The Hudson's Ups and Downs

Students will interpret line graphs of Hudson River water levels to learn about tides and tidal cycles in the estuary.

Objectives: Students will read line graphs to:

- examine how tides change water levels along Hudson River estuary;
- observe that high tides and low tides occur in predictable cycles;
- understand that high and low tides occur at different times in different places along the Hudson estuary;
- explore how weather can affect water levels and tides.

Grade level: Elementary (Grade 5-7)

Subject Area: Math, Science

Standards: Mathematics, Science, & Technology Standards 3, 4

Skills:

- Use line graphs to analyze patterns observed in the physical environment.
- Use line graphs to compare and contrast data and events.

Duration:
Preparation time: 5 minutes
Activity time: 50 minutes

Materials: Each student should have:

☐ Worksheet: The Hudson's Ups and Downs
☐ Pen or pencil

It would be helpful for the teacher to have:

☐ A jump rope or other length of rope

Background:
The Hudson's surface is roughly at sea level from New York Harbor to the dam at Troy, and is influenced by ocean tides over that distance. These tides are important to the movement of ships, the plans of kayakers and anglers, the distribution of aquatic plant communities, and many other aspects of economic, recreational, and ecological activity along the river.

This lesson explores the cycle of high and low tides but not their causes, which involve the gravitational attraction between the moon and earth and their relative positions—topics difficult for elementary students to comprehend. That said, a brief and greatly simplified explanation may be useful as background.

Imagine the earth as an idealized ball covered with water at the same depth all around. The moon's gravitational attraction shapes this idealized ball into an ovoid, an egg-shaped object. One of the oval's elongated ends is directly under the moon; the other is on the opposite side of the earth. These elongated ends can be thought of as bulges. While both earth's crust and the oceans bulge, the effect is much greater in the water. These bulges are high tides.

Now put this picture in motion. As the earth spins on its axis, the bulges remain in position under the moon, and are experienced as two daily high tides along the Atlantic coast. In between the bulges, ocean levels are lower, causing low tides. So in the 24 hours it takes the earth to rotate once on its axis, we will usually have two high tides and two low tides. Actually, because the moon revolves around the earth, a complete tidal cycle takes more than 24 hours. Imagine checking your watch when you are directly under the moon and then waiting for the earth to spin full circle. In that time the moon doesn't stand still. It moves ahead towards the east, so 24 hours plus 50 minutes go by before you are directly under the moon again. Thus the timing of a given tide falls back 50 minutes each day, on average. For example, if low tide on Monday morning is at 9:00, low tide Tuesday morning would be at 9:50.

While the above theoretically explains the forces that produce tides, the response of actual oceans, divided up into basins separated by continents, depends on the shape of the perimeter and sea floor of these basins. The bulges do not literally move across the oceans in two massive waves. An explanation of these tidal dynamics goes beyond the space available here.

Activity:
1. Discuss what tides are, perhaps by having students recount visits to the ocean.
2. Relate what the line graphs show to the reality of water levels rising and falling.
3. This activity is best done in class with the teacher available to provide assistance.

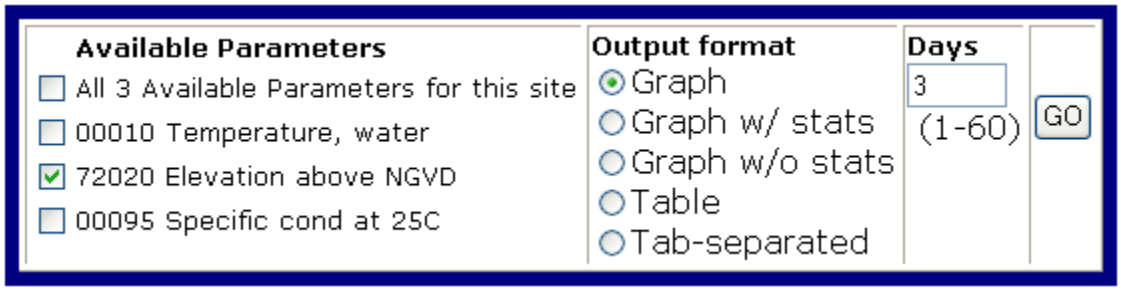
Assessment:
- Have students share answers to questions, or collect and grade sheets.
- On a classroom computer or Smartboard, visit a Hudson River remote sensing website and use current water level data (see below) to have students identify high and low tides.

Vocabulary:

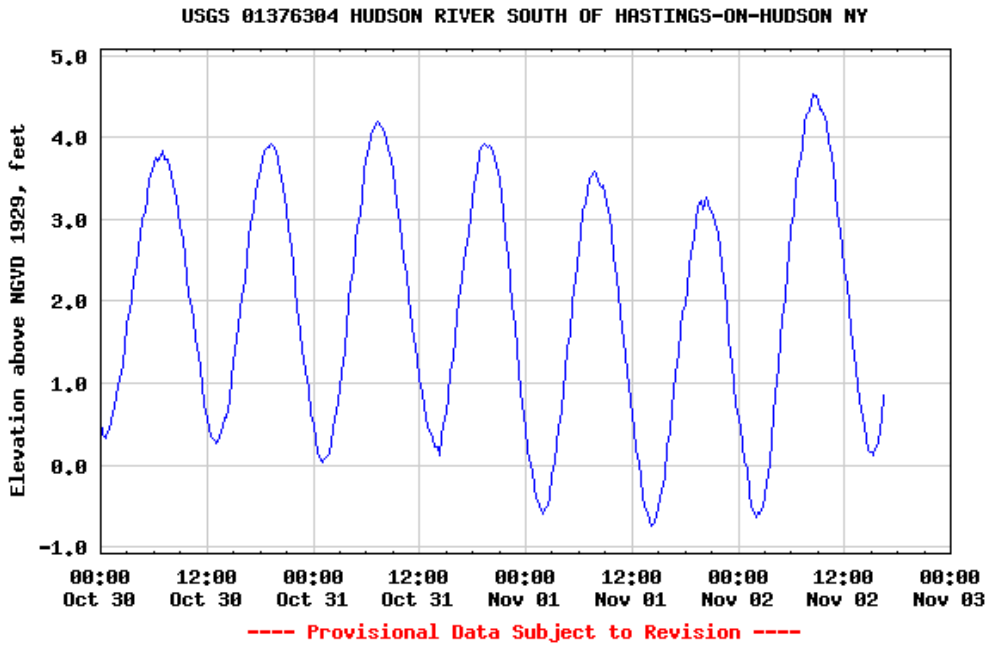
dam: a barrier built across a stream
estuary: a body of water in which fresh and salt water meet
high tide: highest water level in the tidal cycle
low tide: lowest water level in the tidal cycle
sea level: the average height of the ocean
tidal cycle: the repetitive rise and fall of the ocean's surface over a 24-hour period
tides: the alternating rise and fall of the surface of the ocean and bodies of water closely linked to it

Resources:

http://ny.water.usgs.gov/projects/dialer_plots/saltfront.html The **U.S. Geological Survey's Hudson River Salt Front website** offers real-time data recorded every 15 minutes by gages at Hastings on Hudson, West Point, Poughkeepsie, and Albany. Click on the 15-minute data link for one of the gages, then scroll down to this table. Select the parameter, output format, and number of days to display, then click on GO.

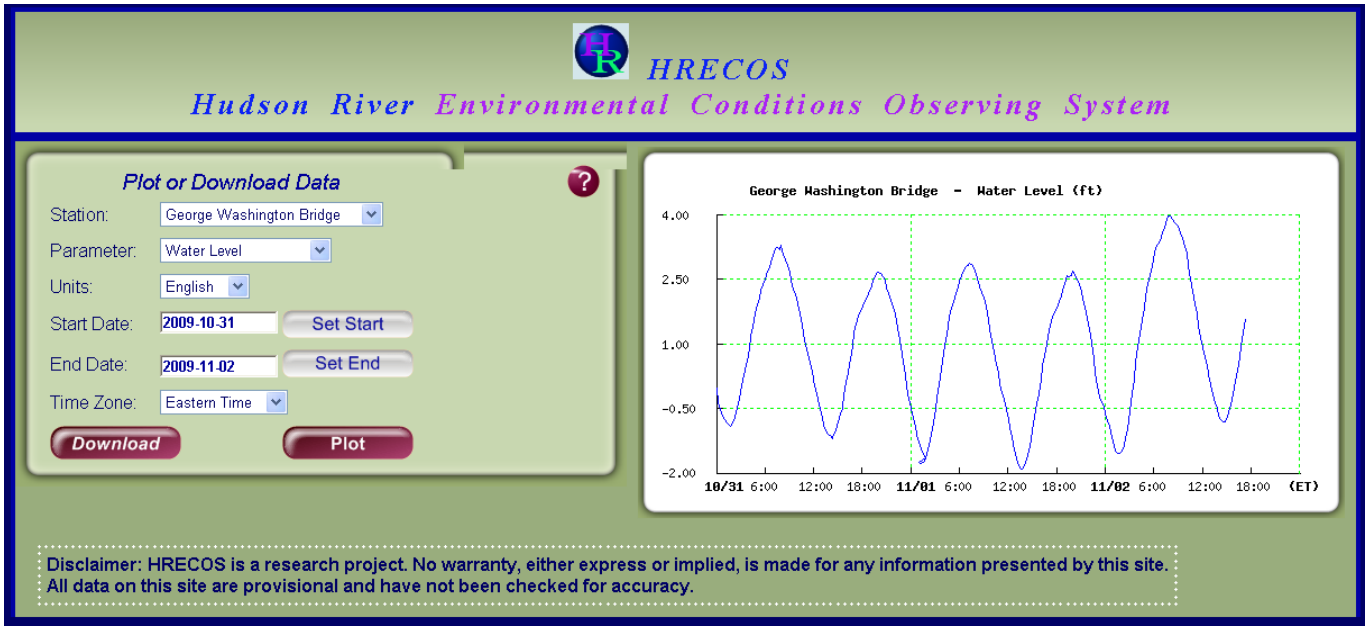


On November 2, 2009, visiting the 15 minute data site for the gage at Hastings on Hudson, selecting "Elevation above NGVD" from the available parameters (NGVD is an approximation of sea level), "Graph" from the output format list, 3 days of coverage, and clicking on "GO" produced this graph of high and low tides.



www.hrecos.org The **Hudson River Environmental Conditions Observing System (HRECOS)** is a network of real-time monitoring stations geographically distributed at six sites from Schodack Island in Rensselaer County to the New York/New Jersey harbor. Its sensors take measurements every 15 minutes, and offer a range of water and weather data. From the home page, select the link to Current Conditions to bring up the interactive screen below.

Start by choose a station using the dropdown menu; for most of the stations, you will have the option of weather (met) or water (hydro) readings. Then choose a parameter, units (English or metric), and start and end dates. Click on Plot to produce the desired graph.



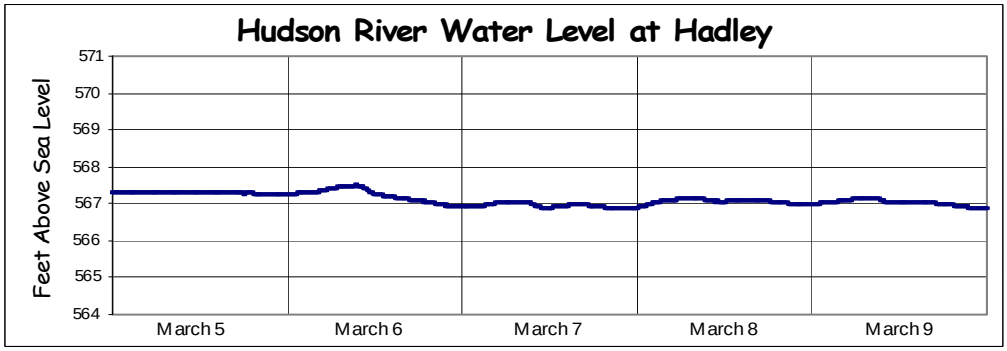
This graph showing tides was produced by selecting the George Washington Bridge station, the Water Level parameter, English units, a start date of October 31, 2009, and an end date of November 2, 2009.

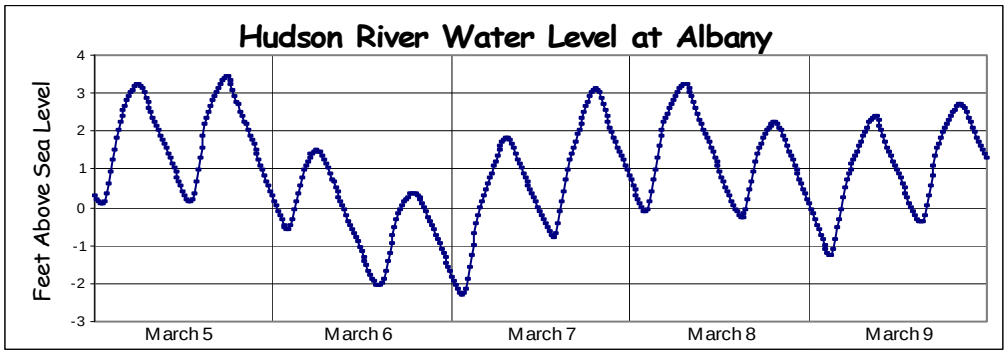
http://tidesandcurrents.noaa.gov/tides09/ For **predictions of high and low tides**, visit this National Ocean Survey site. (After 2009, change 09 to 10, 11, etc. in the URL.) Once the page has opened, select New York from the list of states on the left. From the list of waterways on the next page, click on Hudson River. In the list of locations then presented, choose the one desired and—in the far right hand column—click on predictions. Keep in mind that these are only predictions; weather conditions may affect the actual tide times.

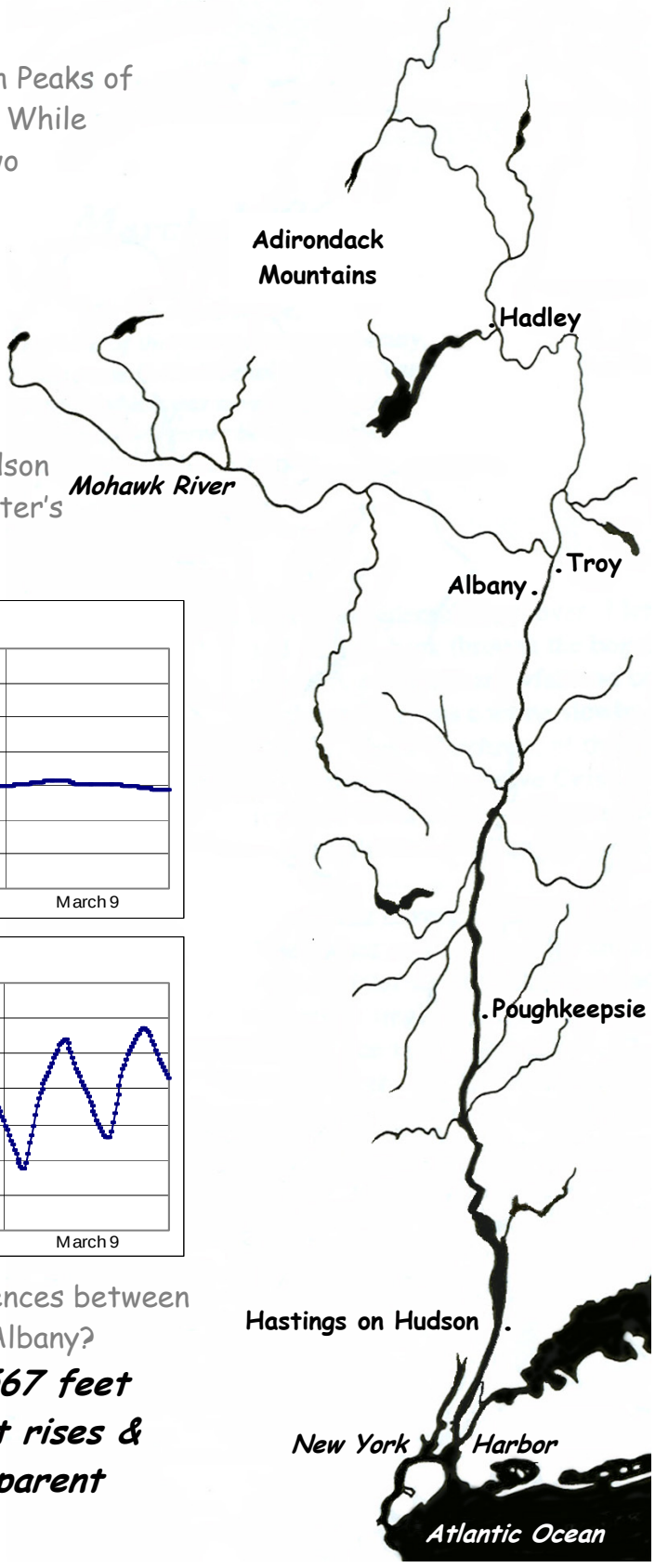
The Hudson's Ups and Downs – ANSWER KEY

The Hudson River flows 315 miles from the High Peaks of the Adirondack Mountains to New York Harbor. While the river has one name, it can be divided into two distinct sections. The two line graphs below illustrate some of the differences between these sections. They show the water level of the Hudson at Hadley and at Albany.

To make these graphs, instruments record the water level every 15 minutes. The water level is not measured from the river bottom; the Hudson is not 567 feet deep at Hadley! Instead, the water's height is measured in relation to **sea level**.







1. Compare these graphs. What are two differences between Hudson River water levels at Hadley and at Albany?

The river is at sea level at Albany - 567 feet above sea level at Hadley. In Albany it rises & falls in regular pattern; there is no apparent pattern at Hadley.

Hudson River Estuary

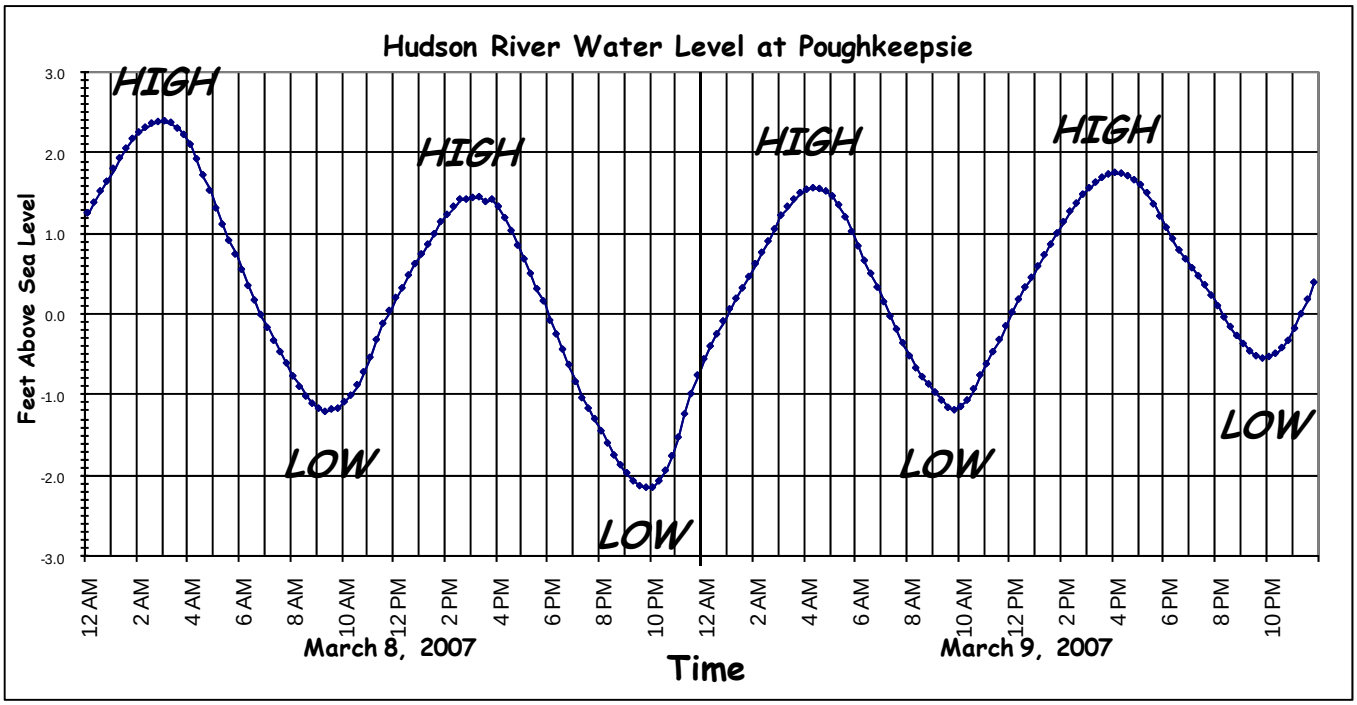
The dividing line between the two sections of the Hudson is a **dam** at Troy. Below the dam, the Hudson's surface is roughly at sea level. This allows ocean **tides** to affect the river all the way to the dam, more than 150 miles north of the Atlantic Ocean. Like ocean water at the seashore, the Hudson rises and falls with the tides.

2. These pictures show high and low tides at Poughkeepsie. Which is which?

In this picture, the tide is ***_high__***.

In this picture, the tide is ***_low__***.

3. On the graph below, label each **high tide** and each **low tide**.



4. At 3 PM on March 8, is the tide at Poughkeepsie high or low? ***High***

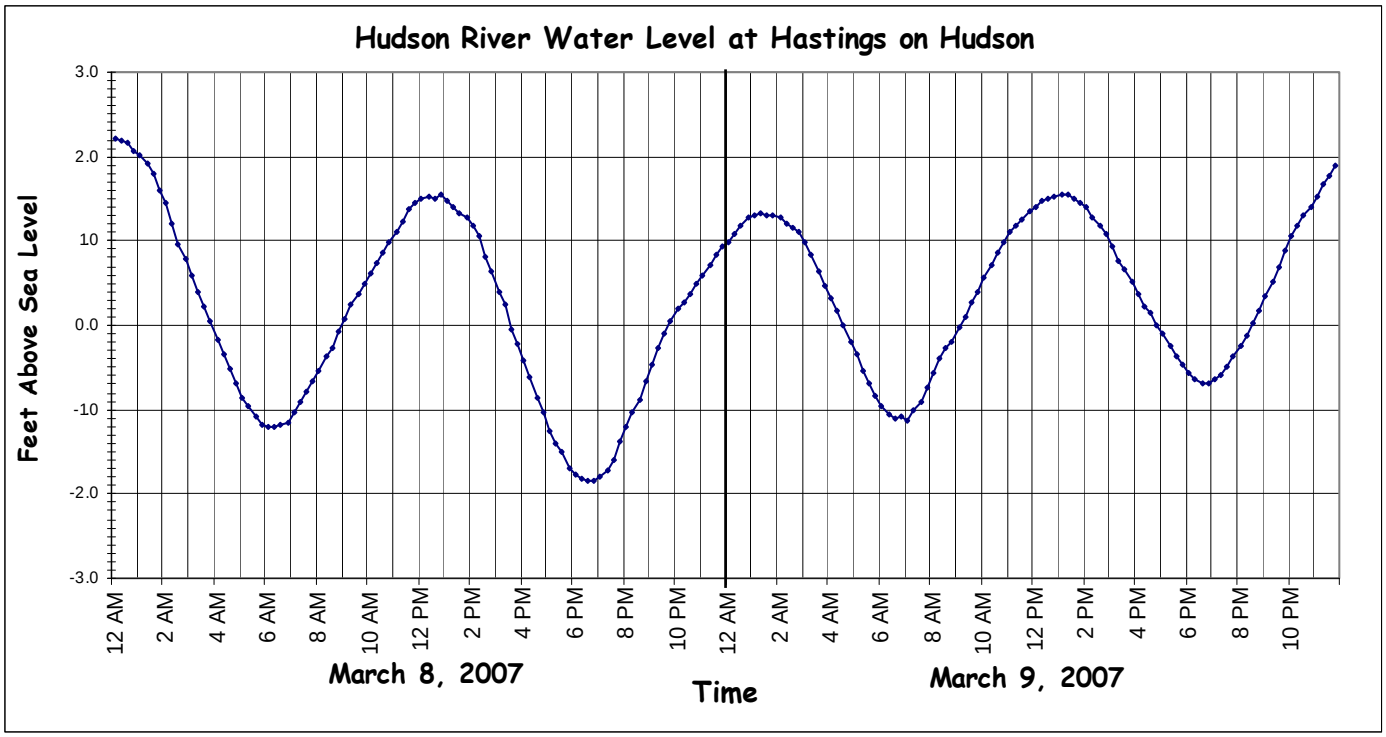
5. At 10 AM on March 9, is the tide at Poughkeepsie high or low? ***Low***

6. How many low tides occur each day at Poughkeepsie? How many high tides?

2 low tides; 2 high tides

Hudson River Estuary

Tides occur in **cycles** – there is a pattern in the timing of high and low tides.



7. Early on March 8 at Hastings on Hudson, the tide was high at 12 AM (midnight). How long did it take for the water level to go down to the next low tide?

About 6 hours

8. How much time went by between the morning low tide on March 9 and the afternoon high tide on that day?

About 6 hours

9. How much time went by between the 12 AM high tide on March 8 and the next high tide that day?

About 12-13 hours

10. How much time went by between the morning low tide on March 9 and the next low tide?

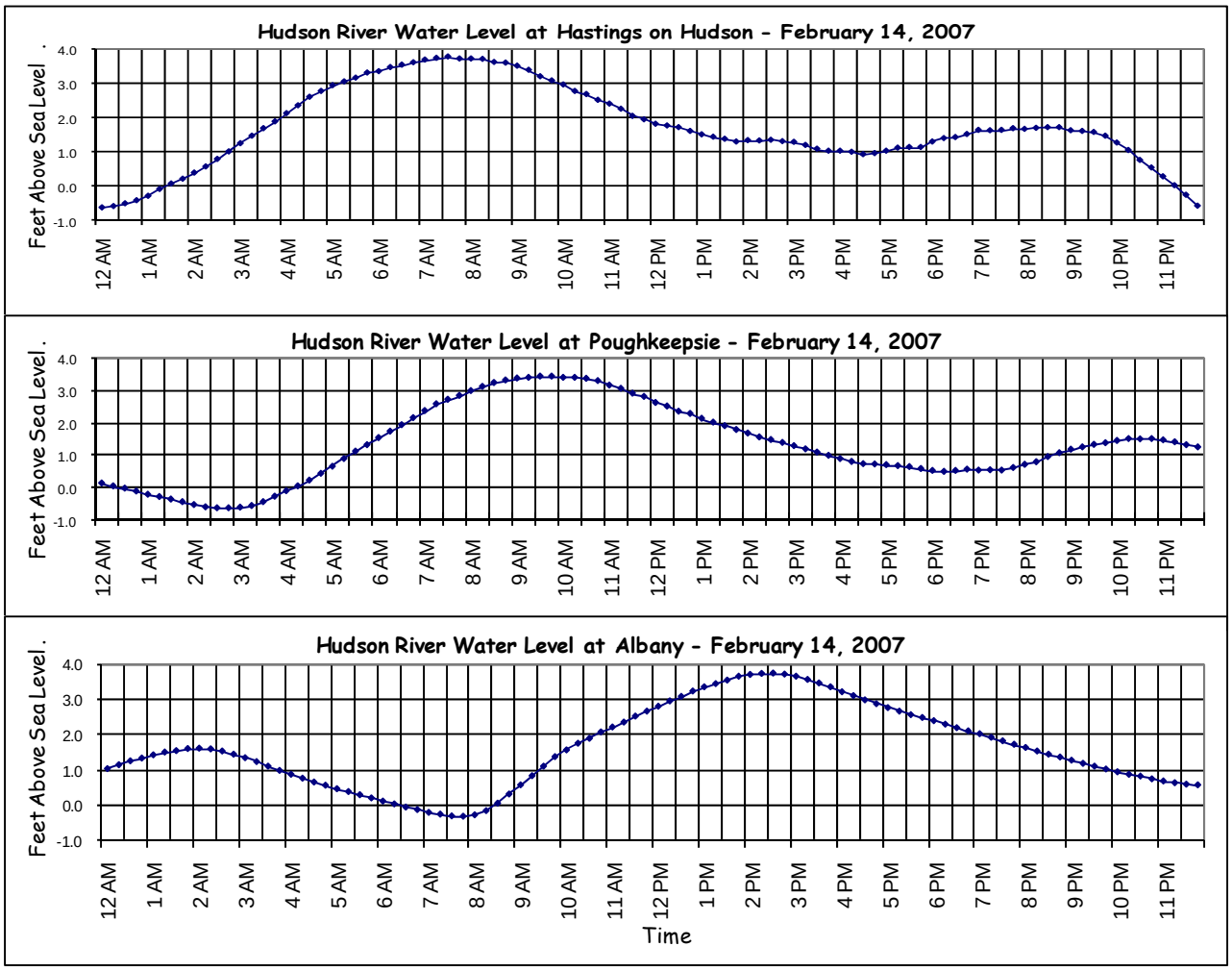
About 12-13 hours

11. What time will the first high tide occur on March 10? The first low tide?

First high about 1-2 AM; first low about 7-8 AM

Hudson River Estuary

Lay a jump rope out on the ground. Give one end a quick up and down snap to make a hump move from one end of the rope to the other. "Snapped" by a rising tide in the ocean, a high tide moves up the Hudson the same way, as shown by the line graphs below. This high tide will reach towns along the river at different times.



12. At 7:30 AM on February 14, there was a very high tide in Hastings on Hudson. At the same time in Albany, was the tide high or low?

Low

13. How long did it take this very high tide to go from Hastings to Albany?

7 hours

14. In Poughkeepsie, how many feet did the river rise from 3 AM to 9:30 AM?

About 4 feet

15. Catskill is halfway between Poughkeepsie and Albany. Based on times of the very high tide in Poughkeepsie and Albany, when will it reach Catskill?

At about 12 noon

Hudson River Estuary

16. Extra Credit Challenge Questions

So far, the graphs have shown normal tide conditions on the Hudson. However, weather – strong winds or heavy rains – may affect the tides.

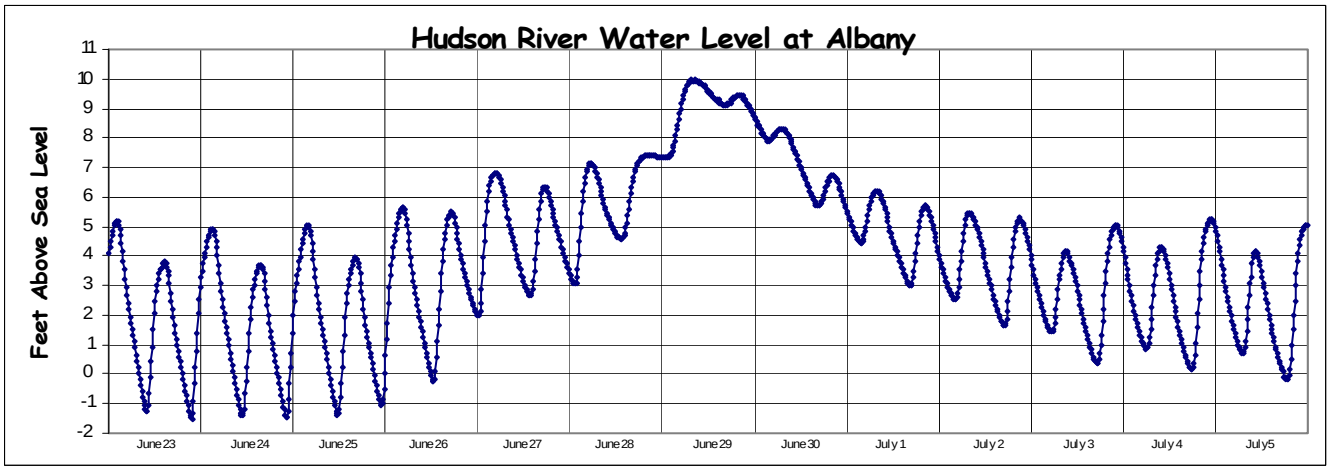
Look at the line graph of water levels in Albany in late June and July, 2006.

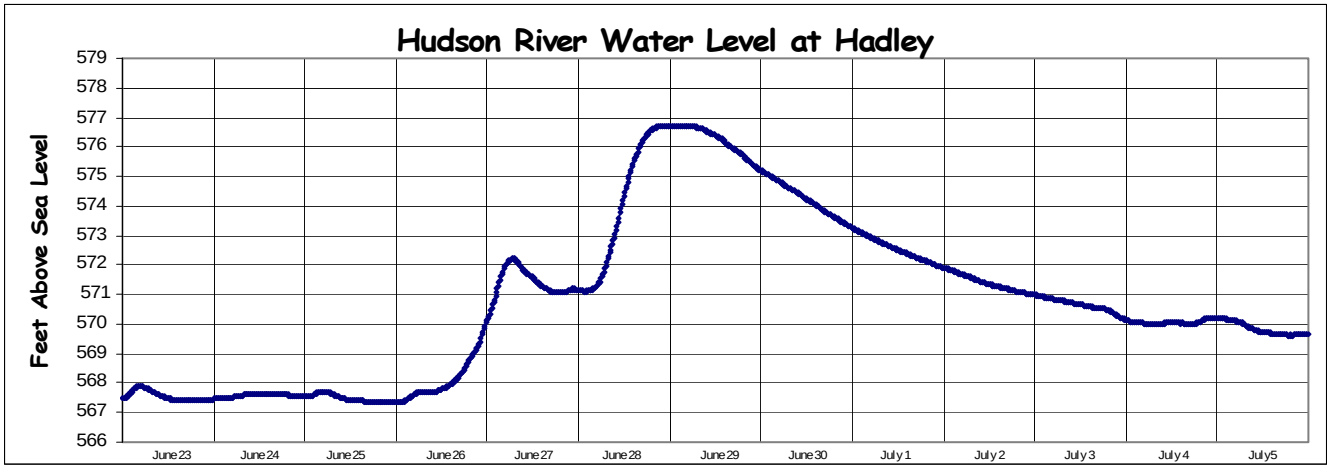
(a) Explain what was going on in the Hudson during this period, and what caused it. As a hint, look at the graph showing river levels in Hadley during the same time period. Was the event shown in this graph connected to the event in Albany?

Heavy rains caused the Hudson to flood. At Albany, the water level rose starting June 26, reached its highest point June 29, and then fell back to normal levels. The flood crest was later at Albany than at Hadley; the high waters took time to run downriver.

(b) Did whatever was happening change the cycles of the tides? How do you know?

Both high and low tides were much higher than normal, but the timing of the tide cycle was mostly unchanged.





Hudson River Estuary