Delaware Center for the Inland Bays Scientific and Technical Advisory Committee Meeting
March 9, 2018, 9:00 AM to 12:00 PM
DNREC Lewes Field Facility

Attendees:

STAC MEMBERS	CIB STAFF	OTHER
Jennifer Volk, Acting Chair	Bob Collins	A.G. Robbins
Douglas Janiec	Andrew McGowan	Michael Bott
Chris Main	Marianne Walch	Chris McMahon
Kelly Somers		Anne Riley
Bob Stenger		Andrew Bell
Kari St. Laurent		Melissa Hubert
Ed Whereat		Ellen Dickey
John Austin		Sergio Huerta
Susie Ball		A. G. Robbins
Claire Simmers		Marcia Fox
Rob Garo		Bennett Anderson
Tyler Monteith		
Richard Watson, Secretary		

Meeting called to order at 9:01 AM by Jennifer Volk, Vice Chairperson

1. Round robin introductions were made.
2. Jennifer Volk made STAC announcements.
3. Dr. Marianne Walch provided CIB announcements.
   a. New STAC Members
      i. Claire Simmers
      ii. Tyler Monteith - Watershed coordinator
   b. New DCIB staff members
      i. Outreach and Education Coordinator Amy Barra;
      ii. Development Coordinator Mary Knight; and
      iii. Science and Restoration Project Manager Victoria Spice.

Microbial Source Tracking in the Love Creek Watershed of Delaware's Inland Bays, Chris Main, DNREC

Overview

One measureable type of potential human-related water pollution is fecal bacteria that may derive directly from humans, from the various domestic animals with which we are associated and/or from wild creatures. For well over half a century scientists have had the capability to test for the bacteria that are indigenous to the gut of warm blooded animals and for over 30 years total Enterococcus bacteria has been widely used to indicate the presence of such in 305(b) monitoring efforts, Including in Delaware. Next Generation Sequencing (NGS) methods have emerged as a potential tool for bacterial source tracking, which have the potential of increasing sensitivity to distinguish between sources of fecal contamination. The Love Creek watershed has undergone extensive human development of various types in its tidal and non-tidal segments, making it an excellent area for testing.

Chris emphasized that the data he is presenting today is very preliminary and that he will have to perform additional analyses in the near future.

DNA Sequencing

1. Sanger Sequencing (1st Generation)
    a. The Gold Standard for sequencing;
    b. Larger Sequences (>70 bp); and
    c. Increased cost ($100M for the original human genome versus $1500 today to do the same analyses), sequencing and analysis times.
2. Next Generation Sequencing (NGS)
    a. Shorter sequences (50-300 bp);
    b. Less cost and DNA required; and
    c. Increased computational power (still takes about three days to run the analyses).
3. Chris discussed the uniqueness of the DNA in the species which allows a "fingerprint type analyses.

Love Creek Watershed

1. Major tributary of Rehoboth Bay with a watershed of approximately 24 square miles.
2. Last several decades have seen a dramatic increase in urbanization with a decrease in agricultural and forested areas.
3. Watershed is listed as impaired for nutrient loads. Nutrient input sources include:
    a. Agricultural and residential fertilizers;
    b. Stormwater runoff; and
    c. Wastewater disposal including septic systems (large number of septic system sources (3rd densest on Rehoboth Bay) – Chris noted that sewer systems are being installed).
4. The watershed is currently listed as impaired under the CWA for both bacteria and nutrients. The study area is tidally driven up to Goslee Pond at Robbinsonville Road.

Sampling

1. Monthly sampling was performed from March through October (to determine seasonal human impact) at seven sites within the watershed of which 3 were non-tidal and 4 were tidal along mouth of Love Creek. Two replicates were also taken. There was also a sample taken after major rainfall events (2.5" of rainfall).
2. Samples were analyzed for:
    a. Nutrients:
        i. DOC/TOC;
        ii. NOx;
        iii. Orthophosphate;
        iv. NH3;
        v. Total N and P;

vi. TSS, TDS, and Turbidity.

b. Bacterial:

i. Enterococci via Enterolert; and

ii. Microbial community via Illumina MiSeq (next generation method using Source Tracker).

c. Fecal Samples:

i. Chicken, Cow, Duck, Goat, Goose, Horse, Pig and Sheep; and

ii. Human (Chris used his excrement to avoid HIPAA issues)

iii. 91 samples generated 19,000,000 reads and three days of computer analyses.

d. Could not obtain cat and dog samples; may obtain in the future.

3. Chris discussed sampling from Jimtown Road to mouth of Love Creek. 63% samples were above marine and freshwater standards at Jimtown Road and varied as he progressed down the watershed. It was non-detect at the mouth of the Creek.
4. Source Tracker Software uses statistics to estimate how much each of the fecal sources contribute to the main microbial community of your sample. They are still analyzing the data to make sure that they have reasonable estimates.
5. Main purpose of using the new method is when they detect high bacterial loads, they want to be able to determine where it is coming from (human versus non-human). They were trying to standardize the analyses for future use.
6. When they detect a harmful pathogen, they can store the DNA for future analyses. They are also looking for patterns with existing nutrient conditions.

Conclusions

1. Next Generation Sequencing Techniques are able to determine potential sources of bacterial contamination.
   a. Ground trothing must be performed to locate potential sources; and
   b. Greater fidelity can occur from fecal samples collected within the watershed.
2. Future Analysis
   a. Functional analysis of the microbial community;
   b. Emerging pathogens;
   c. Viral source tracking; and
   d. Linkages between nutrients and the microbial community?

Questions

1. There was a discussion about whether the actual source of bacteria could be determined – Chris indicated the study is at a very preliminary stage and that you could monitor the bacterial levels but may not be able to actually identify the source. The discussion continued about whether additional farm BMPs are needed and whether there should be changes to existing BMPs.
2. There were several questions concerning specificity of the animal samples. Chris indicated that samples were taken from at least two of each specie. Most of the samples were taken at the state fair.

3. There was a discussion about the sampling procedures. Chris indicated that the samples were taken at the same time to avoid issues related to possible tidal influences. Chris indicated that they were attempting to standardize the procedure so that there would be consistency in results. He also stated that they wanted to standardize the analytical procedures so that a "PhD" would not be needed to review the data. He also discussed the fact the analysis software used was continually being updated which makes obtaining consistent data sometimes difficult.
4. One questions concerned whether a relationship could be established between nutrients and bacteria. Chris indicated that would be investigated in the future. Chris again emphasized that the work is very preliminary and that there is much additional work to be done.
5. A discussion was held on how to classify "pristine" sites (if there are any remaining?). Whether unique criteria should be used or if bacteria function would be a better method.
6. The sensitivity of the protocol was discussed. Again Chrius indicated that cow and sheep samples were obtained from the state fair. He also indicated that samples were taken in triplicate.
7. Chris summarized the discussions by stating that the goal of the research was to develop additional "tools" for monitoring for which a PhD would not be needed for the data analyses.

Reducing Non-Point Source Pollution through Effective Ditch Management, Melissa Hubert, University of Delaware (copy available on CIB Website)

The objectives of this research are to characterize ditch bottom sediments prior to maintenance to determine their potential to release Phosphorus (P) to overlying waters under normal conditions. This information will be used to quantify the amount of P removed by the maintenance "dip out". In addition, predictions of potential P loss from spoil amended areas following maintenance will eventually be made. Ultimately the tests completed will be used to provide recommendations that may improve the dip out maintenance process to help reduce potential P losses.

Artificial drainage is an engineered system designed to remove excess water from the soil surface and subsoil and can be achieved in a variety of ways including through open public and private ditches, channelized streams, and tile drains. Being part of the Atlantic Coastal Plains, Delaware is characterized by flat topography and poorly to well drained soils with high water table. As a result, artificial drainage is necessary for use of the land in many areas because excess water can make use of machinery, construction, animal agriculture, or crop production impossible, particularly in Sussex County. Overtime, ditch systems accumulate sediment that hinders their functionality and require excavation to restore.

While there is a long history dating back to 1793 of constructing artificial drainage throughout Delaware because of its needs, the Delaware General Assembly enacted the Drainage Law in 1951 to establish, finance, and maintain drainage organizations or tax ditches. Tax ditches are formed through a legal process in Superior Court and are governmental subdivisions of the state. Tax ditches are watershed based organizations that levy taxes from property owners within the watershed to be able to perform major and minor maintenance activities to maintain drainage throughout the system. These organizations are overseen by elected ditch managers and a secretary/treasurer who are all landowners within the watershed. During the formation of tax ditches, rights of way are established for dedicated maintenance. Currently there are 228 Tax Ditch organizations in Delaware which manage over 2,000 miles of channel and provide benefit to over 100,000 people.

Drainage and prevention of flooding of lands and the management of water for resource conservation are considered a public benefit and conducive to the public health, safety and welfare. While ditches provide benefit to those in the surrounding area including farmers and residents alike there are some concerns associated with artificial drainage:

1) Ditches can serve as direct conduits for nutrient and sediment losses by connecting edge of fields with a channel of water draining to downstream water bodies. This increases the risk of N and P transport from fertilizers and other adjacent management practices to downstream waters which when in excess can lead to eutrophication or algae blooms. This is a major concern on the Delmarva Peninsula since these ditches drain to the sensitive estuaries of the Chesapeake and Delaware Bays.

2) We know that the ability of a ditch to effectively drain fields decreases over time due to sedimentation and the growth of vegetation within the ditch channels. In order to restore drainage functionality maintenance is required however maintenance activities may contribute to the release of previously stored nutrients by disturbing what appears to be a functioning wetland.

3) Overall physical and chemical properties of ditch bottom sediments have not been extensively studied and the impact of ditch maintenance on water quality are unknown which is the focus of the research presented here.

Minor tax ditch maintenance activities include spot treatments to replacement of deteriorated pipes, clearing pipe blockages, and removing beaver dams as needed to improve drainage functionality. In addition, annual mowing is used to control woody vegetation within the ditch channel and at the top of banks within the Tax Ditch ROW to maintain ditch flow and access for future maintenance.

The major maintenance activity implemented to restore ditch functionality throughout Delaware Tax Ditches is the dip out. It is performed every 15-20 years as needed usually between September and March when crops are not in the field. A hydraulic excavator is used to remove the accumulated sediment from the ditch channel to original engineered specifications. The excavated sediments are called spoil and are piled in the ROW to dry. Most of the time the ROW is an agriculture field and once the piles have dried out, a bulldozer is used to thinly spread (2-6 inches) the spoil across the field for the farmer to later incorporate before planting. Sometimes farmers will pay to have the spoils hauled away from the site because they do not like the consistency or texture of the spoils and feel the plants do not grow well in spoil amended areas. The time between the steps of this process are highly variably and as a result it is hard to know for certain the nutrient loss potential from the spoil piles prior to incorporation as well as from the spoil amended areas which is a focus of this research.

Seven ditches were selected for dip out last year. Six of the ditches studied were in Sussex County, and the other was located in Kent County. Generally, dip outs occur over a long stretch of the tax ditch but not the entire network due to costs. For this study, the dip outs ranged from about 0.75 – 2.25 miles depending on the ditch and the surrounding land use. Soil sampling was conducted before and after the maintenance operations.

Chemical and physical characterization of the field and spoil samples collected were performed to determine potential P losses during maintenance. To ensure constant conditions, field capacity of the representative field and spoil samples were determined and maintained for field soil-spoil mixtures throughout the duration of the experiment. Field only and spoil only cups were also included in the experiment as controls. Field only and spoil only cups were also included in the experiment as controls. The incubation cups were subsampled after 2 and 30 days of the experiment and analyzed for water soluble P or the P likely to be transported during runoff events and Mehlich 3 P which is used to determine P saturation of the soils.

(*The risk of phosphorus loss from agricultural soils can have serious implications for water quality. This problem has been noted particularly in sandy soils in several parts of the world including Europe (e.g., the Netherlands, Italy, and UK) and the southeastern USA. However, the capacity of a soil to retain P is limited and even non-sandy soils have the potential to eventually release P when inorganic or organic fertilizer is added over a period of time. A threshold phosphorus saturation ratio (PSR), calculated from P, Fe, and Al in an oxalate or a soil test solution such as Mehlich 1 or Mehlich 3, has been recognized as a practical means of determining when a soil has reached a level of P loading that constitutes an environmental risk. When soils are below a threshold PSR value, the equilibrium P concentration (EPC_0) is minimal. Further, the soil P storage capacity calculated from the same data is directly linked to the strength of P bonding (K_L) as determined from Langmuir isotherms, and K_D, the distribution coefficient related to the strength of sorption. While the PSR is occasionally used as a predictor of the onset of environmentally significant P loss from a soil, the procedure might be adopted as a routine soil test.)*

All but two of the field soils were found to be already above the agronomic needs for P. Nearly half of the spoils were above the agricultural need threshold but no spoil exhibited PSR values indicative of environmental risk (most were very close).

In general, a PSR of 0.23, would indicate that P losses through leaching will most likely occur. Depending on site conditions (i.e. the likelihood of surface run-off, rapid drainage, lack of plant cover, and vicinity to waterways) a range of 0.10 to 0.15 M3-PSR may already indicate a risk of P losses. Considering this, it is important to integrate any form of soil P testing with other site risk assessments to avoid P effects on water quality. This is especially important for water reuse schemes effluent and manure use.

Some general observations from the initial testing are as follows:

1. There is an enrichment of phosphorus in the top five centimeters of the ditches.
2. The spoils or accumulated sediment may be the result of the redistribution of sediments within the ditch channel instead of erosion from the adjacent fields. This is probable as the soil test P concentrations of the spoil were much lower than the fields.
3. Incorporation of these materials may reduce the risk of P loss since the results after 48 hours of incorporation indicated that the amended areas exhibited less P than the corresponding fields originally.

4. Potential solutions may be to limit the time between the steps in the dip out process (excavate, spread, incorporate) or to change how frequently dip outs are performed or the prioritization of ditch dip out (currently based on timing of last dip).

The next step will be to more fully characterize these sediments before and after dip and complete incubation soil tests on future time intervals. From these results, recommendations for improving current maintenance practices will be made.

Questions

1 A brief discussion was held about the year one phosphorus concentrations being lower.
2 There was a comment/question as to whether the Tax Ditch System was properly funded. Melissa indicated that it was not and additional funding would help.

Monitoring Subcommittee
A discussion was held concerning the proposed monitoring subcommittee. An initial meeting will be held in April and volunteers are needed. Please let Chris Main of your interest.