

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.

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/wwa/datasets.html>. An upgrade is underway to add boxplots to the graphing options and site-specific percentiles to the summary statistics tables. Web counters are used to document traffic at these sites. Data are also being uploaded to the national STORET Data warehouse using the US EPA's Water Quality Exchange (WQX) portal. These data can be downloaded through the Water Quality Portal (<http://www.waterqualitydata.us/index.jsp>) which is maintained by the National Water Quality Monitoring Council and also houses data from the USGS's National Water Information System (NWIS) and the 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, SCASM, and the SC Water Resources Journal.

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 percentile rankings developed from each sampling site's historical dataset. 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 SC DHEC uses for its watershed water quality assessment reports, i.e. the seasonal Mann-Kendall test for monotonic trends.

To address MCM #2, Horry and Georgetown Counties, the City of Conway, and the town of Surfside Beach support volunteer water quality monitoring programs that are run collaboratively with CCU's Waccamaw Watershed Academy (WWA) and field leaders 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.

More details on each of the monitoring programs along with highlights from 2014 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 on the following page.

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	49	2006	Georgetown & Horry Counties, Conway
Murrells Inlet	Murrells Inlet 2020	8	18	2008	Georgetown & Horry Counties
Surfside Beach	Ken Harth	2	6	2010	Surfside Beach
CCU Campus	Waccamaw Riverkeeper	2	5 to 10	2011	CCU's WWA & QEP Program

Sampling is conducted biweekly year round and data are posted within one month 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 and a luncheon for their volunteers. Presentations from these events are posted at the program websites (<http://www.coastal.edu/wwa/vm/>) maintained by the WWA who also provides technical support for these programs. 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 subwatershed.

An inventory of the water quality measurements made to date in each of the programs is provided in Table 2. These collectively represent over 69,000 measurements.

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 in the US (<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.

An important transition that occurred in 2014 was the departure of the volunteer water quality monitoring coordinator, Heather Young, who had served in this capacity for two years. She is now the Stormwater program administrator for the City of Largo, Florida. In November 2014, Kelly Hall took over as the interim volunteer monitoring coordinator.

The Murrells Inlet and Waccamaw River volunteer monitoring programs also continued to collect water samples to support a research project being conducted by a CCU student, Joe Cannon, who is investigating the use of coliphages as a fecal indicator. He uses the volunteer's E. coli data to compare with his coliphage concentration measurements.

Additional detail on each of the volunteer monitoring programs and highlights from 2014 are provided on page 27.

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

<i>Program</i>	<i>Site</i>	<i>Samplings</i>	<i>Measurements per sampling event</i>	<i>Total independent measurements</i>
Waccamaw River since June 2006	Maple Street	65	11	715
	Canal Cove	65	11	715
	Big Creek	65	11	715
	LAWA Dam	65	11	715
	Babson's Landing	34	11	374
	Pireway	35	11	385
	Hwy 9	202	11	2222
	Reaves Ferry	203	11	2233
	Murrells Landing	1497	17	25449
	Conway	200	11	2200
	Pitch Landing	165	11	1815
	Peachtree	158	11	1738
	Enterprise	201	11	2211
	Bucksport	201	11	2211
	Wachesaw	203	11	2233
Hagley	200	11	2200	
Sampit	201	11	2211	
Total =				50,342
Murrells Inlet since May 2008	Woodland Drive Pond	157	11	1727
	Point Drive Canal	156	11	1716
	Rum Gully Creek	157	11	1727
	Marina Colony Pond	157	11	1727
	HS	159	11	1749
	BHR	159	11	1749
	Bike Bridge	159	11	1749
	Oyster Landing Beach	158	11	1738
Total =				13,882
Surfside Beach since May 2010	11th Ave N	103	11	1133
	4th Ave N	103	11	1133
Total =				2,266
Campus Volunteer Monitoring since Oct 2011	501 West	85	11	935
	544 East	14	11	154
	544 West	76	11	836
	Wall Pond Bridge	69	11	759
	Wall Pond East	2	11	22
	Wall Pond West	2	11	22
Total =				2,728

Murrells Inlet

Eight sites have been monitored since 2008 by 18 volunteers. CCU and Murrells Inlet 2020 have partnered on a weather station with observations accessible through a Weather Underground site that went online in Sept 2013

(<http://www.wunderground.com/personal-weather-station/dashboard?ID=KSCMURRE10>). The link for this URL is included in the MI 2020 newsletters and on their website.

The 2014 data conference was held on October 21, 2014 in Inlet Affairs. The theme of the conference was the recently completed watershed plan and how the volunteer monitoring program would be engaged in the plans implementation efforts. A presentation was also delivered reporting the findings of a microbial source tracking effort funded by Georgetown County and conducted by the volunteers. Copies of the presentations are archived at <http://www.coastal.edu/wwa/vm/mi/publications.html>.

Important personnel transition occurred in 2014. Namely, Jim Wilkie (*shown to the right*) stepped down as the field leader and Sue Sledz retired as the executive director of Murrells Inlet 2020. Renee Williamson, the new executive director, and Stephen Williams, a new board member, have jointly assumed the field leader duties. Jim stepped down shortly after receiving the Golden Oyster award at the Chowder Talk held on October 15, 2014 in recognition for being “an exemplary steward of the Inlet, (who) was instrumental in the formation of the Inlet’s Water Monitoring Program in 2008 and has led and inspired a team of twenty water monitoring volunteers. Jim also led the call for the creation of the Murrells Inlet Watershed Plan. His passion and leadership has guided MI2020’s continued commitment to its mission to protect the Inlet.” Jim sadly passed away on January 30, 2015 and will greatly missed.

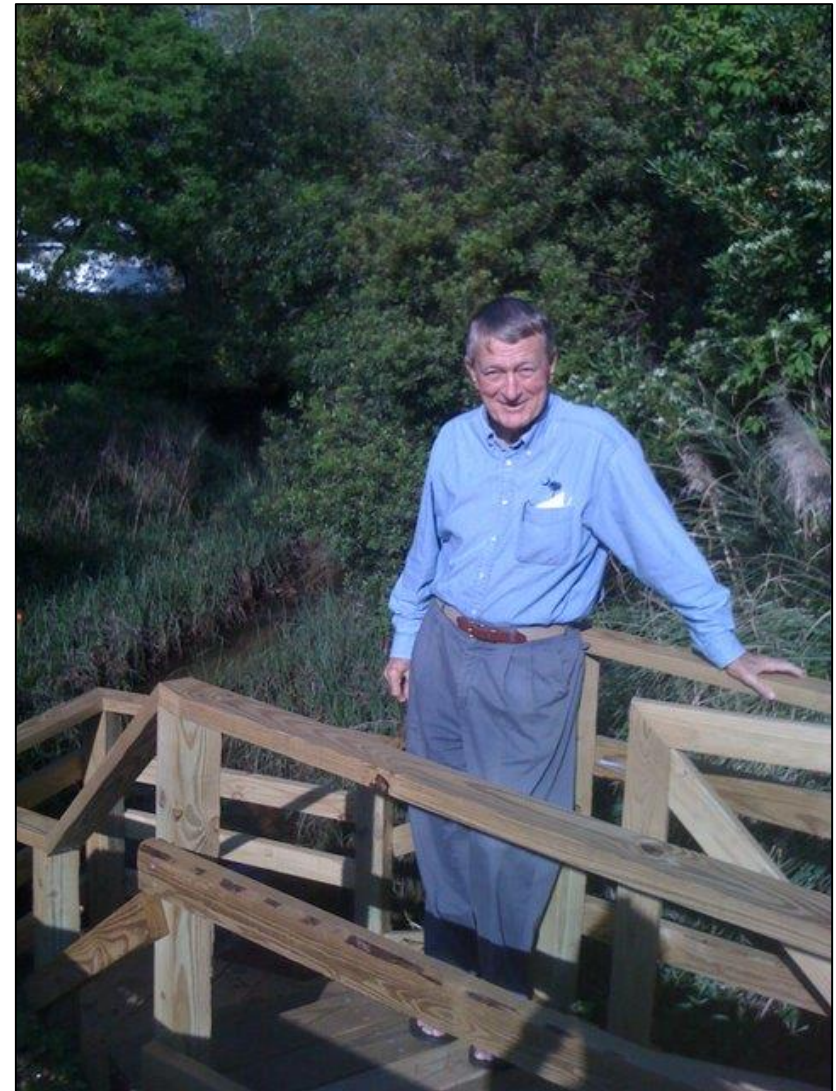


Figure 1 - Jim Wilkie at the BHR site. The elegant sampling platform was installed at his direction.

The watershed-based plan for Murrells Inlet was approved by SC DHEC in August 2014. A copy of the plan is located at <http://wrcog.org/transportation-planning/air-quality-coalition/>. A description of the plan and its development was recapped at the 2014 SC Water Resources Conference (SC WRC) held on October 15th and 16th in a special session entitled “Development of a Watershed-Based Plan for Murrells Inlet”. This was the first special session conducted at a SC WRC and was broadcast via live streaming on the internet. An archived copy is located at http://www.clemson.edu/restoration/events/past_events/sc_water_resources/videos_2014.html. The session was organized by the WWA and moderated by Amy Bennett and Delaney Faircloth (SC DHEC). It was comprised of the following six papers.

Williams, S.G., D. Newquist, S. Libes, S. G. Strickland. 2014. Watershed Management Planning for the Murrells Inlet Estuary using GIS: Delineation, Assessment, Identification, and Solutions for Fecal Coliform Loading.

Newquist, D., S. Sledz, S. Libes, S. Williams, D. Fuss, T. Jones, and D. Hitchcock. 2014. Murrells Inlet Watershed: Positive Outcomes from a Multistakeholder Planning Process.

Young, H., S. Libes, D. Newquist, D. Fuss and T. Jones. 2014. Water quality stewardship informs management directions.

Sturgeon, A., S. Libes, E. Burge, and M. Trapp. 2014. Building local capacity for microbial source tracking in the Myrtle Beach Urbanized Area.

S. Libes, Young, H., D. Newquist and S. Sledz. 2014. Watershed-Based Planning for Murrells Inlet: Source Assessment of Fecal Bacteria Using Volunteer and Shellfish Sanitation Program Data.

Fuss, D. Watershed Plan Implementation: Challenges for SMS4s in Murrells Inlet

The story of the volunteer monitoring program and the subsequent source tracing efforts and watershed planning were presented at the 2014 National Water Quality Monitoring Conference by the WWA. The watershed plan is being implemented by a steering committee that includes CCU’s WWA, Murrells Inlet 2020, and the stormwater managers of Horry and Georgetown Counties. In October 2014, SC DHEC awarded a US EPA 319 grant to the Waccamaw COG to fund implementation work. Discussions are underway to identify how the volunteer monitoring data can be used to inform the required assessment work on this project and a TMDL monitoring program.

Waccamaw River

Twelve sites in SC have been monitored since 2006 and 6 sites in NC since 2011. This bi-state effort engages 49 volunteers. A new benthic macroinvertebrate monitoring program was started in 2013 by the Waccamaw Riverkeeper with support from SC DHEC and Clemson University. Grant funding was provided by International Paper. It is staffed by Winyah Master Naturalists. A description of this program was a featured presentation at the annual data conference which was held on Sept 18th 2014. The annual volunteer appreciation luncheon was held on March 20, 2014. Presentations from both are archived at <http://www.coastal.edu/wwa/vm/wr/publications.html>. A comparison of the data from the North Carolina sites to those from South Carolina was also presented at the annual data conference. The North Carolina volunteers were recognized for their efforts by winning the NC Governor's Award for Volunteerism (Columbus County). The award presentation was held on April 8, 2014. The Waccamaw Riverkeeper delivered a presentation at the 2014 SC WRC entitled “Volunteer Water

Monitoring: Educating and Building Relationships to Manage our Watershed”.

Christine Ellis, the former, Waccamaw Riverkeeper, has been seeking funding to support the volunteer monitoring efforts in North Carolina. In November 2014, she received funding from International Paper’s Riegelwood Facility to purchase a new water quality meter, but is still in search of continued funding to support operational needs.

This program also partnered with Clemson University researcher, Dr. A. Chow, on an NSF proposal that was submitted in January 2014 to study salinity intrusions on the river.

Surfside Beach

Two sites have been monitored since 2010 by 6 volunteers. Data updates are being provided by the field leader, Ken Harth, to Surfside’s Stormwater Committee during their quarterly business meetings, which is also attended by CCU’s Waccamaw Watershed Academy to help address any water quality questions. The next data conference is being planned for early 2015. Copies of presentations from prior conferences are archived at <http://www.coastal.edu/wwa/vm/sb/publications.html>.

A water quality BMP (StormBasin from Fabco Industries, Inc.) was installed in Jan 2014 to reduce loading of bacteria upstream of the volunteer monitoring sampling site located at Myrtle Lake where elevated E. coli concentrations are commonly observed.

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. The monitoring data are being used to characterize normal conditions for oxygen, 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 via a weather station. CCU’s Environmental Quality Lab (EQL) is responsible for technical support and data management.

The data are accessible through YSI Econet’s data portal (<http://www.ysi-conet.com/public/WebUI/Default.aspx?hidCustomerID=131>) and CCU’s Long Bay Observing System: <http://bccmws.coastal.edu/lbos>. Real-time data displays are streaming to monitors at each of the piers. EQL continues to conduct outreach activities biannually at Apache Pier; Local’s Appreciation Day was August 23rd 2014 and Kid’s Appreciation Day was March 29, 2014.

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 innovative collaboration represented by the LBHMC was the subject of a peer-reviewed article published in the first volume of the new SC Water Resources Journal.

Libes, S., M. Trapp, S. Kindelberger and D. Doremus. 2014. Long Bay Hypoxia Monitoring Consortium. Journal of South Carolina Water Resources, Vol.1, Issue 1, p. 26-31.

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.

The data also used to support assessment required as a special condition of a SC DHEC 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.

Beach Monitoring

Enterococcus data collected at 61 sites along the Grand Strand since 1997 by SC DHEC 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 Environmental Quality Lab (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 SC DHEC 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 4th Ave N Ocean Outfall in Myrtle Beach.

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.

River Gauge Monitoring

Since Jan 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 in the Waccamaw and Pee Dee Rivers. The USGS is maintaining real-time water quality sensors at

one site in the Pee Dee and eight sites in the Waccamaw River. Data are available at <http://waterwatch.usgs.gov/wqwatch/map?state=sc&pcode=00010>. CCU's EQL has been performing bimonthly grab sampling at 8 of these sites under a SC DHEC approved QAPP. The water quality data from these samples are posted within one month of sampling at: http://bccmws.coastal.edu/river_gauge/.

In June 2013, a new USGS gaging station and CCU sampling site was established at Reaves Ferry in the Waccamaw River. Based on information obtained from the first year of samples, the river exhibits semidaily tidal behavior at this site, approximately 60 miles upstream of Winyah Bay. The tidal behavior is being characterized by a CCU masters student who is performing a local internship with the USGS. The student's results were presented at the 2014 SC WRC as a poster entitled "The Tidal Reach and Distribution of Tidal Freshwater Forested Wetlands in the Waccamaw River, South Carolina." This presentation won the best student poster award at the conference.

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.

In June 2014, the EQL commenced measurements of E. coli. Fecal coliform measurements will continue to be made for one year to facilitate a transition to the new regulatory water quality fecal indicator, i.e. E. coli.

CCU Student Monitoring

The following three monitoring programs are being conducted by CCU's undergraduate students to provide data for the SMS4's. As noted below, these efforts are being supported by the SMS4s and CCU. CCU's boundaries lie within the jurisdictions of Conway and Horry County SMS4 programs.

Briarcliffe Acres Groundwater

Horry County and the town of Briarcliffe Acres are 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 flow 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 at this site. This project was designed to engage students by having them perform the data download. In 2014, the students delivered a poster presentation at the SC Environmental Conference on March 9, 2014 and CCU's Undergraduate Research Competition on April 2, 2014 entitled: "Continuous Ground and Lake Water Level Monitoring in Briarcliffe Acres, SC".

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 is currently being conducted by CCU students who are performing annual tree counts to track survival rates and downloading water-level logger data for use by

Clemson University to infer floodplain inundation activity. Clemson University is also monitoring channel and floodplain bathymetry and topography.

The Waccamaw Riverkeeper has been working with Horry County to engage Conway High School students in outreach efforts and has submitted a funding request to the Five Star Restoration Program to expand this program. Also notable in 2014 have been: (1) continued efforts of the NRCS to remediate septic tanks using US EPA 319 funding awarded by SC DHEC, (2) installation of bank stabilization BMP's by Horry County, and (3) invasive plant control conducted by Horry County.

In August 2014, the US EPA Region IV awarded Horry County its inaugural Rain Catcher Award in the Neighborhood/Community Category for the Crabtree Swamp Restoration Project in Conway, South Carolina. The award was given at an award ceremony during the Environmental Protection Agency, Region 4/International Erosion Control Association Municipal Wet Weather Stormwater Conference, in Charlotte, North Carolina. The award application was collaboratively prepared by the WWA, Clemson University and Horry County's stormwater manager.

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. Due to the popularity of this program, sampling is now being conducted weekly by CCU undergraduate students year round. The Waccamaw Riverkeeper serves as the field leader. CCU's Waccamaw Watershed Academy provides technical support. Both organizations are providing pro bono assistance in this effort.

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. As field leader, the Waccamaw Riverkeeper ensures that the data are relayed to CCU's Building and Grounds staff for follow up on potential illicit discharges.

In 2014, CCU's QEP program awarded a second round of funding to the Campus Monitoring Program. Another funding request has been submitted for 2015. In Fall 2014, the students held the first mini data conference to review their results. A new website was launched for the program (<http://www.coastal.edu/wva/datasets/coastalcarolinauniversitycampusmonitoring/>) and links to a new web app that houses their data (<http://bccmws.coastal.edu/ccum/sites.php>). A poster describing this program, entitled "Water Quality Monitoring on CCU Campus: A MSCI 399Q course designed for freshmen and sophomores", as presented at the first Faculty Excellence Summit held on October 14th 2014. The campus monitoring program was featured in QEP brochure given to entering freshmen, "In My Experience: Experiential Learning at Coastal Carolina University." The second mini data conference was held at the end of the Spring 2014 semester and engaged 11 students.