34. Water Budget Activity

Description: Students will predict and calculate how much water is used from the Rio Grande, both for an average year and for a drought year. Students will make water budget decisions and learn the consequences of those decisions.

Objective: Students will understand the concept of a regional water budget and its complexities.

Materials: calculator

worksheets

Background: Water is a scarce resource in the arid Southwest, and people rely on the river and aquifer for irrigation, livestock, personal consumption, and industrial and commercial uses. Because the Rio Grande flows through three states, Colorado, New Mexico, and Texas, and two countries, the United States and Mexico, the right to use water from the river is regulated by local, state, federal and international agencies. The treaty with Mexico that governs the use of the Rio Grande dates back to 1906. Tribal governments also have water rights.

The Rio Grande Compact (1938) allocates Rio Grande water between the states of Colorado, New Mexico, and Texas through a complex set of delivery schedules that relate runoff volumes to delivery obligations at set river index points. During normal water years, New Mexico must ensure that about 60% of the Rio Grande flow passing the Otowi Gage reaches Elephant Butte Reservoir (Crawford, et al. 1993). On average, this delivery requirement is 790,000 acre-feet per year. This requirement is significantly reduced during a drought year. To assure that each jurisdiction receives

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Grades: 6–12

Time: three one-hour class periods

Subjects: science, math, social studies

Terms: *acre-foot, aquifer, evapotranspiration, evaporation, riparian, water budget*

its share of water, a water budget is developed. A water budget records the amount of water that goes into the system, which includes tributary and ground water sources (the inflow), and the amount of water that is taken out of the system (the outflow).

Although a water budget may seem simple at first glance, the reality is incredibly complex. A water budget is affected by forces over which humans have no control, such as precipitation, weather patterns, and evaporation, as well as by the interests of the environment, agriculture, industry, and national, state, municipal, and tribal governments. There simply is not enough water for all the competing interests that a water budget has to satisfy.

For the purposes of this activity, the Middle Rio Grande is defined as the reach between the Otowi Gage (near Los Alamos) to the Elephant Butte Dam.

Note: In order for students to gain an understanding of the complexity of water budgets, it is strongly suggested that all three sections of this activity be completed.

Terms:

water budget: A summary that shows the balance in a hydrological system between water supplies (inflow) to the system and water losses (outflow) from the system. It is a common reporting tool for water-resource systems.

riparian: relating to or living or located on the bank of a natural fresh watercourse such as a river, stream, pond or lake.

evapotranspiration: a term that includes the portion of precipitation being returned to the atmosphere either by direct evaporation or by transpiration through vegetation, with no differentiation being made between the two processes.

evaporation: the change from liquid or solid to vapor; water in a lake evaporates into the air.

acre-foot: a quantity of volume of water that covers one acre to a depth of one foot; equal to 43,560 cubic feet, 325,851 gallons or 1,233.48 cubic meters.

aquifer: the stratum or rock below ground that bears water, typically in a location capable of producing water usable by humans, such as from a well.

Procedure: **Part I**

1. Brainstorm with students where the water in the river comes from. Answers include:
   rain (and all forms of precipitation)
   melting snowpack
   inflow from tributaries
   run-off from urban storm drains
   aquifer (shallow and deep)
2. Explain that the river and the aquifers are not closed systems, independent from one another, but instead are connected. The shallow aquifer discharges water into the river, and the water in the river flows into (recharges) the shallow aquifer. In Albuquerque, more water is "mined" from the deep aquifer than is recharged. The water table falls several feet a year as a result of this ground water mining.
3. Brainstorm with students the Rio Grande water consumers. Who takes water away from the river? Some possible answers are:
   residential use (personal consumption, lawns, dishwashing, laundry, etc.)
   agriculture
   livestock
   commercial (office buildings, stores, etc.)
   industry (factories)
   governments
   evaporation
   riparian evapotranspiration
   aquifer recharge
   downstream users
   aquatic wildlife (fish, etc.)
   terrestrial wildlife (deer, etc.)
4. Introduce the idea of a budget. When do people use a budget? What do you think a water budget is? How would you know if a water budget is balanced?
5. Assign students to work in groups of two or three. Pass out Worksheet I to each group. Have students predict the percent (%) and answer the first two questions.
6. Reveal the actual percent and have students record this on their worksheets. Have them answer the last two questions. Review each category and discuss results as a class.

Part II

1. Pass out Worksheet II.
2. Introduce the Rio Grande Compact.
3. Explain the definition of acre feet: quantity of volume of water that covers one acre to a depth of one foot; equal to 43,560 cubic feet, 325,851 gallons, or 1,233.48 cubic meters.
4. Review the procedure for calculating ac-ft using percentages. For example: 8.4% of 1,424,000, multiply .084 x 1,424,000 = 119,890.
5. Have students calculate and decide whether the requirements of the Rio Grande Compact are met.

Part III

1. Pass out Worksheet III.
2. Discuss drought conditions and how drought affects the water flow in the river.
3. Have students allocate the remaining water and figure out the percentages.
4. Discuss consequences using notes below.

   If "Agriculture" is less than 119,890 ac-ft: There is not enough water to support all the agriculture needs in the Middle Rio Grande Valley. Some farmers will have to leave their land fallow; others may have to sell land. Ways that farmers could adapt to less water are to plant crops that require less water or develop more efficient methods of watering (drip irrigation vs. sprinklers).

   If "Riparian Evapotranspiration" is less than 164,060 ac-ft: Riparian evapotranspiration cannot be controlled in the same way that human water consumption is controlled. There is no "switch" to turn off riparian evapotranspiration. In fact, during a drought year, riparian trees and plants may use more river water because they are receiving less water in the form of precipitation (rain). One way to reduce evapotranspiration is to remove water-thirsty non-native species like saltcedar and Russian olive. This work is already being done at Bosque del Apache, with water savings of 25 to 30 percent.

   If "Residential Use" is less than 69,410 ac-ft: Water-saving measures go into effect. Depending on the severity of the drought, people may only be allowed to water their lawns once a week, or even not at all. The cost of water may also increase. Building of new homes may be limited.

If "Business and Government" is less than 37,860 ac-ft: Golf courses might not be watered, swimming pools could be closed, restaurants might have to use paper plates to save water used in dishwashing.

If "Water Left in the River" is less than 350,000 ac-ft: The requirements of the Rio Grande Compact are not met and a debit is accumulated which will have to be met in future years. The Treaty of 1906 between the U.S. and Mexico may be violated because 60,000 ac-ft must be delivered annually to the border.

5. Discuss as a class who or what consumes water or needs the river but is not reflected in the water budget. Historically, water budgets have reflected the needs of people, and by extension the needs of agriculture. It is important for students to understand that many plants and animals are affected by water budgets even though their needs are not specifically addressed. What happens to fish and other aquatic animals during a drought? Do they have enough water? How about riparian plants like the cottonwood that are directly tied to the flow of the river? Students may also think about ways they use the river that are not reflected in a water budget—for recreation (boating, fishing, hiking along the bank) and quality of life (the existence of a riparian forest in an urban area).

Extensions:

1. Make a pie chart for an average year and a drought year to illustrate water use.
2. Develop the following scenarios and have students debate the pros and cons of each position.
   a. The City of Albuquerque has depleted significant portions of the shallow and deep aquifer and decides to rely on the river to provide a percentage of the city water supply. (Note: this is due to happen beginning in 2005.)
   b. The Rio Grande silvery minnow, an endangered species, is only found between Cochiti Dam and the headwaters of Elephant Butte Reservoir, in about 5% of its historic range. This fish requires that a certain amount of water be in the river at all times. During parts of the summer, the total flow of the river dips below the level that the silvery minnow requires.
3. Have groups take one water consumer and propose a way to reduce water usage, listing pros and cons.
4. Have students collect news stories about the Rio Grande's water users.
5. See the "How Deep Is the Water Table?" activity for information about how the river is connected to the aquifer.

6. Investigate these state and federal agencies to find out more about water decisions: N.M. State Engineer's Office, U.S. Bureau of Reclamation, Middle Rio Grande Conservancy District, United States Geological Survey, Army Corps of Engineers, U.S. Fish and Wildlife Service.

References:

NM State Engineer's Office Web site, "Summary of Water Use (in acre-feet) in Rio Grande Basin, 1995." www.seo.state.nm.us/publications/wrri/wateruse/basin95/rg.html

Middle Rio Grande Water Assembly Web site www.waterAssembly.org

Middle Rio Grande Water Budget Averages for 1972–1997, Middle Rio Grande Water Assembly, Inc. October 1999.

Crawford, Clifford et al. October 1993. The Middle Rio Grande Ecosystem: Bosque Biological Management Plan. U.S. Fish and Wildlife Service, District 2, Albuquerque.

Shupe, Steven, and Folk-Williams, John, 1988. The Upper Rio Grande; A Guide to Decision Making. Western Network.

Teacher Key for Water Budget Worksheets

Average Water Year

Use	Percent of Total	Acre Feet per Year	Note
Agriculture	8.4%	119,890	Farmers get water from the river via ditches and acequias.
Open-water Evaporation	4.9%	69,410	This is the water that evaporates from the moving part of the river, as well as from streams, wetlands, ditches and pools.
Riparian Evapotranspiration	11.5%	164,060	Riparian evapotranspiration occurs when plants lose water from their leaves as a natural part of their plant processes, as well as by direct evaporation from the forest.
Evaporation from Elephant Butte	12.0%	170,370	
Residential Use	4.9%	69,410	
Business and Government	2.7%	37,860	
Water left in the river (Rio Grande Compact)	55.6%	793,000	This portion is regulated by the Rio Grande Compact. See ***Background*** for more information.
Total	**100%**	**1,424,000**	

Data based on Middle Rio Grande Water Budget Averages for 1972–1997, Middle Rio Grande Water Assembly, Inc., October 1999; confirmed and adjusted in 2002.

Water Budget Worksheet I

In your group, estimate how much water is consumed in the Middle Rio Grande Valley in the following categories. The total percentage you predict must add up to one hundred percent.

Water Use During an Average Year

Use	Prediction	Actual Percentage
Agriculture		
Open-water Evaporation		
Riparian Evapotranspiration		
Evaporation from Elephant Butte		
Residential Use		
Business and Government		
Water Left in River (Rio Grande Compact)		
Total	100%	100%

In your prediction, who or what uses the most water? Explain your answer.

Who or what uses the least water? Explain your answer.

Answer the following questions after your teacher tells you the actual percentages for an average year.

How do your predictions compare with the actual percentages?

Were you surprised by any of the percentages? Why?

Water Budget Worksheet II

1 acre-foot (ac-ft) = a quantity of volume of water that covers one acre to a depth of one foot; equal to 43,560 cubic feet, 325,851 gallons, or 1,233.48 cubic meters.

Using 1,424,000 ac-ft as the total amount of water available (from the river, tributaries, ground water and storm drains), calculate the acre-feet allocated to each category. Round up to the nearest whole number.

Water Use During an Average Year

Use	Percentage	Acre Feet
Agriculture	8.4%	
Open-water Evaporation	4.9%	
Riparian Evapotranspiration	11.5%	
Evaporation from Elephant Butte	12.0%	
Residential Use	4.9%	
Business and Government	2.7%	
Water Left in River (Rio Grande Compact)	55.6%	
Total	100%	1,424,000

The Rio Grande Compact is an agreement between Colorado, New Mexico, and Texas that regulates the allocation of river water. As it relates to the Middle Rio Grande, the compact stipulates that during an average water year at least 790,000 ac-ft must be "delivered" annually from Elephant Butte for use downstream. Does the water budget above meet the Rio Grande Compact requirements?

Water Budget Worksheet III

Imagine that there is a drought and the water available is reduced to 753,000 ac-ft annually. In a drought year, the Rio Grande Compact stipulates that 350,000 ac-ft must be delivered. Recalculate how much water, in acre feet, is available for each use. Consider how water use will change during a drought year. Will households use more or less water during a drought? How about agriculture?

After you have allocated all the water (remember, it needs to add up to 753,000 ac-ft), calculate the percentages.

Water Budget for a Drought Year

Use	Percentage	Acre Feet
Agriculture		
Open-water Evaporation		
Riparian Evapotranspiration		
Evaporation from Elephant Butte		
Residential Use		
Business and Government		
Water Left in River (Rio Grande Compact)		
Total	100	753,000

Describe the consequences of this water budget on river users compared to an average year.

Who (or what) consumes water or needs the river but is not reflected in the water budget? How would a drought affect them?