

## APPENDIX C - WATER QUALITY MONITORING IN THE MB UA: SUPPORT FOR MCMS #1 AND #2

The SMS4s of the Myrtle Beach Urbanized Area continue to partner in water quality monitoring programs that help fulfill MCM #1 for outreach, MCM #2 for public engagement and MCM #3 for illicit discharge detection and elimination. The monitoring data can also provide insight into long-term water quality trends, and hence, help evaluate progress in MCM #5 for post construction discharges. Some of these programs are staffed by volunteers and others are conducted by CCU's Environmental Quality Laboratory (EQL) that is certified by SCDHEC.

To address MCM #1, all monitoring data are accessible through public websites. The URLs are advertised via business cards that are program specific. These URLs are presented in collated form at: <http://www.coastal.edu/wva/datasets.html>. An upgrade has been completed to enable co-plotting of sites on time trend graphs and co-plotting of parameters on time trend graphs. Web counters are used to document traffic at these sites and these quantitative results are included in the CWSEC (bi)annual reports to the SMS4. Data are also being uploaded to the national STORET Data warehouse using the US EPA's Water Quality Exchange (WQX) portal. The uploaded data are available to the public via US EPA's My Waters Mapper (<http://www.epa.gov/waterdata/my-waters-mapper>) and the National Water Quality Monitoring Council's Water Quality Portal (<http://www.waterqualitydata.us/index.jsp>). The latter also houses data from the United States Geological Survey's National Water Information System (NWIS) and the United States Department of Agriculture, Agricultural Research Service's (USDA ARS) Sustaining the Earth's Watersheds - Agricultural Research Database System (STEWARDS). The monitoring programs in the Myrtle Beach UA and their data have been described in the proceedings of the SC Water Resource Conference, StormCon, the SC Environmental Conference, SC

Association of Stormwater Managers, and the SC Water Resources Journal, as well as the National Water Quality Monitoring Council's National Monitoring Conference.

In 2016, that South Carolina Sea Grant Consortium established a data portal, the South Carolina Coastal Water Monitoring Network (SCCWMN) to provide a map-based depiction of locations of long-term water monitoring and monitoring in response to events such as flooding in coastal South Carolina. All of the monitoring programs being conducted in the Myrtle Beach Urbanized Area are featured at this data portal. In addition to site locations, metadata is provided for when the monitoring has been conducted, what has been measured and how to get access to the data. This portal is in beta testing mode and located at: <https://scseagrant.maps.arcgis.com/apps/webappviewer/index.html?id=34eafc714c8e4007ad7b9d891386888f>

The monitoring data continue to be used in presentations to municipal councils and committees. Use of the data for IDDE is facilitated through production of biweekly provisional reports. These reports highlight findings of regulatory exceedances of water quality criteria and site-specific norms. The latter are based on annually updated percentile rankings developed from each sampling site's historical dataset. This rapid reporting was the subject of a talk presented at the May 2016 meeting of the National Water Quality Monitoring Conference.<sup>1</sup> A similar presentation was delivered at the biennial South Carolina Water Resources Conference held in October 2016.

In most of the programs, data sets are now long enough to conduct statistical tests for long-term trends. These have been performed using the same tests that SCDHEC uses for its watershed water quality assessment reports, i.e. the seasonal Mann-Kendall test for monotonic trends.

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<sup>1</sup> Libes, Susan (2016) Rapid provisional reporting in long-term monitoring programs for detection of illicit discharges by NPDES SMS4 communities. 2016

National Water Quality Monitoring Conference held in Tampa, Florida, May 2-5, 2016 (oral)

To address MCM #2, Horry and Georgetown Counties, the City of Conway, and the Town of Surfside Beach support volunteer water quality monitoring programs run collaboratively with CCU’s Waccamaw Watershed Academy (WWA) and field leaders as shown in Table 1.

To address MCM #3, CCU’s WWA produces provisional reports and potential IDDE reports that are sent to the relevant stormwater managers. These reports compare measurements to state water quality standards, site-specific norms established by the program data, and US EPA recommended water quality thresholds. In the case of findings that suggest a new acute illicit discharge has been detected, the volunteers and EQL staff alert the program coordinator immediately so that this information can be transmitted as quickly as possible to the stormwater managers. Several such cases occurred and resulted in site reconnaissance efforts on the part of the stormwater managers.

More details on each of the monitoring programs along with highlights from 2016, such as the IDDE investigations, are provided below.

**Volunteer Water Quality Monitoring**

Three volunteer monitoring water quality monitoring programs are being supported in the MB UA. Details are provided in Table 1.

Sampling is conducted biweekly year round and data are posted within two weeks of collection at <http://bccmws.coastal.edu/volunteermonitoring/>. Management meetings are held with the field leaders. With some exceptions, each program hosts an annual data conference for the public and a luncheon for its volunteers. Presentations from these events are posted at the program websites (<http://www.coastal.edu/wwa/vm/>) maintained by the WWA. These websites include rain data from NOAA’s CoCoRaHs (Community Collaborative Rain, Hail and Snow Network) volunteer monitoring program. NOAA’s NERRS Central Data

Management Office is also providing areal estimates of daily rainfall by sub-watershed.

Table 1 - Volunteer Water Quality Monitoring Programs in the Myrtle Beach Urbanized Area

Monitoring Program	Field Leader	Sampling Sites	Number of Volunteers	Start Date	Funding Partners
Waccamaw River	Waccamaw Riverkeeper	6 in NC 12 in SC	54	2006	Georgetown & Horry Counties, City of Conway
Murrells Inlet	Murrells Inlet 2020/Robert Steffens	8	18	2008	Georgetown & Horry Counties
Surfside Beach	Ken Harth	2	6	2010	Town of Surfside Beach
CCU Campus	Waccamaw Riverkeeper	3	5	2011	CCU’s WWA & QEP Program

These programs are included in the: (1) Volunteer Water Quality Monitoring National Water Resource Project’s listing of Volunteer Water Quality Monitoring and Master Naturalist Programs (<http://www.usawaterquality.org/volunteer/VolunteerMonPrograms/index.html>); (2) US EPA’s National Directory of Volunteer Monitoring Programs: <http://yosemite.epa.gov/water/volmon.nsf/Home?OpenForm>; and (3) National Water Quality Monitoring Council’s Volunteer Water Quality Monitoring Program Directory: [http://acwi.gov/monitoring/vm/programs/vm\\_map.html](http://acwi.gov/monitoring/vm/programs/vm_map.html).

An inventory of the water quality measurements made to date in each of the programs is provided in Table 2. These collectively represent about 83,000 measurements.

Table 2 - Water quality measurements made to date in the volunteer monitoring programs of the Myrtle Beach UA

Program	Site	Samplings	Measurements per sampling event	Total independent measurements
Waccamaw River since June 2006	Maple Street	93	11	1,023
	Canal Cove	93	11	1,023
	Big Creek	93	11	1,023
	LAWA Dam	93	11	1,023
	Babson's Lndg	60	11	660
	Pireway	60	11	660
	Hwy 9	226	11	2,486
	Reaves Ferry	217	11	2,387
	Murrells Lndg	1670	17	28,390
	Sterritt Swamp	206	11	2,266
	Conway	226	11	2,486
	Pitch Landing	226	11	2,486
	Peachtree	189	11	2,079
	Enterprise	224	11	2,464
	Bucksport	227	11	2,497
Wachesaw	228	11	2,508	
Hagley	224	11	2,464	
Sampit	220	11	2,420	
			Total =	60,345
Murrells Inlet since May 2008	Woodland Drive Pond	180	11	1980
	Point Drive Canal	179	11	1969
	Rum Gully Creek	179	11	1969
	Marina Colony Pond	179	11	1969
	HS	181	11	1991
	BHR	180	11	1980
	Bike Bridge	181	11	1991
	Oyster Landing Beach	180	11	1980
			Total =	15,829
Surfside Beach since May 2010	11th Ave N	128	11	1408
	4th Ave N	128	11	1408
			Total =	2,816
Campus Volunteer Monitoring since Oct 2011	501 West	119	11	1309
	544 East	17	11	187
	544 West	115	11	1265
	Wall Pond Bridge	103	11	1133
	Wall Pond East	2	11	22
	Wall Pond West	2	11	22
			Total =	3,938

All datasheets and QA/QC paperwork continue to be bound annually using a uniform format. The binders are maintained in an archive in the EQL that requires users to sign out the binders. This procedure is modelled after the one in use in the EQL. A new archive room was secured in CSC 111. Hard copies of the volunteer training records are kept in individual folders. Records are reviewed quarterly to insure that retraining is conducted annually for each activity that a volunteer is qualified to conduct.

In 2016, the following initiatives were undertaken to enhance data quality: (1) Development and implementation of a document control system for all standard operating procedures and forms. This required renumbering and unifying formats as well as instituting an electronic and hard copy archiving system. This was done to align records for a planned revision of the Quality Assurance Project Plan in 2017. (2) Concerted investigation into methodology issues with dual confirmation medium used for enumerating E. coli. This investigation was prompted by comparison of volunteer data with results from a microbial source tracking study performed in Surfside Beach during the summer of 2015. This investigation was performed as part of a graduate student research thesis and was the subject of a presentation at the April 2016 annual joint program volunteer luncheon.

CCU's staffing changes in 2016 were required as the program coordinator (Kelly Hall) stepped back into a part-time role due to health issues. The assistant coordinator, A.J. Taylor, assumed the duties that she is no longer covering.

On the field leader front, personnel changes included:

- Murrells Inlet: Executive Director of Murrells Inlet 2020 has resigned. One of the volunteers, Robert Steffens continues to perform the field leader duties previously performed by the late Jim Wilkie.
- Waccamaw River: Emma Boyer, Waccamaw Riverkeeper, is stepping down effective June 2017, and a search is underway for her replacement.

- **Campus Monitoring:** The Coastal Marine and Wetland Studies program awarded a graduate fellowship to a graduate student to serve as a teaching assistant who primary duties are to run the campus monitoring program.

Additional details on each of the volunteer monitoring programs and highlights from 2016 are provided below.

### Murrells Inlet

Eight sites have been monitored since 2008 by 18 volunteers. CCU and Murrells Inlet 2020 had partnered on a weather station with observations accessible through a Weather Underground site that went online in September 2013. Due to issues with the wireless data transmission, plans are underway to relocate the weather station from the Crazy Sister Marina to a pole behind the offices of Murrells Inlet 2020.

The watershed-based plan for Murrells Inlet, approved by SCDHEC in August 2014, is being implemented by a steering committee that includes CCU’s WWA, Murrells Inlet 2020, and the stormwater managers of Horry and Georgetown Counties.

A data presentation was given as requested at one of the semiannual meetings of the steering committee on April 21, 2016. This was done in lieu of the more traditional data conference that has been done in past years to deliver information to another audience. The data conferences are typically attended by the volunteers, CWSEC and stormwater staff. The volunteers did attend a joint annual luncheon held on April 20<sup>th</sup> at the Burroughs & Chapin Center for Marine and Wetland Studies. On January 9, 2016, WBTW conducted interviews of the Murrells Inlet Field Leader and Volunteer Monitoring Coordinator at the sampling sites for an extended TV report.

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<sup>2</sup> Cara Schildtknecht, Jeff Barley, Adam Leaphart, and Susan Libes (2016) Murrells Inlet Estuary Microbial Source Tracking Study. SC Environmental Conference held at the Myrtle Beach Convention Center, March 13-15, 2016 (poster)

Robert Steffens has continued as the field leader. Renee Williamson (MI2020) continued to serve the program by providing outreach through her organization that includes posting information in the printed newsletters and the emailed updates. This has been used as a venue for recruiting new volunteers. Stephen Williams represents MI2020 as a reviewer of the biweekly provisional reports. Renee resigned her position in December 2016. Details regarding her replacement are to follow shortly.

In October 2014, SCDHEC awarded a US EPA 319 grant to the Waccamaw COG to fund implementation work. The volunteer monitoring data will be used to assess the degree to which the BMP’s are reducing fecal bacteria. A microbial source tracking efforts at three sites on the south end of Murrells Inlet was conducted during the summer and fall at the request of Georgetown County. The final project report was produced in October 2016. The results were presented in a poster at the SC Environmental Conference.<sup>2</sup>

### Waccamaw River

Twelve sites in SC have been monitored since 2006 and 6 sites in NC since 2011. This bi-state effort engages 54 volunteers and over the life of the program has generated over 60,000 measurements, providing the basis for spatial and temporal trend analyses.

The annual volunteer appreciation luncheon was held on April 20, 2016. The purpose of the luncheon is to recognize and provide an update to our volunteers. This meeting was a joint effort to bring all the volunteers from all the programs together to compare results from their bacteria monitoring. This also provided an opportunity to socialize with other volunteers and was such a success that we plan to continue this in 2017.

Data generated from this program is presented at the Annual Data Conference that is usually scheduled to coincide with the World Water Monitoring Challenge from September 18<sup>th</sup> – October 18<sup>th</sup>. In 2015, the scheduled conference was pre-empted by the historic flooding on the Waccamaw and deferred until January 20<sup>th</sup> 2016. The next data conference was held on October 18, 2016 and featured results of sampling after Hurricane Matthew that occurred the week prior to the meeting. This enabled a discussion of how to implement lessons learned from sampling in the aftermath of Hurricane Joaquin flooding in 2015. After the latter, unusually low oxygen saturation and high turbidity was observed. A possible cause was leaching of reduced metals, sulfide and methane from the shallow groundwater as it drained into the river. To test this hypothesis, Horry County requested that the USGS undertake some trace metal sampling.

An IDDE investigation was continued at Sterritt Swamp in response to continued episodic elevations in turbidity and conductivity. Not all of these coincide with rain events and some of the turbidity measurements exceeded the state water quality criteria of 50 NTU. Horry County has engaged with SCDHEC for site investigations seeking the source of the sediment. The Waccamaw Riverkeeper has engaged with the Horry County Solid Waste Authority to compare sampling data and request partnering on monitoring upstream of their property.

In June 2015 the program entered its 10<sup>th</sup> year of volunteer monitoring and this fact was celebrated at the January 20<sup>th</sup> 2016 Annual Data Conference. Included were presentations from: USGS (USGS National Water Census, Coastal Carolinas Water Availability Study); SCDHEC (SC Surface Water Quality Monitoring – Waccamaw Basin); CCU's WWA (Using the Online Database to Visualize Spatial and Temporal Water Quality Trends); Horry County Stormwater (Freshwater Mussels in the Waccamaw and Pee Dee Rivers); as well as updates from

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<sup>3</sup> Libes, S. (2016) What the weather has brought to the Waccamaw this year: Impact of flooding on water quality. 2016 Annual Waccamaw Conference,

Georgetown County Stormwater and the Waccamaw Riverkeeper, including an update on the benthic macroinvertebrate monitoring program that commenced in 2013 as a citizen science project with support from SCDHEC, Clemson University and grant funding from International Paper.

Presentations from both the volunteer appreciation luncheon and the annual data conference are archived at <http://www.coastal.edu/wwa/vm/wr/publications.html>.

The Waccamaw RIVERKEEPER® Program oversees the volunteer monitoring effort in North Carolina in partnership with Lake Waccamaw State Park and financially support through grants from International Paper, Columbus County and Z Smith Reynolds Foundation. CCU's WWA provides pro bono support for this effort. Efforts continue to secure a sustainable funding source for continued operational needs. Of particular concern is a recent trend in elevated turbidity at the two sites immediately upstream of the NC/SC state line whose source is thought to be from logging operations. These turbid waters flow into South Carolina, and thus, pose a threat to water quality downstream.

The program continues to rely on data generated by the USGS gages (water quality, discharge, gage height) and corroborate the VM generated data. The USGS presented a report at the October 18, 2016 data conference.

Information from the Waccamaw River Volunteer Monitoring Program is also presented at the Waccamaw Conference, an annual public education event hosted by the Waccamaw Riverkeeper<sup>3</sup>. The 2016 Waccamaw Conference was held on March 5, 2016.

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#### Surfside Beach

Two sites have been monitored since 2010 by 2 to 4 volunteers. Data updates are being provided by CCU (S. Libes) to the Town of Surfside Beach's Stormwater Committee during their quarterly

Waccamaw Riverkeeper, Horry-Georgetown Technical College Conference Center, Myrtle Beach, March 5, 2016.

business meetings. These include printed reports that summarize Surfside's volunteer water quality monitoring and SCDHEC beach Enterococcus monitoring data. A requested presentation was delivered on July 25, 2016 to educate committee members on the sources of nonpoint source pollution in Surfside and what steps residents and tourists can take to minimize this.

An IDDE event involving turbidity issuing from construction sites upstream of Surfside was detected by the volunteers in Lake Dogwood in January - February 2015. Through engagement of the stormwater managers, the source was identified and eliminated. The turbidity in Lake Dogwood returned to site-specific normal values in June. Another IDDE event occurred in February 2016 and was similarly addressed.

In the summer of 2015, a microbial source tracking effort that was conducted by CCU's EQL at the request of Surfside's stormwater manager in Myrtle Lake revealed E. coli concentrations substantially higher than had been reported from the volunteer monitoring program. The cause of this discrepancy was investigated as part of the thesis research performed by a CCU graduate student in 2016 and was discussed at the joint Volunteer Luncheon held on April 20, 2016. As a result, after extensive field validation and training, a new methodology is being used for E. coli monitoring (3M™ Petrifilm) at both sites.

In 2016, the volunteer monitoring informational trifold brochure was revised for use at 2017 outreach events planned by the Town.

### Long Bay Hypoxia Monitoring Consortium

Horry County and the Cities of Myrtle and North Myrtle Beach are collaborators in the Long Bay Hypoxia Monitoring Consortium (LBHMC). The goal of the LBHMC is to monitor water quality and meteorology at three fishing piers (Second Ave. Pier, Apache Family Campground and Pier, Cherry Grove Pier). The monitoring data are being used to characterize normal conditions for oxygen, salinity, temperature, pH, turbidity and

chlorophyll in the coastal waters of Long Bay and to detect occurrence of hypoxia and eutrophication. Data are collected every 15 minutes from the surface and bottom waters and every 5 minutes via a weather station. CCU's EQL is responsible for technical support and data management.

In 2015, the data relay was transitioned from YSI Econet to SutronWin with funding provided by the Burroughs and Chapin Center for Marine and Wetland Studies. Data from July 2015 are made available to the public at SutronWin website: <http://sutronwin.com/sutron/logincontroller?action=login&username=user&password=user>. A new series of real-time displays were also implemented for the large screen monitors deployed at the piers (<http://www.coastal.edu/pierdata>). A new website was developed to direct users to the multiple ways the data can be viewed and to the data collected prior to July 2015 (<http://scmss.coastal.edu/project/lbhmc>), including CCU's Long Bay Observing System: <http://bccmws.coastal.edu/lbos>. Real-time data are streaming to monitors at each of the piers. The EQL continues to conduct outreach activities biannually at Apache Pier; Local's Appreciation Day and Kid's Appreciation Day.

All of the data have been ingested into CCU's Long Bay Observing System. The goal is to expand the web app to provide public access to the entire data set, both raw and corrected versions. In the meantime, static versions of the historical data have been posted at <http://scmss.coastal.edu/project/lbhmc>. In 2016, the LBOS data portal (<http://bccmws.coastal.edu/lbos>), which had displayed the past 24 hours of data, was upgraded to display the past 30 days of data.

The data are being harvested for deposit into regional and national databases, such as the Integrated Ocean Observing System's Southeast Coastal Ocean Observing Regional Association (SECOORA) and the National Weather Service's Meteorological Assimilation Data Ingest System (MADIS) via US Mesonet.

The data collected are notable, as they represent the only continuous water quality information on pH, turbidity and



chlorophyll being collected in the coastal waters of South Carolina. The pH data are of particular interest to national initiatives directed at studying impacts of ocean acidification in coastal waters. In 2016, the effects of an historic flood associated with Hurricane Matthew initiated a period of anomalously low salinity in the nearshore of the Grand Strand that was detected by the pier sensors and was similar to that detected following Hurricane Joaquin in 2015.

The data are also being used to support assessment required as a special condition of a SCDHEC OCRM permits issued for installation of the Main Street Ocean Outfall in the City of North Myrtle Beach and the 4th Ave N Ocean Outfall in Myrtle Beach. An update on this connection was presented on December 8, 2016 as part of workshop conducted by the Governor's South Atlantic Alliance.<sup>4</sup>

Two peer-reviewed papers were generated in 2016:

Peterson, R.N., W.S. Moore, S.L. Chappel, R.F. Viso, S.M. Libes and L.E. Peterson (2016) A new perspective on coastal hypoxia: The role of saline groundwater, *Marine Chemistry*, 179(1), 1-11.

Troup, M.L., D.B. Fribance, S. Libes, R. Gurka and E.E. Hackett (2016) Physical conditions of coastal hypoxia in Long Bay, South Carolina: 2006-2014, *Estuaries and Coasts*, in revision.

Low oxygen continues to be episodically observed during summer months. From analysis of the data collected at all three piers since spring 2012, conditions of low oxygen have been documented at all three piers, occurring concurrently along with low pH, high turbidity and chlorophyll. Spectral analysis performed by Troup et

al. (submitted) suggests that these episodes are related to vertical temperature stratification that limits mixing in the nearshore waters and that the current inshore are substantially different from the ones more than ½ mile offshore.

In 2016, a proposal was submitted to NOAA's Coastal Hypoxia Research Program to investigate the offshore spatial extent of low oxygen in Long Bay using continuous sensors deployed in a grid about 1 km from the coast.<sup>5</sup> These data were to be used to validate models that will seek to test the sensitivity of oxygen levels in Long Bay to increased terrestrial nutrient and organic matter loading and to climate change (i.e. intensification of the hydrological cycle and warming waters). The proposal was not funded but the USACOE is exploring options for funding through their Planning Assistance to States Program. Another proposal will be submitted to NSF in 2017 to request funding to support this work.

While no gear was lost during Hurricane Matthew that hit on October 8, all of the piers sustained damage, which has had an impact on the monitoring programs. At all piers, deployment hardware was damaged and had to be replaced. Estimated costs were about \$10,000 including travel and salary time that include preventative removal of all sensors on October 4, 2016. Most notably, the pier end at 2<sup>nd</sup> Ave. was destroyed so we were not able to resume operations until January 10, 2017. The Apache Pier record resumed on November 1, 2016 and the Cherry Grove record, on October 13, 2016. When the 2<sup>nd</sup> Ave. Pier is rebuilt, some interruption in monitoring is anticipated and the deployment set up will need to be replaced. A similar disruption might occur at the other piers depending on the extent of repairs performed.

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<sup>4</sup> Blayton, K. and Libes, S. (2016) Reduction of Pollutant Loads as a Stormwater Management Option: City of North Myrtle Beach Ocean Outfall Program. Workshop on Strategies and Tools to Protect and Restore Coastal Water Quality. Governor's South Atlantic Alliance, held in North Myrtle Beach, SC on December 8, 2016. (oral, invited)

<sup>5</sup> Hackett, E., Libes, S., Coles, V., Fribance, D. and Gurka, R. Assessing Risks for Prevention of Severe Hypoxia and Ecosystem Degradation in the Open Embayment of Long Bay, South Carolina, submitted to NOAA's CHRP

Another casualty of Hurricane Matthew was NOAA's sole tide station which had been deployed at Springmaid Pier. The latter was completely destroyed. So at present, the only water level monitoring on the Grand Strand is occurring in the deep water sondes deployed by the LBHMC.

In 2016, discussions were initiated concerning the renewal of the five year contracts that fund the LBHMC's monitoring program. Each pier is on a somewhat different contract timeline. The one first up for renewal was Cherry Grove and that contract paperwork has been completed to be effective in February 2017. With this second five-year cycle, we will be migrating to YSI's current generation of datasondes (Exo's) and switching from Vaisala weather stations to products from Gill Instruments. During 2016, YSI performed a pilot test of the Exo's at the Apache Pier to ensure smooth communications with the Sutron dataloggers. We also field tested SeaBird's Coastal SeaCAT in an effort to find a solution that requires less maintenance to remove biofouling.

#### Beach Monitoring

Enterococcus data collected at 61 sites along the Grand Strand since 1997 by SCDHEC and the Cities of Myrtle Beach and North Myrtle Beach have been made available to the public at a website (<http://bccmws.coastal.edu/enteroview/>) constructed and maintained by CCU's EQL. This is a pro bono effort designed to support development of TMDL's microbial source tracking projects and to meet other needs for temporal and spatial trend analysis.

The Enterococcus data trends are used as a component of the water quality assessment required by SCDHEC as part of the special conditions for the permits issued for installation of the Main Street Ocean Outfall in the City of North Myrtle Beach and the 4<sup>th</sup> Ave. N Ocean Outfall in Myrtle Beach.

The EQL continues to coordinate sampling with SCDHEC during beach season to minimize the number of additional samples

needed to cover required follow up activities following reports of contraventions. In 2014, the EQL began issuing weekly potential IDDE reports for samples that contravened the Enterococcus water quality standards. The reports compare the weekly results to site-specific norms for Enterococcus and salinity using data collected from 2008 when the current monitoring protocol was initiated. Samples with unusually low salinity suggest that elevated bacterial levels could be due to stormwater runoff. Samples with normal salinity suggest that an illicit discharge could be the cause of the elevated bacteria levels. In 2016, at the request of SCDHEC, we added evaluation of swash sampling sites against site-specific norms. These norms are updated annually using the 90<sup>th</sup>, 95<sup>th</sup> and 99<sup>th</sup> percentiles for Enterococcus and the 10<sup>th</sup> and 25<sup>th</sup> percentiles for salinity.

In 2016, several microbial source tracking efforts was undertaken by the EQL at the request of the stormwater managers to investigate the sources of impairments. These include: 16<sup>th</sup> Ave. S in North Myrtle Beach and Hog Inlet.

The EQL met with SCDHEC on March 16, 2016 to discuss coordination for the upcoming beach season. This included robust discussions about the need for improved outreach so that a second meeting was held on August 18, 2016. This led to plans for an outreach workshop for the hospitality industry scheduled for February 2017. A presentation for property managers was given on April 6, 2016 that also focused on the causes and prevention of fecal indicator bacteria contamination. Content was also added to <http://www.coastal.edu/eql/projects/beaches.html> to address recent local concerns regarding ENTERO levels in surf zone bathing waters.

SCDHEC also requested that the EQL undertake an update of its beach monitoring Quality Assurance Project Plan in advance of the 2017 beach season. This update is currently underway.



## River Gauge Monitoring

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Since January 2008, Horry and Georgetown Counties and the City of Conway have been partnering with CCU's EQL and the USGS to maintain a monitoring program at eight sites in the Waccamaw River and one site in the Pee Dee River. The work is being performed under a SCDHEC approved Quality Assurance Project Plan.

Concurrently where the USGS is maintaining real-time water quality sensors, grab sampling is conducted for parameters that cannot be measured in-situ. The EQL also performs in-situ measurements to provide a back-up source of data for interpreting the grab samples. These data are being collated to provide a statistical comparison with the USGS real time data. The former have been certified by the SC DHEC, but not the latter so this comparison provides confirmation of the USGS data. When a lack of agreement is observed, the EQL notifies the USGS who then follows up to investigate a possible sensor failure.

The USGS real-time data are made available to the public at <http://waterwatch.usgs.gov/wqwatch/map?state=sc&pcode=00010>. The EQL's results are posted within one month of sampling at: [http://bccmws.coastal.edu/river\\_gauge/](http://bccmws.coastal.edu/river_gauge/).

The results are transmitted to the stormwater managers in provisional reports. A first report is sent within one to two days following sampling. The rest of the results can take as much as a month to generate, so a follow-up report is sent. As with the volunteer monitoring reports, these provisional reports compare the observations to regulatory standards, recommended levels and site-specific norms. The latter have been established from the entire dataset. Sampling is conducted on alternating weeks from the volunteer monitoring program to increase the temporal resolution of the monitoring data. Thus, data analysis includes a comparison with the results from the volunteer water quality monitoring program.

The monitoring information has also been enhanced by pro bono analysis of samples for dissolved organic carbon, True Color and colored dissolved organic matter. This information, coupled with DO and BOD measurements, is being statistically analyzed to try to distinguish natural from anthropogenic sources of oxygen-demanding substances that contribute to continuing contraventions of the DO water quality criteria throughout the Waccamaw River, especially during warm weather.

As in 2015, 2016 was highly influenced by the effects of flooding on the Waccamaw and Pee Dee Rivers following Hurricane Matthew in early October. Another issue has been observation of toxic effects most notably in October after the hurricane flooding started and during both samplings in February. Similar to 2015, unusually low oxygen saturation has been observed. A possible cause was leaching of reduced metals, sulfide and methane from the shallow groundwater as it drained into the river. To test this hypothesis, Horry County requested that the USGS undertake some trace metal sampling.

In 2016, the City of Conway and Horry County requested a microbial source tracking effort in Crabtree Canal in response to continuing episodic elevations of E. coli that exceed the state water quality criteria. To date, five genotypic assays were performed on samples collected from June to December 2016. These samples had elevated levels of E. coli and the genotypic assays provided evidence of human-sourced fecal bacteria. Both SMS4's have requested additional source tracking to narrow down the geographic location of the source of these bacteria.

In 2016, a new real-time sampling site was deployed in Winyah Bay by NOAA's North Inlet-Winyah Bay National Estuarine Research Reserve with funding provided by the Donnelly Foundation. The data are accessible in real time at [nerrsdata.org/get/realTime.cfm?stationCode=NIWWBWQ](http://nerrsdata.org/get/realTime.cfm?stationCode=NIWWBWQ) and [nerrsdata.org/get/realTime.cfm?stationCode=NIWWSWQ](http://nerrsdata.org/get/realTime.cfm?stationCode=NIWWSWQ) from a bottom and surface water sonde reporting oxygen, temperature, salinity, pH, turbidity and water level. The sondes are also

reporting chlorophyll, but these data are not reported online. These data add value to the information being collected by the upstream USGS gages and the EQL. Specifically, the new data will help quantify the impact of river discharges on the coastal ocean.

#### CCU Student Monitoring

Three monitoring programs are being conducted by CCU's undergraduate students to provide data for the SMS4's. This includes: (1) ground and lake water levels in Briarcliffe Acres, (2) survival of native trees and shrubs planted as part of a floodplain restoration along Crabtree Canal, and (3) water quality monitoring on CCU's campus. As noted below, these efforts are being supported by the SMS4s and CCU. CCU's boundaries lie within the SMS4 jurisdictions of the City of Conway and Horry County.

#### Briarcliffe Acres Groundwater

Since June 2012, Horry County and the Town of Briarcliffe Acres have been partnering on a monitoring program to characterize lake and groundwater levels. The goals of this program are to provide insight into: (1) how to manage limited water resources during times of drought and (2) the frequency and timing of high water tables that have the potential to intercept septic tank drain fields. These data are to be used to engage the local community in water stewardship efforts.

The data are collected from three groundwater wells and two lakes. They are downloaded monthly and posted at a public website: <http://bccmws.coastal.edu/bagw/>. Project presentations and reports are also posted. This project was designed to engage students by having them perform the data download. Since the first three years of funding reached completion in 2015, CCU sought and obtained grant funding to support replacement of all equipment. Horry County has agreed to continued support of travel and undergraduate student salary. This grant funding supports student enrollment for credit in a section of independent study to enable experiential learning under CCU's QEP program.

In 2016, CCU began providing a fellowship to a graduate student who serves as the teaching assistant for this QEP course. Her role is to provide hands-on technical coordination and perform the first layer of data review.

After four years of successful deployment, vandalism resulted in the loss of sensors from two of the groundwater wells. The sensors were replaced. Work is still underway to accurately resurvey their deployment level. Data posting has been on hiatus due to turnover in computer support staff in CCU's Burroughs and Chapin Center for Marine and Wetland Studies.

In May 2016, the data were used to provide feedback on a draft "Resolution to Establish the Briarcliffe Acres Floodplain Improvement District". This is meant to address long standing issues with fecal bacteria contamination in Briarcliffe Swash and the nearby surf zone. On a related note, a microbial source tracking project was conducted for Briarcliffe and White Point swash in 2015 at the request of Horry County, with the final report being generated in April 2016.

#### Crabtree Canal Floodplain Restoration

Restoration of a channelized swamp, Crabtree Canal, was initiated in 2009 by the City of Conway and Horry County following identification as a top priority action in the Kingston Lake Watershed Management Plan. Assessment work is being performed to demonstrate restoration of floodplain structure and function. The US FWS has provided funding for the restoration and assessment work. The latter was conducted by CCU students who performed annual tree counts to track survival rates and downloaded water-level logger data for use by Clemson University to infer floodplain inundation activity. Clemson University was also monitoring channel and floodplain bathymetry and topography. Water monitoring ended in July 2015 due to lack of funding. The tree surveys were suspended by mutual agreement of the Crabtree Restoration working group in light of the relative stability of the restored vegetation.

In 2016, the USACOE has entered into a formal agreement with Horry County to study how they can support additional restoration work. Flooding in 2015 and 2016 from Hurricanes Joaquin and Matthew did not cause significant damage, suggesting the design of the restoration has created a sustainable floodplain.

### CCU Campus Monitoring

The goal of CCU's Campus Monitoring Program is to provide an assessment of water quality conditions in the stormwater ditches and retention ponds on campus, all of which eventually send waters off campus towards the Waccamaw River. This program was started in 2009 to help meet the requirements of a wetlands permit issued to enable construction of Wall Pond. Data collected since 2011 are made available to the public at:

<http://bccmws.coastal.edu/ccum/index.html>. A web page with a program description and portal to the data is located at: <http://www.coastal.edu/wwa/datasets/coastalcarolinauniversitycampusmonitoring/>

In its current incarnation, CCU undergraduate students can participate by enrolling for 1 credit under MSCI 399Q or volunteering in a non-credit role. The data are being used to evaluate whether water quality is improving or degrading over time at some or all of the sites using a watershed approach. CCU's Waccamaw Watershed Academy provides technical support. The Waccamaw Riverkeeper serves as the field leader and ensures that the data are relayed to CCU's Building and Grounds staff for follow-up on potential illicit discharges. Both organizations are providing pro bono assistance in this effort.

In 2016, CCU's QEP program was awarded another round of funding to support this program. A request has been submitted to continue funding into 2017. This funding has helped support acquisition of a Hanna multimeter for in-situ measurements. A new SOP was generated for use of this meter. CCU also began providing a fellowship to a graduate student who serves as the teaching assistant for the QEP course. Her role is to provide

hands-on technical coordination and perform the first layer of data review.

In 2016, the students generally sampled weekly at three locations (501 West, Wall Pond, 544 West) and generated 252 sample measurements in 2015, resulting in a total of 1398 data points since the program commenced on October 13, 2011.

At the end of each semester, the students and the Riverkeeper hold a mini data conference to review their results. In 2016, these data conferences were held on April 28<sup>th</sup> and December 9<sup>th</sup>. Biweekly sampling is conducted during the summer by EQL work-study students.

A notable gap in all the volunteer monitoring programs has been measurement of phosphate. To address that, two honors program students commenced an investigation in 2016 of several methods for phosphate analysis that appeared practical for use in the volunteer monitoring programs. This work was funded by the Honors Program. The students have identified a method with a sufficiently low detection limit that will be used starting in Spring 2017 in the CCU Campus Monitoring program.



Image 1 - CCU campus monitoring in Spring 2016 using Hanna HI 9829 meter