



Teacher Guide—Physical Science Module

Activity 3: Human Impact on Estuaries: A Terrible Spill in Grand Bay



Featured NERRS Estuary:
Grand Bay National Estuarine
Research Reserve
<http://www.nerrs.noaa.gov/GrandBay/welcome.html>

Activity Summary

In this activity, students make a model of a pollution spill that occurred at Bangs Lake, a tidal lake within the Grand Bay NERR in Mississippi, in April 2005, and measure water quality parameters in their model. Students then study the actual spill, analyzing various forms of data to determine the date of the spill and identify how the spill changed water quality parameters in the estuary during and after the spill. They speculate on how various life forms in the estuary were affected. Finally, students produce a timeline of the spill event with recommendations to the state Department of Environmental Quality about how to prevent large-scale pollution spills like this in the future.

Learning Objectives

Students will be able to:

1. Describe how a chemical reaction affects water quality parameters of a sample of estuary water.
2. Use their lab results to predict the effects of an actual pollution event on water quality and life forms in an estuary.
3. Revise predictions based on new evidence.

4. Analyze water quality and nutrient data to identify variables that are out of a typical range and that may be indicators of a disturbance to the estuary, such as a pollution event.
5. Explain how estuarine species are threatened by drastic changes in water quality and nutrients.
6. Explain how the water chemistry of an estuary affects the health of the estuarine ecosystem and how monitoring estuary water chemistry can account for and predict changes to the health of the ecosystem.
7. Summarize data and develop a hypothesis to make a timeline that describes the spill and explains how it affected the chemistry of and life in an estuary.
8. Suggest ways to prevent adverse human impacts on estuaries.

Grade Levels

9-12

Teaching Time

3 (55 minute) class sessions +
homework



Organization of the Activity

This activity consists of 3 parts which help deepen understanding of estuarine systems:

Modeling a Chemical Spill

Learning More about the Spill

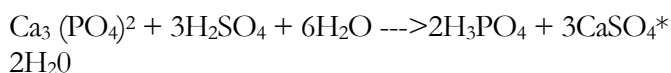
Analyzing Data Before and After the Spill

Background

On the morning of April 14, 2005, a catastrophic pollution event occurred at Bangs Lake, a tidal lake within the Grand Bay National Estuarine Research Reserve (NERR) in Mississippi. The spill occurred when the walls of retaining ponds filled with wastewater collapsed at a fertilizer manufacturing company located 1.1 km (0.7 mi) from the lake. Approximately 17.5 million gallons of polluted water flowed out of the retaining ponds and into the lake. The released wastewater had a pH of 2.2 to 2.4 and contained elevated levels of phosphorus 4000-5000 ppm (parts per million). Mississippi Phosphates, the company that operates the fertilizer manufacturing plants, says that walls of the retaining ponds may have collapsed because of unusually high rainfall (over 43 cm) from March 31 to April 11.

Water quality data from the spill was captured at a monitoring station 1.9 km (1.2 mi) from where the spill entered the lake. The spill caused an immediate drop in pH. A water quality monitoring station maintained by Grand Bay NERR at the center of the lake showed that on April 15, the pH dropped three entire units in one hour. That day, the water registered a pH low of 3.7 units. Eleven days later, phosphorous levels in the lake were about 5000 times greater than levels before the spill. Chlorophyll-alpha (or chlorophyll-a), a measure of primary productivity was non-existent, suggesting that there was little or no phytoplankton or algae in the lake.

The contaminants of the spill were two sources of waste products that come from the creation of phosphates for fertilizer: calcium sulfate and wastewater (contaminated with phosphoric acid and other pollutants). In order to get useable phosphate for fertilizer, phosphate ore is reacted with sulfuric acid to produce phosphoric acid. The simplified equation of this reaction is:



A byproduct of the reaction is calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), commonly called gypsum. For every ton of phosphoric acid that is produced, five tons of gypsum are also created. Gypsum can be made into sheet rock or plaster of paris, however, the gypsum created in the production of fertilizer contains small amounts of radioactivity so it cannot be used for these purposes. Instead, the gypsum created at the fertilizer plant is piled in mounds or “stacks” that surround and contain pools of wastewater. The wastewater contains a diluted mixture of residual phosphoric and sulfuric acids, so the pH of the water is generally close to 2.0. The water may also contain contaminants such as ammonia, fluoride, selenium, chromium, copper, cadmium, nickel, aluminum and even uranium, which can be toxic in sufficient doses.

Much of the damage was not immediate, but resulted from a chain of causes and effects. For example, several weeks after the spill, large algal mats covered the surface of some of the shallow, enclosed areas of the lake. Scientists believe that the algae populations exploded because there were so many nutrients in the water. Phosphates are some of the nutrients necessary for algae growth. In some estuaries, phosphates may be the growth-limiting nutrient.

The extensive algal blooms occurred in the shallow, enclosed waters near the point where the polluted water entered Bangs Lake. As these algal mats decayed, oxygen was removed from the water, eventually contributing to lower levels of dissolved oxygen (DO) in the lake. These hypoxic conditions contribute to the stress and death of various forms of life. Low dissolved oxygen levels continued into the fall.

Despite the extent of the damage, the estuary recovered relatively quickly. The algal blooms cleared up within a couple of months. Also within 4-8 weeks, fish and blue crabs had moved back into the area. The marsh vegetation began to recover during the summer and appeared to be “normal” by the time Hurricane Katrina hit the area in August of 2006. The upland vegetation has taken longer to recover; the grasses have come back but the shrubs and trees



suffered high mortality.

The phosphate company where the gypsum stacks failed, Mississippi Phosphate, claims that the gypsum stack holding the wastewater failed because of heavy rainfall. Although the Mississippi Department of Environmental Quality (MDEQ) accepts this as a possibility, it also believes that the company tried to increase the capacity of the ponds and built the retaining walls too big and too fast. The gypsum stacks are ringed by a moat-like system, which environmental permits say should be designed to capture such spills. MDEQ believed that the levees around the gypsum stacks were not sufficient to catch the pond spill before it poured into the marsh.

The company's permits from MDEQ specify that the waste ponds must be designed to withstand a storm producing about 11 inches in a 24-hour period, according to the standard calculations produced by the National Oceanic and Atmospheric Administration for this part of the Gulf Coast.

Weather information from the Southern Climate Data Center indicates that there was no rainfall in Pascagoula on April 13 or 14, when the spill occurred. Weather service radar and Southern Climate Data Center reports indicate that on April 1, two weeks before the spill, an area along the Mississippi/Alabama border may have received about 8 inches of rain, the largest rainfall the Climate Data Center reported for that month.

Preparation

- Collect or make enough brackish water (with a salinity of about 8 ppt) for each team of students. Each team should have a sample of about one to two liters. To make a water sample of this salinity, mix 8 grams of salt or Instant Ocean per liter of tap water, or dilute a sea-water sample until it is 8 ppt —1.026 specific gravity on a hydrometer.
- Prepare one or multiple estuary models, such as in the following image. Add the brackish water to the basin. Set it up so that you can pour the simulated wastewater

Materials

Students

- Copy of Student Reading—A Terrible Spill in Grand Bay
- Copy of Student Worksheet—A Terrible Spill in Grand Bay
- Copy Student Data Sheet—Data on Conditions in Grand Bay.

Teachers

- Download the PowerPoint—*Terrible Spill in Grand Bay*. (To find the presentation go to the estuaries.gov site, choose the Teachers tab, click on the sub-tab titled Physical Science, and find it under “Supporting Materials”.) For quick access go to: <http://www.estuaries.gov/estuaries101/Teachers/Default.aspx?ID=103>
- Plastic shoeboxes or similar container(s)
- Clay, soil, cardboard, etc. for preparing estuary models
- Brackish water (salinity at about 8 ppt) — 1-2 liters per team
 - Prepare using, salt, seawater, or Instant Ocean
- Beakers or other containers for chemicals
- Graduated Cylinders
- Citric acid
- Gypsum—plaster of Paris OR sheet rock ground up into powder (with a mortar and pestle)
- pH papers (preferably from 2-14)
- Water test kits or probes for measuring water quality parameters
- Safety glasses
- Protective gloves
- Plastic bags for disposing of the simulated wastewater and any other gypsum, as gypsum may clog the sink
- Poster board for final assessment project



over a surface (of soil, clay, cardboard, etc.), allowing the wastewater to enter and mix with the water in the basin gradually.

- Review the first aid measures for gypsum at:

<http://www.cameochemicals.noaa.gov/chemical/25028>

Scroll down to Section 3 and read the “Response Recommendations”. For another source of information, check out the following document:

<http://www.allianceenergy.ca/downloads/MSDS/Alliance%20Gypsum.pdf>

- Measure out the materials for students to make the simulated wastewater. For each group:
 - 6 g of citric acid,
 - 20 g of plaster of Paris or ground up sheet rock*
 - 300 ml of tap water.

Instructions for making the simulated wastewater:

- Add 300ml of tap water to a 500 ml beaker.
- Measure 20 g of gypsum, add it to the tap water, and stir until all the plaster is well mixed with the water.
- Measure 6 g of citric acid and add it to the gypsum and water mixture.

*If you do not have plaster of Paris, you can grind up pieces of sheet rock with a mortar and pestle. The pH of the wastewater (citric acid plus gypsum in water) should be about 3 units.

IMPORTANT NOTE: Be careful while preparing these materials, particularly if grinding sheetrock. Wear goggles and gloves, and clean up thoroughly.

- Download the PS3 PowerPoint—*Terrible Spill in Grand Bay* onto a computer that can project in front of the class, or onto computers the students can access directly.

- Make copies of *Student Reading—A Terrible Spill in Grand Bay*, *Student Worksheet—A Terrible Spill in Grand Bay*, and *Student Data Sheet—Data on Conditions in Grand Bay*. Alternatively, the *Student Data Sheet* can be projected.

Procedure

Part 1 — Modeling a Chemical Spill

1. Write the following questions on the board and have students discuss answers in small groups.
 - What kinds of pollution can affect estuaries?
 - What are the effects of the pollution on water quality and on living things in the estuary?
2. Bring the groups back to share and discuss their ideas.

Students may suggest natural sources of pollution, such as excess sedimentation and turbidity from heavy stream runoffs. But focus this discussion on pollution caused by human activity, such as heavy metals from industries, pathogens from sewage, and excess nutrients from farms and lawn fertilizers.

Students may identify both point and non-point source pollution. If not, it is worth making the distinction. Non-point source pollution can introduce substances into the estuary that originate even far away from the estuary, including trash, waste, and chemicals that wash off of city streets, and sewage that overflows from storm drains after heavy rains.

3. Explain to students that they will model a chemical spill and use their observations and results to predict how an actual spill would affect life and water quality in an estuary. Students’ work in Part 1 will relate to industrial chemical pollution disaster from a fertilizer manufacturing plant that occurred less than a mile away from the estuary.
4. Provide students with the necessary materials and have them complete Part 1 of the *Student Worksheet—A Terrible Spill in Grand Bay*. Tell students that the simulated wastewater is just an approximation of what actually went into Bangs Lake. The simulated wastewater contains most of the same components as



the actual wastewater, but in different forms and amounts so that it is safer for the students to handle. For example, the simulated wastewater includes citric acid in place of phosphoric acid. There is no radioactive waste in the wastewater.

IMPORTANT NOTE:

- Make sure that the students are careful with the simulated wastewater and its components. They should wear gloves and goggles at all times, carefully wash their hands afterward, and thoroughly clean up their supplies and work area.
 - The water quality test your students conduct will depend on the materials available.
 - Be aware that your students' results will differ from actual spill results.
5. Discuss the students' models, measurements, predictions, and answers.

NOTE: Consider having students read the *Student Reading—Introduction to Grand Bay* as homework in preparation for Parts 2 and 3.

Part 2 — Learning More about the Spill

6. Have students read the *Student Reading — Introduction to Grand Bay*.
7. Project or have students view the PowerPoint—*Terrible Spill in Grand Bay*, which addresses the conditions in Bangs Lake before and after the phosphate spill. Have students note the things that show the effects of the pollution or suggest damage to the estuary. Have them speculate on the cause(s) of the damage.
8. Have students complete Part 2 of the *Student Worksheet—A Terrible Spill in Grand Bay*, refining their predictions. Encourage them to think about the results from their experiment, the new information they have read, and the images of the estuary they observed.

National Science Education Standards

Content Standard A: Science as Inquiry

- A3. Use technology and mathematics to improve investigations and communications.
- A4. Formulate and revise scientific explanations using logic and evidence.
- A6. Communicate and defend a scientific argument.

Content Standard B: Physical Science

- B2. Structure and properties of matter
- B3. Chemical reactions
- B6. Interactions of energy and matter

Content Standard C: Life Science

- C4. The interdependence of organisms
- C5. Matter, energy, and organization in living systems

Content Standard D: Earth and Space Science

- D1. Energy in the earth system
- D2. Geochemical cycles

Content Standard F: Science in Personal and Social Perspectives

- F3. Natural Resources
- F4. Environmental quality
- F5. Natural and human-induced hazards
- F6. Science and technology in local, national, and global challenges

Part 3 — Analyzing Data Before and After the Spill

9. Have students complete Part 3 of the *Student Worksheet—A Terrible Spill in Grand Bay*, using the data provided on the *Student Data Sheet—Data on Conditions in Grand Bay*.

Consider giving the students the Month of Spill portion of the *Student Data Sheet* only after they have identified April as the month of the spill.



For students who do not identify April as the month of the spill, ask probing questions to get them to see the spikes in pH and phosphorous—the clearest indicators—during that month.

10. Discuss the data, answers, charts, and timelines.
11. Provide students with the complete story of the Bangs Lake spill and have them compare their hypotheses and analyses with actual effects.

Check for Understanding

Discuss the following:

- What caused the massive spill in Grand Bay? What could have been done to prevent it?
- What were the immediate effects on organisms living in the bay?
- What are the reasons that water quality returned to normal after a brief span of weeks?

Optional Extension Inquiries

- Have students complete the online activity, Affect of pH on Aquatic Organisms, available online at:

<http://waterontheweb.org/curricula/bs/teacher/ph/teaching.html>

If the activity can't be found its original site, please find it in the following site where it has been archived:

Accessed: 2008-08-06. Archived by WebCite® at:

<http://www.webcitation.org/5Zs34rTm9>

- Use a nearby body of water as a field study site to compare to the water and contaminants of Grand Bay with those at your local site. Check out monitoring equipment and test kits to different students each weekend and have them take measurements at the same location at your field site. After collecting data for nine consecutive weeks, have students plot rainfall amounts over the nine-week time period and compare their graphs against graphs of water quality and nutrient data at Grand Bay for the same time frame.





Teacher Worksheet with Answers

Activity 3: A Terrible Spill in Grand Bay

Part 1 — Modeling a Chemical Spill

1a. Measure and record the following water quality indicators in your 1 liter sample of brackish water:

Answer: Student answers will vary.

1b. Measure and record the following water quality indicators of the wastewater:

Answer: Student answers will vary.

1c. Predict how adding the mixture will affect the water quality variables.

Answer: Student answers will vary.

1d. Add the wastewater mixture to the sample of seawater, take measurements, and record your results in the chart above.

Answer: Student answers will vary.

1e. What do your new readings indicate about how the mixture might affect estuarine life?

Answer: Since it is acidic and contains other possibly toxic components, the mixture may be harmful to estuarine life.

1f. If a similar chemical mixture spilled into an estuary, how do you think the water quality would change over a week? Over a month?)

Answer: Short-term effects on plants and animals would be evident. Over the long term though, the tidal flushing and natural filtering process that takes place in estuarine environments would absorb most of the toxic components of the wastewater.

1g. How is this experiment different from an actual spill in an estuary? Explain why you may get different results in this experiment than the results that would occur in an estuary.

Answer: The volume of the beaker compared to the wastewater introduced is miniscule compared to the spill into Grand Bay. Only a portion of the estuary would be affected by a spill.

Part 2 — Learning More about the Spill

2a. Think about what went into the estuary water. How could the different chemicals affect the water quality and plant and animal life in the estuary? Update your predictions of how the spill would affect the estuary in the short and the long-term. Explain in terms of specific water quality variables.

Answer: Student answers will vary.



Part 3 — Analyzing Data Before and After the Spill

3a. Determine the month in 2005 during which the spill occurred. Look for extremes that may suggest something out of the ordinary is happening.

Answer: Students will notice that many graphs spike during the month of April.

3b. Complete the following chart.

	Typical average values for	Average values for spill
Salinity	5 ppt	20 ppt
Temperature		
Dissolved oxygen	5.0	5.0 (no sig. difference)
pH	7.5	6.5
Chlorophyll-a	No data	No data
Total Dissolved phosphorous	4.3	About 0.4
Orthophosphates	4.2	About .3
Turbidity	20	About 10

3c. The spill occurred on which date?

Answer: Graphs indicate April 13th to 18th.

3d. Why do you think so? Which variables seem to suggest this?

Answer: Salinity drops precipitously on April 18th. DO drops on the 15th. There is a huge spike in turbidity on the 13th. The pH plunges on the 15th as well.

3e. Look at actual daily records of water quality and nutrient data for the month during which the spill occurred in 2005. Describe these values during that time. What were the most extreme values?

Answer:

- phosphorous peaked over 4.0 in April compared to levels normally about .2.
- dissolved phosphates peaked at 4.5, a 1000X higher than normal levels of about .1.
- pH plunged to less than 4.0 way below normal levels of 7.3.
- salinity dropped about 7 ppt during the event.
- DO dropped about 20% during the event to a seasonal tying low of 60 %.
- DO concentration showed a similar drop—from 7.0 to 5.0 mg/L, a yearly low.
- turbidity had a huge spike, moving from a modest value of 25 NTUs to a whopping 300 NTUs.



3f. When did the measures look “normal” again? What might be some reasons for the time it took to attain normalcy of water quality?

Answer: Phosphorous and phosphate remained at very high levels for month afterwards. Most of the other water quality factors rebounded in a matter of a few days to a week.

3g. Look at the charts on the following pages to determine what the effects would be on various life forms in the estuary.

Answer: Chart 1

- Oysters: Salinity levels would prevent oysters from surviving. pH levels too low as well.
- Clams: Same as oysters. The water would be toxic for them.
- Blue crab: pH is a little low for blue crabs so some will survive. Other will migrate to cleaner waters.
- Coho salmon: DO and salinity both too low for Coho salmon to exist.

Answer: Chart 2

With DO concentration at 5.0 mg/L, striped bass, shad and perch would not be able to survive in the spill area.





Student Reading

Activity 3: Introduction to the Grand Bay National Estuarine Research Reserve

About the Estuary

The Grand Bay National Estuarine Research Reserve (GNDNERR) is a protected marine area located in extreme southeastern Mississippi in Jackson County near the small community of Pecan (see map). The GNDNERR is comprised of approximately 18,000 acres, found chiefly within the Grand Bay National Wildlife Refuge and the Grand Bay Savanna Coastal Preserve. This reserve contains a variety of wetland habitats, both tidal and non-tidal, such as pine savannas, salt marshes, saltpans, bays and bayous as well as terrestrial habitats that are unique to the coastal zone like maritime forests.



Figure 1. Grand Bay NERR is composed of diverse habitats for estuarine plants and animals.

Healthy estuarine salt marshes and fire-maintained pine savannas are some of the most diverse habitats in North America, and the reserve is fortunate enough to contain considerable amounts of both. These habitats support many important species of fish and wildlife. Commercially and recreationally important species of finfish and shellfish, such as brown shrimp, speckled trout and

oysters, abound here. Sea turtles, bottlenose dolphin and, on occasion, manatees can be found in the deeper waters of the reserve. Many species of carnivorous plants and orchids can be found in the higher savanna habitats.

The lands within the Grand Bay NERR are classified as either core areas or buffer areas. The core area (outlined by yellow on the above map) consists of approximately 12,800 acres of: estuarine tidal marsh, tidal creeks or bayous; shallow, open-water habitats; oyster reefs; seagrass beds; maritime forests; salt flats; sandy beaches; and shell middens. These habitats supply nutrients for many marine species. They also serve as buffer zones for hurricane protection and places of shelter for animals. Tidal marsh regions function as filters, removing pollutants such as sewage and surface run-off that otherwise would flow into the Mississippi Sound and degrade valuable marine aquatic resources.

The buffer area (outlined by blue above) consists of approximately 5,600 acres of tidal marsh, scrub shrub, pine flatwood and wet pine savanna habitats. Buffer areas are defined as “areas adjacent to the core areas that provide additional protection for estuarine-dependent species.” Additionally, a small portion of intertidal marshes located adjacent to the boat ramp at Bayou Heron is also included in the buffer area. This disturbed area currently provides the only publicly-owned, waterway access point within the boundaries of the GNDNERR.

- Adapted from the Grand Bay NERR website.
 URL:<http://grandbaynerr.org/aboutus/>. Accessed: 2008-07-19.
 (Archived by WebCite® at <http://www.webcitation.org/5ZREBtdl>)



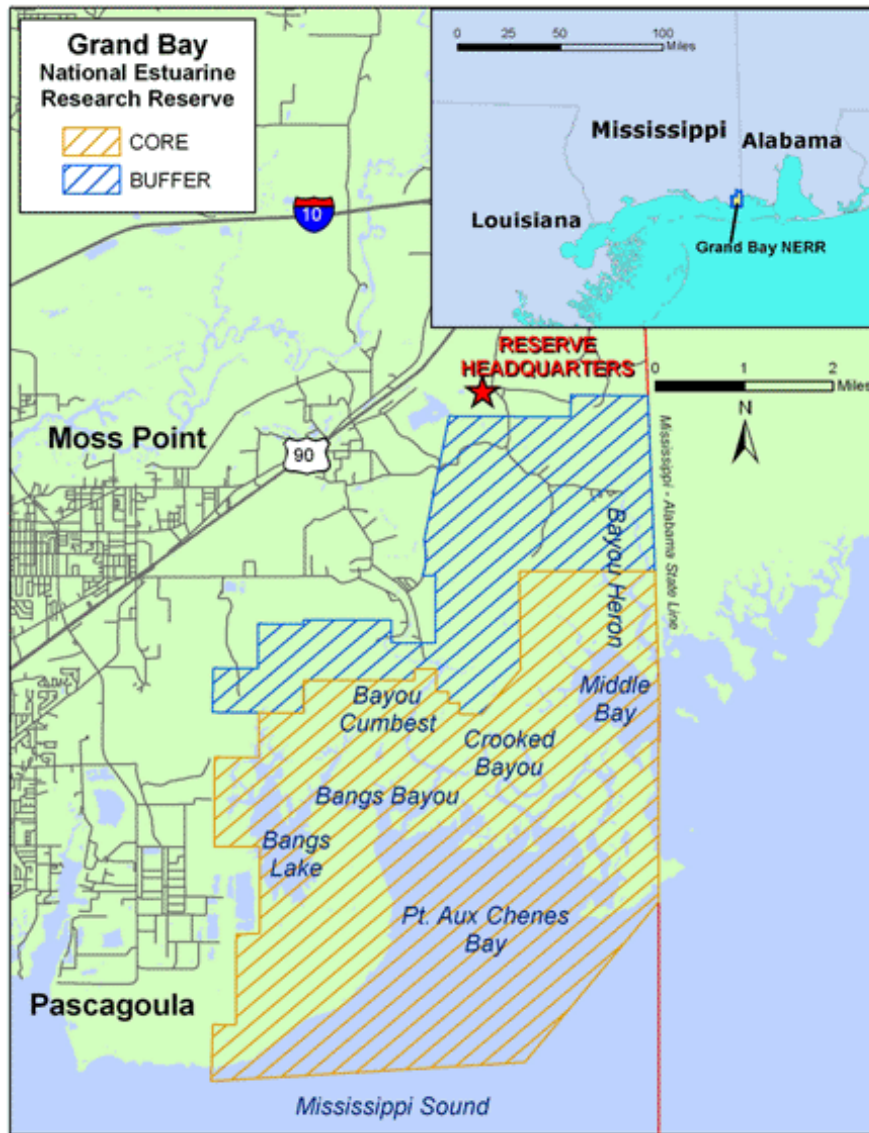


Figure 2. Your study will focus on Bangs Lake, which is situated on the western edge of the reserve.



Student Reading

Activity 3: A Terrible Spill in Grand Bay: A Case Study of an Environmental Disaster

The Massive Spill

In 2005, a catastrophic pollution event occurred at Bangs Lake along the western border of Grand Bay NERR, MS. The spill occurred when the walls of retaining ponds filled with wastewater collapsed at a fertilizer manufacturing company located 1.1 km from the lake. Approximately *17.5 million gallons of polluted water* were released from the ponds and subsequently flowed into the estuary. The released wastewater had the following characteristics:

- a pH of 2.2–2.4
- elevated levels of phosphorus (4000-5000 ppm)
- high levels of aqueous ammonia (280-350 ppm).

The spill was sudden and organisms in the estuary felt the effects immediately.

Sources of the Pollution

The contaminants of the spill came from two sources that are produced in the creation of phosphates for fertilizer: calcium sulfate (or gypsum) and wastewater that was contaminated with phosphoric acid and other pollutants. In order to get useable phosphate for fertilizer, phosphate ore is reacted with sulfuric acid to produce phosphoric acid. A byproduct of the reaction is calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), commonly called gypsum. The gypsum is piled in mounds or “stacks” which are used to create walls that surround and contain pools of wastewater. The wastewater contains a dilute mixture of residual phosphoric and sulfuric acids, so the pH of the water is close to 2.0. The water may also contain contaminants such as ammonia, fluoride, selenium, chromium, copper, cadmium, nickel, aluminum and even uranium, all of which can be toxic.

The Effect on the Estuary

Water quality data from the spill was captured at a monitoring station 3.0 km (1.9 mi) from where the spill entered the lake. The monitoring stations that measure

the data are about 9 m from the bottom of the lake. When measured, chlorophyll-a, a measure of primary productivity, was non-existent. Two to three weeks later, large algal mats covered the surface of some shallow, enclosed areas of the lake.

The wastewater caused immediate damage to estuarine flora and fauna.

- 77 hectares of upland habitats were killed or seriously damaged from the chemicals in the polluted water.
- The value of the marsh grass killed was estimated to be \$262,500.
- The average death rate for oysters in Bangs Lake was 74%.
- Fish and blue crab deaths (16 species) included over 100,000 individuals worth over \$400,000.

Who is at Fault?

The phosphate company, Mississippi Phosphate, claims that the gypsum stack holding the wastewater failed because of heavy rainfall. It was also claimed that the company tried to increase the capacity of the ponds and built the retaining walls too large and put them up too fast. The gypsum stacks are ringed by a moat-like ditch-and-berm system, which environmental permits say should be designed to capture such spills. The Mississippi Department of Environmental Quality (MDEQ) believed that the levees around the gypsum stacks weren't sufficient to catch the pond spill before it poured into the lake.

The company's permits from MDEQ specify that the waste ponds must be designed to withstand a storm producing about 11 inches in a 24-hour period, according to the standard calculations produced by the National Oceanic and Atmospheric Administration for this part of the Gulf Coast. Weather information from the Southern Climate Data Center indicates that there was no rainfall in





Figure 3. The gypsum walls containing the wastewater are seen in this image taken before the collapse. (<http://www.fluoridealert.org/phosphate/>)



Figure 4 . Phosphate processing facility adjacent to gypsum stacks in Polk County, FL.

(Image: Grand Bay National Estuarine Research Reserve)

Pascagoula on the two days before the spill occurred. Weather service radar and Southern Climate Data Center reports indicate that two weeks before the spill, an area along the Mississippi/Alabama border may have received about 8 inches of rain, the largest rainfall the Climate Data Center reported for that month. NOAA records indicate a storm of that intensity could be expected about once every five years along the Mississippi coast.



Figure 5. Algae bloom and dead marsh grass, Bangs Lake, Grand Bay National Estuarine Research Reserve

(Image: Grand Bay National Estuarine Research Reserve)



Student Worksheet

Activity 3: A Terrible Spill in Grand Bay

Part 1 — Modeling a Chemical Spill

To make a model that represents the spill in Grand Bay, you will pour a chemical mixture into a basin of brackish water representing the estuary. You will predict the effects of the chemical mix on the water quality of your sample. You will then consider the effects of the actual spill.

IMPORTANT NOTE: The chemicals in the wastewater you will make are much safer than those in the actual spill, but you must still use care and wear goggles and gloves because these chemicals can harm your eyes and may irritate your skin. Make sure you clean up and wash your hands carefully.

1a. Measure and record the following water quality indicators in your 1 liter sample of brackish water:

- salinity _____
- temperature _____
- pH _____
- dissolved oxygen (if equipment is available) _____
- conductivity (if equipment is available) _____

Add 300ml of tap water to a 500 ml beaker.

Measure 20 g of gypsum, add it to the tap water, and stir until all the plaster is well mixed with the water.

Measure 6 g of citric acid and add it to the gypsum and water mixture. This will be your model of a wastewater or chemical spill.

1b. Measure and record the following water quality indicators of the wastewater:

- salinity _____
- temperature _____



- pH _____
- dissolved oxygen (if equipment is available) _____
- conductivity (if equipment is available) _____

1c. Predict how adding the mixture will affect the water quality variables.

How will these	Prediction	Result after addition of
Temperature		
Salinity		
Conductivity		
pH		
Dissolved oxygen		

1d. Add the wastewater mixture to the sample of seawater, take measurements, and record your results in the chart above.

1e. What do your new readings indicate about how the mixture might affect estuarine life?



- 1f. If a similar chemical mixture spilled into an estuary, how do you think the water quality would change over a week? Over a month?
- 1g.. How is this experiment different from an actual spill in an estuary? Explain why you may get different results in this experiment than the results that would occur in an estuary.

Part 2 — Learning More about the Spill

Read the *Student Reading—Introduction to Grand Bay* and watch the PowerPoint presentation showing the Grand Bay NERR before and after the phosphate spill.

- 2a. Think about what went into the estuary water. How could the different chemicals affect the water quality and plant and animal life in the estuary? Update your predictions of how the spill would affect the estuary in the short and the long-term. Explain in terms of specific water quality variables.



	How would these indicators	Explain reason for change or no change
Temperature		
Salinity		
Conductivity		
pH		
Dissolved oxygen		
Phosphates		
Nitrates		

Part 3 — Analyzing Data Before and After the Spill

In this final part of the activity, you will analyze actual data related to the spill. The data are provided on the *Student Data Sheet—Data on Conditions in Grand Bay*.



3a. Determine the month in 2005 during which the spill occurred. Look for extremes that may suggest something out of the ordinary happened.

Note: Some extremes can be caused by natural conditions, but they are still worth looking into. Try to see if there are dates when several factors seem to be higher or lower than ordinary. Also, keep in mind that the quick charts and trend analysis graphs show **averages** for each day. On any one of those days, actual values at any given time could be much lower or much higher than those averages. You will not know until you look at the actual results for a particular day.

3b. Complete the following chart

	Typical average values for this month	Average values for spill month 2005
Salinity		
Temperature		
Dissolved oxygen		
pH		
Chlorophyll-a		
Total Dissolved phosphorous		
Orthophosphates		



3c. Determine exactly when during the month the spill occurred and identify the dates and effects of the spill on water quality.

The spill occurred on which date? _____

3d. Why do you think so? Which variables seem to suggest this?

3e. Look at actual daily records of water quality and nutrient data for the month during which the spill occurred in 2005. Describe these values during that time. What were the most extreme values?

3f. When did the measures look “normal” again? What might be some reasons for the time it took to attain normalcy of water quality?

3g. Look at the charts on the following pages to determine what the effects would be on various fish in the estuary and the four life forms listed in the Chart 1.



Final Assessment

Create a timeline from the month of the spill to 6 months after the spill that explains the effects on the estuary that resulted from the spill. Include the following components:

- Dates that show extreme values of the water quality parameters you analyzed in the activity.
- The following terms: pH, phosphorous, phosphate, salinity, dissolved oxygen, rainfall, algae blooms, marsh grass, oysters, clams, crabs, and fish.
- Recommendations to the state Department of Environmental Quality for the future. Explain what should be done to prevent any future environmental impacts from the fertilizer plant. Place the recommendations in the form of a letter and attach it to your poster board presentation.



Chart 1**Limits of Tolerance to Environmental Factors for Selected Organisms****Oysters**

- Grow best in water with a salinity of 12 ppt and above, perish if salinity is below 5 ppt or above 15 ppt
- Spawn only when the water temperature hits 18°C for four hours
- Spawn much more prevalent when salinity is over 20 ppt
- Need a DO level of around 4 mg/l
- Best growth when pH is between 7.5 and 8.5

Clams

- Grow best when the water salinity is above 15 ppt
- Spawn only when the water temperature hits 24°C for four hours
- Clam eggs die when the salinity is below 20 ppt
- Need a DO level of around 4 mg/l
- Optimal growth occurs between 10° and 25°C

Blue Crab

- Needs a DO level of 3 mg/l or more for survival, optimal at 5 mg/l
- Thrives if pH is between 6.8 and 8.2

Coho Salmon

- Like a DO level of 6 mg/l or higher
- Require a salinity of greater than 15 ppt
- Prefer temperatures between 4 and 20°C, do best at 13°C
- Spawn only when temperature is 18°C or higher
- Newly hatched salmon need a DO level of at least 5 mg/l to survive
- pH of 4.0 or lower or higher than 9 is lethal for salmon



Chart 2

Limits of Tolerance to Environmental Factors for Aquatic Animals

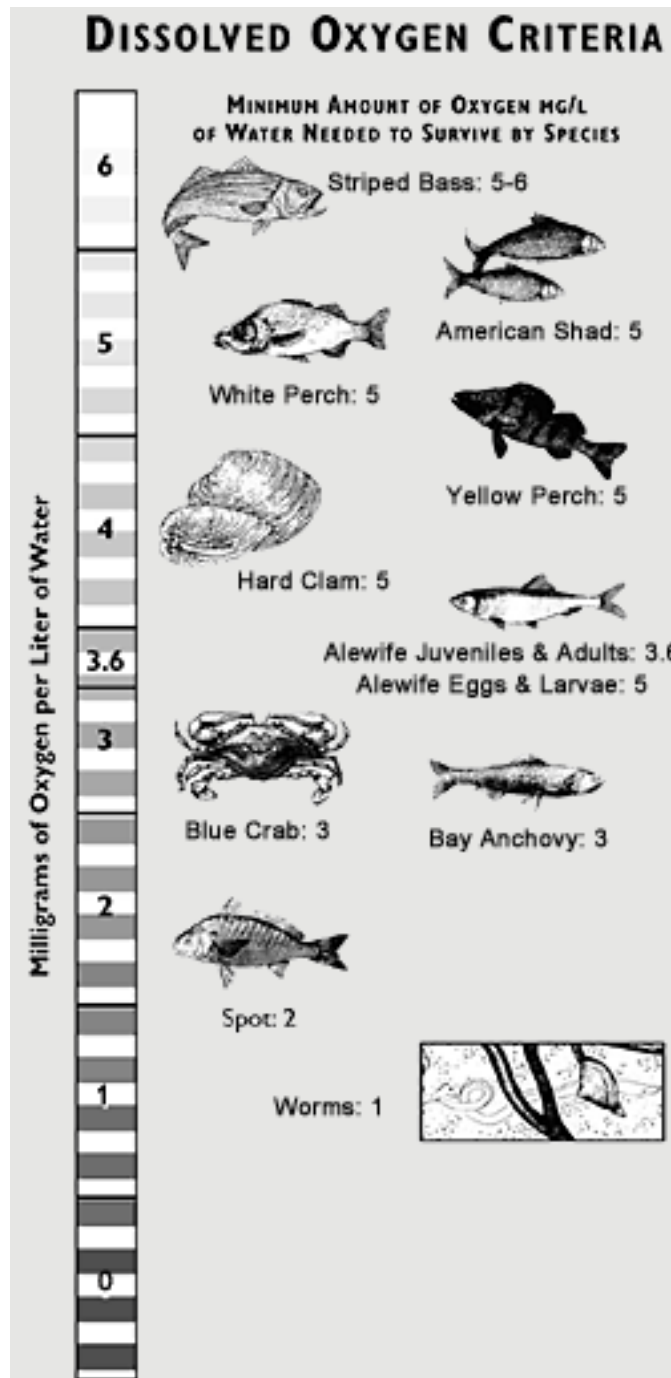


Figure 6. Minimum amount of DO needed for species to survive.

(Credit: Chesapeake Bay Program. URL:<http://www.chesapeakebay.net/dissolvedoxygen.aspx?menuitem=14654>. Accessed: 2008-08-06. [Archived by WebCite® at http://www.webcitation.org/5Zs5lwMmM](http://www.webcitation.org/5Zs5lwMmM))



Student Data Sheet

Activity 3: Data on Conditions on Grand Bay

Quick Charts of 2005 Water Quality Data from Bangs Lake, Grand Bay NERR, MS

Water Station: gndblwq Bangs Lake, MS 30° 21' 25.56 N, 88° 27' 46.44 W

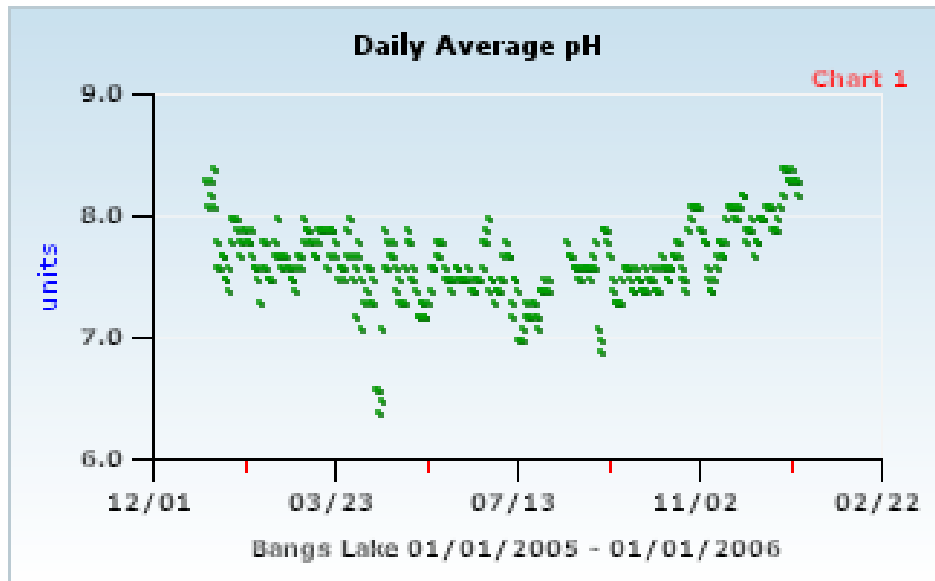


Figure 7. Daily pH:
Grand Bay NERR—Bangs Lake

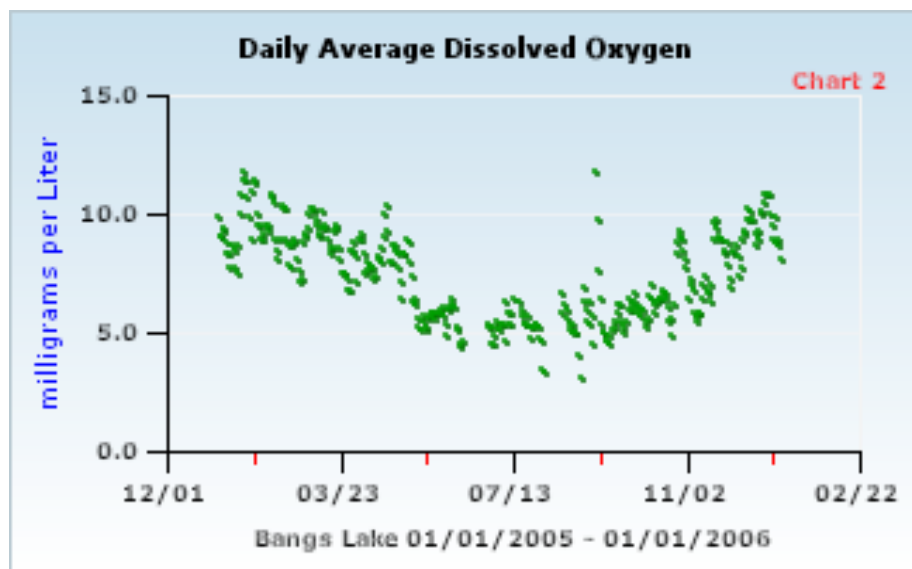


Figure 8. Daily DO:
Grand Bay NERR— Bangs Lake



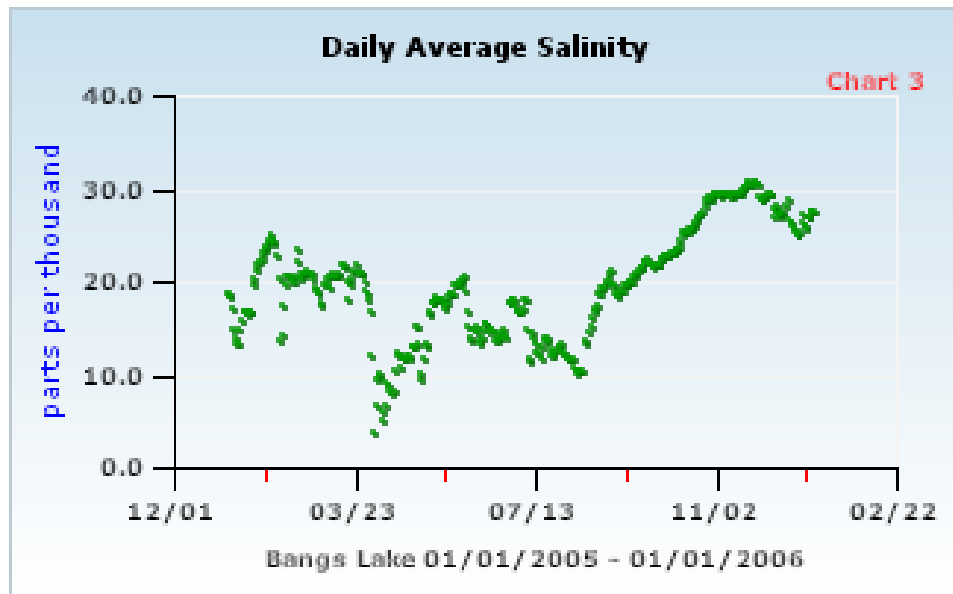


Figure 9. Daily Salinity:
Grand Bay NERR— Bang's Lake

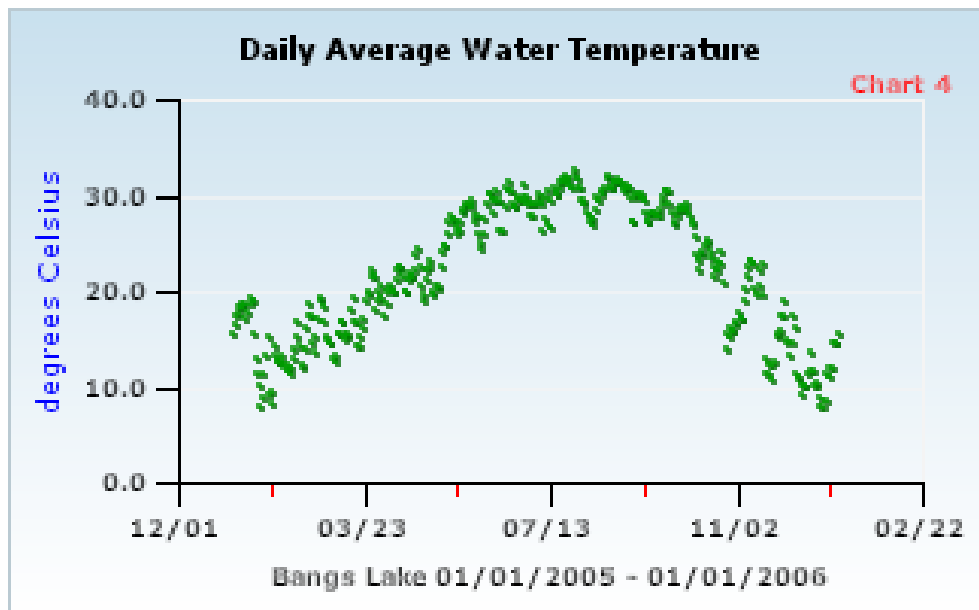


Figure 10. Daily Water Temperature:
Grand Bay NERR— Bangs Lake

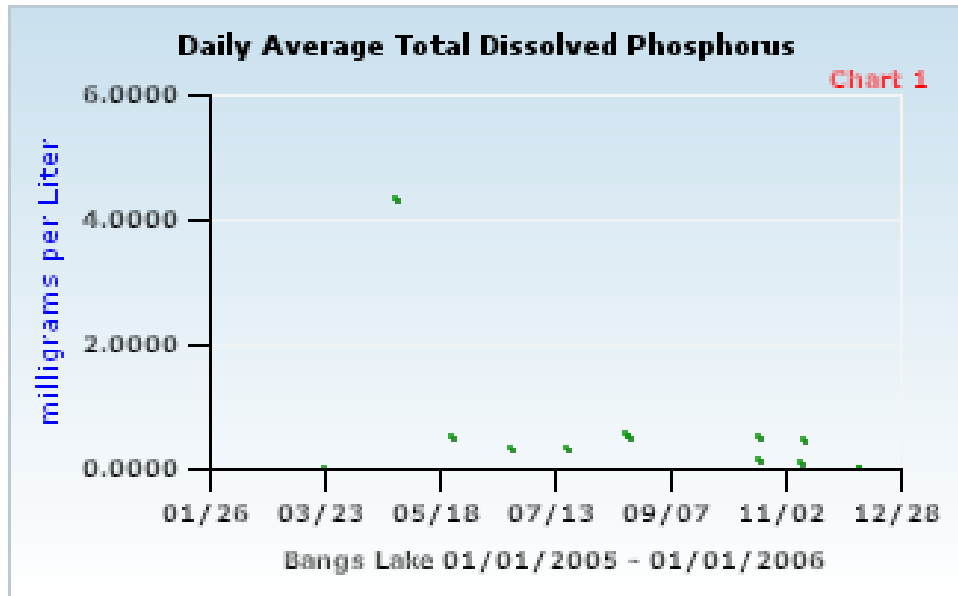


Figure 11. Daily Phosphorus:
Grand Bay NERR— Bangs Lake

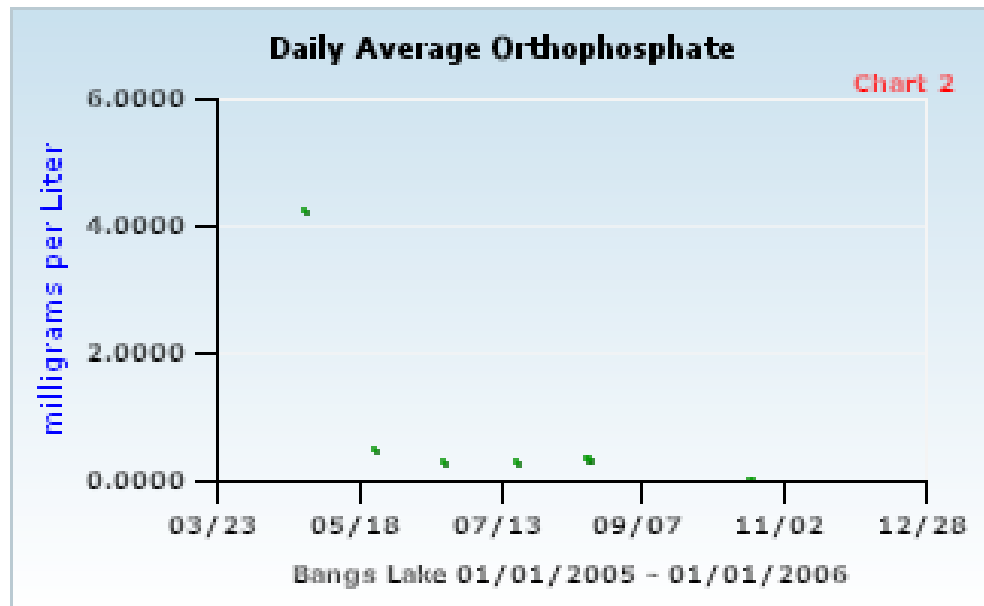


Figure 12. Daily Orthophosphate:
Grand Bay NERR— Bang's Lake

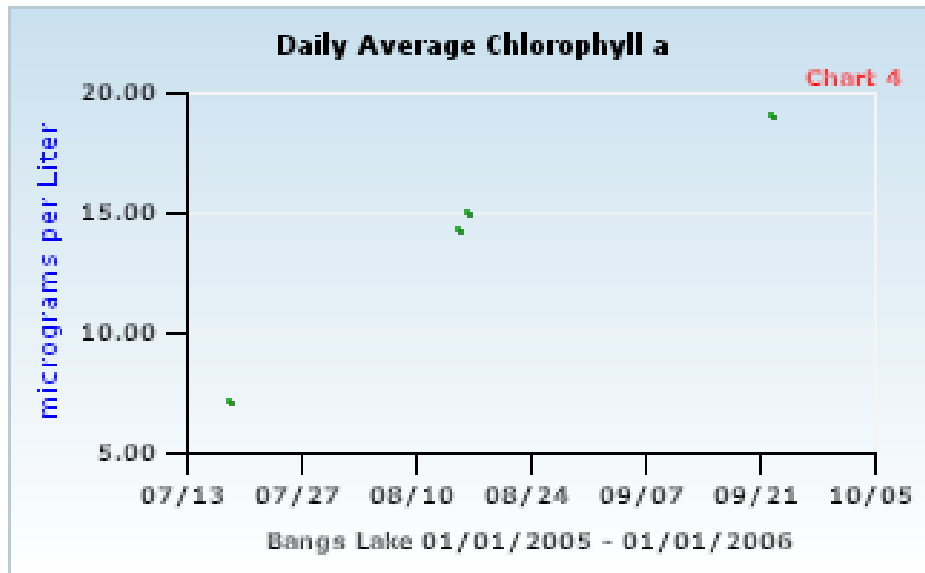


Figure 13. Daily Chlorophyll a:
Grand Bay NERR— Bangs Lake

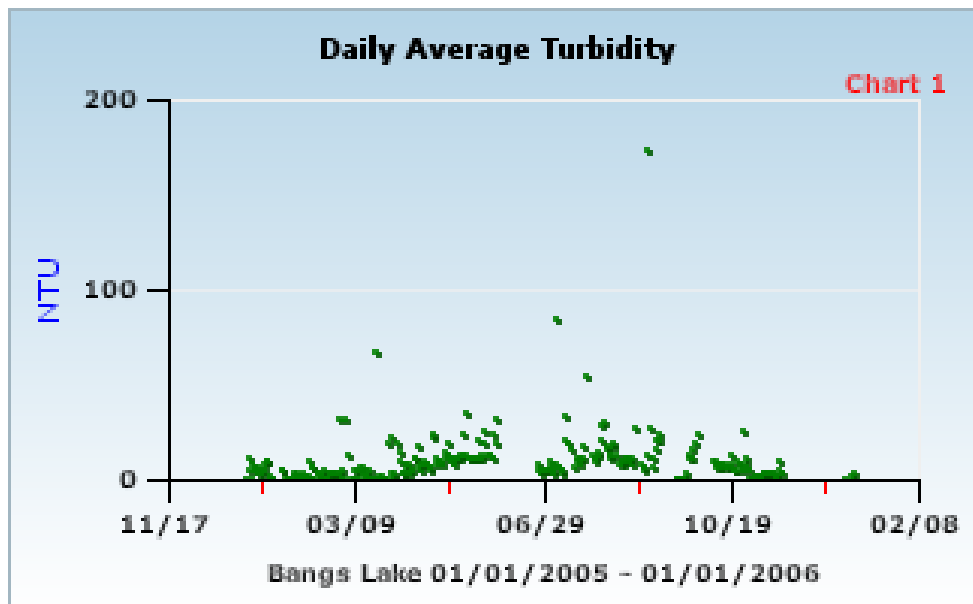
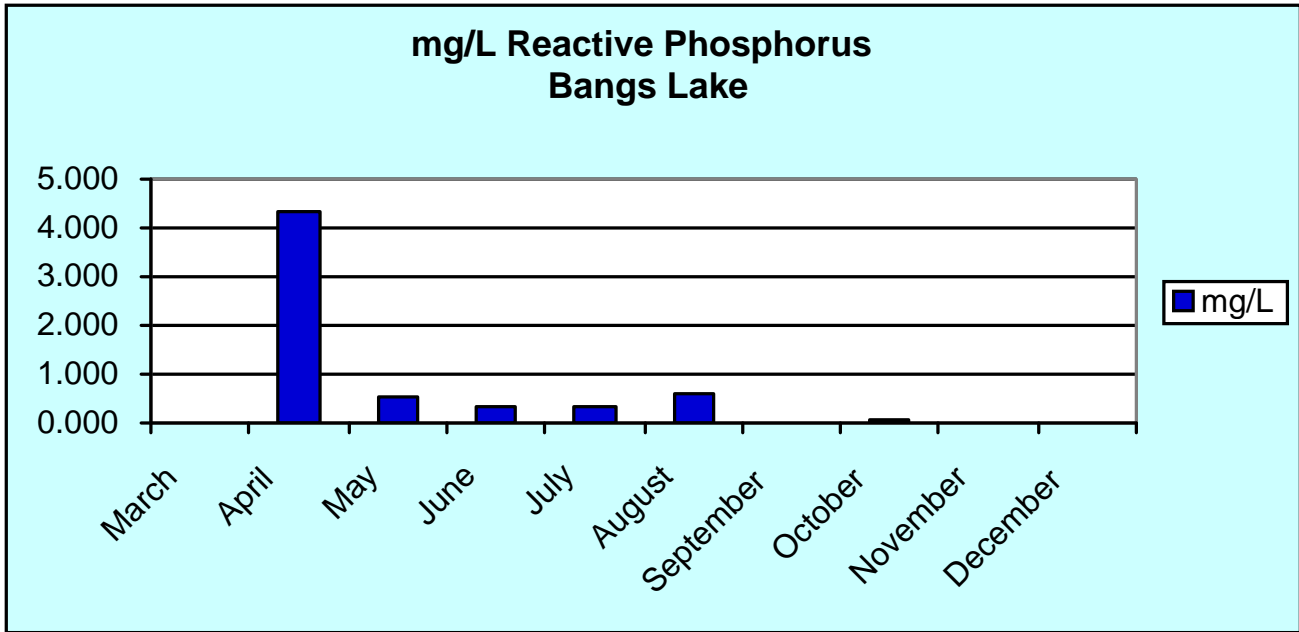


Figure 14. Daily Turbidity:
Grand Bay NERR— Bangs Lake

Month of Spill

Water Quality Readings, Bang's Lake, Great Bay NERR



NOTE: Even though the scale indicates a four-fold increase in phosphorous, the reading is actually 1,000X greater than normal. During May through August, phosphorous levels remained 100X normal.

Figure 15. Reactive Phosphorous (mg/L): Grand Bay NERR—Bangs Lake

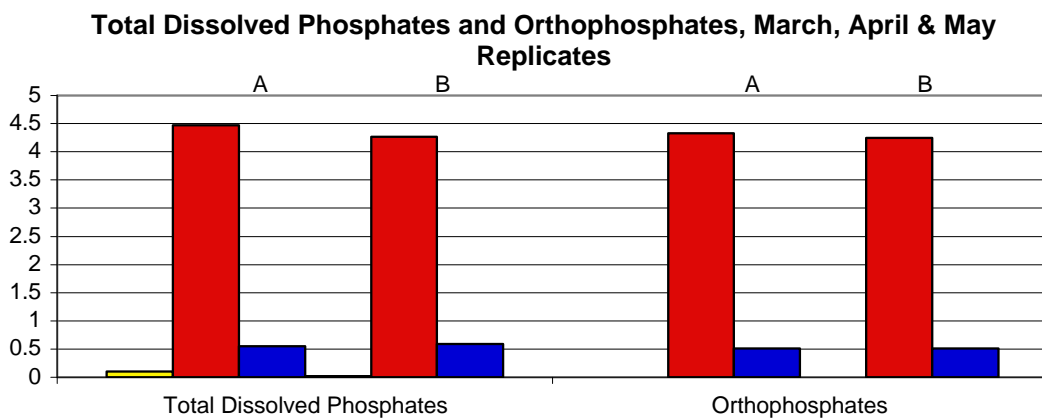


Figure 16. Total Dissolved Phosphates and Orthophosphates: Grand Bay NERR—Bangs Lake

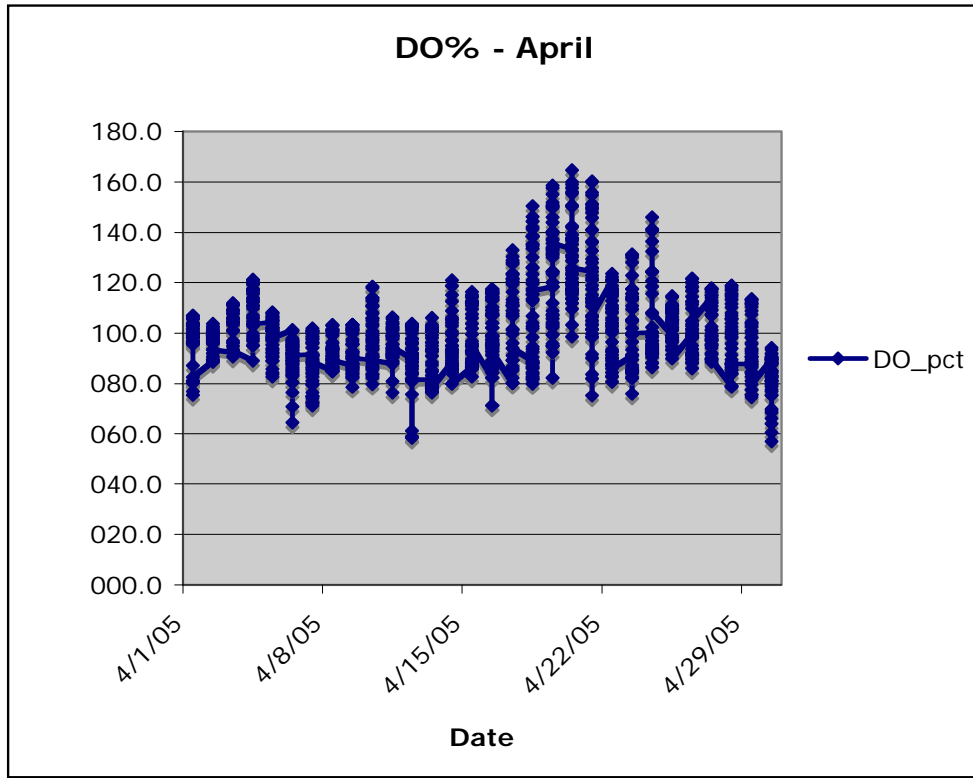


Figure 19. DO% during April: Grand Bay NERR—Bangs Lake

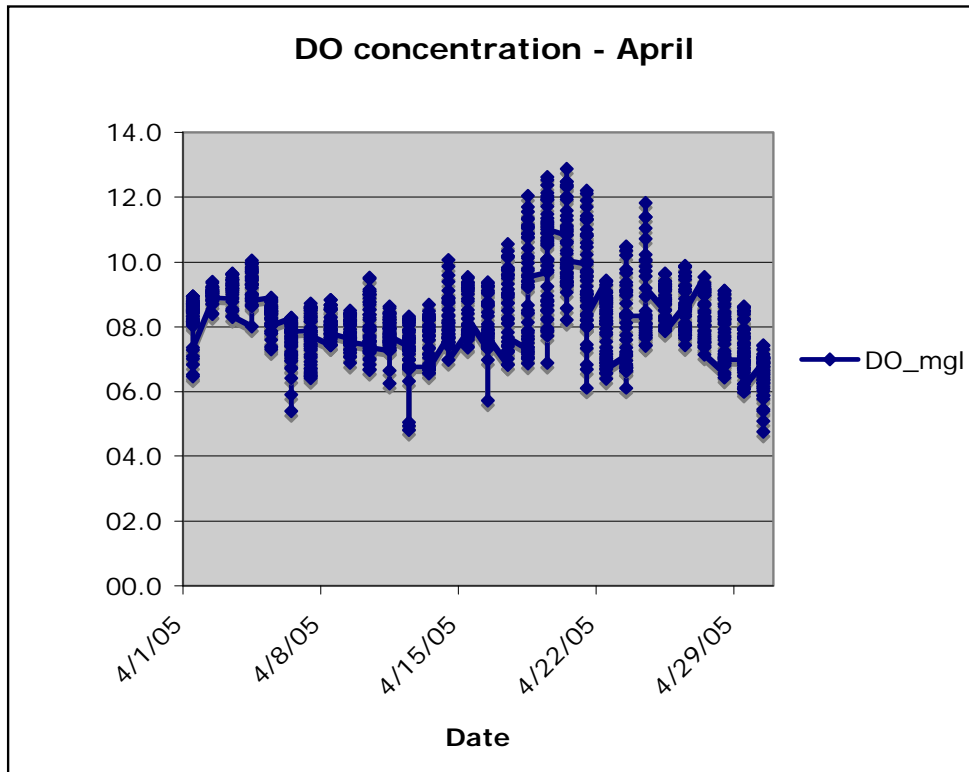


Figure 20. DO Concentration during April: Grand Bay NERR—Bangs Lake



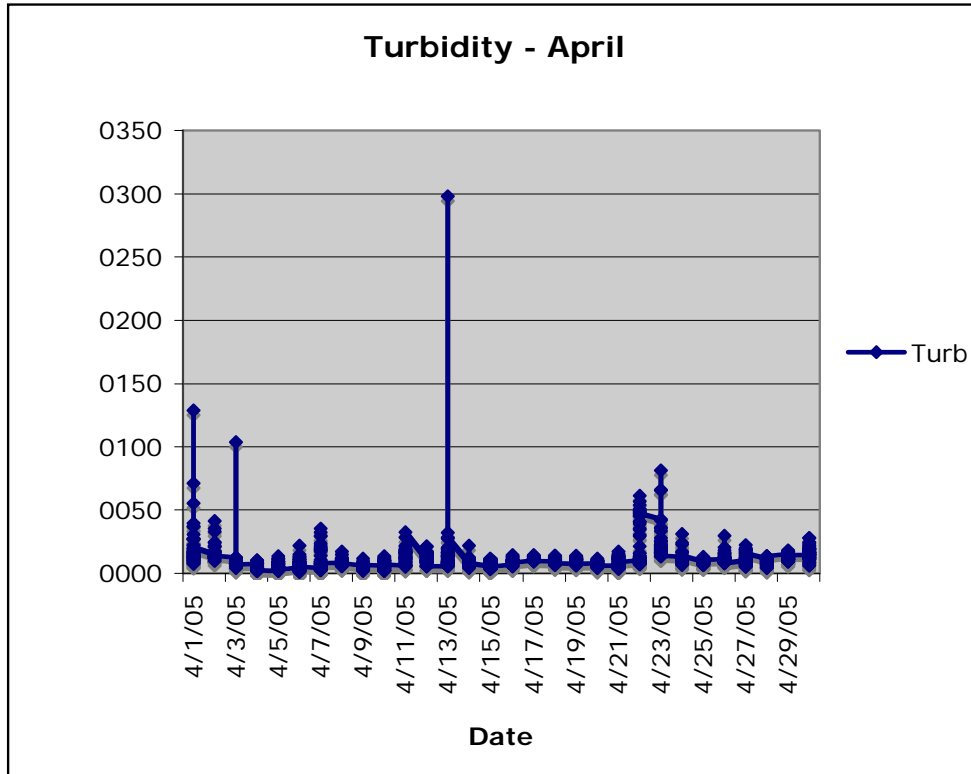


Figure 21. Turbidity during April: Grand Bay NERR—Bangs Lake

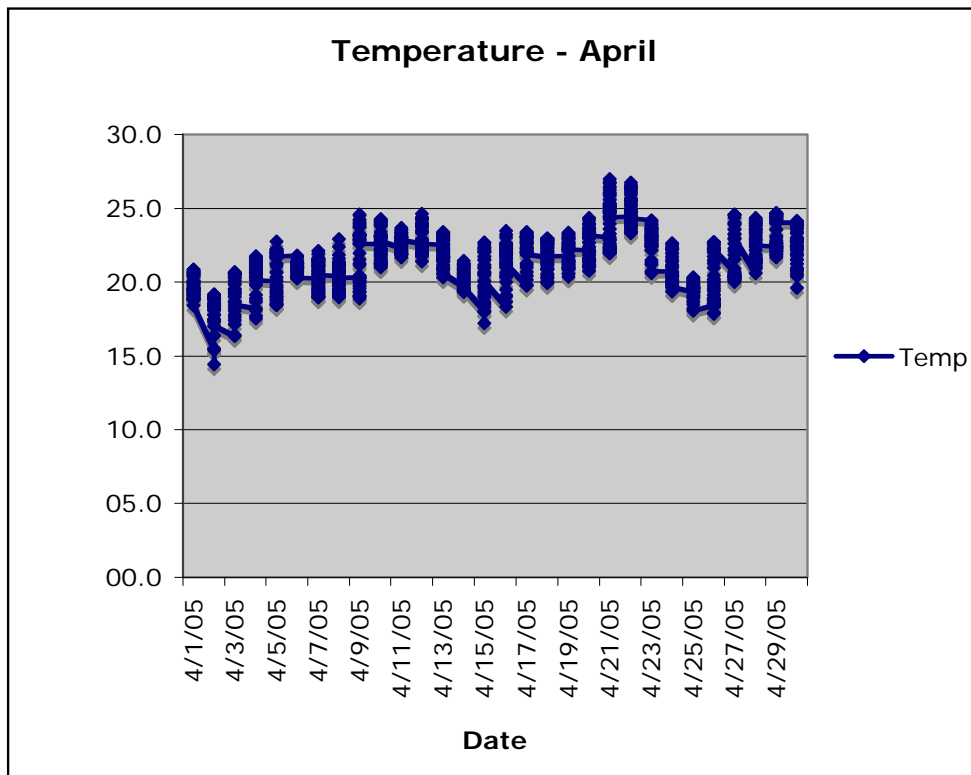


Figure 22. Temperature during April: Grand Bay NERR—Bangs Lake