

Mount Bethel Fens Complex

Spring 2004

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The Nature Conservancy and
The Lehigh Earth Observatory

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Introduction:

A fen is a type of wetland in which the hydrology is primarily driven by groundwater. Along with a constantly moist environment, mineral-rich groundwater flowing through the fens is necessary for the development and maintenance of the rare vegetative and animal species found in such areas. This project in particular focuses on a collection of five fens. Lehigh Earth Observatory (LEO), in conjunction with The Nature Conservancy (TNC), monitors these fens on a monthly basis. Hydrologic interaction between the fens and Jacoby Creek plays an integral role in defining the overall water composition of the system. In addition to studying the fens and Jacoby Creek, LEO and TNC have included two weather stations to monitor rainfall, temperature and relative humidity. The overall goal of this long-term project is to continuously monitor the flow and quality of the water in the fens to help assess the impact of nearby industries and residential areas. Pollution of the fens or lowering of the water table will ultimately impact the rare and endangered species residing in this sensitive habitat. This report in particular focuses on the data collected during the months of January, February, March, and April of 2004.

Site Description:

This area is mainly comprised of forests, residential lots, and a few industrial areas. The Mount Bethel Fens Complex encompasses five fens that are monitored by a total of eight peizometers, which are steel pipes partially submerged in the ground: Savadge Fen #1 (SF1), Bartlett Fen #3, 5, and 8 (BF3, BF5, BF8), Taylor Shrub Fen #1, 3 (TSF1, TSF3), Taylor Seep #1 (TS1), and Taylor Fen #1 (TF1). Water running through

the fens may emerge in some places as streams, but ultimately all water flows to Jacoby Creek. Three major aquifers feed the fens complex: the surficial glacial aquifer, the limestone Allentown Formation aquifer, and the Martinsburg Formation slate aquifer. The irregularity of the glacial deposits and its proximity to the ground surface creates many seeps and springs that feed the fens. The blue-green lacustrine clay forms an impermeable layer that retards both the upward and downward flow of water, in some areas decreasing the input to the fens from the underlying bedrock aquifers. However, the geochemical signatures of the water in the fens show that all three aquifers are contributing to different fens in the complex.

Methods:

The Mount Bethel Fen Complex encompasses Savadge Fen, Bartlett Fen, Taylor Shrub Fen, Taylor Fen, and Taylor Seep. Piezometric water heights are monitored monthly in each of the fens, while water quality is analyzed on a quarterly basis. Water quality data is used to ascertain the water type of each of the fens and seeps. Water quality tests consist of analyzing samples of water taken from one well in each of the fens and running a series of tests including pH, temperature, conductivity, nutrients (NO_4^{2-} , PO_4^{3-}), Ion Chromatograph (IC) and Inductively Coupled Plasma (ICP). IC detects the concentrations of anions SO_4^{2-} and Cl^- , while ICP detects the concentration of cations Na^+ , Al^{3+} , Mg^{2+} , Ca^{2+} , and Fe^{2+} . The water chemistry is compared through time to determine the natural variability associated with nutrient cycling, budgets in the complex, and any changes in chemistry. Since the fens and the Jacoby Creek are closely

intertwined, two sites along Jacoby are studied, one site upstream and one downstream from the fens.

Quarterly water samples taken at these sites are analyzed in the same manner as the fen samples in terms of water quality. This analysis is performed to monitor any changes in the Jacoby Creek watershed, as well as changes in the water quality as Jacoby Creek runs through the fens. Both may possibly change the water composition and water quality of the fens. The stream gauging station, which is located on the Jacoby Creek at a site within the fens complex, collects stream stage data with 15-minute frequency in order to calculate discharge. This information will provide a better understanding of the watershed in which the fens are located.

Along with monitoring water quality, other factors of the environment such as rainfall, temperature, and relative humidity are also analyzed. This data is collected from weather stations located on two sites in the same area as the fens. One weather station, Godshalk Weather Station, is located in the middle of the fens complex and the other one, Jones Weather Station, is on a nearby ridge within the Jacoby Creek watershed. These aspects are monitored to more completely assess the fen environment and possibly explain any influences on the fens, such as varying piezometric water height and composition of the water. All of the specific methodology for sampling and analyzing the water quantity and quality can be found on the Lehigh Earth Observatory website <www.leo.lehigh.edu> under the Mount Bethel Fens project.

Monthly Well Heights:

Site	January	February	March	April
BF3	NA	-30.67	-22.00	-8.67
BF5	NA	31.67	19.00	33.67
BF8	NA	150.67	138.00	169.67
SF1	NA	145.33	118.33	115.67
TF1	NA	Data Not Available	1018.00	1406.00
TS1	NA	455.00	334.67	389.67
TSF1	NA	350.00	432.33	348.67
TSF3	NA	Data Not Available	135.00	153.00

Results:

No data is available for January due to ice obstructions in the aboveground portion of the well. In addition, the wells at TSF3 and TF1 were still frozen in February. For most of the wells, little well height variation is observed: the average standard deviation is 55.8 mm for the wells sampled from February to April. Minor fluctuations of between 10 and 20 mm occurred for wells BF3, BF5, BF8, SF1, and TSF3, as shown in Table 1. The only considerable difference was observed in Taylor Fen 1 (TF1), as the water column height increased from 1018 mm to 1406 mm from March to April. For the other wells in the Taylor Fen area, such as TS1, the water column height dropped from 455 mm to 334.67 mm from February to March. In contrast, there was a slight rise in well height from 334.67 mm to 389.67 mm from March to April. TSF1 rises from February to March, but drops from March to April by 84 mm. BF3 had the lowest values, whereas TF1 had the highest. See Appendix for graphical representation.

Discussion:

To calculate well height, factors such as peizometric depth below ground and reference measurements are used to calculate the height of the water table in millimeters.

Changes from February to March may be due to the melting of frost and groundwater after the sampling in February. This may have affected the relative heights.

Because of changes in well height calculations, the well heights cannot be compared to the past years' heights at this time. These calculations will be standardized in the future. This year's calculations were in relation to the ground level to simplify comparisons of the water table. Though it was observed that TF1 had a large increase between March and April, because there are only two data points, no correlation can be made. In addition, since the relative elevation of each well is unknown, individual well heights cannot be compared to each other at this time.

Weather and Jacoby Creek Gauging Station:

Results:

Temperature and relative humidity data were collected from January to February and for part of March. Due to instrument failure at both Godshalk and Jones weather stations, no data was collected from the sampling in February through March. Daily fluctuations were observed, with a general trend of warming. The highest temperature observed at Godshalk was 7.83°C, which is only 0.53°C above the highest temperature for Jones, 7.3°C. Jones had the higher lowest temperature at -18.76°C, which is a full 1.48°C above the -20.24°C of Godshalk. No clear trends were observed as to which station had higher temperatures or relative humidity, as Godshalk had a higher average temperature in January, the average temperature was almost identical in February, and Jones had a higher temperature in March. Godshalk generally had less deviation than

Jones. Due to complications formatting the data, statistical analysis cannot be calculated at this time. See Appendix for graphical representation.

Discussion:

Temperature is the average kinetic energy of a substance. For scientific purposes, it is standard to use the Celsius scale.

Relative humidity measures the amount of water vapor in the air. At higher temperatures, more moisture can be held in the atmosphere. At 100% relative humidity, a precipitation event occurs.

The instrument that measures the rain data is only accurate at temperatures above freezing. Below freezing, it may record that a precipitation event occurred, but the actual amount is unknown. The relative humidity data can be used to verify that an event occurred, for at 100% relative humidity, there is a precipitation event. Precipitation in the winter months is generally low, as shown by both the rain data and the lower relative humidities. Temperature increased through the period due to seasonal warming. Though no conclusive data was observed, Godshalk demonstrated the extremes for temperature: it had the highest high temperature and the lowest low temperature. This could be due to micro-differences in elevation or exposure to the elements. The two stations' data follow the same weather patterns but there is a difference in the intensity.

Water Quality for Fens:

Table 2: Spring 2004 Monthly pH				
Site	January	February	March	April
Bartlett Lake	NA	6.78	7.28	6.91
JC2	NA	7.66	8.44	8.16
JC4	NA	7.74	7.73	7.79
JCH1	NA	NA	7.90	7.62
Savage Pit	NA	NA	6.96	NA

Table 3: Spring 2004 Monthly Water Temperature (°C)				
Site	January	February	March	April
Bartlett Lake	NA	2.86	9.40	10.93
JC2	NA	2.92	5.13	10.45
JC4	NA	3.59	7.87	12.03
JCH1	NA	NA	8.31	10.92
Savage Pit	NA	NA	11.57	NA

Table 4: Spring 2004 Monthly Conductivity (µS/cm)				
Site	January	February	March	April
Bartlett Lake	NA	0.537	0.334	0.432
JC2	NA	0.267	0.234	0.208
JC4	NA	0.387	0.420	0.338
JCH1	NA	NA	0.372	0.388
Savage Pit	NA	NA	0.940	NA

Table 5: Spring 2004 Monthly Dissolved Oxygen (mg/L)				
Site	January	February	March	April
Bartlett Lake	NA	9.60	11.60	6.40
JC2	NA	14.34	4.00	10.96
JC4	NA	14.52	13.07	11.14
JCH1	NA	NA	11.72	11.00
Savage Pit	NA	NA	9.67	NA

Results:

The pH of JC4 and JCH1 were slightly basic, ranging between 7.73-7.79 and 7.62-7.90, respectively, as shown in Table 2. For JC2, the pH rose from a slightly acidic 6.78 from January to a basic 8.44 in March, but then decreased to 8.16 in April. See Appendix for graphical representation.

Water temperature increased from January to April, with an average standard deviation of 3.55, which was calculated from data in Table 3. Of the locations where samples were taken from February through April, JC4 and Bartlett Lake had similar average temperatures of 7.83° C and 7.73° C, respectively, but JC2 had a lower average temperature with 6.17° C. Savage Pit, though only analyzed in March, had a significantly higher temperature, with a difference of 2.17° C from the next highest temperature of the other locations taken that day. See Appendix for graphical representation.

For conductivity, only Bartlett Lake had a significant fluctuation, with a standard deviation of 0.102 from February to April. Its conductivity dropped from 537 $\mu\text{S}/\text{cm}$ in February to 334 $\mu\text{S}/\text{cm}$ in March, and then rose to 432 $\mu\text{S}/\text{cm}$ in April, as shown in Table 4. JC2's conductivity decreased through the months, but the standard deviation was only 0.030 from its average of 237 $\mu\text{S}/\text{cm}$. Savage Pit, though only measured once in March, had the highest conductance at any time with 940 $\mu\text{S}/\text{cm}$. JC4 and JCH1 both had an average conductance of 0.38 $\mu\text{S}/\text{cm}$. See Appendix for graphical representation.

The dissolved oxygen had large fluctuations without any clear trends. Bartlett Lake's dissolved oxygen increased from February to March, but then decreased again to its lowest amount in April, as displayed in Table 5. JC2 did the opposite, ranging from

14.34 mg/L to 4.00 mg/L and with the highest standard deviation of 5.27. JC4 had the smallest deviation of the locations measured at each month with 1.70 and had an average of 12.91 mg/L. Savage Pit had the lowest average with 9.67 mg/L, and JC4 had the highest. Though JCH1 was only measured twice, it deviated by only 0.51. See Appendix for graphical representation.

Discussion:

pH is a logarithmic scale, with base 10, which measures the hydrogen ion concentration. It has a standard range of 0 to 14; 7 is neutral, anything below 7 is considered acidic, and anything above it is considered alkaline, or basic. The pH is calculated by taking the negative log of the hydrogen ion concentration. Since it is a logarithmic scale, every integer increase on the scale is an increase of a factor of 10. This makes seemingly small fluctuations actually much more significant.

Conductivity is the measure of the ability of a liquid to conduct a current. It is directly related to the amount of ions in the water, and it is measured in microsiemens per centimeter.

Dissolved oxygen is a measure of the amount of dissolved oxygen in the water with units milligrams per liter. It is inversely proportional to the temperature. As biological activity increases, dissolved oxygen levels will fluctuate as heterotrophs consume oxygen and autotrophs produce it.

The water flows into the fens at JC2 and leaves the fens at JC4. As the water travels through the fens, some buffering may occur. This would explain why though JC2 had large fluctuations in pH, JC4 differed by only 0.06 pH units. Temperature is based on season and time of day, so the temperatures steadily rose with each passing month.

Dissolved oxygen fluctuated with temperature and season. As biological activity increases, the use of oxygen by plants and animals also increases. The increase in temperature made the water less soluble to oxygen, so that would explain why the levels decreased in later months.

Water Quality for Wells:

Table 6: Spring 2004 Physical Parameters for Wells				
Site	March 2004 pH	March 2004 Water Temp (°C)	March 2004 Conductivity (µS/cm)	March 2004 DO (mg/L)
BF5	7.22	6.21	0.463	7.81
SF1	7.08	6.20	0.944	8.47
TF1	7.43	8.60	0.489	5.24
TS1	7.05	12.20	0.584	2.42
TSF1	7.35	7.57	0.756	5.70

Results:

The physical parameters for the wells were recorded in March. The pH of the wells was between 7.05 and 7.43, as shown in Table 6. The conductivity varied greatly between the wells, ranging from 0.463 µS/cm in BF5 to 944 µS/cm in SF1. Temperature varied according to time of data collection, steadily increasing throughout the day. See Appendix for graphical representation.

Discussion:

The pH of the wells was basic, which was expected due to the limestone bedrock formations. Compared to last spring’s data, the pH has remained relatively constant except for TS1, as the pH dropped from 7.22 to 7.05. pH can be influenced by plant life,

but due to low biological activity through the winter months, rain has had a greater affect on the alkalinity of the pH. Thus, any acidic rainfalls could have caused a decrease in the pH. By comparing this data with other fens in North America in “Fens in the United States: Characteristics and Scientific Connection vs. Legal Isolation,” from *Wetlands*, a quarterly journal, Mount Bethel Fens has more alkaline groundwater than most on the continent (613). This could be contributed to the limestone bedrock.

The conductivity of the wells has also remained fairly constant except for an increase in well SF1 from 681 $\mu\text{S}/\text{cm}$ in spring of 2003 to 944 $\mu\text{S}/\text{cm}$ in Spring 2004.

Conclusion:

Overall, Mount Bethel Fens appears to be relatively stable and the parameters examined show a healthy ecological community. Because the method for calculating well heights was changed this semester, comparisons with previous years was not possible. This discrepancy will be corrected by the summer interns. The pH values between 6.78 and 8.44 signify water quality within an acceptable range for life. Conductivity influences the physiological processes in plants and animals and is also influenced itself by those processes. As biological activity increases in the spring, fluctuations in conductivity are expected. The Jacoby Creek water temperature, Jacoby Creek flow rate, Godshalk and Jones air temperature, Godshalk and Jones relative humidity, and Godshalk and Jones rainfall data were generally similar to years past with exceptions of errors due to faulty sensors. Steps are being taken to improve sensor reliability.

In the future, GIS mapping software will be used to find the relative elevations of the wells in an attempt to better understand correlations in well heights. Nutrient data

and well recharge rate data were not available for analysis this spring, but further study will be forthcoming. The computer program, Aabel, was used for graphing, and continued work is being done to build templates and a more accessible database. A new ICP machine will be installed shortly. The data gathered this spring will be used for a comparison between other seasons and years past by summer interns.

Resources:

Bedford, Barbara L. and Godwin, Kevin S. "Fens of the United States: distribution, characteristics, and scientific connection versus legal isolation." *Wetlands*. Vol. 23, No. 3. Sept. 2003. The Society of Wetland Scientists: 2003. pp. 608-629.