35. Interpreting a Hydrograph

Description: Students interpret a graph showing the volume of flow of the Rio Grande in three different years and look on the Internet for current information to compare with the data presented.

Objectives: Students will:

- read and interpret a graph of the flow of the Rio Grande from three different years;
- see the difference between the uncontrolled flow and after dams and diversions were put in place; and
- be able to characterize the flow volume and timing over the course of a year.

Materials: copies of the hydrograph and worksheet for each student

Internet access for Part 2

graph paper for extensions

maps of New Mexico

Background: Terms:

cubic feet per second (cfs): the typical unit to record river flows; calculated by measuring the width and depth of the channel (area) times the velocity of the flow (feet per second)

discharge: in a stream or river, a measure of the amount of water passing a given point, measured as volume per unit of time (units typically cfs)

flood pulse: a predictable inundation of the floodplain from the river, which results in adaptations to flooding by local organisms; in this region, typically annual spring snowmelt sends a large volume of water downstream

35. Interpreting a Hydrograph

Grades: 6–12

Time: Part 1: one class period; Part 2: one additional class and Internet time

Subjects: science, math

Terms: cubic feet per second, discharge, flood pulse, gage, hydrograph, overbank flooding

gage: a device used for measuring or testing something, especially for measuring a dimension or quantity; in this activity we talk about stream-gage, which collects water data, especially the discharge of a stream or river; note that the spelling "gage" is typically used in technical applications rather than "gauge"

hydrograph: a graph showing the volume of flow of water in a river over time

overbank flooding: the water in the river increases so much that the river flows over its banks spreading water and sediment beyond its channel

real-time data: data available as soon as they are collected, continually sent from the collecting equipment to a central computer through some means such as a dedicated phone line, a radio or a satellite

The Rio Grande is the life-blood of central New Mexico. In this arid state, it is the source of water for the diversity of life along its native bosque and important irrigation for food production.

The Rio Grande bosque is the result of the interaction between biological and physical processes. The native plant and animal communities evolved and adapted to a river that overbanked on a regular basis, probably every three to five years. These floods were a key component of the cottonwood–willow ecosystem, as well as the thriving aquatic environment. In the last century the river has undergone a disruption of the once-normal floods, including a significant narrowing of the floodplain. Along the Middle Rio Grande, for instance, the river was squeezed into a narrower channel by stabilizing new banks with Kellner jetty jacks, large, steel crossbeams similar in appearance to anti-tank barriers encountered by Allied troops when they landed on the beaches of France during Word War II. Along the Lower Rio, the Rio Grande Canalization Project (1938-1943) constructed hundreds of miles of canals and levees to confine and control the river, slowly distributing as needed the bounty of the flood pulse that was now stored behind Elephant Butte Dam. Non-native saltcedar and Russian olive trees found the altered habitat quite suitable, and they began to spread along the Rio's length. All of this has had a dramatic effect on the native plants and animals. Of the five native minnow species found at the turn of the 20th century in the Rio Grande, only the silvery minnow remains, and now only between Cochiti and Elephant Butte dams as a federally endangered species.

Before dams and diversions there was a typical cycle over the course of a year. Starting with spring, the flow of the river began to increase as the snows that accumulated in the mountains began to melt. In wet years, the river flowed over its banks (**overbank flooding**) spreading water and sediment beyond its channel. Typically this was a low-intensity inundation that rose gradually and dropped nutrient-laden sediment. Water in the floodplain was critical for the decomposition of wood and leaves in the forest, breaking down nutrients that became available for other living things. Sometimes the river would change course or erode its banks, but it also would leave new sand bars that gave young cottonwoods a place to become established, since cottonwood trees release their seeds during high water. Cottonwood seed germination is best with a peak flow and rapid decline; extended flows favor saltcedar.

Aquatic systems benefited from this high flow as well. For example, the Rio Grande silvery minnow depends on a high peak flow when its eggs are laid and dispersed across the flood plain. Then a quick receding flow leaves them in quiet backwaters to grow. The longer but lower peak flows since the river was regulated mean less overbank volume, thus less backwater for minnows, so the eggs are moved downstream out of local habitats.

Such a predictable inundation of the floodplain from the river, which results in adaptations to flooding by local organisms, is called a **flood pulse.** Following the flood pulse, the late-summer to fall flows would vary, increasing with summer thunderstorms and then tapering off periodically. Winter flow in the region was typically low, providing habitat for birds.

Controls such as dams, irrigation diversions and levees have regulated the flow of the river. The result is lower peak flow, with high flows occurring later in the year, and higher minimum flows. Now the early snow-melt is held in reservoirs to be released over the growing season. This can be seen in the hydrograph in this activity. In 1920 the flow of the Rio Grande in June reached 18,000 cfs (cubic feet per second), whereas the peak flow in 1997 was 4,000 cfs. Although some regulation was already present along the river in Colorado, Cochiti Dam was completed in 1975 and most directly affects the river flow through the Middle Rio Grande Valley. Along the Lower Rio, Elephant Butte Dam has had the most significant impact on the river's flow in southern New Mexico and beyond. This activity includes hydrographs from a Rio Grande gage in El Paso before and after the completion of the dam. There are also dams on tributaries of the Rio Grande that affect its flow.

Water managers in the Middle Rio Grande Valley now want to allow the overbank flow during wet years again. They want to maintain as many aspects of the early, uncontrolled river (Rio Bravo) as possible to provide the processes necessary for maximum biological diversity. Flooding the bosque now is difficult, however, in part because the volume of water needed for overbank flooding is different at different areas. Bosque del Apache National Wildlife Refuge, south of Socorro and just north of the San Marcial gage used in this activity, takes 3,500 cfs to breach the bank and flow into the floodplain. At Albuquerque it takes 10,000 cfs to do the same. This reflects differences in the structure and depth of the channel. For example, the southern end of the valley has high sediment deposition due to input from the Rio Salado and Rio Puerco, so it is shallow and floods relatively easily, while the channel along the upper reaches is down-cut (deeper) due to sediment retention behind Cochiti Dam. This makes it difficult to inundate the bosque through Albuquerque without flooding a much greater area to the south.

Water managers in the Rio Grande Valley use stream gages to monitor the flow of water in rivers and streams. As the country developed, with an increasing need for reliable water sources, there was a need for streamflow data to aid in planning water storage and distribution facilities. The first stream-gaging station in the United States operated by the U.S. Geological Survey (USGS) was installed on the Rio Grande near Embudo, NM, in 1889. That gage is still active, with a total of 84 stations now in New Mexico, including nine on the main stem of the Rio Grande. As of 1994, 7,292 continuous-record stream-gaging stations were operating in the United States, Puerto Rico, and the Trust Territories of the Pacific Islands. About 4,200 of them are telemetered by an Earth-satellite-based communication station and so provide real-time data, which can be accessed through the Internet. The USGS stream-gaging program provides a resource for water managers, with uses including forecasting and managing floods, characterizing water quality, and operating reservoirs. This is a resource that is also readily available to teachers and students.

The gage called San Marcial has the name of a former community with a floodwater story of its own. It began on the east side of the Rio Grande but moved to the west side after a flood in 1866. The town grew after the railroad arrived in 1880 and was the second largest in Socorro County. The town suffered periodic floods, especially in the 1920s, when silt was deposited in many buildings, but residents cleaned up and continued on. One night in 1929, however, the water began to rise. Residents evacuated, but by morning they saw that floodwaters had reached the second-story level. The destruction was so great that the town was abandoned.

In short, whatever happens upstream will affect downstream users. Too little water flowing through the Middle Rio Grande (because of drought or senior water rights obligations further upstream, for instance) will mean less water flowing past the San Marcial gage into Elephant Butte Reservoir. Water managers below Elephant Butte Dam will have to carefully consider how to manage the water in the lake for downstream users, which includes mandatory deliveries to Texas and Mexico. Conversely, runoff from wet winter years will raise lake levels in Elephant Butte, but managers will still have to plan water deliveries to keep enough water handy for the inevitable dry years. Hydrograph data from upstream will help them with these sometimes difficult and complicated decisions.

Procedure: Provide information from the Background about the historical pattern of stream flow along the Rio Grande, the beneficial aspects of an annual flood pulse and the use of stream gages to collect water data. Stress that decisions made by water managers are affected by data and decisions upstream.

Hand out the copies of the hydrograph and the worksheet. Have students interpret the graph and write their answers on the worksheet. Part 2 must be done with Internet access. Students look up current data from the United States Geological Survey web sites and compare current information to the hydrograph handout.

Have students find where San Marcial is on a map of New Mexico. The gage here is the last gage on the Rio Grande above Elephant Butte Reservoir.

Teacher Answer Key

Part 1

1. Was the river dry at any time(s)? List months and years.
Yes, flow at 0 in 1920 from early September to early October; in 1952 from early September to mid-November; in 1997 July and from mid-August to mid-September.

2. What were the flows on June 18 on each of the years shown?
1920: 10,000; 1952: 5,800; 1997: 3800

3. What causes these high flows at this time of the year?
High flows are caused by extra water from mountain snowmelt.

4. Count the number of days in each of the three years the water flowed over 3,500 cfs. This represents overbank flooding conditions in the area of Bosque del Apache National Wildlife Refuge just north of San Marcial.
1920: 80 days; 1952: 41 days; 1997: 33 days

5. What causes the smaller peaks in late summer?
Increased flow from thunderstorms.

6. Which year had the highest flows during the late fall/early winter?
1997

7. Describe in sentences the rhythm of flow of the Rio Grande over the course of a year.
This river begins the year with a low flow and spikes in May, climbing until June when it peaks. It then returns to a low flow for the remainder of the year, though there may be smaller, late-summer peaks.

8. Why has the hydrograph changed over the century?
Humans have controlled the flow of the river, building diversion dams, and specifically Cochiti Dam that holds the spring run-off and releases water more gradually over many weeks.

9. In this system, what effect have dams had on river flow?
Dams result in lower peak flows and higher minimum flows.

Part 2: Internet Access

1. Look up the river flow today at the San Marcial gage on the USGS web site http://waterdata.usgs.gov/nm/nwis/uv?08358400—"Rio Grande Floodway at San Marcial, NM" site. (The term "floodway" has the numbers you want for the river flow. There are two San Marcial gages; the other is the "Conveyance Channel.") Look at "Real time" data and the chart that shows "Discharge": this shows the current flow as well as the flow for the last few days.

a. What is the flow today? date_________ time__________ flow ________

b. Print out a hydrograph for the last week or last month—you define the number of days.

2. Look on the USGS web site for the gage that is closest to where you live. "USGS Real time data for New Mexico" http://waterdata.usgs.gov/nm/nwis/rt includes a map of the gages in the state. You can select the closest one. You can also type in the county or other location to help locate the closest gage.

a. Name of the gage site _________________________________

USGS Station # ____

Web address of the site __________________________________

What is the flow today? date_________ time__________ flow ________

b. Print out a hydrograph of the water flow at this location for the last week or month—choose the same days as the San Marcial hydrograph you printed above.

c. Compare the two hydrographs: write a paragraph comparing them.

Students should compare the flow of water: is one location higher than the other? What reasons might there be for the difference? Or are they about the same? Were there any changes over the week or month? Why might that be?

3. From other information in this unit and what the you have learned in this activity, write about the role/importance of spring run-off in the bosque ecosystem. The answer should include some of the following:
High spring flows bring nutrients and new sediments. Cottonwood trees release their seeds coinciding with the high water. In wet years, the river flows over its banks (overbank flooding) spreading water and sediment beyond its channel. When the water spreads to the floodplain, it slows its flow and drops sediment across the plain. Water in the floodplain provides the key component for decomposition, breaking down nutrients that will be available for other living things. Some species of fish (e.g., silvery minnows) spawn in response to the high flow. Sometimes the river would change course in the spring and erode banks while leaving new sand bars for new cottonwoods to establish themselves as well.

Assessment: All questions finished, accuracy, interpretation of the data.

Extensions: Use USGS site to relate the cubic feet per second information to acre feet and calculate acre feet.

Add to the San Marcial Floodway hydrograph the data for this year. Look under "Surface water—Measurements" option at the gage site; the term "stream flow" is the cubic-feet-per-second (cfs) value to graph. You can limit the data presented in the chart to the months you want with "reselect output format." How does this compare to the previous years shown on the San Marcial hydrograph hand-out?

You can use the same process above to create a hydrograph from the gage closest to your community. Compare this graph to the San Marcial hydrograph handout.

As students explore gage data, have them consider the climatic events for a current year. For instance, if they review gage data along the Rio Grande from 1930 to 1960, they will find dramatic peaks and valleys. Refer them to the Western Regional Climatic Center's Historical Summaries website (http://www.wrcc.dri.edu/ Historic Climate Information, Climate and Weather Information heading, Western U.S. Historical Summaries (individual stations), select New Mexico link). Red dots indicate climate reporting stations across New Mexico. Selecting one will bring up lists of average precipitation and temperature measurements over many decades, as well as listings for daily and monthly readings.

Have students compare hydrograph readings with climatic data to see any corresponding trends. Returning to the 1930-1960 example above, students should discover a period of historic precipitation in the early 1940's which corresponds to higher river gauge readings. Conversely, lower readings in the 1950's should correspond with climatic data that indicates an equally historic drought. What other trends might they discover?

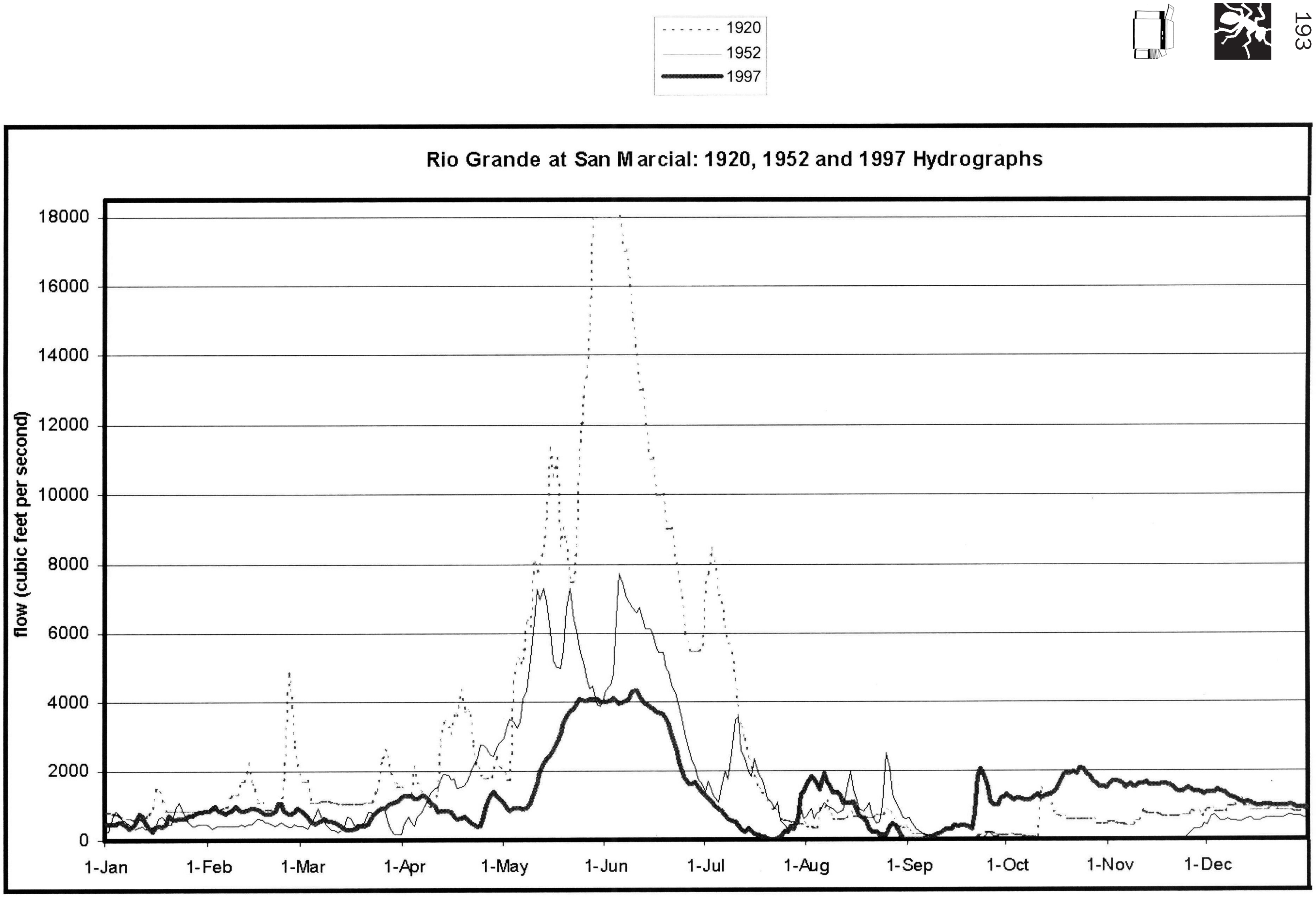
Resources: Bosque Hydrology Group web site, hosted by the U.S. Fish and Wildlife Service site

http://bhg.fws.gov/

http://waterdata.usgs.gov/nm/nwis/uv?08358400 (San Marcial site)

http://waterdata.usgs.gov/nm/nwis/ New Mexico water data

Western Regional Climatic Center http://www.wrcc.dri.edu


1920
1952
1997
Rio Grande at San Marcial: 1920, 1952 and 1997 Hydrographs
flow (cubic feet per second)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

Hydrograph Worksheet 1

Part 1

1. Was the river dry at any time(s)? List months and years.

2. What were the flows on June 18 on each of the years shown?

3. What causes these high flows at this time of the year?

4. Count the number of days in each of the three years the water flowed over 3,500 cfs. This represents overbank flooding conditions in area of Bosque del Apache National Wildlife Refuge just north of San Marcial.

5. What causes the smaller peaks in late summer?

6. Which year had the highest flows during the late fall/early winter?

7. Describe in sentences the rhythm of flow of the Rio Grande over the course of a year.

8. Why has the hydrograph changed over the century?

9. In this system, what effect have dams had on river flow?

Hydrograph Worksheet 2

Part 2: Internet Access

1. Look up the river flow today at the San Marcial gage on the U. S. Geological Survey web site by searching for National Water Information System, USGS Station #08358400—"Rio Grande Floodway at San Marcial, NM." (The term "floodway" has the numbers you want for the river flow. There are two San Marcial gages; the other is the "Conveyance Channel.") Look at "Real time" data and the chart that shows "Discharge": this shows the current flow as well as the flow for the last few days.

a. What is the flow today? Date__________ time___________ flow___________

b. Print out a hydrograph for the last week or last month—you define the number of days.

2. Look on the USGS web site for the gage that is closest to where you live. "USGS Real time data for New Mexico" http://waterdata.usgs.gov/nm/nwis/rt includes a map of the gages in the state. You can select the closest one. You can also look for a place to type in the county or other location information to help locate the closest gage.

a. Name of the gage site ___________________________________

USGS Station # ___________________________________

Web address of the site___________________________________

What is the flow today? Date__________ time___________ flow___________

b. Print out a hydrograph of the water flow at this location for the last week or month—choose the same days as the San Marcial hydrograph you printed above.

c. Compare the two hydrographs: write a paragraph comparing them.

3. From other information in this guide and what the you have learned in this activity, write about the role/importance of spring run-off in the bosque ecosystem.