Water Distribution 2

📖 Duration:
Pre-visit: 40 minutes
Visit: 20 minutes
Post-visit: 1-1/2 hours.

📖 Setting:
Classroom, Mission Espada *acequia* & aqueduct

📖 Skills: Grades 6-8
Math: 6.11 Applies mathematics to solve problems connected to everyday experiences, investigations in other disciplines and activities in and outside of school.
7.9 Solves application problems involving estimation and measurement.
8.10 Describes how changes in dimensions affect linear, area and volume measures. Science:
6,7,8.1B Uses scientific inquiry methods during field and laboratory investigations using safe, environmentally appropriate and ethical practices.
6,7,8.2 Uses scientific inquiry methods during field and laboratory investigations.
6,7,8.4 Knows how to use a variety of tools and methods to conduct science inquiry.
6.6C Identifies forces that shape features of the Earth including movement of water.
7.5A Illustrates examples of potential and kinetic energy in everyday life such as in movement of water.

📖 Essential Terms:
gravity, slope of land, potential energy, kinetic energy, velocity of water, discharge of water, *acequias*, substrate

ENERGY

Big Idea
What factors affect the velocity and volume of discharge of an acequia?

Objectives

Students will:

- Measure to obtain data needed to find water velocity in the *acequia* at the Espada aqueduct and calculate the velocity.
- Calculate the volume discharge of the water in the *acequia* from the data obtained at the Espada aqueduct.
- Investigate variables that affect the velocity of the water.
- Prepare a written report containing the students' conclusions of their investigation.
- Present to the class an oral report summarizing their investigation.
- Record the data in the park's database.

Making Connections

The energy of the water flowing in the *acequia* is due to gravity. Water at the top of the slope of land has this energy. It is called potential energy. The slope of land is directly related to the amount of this energy. Potential energy is changed to kinetic energy as water flows downstream. Kinetic energy can be increased by having more water in the stream and/or by having it move faster. Scientists measure velocity and discharge of water to learn about its energy.

The velocity of the current in Mission Espada's *acequia* depends on the *acequia's* slope and the roughness of its bottom. Its discharge depends on the speed of the water, the volume of the water, and the composition of the surrounding land (substrate). The factor reflecting the type of underlying material is used in calculations to determine the discharge of water. Fast currents remove smaller particles and rocks from a streambed, leaving behind large rocks and bedrock.

Materials

Engagement (Pre-visit) and Elaboration (Post-visit):

- 1.0 meter piece of drainpipe
- grapes
- watch with second hand
- gallon jug of water with a hose connected to water source.
- two corks
- measuring tape or meter sticks
- 2 plastic bottles cut to hold the drainpipe (two milk bottles)

Exploration (Visit):

- 1 orange per team
- meter stick per team
- watch with second hand
- dip net

Engagement (Pre-visit):

1. Brainstorming session: How can the velocity of the water in the Espada *acequia* be measured? What data are needed to calculate the velocity of the flow of water? Write down your ideas. Use multimedia and technology resources as needed to obtain the answers.

2. Suggested procedure for determining velocity:

a. Place a 1.0-m piece of drainpipe on a table so that one end is positioned 5 cm above the table. A holder for the drainpipe can be made from a plastic milk bottle by cutting a horizontal line 5cm from its bottom across 3 sides of the bottle. On the fourth side cut a large hole to support the drainpipe. (See illustration.)

b. Prepare a plastic gallon jug with two holes of equal size near the bottom. Place a cork in each hole. Water will be continually added to the gallon container from a faucet so that the water is always at the same level during the investigation. The end of the drainpipe will be over a sink to collect the wastewater.

c. At the high end of the drain pipe, position the gallon jug on a ring stand so water from the hole near the bottom will fall on the drain pipe 100cm from the low end.

d. When a student gives the signal, one cork is removed and one person drops a grape into the flowing water at the highest point.

e. Measures how many seconds it takes the grape to flow to the end of the drainpipe. Record.

f. Repeat the grape-timing procedure 2 more times. Calculate the average time.

g. Use the average time to find the average velocity. Record in data table. Velocity equals distance (100 cm) divided by average time.

h. Elaboration (Post-visit) deals with the effects of changing slope and changing volume. If there is time, it could be completed before the visit to the Missions.

3. Questions:

a. Where does the water in the drainpipe have the most potential energy?

b. What force causes the water in the drainpipe to have potential energy?

c. What kind of energy does the water have as it flows down the drainpipe?

Exploration (Visit):

DO NOT CROSS THE CREEK AND DO NOT WALK ON THE WALL OF THE AQUEDUCT.

How can the velocity of the water in the *acequia* be measured? Investigations of the *acequia* at the Espada Aqueduct:

1. Measure 5 meters along the *acequia* on the street side of the aqueduct.

2. One student remains upstream to release an orange into the *acequia*. That person signals as the orange is released.

3. Another student is downstream at the end of the *acequia* section to catch the orange. This person signals as the orange is caught.

4. A third student, using the watch to measure seconds, times how long it takes the orange to float from release to capture

5. Using different students, repeat the test two more times and then average the results. Record velocity in meters/seconds.

How can the discharge of the *acequia* be measured? (See reference on monitoring water quality.)

Background: Discharge is a measure of the volume of water passing a certain point over a specific period of time. The Embody Float Method involves the formula: D = WZAL/T, where

- D = discharge,
- W = average width of *acequia*,
- Z = average depth,
- L = length of stream measured,
- A = a constant (0.9 for sandy/muddy bottom, 0.8 for gravelly/rocky bottoms), and
- T = time in seconds.

This can be restated as D = average area X constant X velocity since velocity equals distance (length of the *acequia*) for a specified period of time.

1. Measure the depth of the water at the upstream location every 0.5meter across the *acequia*. Calculate the average depth.

2. Measure the width at this point. Find the area by multiplying the width times the average depth. Record the total area in square meters in the data table.

3. Repeat steps 1 & 2 to measure a lower section of the *acequia*. Record in data table.

4. Average the data of the cross-sectional area upstream and downstream. Record in data table.

5. Determine whether the bottom of the *acequia* is sandy/muddy (constant =0.9) or has a gravel/ rock bottom (constant = 0.8).

6. Calculate discharge. Discharge equals average cross-sectional area X constant X average velocity from section 1 above. Record in data table.

Questions: See “Making Connections” or multimedia resources if more information is needed.

1. Why does the constant differ for sandy and muddy bottoms compared to gravelly or rocky bottoms?

2. What would have been the discharge if the other constant had been used?

3. What is the relationship between the velocity and the kinetic energy of the water?

Elaboration **(Post-visit):**

How does increasing or decreasing the slope of the land affect water flowing in the Espada *acequia*?

1. Brainstorming session: What data does one need to find the effect of increasing or decreasing the slope of the land on flowing water?

2. Design an investigation to determine the effect of increasing or decreasing the slope of the land on water flowing in the *acequia*.

a. Use the procedure used in Engagement (Pre-visit) to determine velocity, with the exception that the bottle holding the drainpipe will be 10cm above the table at the high end in this investigation. The data from a 5cm height and the data from the 10cm height can be compared to form conclusions about the effects of the slope of the land on the flow of water.
b. Determine the slope at the 5cm height and at the 10cm height. (See the clinometer in Water Distribution #1).

2. Questions:

a. What was the effect of increasing the slope on the velocity of the water?
b. Which has more energy, a volume of water at low velocity or an equal volume of water at high velocity?
c. What causes the water to have energy?

What happens to the velocity of water if the volume is increased?

1. Repeat the procedures outlined in #2 above with the exception that both corks are removed thereby doubling the area through which the water flows. Follow the same procedure for finding velocity. Record your data.

2. Questions:

a. What was the effect of increasing volume on the velocity of the water?
b. What similar properties do the drainpipe model and the *acequia* (real-world situation) have?
c. What properties does the drainpipe not have when compared to the real-world situation?
d. What variables affected the velocity of the water in the drainpipe model of the *acequia*?
e. What other variables might affect the velocity of the water in the *acequias*?

Evaluation (Post-visit):

1. Prepare a written report using data and conclusions from investigations at the school and at the San Antonio missions. Assess using the general rubric (Alter as needed).

2. Present an oral report to the class summarizing the data and conclusions from investigations at the school and at the San Antonio missions. Students will use an oral report rubric for assessment.

3. Record data in the San Antonio Missions National Historical Park's data bank.