# Assignment Information

**Purpose** To use a computer simulation to help choose the best solution to a complex real-world problem

**Time** Approximately 90 minutes

**Question** Which solution is the best for the neutralization of an acidic lake?

**Summary** In this simulation, you will measure the pH and the dissolved oxygen (DO) content of a lake. You will also analyze the effect of three methods of lake neutralization on the pH of the lake, and the egg and adult populations of a certain type of fish. You will then conduct cost analysis. You will use your data from the simulation and your cost analysis to determine the best solution given the requirements and constraints of the solution to be implemented.

# Background Information

pH is a measure of the hydronium ion (H+) concentration of an aqueous solution. It is used to describe the acidity or the alkalinity (basicity) of a solution. A solution that has a pH that is less than 7 is acidic. A solution that has a pH of 7 is neutral. A basic or alkaline solution has a pH that is greater than 7.

pH is important in determining the health of bodies of waters, including lakes. A healthy lake typically has a pH of 6–8. It is at this pH that most flora and fauna in lakes thrive. For example, snails live in waters with a pH of 6–7.5. Each organism has its own pH level requirement.

The pH of lakes can decrease or can become more acidic as a result of acid rain and acids that form from industrial processes and human activities. Acidification of a lake can affect the population of organisms that live in it. A lake that has a pH of 5 will not be able to support the growth and development of snails.

Another property that is used to describe the water in a lake is dissolved oxygen. As the term implies, it is the amount of oxygen dissolved in water. This value is measured in mg/L. Organisms use dissolved oxygen to carry on life-supporting processes such as releasing energy from the food they consume. Each organism has a dissolved oxygen range in which it can grow and develop.

There a few ways to neutralize acidic lakes: adding lime, oxygenation, and a combination of the first two ways. Adding agricultural lime to acidic lakes dissolves the lime and releases a base. The base neutralizes the acid in the lake and changes its pH. Oxygenation, or adding oxygen to the lake, decreases the amount of acids in the lake. This decrease is a result of the decrease of the number of organisms that produce acids. Additionally, the increase in dissolved oxygen increases the population of the organisms that use substances that would otherwise be converted to acids. Adding the right amount of oxygen to a lake can help maintain the health of the organisms in a lake.

# Assignment Instructions

1. **Prepare for the project.** 
   1. Read through this guide before you begin, so you know the expectations for this project.
   2. If anything is unclear, be sure to ask your teacher.
2. **Consider the requirement and constraints of the best solution.** 
   1. Gain access to the simulation.
   2. Read the introduction and select “Next”.
   3. Understand the requirement and constraints of the best solution. This will guide you in making the best choice.

The requirement of the solution is the following.

* The solution should neutralize the acidic lake to support the development and growth of the egg and adult fish populations.

Constraints of the solution include the following.

* The solution should be cost-effective and should not exceed the amount of $165,000.
* The solution should create a healthy lake within five years.
  1. Select “Next” to move on to the next section.

1. **Collect pH testing samples and DO data from the lake.**
   1. Select one of the three locations to start collecting your samples and data.
   2. Select the lab bag to access the materials you will be using to collect pH testing samples and dissolved oxygen data.
   3. Select the gloves to put them on.
   4. Drag the sample bottle to the ripple on the lake to fill it with water.
   5. Drag the sample bottle filled with water to the cooler.
   6. Drag the DO meter and drop it in the ripple on the lake to measure the DO in the lake.
   7. Record the DO value in Table A of the **Data and Analysis** section of this guide.
   8. When you are ready to continue, select the “Next” button.
   9. Repeat Steps 3d–3h for the other two sampling sites.
   10. Determine the average of the DO readings. Note the average in Table A.
   11. Select “Next” to move on to the next section.
2. **Determine the pH of the lake water samples.**
   1. Now it is time for you to determine the pH of the water samples. Select the box of gloves on the shelf to begin.
   2. It is good science practice to stir the solution very gently while determining its pH to get an accurate measurement. The magnetic stirring rod has already been placed into your water sample. Drag the beaker on the table to the stirring platform.
   3. Select the stirring platform to gently stir your first water sample.
   4. Your sample is ready for pH determination. Drag the pH meter on the shelf to the beaker.
   5. Record the pH value in Table A.
   6. When you are ready to continue, select the "Next" button.
   7. Repeat Steps 4b–4f for beakers #2 and #3. Record the readings in Table A.
   8. Determine the average of the pH readings. Note the average in Table A.
   9. Select “Next” to move on to the next section.
3. **Use a computer simulation to test possible solutions to the acidic problem.** 
   1. Now that you have gathered pH and DO data, it is time for you to test the options for the best solution. To better understand the options, here are the specifics of each option.

**Liming**: Two hundred tons of agricultural lime will be added to the lake once a year for three years. The effect of liming on the pH and fish population will be monitored.

**Oxygenation**: Oxygen will be added to the lake at a rate of 0.5 tons twice a week by each of the four oxygenation devices. The effect of oxygenation on the pH, DO, and fish population will be monitored.

**Liming + Oxygenation**: Six hundred tons of agricultural lime will be added to the lake during the first year. Oxygen will be added to the lake at a rate of 0.5 tons twice a week by each of the four oxygenation devices. The effect of oxygenation on the pH, DO, and fish population will be monitored.

* 1. Select one of the fish icons to test an option.
  2. Watch the animation to observe the effect of the option on the egg and fish population. Take note of the total number of years indicated in the animation. Record this value in Table E.
  3. Select the “Show the Graphs” button to view the data for this option. Use the information from the graphs to complete Table B if you are analyzing the Liming option, Table C if you are analyzing the Oxygenation option, and Table D if you are analyzing the Liming + Oxygenation option. Record only the data for the years in which the egg and adult fish populations are thriving. Take note of the pH and DO requirements of the fish population. You will use all this information data to justify and support the option of your choice. Use the “Hide Graphs” button to go back to the animation. Make sure to take note of trends and relationships in the graphs.
  4. Select the “Choose a Different Option” button to test the other two options. When testing the Oxygenation option, select the “See Oxygenation Process” button to see how this process works.
  5. Repeat Steps 5b–5e to test all options.
  6. Select “Next” to move on.
  7. Next, use your Student Guide to analyze the cost of each solution.

1. **Determine the cost of implementing each solution.**
   1. Use the information about the three options in Step 5a and the information in the table below to complete Table F.

|  |  |
| --- | --- |
| **Item** | **Cost** |
| Agricultural lime | $50.00 per ton |
| Labor cost of agricultural lime application | $750.00 per application |
| Barge gas | $100.00 per application |
| Transport of lime from factory to lake | $200.00 per ton |
| Oxygenation device | $3,500.00 per device |
| Electricity to run oxygenation device | $240.00 per device per year |

1. **Identify the best solution.**
   1. In the first row of Table G, write the pros and cons of each solution.
   2. In the third row of Table G, choose the best solution. Justify your choice and tradeoffs, if making tradeoffs, using data and the observations you obtained from the computer simulation and your cost analysis.
2. **Complete the Follow-Up Questions.**
3. **Upload your completed Student Guide in the Virtual Classroom or submit them to your teacher.**

# Data and Analysis

Record your data/observations and take note of your analysis in the tables below.

**Table A. Initial pH and Dissolved Oxygen Readings**

|  |  |  |
| --- | --- | --- |
| **Sampling Site** | **pH** | **Dissolved Oxygen**  **(mg/L)** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| **Average** |  |  |

**Table B.** **Liming Option Data**

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **pH** | **Egg Population**  **(% of TP)** | **Adult Population**  **(% of TP)** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Table C. Oxygenation Option Data**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **pH** | **DO**  **(mg/L)** | **Egg Population**  **(% of TP)** | **Adult Population**  **(% of TP)** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Table D. Liming + Oxygenation Option Data**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **pH** | **DO**  **(mg/L)** | **Egg Population**  **(% of TP)** | **Adult Population**  **(% of TP)** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Table E. Number of Years the Lake Is Monitored**

|  |  |
| --- | --- |
| **Option** | **Number of Years Monitored** |
| Liming |  |
| Oxygenation |  |
| Liming + Oxygenation |  |

**Table F. Cost Analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **Liming Solution** | | | |
| **Item** | **Cost per Unit**  **($)** | **Number of Units Used** | **Total Cost**  **($)** |
| Agricultural lime |  |  |  |
| Labor cost |  |  |  |
| Barge gas |  |  |  |
| Transport of lime from factory to lake |  |  |  |
| **TOTAL** | | |  |
| **Oxygenation Solution** | | | |
| **Item** | **Cost per Unit**  **($)** | **Number of Units Used** | **Total Cost**  **($)** |
| Oxygenation device |  |  |  |
| Electricity |  |  |  |
| **TOTAL** | | |  |
| **Liming + Oxygenation Solution** | | | |
| **Item** | **Cost per Unit**  **($)** | **Number of Units Used** | **Total Cost**  **($)** |
| Agricultural lime |  |  |  |
| Labor cost |  |  |  |
| Barge gas |  |  |  |
| Transport of lime |  |  |  |
| Oxygenation device |  |  |  |
| Electricity |  |  |  |
| **TOTAL** | | |  |

**Table G. Solution Comparison**

|  |  |  |  |
| --- | --- | --- | --- |
| **Comparison Descriptions** | **Solutions** | | |
| **Liming** | **Oxygenation** | **Liming + Oxygenation** |
| Pros and cons |  |  |  |
| Best solution and justification |  |  |  |

**Follow-Up Questions**

Answer the following questions.

* 1. When water is added to agricultural lime (CaCO3), calcium hydroxide, a base, is produced in the following reaction:

CaO(s) + H2O(l) → Ca(OH)2(s)

The solid calcium hydroxide dissolves in water and the solution become alkaline.

Ca(OH)2(s) + (aq) → Ca(OH)2(aq)

Based on the information, determine the neutralization reaction involved when agricultural lime is added to a lake with a high volume of nitric acid. Identify the net ionic reactions involved in the neutralization reaction involving lime. What salt was formed during the neutralization reaction? Describe the salt formed.

* 1. Based on the data you obtained from the computer simulation, what is the range of pH and dissolved oxygen values that allow the egg and adult fish populations to thrive?
  2. What other constraints would you consider when determining the best solution? Why?