HEP Citizen Science
Final Report

Project Title: Raritan Bayshore Water Quality Project
NY/NJ Baykeeper
December 15, 2014

Project period: February-December, 2014

HEP award: $24,895 and matching funds: $960

Purpose: This project allowed the NY/NJ Baykeeper the opportunity to collaborate with HEP, EPA, NJ DEP, and others to provide data collection and information on water quality in areas of our watershed that previously lacked sufficient information. In addition, NY/NJ Baykeeper was able to mentor citizen scientists and expand our volunteer program into Middlesex and Monmouth counties, NJ. The data generated from this project have the potential be used to inform water quality policy and regulatory decisions at all level of government (state, federal, local) within our watershed and to educate our members.

Summary of project: Throughout the course of June-August, 2014, NY/NJ Baykeeper (hereafter, NNB) conducted weekly monitoring events at several locations along Matawan Creek (Monmouth/Middlesex County) and South River (Middlesex County). At each location, several physicochemical measures were taken (i.e., temperature, salinity, oxygen, pH) along with observations regarding weather patterns, potential pollution inputs (point and non-point sources), and recreational use (e.g., fishing, boating). Additionally, water samples were collected, and analyzed at the EPA laboratory, to determine the levels of *Enterococcus* bacteria (an indicator of pathogen contamination). Data were analyzed and mapped, indicating that the highest areas of Enterococcus were found in South River. It should be noted that even at the elevated levels, the geometric monthly means were not well above the EPA standards, but the sampling events immediately following precipitation were 10-fold higher.

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Course of Action: There were ten locations chosen to be analyzed over the summer (6-Matawan Creek, MC; 4-South River, SR). Each location was monitored five times per month, for a total of fifteen dates over the three month period. During each monitoring session, the following parameters were measured (with a hand-held YSI probe): water temperature (^{o}C), salinity (conductivity, mS), dissolved oxygen (mg/L), and pH; the following observations were made and recorded: cloud cover, precipitation (current, 24 hours, 48 hours), tide stage, water 'condition' (discoloration of water, floating debris and sewage, odors), pollution sources (point and non-point), and observed recreational uses (boating, fishing, etc); and the location (latitude, longitude) was determined (using a hand-held GPS unit). Observations on weather and pollution were made by looking in a 360^{o} arc around the site. A YSI hand-held probe was placed into the water, approximately 1m below the surface, and gently agitated for 30-60 seconds to allow for a reading to stabilize. A hand-held GPS unit was used to record the latitude/longitude for each site. Additionally, each sampling event included a water sample for *Enterococcus* levels. The water sample was placed on ice, and transported to the EPA laboratory (Edison, NJ) within six hours. At the laboratory, standard protocols were followed to incubate the sample with Enterolert for 24-hours, after which the specimens were observed under fluorescent lighting to quantify the amount of *Enterococcus* within the water sample (EPA QAPP methods: http://www.harborestuary.org/citizenscience-2014project.htm). Data were analyzed using simple statistical measures (mean, geometric means, standard deviation) over the entire season (June-August). Conclusions were drawn between precipitation events and the increase in *Enterococcus* levels

Quality Control Measures: In accordance with the USEPA-approved Citizen Science QAPP (April 2014), the following measures were taken to ensure that data collection was within all quality control means.

1. Precision: For field sampling measures, on every sampling date (n=15), at least two sites (one from each Matawan Creek and South River), a duplicate of the YSI readings was taken (temperature, conductivity, pH, dissolved oxygen). If the duplicate was not similar, a third reading was taken to determine the proper measurements. The measures were only accepted if within 10%. In the laboratory, a duplicate sample was run by EPA staff at least once a month, with an alternate method (not Enterolert), to check for agreement between the old and new accepted methods. Existing data were checked for precision by QA/QC officer (M. Comi).

2. Bias: The sampling sites were often on the edges of the stream due to accessibility. Though spread out along the length of the stream, it is possible that having sites along the edges (where docks and shoreline access were available) may have biased the measurements slightly. Along each creek, at least two of the locations were done off of a bridge, and therefore the probe readings and water sample were from the middle of the stream. This allowed us to lower the bias as along the creek length, we have both shoreline and middle of the stream samples. In the laboratory, blank samples were used to calibrate the field samples against. There was a 'blank' with no bacteria (distilled water), and a 'positive control' with a known concentration of *Enterococcus* placed in to the distilled water. Then, the 'unknown' samples were run and calibrated against the controls.

3. Representativeness: Along the course of Matawan Creek, six locations were chosen spanning the mouth of the creek to the end (Lake Lefferts), giving us a large portion of the area of the stream sampled. Along South River, four locations were chosen from the mouth of the creek to the headwaters; however due to accessibility, these sites were more clustered together and therefore may not be truly representative of the entire length of the stream. The creeks were only sampled for three months out of the year, which does not give data over any season but summer; however, during the summer months there were samples from five timepoints each month giving a very representative sample of these three months.

4. Comparability: Only one method was used to collect data (YSI, GPS, or Enterolert methods). Therefore, we are unable to compare data to other methods for each sampling point. At random intervals, a standard refractometer was used to measure salinity at several sites (only anecdotal data), but this did correspond with the conductivity measures taken on the YSI. For the laboratory data, standard USEPA QAPP protocols were followed, so the data will be comparable to other studies using this method (other citizen science projects this summer, among those).

5. Completeness: Of all the samples collected along the creeks (n=15 sampling events, n=10 sites, for a total of 150 samples), 100% were analyzed for Enterococcus levels and 100% used in analysis of stream conditions and water quality. There are no pre-existing data on the sites that were used for this study.

6. Sensitivity: The YSI hand-held probe has a sensitivity of 0.01mg/L for DO. Depth was measured using a secchi disk marked at 1m intervals, and was measured to the nearest 0.5m. In the laboratory, the Enterolert method has a method detection limit of 10MPN. All readings are considered accepted as the calibration and quality control checks were within 10% of the accepted values.

In terms of data management, all data collected at field sites were recorded on pre-printed datasheets provided by the USEPA. Data were transcribed into an Excel data file (again, provided by USEPA). All of the data (100%) were QA/QC'd by the QA/QC officer (M. Comi). Original copies of the data sheets are stored at the NY/NJ Baykeeper offices, and scanned copies are kept on the computers, and were sent to the EPA/ HEP (G. Munoz). Laboratory results were transcribed onto a pre-printed data sheet (from USEPA), and then into the same Excel data file, checked by M. Comi.

Interpretation of results:

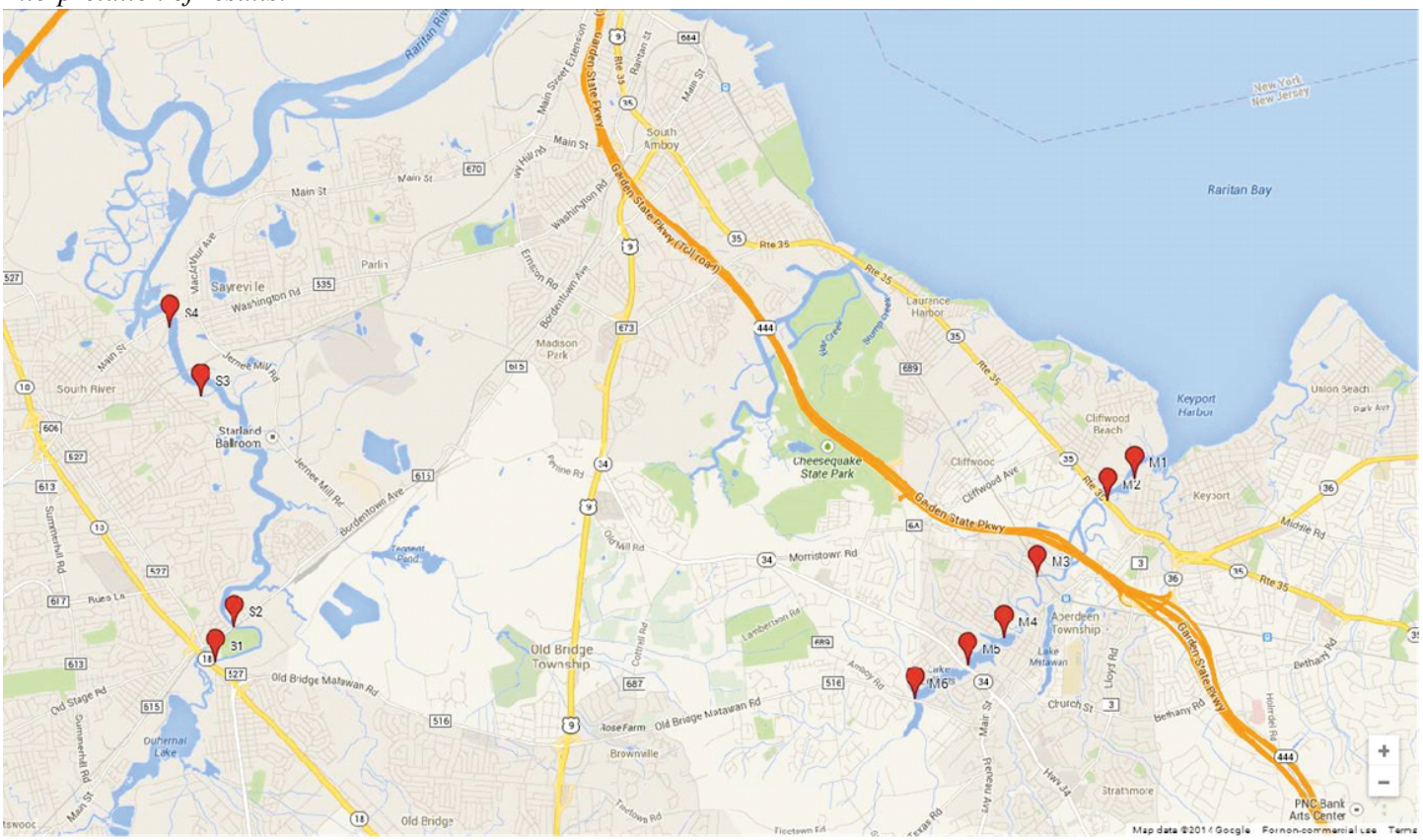


Figure 1: Map of the sampling sites. M1-M6 are on Matawan Creek, from the mouth of the creek (Raritan Bay) towards the end (Lake Lefferts). S1-S4 are on South River, from the headwaters of the creek to the mouth (Raritan River).

Over the course of this project, there were 150 discrete sampling sessions performed (n=15 sampling days, n=10 sites sampled each date). On each sampling date, at each site, there were measurements collected for (a) temperature, (b) conductivity, (c) pH, (d) dissolved oxygen, (e) Enterococcus levels, (f) weather observations, (g) pollution sources, and (h) recreational uses of the site. For the purposes of this report, the authors focused on parameters most commonly used to classify polluted waters: Dissolved Oxygen, Temperature, and *Enterococcus* levels.

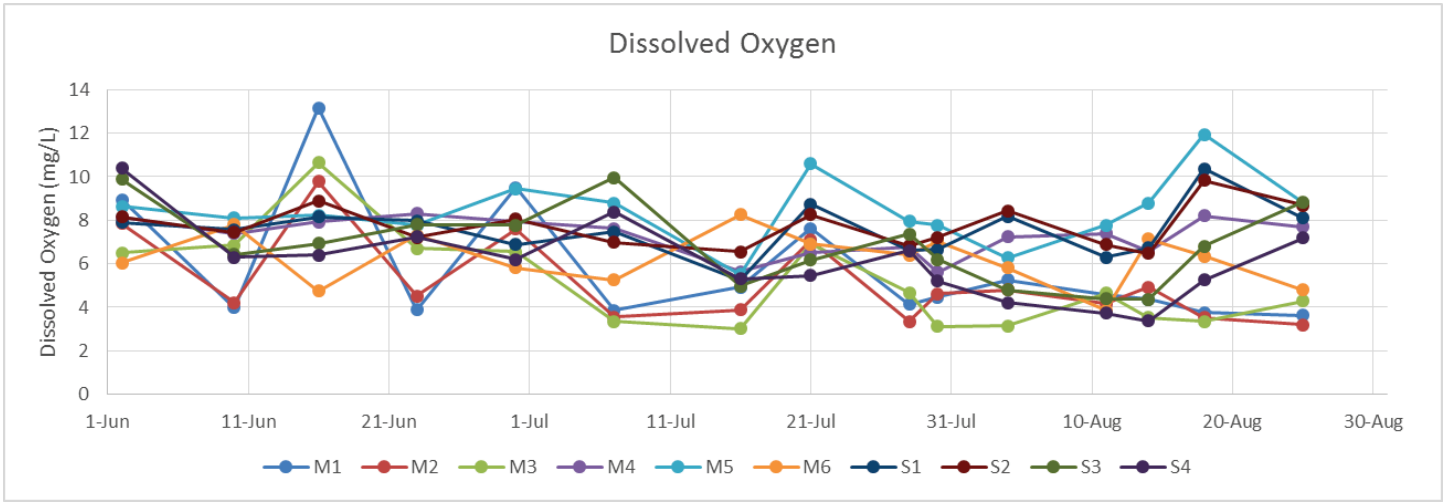


Figure 2: Dissolved oxygen. At the sites, dissolved oxygen was variable over time and site. Dissolved oxygen was mostly within the NJDEP acceptable range (above 4mg/L), meaning that hypoxic events were rare at these sites. It should be noted that this represents a discrete measurement; oxygen levels are highly variable over time and throughout the day

due to photosynthetic activity of the associated flora (Huggins & Anderson, 2005), and therefore this may not be representative of the daily average. Additionally, there may be periodic hypoxic events that were not recorded over the summer.

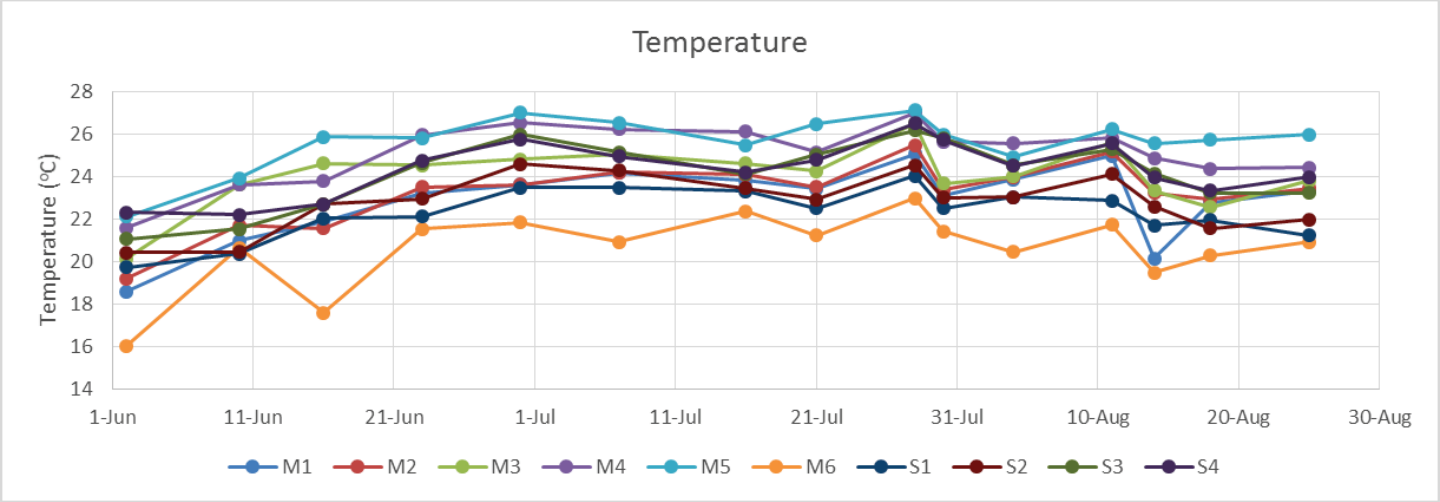


Figure 3: Temperature. At the sites, temperature followed the general pattern of warming over the summer months. At all sites except M6, temperature was fairly constant and within the range of 20-26°C. However, M6 (located at the headwaters of the creek, in Lake Lefferts) displayed variability of temperature. At this site, the shallow waters warmed easily in the sun. Depending on the time of day and cloudiness of the day, the water may have been cooler during the time at which it was sampled. Again, as stated above, a discrete measurement does not give the most accurate picture of the long-term temperature readings at the site.

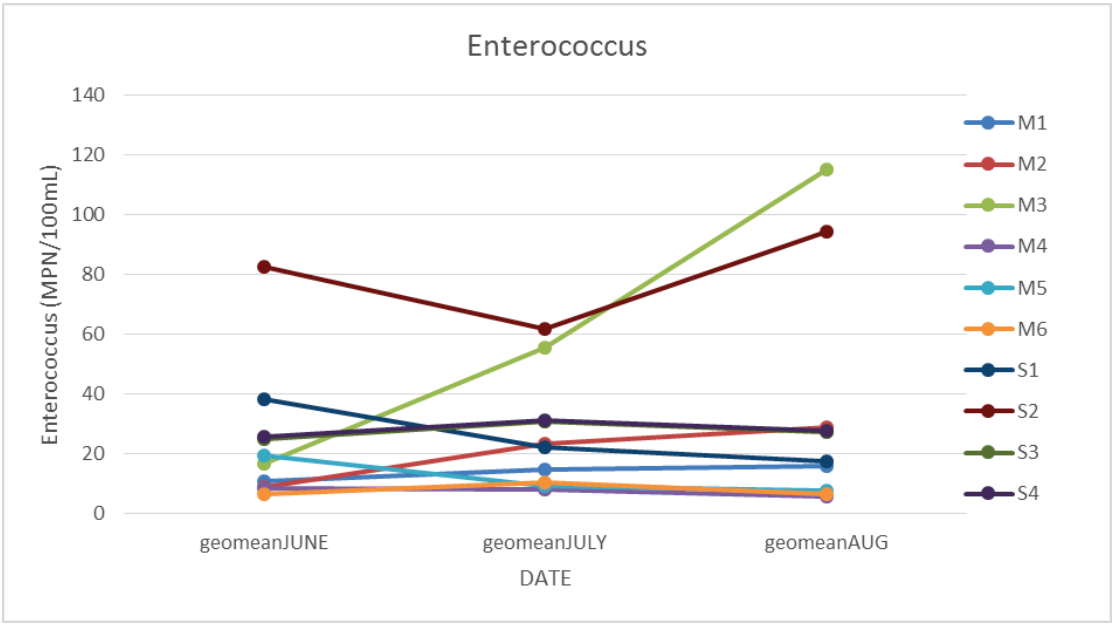
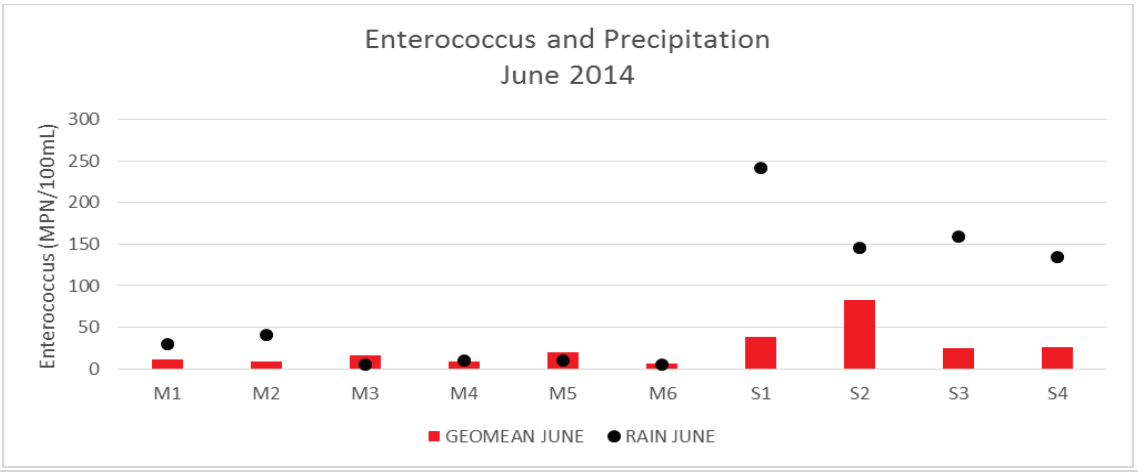
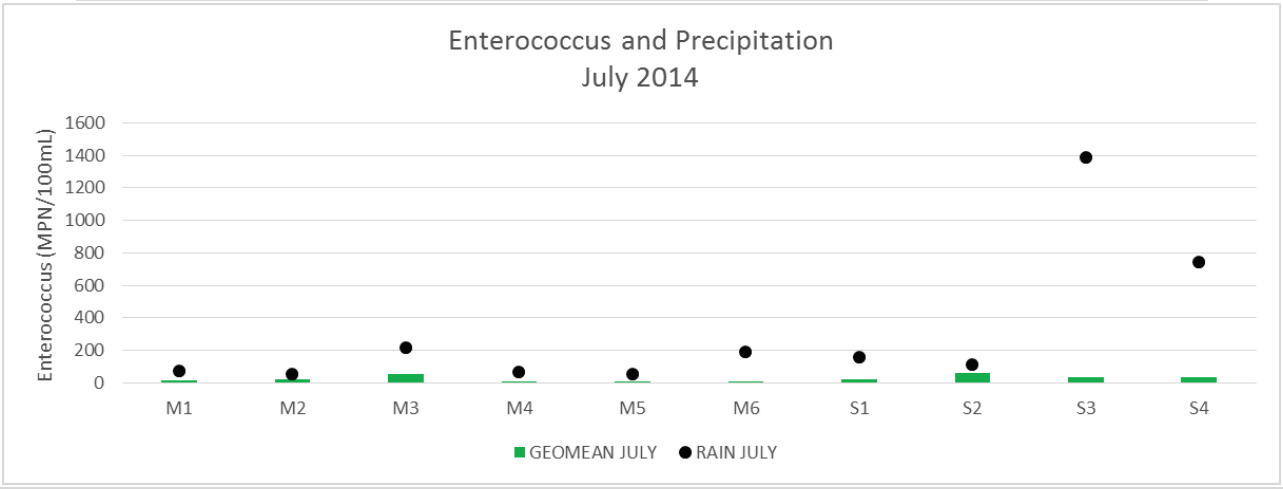


Figure 4: *Enterococcus* levels. Geometric means were calculated over the month (n=5 sampling dates; once a week plus an additional date following a rain event). The levels of *Enterococcus* were below the EPA standard for health of recreational waters for the most part (35 CFU, USEPA 2012). At sites S2 and M3, however, the geometric means escalated above the threshold and were found at levels that could be harmful to human health. Since the additional date was always following a rain event, it is possible that the geomean is slightly higher than average (biased) which has been taken into account when analyzing data.

A closer look at the *Enterococcus* data, correlated with the rain events, yielded additional insights about site conditions. It was noticed that the *Enterococcus* levels were much higher immediately following precipitation rather than during a dry period.





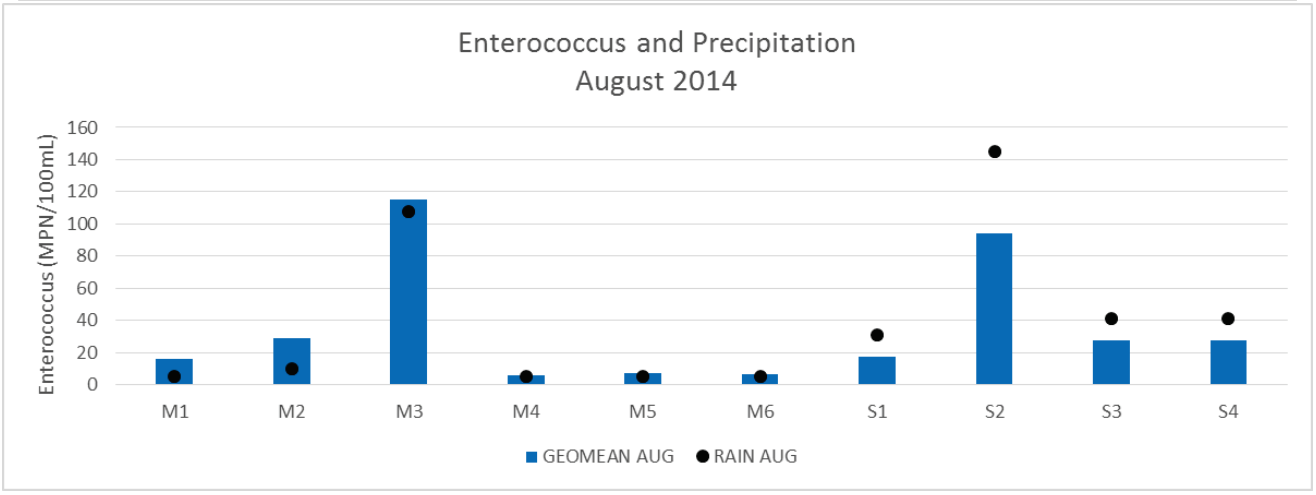


Figure 5: *Enterococcus* levels and rain events during June (top), July (middle), and August (bottom) 2014. On each panel, the geometric mean of the month is shown, with the *Enterococcus* levels on the rain event superimposed over the mean. Please note the differences in scale of the y-axis. In the top panel, the geometric mean over June is shown. The highest *Enterococcus* levels were found in South River, with S2 having the highest at 82.7 MPN. However, the rain event yielded 241MPN at S1, and the rest of South River was elevated (134-159 MPN) as well. Matawan Creek remained low, even following rain. In the middle panel, the geometric mean over July is shown. The scale on the y-axis is greatly increased, due to the elevation of the Enterococcus in South River following the rain event. The average *Enterococcus* levels were once again highest at S2, and in South River in general. The highest site after a rain event was S3 (1391 MPN), and the rest of south river was above 100 MPN as well. Matawan Creek was not elevated following the rain event except at M3, which has an outfall pipe very close to the sampling site and is located along a residential street. The bottom panel shows the geometric mean over August. South river is not the highest during this month. The highest mean was found at M3 (115 MPN), though the next highest was S2 again. The highest sites during the rain event were S2 (145 MPN) and M3. Though the scale fluctuated over the summer, the sites with the highest *Enterococcus* levels remained the same. The

increase of *Enterococcus* in the streams during July could be due to the increased precipitation during the month; according to the weather station in New Brunswick NJ, the average rainfall amount in July 2014 was 7.15", whereas only 3.93" fell in June, and 1.88" in August.

Accomplishments: A list of deliverables produced during this project:
1. Presentations: A presentation was given November 21, 2014, as part of a final seminar on Citizen Science. This was put together by HEP and the Hudson River Foundation, and featured a presentation by all Citizen Science Groups and a panel featuring DEP and EPA representatives. Copies of the presentations are available via HEP (http://www.harborestuary.org/citizenscience-2014project.htm).

A presentation was given to NY/NJ Baykeeper staff on October 8, 2014. During this presentation, summer interns Qi Zhang and Jia Huang gave an overview of the summer sampling protocols and laboratory procedures to staff as the final completion of the summer internship program. Copies are available (email allison@nynjbaykeeper.org).

2. Interactive Map: An interactive map was developed by the Center for Urban Research at the CUNY Graduate Center for HEP using the water quality data gathered during the summer. The map places all NY/NJ Baykeeper sites, along with those from other groups, into an interactive display where date, *Enterococcus* levels, rain events, and other metrics can be viewed. (http://www.harborestuary.org/citizenscience-2014project.htm).

3. Participation in training sessions with the USEPA: All staff connected to this project were required to attend several training sessions at the USEPA (Edison NJ) with HEP staff, EPA staff, and DEP representatives. The aim of these sessions was to teach citizen scientists (a) how to use the equipment (YSI, Garmin GPS) and collect samples; (b) how to follow quality assurance and quality control procedures as described in the QAPP, (c) how to manage and analyze data and upload to the USEPA STORET water quality portal, and (d) how to analyze *Enterococcus* using the Enterolert method in the laboratory. During these trainings, citizen science groups had the opportunity to ask questions and practice protocols with trained professionals.

4. Development of final project design, implementation of the field and lab protocols, data analysis, and input into STORET: The entire project detailed above was designed and performed by NY/NJ Baykeeper staff and interns. Though HEP and USEPA had input into the project design, the ultimate design (including choice of creeks, type of field collection, and data analysis) was NY/NJ Baykeeper's. Interns and staff were out at the field sites every week, in the laboratory to analyze Enterococcus samples twice a week, and spent extra time inputting data from field collection sheets to the Excel program and eventually the STORET database.

5. Required reporting of grant progress: As per NEIWPCC/HEP requirements, quarterly progress reports were submitted, with details as to what NY/NJ Baykeeper was doing each month. Additionally, a final report was prepared, and a final presentation to the grantors was given.

Project evaluation:
1. Overall success: This project was termed successful as it met or exceeded all requirements and produced all deliverables necessary. The project was able to (1) identify a watershed in need of water quality data, that would be positively impacted by the data conclusions (whether they be positive or negative), (2) use citizen scientists to gather water quality data and analyze results, (3) map all data and produce a final report analyzing results, and (4) provide these data to the proper state and federal agencies to be used as appropriate.

2. Data use and recommendations: The data gathered and produced via this project will be used: (1) by NY/NJ Baykeeper as part of the larger data file of water quality in the Hudson-Raritan Estuary, (2) to inform local government policy and regulatory decisions, (3) to inform national and state government policy and regulatory decisions within the local watershed and (4) to educate NY/NJ Baykeeper members and the general public on local water quality through dissemination of information on the NY/NJ Baykeeper website, social media and presentations. The conclusions drawn

from this project helped NY/NJ Baykeeper to determine the relative health of the Lower Raritan River (WMD 9) and Monmouth (WMD 12) watersheds (as per NJ DEP), which will be used to structure future studies and inform policy decisions around the watershed.

Though this was a well-designed study, throughout the course of performing the data collection some potential improvements became clear. If this project were to be repeated again next season, the following changes would be made: (1) fewer data observations would be gathered per site- there were over 20 parameters observed each time, in addition to the YSI and GPS data; and (2) a second bacterial count would be performed, as per the NJ DEP, enumerating the *E.coli* bacteria as an alternative indicator of water quality health in freshwater (less than 5ppt salinity) systems.

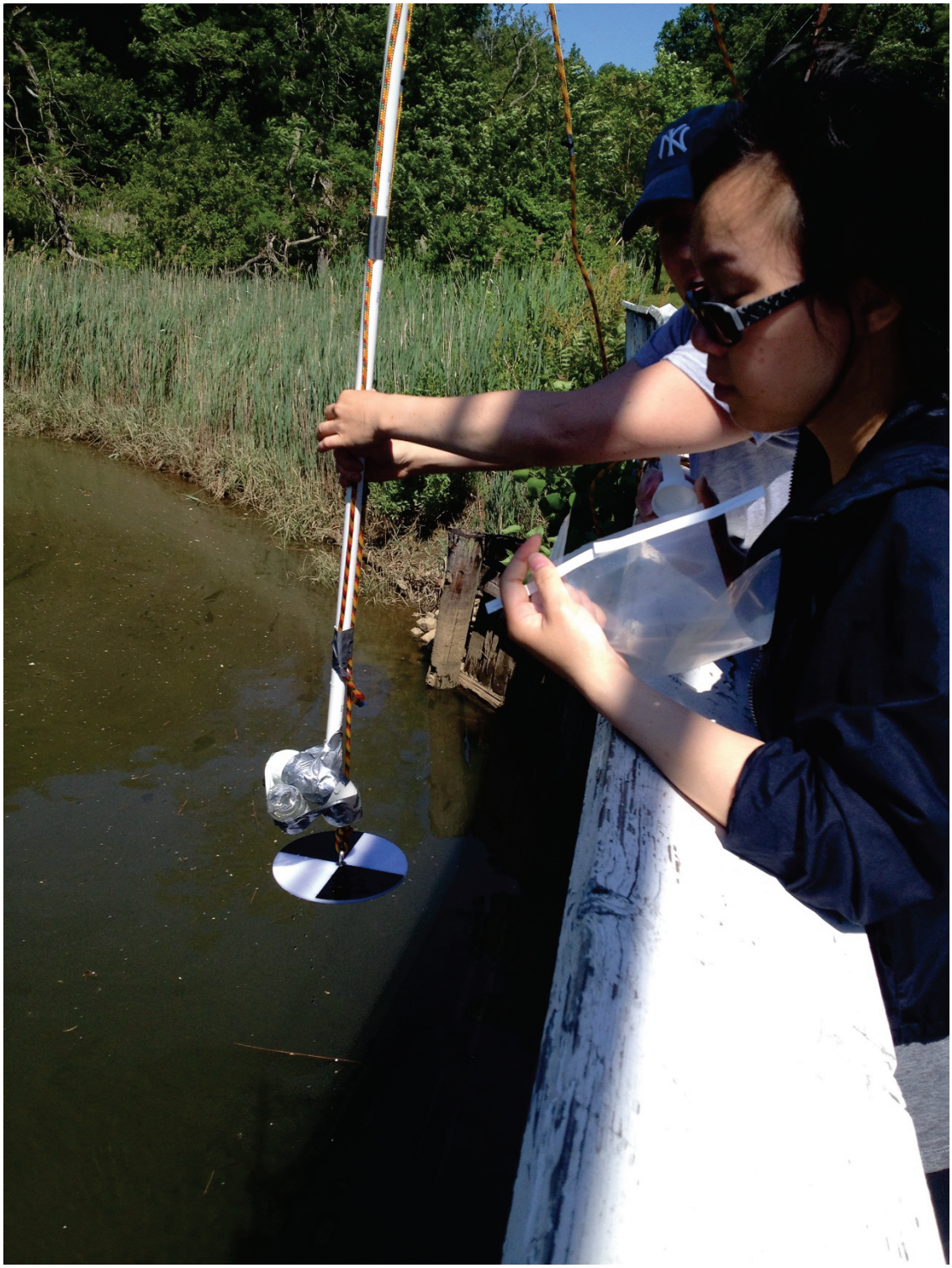
Lessons learned: There were many lessons learned throughout the course of this study.
1. Choose sites wisely: At the beginning of this study (February 2014), fifteen sites were chosen. However, as the weather warmed and sites were physically looked at, it was determined that accessibility at several of those was impossible. The sites were then weaned down to the ten detailed above (see Figure 1).

2. Practice sampling measures: The first sampling event in June took much longer due to unfamiliarity with the equipment and data collection. After the first few sampling events, the collection went much more smoothly.

3. Laboratory practices must be exceptionally thorough and clean: As per the US EPA guidelines, the laboratory examination of *Enterococcus* bacteria must follow a rigid and precise procedure, to ensure that the data are reliable.

Conclusions and Recommendations: As stated above, the conclusions drawn from this project are that the South River watershed harbors more Enterococcus bacteria on a monthly basis than the Matawan Creek watershed. Additionally, following a large precipitation event, more Enterococcus bacteria washes into the South River watershed (and at some locations along Matawan Creek). The increased flushing of Matawan Creek (via Raritan Bay) and higher salinity waters at M1-M3 may contribute to this. NY/NJ Baykeeper strongly recommends that these data be used by the NJ DEP and the US EPA to inform water quality decisions in the local watershed, and throughout the Hudson Raritan Estuary, including land use policies, stormwater management and the development of Total Maximum Daily Loads (TMDLs) for impaired waterways.

Pictures: For additional photos of each site, please contact allison@nynjbaykeeper.org



Picture 1: Summer intern Jia Huang (front) and Dr. A.M. Fitzgerald (back) using a sampling apparatus to gather water sample for Enterococcus testing at site M3 (Matawan Creek), June 2014.

Picture 2: Possible pollution source- outflow pipe at site M3 (Matawan Creek), July 2014. The pipe is only visible at low tide.

Picture 3: Summer interns Jia Huang (front) and Qi Zhang (back) using the YSI probe and recording weather observations at site S1 (South River), June 2014.

Picture 4: Site S4 (South River). The water was sampled from the rocks above via a sampling apparatus. The bridge visible is a roadway over the river. August 2014.

Disclaimers and logos:

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Works Cited:

Huggins, D.G., and J. Anderson. 2005. Dissolved Oxygen Fluctuation Regimes in Streams of the Western Corn Belt Plains Ecoregion. Report No. 130 of the Kansas Biological Survey. University of Kansas, Lawrence KS.

USEPA. 2012. Recreational water quality criteria. Handbook.