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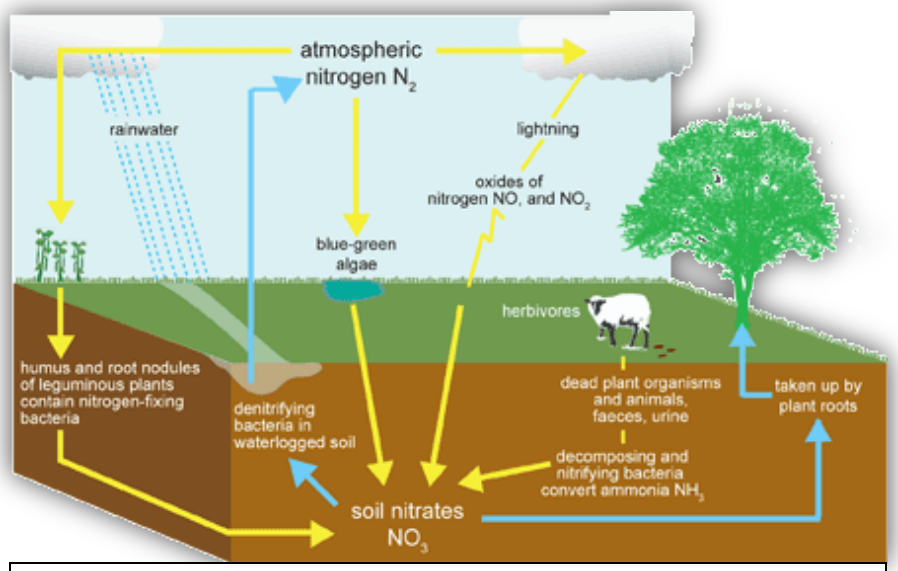
The Impact of Nitrate Concentration on the Cove River Biome and the Surrounding Region

## I. Introduction/Background

Nitrate is an inorganic compound that is made of one nitrogen atom and three oxygen atoms ($NO_3$) and is one of the most frequent groundwater pollutants in rural areas ("Nitrate" Lenntech.com). The compound can commonly be found in nitrogen-based fertilizer, animal manure, sewage treatment plants and leaky septic tanks (Scott). Due to its prominence in fertilizer, nitrate is a common part of the soil in which farmers grow their crops so when heavy rainfall occurs, the nitrates in the ground mix into the groundwater and runoff into nearby bodies of water. This runoff and the leaking of sewage, septic tanks and animal manure into the ground can result in high levels of nitrates in the soil that nearby plants utilize. Though that shows the positive benefits of the nitrate reservoir that is created underground, the majority of groundwater nitrates pollute bodies of water and the organisms that reside in them. The Environment Protection Agency has set a Maximum Contaminant Level (MCL) of 10 milligrams per Liter (mg/L) or 10 parts per million (ppm) for the nitrates. If the Cove River were to have more than 10 mg/L or 10 ppm of nitrates, then it would be highly polluted with nitrogen and would have to be treated to reduce its nitrate level ("Basic").

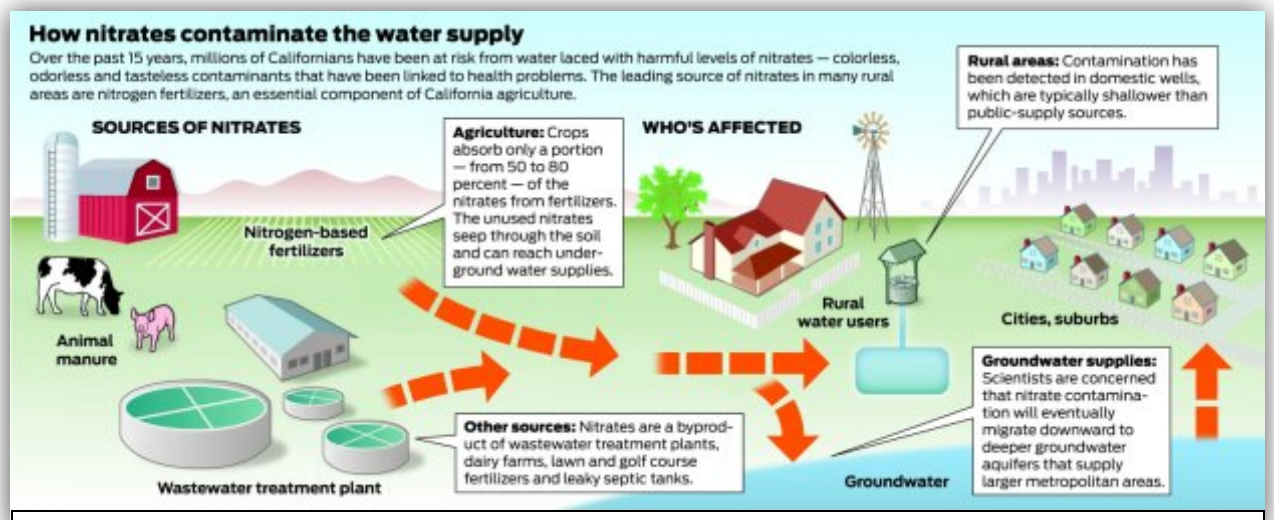



"Common Water Problems [NITRATES]." *Ecowaterofatlanta.org*. EcoWater of Atlanta. Web. 25 Apr. 2012.

High nitrate levels can cause pollution that is deadly to underwater organisms. Algae consume nitrogen and bloom to large amounts when there is a high nitrate concentration. Photosynthetic organisms would not be able to produce nutrients and oxygen if they did not

receive any sunlight, thus causing “dead zones” to be created. “Dead zones” are, basically, areas where dissolved oxygen has been depleted, making them unsuitable of sustaining life (“Nitrate” EWG.org). The lack of oxygen in the water and the prominence of nitrogen would cause nitrogen to diffuse into the blood of fish through their gills rather than oxygen due to the countercurrent exchange of gases between the water and the blood vessels in gills. This would cause a high amount of fish kills and result in more pollution in the Cove River, for example, because there would be a large amount of organisms decomposing at the same time, thus leaving a large amount of biological waste.

Nitrates also have an effect on the health of terrestrial animals. Nitrates have been linked to methaemoglobinaemia or “blue-baby syndrome”, in which an infant’s supply of oxygen is cut off (Scott). When runoff nitrates enter bodies of water, they can get to the tap water systems in people’s homes, thus causing many individuals to drink nitrate-rich water. So, if infants were exposed to the water frequently, then their hemoglobin would be converted to methaemoglobin,




Scott, Julia. "State's Nitrates Problem Grows Unchecked." *Www.SFGate.com*. Hearst Communications Inc., 17 May 2010. Web. 25 Apr. 2012.

which is unable to carry oxygen. This would cause blood to always be oxygen-poor and would, eventually, cause parts of the body to die due to lack of oxygen-rich blood. Excess nitrate levels in adults has also been known to cause kidney and spleen damage (“Nitrate” EWG.org).

If there is a high concentration of nitrates in the Cove River, then it will reflect the high amount of precipitation that causes runoff into the river from the soil of the biome because heavy precipitation, which West Haven had high levels of this testing season, is known to pull soil nitrates with water into surrounding aquatic areas. The problem at hand is that the nitrate concentration of the Cove River must be kept at a low, survivable level to allow organisms to live and to prevent pollution of the river due to an excess of nitrogen. Steps will have to be taken

to prevent pollution and to lower the nitrate levels if they reach this excess. The nitrate levels of the Cove River and their effect on the river will be studied over a period of six months. The independent variable is the time of date collection, which spanned a period of six months. The dependent variable is the nitrate level of the Cove River's water sample for each test done over that six month time period. This experiment lacked a control group because the standard set by the EPA was used as a comparable piece of data, rather than a control group. If there was a control group, it would most likely be a normal water sample from a sink or bottle to compare the nitrate levels of water that is not exposed to the environment to water that is in constant contact with the environment. The dissolved oxygen level, the water pH, and the water temperature will be measured in order to observe the correlation between these factors and the nitrate level of the river. While the time and conditions of the environment may change for each water collection, the location of water collection, the method used to measure the nitrate levels, and the amount of water tested will remain constant.

**II. Experimental Design**

A. Materials

1. Bucket
2. Water sample
3. SAPI™ Aquarium Pharmaceuticals Testing Kit
4. Vernier Probe Ware

B. Procedure

1. Collect a water sample in the bucket from the predetermined location at Cove River.
2. Use the Vernier Probe Ware immediately after the collection of the water to determine the Dissolved Oxygen level and temperature. There is a stress on immediate use of the probe ware because the measurable factors and environmental effects on them can change very quickly, so an instantaneous measurement is needed to ensure accuracy of the data.
3. Bring sample back to the lab for the testing using the SAPI™ Aquarium Pharmaceuticals Testing Kit.

a) Fill test tube (0106) to 5 mL line with water sample.
b) Add one Nitrate #1 Test Tablet (2799) to the test tube.
c) Cap the tube and mix until the tablet has disintegrated.

d) Add one Nitrate #2 CTA Test Tablet (NN-3703) to the test tube. Immediately slide the tube into the Protective Sleeve (0106-FP).

e) Cap the tube and mix until the tablet has disintegrated.

f) Wait five minutes. Remove the Protective Sleeve.

g) Compare the color of the sample to the Nitrate Color Chart (5591 CC). Record the result as ppm Nitrate.

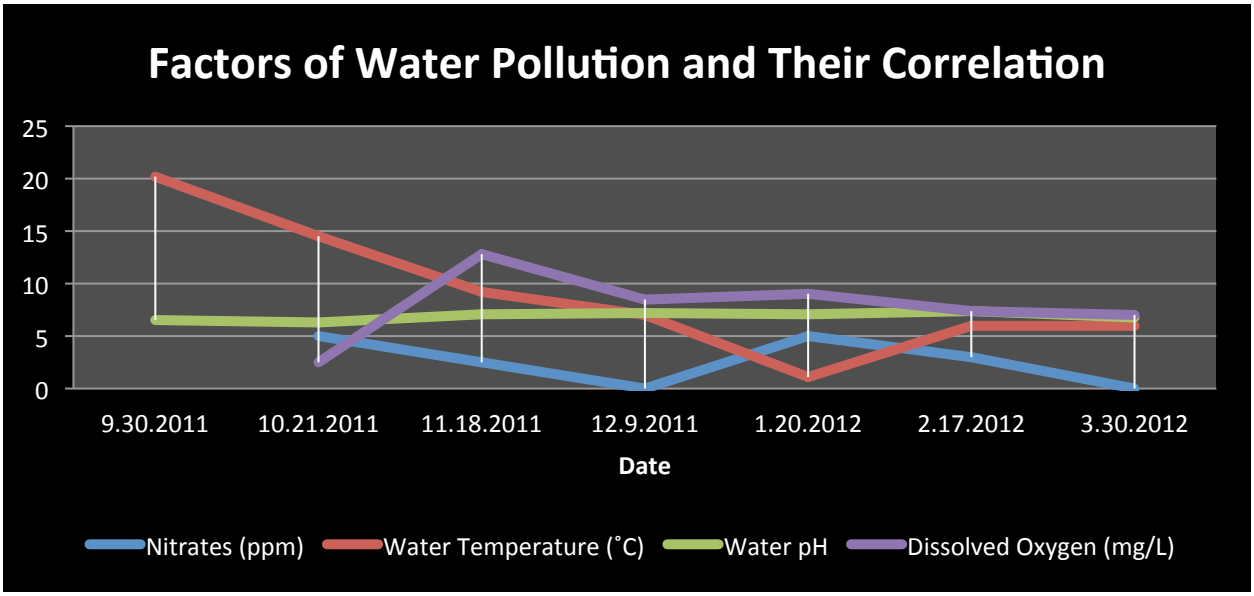
h) Repeat the same process to determine the pH of the water.

4. Dispose of chemical wastes appropriately.

## III. Data Presentation

Factors of Water Pollution and Their Correlation

| Date | 9.30.11 | 10.21.11 | 11.18.11 | 12.9.11 | 1.30.12 | 2.17.12 | 3.30.12 |
|---|---|---|---|---|---|---|---|
| Water Temperature (˚C) | 20.2 | 14.5 | 9.2 | 7.0 | 1.1 | 6.0 | 6.0 |
| Water pH | 6.5 | 6.3 | 7.1 | 7.2 | 7.1 | 7.4 | 6.8 |
| Dissolved Oxygen (mg/L) | N/A | 2.5 | 12.8 | 8.5 | 9.0 | 7.4 | 7.0 |
| Nitrates (ppm) | N/A | 5.0 | 2.5 | 0.0 | 5.0 | 3.0 | 0.0 |
| Recent Precipitation | Yes; Heavy Rainfall on Previous Night | Yes; Constant Rainfall Throughout the Week | No | No | Yes; Snow on Previous Night | Yes; Rainfall on the Previous Night & Morning | Yes; Constant Rainfall Throughout the Week |



## IV. Observations

Before the data is analyzed, it should be noted that the Cove River is surrounded by several places of human activity that can serve as sources of nitrates and pollution. West Haven High School, a gas station, a busy road and several homes surround this river, thus exposing it to possible pollution from car exhaust and gases that are created when the houses and school are heated.

It is evident from the data and graph that there is no clear correlation between nitrates, water temperature and water pH. However, it is shown that dissolved oxygen and nitrate levels have a contrast that may be affected by one another's presences. When the dissolved oxygen was at the low level of 2.5 mg/L on October 21, 2011, the nitrate level was at 5.0 ppm. But, as the dissolved oxygen level increased to 12.8 mg/L on November 18, 2011, the nitrate level dropped to 2.5 ppm. Though this pattern only occurs shortly in the data, it is worth noting that high dissolved oxygen levels can possibly cause low nitrate levels.

In addition, there seems to be a correlation between precipitation and the nitrate level. Besides in September and March, the precipitation seemed to have a positive effect on the nitrate level. On days of high precipitation, such as October 21, 2011 and January 30, 2012, the nitrate levels reached 5.0 ppm. However, on the dates without precipitation, the nitrate levels were at 2.5 and 0.0 ppm, thus showing that the precipitation (rain or snow) had a certain effect on nitrate levels in the Cove River. This could possibly relate to the fact that increased precipitation causes increased runoff into the Cove River, thus causing nitrate-laced soil to be added to the river in large amounts. If there is no rain, then there is a low chance of runoff and, thus, a low chance of nitrates entering the Cove River.

There are several other observations that are not related to correlations. For example, the water pH level stays constant throughout the six month testing period, thus showing the river's ability to sustain its neutrality. The changing temperatures associated with each month and season had no effect on the pH levels of the Cove River. It should be noted that the water temperature dropped dramatically when the tests entered the winter season, but started to regain heat in March, thus showing an uncommon high increase in heat during the winter month of March. A final and somewhat amusing observation is that all the factors besides nitrate happen to meet at the 7.0 area of the graph in March. Though each factor is measured in different units, it is still important to notice this odd and rare convergence.

## V. Conclusion

The hypothesis stated that "If there is a high concentration of nitrates in the Cove River, then it will reflect the high amount of precipitation that causes runoff into the river from the soil of the biome." The data and observations mention the correlation of the precipitation and the nitrate levels, thus proving the hypothesis correct and showing how one factor of an environment could affect another. The nitrate levels did not reach or exceed the Maximum Contaminant Level of 10 ppm/ 10 mg/L set by the EPA, thus showing that the Cove River is currently void of pollution. The nitrate level remained at half the standard level or lower, thus proving how far the Cove River is to pollution, at the time. However, the Cove River is still subject to pollution as it is surrounded by a gas station, school, several homes and a busy road. The gas station can leak gases into the woods that encompass the Cove River and any type of heavy precipitation can cause the gases that are infused in the soil to runoff into the river. The school has about 1,550 students that walk around the area and leave waste that can pile up and enter the Cove River's environment. In addition, any excess gas from the school's heaters can pollute the surrounding soil or surrounding air. The nearby homes have a similar effect on the Cove River due to their heating units. The busy road that passes by the Cove River area has multiple cars that have exhaust full of pollutant gases. Nitrogen dioxide, a pollutant that increases nitrate levels in water, can actually enter the Cove River environment from the cars and mix in with the water of the river. As the data, graph and observations show, there is rare and random correlation between the four factors, thus showing that it is necessary to record each factor rather than assuming they have an effect on each other.

This experiment serves as a fine model for future research of nitrate levels in water and overall pollution of a body of water. It successfully measures multiple factors that can be compared and analyzed while also ensuring that unnecessary errors are limited. For example, the water sample used for testing was collected, tested and closed quickly to prevent any gases, such as nitrogen or oxygen, to escape. This measure shows the experiment's use of materials to ensure the limitation of unforced errors. However, though measures are taken, errors are still a possible occurrence. The bottle that holds the water may not be closed in time, thus allowing a large amount of measurable factors to be distorted. The testing procedures using the lab kits may have been performed incorrectly or hastily, thus causing unreliable results to be found. So, overall the experiment is a great way to test for water pollution, but may have some flaws that can be improved.

Improvements to the experiment are as follows. Multiple water samples should be collected and closed immediately while one sample is used to find the immediate dissolved oxygen level and temperature. This would allow all measurable factors to be found without distortion because the quickly closed bottles would retain all the gases and components that are needed for testing. Multiple locations should be tested rather than just one to show if the location of the river affects its pollution. From this it can be determined if the part of the river that is closer to the gas station has more nitrate pollution than the part of the river that is closer to the school. As more of a precautionary message than an improvement, it should be noted that all measurements and collection is kept constant. This will allow for each tested sample to be given the same treatment, thus lowering the level of distortion caused by error and promoting the equality of the tests.

Furthermore, it is important to monitor the nitrate levels in water because of their environmental and health effects. The exposure of nitrates to a body of water can kill the organisms in the water and, thus, kill the land organisms that thrive on those sea creatures. The exposure of nitrates to the human body through drinking water can cause diseases such as methaemoglobinaemia and lead to reduction of the nearby human population. This experiment serves as a determinant of the local areas environmental footprint and allows people to see what their actions can do to the environment and themselves. Further experimentation should involve the gases in the atmosphere and air that can enter the water and increase pollution of the water or habitats. If the amount of pollutants in the air was determined, then the next step would be to reduce the factors that cause this pollution. This experiment brings a point to the people that our actions ultimately affect everything around us.

**VI. Resources**

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AP Biology
April 13, 2012

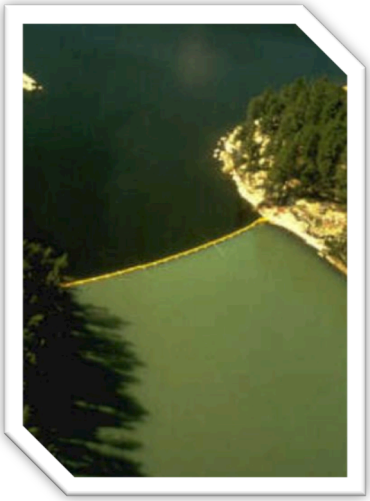
**The Effect of Nitrate Levels on the Water Quality of Cove River**

## I. Introduction

Nitrate ($NO_3$) is a nitrogen-oxygen compound that readily combines with inorganic and organic materials. In nature, it is found as a negatively-charged ion and is easily converted to nitrite ($NO_2$). Nitrate is converted into nitrite by bacteria, and then incorporated into plant tissues. Animals that consume these plants take in nitrite and release it in their feces. Bacteria can then convert nitrite into nitrogen, which is released into the atmosphere. Bacteria also conduct these conversions in the digestive tracts of many animals, including humans. Thus, nature maintains the appropriate balance of nitrogen oxides and prevents nitrates from accumulating in the environment. However, the use of nitrates in fertilizers can disrupt this cycle ("Nitrate and Nitrite." *Anl.org*). Excess nitrate reaches water via runoff from fertilizers; leaking from septic tanks and sewage; and decomposition of animal waste ("Basic"). The health goal for nitrate, as established by the Environmental Protection Agency (EPA), is 10 parts per million (ppm) or 10 milligrams per liter (mg/L). Nitrate levels above 10 ppm threaten the ecosystem ("Basic").

An excessive amount of nitrate in the water supply creates environmental and health concerns. For instance, because algae consumes nitrate, a superfluous amount of $NO_3$ in the water contributes to algae overgrowth. A sufficient amount of overgrowth can block sunlight from reaching the photosynthetic organisms found in the water, thus preventing them from carrying out photosynthesis. This reduces the amount of dissolved oxygen in the water and can result in death among populations that require oxygen for survival ("Measuring"). Moreover, nitrates consumed by water can change hemoglobin, the pigment responsible for transporting oxygen throughout the body, into methemoglobin, "which reduces the ability of blood to transport oxygen to cells". Excess nitrate in the body could cause a bluish tint in the lips, ears, and nose to develop, indicating a lack of oxygen. In extreme cases, it could lead to respiratory problems and death. Infants are particularly susceptible because of their high stomach pH, which promotes the growth of nitrate-converting bacteria ("Nitrate and Nitrite." *Deleware.gov*). Therefore, it is essential to determine the nitrate levels found in water.

In order to determine the extent of water pollution in West Haven, the effect of nitrate on the water quality of Cove River will be studied over a period of six months. If the nitrate levels in the water exceed the standards permitted by the FDA, then Cove River is polluted and steps must be taken to prevent long-term consequences. In addition, the amount of dissolved oxygen in the water, the water pH, and the water temperature will be measured in order to determine if there is a correlation between these factors and the levels of nitrates found in the water. Nitrate levels will be measured over the course of several months, and thus conditions under which the nitrate is being measured will not be uniform. However, the location from which the water is obtained, the method used to measure the nitrate levels, and the amount of water tested will remain the same each time.



This body of water was artificially separated. The upper half was left in its natural state, where as the bottom half was polluted by nitrates. The difference in color is due to the overgrowth of algae in the bottom half.
*Tamu.edu*

## II. Experimental Design

### *A. Materials*

5. Bucket
6. Water sample
7. SAPI™ Aquarium Pharmaceuticals nitrate testing kit
8. Vernier Probe Ware

### *B. Procedure*

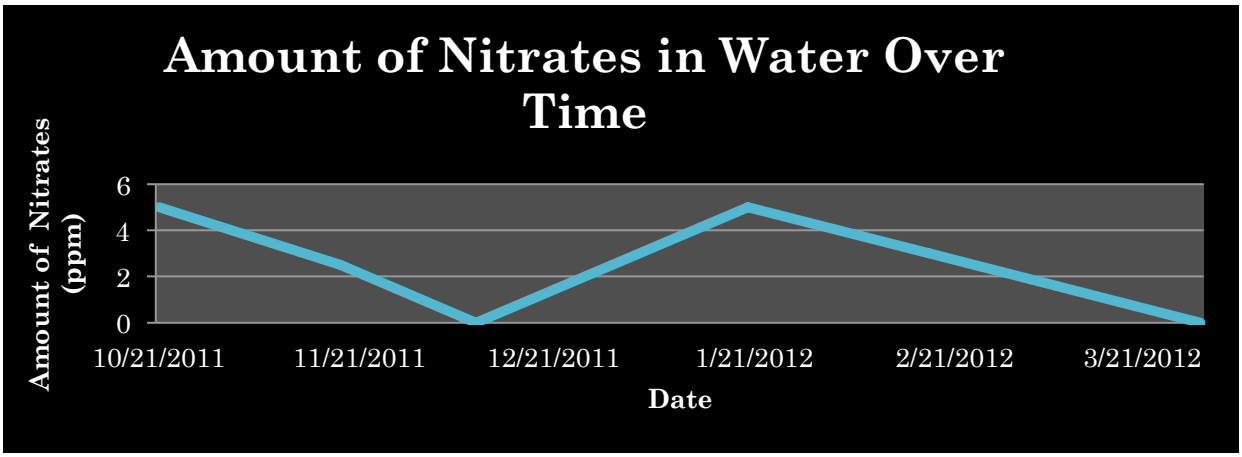
5. Obtain water sample in bucket from predetermined location at Cove River.
6. Measure the dissolved oxygen levels and temperature of the sample immediately so as to not invalidate the results by exposing the water to the atmosphere.
7. Record the dissolved oxygen levels and water temperature/.

8. Bring sample back to the lab to test the nitrate levels using the SAPI™ Aquarium Pharmaceuticals testing kit.
   i) Fill test tube (0106) to 5 mL line with water sample.
   j) Add one Nitrate #1 Test Tablet (2799) to the test tube.
   k) Cap the tube and mix until the tablet has disintegrated.
   l) Add one Nitrate #2 CTA Test Tablet (NN-3703) to the test tube. Immediately slide the tube into the Protective Sleeve (0106-FP).
   m) Cap the tube and mix until the tablet has disintegrated.
   n) Wait five minutes. Remove the Protective Sleeve.
   o) Compare the color of the sample to the Nitrate Color Chart (5591 CC). Record the result as ppm Nitrate.
9. Bring sample back to the lab to test the water pH using the SAPI™ Aquarium Pharmaceuticals testing kit. Follow the instructions attached to the testing kit.
10. Record the water pH and nitrate levels.
11. Dispose of chemical wastes appropriately.

## III. Data Presentation

*A. Data*

| Date | 9.30.11 | 10.21.11 | 11.18.11 | 12.9.11 | 1.30.12 | 2.17.12 | 3.30.12 |
|---|---|---|---|---|---|---|---|
| Water Temperature (˚C) | 20.2 | 14.5 | 9.2 | 7.0 | 1.1 | 6.0 | 6.0 |
| Water pH | 6.5 | 6.3 | 7.1 | 7.2 | 7.1 | 7.4 | 6.8 |
| Dissolved Oxygen (mg/L) | n/a | 2.5 | 12.8 | 8.5 | 9.0 | 7.4 | 7.0 |
| Recent Precipitation | yes; rained heavily the previous night | yes; constant rainfall within the week | no | no | yes; snowed the previous night | yes; rained in the morning and the previous night | yes; rained within the week |
| Nitrates (ppm) | n/a | 5.0 | 2.5 | 0.0 | 5.0 | 3.0 | 0.0 |




*B. Observations*

The amount of nitrates in the water appears to have no correlation with the season, water temperature, or water pH. However, there is an increase of nitrates after periods of heavy rainfall. For example, on October 21, 2011, after a week of rain, the nitrate levels reached 5.0 ppm. In contrast, on December 12, 2011, after no rain, the nitrate level was 0.0 ppm. In addition, the greater the amount of dissolved oxygen in the water, the lower the nitrate level is. On November 18, 2011, there was 12.8 mg/L of dissolved oxygen in the water and the nitrate level was 2.5 ppm. On October 21, 2011, there was only 2.5 mg/L of dissolved oxygen in the water and the nitrate level reached 5.0 ppm. The remainder of the data supports these patterns.

Near the testing site there is a school, a busy road, and a gas station that uses an outdated, leaking gas tank. All are possible sources of pollution.

## IV. Conclusion

In conclusion, the levels of nitrate in Cove River did not at any point reach unhealthy standards as defined by the FDA. However, Cover River remains vulnerable to pollution, especially considering its location. The nearby gas station has a leaking gas tank that can become a source of nitrates. Moreover, Cove River is consistently exposed to the pollutants emitted by vehicles and the waste released by the school. As noted by our observations, West Haven is also frequently subject to rain, causing the runoff of these wastes into Cove River and a spike in the nitrate levels. It is important to note any significant changes in pH because, although the water pH remained steady as the nitrate levels fluctuated, high pH can promote the overgrowth of nitrate-converting bacteria. Furthermore, an excess of nitrates will decrease the amount of dissolved oxygen in the water because nitrates contribute to algae overgrowth, blocking sunlight and preventing photosynthetic organisms from producing oxygen. This is reflected by the majority of our data. When the dissolved oxygen levels reached maximums of 12.8 mg/L and 8.2

mg/L, the nitrate levels were 2.5 ppm and 0.0 mg/L respectively. In contrast, when dissolved oxygen levels reached a minimum of 2.5 mg/L, the nitrate levels were at 5.0 ppm. However, dissolved oxygen levels can be affected by water pH and temperature, so its levels will not always correlate with the amount of nitrate in the water. For instance, when dissolved oxygen levels reached 9.0 mg/L, the nitrate levels were at a high 5.0 ppm. Therefore, all factors must be taken into consideration during one's analysis of the data.

This experiment can be used as a model for future research regarding how to accurately determine and analyze the level of nitrates in a body of water. Several steps were taken in order to ensure that the water samples were not contaminated and that the data was reasonable. For instance, water obtained directly from Cove River was kept enclosed in a bucket to prevent the release of measurable nitrates. Also, The FDA standard for nitrate levels in water served as a control group. The data was then compared to these standards to verify its validity and to identify abnormalities. However, there were several sources of error in this experiment that could have affected the results. The bucket that was used to hold the water may not have been closed quickly enough each time, allowing nitrates to leave the water and mix into the surrounding atmosphere. Also, mistakes in following the procedure when testing the water samples for nitrates or misreading the results would invalidate the data. Moreover, only one water sample was tested each day. If there was an error in testing this one sample, it went undetected because there were no other samples to compare it to. Nevertheless, the results appear to be reliable because they demonstrate a predictable, consistent relationship with the supplementary data.

Overall, the experimental design remains reliable. Another group can effectively replicate this experiment by following the procedure and minimizing and sources of error. The procedure is clear, complete, and easy to follow. Key variables, such as the location of the water source, the method used to measure the level of nitrates, and the amount of water analyzed each time, remain constant and controlled. This experiment can be improved by testing multiples areas of Cove River and obtaining several samples from each area. Testing several spots of the river would produce a variety of results, thereby increasing the reliability of the experiment. Furthermore, more frequent testing would enhance the data by providing researchers with more information to determine what may cause a change in nitrate levels. It would also be beneficial to include a more detailed examination of each manmade establishment near the testing location. If the nitrate levels are unusually high, then it would be easier to identify the source of any pollution or runoff.

Monitoring the levels of nitrates in the local water supply is important. If there is a sudden increase in nitrates, it could have fatal impact on the surrounding environment. In addition, if the water at Cove River became part of the drinking water for West Haven residents then there is a high chance that these residents will become ill. If research reveals an excess amount of nitrates, then immediate action can be taken to rectify the situation before there is any major consequence. Understanding the impact of nitrates on the environment and human health is useful in one's understanding of biology. Further experimentation extending outside the hydrosphere can be undertaken to increase one's understanding of the topic. In the future, there could be an additional focus nitrogen dioxide, a major air pollutant. Nitrogen dioxide that dissolves in the water could increase the nitrate level and thus a spike in nitrate levels could indicate an excess in air pollution. Additional research such as this can be used to determine the status of the environment.

**V. Works Cited**

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