ABSTRACT:

The level of dissolved oxygen in streams can be drastically affected by pollution produced by riverside sewage treatment plants. This problem can be solved by building more efficient water cleaning sewage plants. Using the mathcad computer program, a series of experiments were run to see how certain variables affect how efficient of treatment design would be chosen and river health. These experiments included the variables of; fine amount, minimum oxygen level in parts per million (ppm), wet and dry years, as well as the effect of dams on the river system. Results showed that a heavy fine is needed to push sewage plants to build more effective plants. All experiments ranked results by how much cost would be per person. Heavy fines will need to be administrated if the sewage plants are going to lessen the pollution put into the rivers. Building a more efficient plant has to cost less than the heavy fines put on less efficient treatment plants, if environmentalists want to push the plants to clean up how much pollution is put into the river.

INTRODUCTION:

The level of dissolved oxygen (D.O.) in rivers is a main variable in assigning the streams health. D.O. is used by all aquatic organisms, most as the only means of available oxygen. The amount of dissolved oxygen, usually measured in parts per million (ppm) is one of the main determining factors of what type of biota will live in the rivers and streams. Many big game fish, such as trout, are very sensitive to D.O levels, and require high levels to survive. The pollution put into river systems consists of excess nutrients, and raw sewage full of bacteria.

The current pollution problem in many streams and rivers are caused by sewage plants dumping too many nutrients into the water. Because water treatment plants need someplace to put the treated water, most industries are found near natural stream and rivers. However, the efficiency of these sewage treatment plants varies greatly. How efficient a treatment plant is, is determined by the amount of bacteria and nutrients that is put into the river as "treated" water. The nutrient rich byproduct from sewage plants entering the river increase the bacterial levels in the river, and thus increase the biological oxygen demand (B.O.D.) The B.O.D. is the amount of oxygen needed for bacteria to decompose waste. Increasing the concentration and overall amount of bacteria will raise the B.O.D. If the demand for oxygen is increased, all the oxygen in a reach of a stream, near the pollution site, will be used up by the bacteria, leaving nothing for the other organisms, mainly fish, and microorganisms to use. Healthy rivers will be able to absorb a fair amount of nutrients and bacteria before the oxygen levels drop to dangerous levels. However, sewage treatment plants tend to dump massive concentrations into the river, which it cannot process in a short period of time.

The problem addressed in this essay is to see how different factors will lead to building treatment plants of different efficiency. Also, looking at the system between which design of treatment plants will be build, the cost to the city members, and the cost to the environment. In this experiment four general designs of plants are available to build. The designs are numbered one through four, and vary in efficiency, one being the least efficient and four being the most efficient at removing bacteria and nutrients from the treatment water. Another key factor when looking at the efficiency of the different plant designs in that the more efficient a plant design is the more expensive to build it is for the people of the city. This brings up the common problem of saving money or doing what is right for the environment. In writing this essay, the topic of saving money going against caring for the environment will be a central discussion point. In discussing this topic, a few variables such as the amount of a fine, as well as setting the minimum ppm standard will be included. I predict that is using a ranking system that places priority on the cost per person and not the cost to the environment, high fines will be needed to preserve the river ecosystem.

METHODS:

Using the computer program Mathcad, our group set up, using mathematical equation, a chart where we could find the cost of building different designs of sewage plants, relative to different variables.

TABLE 1. Simplified example of table used in experiment 1.

Design	Failure Rate	Cost / person	Rank
1			
2			
3			
4			

Failure rate indicates the number of days, per year that the D.O. level of a stream, that the sewage treatment plant is on, drops below the standard 6ppm. Dropping below this standard rate will result in a fine for that day. The higher the percentage of the failure rate, the more fines that specific design will cost the people of the city. Cost per person is used as a price set, due to the setting of the people of the city having the decision of which plant to build. For this study, we will assume that the people of the city will always choose the cheapest design, even if it is not the best environmental choice. The final column is for ranking the sewage treatment plants in order of cost, 1 being the least expensive, and the choice picked by the city, and 4 being the most expensive.

Four main types of experiments were run in lab. One experiment used the effects of fines to rank which sewage plant design would be cheapest per person. Two limits of fines were used, one setting the fine for going under the standard D.O. at five thousand dollars everrry day of failure, and another test run setting the fine at five million dollars. Another variable looked at in our system was one of setting the standard of B.O.D. at 4 ppm, rather than 6 ppm. This lowered the amount of pollution the sewage plants would have to correct for, and thus had an effect on the price and ranking of each sewage design. Other variables included the effects of a wet or dry year on design cost. Also how a dam, and dam removal would affect the cost ranking of the different sewage designs.

RESULTS:

For experiment number one, two different fine levels were set and then run through our mathcad system in order to rank the sewage plant designs in order from cheapest to most expensive per person to build and maintain.

Table 2: (A) Fine for causing the river D.O. level to fall below the set 6ppm is set at $5,000 dollars per day, for failure to stay above set D.O. level. (B) Fine for causing the river D.O. level to fall below the set 6ppm is set at $5,000,000 dollars per day, for failure to stay above set D.O. level.

(A.) ($5,000 fine)					(B.) ($5,000,000 fine)			
Design	Failure Rate	Cost/ Person	Rank		Design	Failure Rate	Cost/ Person	Rank
1	.992	42.05	1		1	.992	9,085	4
2	.792	91.23	2		2	.792	7,311	3
3	.668	111.10	3		3	.668	6,200	2
4	.258	208.35	4		4	.258	2,560	1

In the above table the failure rate is highest for design one of the sewage treatment plants. This is a way of indicating that design one is least efficient in removing bacteria from sewage waste water. The higher the bacteria levels in the incoming waste water the more it will drive the D.O. level down, increasing the number of days of failure. When comparing the cost/ person and rank the table must be broken down further into A and B sections. In section A, where the fine for failure to meet the standard 6ppm D.O. level is five thousand dollars, we find design one is least expensive, and design four most expensive. This is due to design four being more expensive to build then the less efficient design one. The cost of the fines for the increased number of days for design one, is not enough to outweigh the cost of the more expensive plant design. In section B, of Table 2, the cost / person is more for design one, then design four, opposite from section A. In this case with the fine being extremely high at five million dollars, the cost of the more expensive plant, design four, is much less than the cost of paying the fine more often, in the case of the high failure rate of designs one.

Another variable viewed in the lab experiment was the effect of lowering the minimum D.O. level from 6ppm to 4ppm. Table 3, shows the results.

Table 3. Effects of lowering the minimum ppm D.O. level from 6ppm section A, to 4ppm, section B.

(A.) 6ppm standard					(B.) 4ppm standard			
Design	Failure Rate	Cost/ Person	Rank		Design	Failure Rate	Cost/ Person	Rank
1	.992	9,085	4		1	.468	4,303	4
2	.792	7,311	3		2	.181	1,736	3
3	.668	6,200	2		3	.027	351.37	2
4	.258	2,560	1		4	0	206.00	1

In table 3, lowering the minimum standard ppm from 6 to 4 ppm has a reversal effect on the ranking of the sewage treatment designs. Lowering the minimum standard ppm lowers the impact that the sewage treatment plants have to counteract. With lower standards less must be put into the efficiency of the plants to meet the limit. This lower limit is most noticeable when comparing the failure rates of similar designs in section A, and section B. The lower standard limit lowers the number of failure days of each design. Special note is added to design four in the 4ppm standard section where the efficiency of the sewage treatment plant, allows the plant to have a failure rate of zero.

The other two experiments; wet and dry season, as well as a dam, and dam removal, are not vital to my discussion so the results of those experiments will not be explained at this time.

DISCUSSION:

The overall focus of this experiment is to discuss whether or not substantial fines are necessary to protect the ecological values of our rivers and our systems. In my opinion substantial fines are necessary to protect the ecological value of our river systems. Substantial fines are needed to force sewage treatment plants to take accountability for their waste deposits, and also for the members of the city to provide funding for the best water treatment possible.

When looking at the results from the fines experiment, when fines are low (five thousand dollars) the cost per person is lowest if the least effective treatment plant is built. When determining the cost per person, two values must be assessed. The first value is the basic cost of the treatment power plant, which is dependent on how efficient it is. The second cost is the cost of the fines given to the treatment plant for failure to meet the set standards of nutrient levels, which effect B.O.D. In the case where the fine amount is low, the less efficient plant is still cheaper to build then the more efficient plant, even though it is fined nearly four times as much. The price of the more efficient treatment plant (design four), even though it has a failure rate of .258, compared to the .992 of design one, is more expensive to build. In ranking the designs by cost per person, we are saying the determining factor for how well we care for the river system, is the cost per person of the treatment plant. This is not necessarily the best way to rank treatment plants, if caring for the river ecology is one of our main goals. Luckily, we can change the severity of the fine, and force the city to choose a more ecological friendly choice. As seen in the results, when the fine amount for minimum dissolved oxygen failure is increased to five million dollars the ranking of sewage treatment plant designs is reversed. In this case the high percentage of fines of design one, outweighs the high initial cost of the more effective design four. Although the cost per person is higher in every category then when the fine was five thousand dollars, when ranked by cost per person, the most efficient treatment plant is chosen, and our rivers will be cared for much better. This portrays when ranking treatment designs strictly by cost per person when considering installation, the environment takes a back seat to money in the pockets of the city members. But in making the most environmentally sound choice the most affordable, through heavy fines, doing what is right for the environment can be chosen through this ranking system.

It should be noted that smaller fines are not always bad. In this system of the city, treatment plants, and the river ecosystem, lower fines have benefits for the city. A lower fine means less cost per person in the city, which is always a good thing. In this particular example, however, we are pinning what is good for the pocket books of the people directly against what is good for the environment.

The other experiment that shows how environmental factors take a back seat to money in the city members pockets is the experiment done adjusting the minimum dissolved oxygen ppm level. Although the ranking of the different treatment design systems stay the same for both experimental findings, interest should be taken in the costs. When the minimum ppm level is dropped to 4ppm, the costs to meet this standard are dramatically lowered, when compared to the

6ppm minimum standard costs. In the real world, industries will always do just enough to stay above the failure rate. Even if dropping the minimum standard to 4ppm, instead of 6ppm, would have drastic effects on the river ecosystem, the treatment industry would not care, because it is cheaper to meet the minimum standards for 4ppm, then 6ppm levels.

The ranking system in this group of experiments always placed more emphasis on the price per person, then the consequences to the environment. Sadly, this is the way that the real world works as well. If tables were made ranking different situations by their total negative effect on the environment, many findings from this lab would be turned completely around. However, in what may seem like a system setting up an environmental crisis, there are ways to set standards for environmental care. If we set fines or consequences, on environmental harm, higher than the amount saved by doing the cheapest design, then the cost per person ranking system will pick the most environmentally friendly choice. In this aspect high fines are a necessity for preserving our river ecosystems, and our environment in general. Finding the right amount to fine is another story. In the above experiment, it is obvious that a five million dollar fine would never work in the real world. As long as we keep the combined fine amount above the overall cost difference between environmentally friendly choices and those that may harm the environment, we will be able to preserve our fragile ecosystems, in a world where everyone is looking for the cheapest alternative.