Water Quality Analysis of Pearson Creek

Comparison of Pearson Creek Water Quality Since Discharge of Effluent Lagoon Water

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1. Abstract

In the early 1990s, Clark Township approved the discharge of wastewater treatment lagoon water into Pearson Creek. Pearson Creek water chemistry has been monitored by Cedarville High School science students for fifteen years. Pearson Creek flows into Cedarville Bay. The purpose of these tests was to determine if lagoon discharges, or any other environmental factor had any effect on the water quality of Pearson Creek and subsequently, Cedarville Bay.

2. Introduction:

Pearson Creek flows into Cedarville Bay, which is located in the Les Cheneaux Islands on the north western side of Lake Huron. In the early 1990s, the discharge of wastewater treatment lagoon water into Pearson Creek was approved by the Michigan Department of Natural Resources. Since that time, Cedarville Bay has experienced a growth of aquatic vegetation that has affected the local water systems. The overgrowth of aquatic vegetation has obstructed boating lanes and may have affected local wildlife populations by depleting oxygen levels. The damage came mostly in the overgrowth of Eurasian Milfoil, an invasive species to the area. The milfoil has been knows to cause aquatic wildlife, most notably perch, to die off due to lack of oxygen and the aquatic vegetation has choked off many of the waterways that boaters use (6, 7). The purpose of this research study is to examine the quality of the water entering into Cedarville Bay from Pearson Creek since the discharges have started and determine if this could be the cause of the growth. The quality of water from Pearson was compared to itself from the past and to another local creek (Scotties Creek) to find any drastic changes.

This report is based on 16 years of field testing that has been conducted by Mr. R Schaedig's or Mr. K. St. Onge's highest level science class of that year. Mr. St. Onge continued Mr. Schaedig's work in 2000. The classes were using methods that are recommended by the National Sanitation Foundation (NSF). The NSF issued a Water Quality Index (WQI) that shows what they feel are the most important components of water quality. Classes performed the WQI with field kits purchased from the Hach Equipment Company.

3. Methods & Materials:

The methods that were used are outlined in “Field Manual for Water Quality Monitoring” by Mitchell and Stapp (1). The only alternative method was the quantitative analysis of coliform bacteria. Water samples were collected and taken to an E.P.A. certified lab at Lake Superior State University beginning in 2002. The reason for this is because the methods outlined in the handbook were not reproducible enough. All other tests were done as the handbook suggests and shows. Nearly all of the tests were done by adding chemical reagents to the sample water and performing a colorimetric test.

The National Sanitary Foundation's Water Quality Index (NSF WQI) was used to analyze and quantify the sample data. The NSF index is composed of 9 separate factors: Dissolved Oxygen, Fecal Coliform, pH, B.O.D., Temperature Change, Total Phosphates, Nitrates, Turbidity, and Total Solids. The actual results are then entered into a graph which for conversion of the data into a Q-value. A Q-value is a number that will express the overall health of that nutrient in the water on a scale of 1-100 with 100 being the healthiest. The results from these individual tests are then put into a weighted monogram which places the Q-values on the same level with each other based on importance of that factor to the water's overall quality. Q-values are combined to create an aggregate Q-value that shows the total water quality.

There are many advantages to using a system such as this, especially when dealing with a study that factored in many different variables such as this one. The NSF WQI places each of the separate factors on the same scale relative to each other. This eliminates confusion that can come with evaluating many different factors in the same study. For instance, a change of 50 mg/L in phosphates would be a cause for concern and further investigation. The same change of 50 mg/L in total solids would not cause nearly as much concern or investigation. The NSF WQI eliminates this problem as all of the factors are on the same relative scale.

The tests were conducted at 3 sampling sites. The first was located 1 mile upstream on Pearson Creek and is upstream from the discharge point. This location was tested from 2001 to 2008 and is called Pearson Upstream. The second was located on downstream Pearson Creek and was approximately 100 meters from where the creek enters into the bay. This location was tested from 1994 to 2008 and is known as Pearson Downstream. The last testing site was on Scotties Creek. That site was located downstream and approximately ¼ mile from the point where Scotties Creek enters into Prentiss Bay. This location was tested from 1992 to 2008. Scotties was chosen as a reference stream because it has stream characteristics comparable to Pearson Creek and it has no known human impact. Pearson is also being compared in both a downstream location, which is downstream of the discharge point, and an upstream point, which is upstream of the discharge and unaffected by the discharges.

4. Hypothesis:

Due to the explosive growth of Eurasian Milfoil in Cedarville Bay, our null hypothesis is that the discharge of treated sewage will have an effect in the quality of the water flowing from Pearson Creek, particularly with the nutrients that affect plant growth the most, phosphates and nitrogen. The increase in these variables would show that the discharge of treated sewage is negatively affecting our water quality. Because of Pearson's importance as the main tributary for Cedarville Bay, the nutrients flowing out of that creek have a direct link to the nutrients that are within the bay. The theory is that because the growth of Eurasian Milfoil occurred after the discharge of treated sewage had already been approved, that the extra nutrients are affecting the bay and causing the growth. However, much of this aquatic vegetation growth has come from an invasive species of milfoil. These tests should show whether or not the discharge is related to the growth.

The testing of these three sites will show how Pearson Creek has been affected by the discharges. It will show the nutrient levels of Pearson to another local creek in its natural state and to itself from the past. The major components that will reveal any change in the water would be fecal coliform, which would indicate that the discharge of treated sewage is potentially not being treated well enough as it is treated sewage lagoon discharge water that is full of fecal coliform before treatment, and total nitrates and phosphates, which are the two main nutrients that aquatic vegetation needs in order to grow. These nutrients would remain detectable with residual amounts of nutrients that remain in the soil. Testing was also done within several weeks of the discharge. If these two nutrients have increased over the years due to the discharge of treated sewage, that could explain for the growth of weeds in Cedarville Bay that has occurred.

5. Results:

Tabulated results are shown in Figure 1a and 1b. Results suggest little to no correlation between the discharge of sewage and the growth of weeds in Cedarville Bay. The numbers show very little change in the quality of the water over time. Water of good quality can be used for full body contact safely as determined by the National Sanitation Foundation. Some components, such as fecal coliform, have changed significantly, but those results are addressed in the observation section (section 6).

Numbers stayed fairly level and consistent for major parameters monitored. The factors not only stayed consistent for each individual test site, but stayed relatively level among the three separate testing sites. The arithmetic means among all three testing sites were very similar. Standard deviations were also fairly small with the majority of components tested having standard deviations of under 10 value points. As all of the numbers are on the same relative scale after conversion to Q-values, this shows that all of the factors had a small standard deviation.

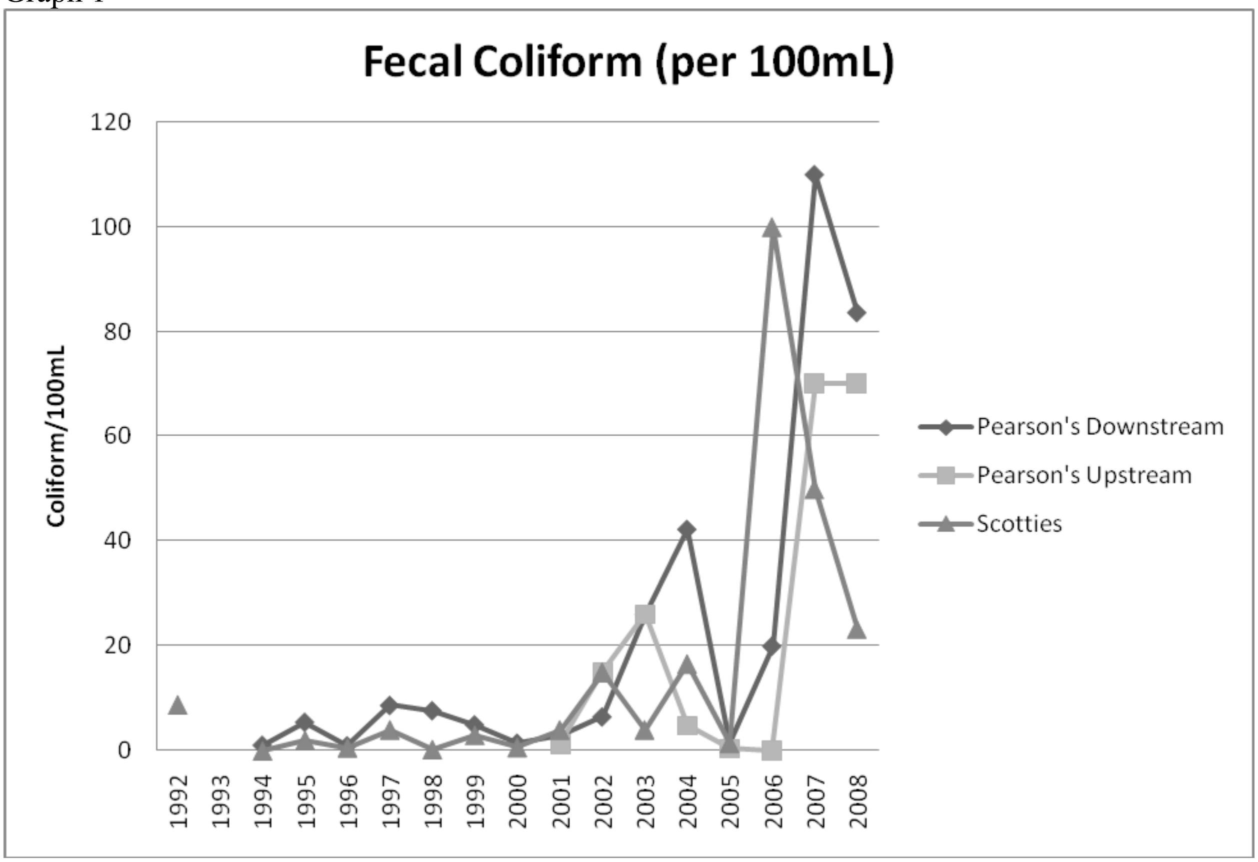
The standard deviation of total phosphates was .06 mg/L for Pearson's Downstream and .08 mg/L for the other testing sites. That equates to a standard deviation on Q-values of 5 Q-value points for Pearson

Downstream testing site and Scotties Creek and standard deviation of 7 Q-value points on Pearson Upstream. The average phosphate levels were .14 mg/L for Pearson's Downstream, .08 mg/L for Pearson Upstream, and .12 mg/L for Scotties.

Nitrates had a standard deviation of between .21 mg/L and .28 mg/L depending on the test site. This translates to a Q-value standard deviation of between .5 and 1.5 Q-value numbers. The average nitrates were between .08 mg/L and .14 mg/L.

Fecal coliform numbers were a bit unusual. There was a noticeable increase in the number of coliform in the last several years. However, this increase was similar for all three testing sites. This increase is shown in Figure 1.

Graph 1



The amount of total solids in the water was fairly high, with numbers as high as 600 mg/L in Pearson Downstream. These raw figures convert into a Q-value of 20 points which is very low on the 100 point scale. The numbers for this factor did increase throughout in all 3 testing sites.

The pH rarely moved from the 7.5 mark on Pearson's Downstream with a standard deviation of only .17. The other two testing sites had a much more varied pH, standard deviation of .3, and Scotties average was 7.7 compared to 7.5 for the other two. The differences in these numbers could be accounted for with probe measurement or human error.

The dissolved oxygen for all testing sites was fairly uniform. The only difference was that Pearson Downstream had an average of about 20 mg/L lower than the other two sites (70 mg/L to 90 mg/L). The standard deviation was also different between the sites in that Pearson Upstream had a standard deviation of 24 mg/L and the other two had standard deviations of 16 mg/L.

Biological oxygen demand (B.O.D.) was very small and had similar averages. Pearson Upstream saw almost no B.O.D. throughout the entire testing period. Pearson Upstream average was 2.4 mg/L and Scotties average was 1.8 mg/L. However, although the trend lines show no change in B.O.D, the standard deviation is almost as large as average with deviations of 2.2 mg/L for Pearson Downstream and 2.3 mg/L for Scotties.

The turbidity of the water was the same for all years the water was tested. It was 6 feet except for one year when it was 3 feet in Scotties Creek. The cause of that shall be explained in the analysis section of the report.

Temperature change was only 1 or 2 degrees for Pearson Creek throughout the testing. Scotties was more varied with highs of 4.5 degrees of change. However the averages were only half a degree separate (1.0 to 1.5).

Figure 1a. Year by year actual results:

Pearson's Downstream

	Dissolved O2	Fecal Coli-form	pH	B.O.D.	Temp. Change	Ttl. Phos.	Nitrates	Turbidity	Ttl. Solids
1994	136	1.1	7.95	4.5	1	0.17	0	6	135
1995	58	5.5	7.5	3	0	0.15	0.01	6	241
1996	72	1	7.6	0.4	2	0.14	0	6	9
1997	72	8.7	7.5	2.7	1	0.16	0	6	70
1998	30	7.7	7.5	1.5	1.2	0.22	0	3	141
1999	82	5	7.5	6.6	1	0.15	0	6	116
2000	67	1.5	7.3	2.7	1	0.2	0	6	130
2001	80	3	7.5	3	2.75	0.3	0.2	6	160
2002	97	6.5	7.5	2.5	2.2	0.07	0.09	6	230
2003	88	26.03	7.4	2	0.6	0.06	0.22	6	452
2004	63	42.3	7.5	1	1.6	0.18	0.233	6	418
2005	51	1.5	7.5	0	0	0.05	0.09	6	375
2006	45	20	7.4	6.7	1	0.1	0.88	6	600
2007	60	110	7.5	0	0.5	0.07	0.8	6	545
2008	82	83.67	7.9	0	0	0.08	0	6	200
Average	72	21.56667	7.536667	2.44	1.056667	0.14	0.1682	5.8	254.8

Pearson's Upstream

	Dissolved O2	Fecal Coli-form	pH	B.O.D.	Temp. Change	Ttl. Phos.	Nitrates	Turbidity	Ttl. Solids
2001	90	1.2	7.8	0		0.04	0	6	160
2002	98	15	7.5	0		0.06	0.09	6	180
2003	87	26.03	7.7	0		0.1	0.26	6	170
2004	116	4.84	7.5	0		0.18	0	6	175
2005	74	0.44	6.8	0.02		0.03	0.09	6	200
2006	83	0	8.1	0		0	0.62	6	220
2007	120	70.05	7.7	0		0.24	0	6	300
2008	83	70.14	7.6	0		0	0	6	170
Average	93	23.4625	7.5875	0.0025		0.08125	0.1325	6	196.875

Scotties

	Dissolved O2	Fecal Coli-form	pH	B.O.D.	Temp. Change	Ttl. Phos.	Nitrates	Turbidity	Ttl. Solids
1992	111	8.8	7.8	1.5	2	0.07	0	6	134
1993									
1994	134	0	8	1.5	0	0.11	0	6	123
1995	81	2	7.7	0.3	4.5	0.09	0	6	171
1996	75	0.6	7.8	0	1	0.13	0	6	89
1997	87	4	7.8		2	0.1	0	6	72
1998	79	0.25	8	0.21	3.2	0.26	0.03	6	150
1999	95	3	8	6	0	0	0	6	81
2000	81	0.67	8	2	2	0.1	0	6	140
2001	117	4	8	7	2.5	0.02	0.02	6	140
2002	106	15	7.9	1	1.2	0.12	0.03	6	215
2003	82	4.02	7.6	5	2.2	0.1	0.264	6	160
2004	86	16.6	7.8	1	1.1	0.115	0.972	6	208
2005	84	1.46	7	0.02	0.5	0.03	0.07	6	170
2006	85	100	7.2	0	0.3	0.3	0.02	6	245
2007	94	49.96	8	1	1.5	0.26	0	6	240
2008	85	23.28	7.5	1	0	0.13	0	6	190
Average	92.625	14.6025	7.75625	1.835333	1.5	0.120938	0.087875	6	158

Table 1b. Year-by-year Q-value results

Pearson's Downstream

	Dissolved O2	Fecal Coli-form	pH	B.O.D.	Temp. Change	Ttl. Phos.	Nitrates	Turbidity	Ttl. Solids	Overall
1994	82	68	87	60	92	98	98	97	83	83
1995	55	76	92	73	93	97	98	97	68	81
1996	81	98	92	97	90	97	98	97	81	92
1997	80	72	91	75	90	96	98	97	86	86
1998	20	73	92	95	91	88	98	33	80	72
1999	89	77	92	53	91	97	98	97	83	86
2000	68	95	92	76	90	94	98	97	80	87
2001	89	85	91	88	88	97	98	97	78	90
2002	98	76	92	87	88	98	98	97	68	89
2003	95	61	90	81	92	94	97	97	41	84
2004	59	56	92	96	90	92	98	97	46	79
2005	44	95	92	98	93	94	97	97	47	82
2006	36	61	90	76	92	91	93	97	20	70
2007	57	43	92	97	92	96	97	97	20	75
2008	89	46	88	97	92	96	98	97	72	84
Average	69	72	91	83	91	95	97	93	64	

Pearson's Upstream

	Dis-solved O2	Fecal Coli-form	pH	B.O.D.	Temp. Change	Ttl. Phos.	Nitrates	Turbidity	Ttl. Solids	Overall
2001	95	96	88	96	88	92	97	97	78	93
2002	96	67	92	96	88	92	97	97	73	88
2003	94	59	90	96	92	88	97	97	76	87
2004	93	79	92	96	90	80	98	97	75	89
2005	80	97	86	96	93	93	98	97	72	90
2006	91	97	83	96	92	97	97	97	71	92
2007	91	46	90	96	92	77	98	97	60	82
2008	91	46	91	96	92	97	98	97	76	85
Average	91.375	73.375	89	96		89.5	97.5	97	72.625	

Scotties

	Dis-solved O2	Fecal Coli-form	pH	B.O.D.	Temp. Change	Ttl. Phos.	Nitrates	Turbidity	Ttl. Solids	Overall
1992	95	71	88	92	89	97	98	97	82	89
1993										
1994	82	97	85	92	93	95	98	97	83	91
1995	90	89	89	97	74	96	98	97	75	90
1996	84	97	88	97	91	94	98	97	85	92
1997	94	81	88	92	89	95	98	97	85	91
1998	87	97	85	95	85	83	98	97	79	90
1999	97	83	85	54	93	97	98	97	85	88
2000	90	97	85	89	89	95	98	97	80	92
2001	91	81	85	44	88	97	98	97	80	84
2002	97	66	87	93	90	95	98	97	71	88
2003	90	81	92	57	89	95	97	97	76	86
2004	92	66	88	93	91	95	92	97	72	87
2005	91	93	89	97	92	97	98	97	75	93
2006	91	44	91	97	93	80	98	97	68	83
2007	97	52	85	93	90	83	98	97	68	84
2008	91	61	92	93	93	94	98	97	72	87
Average	91.1875	78.5	87.625	85.9375	89.3125	93	97.5625	97	77.25	

6. Analysis/Observation:

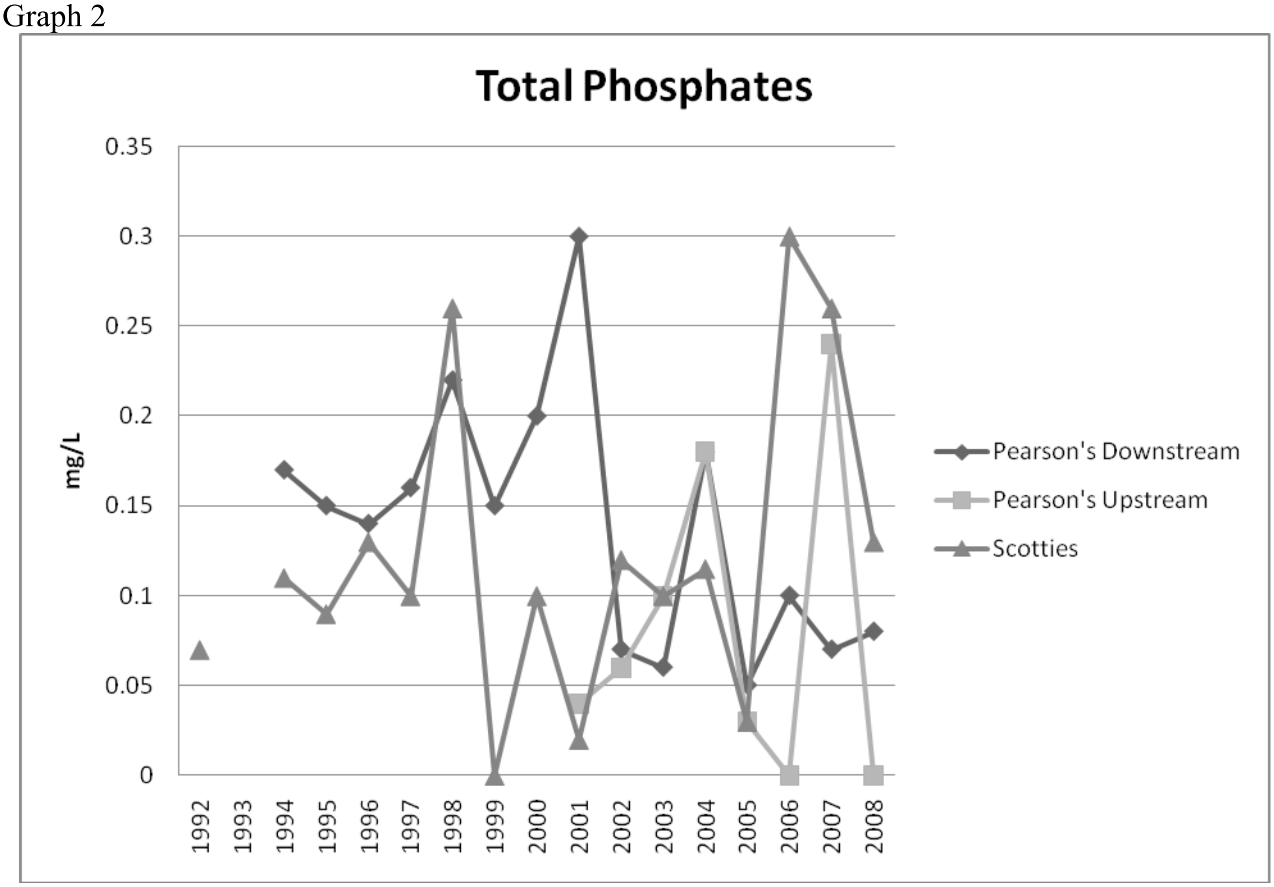
The first outlier that will be accounted for is the change in turbidity in 1998 in Pearson Creek. 1998 also had a low dissolved oxygen level and higher total phosphate levels. This can be seen above in Figure 1a. The numbers for total dissolved oxygen are in line with those that are around it. These numbers seem to indicate that there may have been an algae bloom that year. This is most likely due to the increased phosphates in the water, the phosphates act as a limiting factor for the growth of aquatic vegetation including algae.

The next unusual trend is that although the pH in Scotties Creek declined significantly, the Q-value for it actually rose. This suggests that Scotties Creek naturally has water that is more alkaline then is considered normal by the NSF WQI. This can be explained by the location of Scotties to large natural limestone deposits.

The most unusual trend is the rise in fecal coliform (Figure 1). Fecal coliform increased significantly in all three testing sites. The increase happened in approximately 2000. In 2000, Mr. St. Onge took over control of the testing. At about this time, the testing procedures for fecal coliform changed. Instead of following the instructions in the handbook, water samples were sent to Lake Superior State University to have them analyze for fecal coliform. The more sensitive testing that was done by L.S.S.U. likely was the cause of the change in numbers of fecal coliform. Yet, these numbers were still under the National Sanitation Foundation's guidelines for safe full body contact water (2).

The most significant factor to determine the growth of aquatic vegetation is phosphate concentration (Figure 2). Throughout the testing time, this nutrient has stayed fairly consistent. In fact, as Figure 2 shows, the amount of total phosphates in Pearson Downstream actually declined. Scotties and Pearson Upstream total phosphates both increased but they increased similarly. This similar increase means that the discharge of treated sewage is not the factor that is increasing the total phosphate concentration in the water, as the discharge is only happening in Pearson's Creek. Also the increase is happening in both of our control sites, yet our test site has a decrease of phosphates. This further suggests that the discharge has no effect of the growth of Eurasian Milfoil in the area.

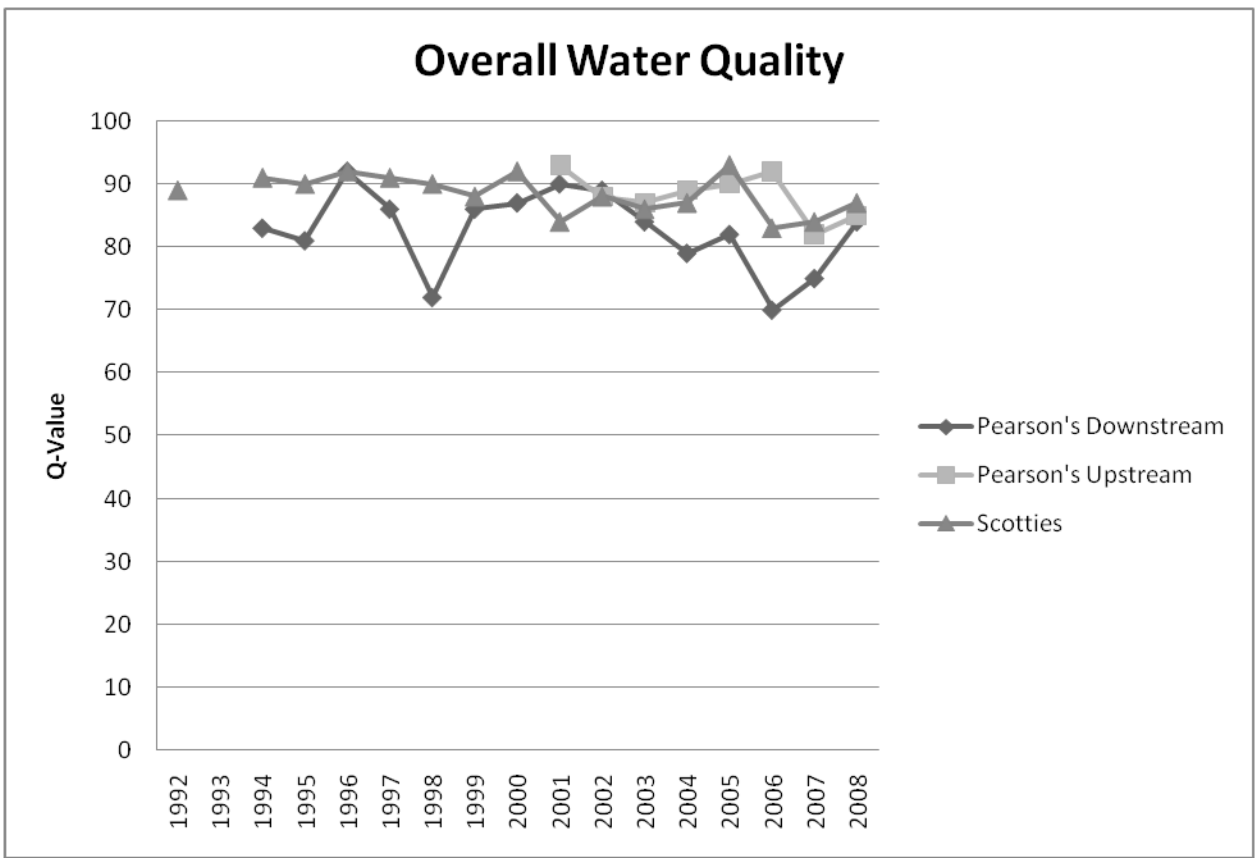
Graph 2



As for nitrates, all three testing sites have seen an increase in total nitrates. The increases were also fairly similar to each other. However, the amount of phosphates is much more important than nitrates as phosphates are usually the limiting factor when it comes to aquatic vegetation growth. Nitrates are also rapidly metabolized and change amounts fairly rapidly whereas phosphate levels will stay similar over a much longer period then nitrates (3, 5).

The advantage of using the NSF WQI is that it gives a composite assessment of the overall water quality. This overall Q-value should be emphasized as it puts all nine parameters on the same measurement, in relation to their importance to the overall water quality, and allows for a comparison with all factors of water quality. This composite is one of the best ways of determining how the discharge of treated sewage affects Pearson Creek. The overall water quality shows that all 3 testing sites have nearly the same change in quality throughout the years. The quality is going down but since it is happening in all three test sites, it cannot be attributed to the discharge of treated sewage. Pearson Downstream does have lower Q-value numbers but the Q-values started lower at the beginning. The similarity in the decrease of overall water quality does not support our hypothesis that the discharge has an effect on the water quality of Pearson Creek. This decrease in overall water quality is shown in graph 3.

Graph 3



7. Conclusions:

Evidence suggests that present lagoon discharges have had minimal effect on Pearson Creek water quality. Although the overall water quality did decline, as determined by the NSF WQI, it declined similarly among all three testing sites. Lagoon discharges can be eliminated as the primary reason for the decline in water quality as discharges are only being made into Pearson Creek and not Scotties Creek. The similar decline in water quality in both creeks indicates that there may be other factors that are affecting the quality of these streams.

8. Literature Cited:

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