33. *How Deep is the Water Table?*

Description: Students work in teams of scientists to analyze ground water data to determine how deep to plant cottonwood poles.

Objective: Students will understand:

- how to graph data in order to make interpretations;
- that Rio Grande levels fluctuate on an annual basis, generally peaking in the spring and early summer because of snow melt;
- that science is an ever-changing pursuit and scientists don't always know all of the answers; and
- that ground water levels are highly variable and ground water systems are complex.

Materials: For each group of four students:
copies of data tables
map of well sites
four rulers
graph paper
colored pencils (optional)

Procedure: Preparations:

1. Make copies of all data tables for each group.
2. Obtain materials for each group.

Doing the activity:

1. Lead an introductory discussion that summarizes what students should already understand about ground water. Points students should already understand:
   a. Cottonwood trees need floods in order to regenerate naturally.

33. How Deep Is the Water Table?

Grades: 7–12

Time: preparation: 10 minutes
class activity: 40–60 minutes

Subjects: science, math

Terms: *runoff, ground water, water table, pole planting, discharge, fluctuation, anomalous*

b. Cottonwood trees and other plants living in the bosque take up water through their roots.
c. Cottonwood trees, and some other trees, have their roots in ground water.
d. Ground water is water stored underground in the pore spaces between sediment grains.
e. Ground water can travel through sediment (permeability).

2. Set the scene for the activity.

   Each student group is a team of scientists. In this situation, the City of Albuquerque is concerned about the Rio Grande bosque. The city would like to plant cottonwood poles. Cottonwood poles are long, live branches off a large cottonwood. When stuck into the ground to the level of the water table, the cottonwood poles will sprout roots and become new cottonwood trees. The problem is, the city wants to know how deep to plant the cottonwood poles so that the roots will sprout. They have come to you for help. Your job is to analyze some data you have collected from wells in the bosque to determine the characteristics of the ground water table at each well site, so that cottonwood poles can be planted at each area. (There is more information on pole planting in the Rio Nuevo section of the "Changing River" activity and in Chapter 7, Service Learning.)

3. Pass out the data tables and graph paper to each group. Each person in the group should graph one set of data. Three of the data sets are measurements of water depth in the wells. Therefore, in order to make interpretation of the graphs easier, students should graph the data with the graph origin (0 feet below the surface) in the upper left-hand corner. Each team member should use the same scale for the graphs so they can be compared.

   Take time to review graphing with your students. If students are very familiar with graphing, you may need to make a few points about the location of the origin. If students are not accomplished with graphs, you may want to get them started by demonstrating how the graph is set up.

   Stress that these are *real* data and that the question about the depth to plant cottonwood poles is a *real* question the City of Albuquerque is investigating. Note that the data sets are incomplete. Equipment failures and logistics problems often contribute to incomplete data sets. In this case, it is permissible to connect all of the data points, except in places where the data skips more than four months. Completed copies of the graphs

are included in this lesson as a key. Note that to reduce space all three well-depth data sets are combined into one graph.

In discussing the data, explain the term discharge. The volume of water in a river is measured in cubic feet per second (cfs). For example, if a river has a discharge of 300 cfs, at any given point, 300 cubic feet of water are flowing by each second. Another way to think about this measurement is that a cubic foot is approximately equal in size to a kitchen sink. At 300 cfs, have students imagine 300 kitchen sinks of water flowing by each second.

4. Once the graphs are complete, begin an analysis of the graphs. Teams should use all of their graphs together to make interpretations. You may either carry out the analysis as a class, or pass out the analysis questions to each group. Analysis questions are listed after each data set.
5. Have each group of student scientists prepare a summary of the well sites and determine how deep to plant the cottonwood poles.

Extensions/ Assessment:

1. For younger students: do the activity as a class.
2. Students can make more graphs using data available from the U.S. Geological Survey available at
   http://nm.water.usgs.gov/waterwatch
   Have students write an interpretation of the graph that characterizes the ground water table at the well site.
3. Transfer the individual team graphs to one graph for better comparison (see key).
4. Visit pole planting areas, assist on a pole planting project or take a trip to well sites with a researcher to see how he/she measures the water table. See Chapter 7, Service Learning, for more information.
5. Discuss or have students write answers to the following questions.

As recently as 1990, scientists and city officials thought that the aquifer beneath the bosque was one continuous layer of sediment with water filling all the pore spaces. People thought we could pump unlimited quantities of water from the aquifer and it would be refilled by water soaking in from the river. Based on the graphs you drew from the three wells in the bosque, what do you think is wrong with what people used to think about the ground water beneath the bosque?

In the Bosque Ecosystem Monitoring Program, students have been measuring ground water wells for several years. At sites with deep ground water, the plants under the trees are mostly shrubs. At sites with shallow ground water, grasses and sedges dominate. Do you think this is a coincidence or does the depth of the ground water affect the plants that grow there? Support your answer.

Resources: Data for this activity are real data obtained from "Analysis of the Groundwater Monitoring Program in the Rio Grande Valley State Park, February 1998 through December 1999," City of Albuquerque Parks and Recreation Department, Open Space Division.

Possible Answers to Analysis Questions

Rio Grande Discharge Questions

1. In which months is the river discharge (flow) the highest?
   May 1998, May 1999, June 1999, July 1999
2. List at least two reasons why river discharge would be highest in these months.
   Snow is melting from the mountains and flowing into the rivers.
   There is a release of water from upstream dams.
3. In which months is the river discharge (flow) the lowest?
   February 1998, November 1999, April 1999
4. List at least 2 reasons why river discharge would be lowest in these months.
   The temperatures are cool and no snow is melting into the rivers.
   There are no releases of water from upstream dams.

Well Questions

1. In which months of each year is the water table closest to the ground surface (the shallowest)?
   Rio Bravo—May 1998, June 1999, July 1999
   Zoo Burn—May 1998, July 1999, December 1999
   Rio Grande Nature Center—May 1998, February 1999, May 1999
2. Compare your graph to the Rio Grande discharge graph. Does your graph follow the patterns of the river? List two reasons why the water level in the well would be shallowest in the months that you listed in Question 1.
   More water in the river in May and June
   More water as rain in July (monsoons)
3. Compared to the graphs of the other well sites, does your well show lots of fluctuation (up and down movement), or little fluctuation?
   Rio Bravo—some fluctuation
   Zoo Burn—lots of fluctuation
   Rio Grande Nature Center—little fluctuation, except for anomalous readings in 1999.

4. Is the water table in your well shallower or deeper than the other well sites?
   Rio Bravo—shallowest
   Zoo Burn—deepest
   Rio Grande Nature Center—middle level

Site Characterizations

These are characterizations to be used as background information in helping your students interpret the graphs. Do not expect your students to write summaries this complex. You should encourage varying levels of response, depending on the level of your students' reasoning skills.

Rio Bravo Well

This well is located about a mile north of Rio Bravo in the South Valley on the east side of the river. It has the shallowest water table, with water depths ranging from 2.75 to 8.47 feet deep. It shows moderate fluctuation and does seem to go up when the river discharge is higher. This well is probably well-connected to the river. Cottonwood poles should probably be planted about 5 feet deep. Cottonwoods use the least amount of water in the winter, so 5 feet deep would ensure that their roots are in the water for most of the year, especially in the growing season.

Zoo Burn Well

This well is located near the Rio Grande Zoo on the east side of the Rio Grande. It has the deepest water table, with water depths ranging from 4.1 to 9.5 feet deep. It shows high fluctuation and seems to go up when the river discharge is higher. This well is probably well-connected to the river. Cottonwood poles should probably be planted about 9 feet deep so that roots are in the ground water even when the water table is low.

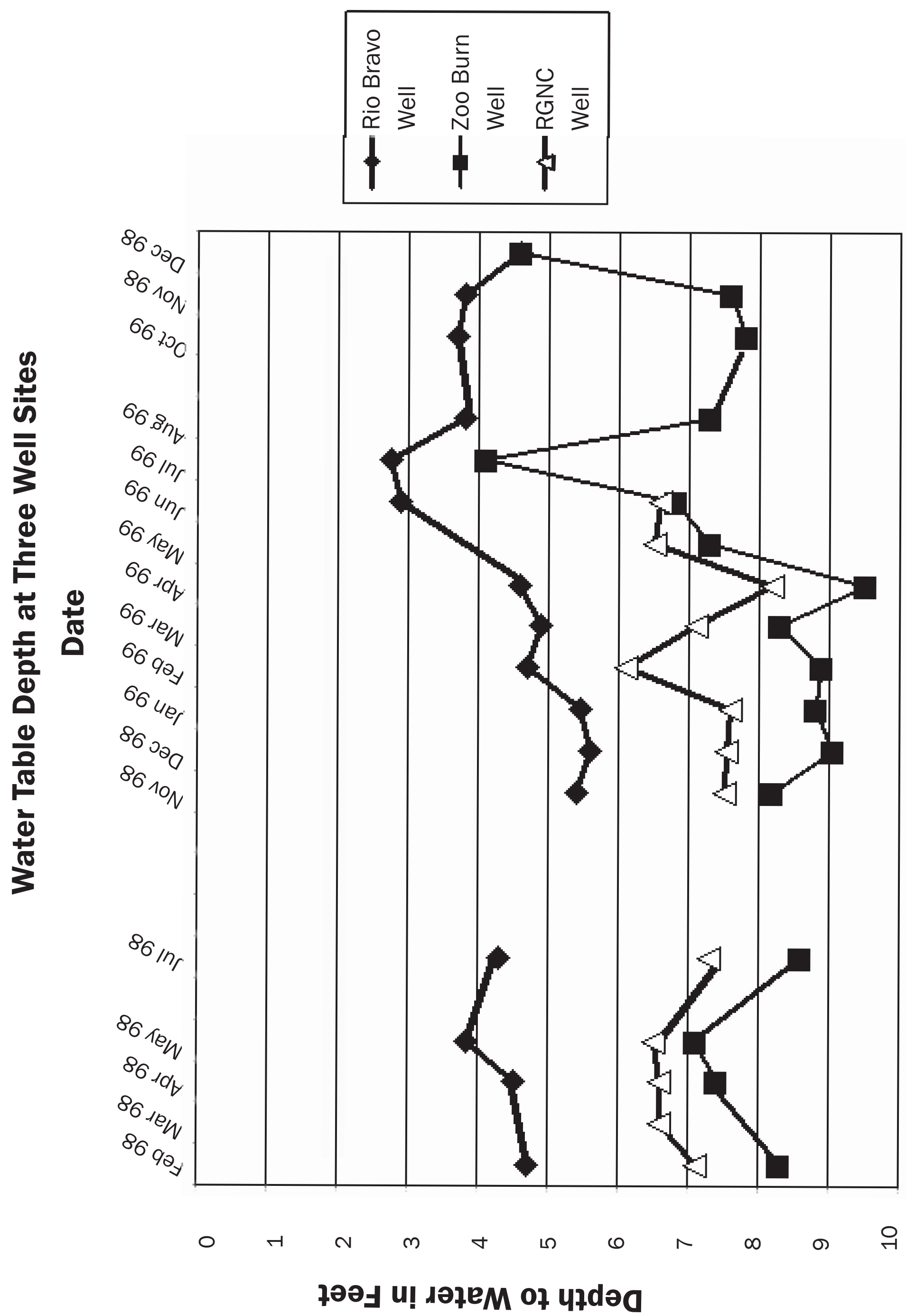
Rio Grande Nature Center Well

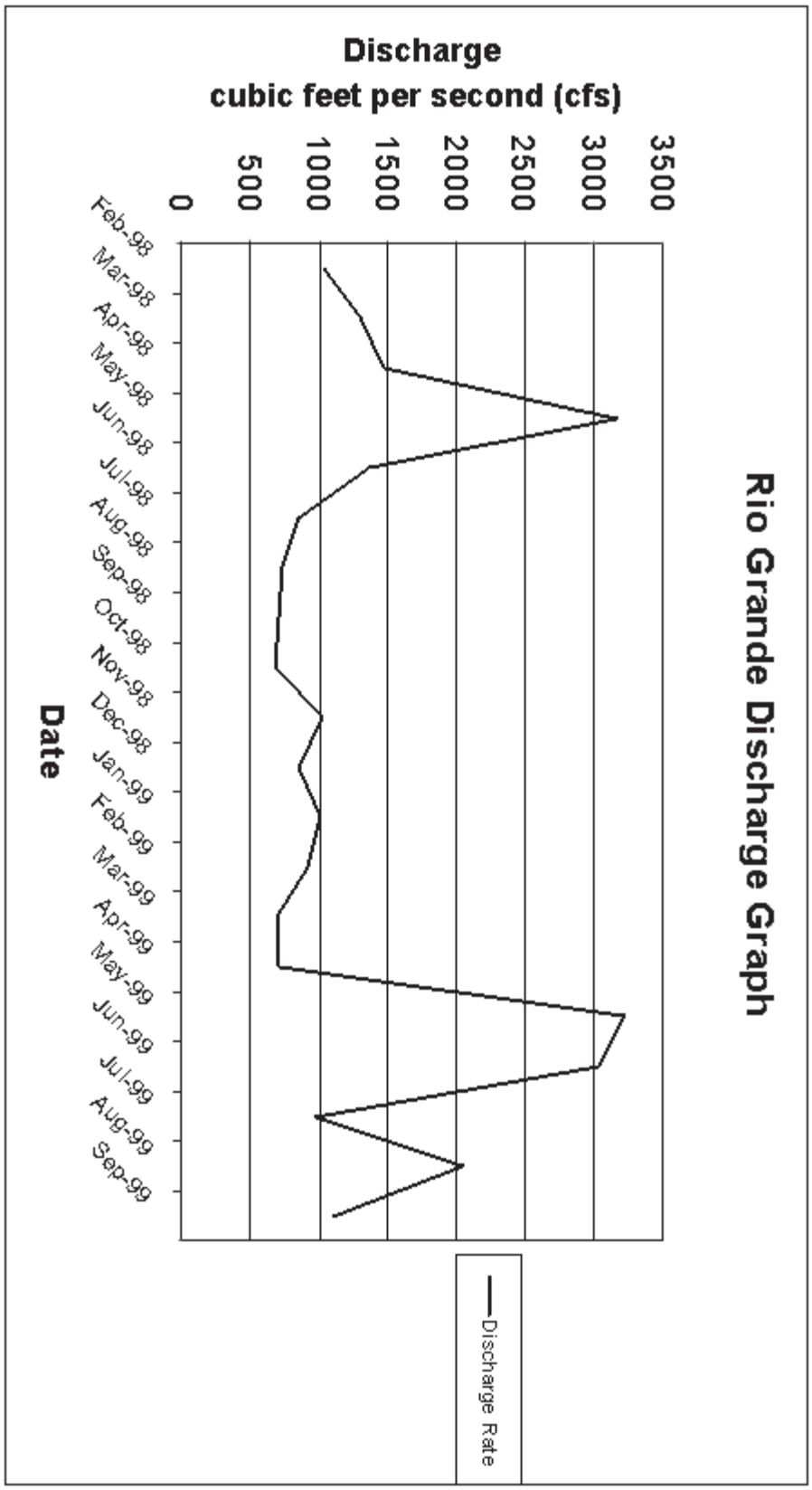
This well is located on the east side of the river in the Rio Grande Nature Center State Park. Its water table is deeper than the Rio Bravo well but shallower than the Zoo Burn well. It shows the least variability, although data is somewhat inconclusive. January 1999 and April 1999 seem like anomalous readings. This well does not follow the trends of the river. This well may not be as well-connected to the river as the other two wells, meaning that the depth to ground water does not vary with the amount of surface water in the Rio Grande. (This may mean that there are clay deposits that are a barrier to ground water movement or that the river channel is incised and the water does not infiltrate to that area.) Cottonwood poles should probably be planted about 7.5 feet deep.

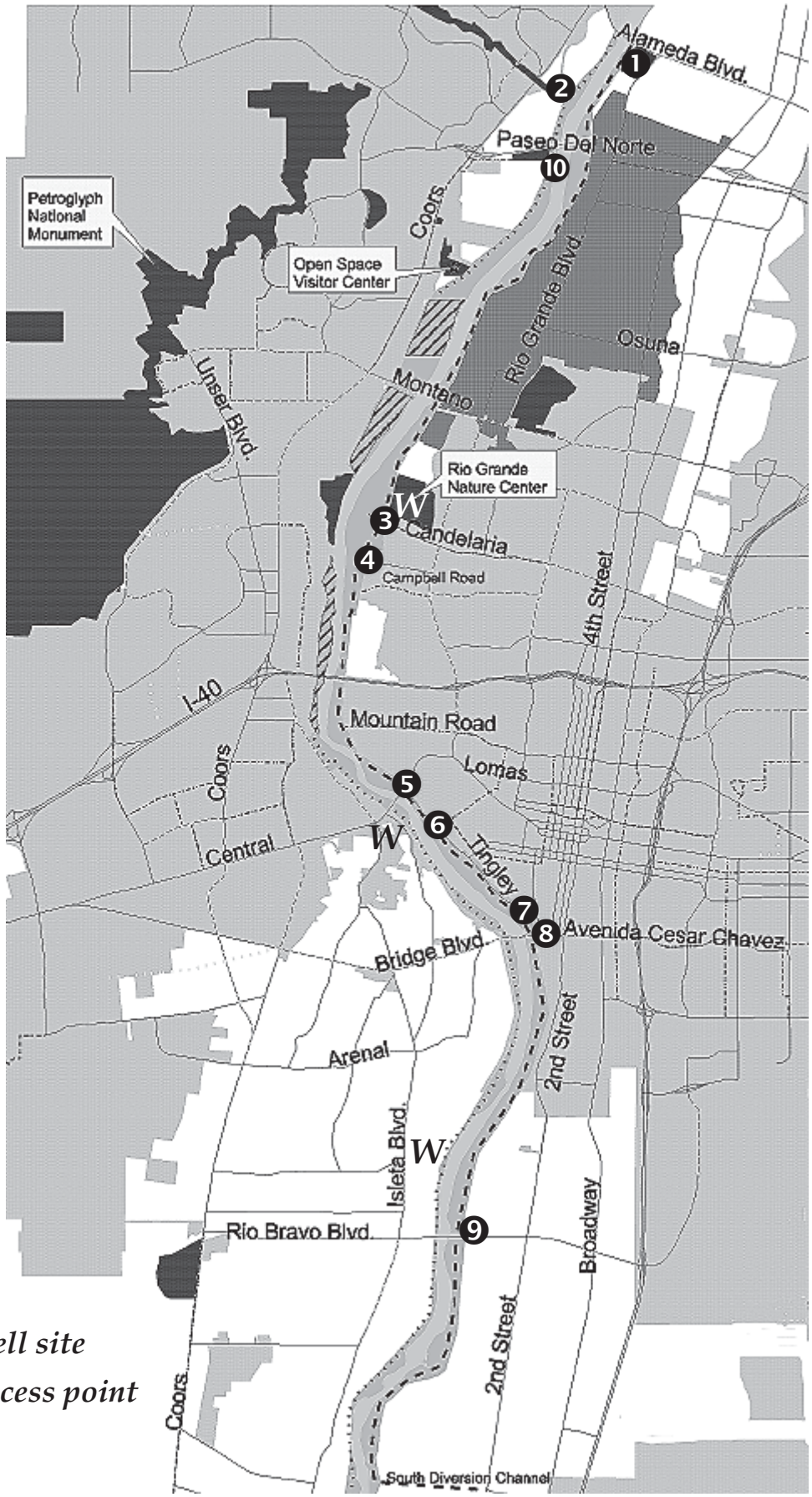
Extension Questions:

As recently as 1990, scientists and city officials thought that the aquifer beneath the bosque was one continuous layer of sediment with water filling all the pore spaces. People thought we could pump unlimited quantities of water from the aquifer and it would be re-filled by water soaking in from the river. Based on the graphs you drew from the three wells in the bosque, do you think this is true?
Based on the data from these three wells, the aquifer beneath the bosque does not seem like one continuous layer of sediment filled with water. Each site is different and appears independent. Researchers have found far less water in the aquifer than once believed. Some of that loss is due to more clay deposits that do not hold available water. Another part is that as ground water is pumped from the aquifer, and water is pulled out for irrigation and other uses, there is not enough water to recharge the aquifer. More research is needed to understand how the ground water, the river, and the bosque are connected.

In the Bosque Ecosystem Monitoring Program, students have been measuring ground water wells for several years. At sites with deep ground water, the plants growing under the trees are mostly shrubs. At sites with shallow ground water, grasses and sedges dominate. Do you think this is a coincidence or does the depth of the ground water affect the kinds of plants that grow there? Support your answer.
Grasses have shorter root systems and shrubs have deeper root systems. Where ground water is deeper, shrubs can out-compete grasses. Although shrubs can tolerate higher ground water, it is harder for them to become established due to competition with grasses.


Water Table Depth at Three Well Sites
Date
Depth to Water in Feet
Rio Bravo Well
Zoo Burn Well
RGNC Well
0
1
2
3
4
5
6
7
8
9
10
Feb 98
Mar 98
Apr 98
May 98
Jul 98
Nov 98
Dec 98
Jan 99
Feb 99
Mar 99
Apr 99
May 99
Jun 99
Jul 99
Aug 99
Oct 99
Nov 98
Dec 98


Rio Grande Discharge Graph
Discharge
cubic feet per second (cfs)
3500
3000
2500
2000
1500
1000
500
0
Feb-98
Mar-98
Apr-98
May-98
Jun-98
Jul-98
Aug-98
Sep-98
Oct-98
Nov-98
Dec-98
Jan-99
Feb-99
Mar-99
Apr-99
May-99
Jun-99
Jul-99
Aug-99
Sep-99
Date
Discharge Rate



W = well site

▶ = *access point*

How Deep Is the Water Table?

1. Rio Grande Discharge Graph

Date	Feb 98	Mar 98	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98
cfs*	1,034	1,288	1,471	3,177	1,366	858	732	700	682	1,032

Date	Dec 98	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99	Jul 99	Aug 99	Sep 99
cfs*	851	1,001	913	689	703	3,220	3,042	973	2,047	1,103

*cubic feet per second

Analysis Questions

1. In which months is the river discharge (flow) the highest?
2. List at least two reasons why river discharge would be highest in these months.
3. In which months is the river discharge (flow) the lowest?
4. List at least two reasons why river discharge would be lowest in these months.

Now use your graph to help others in your team of scientists answer questions about the well sites.

How Deep Is the Water Table?

2. Rio Bravo Well

Date	Feb 98	Mar 98	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98
Depth*	4.7	—	4.5	3.85	—	4.3	—	—	—	5.4

Date	Dec 98	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99	Jul 99	Aug 99	Sep 99
Depth*	5.6	5.45	4.7	4.9	4.6	—	2.9	2.75	3.8	—

Date	Oct 99	Nov 99	Dec 99
Depth*	3.7	3.8	4.6

*depth to water in feet

Analysis Questions

1. In which months of each year is the water table closest to the ground surface (the shallowest)?
2. Compare your graph to the Rio Grande discharge graph. Does your graph follow the pattern of the river? List two reasons why the table table in the well would be shallowest in the months that you listed in Question 1.
3. Compared to the graphs of the other well sites, does your well show lots of fluctuation (up and down movement), or little fluctuation?
4. Is the water table in your well shallower or deeper than the other well sites?
5. Circle any points on the graph that seem like they don't fit. What reasons can you think of to explain this?
6. What difficulties did you have in reading this graph?

How Deep Is the Water Table?

3. Zoo Burn Well

Date	Feb 98	Mar 98	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98
Depth*	8.3	—	7.4	7.1	—	8.6	—	—	—	8.2

Date	Dec 98	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99	Jul 99	Aug 99	Sep 99
Depth*	9.05	8.8	8.9	8.3	9.5	7.3	6.8	4.1	7.3	—

Date	Oct 99	Nov 99	Dec 99
Depth*	7.8	7.6	4.6

*depth to water in feet

Analysis Questions

1. In which months of each year is the water table closest to the ground surface (the shallowest)?
2. Compare your graph to the Rio Grande discharge graph. Does your graph follow the pattern of the river? List two reasons why the table table in the well would be shallowest in the months that you listed in Question 1.
3. Compared to the graphs of the other well sites, does your well show lots of fluctuation (up and down movement), or little fluctuation?
4. Is the water table in your well shallower or deeper than the other well sites?
5. Circle any points on the graph that seem like they don't fit. What reasons can you think of to explain this?
6. What difficulties did you have in reading this graph?

How Deep Is the Water Table?

4. Rio Grande Nature Center Well

Date	Feb 98	Mar 98	Apr 98	May 98	Jun 98	Jul 98	Aug 98	Sep 98	Oct 98	Nov 98
Depth*	7.1	6.6	6.6	6.5	—	7.3	—	—	—	7.5

Date	Dec 98	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99	Jul 99	Aug 99	Sep 99
Depth*	7.55	7.6	6.1	7.1	8.2	6.5	6.6	—	—	—

Date	Oct 99	Nov 99	Dec 99
Depth*	–	–	–

*depth to water in feet

Analysis Questions

1. In which months of each year is the water table closest to the ground surface (the shallowest)?
2. Compare your graph to the Rio Grande discharge graph. Does your graph follow the pattern of the river? List two reasons why the table table in the well would be shallowest in the months that you listed in Question 1.
3. Compared to the graphs of the other well sites, does your well show lots of fluctuation (up and down movement), or little fluctuation?
4. Is the water table in your well shallower or deeper than the other well sites?
5. Circle any points on the graph that seem like they don't fit. What reasons can you think of to explain this?
6. What difficulties did you have in reading this graph?

How Deep Is the Water Table?

Site Characterizations

For each well, write complete sentences that describe the following characteristics of the well. Work as a team to answer the questions. Share the writing responsibility.

1. Where the well is located (refer to the map).
2. How deep you would plant the cottonwood poles.
3. Two reasons why you would plant the poles this deep.

Rio Bravo Well

Zoo Burn Well

Rio Grande Nature Center Well

For the Rio Grande Discharge, write a short summary about:

1. What typical discharge levels are for spring, summer, fall and winter.

2. Reasons why flows increase and decrease.

3. How the river influences the water table level at the nearby well sites.