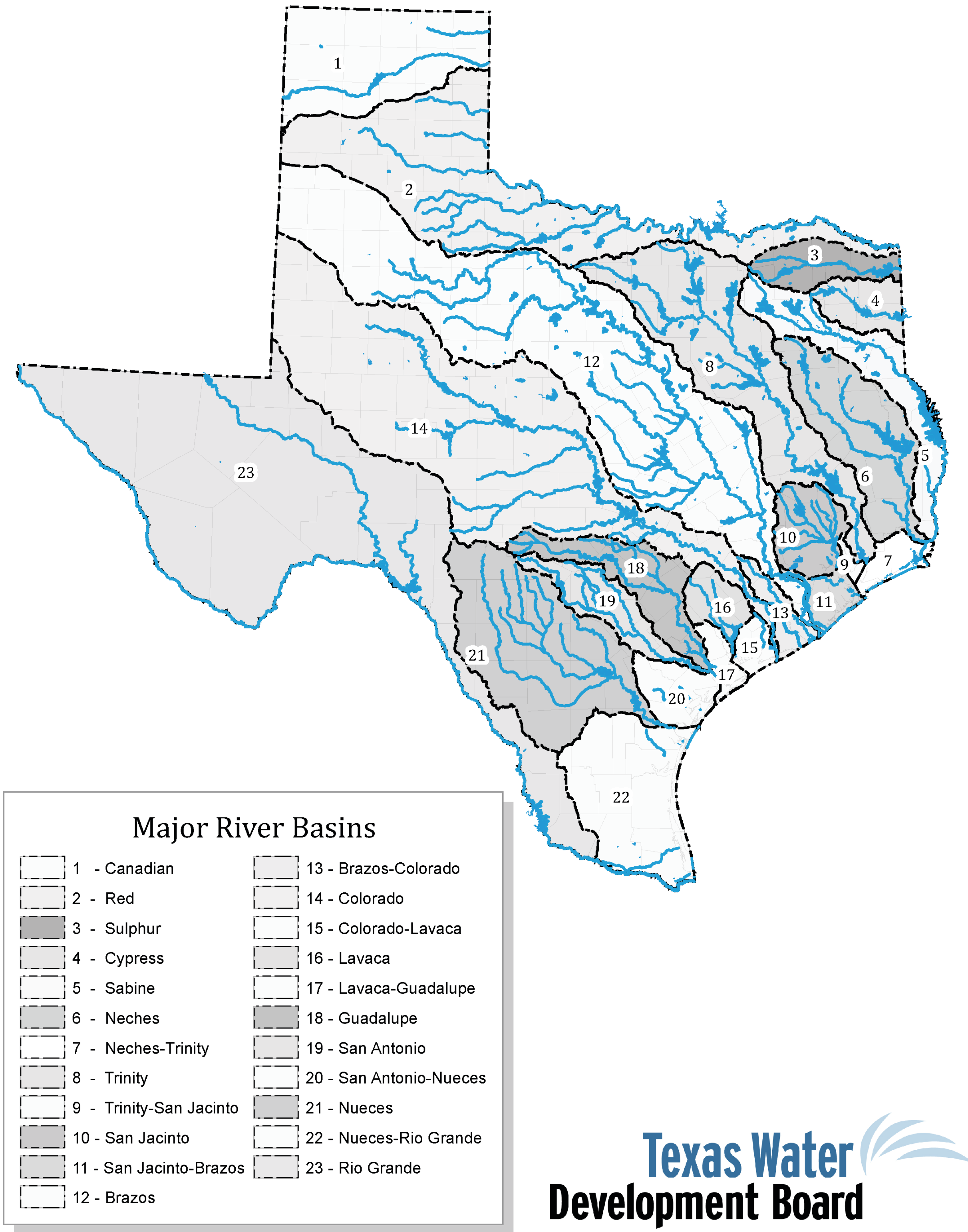
Maps for this activity are included here. Each team of students will need one full set of maps.

Regional Water Planning Areas

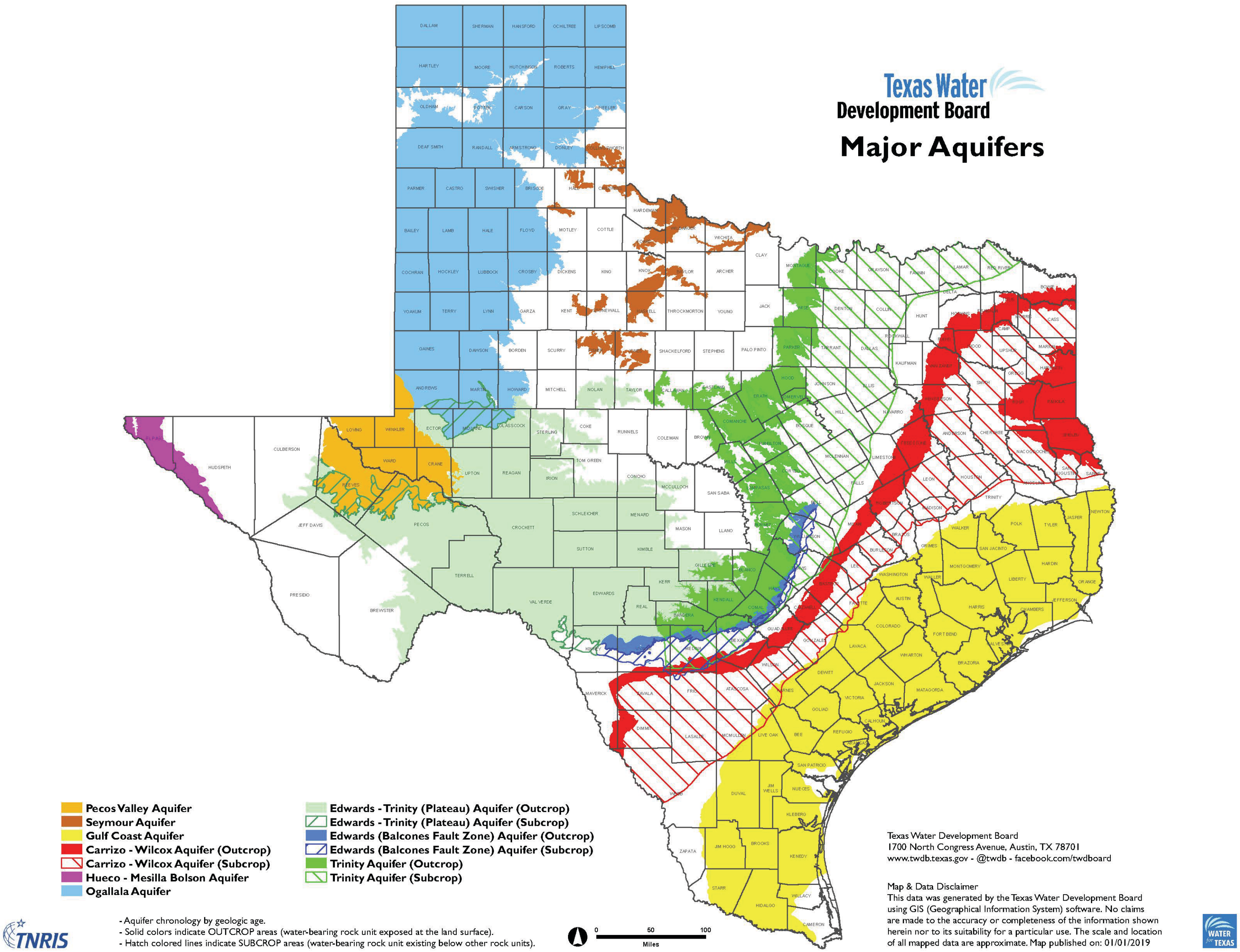


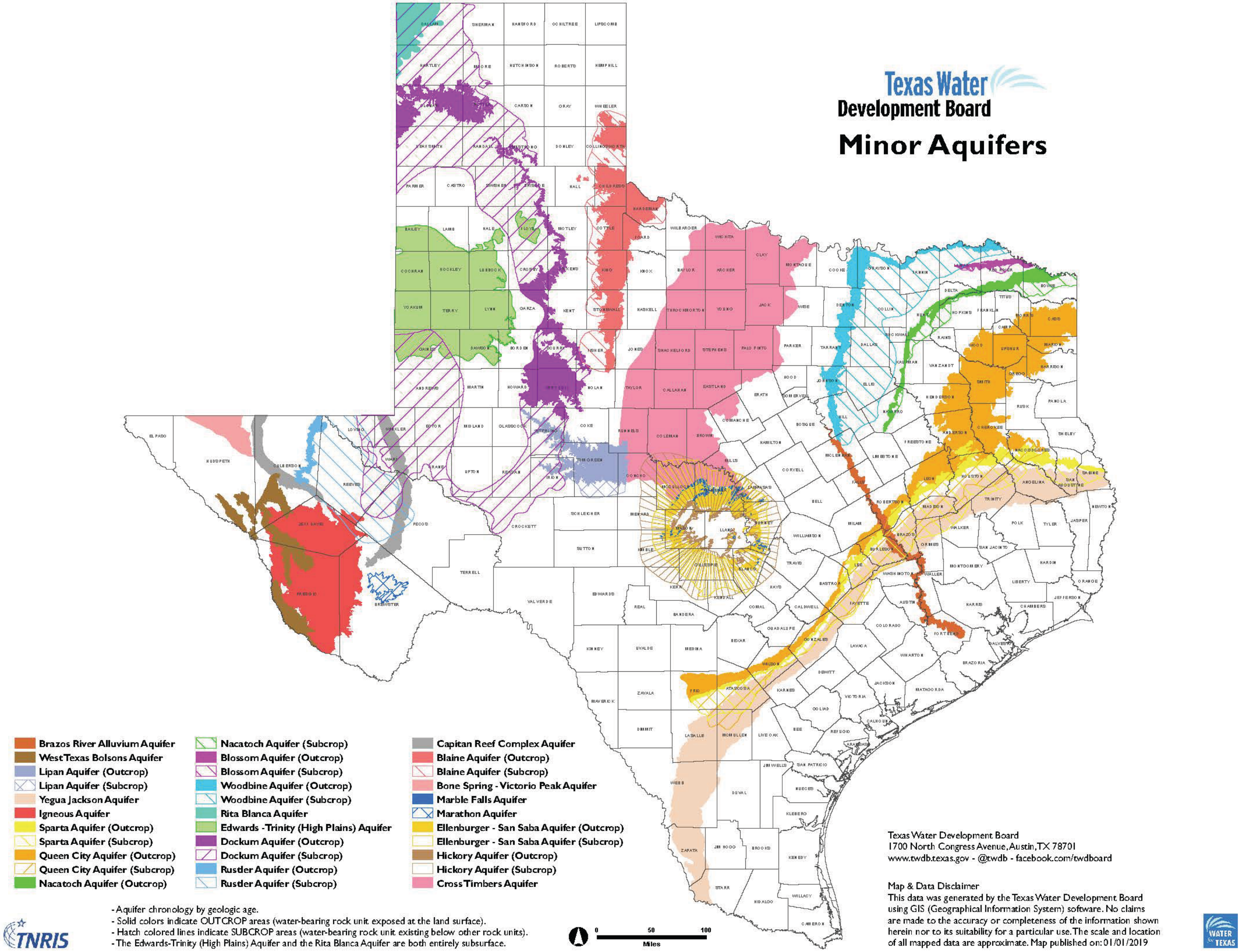
Texas Water Development Board

Major Surface Water Features



Texas Water Development Board


Texas Water Development Board
Major Aquifers
Pecos Valley Aquifer
Seymour Aquifer
Gulf Coast Aquifer
Carrizo - Wilcox Aquifer (Outcrop)
Carrizo - Wilcox Aquifer (Subcrop)
Hueco - Mesilla Bolson Aquifer
Ogallala Aquifer
Edwards - Trinity (Plateau) Aquifer (Outcrop)
Edwards - Trinity (Plateau) Aquifer (Subcrop)
Edwards (Balcones Fault Zone) Aquifer (Outcrop)
Edwards (Balcones Fault Zone) Aquifer (Subcrop)
Trinity Aquifer (Outcrop)
Trinity Aquifer (Subcrop)
TNRIS
- Aquifer chronology by geologic age.
- Solid colors indicate OUTCROP areas (water-bearing rock unit exposed at the land surface).
- Hatch colored lines indicate SUBCROP areas (water-bearing rock unit existing below other rock units).
0 50 100
Miles
Texas Water Development Board
1700 North Congress Avenue, Austin, TX 78701
www.twdb.texas.gov - @twdb - facebook.com/twdboard
Map & Data Disclaimer
This data was generated by the Texas Water Development Board using GIS (Geographical Information System) software. No claims are made to the accuracy or completeness of the information shown herein nor to its suitability for a particular use. The scale and location of all mapped data are approximate. Map published on: 01/01/2019
WATER for TEXAS


Texas Water Development Board
Minor Aquifers
Brazos River Alluvium Aquifer
West Texas Bolsons Aquifer
Lipan Aquifer (Outcrop)
Lipan Aquifer (Subcrop)
Yegua Jackson Aquifer
Igneous Aquifer
Sparta Aquifer (Outcrop)
Sparta Aquifer (Subcrop)
Queen City Aquifer (Outcrop)
Queen City Aquifer (Subcrop)
Nacatoch Aquifer (Outcrop)
Nacatoch Aquifer (Subcrop)
Blossom Aquifer (Outcrop)
Blossom Aquifer (Subcrop)
Woodbine Aquifer (Outcrop)
Woodbine Aquifer (Subcrop)
Rita Blanca Aquifer
Edwards -Trinity (High Plains) Aquifer
Dockum Aquifer (Outcrop)
Dockum Aquifer (Subcrop)
Rustler Aquifer (Outcrop)
Rustler Aquifer (Subcrop)
Capitan Reef Complex Aquifer
Blaine Aquifer (Outcrop)
Blaine Aquifer (Subcrop)
Bone Spring - Victorio Peak Aquifer
Marble Falls Aquifer
Marathon Aquifer
Ellenburger - San Saba Aquifer (Outcrop)
Ellenburger - San Saba Aquifer (Subcrop)
Hickory Aquifer (Outcrop)
Hickory Aquifer (Subcrop)
Cross Timbers Aquifer
- Aquifer chronology by geologic age.
- Solid colors indicate OUTCROP areas (water-bearing rock unit exposed at the land surface).
- Hatch colored lines indicate SUBCROP areas (water-bearing rock unit existing below other rock units).
- The Edwards-Trinity (High Plains) Aquifer and the Rita Blanca Aquifer are both entirely subsurface.
TNRIS
0 50 100
Miles
Texas Water Development Board
1700 North Congress Avenue, Austin, TX 78701
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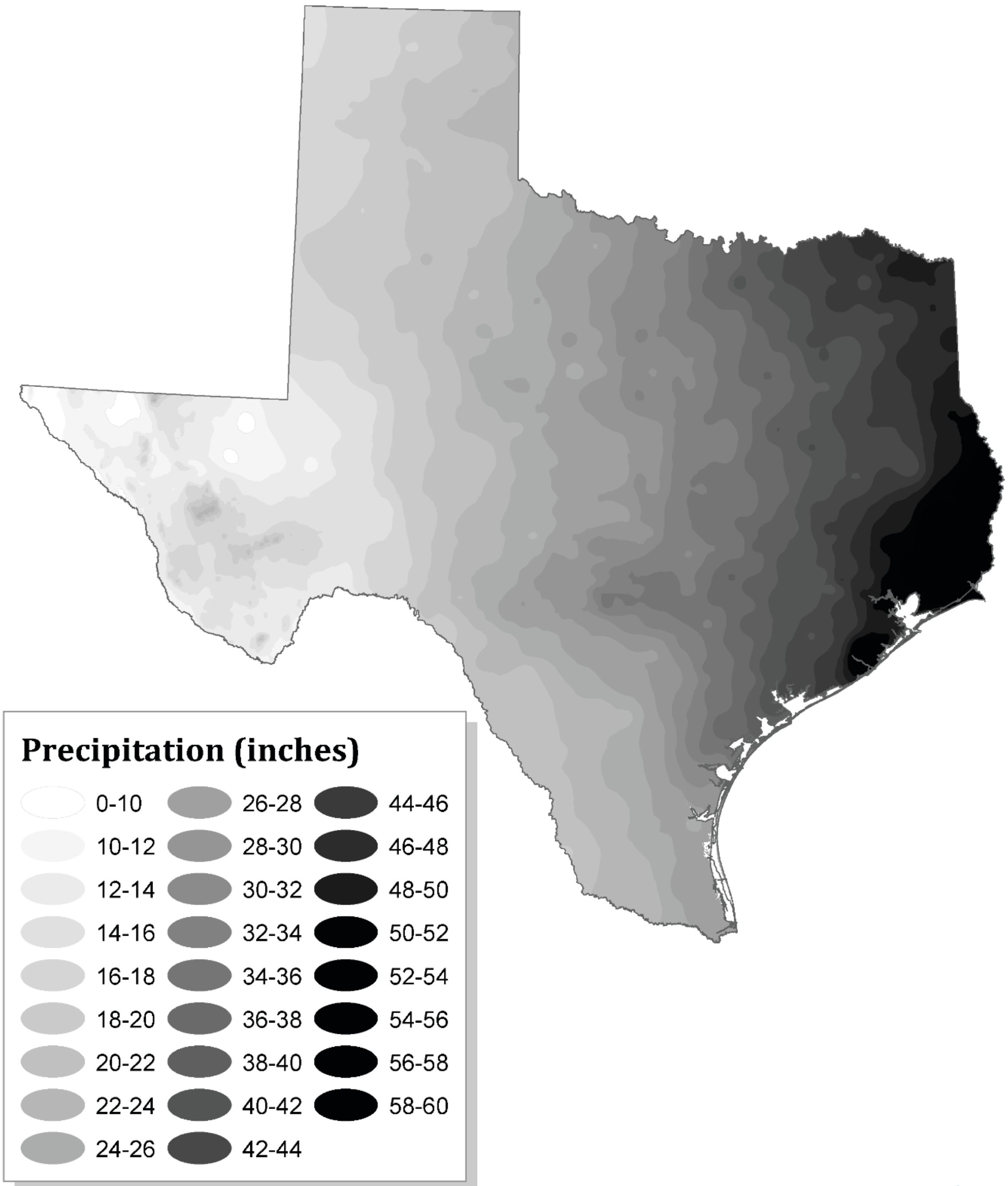
WATER for TEXAS

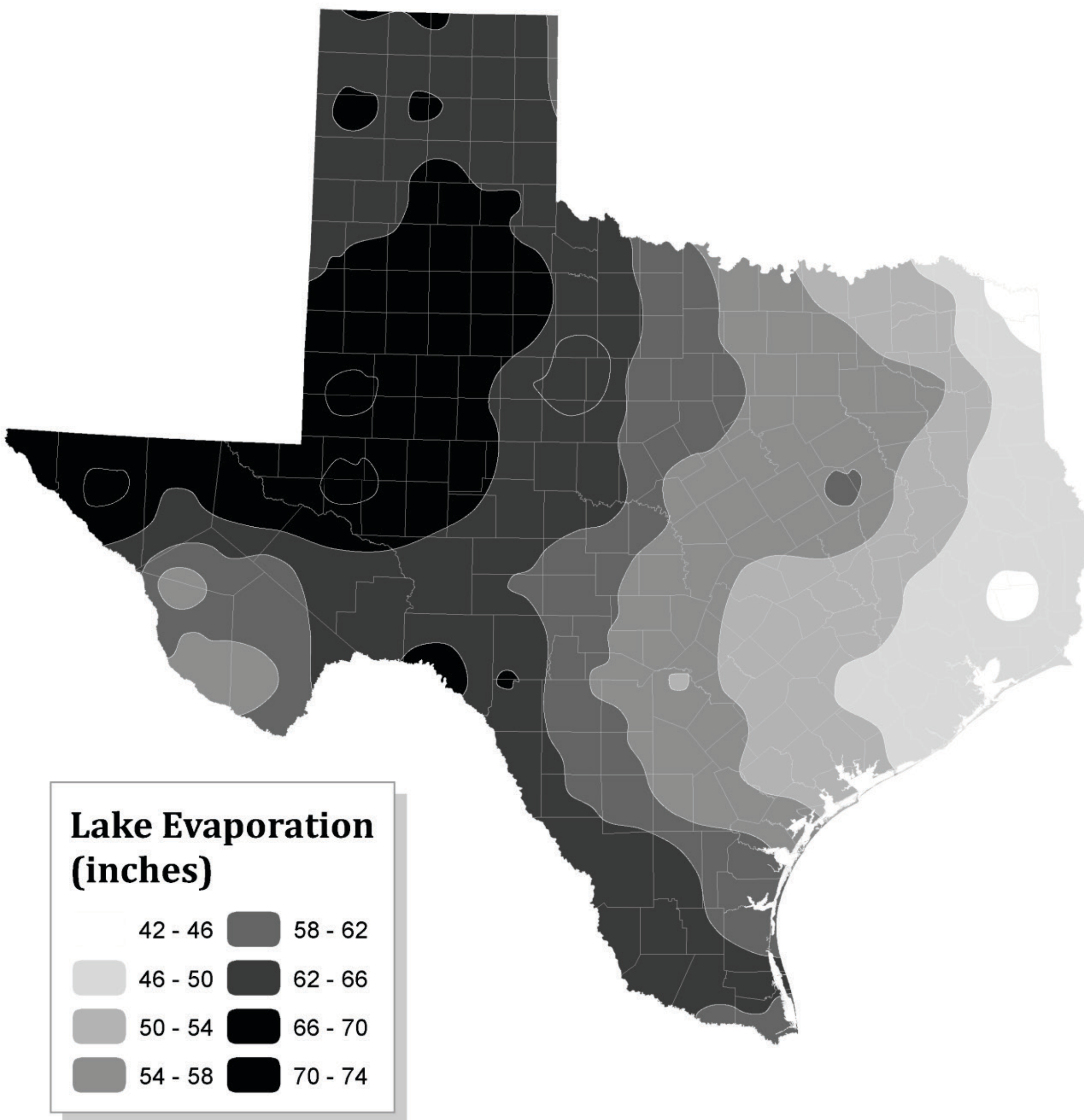
Average Annual Precipitation



Source: Natural Resources Conservation Service (NRCS) Water and Climate Center, NRCS National Cartography and Geospatial Center (NCGC), PRISM Model, and the Oregon Climate Service at Oregon State University.

Texas Water Development Board

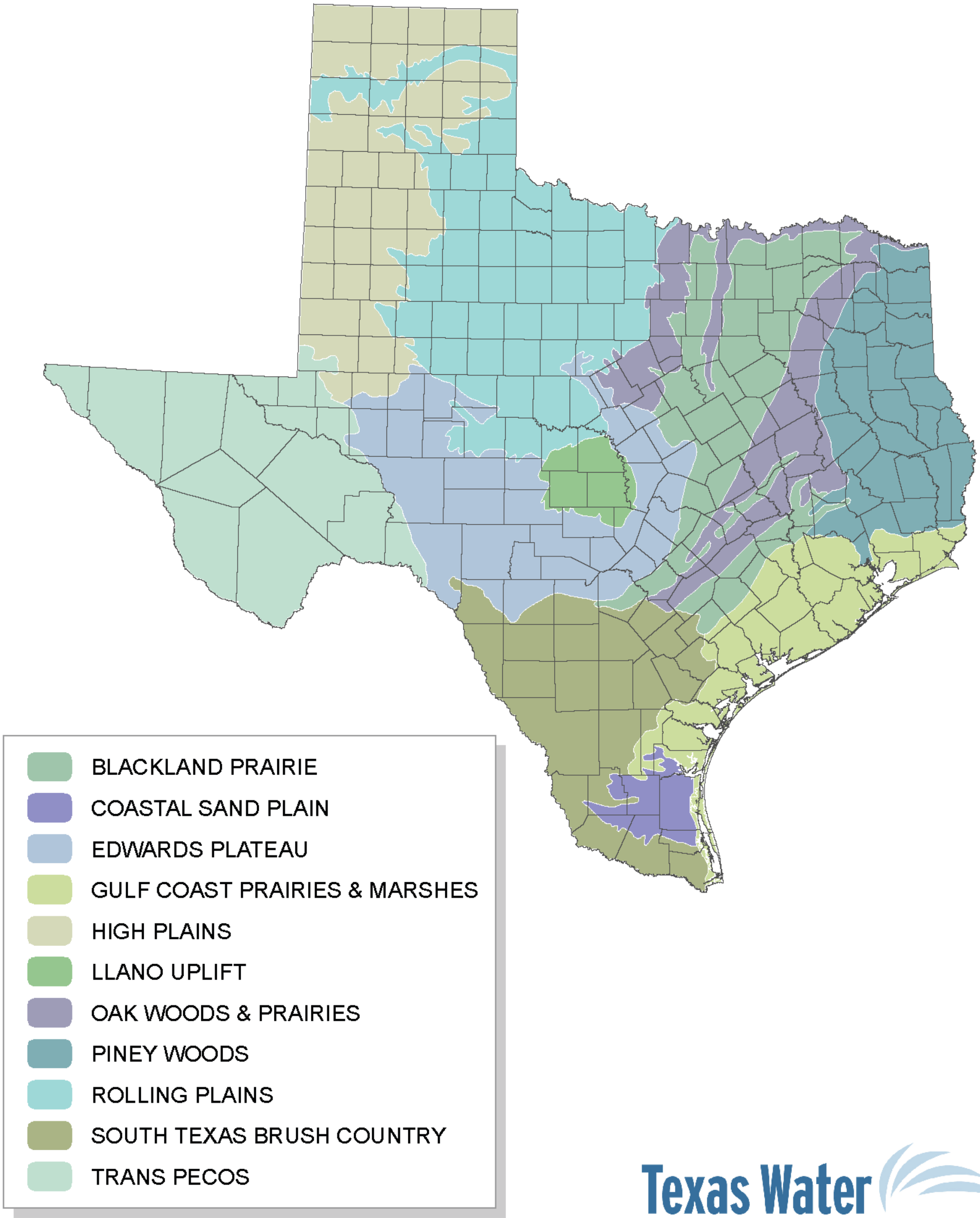
Average Annual Evaporation



Data from Texas Water Development Board (1954-2011)

Texas Water Development Board

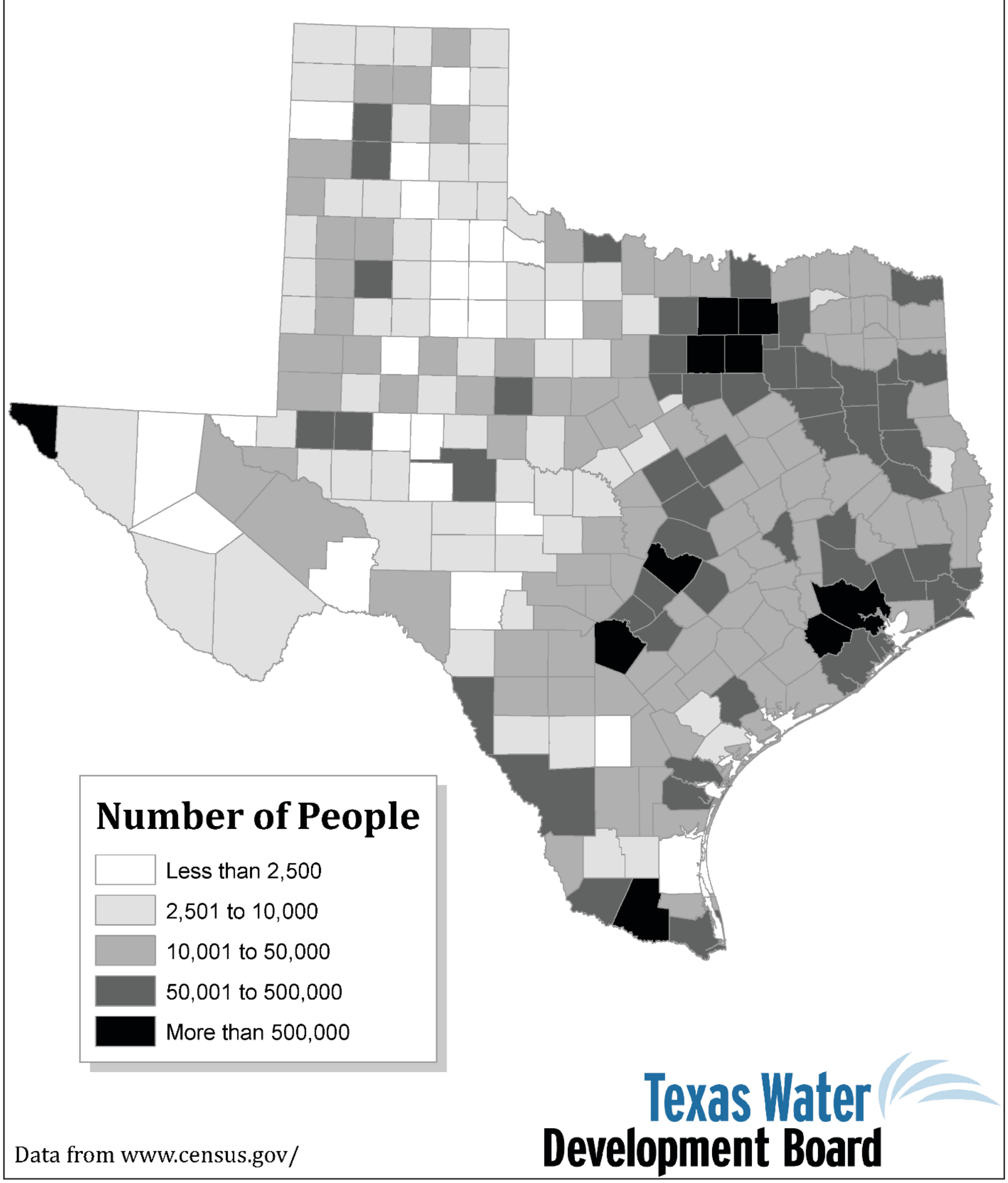
Natural Regions of Texas



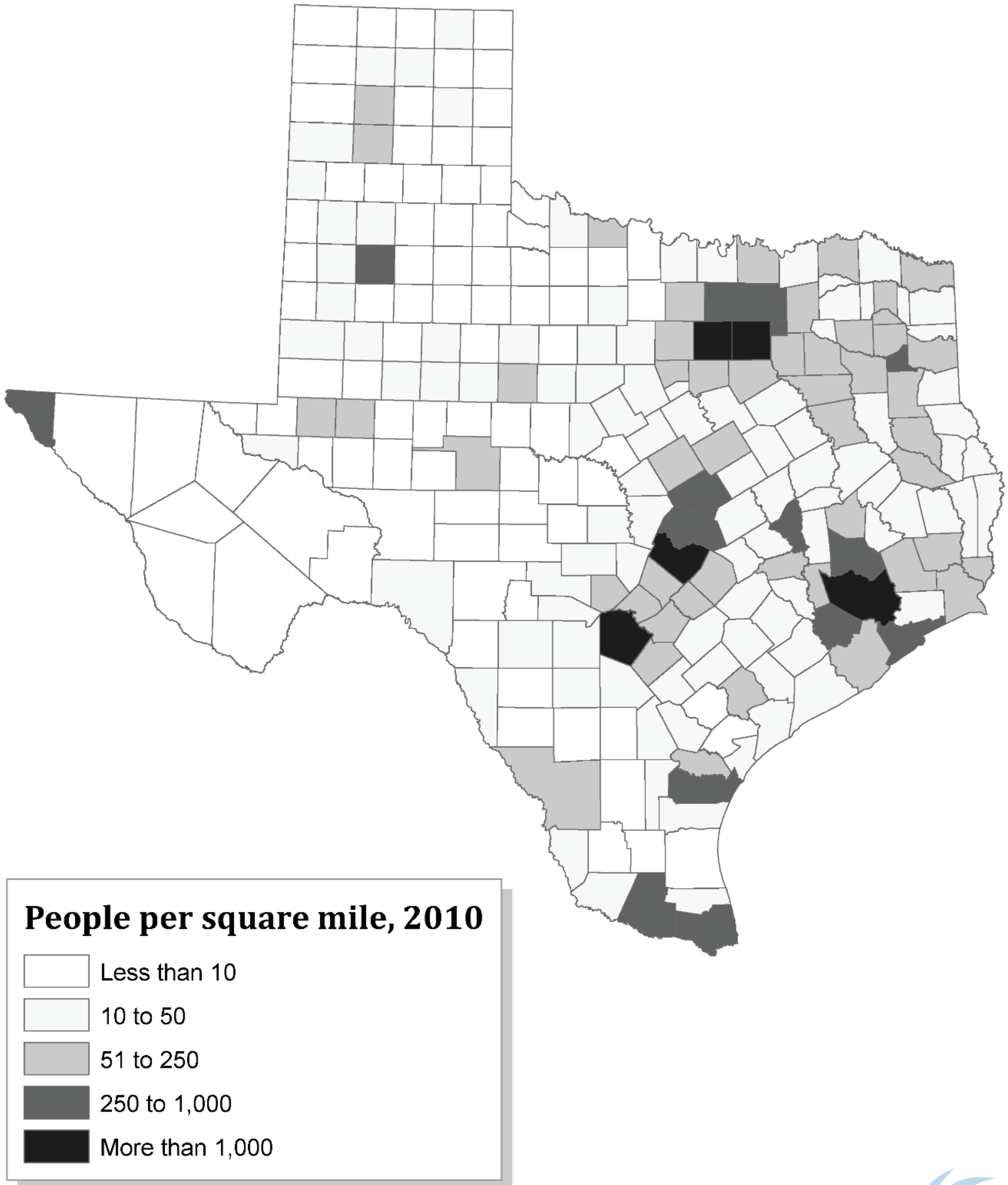
Data from Texas Parks and Wildlife Department.

Texas Water Development Board

County Population, 2010



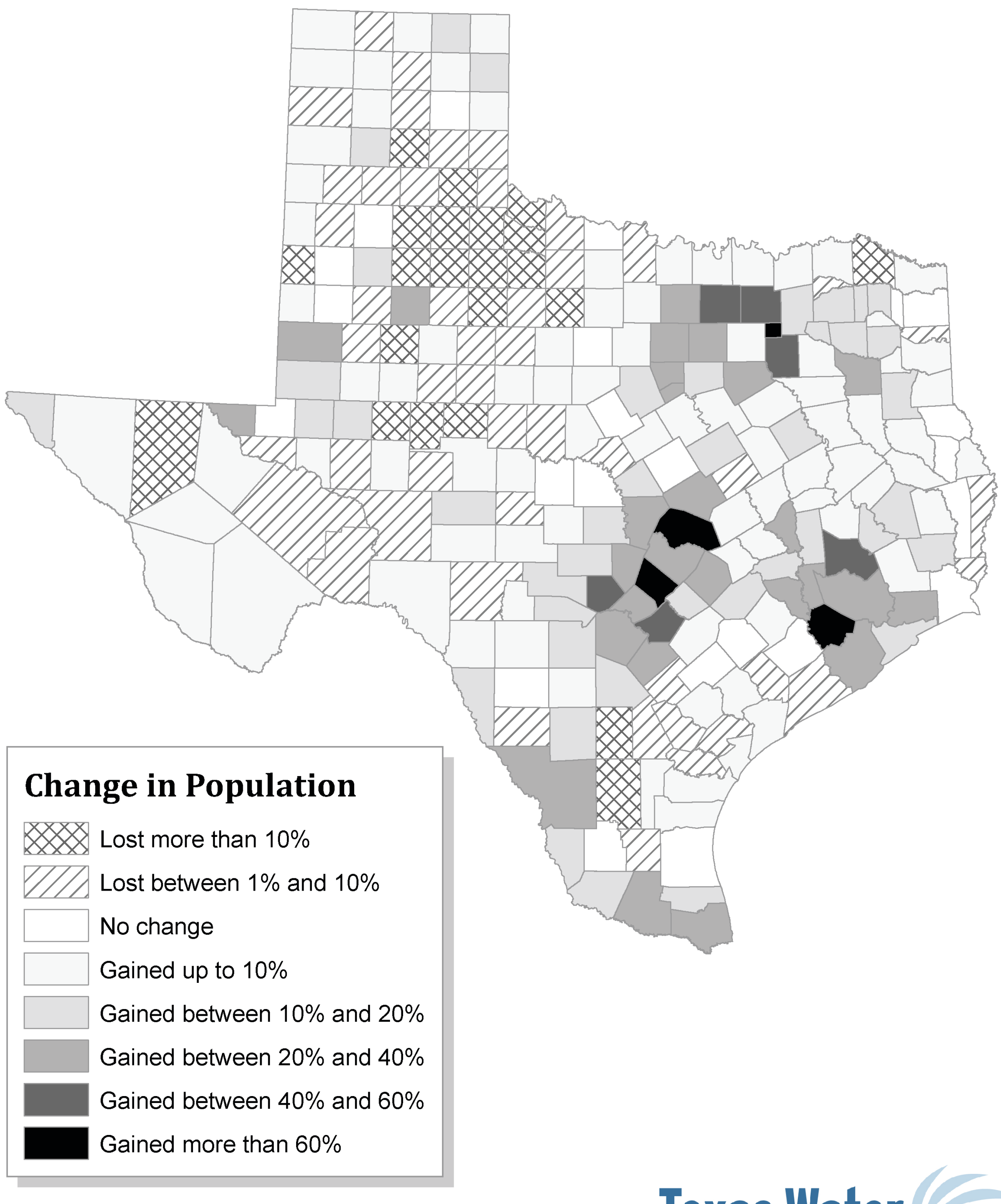
Population Density



Data from www.census.gov/

Texas Water Development Board

Change in Population, 2000 to 2010



Data from www.census.gov/

Texas Water Development Board

Grade	*TEKS*
6th Grade **Social Science**	Geography 3. A, C 4. A Social Studies Skills 20. A 22
7th Grade **Social Studies**	Geography 8. B Social Studies Skills 23
8th Grade **Social Studies**	Social Studies Skills 31

Chapter 6 **Water Use Activity**

GRADE LEVEL 6th–8th

Overview

This activity integrates scientific processes and content and language arts skills.

In this investigation, students will:

- write a persuasive letter enlisting their family's help in the investigation,
- gather data on water usage,
- graph and interpret data, and
- recommend water-saving strategies for their family.

> **Materials**
>
> Water Use Inventory Data Sheets - one per student
>
> Spreadsheet software program (like Excel) or Graph paper
>
> Letter Writing Rubric - one per student

This activity can easily be extended into a wider, community-based water use inventory and a community service-learning project. You will find tips on how to get students involved in community water conservation efforts at the end of this activity.

Students will write a persuasive letter to their family asking for their help in gathering data. Consider partnering with the Language Arts teacher in your school on the Letter Writing Assignment that follows. The letter should explain the investigation, the rationale for doing the investigation, and the importance of water conservation in Texas.

Before students write their letters, ask them to read the "Water Use Inventory Background" article.

The Texas Water Development Board's Water Use Survey staff use data on per capita water use as part of statewide water planning efforts. For useful information on how the data are used, sources of data, and answers to their frequently asked questions, visit www.twdb.texas.gov/waterplanning/waterusesurvey/ or www.savetexaswater.org.

Vocabulary

Conservation — the act of using something carefully or sparingly to avoid waste; the protection, preservation, management, or restoration of natural resources such as water

Resource — anything obtained from the environment that can be used

Shortage — having less of something than you need

Precious — something that is of high value, worth, or cost

Grade	*TEKS*
6th Grade **Science**	Scientific Investigation and Reasoning 2. A, B, E
6th Grade **Language Arts**	10. D 11. D
7th Grade **Science**	Scientific Investigation and Reasoning 2. A, B, E
7th Grade **Language Arts**	10. D 11. D
8th Grade **Science**	Scientific Investigation and Reasoning 2. A, B, E
8th Grade **Language Arts**	10. D 11. D

Background Information

Water is our most precious resource. On average, each Texan uses 80 to 100 gallons of water per day. You aren't drinking that much water per day; how, then, is so much water used? Around 30 percent of that water is used outside for watering landscaping and gardens. The rest is used indoors for a variety of purposes. In this exercise, students will investigate these other uses and explore ways to reduce water use in the home.

Water shortages are occurring in many parts of the world because of rising demand from growing populations and unequal distribution of useable fresh water. In Texas, we want to be smart about how we use this precious resource. We must all be aware of the amount of water we use and should learn ways to conserve. By changing personal habits, people can save a lot of water. Do you leave the water running while brushing your teeth?

As much as half of the water used in the home could be saved by practicing certain conservation techniques. Water can be saved in the bathroom by using low volume shower heads, taking shorter showers, stopping leaks, and by using low volume or even waterless toilets. Toilet flushing is the largest domestic water use; each person uses 13,000 gallons of drinking quality water annually to flush toilets!

Approximate volumes of in-home water usage are as follows:

Water used for…	Estimated amount per use
Bath	30 gallons
Brushing teeth (2 times with water running)	5 gallons
Brushing teeth (2 times with water off)	0.5 gallons
Flushing toilet	1.6–5 gallons/flush
Laundry (1 load)	30–50 gallons
Shower (5-10 minutes)	12.5–25 gallons
Cooking	10 gallons/dinner
Washing dishes (by hand)	20 gallons
Washing dishes (full dishwasher)	7–14 gallons
Washing hands with water running	4 gallons

Preparation

Teacher’s Note - Writing a Letter

Your students will be gathering data over three days: Friday, Saturday, and Sunday. They will need to enlist the help of their families in order to gather accurate data. Early in the week, have students write a letter to their family explaining the investigation and the family’s role in it. Consider partnering with the Language Arts teacher in your school on the Letter Writing Assignment that follows.

Before asking students to write the letter, distribute the ***Letter Writing Rubric***. The purpose of the letter is to enlist the entire family in the collection of accurate data on water usage. The letter should explain the investigation, the rationale for doing the investigation, and the importance of water conservation in Texas.

Use the 5 W’s of journalistic reporting to frame the letters to families:

- ✓ Who – Family members of you and your classmates
- ✓ What – Accurate data on water usage in the home
- ✓ When –Three days: Friday, Saturday and Sunday
- ✓ Where – In the home
- ✓ Why – Water shortages are a very real concern for Texas in the coming years. Gathering accurate data about current water use will help students account for their water use, learn how to conserve water, and plan their water future.

Activity

1. For three consecutive days, record your home's daily water use (bath, shower, clothes washing, etc.) on the **Water Use Inventory Data Sheet**. You can use tally marks to record the “Number of times per day” column for every member of your family.
2. Transfer your data into a spreadsheet, either using graph paper or a program like Microsoft Excel.
3. Create at least three charts to provide a visual graphic of your family's water use. Examples include usage by the family per day, usage by age group, usage per person, usage per time of day, and so on.
4. Convert the number of GALLONS used per day into LITERS.
5. Answer the questions on the “Analyzing Your Data, Drawing Conclusions” page.

Student Name_______________________________________
Date________________

Water Use Inventory: Analyzing Your Data, Drawing Conclusions
Use your data to answer the following questions.

1. What day did your family use more water? What are the likely reasons for this increased use?

2. What was the total amount of water used by your family during the three days?

3. What is the average amount of water used by each person in your family?

4. Estimate the monthly and yearly average of water usage in your home.

5. Would the family's water usage vary during the year? Why?

6. Which single activity used the most water?

7. Did you notice any water usage inside the home that wasn't on the **Water Use Inventory Data Sheet**? Like what? What about outside the home?

8. What recommendations would you make to your family in order to use less water?

9. If your family followed these recommendations, how much water would they save each year?

Student Name___________________________________ Date_______________

Water Use Inventory Data Sheet

Water used for…	Number of times per day				Estimated amount	Total gallons
	Friday	Saturday	Sunday	Total	Per use	used
Bath					30 gallons	
Brushing teeth (2 times with water running)					5 gallons	
Brushing teeth (2 times with water off)					0.5 gallons	
Flushing toilet (1 flush)					1.6–5 gallons/flush	
Laundry (1 load)					30–50 gallons	
Shower (5–10 minutes)					12.5–25 gallons	
Cooking					10 gallons/dinner	
Washing dishes (by hand)					20 gallons	
Washing dishes (full dishwasher)					7–14 gallons	
Washing hands with water running					4 gallons	
Other						

Letter Writing Rubric

(Letter writing rubric – page 1 of 3)

Rubric Element	**Novice (1)**	**Developing (2)**	**Proficient (3)**	**Distinguished (4)**
General Description (Holistic Scoring)	A poor letter: The letter is confused in purpose or does not demonstrate an awareness of the intended audience. Content is not presented in an organized or logical way. Includes few or no details. The reader will not be clear on what is being asked of them	A fair letter: This letter shows some awareness of the purpose and intended audience. Attempts to organize content and idea, but is not particularly smooth. Includes some details. Reader may not be clear on what is being asked of them	A good letter: This letter shows some awareness of the intended audience. Content and ideas are organized in a logical way, although transitions may not be smooth. Includes some details to clarify ideas and help the reader understand what is being asked of them.	An excellent letter: The letter shows a clear awareness of the intended audience. Content and ideas are organized in a logical way. Ideas flow in a way that is fluent and cohesive. Appropriate details clarify ideas and help the reader understand what is being asked of them.
Focus and Coherence	Individual paragraphs and/or the letter as a whole are not focused. The writer may shift abruptly from idea to idea, making it difficult for the reader to understand how the ideas included in the letter are related. The letter as a whole has little or no sense of completeness. The introduction and conclusion, if present, may be perfunctory. A substantial amount of writing may be extraneous because it does not contribute to the development or quality of the letter. In some cases, the letter overall may be only weakly connected to the prompt.	Individual paragraphs and/or the letter as a whole are somewhat focused. The writer may shift quickly from idea to idea, but the reader has no difficulty understanding how the ideas included in the letter are related. The letter as a whole has some sense of completeness. The writer includes an introduction and conclusion, but they may be superficial. Some of the writing may be extraneous because it does not contribute to the development or quality of the letter as a whole.	Individual paragraphs and the letter as a whole are, for the most part, focused. The writer generally shows the clear relationship between ideas, making few sudden shifts from one idea to the next. The letter as a whole has a sense of completeness. The introduction and conclusion add some depth to the letter. Most of the writing contributes to the development or quality of the letter as a whole.	Individual paragraphs and the letter as a whole are focused. This sustained focus enables the reader to understand and appreciate how the ideas included in the letter are related. The letter as a whole has a sense of completeness. The introduction and conclusion are meaningful because they add depth to the letter. Most, if not all, of the writing contributes to the development or quality of the letter as a whole.

(Letter writing rubric continued – page 2 of 3)

Organization	The writer's progression of thought from sentence to sentence and/or paragraph to paragraph is not logical. Sometimes weak progression results from an absence of transitions or from the use of transitions that do not make sense. At other times, the progression of thought is simply not evident, even if appropriate transitions are included. An organizational strategy is not evident. The writer may present ideas in a random or haphazard way, making the letter difficult to follow. Wordiness and/or repetition may stall the progression of ideas.	The writer's progression of thought from sentence to sentence and/or paragraph to paragraph may not always be smooth or completely logical. Sometimes the writer needs to strengthen the progression by including more meaningful transitions; at other times the writer simply needs to establish a clearer link between ideas. The organizational strategy or strategies the writer chooses do not enable the writer to present ideas effectively. Some wordiness and/or repetition may be evident, but these weaknesses do not completely stall the progression of ideas.	The writer's progression of thought from sentence to sentence and paragraph to paragraph is generally smooth and controlled. For the most part, transitions are meaningful, and the links between ideas are logical. The organizational strategy or strategies the writer chooses are generally effective. Wordiness and/or repetition, if present, are minor problems that do not stall the progression of ideas.	The writer's progression of thought from sentence to sentence and paragraph to paragraph is smooth and controlled. The writer's use of meaningful transitions and the logical movement from idea to idea strengthen this progression. The organizational strategy or strategies the writer chooses enhance the writer's ability to present ideas clearly and effectively.
Voice	The writer does not engage the reader, therefore failing to establish a connection. There may be little or no sense of the writer's individual voice. The letter does not sound authentic or original. The writer is unable to express his/her individuality or unique perspective.	There may be moments when the writer engages the reader but fails to sustain the connection. Individual paragraphs or sections of the letter may sound authentic or original, but the writer has difficulty expressing his/her individuality or unique perspective.	The writer engages the reader and sustains that connection throughout most of the letter. For the most part, the composition sounds authentic and original. The writer is generally able to express his/her individuality or unique perspective.	The writer engages the reader and sustains this connection throughout the letter. The letter sounds authentic and original. The writer is able to express his/her individuality or unique perspective.

(Letter writing rubric continued – page 3 of 3)

Conventions	There is little or no evidence in the letter that the writer can correctly apply the conventions of the English language. Severe and/or frequent errors in spelling, capitalization, punctuation, grammar, usage, and sentence structure may cause the writing to be unclear or difficult to read. These errors weaken the letter by causing an overall lack of fluency. The writer may misuse or omit words and phrases and may frequently write awkward sentences. These weaknesses interfere with the effective communication of ideas.	Errors in spelling, capitalization, punctuation, grammar, usage, and sentence structure throughout the letter may indicate a limited control of conventions. Although these errors do not cause the writing to be unclear, they weaken the overall fluency of the letter. The writer may include some simple or inaccurate words and phrases and may write some awkward sentences. These weaknesses limit the overall effectiveness of the communication of ideas.	The writer generally demonstrates a good command of spelling, capitalization, punctuation, grammar, usage, and sentence structure. Although the writer may make minor errors, they create few disruptions in the fluency of the letter. The words, phrases, and sentence structures the writer uses are generally appropriate and contribute to the overall effectiveness of the communication of ideas.	The overall strength of the conventions contributes to the effectiveness of the letter. The writer demonstrates a consistent command of spelling, capitalization, punctuation, grammar, usage, and sentence structure. When the writer attempts to communicate complex ideas through sophisticated forms of expression, he/she may make minor errors as a result of these risks. These types of errors do not detract from the overall fluency of the letter. The words, phrases, and sentence structures the writer uses enhance the overall effectiveness of the communication of ideas.