The Effects of an Irrigation Pond on the Health of Black Rock Creek

By

Joe Bever
Latoya Brown
Rochelle Brunot
Julian Cook
Ryan Dean
Tenesha Hill
Rob Hoffmaster
Kim Murphy
Nixy Osorio
Lauren Runion
Brooke Stanley
Tiffany Townsend
Tahira White
Tyron Young

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Abstract

The purpose of this study is to determine how an irrigation pond affects Black Rock Creek. It was important to test Black Rock Creek, in Smithsburg, MD, because it is a tributary to the Chesapeake Bay. Our first hypothesis was would there be a difference in the sensitivity levels of the macroinvertebrates found above and below the irrigation pond. Our second hypothesis is there would be a difference in temperature above and below the irrigation pond. Finally, we hypothesized that there would be a difference in phosphate, nitrate and pH above and below the irrigation pond. We tested for phosphate, nitrate, temperature, pH and biotic index. Factors such as velocity, depth and width of the stream, and percent slope were also observed in order to determine the amount of oxygen in the water.

Macroinvertebrates have different tolerances to pollution; this aids in determining the overall health of the stream. We found a significant difference in the sensitivity of the macroinvertebrates above and below the irrigation pond. There was no significant difference in the phosphate, nitrate and pH levels found in the stream; however there was a significant difference in the temperature above the irrigation pond and below the irrigation pond. Thus the pond is affecting the Black Rock Creek, therefore affecting the Chesapeake Bay.

INTRODUCTION

For thousands of years, streams and rivers have been a thriving place for human civilization. From the Valley of the Tigris and Euphrates Rivers to the Nile River Valley, humans have depended upon such rivers for successful civilizations. Water is undoubtedly the most precious natural resource that exists on the planet. Without water, life on earth would be non-existent. Although humans recognize this, they disregard it by slowly polluting the streams, rivers, lakes and oceans and harming the planet to the point that organisms are dying. In order to prevent water pollution, people need to understand the problem and become a part of the solution.

When it rains, water flows through storm drains and then into streams. A stream is defined as a natural body of running water flowing on or under the earth (Ask 2005). Most streams flow into larger bodies of water, collecting materials from runoff and smaller streams. Prior to 1972, people regularly disposed of their garbage and waste materials into various rivers and streams, which ultimately discharged into the Chesapeake Bay. Society did not understand environmentally safe techniques for water systems. As populations increased, the scientific community came to realize the destruction.

Urbanization is described as the shift of population from rural areas to more populated areas, which results in deforestation (Encarta 2005). Housing developments, golf courses and parks are products of urbanization. These lead to the destruction of many habitats in the surrounding areas, causing disruptions in the ecosystem. In addition, by bringing more people to an area, there is more runoff from automobiles, fertilizer and grass clippings, which can change the ph, nitrate and phosphate levels in a nearby stream.

Moreover, an increase in population has caused a demand for more land. The process by which a forested area is destroyed in order to accommodate urbanization is called deforestation (Collins 2001). The loss of trees in small areas exposes bodies of water to increased amounts of sunlight, causing higher water temperatures. The warmer the water is, the less amount of dissolved oxygen exists. Deforestation also contributes excessive stream bank erosion and pathogen contamination. Pathogen contamination comes from warm-blooded animal waste (Fine 2005). Trees act as a filter and keep animal waste from being washed into the stream.

Deforestation and urbanization lead to a decrease in biodiversity. Biodiversity is important because genetic identities and variations represent organisms' evolutionary histories of adaptation and are not merely the source of their physical appearance. If biodiversity is lost, a species loses its ability to adapt to a changing world (Van Dyke 2003). The loss of this diversity is mainly caused by habitat destruction and fragmentation of species groups. Fragmentation is the splitting of organisms into isolated and often conflicting parts; it increases the chances for mutations and lowers the organisms' chance for survival (Cardinale et al. 2002).

In 1972, Congress enacted the Clean Water Act (CWA) to manage what substances were allowed to be discarded into streams. To manage pollution, the CWA required that every city install a water treatment plant (CEE 2004). In 1987, it also became a requirement for states to monitor the amount of non-point source pollution (NPS) being dumped in streams. NPS is defined as stormwater runoff from farms, forests and construction sites. In addition, the CWA ordered cities to monitor their Total Maximum Daily Load (TMDL) of pollution. TMDL is calculated by the amount of pollution and its toxicity level over a given day (Frondorf 2001).

Monitoring rivers and streams is important because they are crucial to the ecosystem and society. Pollutants and toxins flow from surrounding rivers and streams into the Chesapeake

Bay. The Bay is the largest and most productive estuary in the U.S.; it is one of Maryland's most important natural resources and a major source of revenue (Gimon et. al. 1998). Therefore, people living in parts of Maryland, Delaware, Pennsylvania and Virginia need to be aware that the Chesapeake Bay is important economically and ecologically.

The three major types of pollution which have the greatest impact on the Chesapeake Bay are nitrate, phosphate and sediment (Bhumbla 2005). Phosphate is found mainly in herbicides, pesticides, fertilizer and grass clippings (Molles 2002). Nitrate primarily comes from faulty sewage lines and farming manure (Bhumbla 2005) Sediment comes from a myriad of places including construction sites and roads.

Phosphate and nitrate cause eutrophication in streams. Eutrophication occurs when nitrate and phosphate levels increase so much that they cause an abundant algae bloom. As the algae die, bacterial colonies increase. The bacteria deplete oxygen levels by respiration. Nitrate and phosphate also affect the pH of streams. Too much nitrate and phosphate can cause streams to be acidic; too little can cause streams to be basic (Bhumbla 2005). Sedimentation reduces water quality and the amount of dissolved oxygen the stream can hold. The diversity of organisms' species will decrease due to less dissolved oxygen in the water. Only organisms of certain tolerance levels can survive in water with decreased amounts of oxygen. Sedimentation contributes to the decrease of viable habitats for organisms. It also allows less light to penetrate, which reduces vegetation growth. (Molles 2002).

Flow velocity is influenced by the slope of the landscape, the dimensions of the stream and its embeddedness. The steeper the slope is, the less time precipitation has to seep into the ground, which causes larger amounts of runoff. When the dimensions of the stream channel change, the area the water must flow through either increases or decreases. The embeddedness of the stream affects the flow velocity because water moves faster over a smooth surface than a rough surface. Therefore, flow velocity is higher when the stream bottom is comprised of sand and clay and lower when it is made of cobble, rock and boulders (Stream Flow 2005).

Macroinvertebrates are found in all rivers and streams. Macroinvertebrates are organisms lacking a backbone and large enough to see with the naked eye. Each macroinvertebrate has a certain tolerance level to pollution. Caddisflies, stoneflies and mayflies have low tolerance levels to pollutions, sedimentation and temperature change. However, crayfishes and midges have higher tolerance levels to these factors. Macroinvertebrates are used to calculate the biotic index, an indicator of stream health. Streams with a higher biotic index can be considered unhealthy because the macroinvertebrates in the streams are more tolerant to pollution. Streams with a lower biotic index can be considered healthy because they have more macroinvertebrates which are less tolerant to pollution. Nitrate, phosphate cause excessive amounts of algae blooms. The algae robs the stream of valuable oxygen that the macroinvertebrates need to thrive in the stream. These pollutants also increases temperature and macroinvertebrates are sensitive to changes in temperature.

When an irrigation pond was installed by the Beaver Creek Country Club it interrupted Black Rock Creek and required the removal of the plant life and wildlife around the pond. This is an example of habitat destruction and urbanization. The plants provided the stream with shade and a buffer between civilization and the stream, and prevented soil erosion. The irrigation pond also decreased the total amount of viable habitat available to macroinvertebrates found within the creek, which is a result of fragmentation.

The purpose of this experiment is to determine if the irrigation pond installed at a neighboring golf course is affecting the health of Black Rock Creek. This study is important because the water of Black Rock Creek will eventually drain into the Chesapeake Bay. Our study will investigate the biological health, the biodiversity and the chemistry of the stream above and below the irrigation pond. For this experiment we have five parts to our hypothesis; there will be a difference in phosphate, nitrate, temperature, pH and macroinvertebrate sensitivity above and below the irrigation pond.

METHODS AND MATERIALS

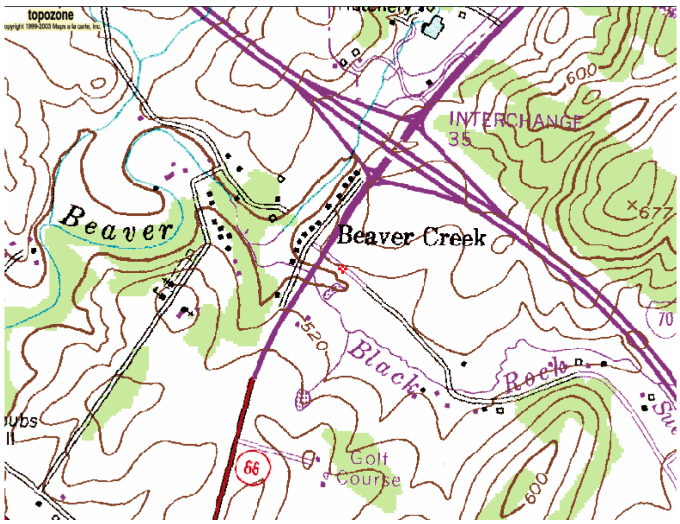

Figure 1- Topographical map of our test sites on Black Rock Creek.

On July 11th, 12th, and 18th 2005, between 12:00 noon and 2:00 pm, we visited two test site locations on Black Rock Creek. This creek is divided into two sections by an irrigation pond owned by the Beaver Creek Country Club. The irrigation pond resides on Country Store Road adjacent to Interstate 70 in Smithsburg, Maryland (Fig. 1). One of the test sites was at Beaver Creek Station, which is located below the irrigation pond. The other test site is located above the irrigation pond at the Heaton Family Property Site.

During the experiment, two of the five groups tested the stream's chemistry. We measured phosphate, nitrate, temperature and pH level. To measure nitrate and phosphate a La

Motte kit was used. We placed a pH meter in the water to measure its acidity. To measure temperature of each section of the stream, a thermometer was placed in the water to receive a reading. The remaining three groups measured the streams dimensions and channel characteristics. The dimensions of the stream and channel characteristics that the groups measured were width, depth, slope and velocity.

Using a measuring tape, we measured the width of the stream by holding the tape horizontally from one bank edge across the water to the other bank edge. To measure the depth of the stream, a meter stick was placed in the bed of the steam. We measured to where the water rose. A clinometer was used to measure the slope of the stream. The velocity was measured by placing a ping pong ball in the water and timing how long it took the ping pong ball to get from zero meters to ten meters.

Macroinvertebrates are organisms without a backbone that dwell in the creek's bed. The sensitivity of the organisms living there can be used to monitor the stream's health. Macroinvertebrates include mayflies, dragonflies, damselflies, stoneflies, true bugs, dobsonflies, alderflies, water beetles, caddisflies, craneflies, midges, black flies and crayfish. The sensitivity levels of macroinvertebrates range from zero to three. For example, dobsonflies have a tolerance of zero, which means they are very sensitive to pollution. Mayflies, stoneflies, true bugs, water beetles and caddisflies have a tolerance of one, making these macroinvertebrates sensitive. Dragonflies, damselflies, alderflies, and crayfish have tolerance levels of two; they are considered somewhat sensitive. Blackflies and midgeflies have a tolerance level of three, making them tolerant to polluted water.

The two groups who tested for macroinvertebrates used a one meter square made out of PVC pipes to define the sample area. After finding a sample using the PVC pipes, we allowed running water to pass through the D-net so that organisms that were released from the rocks could be captured. The number collected for each common name was recorded.

The type of T-test performed was a two-tailed T-test, with six degrees of freedom and a 90% confidence level. We used a two-tailed t-test to see whether there was a significant difference between both sites in temperature, macroinvertebrate sensitivity and the stream chemistry factors: nitrate, phosphate and pH. To calculate the biotic index, we used a method borrowed from Dr. Lundy Pentz of Mary Baldwin College. The equation used to calculate the biotic index was BI = $\frac{\sum_{k=0}^{3}(k \cdot m_k)}{\sum_{k=0}^{3} m_k}$, where k is the tolerance level from zero to three and m_k is the number of macroinvertebrates with k tolerance. The biotic index was calculated to determine the quality of the stream based on the diversity of the macroinvertebrates. A biotic index that is closer to three means that the stream is more polluted.

RESULTS

There was a statistically significant difference between the sensitivity of the macroinvertebrates at the Heaton family property site and the Beaver Creek Station site (p-Value=0.049). As shown in figure 2, the Heaton Family property site had a greater diversity in the sensitivity of the macroinvertebrates than at Beaver Creek Station site. At Beaver Creek Station site we only found somewhat sensitive macroinvertebrates.

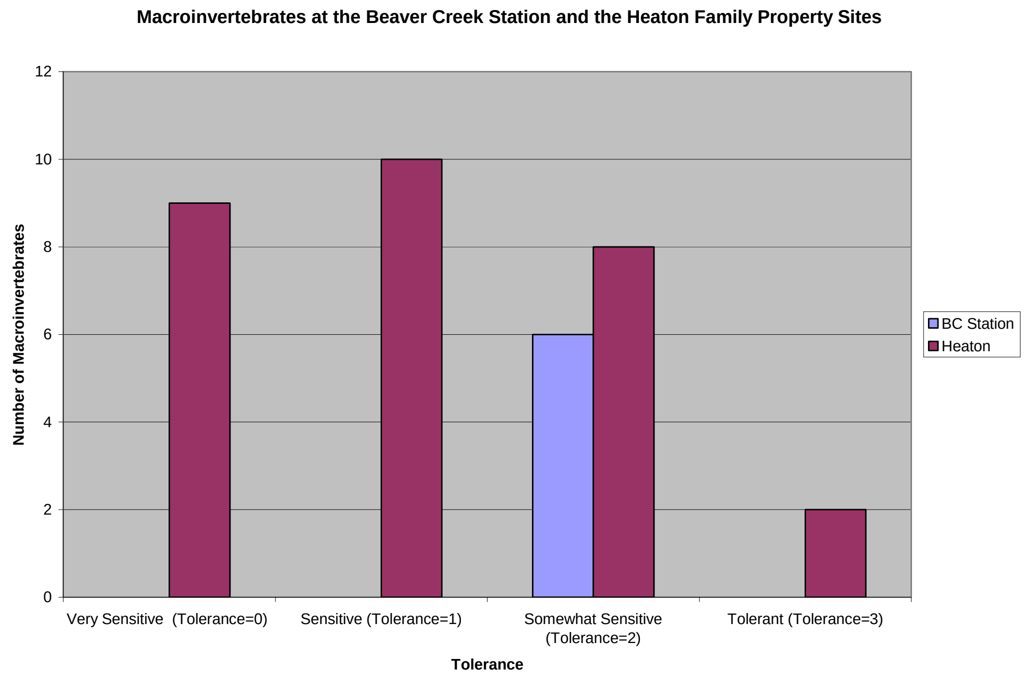

Fig. 2-This graph shows the sensitivity and tolerance levels of the macroinvertebrates at both sites on the Black Rock Creek.

The Heaton site had a biotic index of 0.84. The Beaver Creek Station site had a biotic index of 1.74. The Heaton site had a lower biotic index because more macroinvertebrates of lower tolerance were found. The Beaver Creek Station site had more macroinvertebrates with higher tolerance levels.

For the temperature we determined that there is a significant difference between the temperatures of each site. We used a two-tailed T-test to find the p- value which was 0.081. As displayed in figure 3, the Heaton family property site temperature, which is above the pond, was lower than Beaver creek station site temperature below the pond.

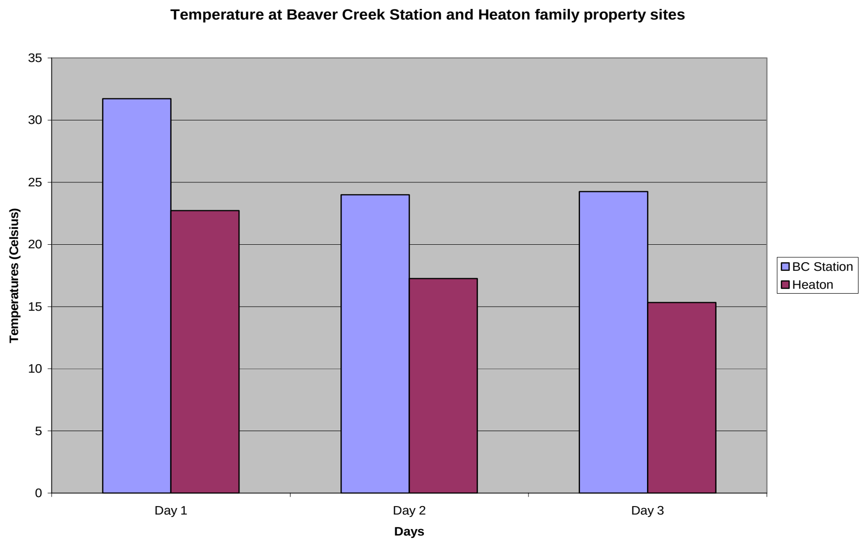

Fig. 3- This graph displays the temperature on each day we studied Black Rock Creek.

The graph below shows the levels of phosphate found in the Heaton family property test site and the Beaver Creek Station site. The p-value for phosphate is 0.37. Figure 4 shows that there is no statistically significant difference in the phosphate levels at both sites.

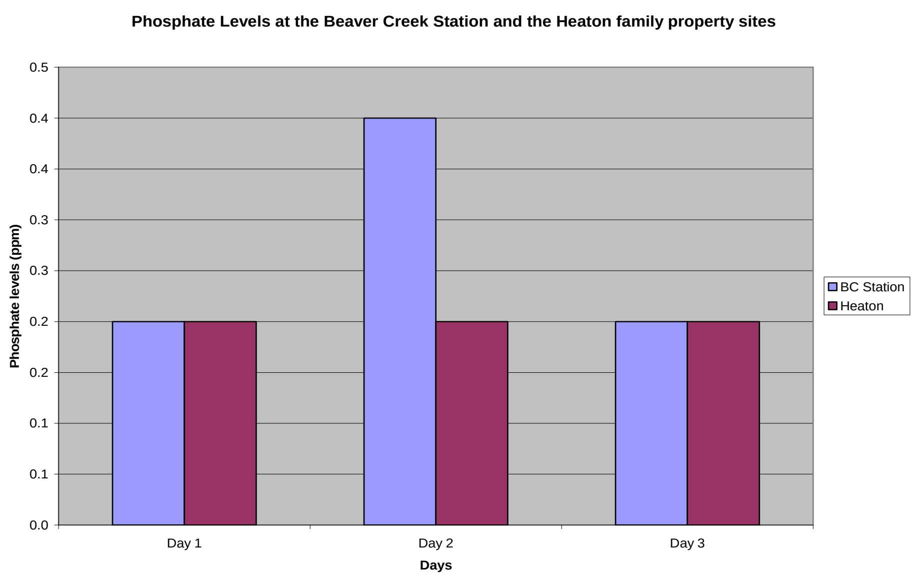

Fig.4 - This graph displays the phosphate levels of Black Rock Creek on the three days that we visited.

The graph below shows the levels of nitrate found in the Heaton family property test site and the Beaver Creek Station site. The p-value for nitrate is 0.37. Figure 5 shows that there was no statistically significant difference in the nitrate levels at both sites.

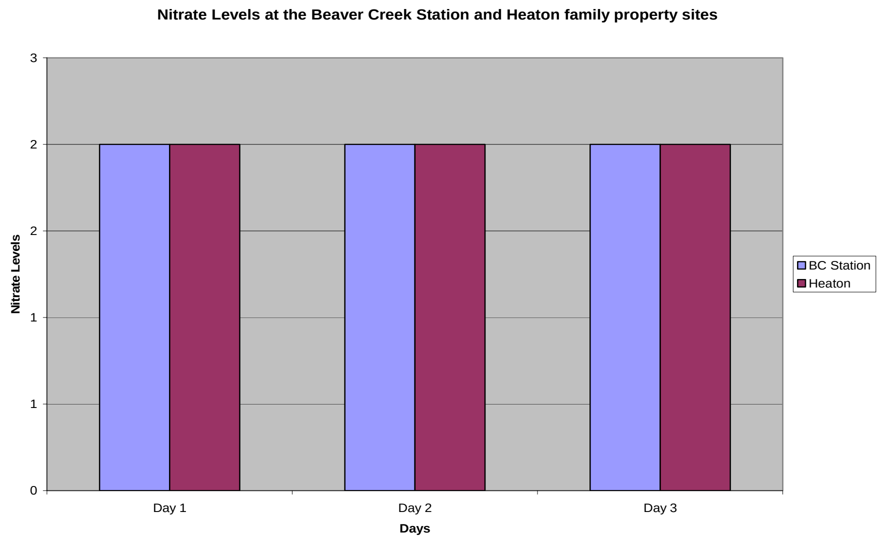

Fig.5 - This graph displays the nitrate of Black Rock Creek on the three days that we visited.

According to figure 6, we did not find a statistical difference in the pH values between both sites. The p-Value for the pH was 0.28 which is above the alpha value of 0.10.

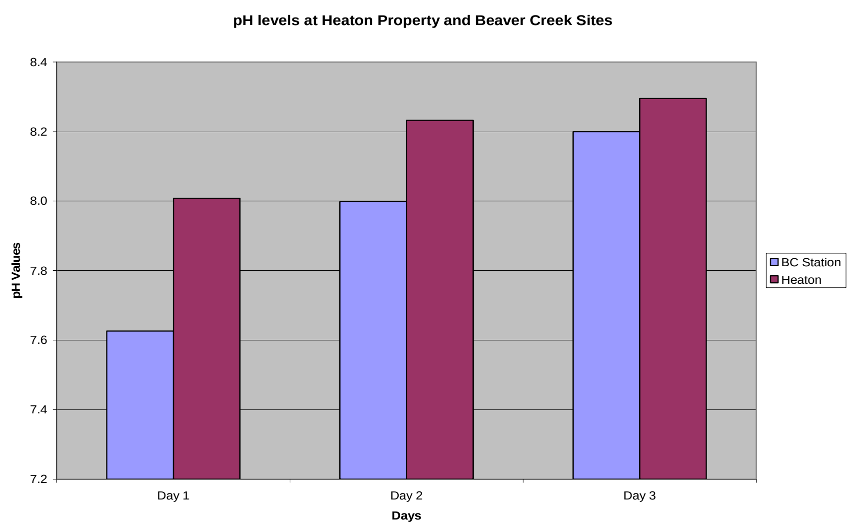

Fig.6- This graph displays the nitrate of Black Rock Creek on the three day we visited.

Discussion and Conclusion

With a P-value of 0.049, we have accepted the hypothesis that there will be a difference in the sensitivity level of the macroinvertebrates found above and below the irrigation pond. We have also accepted our hypothesis that there will be a difference in the temperature of the two test sites. The p-Value for temperature was 0.081. On the other hand, the p-Value for pH was 0.28 which caused us to reject the hypothesis that there will be a difference in pH. Based on the p-Value of 0.37 for both phosphate and nitrate, we were able to reject the hypotheses that there will be differences in phosphate level and nitrate level.

The graph of temperature (figure 3) shows that the Black Rock Creek at the Heaton family property site consistently has a lower temperature than Black Rock Creek at Beaver Creek Station site. The graph of macroinvertebrate sensitivity shows that there was more diversity in macroinvertebrates found at the Heaton site compared to those found at the Beaver Creek site. The biotic index for the Heaton Family site as 0.084, and the biotic index of the Beaver Creek site was 1.74. Because the biotic index of the Heaton Family site was lower than the biotic index of the Beaver Creek site, we can conclude that the Black Rock Creek is healthier at the Heaton Family Property site than it is at the Beaver Creek site. Knowing that the Heaton Property site had more diversity in the tolerance levels of the macroinvertebrates shows that there was a difference in the water quality. However, finding that there was no difference in the nitrate, phosphate and pH on either side of the irrigation pond shows the difference in water quality was not due to the chemicals we tested. The increase in temperature is believed to be the main cause of the decrease in health of the stream below the irrigation pond.

We believe that the reason there was no difference in the stream chemistry above and below the irrigation pond is because of the environment surrounding the stream. We observed that there were equal amounts of trees and grass above and below the irrigation pond. There was also an interstate that ran adjacent to both of the test sites (Figure 1). The irrigation pond, which had no shade to protect the water from excessive sunlight, was 35^{o}C, much warmer than the stream that flowed into it, which was only 18^{o}C. Consequently, the water that flowed out of the irrigation pond was 27^{o}C. This increased temperature, which inversely corresponds with the dissolved oxygen, may have caused the amount of macroinvertebrates in the stream to decrease.

Limitations that we encountered while conducting this experiment were time, appropriate tools and prior knowledge of macroinvertebrates. Time was a major limitation because our experiment had to be completed with in three days. If we were able to test in the morning, when it is cooler, or in the spring time, when the macroinvertebrates life cycle is at its peek, more macroinvertebrates may have been found. Also, if the dissolved oxygen meter had worked, we would have more results to make more accurate conclusions. Finally, prior knowledge of macroinvertebrates would have helped us be more accurate when identifying them.

Some suggestions for those who would like to repeat this experiment include testing in the morning during the spring when it is cooler, and testing other streams located near irrigation ponds to compare the findings. Another suggestion is to become very familiar with the macroinvertebrates throughout each stage of their life cycles to eliminate any confusion in determining species.

After the study was completed, some questions arose. One of these questions was if the irrigation pond was smaller, would the levels of phosphate and nitrate increase? This question was based on the fact that the irrigation pond was so large. Although grass clippings were found in the irrigation pond, there were none found in the lower part of the stream. If the irrigation pond was smaller, it may be possible for the grass clippings, which raise the nitrate level, to flow down stream. Another question that arose while conducting this experiment was if we tested another stream that flowed through an irrigation pond, would the results be similar to those found at Black Rock Creek? Lastly, are there any other chemicals polluting the stream? We ask this because we only tested for phosphate and nitrate. If there were other chemicals polluting the stream, we could not have found them.

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