WATER QUALITY AND HYDROLOGY IN THE CEDAR CREEK WATERSHED WITHIN THE PCCI PROPERTY

Pierce Cedar Creek Institute
for environmental education

Summer 2008 URGE Program

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Executive Summary:

The primary desired outcome of this research was a better understanding of how the Cedar Creek watershed hydrology affects the water quality of the watershed, specifically Cedar Creek, within the Pierce Cedar Creek Institute boundaries. "Best Management Practices" (BMP) of the developed stormwater hydrology on the Institute property were also examined.

The effects of the surrounding hydrology on Cedar Creek seem to be limited at least during the summer months. Temperature fluctuations in the creek were greater than expected and may be of future research interest. The Institute currently employs excellent stormwater management practices. The project was very general, testing for a host of water quality parameters. The large, broad scope in the first year of civil engineering participation creates a useful base for future civil engineering researchers to branch off for more focused projects at Pierce Cedar Creek Institute.

Objectives:

The quantitative results from both the hydrology computations and water quality analyses were analyzed to gain a better understanding of the natural hydrology. Water quality results were found by testing for six different parameters that can be used to calculate a modified water quality index developed by the National Sanitation Foundation. Hydrological analyses were performed by using HYMAPS-OWL and L-THIA computer programs developed by Purdue University. Evaluation of the property BMPs comprised of thorough examination of the field and Institute engineering plans as well as researching the International Stormwater Best Management Practices Database.

Methods and Procedures:

Water Quality:

- **pH** was measured in the field, directly in the water source, by a handheld meter that was regularly calibrated with ph 4.0, 7.0, and 10.0 standard buffer solutions. The combination pH probe was rinsed with deionized water after every test and rinsed with source water before every test.
- **Dissolved Oxygen (DO_2)** and **its percent saturation (DO%)** was measured in the field, directly in the water source using a handheld DO meter that was regularly calibrated with barometric pressure. The probe was rinsed with deionized water after every test and rinsed with source water before every test. Care was taken not to oxygenate the water during testing. However, constant velocity whether caused by manual stirring or water flow is necessary for a proper reading with this instrument.
- **Temperature** was measured in the field, directly in the water source, by two separate handheld meters. The probes were rinsed with deionized water after every test and rinsed with source water before every test. The temperature was recorded after the readings stabilized.

- **Total Dissolved Solids** was measured in the field, directly in the water source using a handheld conductivity meter. It was calibrated regularly. The conductivity probe was rinsed with deionized water after every test and rinsed with source water before every test.
- **Turbidity** was measured in the lab with a turbiditimeter. Samples were collected with a 125 mL Nalgene laboratory grade bottle that was often attached to a 9’ wooden pole to gain access to certain reaches of the waterways. The 10 mL vials used for testing were acid-washed at the beginning of the summer and rinsed with deionized water thereafter. Particular care was taken to clean the outside of the vial with a damp paper towel and then a dry towel to provide a smudge free surface.
- **Reactive Phosphorus** was measured with a HACH DR/4000 spectrophotometer following the HACH procedure “Method 8048”—PhosVer 3 method. Particular care was taken to clean the outside of the test tube with a damp paper towel and then a dry towel to provide a smudge free surface. Testing was done in the lab as soon as possible after field collection.
- **Nitrate** was measured with a HACH DR/4000 spectrophotometer following the HACH procedure “Method 10020”—Chromotropic Acid method. Particular care was taken to clean the outside of the test tube with a damp paper towel and then a dry towel to provide a smudge free surface. Testing was done in the lab as soon as possible after field collection.

Three samples/readings per site were collected for every parameter. At each site readings or samples were taken from spots in the water most representative of the whole. When possible, readings were taken from the middle depth and at every third of the cross section.

Three rounds of sampling were conducted. Samples and direct readings were collected from three different locations on the creek. Other sampling rounds were taken at the same or different times from other streams and Brewster Lake.

The sample sites were chosen strategically for hydrological purposes. The first sampling site was off of the White Trail where Cedar Creek enters the Institute property. The second site on the creek was immediately downstream of a stream that contributes to the creek. The stream has headwaters in agricultural based land use. The stream was also tested right before the mouth. The third location on the creek was at Cloverdale Road bridge and was chosen as the most downstream point that was easily accessible. Brewster Lake was also tested since previous research pointed towards it being productive in regards to nutrients. Brewster Lake was tested at two points: the shallows at the outlet point and the water immediately outside of the shallows. The Brewster Lake outlet drained south under Cloverdale Road. Points immediately upstream and downstream of the culvert were also tested. Cedar Creek was also tested for temperature at Broadway Road bridge.

Hydrology:
Watershed delineation was accomplished with the HYMAPS-OWL GIS tool for spatial hydrologic analysis created by Purdue University Agricultural and Biological Engineering Department. The watershed was defined with a terminal point. This point was the most downstream point of Cedar Creek on the main portion of Institute property. The GIS data from HYMAPS-OWL was transferred over into PU ABE's sister program L-THIA (Long Term Hydrological Impact Assessment).

Results and Analysis:

Due to the large quantity of results, only a sample of the results will be shown for use in discussion while all results are available in the appendixes.

Shown below are sample results from Cedar Creek.

Cedar Creek Site #2 by Tributary				
11:49 AM	8/5/2008			
	Middle	**Away of Trib**	**Near Trib**	**Average**
pH	8.03	8.03	8.03	**8.03**
Temp (°C)	21.9	21.9	21.9	**21.9**
TDS (PPM)	335	338	336	**336**
DO_2 (mg/L)	7.62	7.63	7.55	**7.60**
DO Saturation (%)	87.1	87.1	86.1	**86.8**
Turbidity (NTU)	2.22	3.97	2.90	**3.03**
Phosphates (PO_4^{3-})	0.06	0.00	0.13	**0.06**
Nitrates (NO_3^-)	0.50	0.60	0.90	**0.67**

The pH was consistently close to 8.0, which is higher than generally desired. Between 6.5 and 7.5 would be more ideal. Watershed results ranged from 7.49 to 8.59. Both extremes came from the Brewster Lake outlet. The 8.59 reading came from Brewster Lake immediately outside the shallows whereas the lowest reading came from immediately downstream of the Cloverdale culvert that the outlet stream flows through. The velocity of the stream may contribute to lower pH. However, it was expected that the pH would rise around the road due to the culvert setup.

The culvert seemed undersized and was clogged by sediment that eroded off Cloverdale Road. This caused a dam to form on the north side of the road in which the stream velocity would slow down and stagnate. This allowed for plant growth as well as a larger surface area exposed to solar radiation for longer durations. The observation of algae, which raises pH, is a possible explanation for the high pH, although it unexpectedly was lower right at the culvert.

The temperature readings did not show anything of interest besides the fluctuations. Between the hours of 8:30 PM on August 12 to 10:30 AM on August 13, the temperature of Cedar Creek fluctuated 5.0 degrees Celsius at the Broadway Road bridge. For most aquatic plants and animals, "thermal stress and shock occurs when temperatures change more than 1-2 degrees Celsius within 24 hours” (Lehigh). A possible cause of this fluctuation could be in the creek’s headwaters, Cedar Lake. It may provide warm water to the creek during hot sunny daytime hours.

The results of the water quality index are shown below:

By Creek Site:
Site 1: 90 (excellent)
Tributary: 84 (good)
Site 2: 87 (good)
Site 3: 85 (good)

All Creek Sites By Date:
Round 1: 88 (good)
Tributary: 84 (good)
Round 2: 90 (excellent)
Tributary: 84 (good)
Round 3: 81 (good)
Tributary: 85 (good)

As seen above, the tributary during the summer months did not have significantly lower quality. It is visible that the creek quality decreases as it moves downstream. This may be due to the creek bed and surrounding conditions. Upstream, the creek flows over mainly sandy beds that tend to be less productive in regards to plant growth. Just past Site 2 all the way past Site 3, the creek bed is comprised of dark organic silt and a beaver pond that encourages plant growth and consequently lower oxygen levels. It should be noted that saturated oxygen has the most weight in calculating the quality index.

Shown below are expected nutrient levels and sources calculated from the L-THIA software.

Land Use	**Nitrogen (kg)**
Water/Wetlands	0.0
Commercial	4.1
Agricultural	1931.4
High Density Residential	0.5
Low Density Residential	4.1
Grass/Pasture	121.1
Forest	246.0
Total/Scenario	2172.7
Avg Annual Concentration (mg/L)	2.87

Land Use	**Phosphorus (kg)**
Water/Wetlands	0.0
Commercial	0.9
Agricultural	570.6
High Density Residential	0.2
Low Density Residential	1.4
Grass/Pasture	1.4
Forest	1.4
Total/Scenario	575.8
Avg Annual Concentration (mg/L)	0.76

The calculated concentrations of both nutrients were much higher than observed. However, if the agricultural lands are taken out of the equation, the calculated and measured concentrations are more similar.

Interpretation and Conclusions:

Overall, the Cedar Creek watershed water quality is minimally affected by the surrounding hydrology during the summer months in which research took place. In a general sense, the creek has good water quality. The nutrient concentrations observed in the summer are most likely not reflective of the annual average. The annual average is probably closer in line with the hydrologic analysis. Agricultural fertilizing tends to occur primarily during spring which may be why the tributary nutrient levels were unspectacular. Institute storm water management is appropriate although erosion control measures such as silt fences are needed around county owned Cloverdale Road structures.

Project Limitations and Errors:

Brewster Lake was not a major focus in this research because of scope and earlier PCCI research performed regarding the lake's quality. How the hydrology affects the quality of the lake is something that went left explored. Additionally, more time could be spent examining how Brewster Lake drainage into Cedar Creek influences the creek as well.

Due to the broad scope of the project, generalities were often used. Land use was broken into categories with no respect to what specific conditions might be contained within a certain sub-watershed. For example, a "forest" area could contain a large percentage of nitrogen fixing plants that could alter nutrient levels in the runoff. A micro-focused look at land use could further relate the hydrology to the water quality.

Coursework that ended in mid-June and poor logistics at the start of the project provided for a shorter and later testing frame than desired. A longer regular testing cycle with more rounds would have provided higher quality data along with more variances in precipitation.

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Appendixes:

-Round 1 Quality
-Round 2 Quality
-Round 3 Quality
-Brewster Lake and Outlet Stream Quality
-Bar Graphs for every parameter
-Temperature Change Plot
-Land Use and Impervious Area Distribution
-Runoff Volume and Depth
-Parameter Calculated Concentrations
-Curve Number Rational Method Results