MCAS Cherry Point Implements Innovative Water Quality Monitoring System

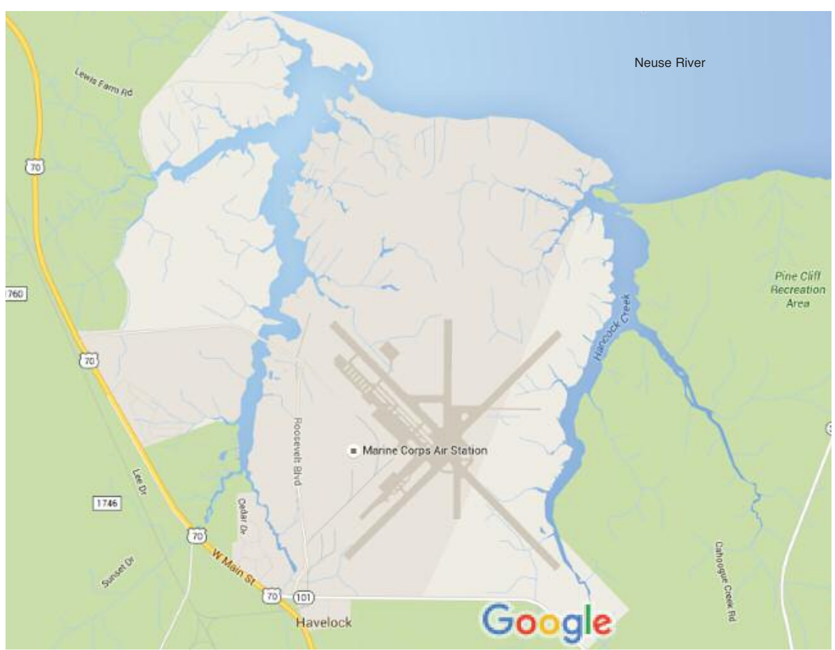
System Reduces NPDES Manpower Requirements, Provides Real-Time Water Quality Data

MARINE CORPS AIR Station (MCAS) Cherry Point's implementation of a state-of-the-art stormwater monitoring system reduces the manpower requirements associated with their National Pollutant Discharge Elimination System (NPDES) stormwater permit and provides real-time water quality data to air station personnel.

Introduction

Stormwater drainage system infrastructure at MCAS Cherry Point carries runoff from rain events to receiving streams within the nutrient-sensitive Neuse River Basin in eastern North Carolina. Water quality concerns with receiving waterbodies such as the Neuse River Estuary are associated with discharges from municipalities, agriculture, commercial/industrial sites, and other point and non-point sources of pollution along the water body.

The North Carolina Department of Environmental Quality (NCDEQ), formerly the North Carolina Department of Environmental and Natural Resources, has developed measures to help eliminate sources of pollution to receiving waters such as the Neuse River, including implementing Surface Water Quality Standards via the issuance of NPDES stormwater permits, establishing water quality benchmarks for the Stormwater Permitting Program, and developing Total Maximum Daily Loads (TMDL) under Section 303 of the Clean Water Act. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL for total nitrogen has been established for the Neuse River Estuary; however, MCAS Cherry Point has not been named as a contributor and has not received load allocations for stormwater. Personnel from the



Marine Corps Air Station Cherry Point.
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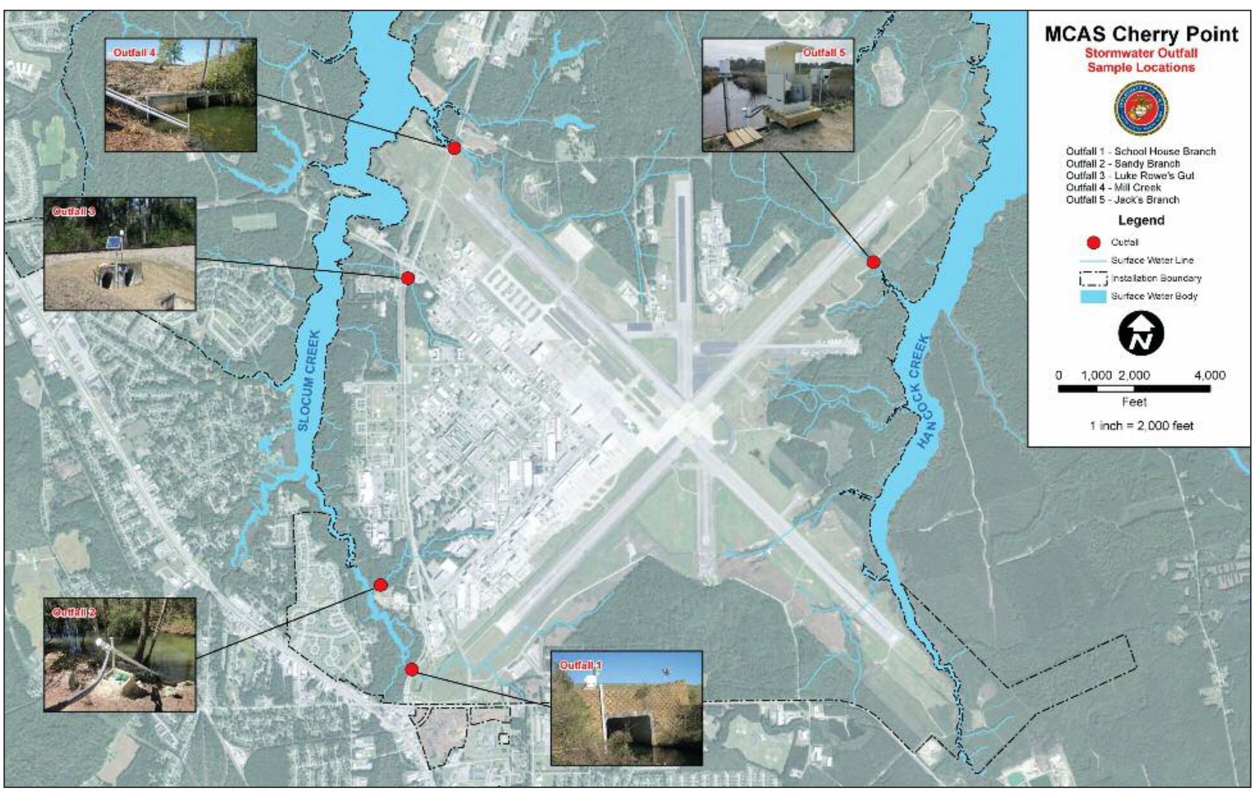
The stormwater program manager uses the laptop to track data trends and monitor the water quality results at each outfall.

MCAS Cherry Point Environmental Affairs Department (EAD) have successfully implemented a real-time, automated water quality and flow monitoring system at five stormwater outfalls at the MCAS Cherry Point. In the event that the State of North Carolina names MCAS Cherry Point as a contributor for stormwater and the air station receives a load allocation, they will be well-equipped to comply.

The environmental contracting team selected URS Group, Inc. (now AECOM) and its teaming partner YSI Integrated Systems and Services, Inc. (YSI) to install compliant and calibrated flow meters, automatic samplers, and continuous water quality monitoring probes (also referred to as water quality sondes) at MCAS Cherry Point in 2013. The objective of the equipment installation project was to provide MCAS Cherry Point with the means to collect NPDES permit-required samples, continuously monitor seven additional water quality parameters, monitor the flow rate through the outfalls, and monitor rainfall at each of the following outfall sites.

- Outfall 1: Schoolhouse Branch
- Outfall 2: Sandy Branch
- Outfall 3: Luke Rowe's Gut
- Outfall 4: Mill Creek
- Outfall 5: Jack's Branch

A stand-alone laptop computer was configured to remotely connect to the monitoring systems allowing the EAD stormwater program manager to conveniently collect and analyze data without visiting each site regularly. The stormwater program manager uses the laptop to track data trends and monitor the water quality results at each outfall to stay on top of water quality issues associated with MCAS Cherry Point's industrial corridor. A case study from Outfall 1, Schoolhouse Branch, will be examined further in subsequent sections of this article.



Stormwater monitoring installation location overview.

Monitoring System Setup & Maintenance

Each of the five sites selected for monitoring receive flow from drainage basins associated with the industrial corridor of the base. The following equipment was installed at each outfall monitoring station:

- Multiparameter YSI EXO2 water quality probes with temperature, conductivity, salinity, pH, turbidity, total dissolved solids (TDS), and optical dissolved oxygen (DO) monitoring capability
- Site-specific SonTek IQ flow meters at four outfalls and a SonTek Argonaut SL-3000 flow meter at Outfall 2 (Sandy Branch)
- Portable ISCO 3700 multiple bottle autosamplers
- Tipping bucket rain gauges equipped with an 8-inch orifice and a mechanism to regulate measurement during intense downpours to improve accuracy
- Integrated datalogger/control systems utilizing CSI CR1000 dataloggers to measure and record parameters, and to actuate the autosamplers based on predetermined trigger events
- Airlink Raven XT cellular modems and peripherals for remote 2-way communication and control
- Fiberglass enclosures to house batteries, electronics, and autosamplers
- 60-watt solar charging systems with 75-ampere hour batteries

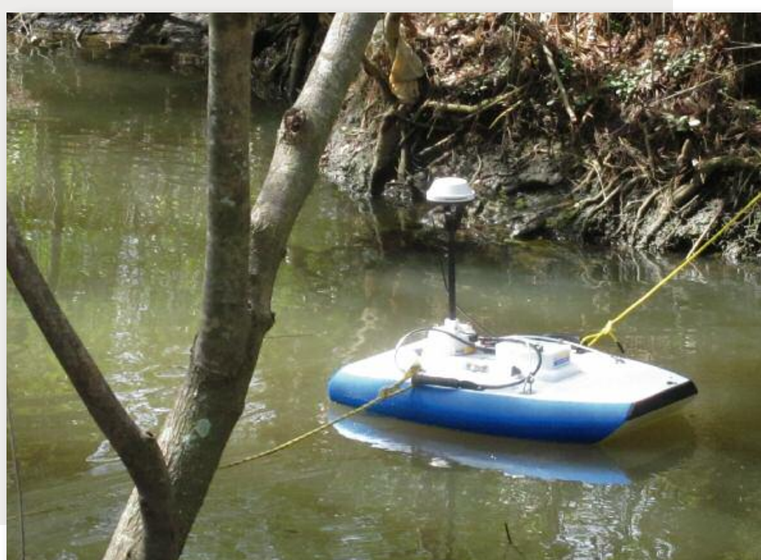
The flow meters installed at each outfall were calibrated in the field by YSI as part of the installation. Measurements of the culverts were collected as part of the calibration effort and input into the SonTek IQ: Intelligent Flow program in order to complete the flow calculation formulas. In addition, the flow meters had an initial pressure calibration. The time period between calibrations is tracked and the user is prompted by the IQ program for subsequent calibrations.

Each monitoring system location is equipped with an ISCO 3700 multiple bottle autosampler. These portable units are programmed to collect NPDES-permit required water quality samples based on one of two triggers—preset readings from the flow meter or remotely by the stormwater program manager using the laptop and data relayed from the monitoring systems. The geographically separated outfalls make it challenging for EAD staff to collect NPDES permit-required water quality samples by hand and within the permit established timeframe. Use of the autosamplers allows EAD staff to focus their effort on performing field measurements for pH and temperature readings and retrieving the samples for preparation and shipment to a contracted laboratory for analysis. MCAS Cherry Point's NPDES permit-required analytical parameters and measurements include the following:

- Acute Toxicity
- Ammonia (NH_3 as N)
- Arsenic (total)
- Biochemical Oxygen Demand

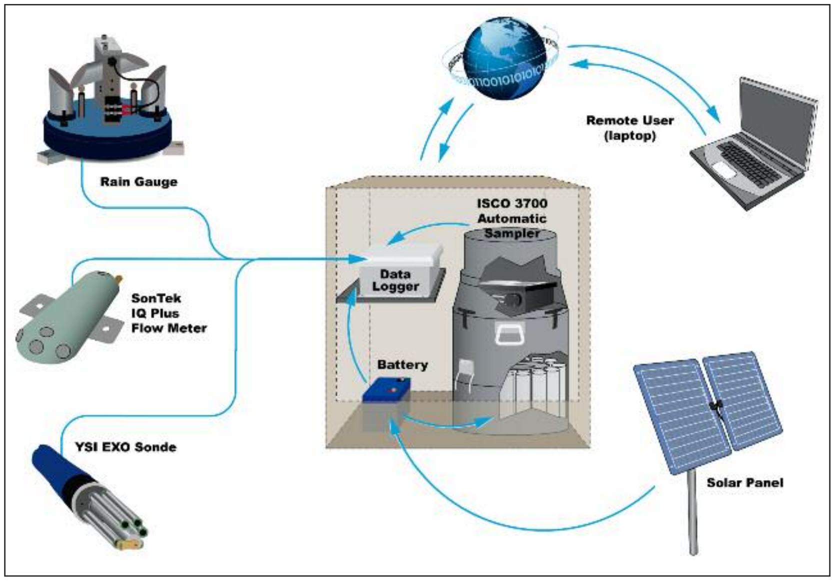
Sandy Branch Outfall

OUTFALL 2 (SANDY BRANCH) is an open channel, as opposed to culverts or pipes similar to the other outfalls. The flow meter that was installed at this location (SonTek Argonaut SL-3000) projects beams across the open channel to calculate flow rates. Due to the site location and determination that the channel for Outfall 2 was an irregular shape, an open channel survey was performed to determine the parameters for flow calculations. The river surveying unit shown in the figure at right was deployed at the outfall location to verify stream dimensions and flow data.



The river surveying unit measuring the Sandy Branch outfall stream dimensions.

- Cadmium (total)
- Chemical Oxygen Demand
- Chromium (total)
- Conductivity
- Cyanide
- Ethylene Glycol
- Event Duration
- Fecal Coliform
- Fluoride
- Lead (total)
- Methylene Blue Active Substances (Detergents)
- Naphthalene
- Nickel (total)
- Nitrate + Nitrite
- Oil and Grease
- Pesticides
- pH
- Silver (total)
- Total Kjeldahl Nitrogen
- Total Flow
- Total Organic Carbon
- Total Rainfall
- Total Suspended Solids (TSS)



Stormwater monitoring system configuration.

The data collected via the integrated datalogger/control system is transferred to the stand-alone laptop by cellular data communications utilizing the Airlink Raven CT cellular modem and associated peripherals (i.e., antennae). Communication between the water quality monitoring equipment, autosampler, datalogger, and the laptop is illustrated in the figure above.

The CSI CR1000 datalogger is the main device controlling the stormwater monitoring system at each of the five outfalls. The datalogger records measurements from each sensor, stores the data, directs sampling during events, and sends out alerts via email. A custom CRBasic program that runs inside the datalogger and defines its operation was developed by YSI and implemented at each monitoring system. The program can be viewed and modified using LoggerNet software, which has been installed on the stand-alone laptop. Rain gauge, water quality, and flow meter parameters are measured at specific intervals controlled by the datalogger.

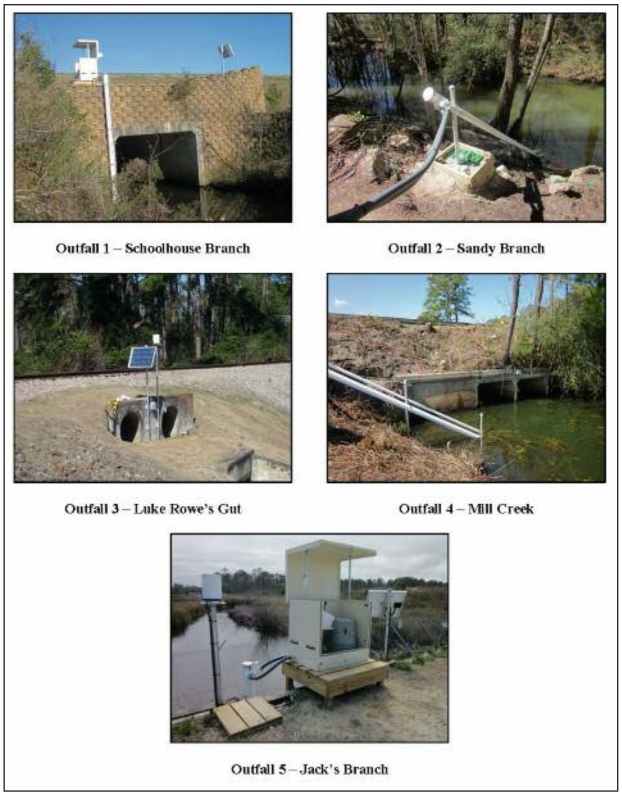
Rain gauge parameters are accumulated in 15-minute increments and reported to the datalogger when queried. Water quality parameters from the EXO2 probe are also logged internally in 15-minute increments. When queried by the datalogger, the EXO2 probe transfers the recorded data to the datalogger. Flow is measured and stored with the SonTek flow meter in five-minute intervals. In addition to water quality parameters, the systems also record diagnostic data (i.e., battery voltage, datalogger temperature, and current set points) on an hourly basis.

During a rain event, specific event data such as flow, samples taken, discharge volume since the last sample, and the time since the start of the event are stored in five-minute intervals for the duration of an event. These data are particularly important with regards to compliance with MCAS Cherry Point's stormwater NPDES permit. As part of the required sampling, the air station must report the total flow and event

As part of the required sampling, the air station must report the total flow and event duration on its discharge monitoring report.

duration on its discharge monitoring report (DMR) that accompanies the annual report submitted for each permit year. These systems allow for these data to be easily captured and reported to NCDEQ for permit compliance. The five monitoring system installation configurations are shown in the figure bleow.

The monitoring systems require regular operation and maintenance (O&M) to remain functional and continue to collect water quality and flow data and stormwater samples remotely. Monthly O&M includes calibration of the EXO2 probe, inspection and cleaning of the rain gauge, datalogger inspection (e.g., desiccant inspection and regeneration based on moisture collection), and removal of debris from the flow meter. AECOM and YSI have assisted MCAS Cherry Point with major annual maintenance at each outfall since installation.



Monitoring system installation areas.

Representative Storm Event

A REPRESENTATIVE STORM event is defined as an event with total rainfall that measures greater than 0.1 inches. To qualify as a representative storm event that MCAS Cherry Point can utilize for required sampling and NPDES Permit Report purposes, the time between the current storm event and the previous storm event measuring greater than 0.1 inches must be at least 72 hours. In addition, a single storm event may have a period of no precipitation of up to 10 hours. For example, if the rain stops before producing any collectable discharge, a sample may be collected if the next rain producing a discharge begins within 10 hours.

Water Quality Event Notification, Data Review & Trend Analysis

The stand-alone laptop is designed to function as the base station for the monitoring systems. The data recorded at each site are automatically collected and stored by the base station via the LoggerNet software while the modem is active and LoggerNet is running. The alerts sent from the sites run independently of the laptop data collection and are sent regardless of whether the laptop is running.

The stormwater program manager is able to identify representative storm events using the rain gauge and flow meter measurements at the outfalls thus providing information needed to trigger sampling. The CRBasic program queries the flow meters every five minutes to enable quick event detection; with the goal to capture the first water sample within 30 minutes of the beginning of an event. Once a representative storm event is verified, the stormwater program manager is notified via email.

In addition to data collection, the LoggerNet software allows the stormwater program manager to complete the following tasks:

- Plot historical data for analysis
- View the latest data at a site remotely
- Adjust certain variables related to the event trigger
- Remotely activate the autosampler

The water quality monitoring systems have been in use since April 2013. Data collected using these systems are analyzed for trends by the stormwater program manager.

Case Study: Outfall 1 (Schoolhouse Branch) Water Quality Monitoring & Data Analysis

The drainage basin associated with Outfall 1, Schoolhouse Branch, has a total area of approximately 646 acres. Typical activities that are performed in the drainage basin include industrial activities (e.g., aircraft and vehicle maintenance) as well as open areas and general flight line activities, such as take-offs and landings.

Stormwater Outfall 1: Schoolhouse Branch stormwater monitoring system overview.

North Carolina receives rainfall throughout the year allowing for many potential storm events, both representative and non-representative, that can be used for examining the time-series based on the data that each of the water quality monitoring systems collects. Below is a discussion of trend analysis during a 1.61-inch rain event on March 7, 2014 at Outfall 1 (Schoolhouse Branch). Rainfall data relayed from the KNKT weather station located on the MCAS Cherry Point flightline, and obtained from www.wunderground.com, show that rainfall peaked between 4 a.m. and 5 p.m. with an hourly rainfall accumulation of 0.30 inches, followed by continuous rainfall until approximately 7 a.m. Light rain continued at irregular intervals throughout the remainder of the day. A snapshot of the hourly rainfall accrual for the beginning hours of the storm event is presented in the table below.

Comparing the precipitation history for March 7, 2014, as shown in the table below and the precipitation chart included in the figure on the following page, to the flow rates at Outfall 1, also shown in the same figure, there is a correlation to the elevated flow rates. The precipitation peaks at approximately 5 a.m., with the flow at the outfall

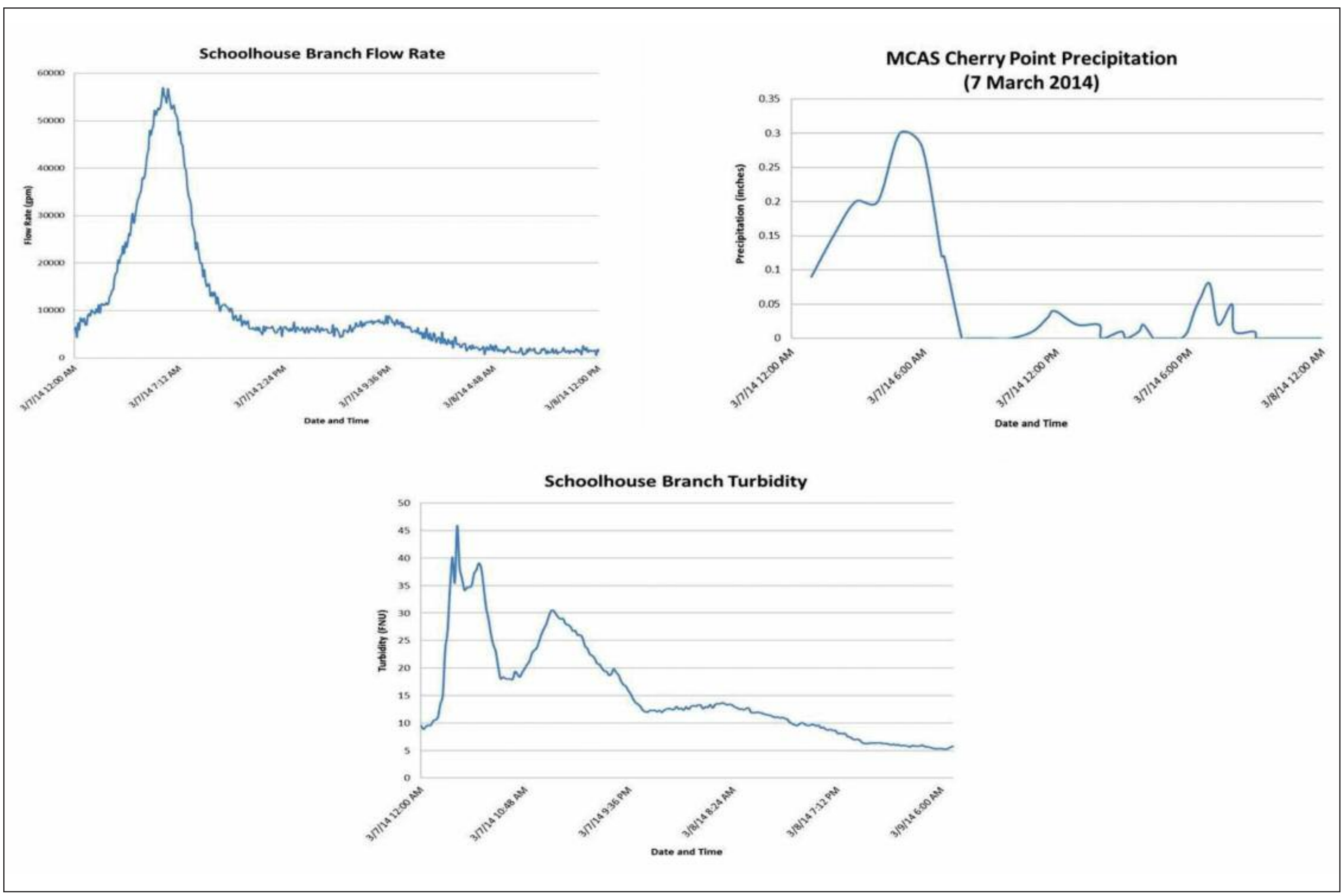
MCAS CHERRY POINT HOURLY WEATHER HISTORY (MARCH 7, 2014)

Time (EST)	Temperature	Precipitation	Events	Conditions
12:54 a.m.	48.9 °F	0.09 inches	Rain	Rain
1:54 a.m.	50.0 °F	0.15 inches	Rain	Rain
2:54 a.m.	50.0 °F	0.20 inches	Rain	Rain
3:54 a.m.	50.0 °F	0.20 inches	Rain	Rain
4:54 a.m.	50.0 °F	0.30 inches	Rain	Heavy Rain
5:54 a.m.	46.9 °F	0.28 inches	Rain	Heavy Rain
6:47 a.m.	46.9 °F	0.12 inches	Rain	Light Rain
6:54 a.m.	46.9 °F	0.12 inches	Rain	Light Rain
7:42 a.m.	48.9 °F	0.00 inches	None	Overcast
7:54 a.m.	50.0 °F	0.00 inches	None	Overcast
8:54 a.m.	52.0 °F	N/A	None	Overcast
9:54 a.m.	52.0 °F	N/A	None	Overcast
10:54 a.m.	52.0 °F	0.01 inches	Rain	Light Rain
11:34 a.m.	52.0 °F	0.03 inches	Rain	Light Rain
11:54 a.m.	52.0 °F	0.04 inches	Rain	Light Rain
12:54 p.m.	52.0 °F	0.02 inches	Rain	Light Rain
1:54 p.m.	50.0 °F	0.02 inches	Rain	Light Rain
2:01 p.m.	50.0 °F	0.00 inches	Rain	Light Rain
2:54 p.m.	46.9 °F	0.01 inches	Rain	Light Rain

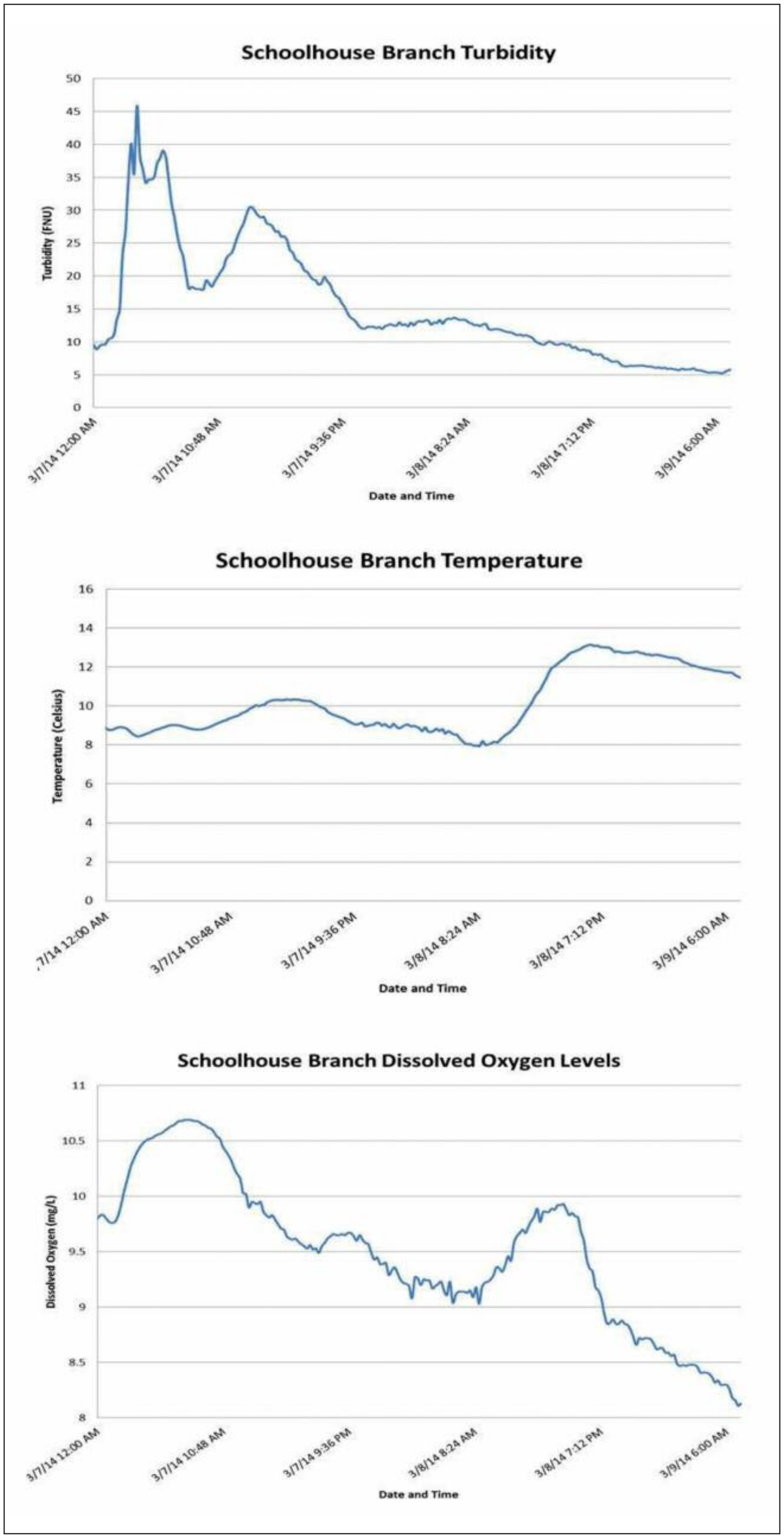
peaking at approximately 6 a.m. The delay in peaks can be expected as the stormwater runoff throughout the drainage basin makes its way through the conveyance system prior to being discharged at the outfall.

When evaluating stormwater quality data, turbidity can be directly related to flow. Turbidity, as defined by the U.S. Environmental Protection Agency (EPA), is a measure of water clarity based on how much the material suspended in water decreases the passage of light through the water. When the turbidity measurements plotted in the figure below are compared to the corresponding flow rates associated with the rain event, there is a direct correlation between the increase in flows during the rainfall event and the increase in turbidity of the water at the outfall. There is a delay in the increase of turbidity levels compared to the rainfall amounts and flow at the outfall; however, the increases and decrease follows the approximate trajectory with peaks and valleys of the rain event. Further review indicates that the turbidity levels take longer to subside after the rain event has passed. It is expected that as the flows increase at the outfall, the turbidity would increase due to the higher flows causing increased agitation of the channel bed, resulting in increased erosion. Furthermore, the extended time for turbidity levels to return to normal can be expected as particles slowly settle out.

While the correlation of turbidity to flow rates and precipitation are discernible, additional correlation between turbidity and the other water quality parameters may also be analyzed as shown in the figure below. High turbidity levels at outfalls can increase the water temperature due to the suspended particles absorbing more heat. The increased temperature can further result in the reduction of DO levels because warmer waters hold less DO than cooler waters. As shown in the figure above, there is a delay between the increase in turbidity



Flow rate, precipitation and turbidity comparison.



Dissolved oxygen, temperature and turbidity comparison.

and the increase in temperature, which can be attributed to the long duration of the rain event and the cloud cover. In addition, the average temperature for March 7, 2014 was 46.4 degrees Fahrenheit, which can be considered a limiting factor in the ability of the water temperature to increase.

Conclusions

The water quality monitoring systems have been operating at the five outfalls along the industrial corridor of MCAS Cherry Point for approximately two and a half years. The ability to track the flow rates and precipitation at these locations have made it easier for MCAS Cherry Point to maintain compliance with their stormwater NPDES permit sampling requirements and to track water quality parameters at these locations. The stormwater program manager can now monitor the outfalls remotely and trigger sampling without having to be at the outfall. This allows for the samples to be collected within the 30-minute time period after the beginning of an event. The added efficiency can also allow the stormwater program manager to devote additional time to other areas of the program.

In addition, the monitoring systems provide EAD with real-time water quality data that can be used to identify potential impacts to the streams on MCAS Cherry Point (e.g., low DO levels that may affect aquatic life). These data can help MCAS Cherry Point target locations on the air station that can benefit from new best management practice implementation. In the event that the State of North Carolina develops TMDLs for the Neuse River Estuary and MCAS Cherry Point receives a load allocation, the air station will be well-equipped to demonstrate whether or not it is a contributor of the targeted pollutant(s). ⚓

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