Proposal

for

Groundwater/Surface Water Interaction near Ellerbe Creek, Durham, North Carolina

Submitted to

City of Durham
Stormwater Services

prepared by

Kristen McSwain
U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, North Carolina 27607
919-571-4022

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Background

Falls Lake has been included in the North Carolina Division of Water Quality's 303(d) list of "impaired" waters due to violations of the State chlorophyll-*a* standard caused by excessive nutrient inputs (North Carolina Department of Environment and Natural Resources, Division of Water Quality, 2010a). The North Carolina Environmental Management Commission has adopted nutrient management strategies for the reservoir that call for comprehensive controls to reduce nitrogen and phosphorus loads from significant sources in the watershed, including urban stormwater, wastewater, and agriculture (North Carolina Department of Environment and Natural Resources, Division of Water Quality, 2010b-d).

The City of Durham, Stormwater Services (DSS), is tasked with implementing best management practices (BMPs) to reduce nutrient inputs from stormwater in the Falls Lake watershed. Ellerbe Creek, a tributary to Falls Lake, has elevated concentrations of nutrients, initially attributed to the presence of the North Durham Water Reclamation Facility (NDWRF) (locations shown in fig. 1). Engineering upgrades have been completed on the plant processing infrastructure, yet elevated nutrient levels in Ellerbe Creek persist. Leachate in groundwater from a closed municipal landfill that is located adjacent and downstream of the NDWRF may also impact surface-water quality.

Problem

The connection between groundwater and surface water needs to be investigated to determine if the closed municipal landfill adjacent to the NDWRF is a non-point source of nutrients to Ellerbe Creek.

A recently recalibrated watershed model for Ellerbe Creek has detected the presence of an unknown source of nitrogen entering the watershed between the NDWRF and Falls Lake (fig. 2). A closed municipal landfill adjacent to Ellerbe Creek is a probable non-point source of nutrients.

Objective

The objective of this study is to collect surface-water discharge, water temperature, and water-quality data to clarify the relation between groundwater and surface water in the area downstream of the NDWRF and adjacent to a closed municipal landfill.

Scope

This work will be conducted in cooperation with DSS on Ellerbe Creek in the Falls Lake watershed, located in the upper Neuse River basin (fig. 1). The scope of work covers a 24-month period, beginning in May 2016 and ending in March 2018. Field data collection activities will be conducted during the first 12-15 months. A walking reconnaissance survey of Ellerbe Creek will be completed using a FLIR camera (thermal imaging). Streamflow measurements will be made to approximate groundwater seepage. Water-quality samples will be collected from seepage locations identified by the FLIR reconnaissance survey and sent for laboratory analysis of nutrient fractions, cations, and anions. During the final nine months of the project, the USGS will develop a report that interprets the results of nutrient and isotope sampling.

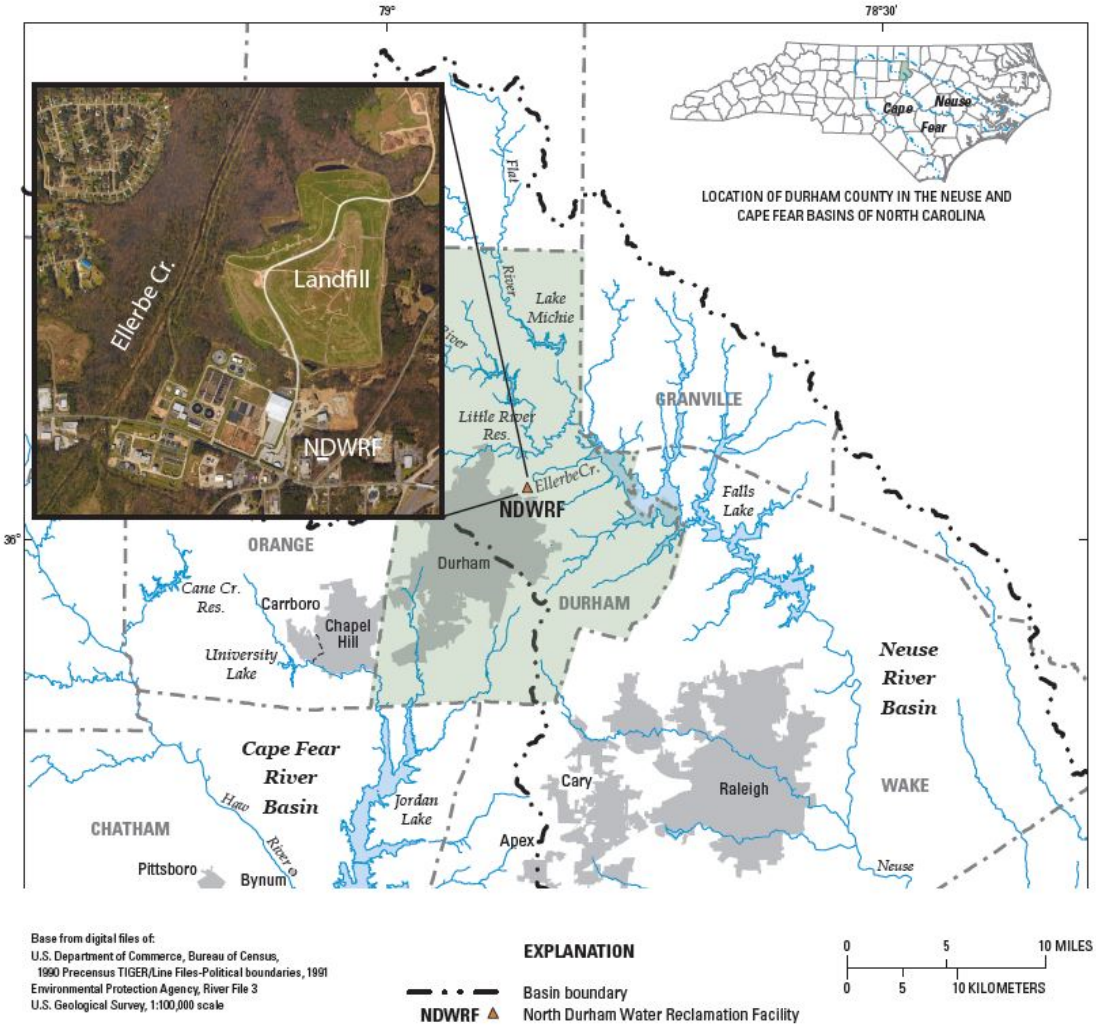

Figure 1. Location of the North Durham Water Reclamation Facility, Landfill, and Ellerbe Creek in Durham County, North Carolina.

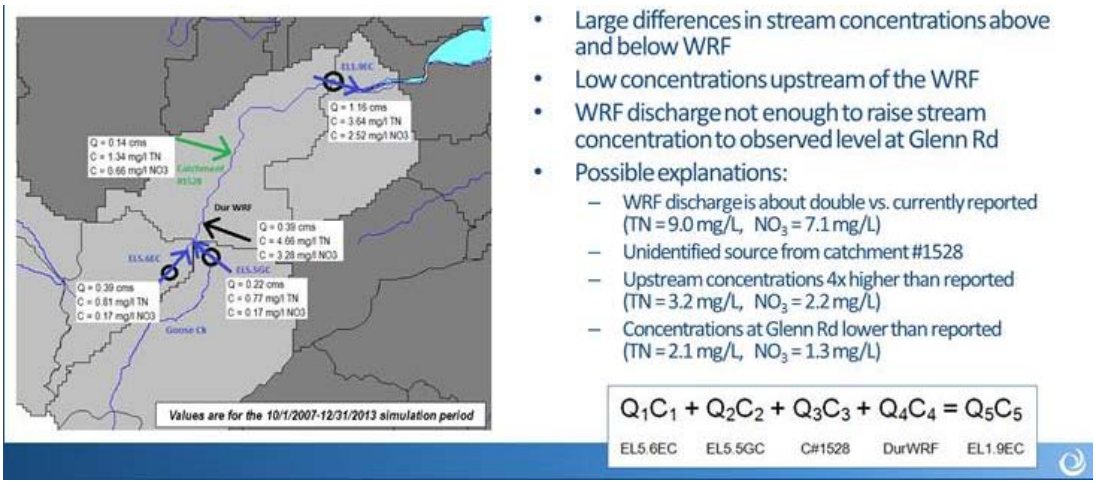

Figure 2. Locations of problematic mass balance observations of total nitrogen (M. Woolfolk, personal communication, March 5, 2015).

Approach

This section describes the study sites and the approach to be used to meet study objectives. Specific tasks to meet the study objectives are as follows:

1. Conduct a reconnaissance survey in the vicinity of the NDWRF and landfill, and collect water-quality samples;
2. Measure groundwater seepage;
3. Measure groundwater flux.

Task 1. Conduct a reconnaissance survey and collect water-quality samples

A walking reconnaissance survey of Ellerbe Creek will be completed to identify potential areas of groundwater discharge. Handheld thermal imaging cameras (FLIR) will be utilized as well as long probe thermistors. The FLIR cameras allow high resolution image capture of real-time variations in temperature in the field. This information helps to identify areas of groundwater discharge and optimize water-quality monitoring/sampling locations. The timing of a thermal survey is crucial, and likely best conducted during the winter or late spring to summer months when groundwater and surface-water temperatures are contrasting the most. Summer may be better because surface-water temperatures are warm, and less affected by latent heat from wastewater discharge. If the reconnaissance survey locates potential areas of groundwater seepage, samples will be collected using a peristaltic pump and placing the tubing as close to the point of groundwater discharge as possible. Water samples will be analyzed for nutrients and major ions by the USGS National Water Quality Laboratory in Denver, Colorado (table 1).

Established protocols will be followed for collecting and processing samples for water-quality analyses (U.S. Geological Survey, variously dated). Dissolved oxygen, water temperature, pH, and specific conductance will be measured in the field at the time of sampling. Field instruments will be calibrated and documented as part of the USGS quality assurance program. Sampling will include the collection and laboratory analysis of 15% replicate samples and field blanks for quality assurance and quality control purposes.

Table 1. Constituents to be analyzed in water samples [filt., filterable].

Constituent group	Analytes	Laboratory
Field parameters	Water temperature, pH , specific conductance, dissolved oxygen	USGS in field
Nutrients	Filt. ammonia, filt. nitrate+nitrite, total ammonia+organic nitrogen, total phosphorus, filt. orthophosphorus	USGS National Water Quality Laboratory, Denver, Colorado
Major Inorganic Ions	Filt. bromide, calcium, chloride, fluoride, iron, magnesium, manganese, potassium, silica, sodium, sulfate	USGS National Water Quality Laboratory, Denver, Colorado

Task 2. Measure groundwater seepage

During the reconnaissance, 4 to 9 appropriate locations to make stream flow measurements for seepage (using acoustic Doppler velocimeters) will be determined. The locations and spacing of discharge measurement sites will be based upon the findings of the FLIR camera. This methodology to quantify seepage may not be appropriate if the DNWRF outfall discharge is not quantifiable at a small (15 min to hourly) timescale. Standard USGS methodologies (Rantz, 1982 and Turnipseed and Sauer, 2010) will be used for measuring and reporting streamflow at each discharge measurement location.

Task 3. Measure groundwater flux

Within Ellerbe Creek, temperature will be monitored with a fiber optic distributed temperature system (FO-DTS). Temperature measurements will be used as a passive tracer to locate areas groundwater discharge. The FO-DTS will be deployed longitudinally over 1650 to 2300 feet and will record temperature every 15 minutes in approximately 3 ft intervals. At least one piezometer will be driven into the streambed to a depth of approximately 3 ft (or less if bedrock is shallow) and equipped with thermisters to measure vertical temperature gradients within the streambed concurrently with the FO-DTS. The FO-DTS will be deployed for 7 days to continually collect data over 6 full diurnal cycles. Previous USGS investigations (Lowry and others, 2007) have shown that the FO-DTS is an ideal instrument to monitor stream temperature spatial variability. If the FO-DTS survey locates areas of groundwater seepage that were not identified using the FLIR camera, similar screening water-quality samples will be collected. Areas of groundwater discharge located during the FO-DTS study will be modeled using a 1-dimensional heat-transport model to simulate groundwater discharge.

Task 4. Prepare final report

The USGS will publish a final USGS-series report summarizing the data collected during the study and an analysis of the potential nutrient inputs from groundwater adjacent to the land-fill.

Quality Assurance

As the Nation's principal earth-science information agency, the U.S. Geological Survey has developed a worldwide reputation for collecting accurate data and producing factual and impartial interpretive reports. To ensure continued confidence in its products, all scientific work is conducted in accordance with documented QA policies and procedures. The USGS Quality Assurance Plan for Water-Resources Activities in North Carolina (U.S. Geological Survey, 2010a; 2010b) provides a framework for defining the precision and accuracy of collected data.

All water-quality activities will be conducted in accordance with the Quality-Assurance Plan for Water-Quality Activities of the North Carolina Water Science Center (U.S. Geological Survey, 2010a). Equipment cleaning and sample collection and processing will follow procedures outlined in the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, variously dated). Any deviations from established protocols that are necessitated by extraordinary field conditions will be documented in writing, and data integrity will be checked with additional quality assurance samples.

Results from environmental sampling may be subject to bias (or systematic error) and variability (or random error) during sample collection, processing, and analysis. The nature and magnitude of bias and variability can be determined by analysis of quality-control samples, including laboratory and field blanks, equipment-cleaning blanks, field replicates, and performance-evaluation samples. Approximately 15 percent of the water-quality samples will consist of equipment blanks, field blanks, and replicate samples for quality assurance of sampling procedures and laboratory analyses. Project personnel and a South Atlantic Water Science Center Water Quality Specialist will review all field and laboratory analytical results and request re-analysis or verification from participating laboratories when results are in question.

Prior to deployment, the FO-DTS will be calibrated in an ice bath in the field with a National Institute of Standards and Technology (NIST) certified thermistor, accurate within 0.1 C. Temperature drift of the FO-DTS during its deployment will be compensated using self-logging thermistors deployed at the upstream and downstream ends of the cable (at a minimum). The location of the fiber-optic DTS cable will be surveyed using a real-time GPS.

Products

All data collected and analyzed by the USGS will be archived in the USGS National Water Information System (NWIS) database and geophysical archive. Periodic progress updates will be made to DSS. The USGS will publish an online USGS-Series Report, documenting the techniques used for data collection and the study findings. Reports receive extensive technical and editorial reviews prior to approval for publication by the Director, USGS. An oral presentation of the study results will be provided to the DSS upon completion of the draft report, and to other interested parties if requested.

Personnel

A senior-level hydrologist of the USGS South Atlantic Water Science Center (SAWSC) experienced in groundwater/surface water interaction and water-quality data collection and report preparation will act as project chief. The SAWSC water-quality specialist will provide general guidance on quality assurance.

Timeline

The proposed project is a 24-month study planned to initiate on May 1, 2016. Data collection will begin in June 2016 and concluding at the end of April 2017 (table 2). Publication of the final project report is planned to be complete by April 30, 2018.

Table 2. Proposed project schedule, by quarter [**X**, task activity is planned]

Task	Project Timeline								
	Apr-Jun 2016	Jul-Sep 2016	Oct-Dec 2016	Jan-Mar 2017	Apr-Jun 2017	Jul-Sep 2017	Oct-Dec 2017	Jan-Mar 2018	Apr-Jun 2016
Conduct reconnaissance survey	X	X							
Collect water quality samples		X							
Measure groundwater flux, deploy DTS				X					
Analyze data and prepare draft of a USGS publication and submit for review			X		X	X			
Publish USGS report online and present results to DSS						X	X	X	X

Funding

The total cost to accomplish the stated objectives will be $100,000 (table 3). Subject to the availability of Federal funds, the USGS proposes to provide $40,000 in matching funds.

Table 3. Project budget summary [FY, federal fiscal year, October to September; ---, no funding required]

Federal Fiscal Year	DSS Funding	Proposed USGS Match
2016	$10,200	$6,800
2017	$36,000	$24,000
2018	$13,800	$9,200
TOTAL	**$60,000**	**$40,000**

References

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