Abstracts

Thursday, May 1

Session K4: Microbial Source Tracking and Health Effects

10:00 – 11:30 am | Room 237

Location of E. coli Bacteria Sources in an Urban Watershed in Seattle, Washington Using a Combination of Repeat In-Stream Sampling, Rapid Bio-assessment, IDDE Sampling of Storm Drains, CCTV of Sanitary Drains, Bacteroides Analysis and Information on Urban Homeless Encampments

Jonathan D. Frodge
Seattle Public Utilities, Seattle, Wash.

Abstract
Urbanized Thornton Creek consistently has high bacteria counts at the mouth of the creek. The study design used to locate bacteria sources within this watershed relied on forty-five samples collected during a morning and afternoon sample collections. Samples were collected during both dry weather and wet weather. Bacteria count differences between adjacent upstream and downstream sites and differences between morning and afternoon were used to identify sub basins where the bacteria potentially enter Thornton Creek. Several sub basins have been identified as priority areas to evaluate for bacteria sources.

Multiple *E. coli* and fecal coliform samples exceeded criteria by one to two orders of magnitude. The upper mainstem of Thornton Creek frequently met or only slightly exceeded criteria. In the lower watershed there was degradation in water quality and higher bacterial loads. Even though *E.coli* and fecal coliform counts in the lower mainstem of Thornton Creek were consistently above criteria, the initial focus is on locating and controlling the upstream and tributary bacteria sources with the assumption that a decrease in upstream bacteria counts will make it easier to discern downstream sources from the current background.

Based on *Bacteroides* sampling in Thornton Creek it is highly probable that human sources of bacteria are prevalent. The *Bacteroides* technique provides reliable information that human sources are present, but the lack of epidemiological studies or a correlation between *Bacteroides*, *E.coli* or fecal coliform bacteria make any quantification of these results beyond the capability of the current study.

Suspect human contributions are the drainage network, the sanitary system and direct human contribution. IDDE techniques are used to investigate the drainage network, CCTV for the sanitary system. Uncontained sources of sewage have been associated with individuals living in vehicles or camping in portions of the watershed. Protocols have been developed in consultation with the Housing Authority to identify and eliminate contribution from transient and homeless encampments in the watershed while protecting both field crews and the rights of the homeless.

Examining Indicator Bacteria at Freshwater Swim Sites in the Los Angeles River Watershed, California

Kristy Morris[1], Christine Lee[2,4], Nancy L.C. Steele[1] and Kate Johnstone[3]
[1]*Council for Watershed Health, Los Angeles, Calif.,* [2]*American Association for the Advancement of Science/National Aeronautics and Space Administration, Washington, D.C.,* [3]*Duke University, Durham, N.C.,* [4]*California Institute of Technology, Pasadena, Calif.*

Abstract
Multiple popular freshwater swimming sites in the upper Los Angeles River Watershed were sampled during summer 2012 to compare the relative extent of bacterial contamination as measured by conventional culture-based methods and qPCR methods. Samples were analyzed for *Escherichia coli*, enterococci, and *Clostridium perfringens* (vegetative cells and spores) to characterize how well indicators correlated with each other, with

respect to ambient levels and to "elevations" from background, possibly indicative of a pollution input. A secondary objective was to evaluate the economic impact of implementing qPCR at our study sites for rapid water quality monitoring. Results showed that indicator species did not correlate well with each other ($R2 < 0.1$) both spatially and temporally, though *C. perfringens* vegetative cells and spores were moderately correlated ($R2 = 0.31$, $p = 0.07$). Elevated concentrations were most common on holidays and weekends, although these were not strongly correlated to the number of bathers. *Clostridium perfringens* may be a useful indicator at our study sites, as a comparison of vegetative to endospore forms of this organism may be used to understand how recently a contamination event or input occurred. Results from the economic analysis demonstrate that qPCR should be allocated to swimming sites where public health costs exceed the public's willingness to pay to use that site and to identify the source of contamination. This is the first study evaluating the utility and economic viability of employing qPCR in freshwater systems in an urban watershed of the western United States.

Epidemiology Studies of Swimming-Associated Illness at Beaches with Non-Point Sources of Fecal Pollution: Evaluating the Predictability of Traditional and Non- Traditional Monitoring Methods for Protecting Public Health

Ken Schiff[1], Jack Colford[2], John Griffith[1] and Ben Arnold[2]
[1]*SCCWRP, Costa Mesa, Calif.,* [2]*Univiversity of California Berkeley, Berkeley, Calif.*

Abstract
Monitoring fecal indicator bacteria (FIB), such as *Enterococcus* or fecal and total coliforms, for protecting public health dates back more than 50 years. Several epidemiology studies have verified the relationships between FIB and swimmer illness, including gastrointestinal symptoms, and these studies have formed the foundation of the US EPA's current water quality standards for FIB. However, virtually all of the epidemiology studies to date have been focused on freshwater or marine beaches impacted by known human sewage inputs. In California, a huge investment has been made in resolving most sewage impacted beaches, but inputs from non-point and non-human sources of FIB continue to impact beach water quality. The goal of this talk is to describe a series of three epidemiology studies conducted in California that assessed: 1) the risk of illness in swimmers compared to non-swimmers at non-point source impacted beaches; 2) the relationship between illness and traditional FIB monitoring methods, and; 3) the relationship between illness and non-traditional monitoring methods for measuring FIB, human markers of fecal pollution, and human pathogens. Across the three studies, common themes emerged for beach managers to consider as they interpret beach monitoring data. First, there was a risk to swimmers at non-point source beaches that increased with increasing swimmer exposure. The relationship of gastrointestinal illness with traditional FIB methods varied strongly as a function of source strength, with several "effect modifiers" based on transport of the non-point source to the beach. These factors play a role in beach monitoring and public health management decisions. New monitoring methods, such as genetic testing (QPCR) of FIB that take less than one hour, human fecal markers (*i.e.*, Bacteroidales), and human pathogens (norovirus), also generated relationships with swimmer illness. However, the relationships were not dramatically better than traditional FIB when the source inputs were strong and the relationships were equally poor to FIB when effect modifiers were at play. Given the similarity in predictability, the new methods offer other advantages that beach mangers may desire.

Implementing a Fecal Coliform TMDL Using Volunteer and Shellfish Sanitation Program Data to Identify Sources and Transport Pathways

Susan Libes[1], Heather Young[1], Daniel Newquist[2] and Sue Sledz[3]
[1]*Coastal Carolina University, Conway, S.C.,* [2]*Waccamaw Council of Governments, Georgetown, S.C.,* [3]*Murrells Inlet 2020, Murrells Inlet, S.C.*

Abstract
Murrells Inlet is a 14.55-mi2 watershed located in South Carolina along the southern boundary of the densely developed Grand Strand, whose economy is based on coastal tourism. The watershed drains into the Atlantic Ocean through a high-salinity microtidal estuary that provides 3108 acres of habitat suitable for shellfish production. The majority is approved (71%) for shellfish harvesting with 24% classified as restricted and 5% as prohibited. A fecal coliform TMDL was approved in 2005 to address the long-term and increasing extent of shellfish

bed closures. It requires an 80% load reduction, but does not identify the source(s) of the microbes. Since 2007, most of the watershed became regulated under the NPDES Phase II stormwater program.

The 2011 annual shellfish sanitation report included an expansion in the acreage of closed shellfish beds. A local volunteer monitoring program, initiated in 2008, had already demonstrated that the headwaters of several of the 20 or so tidal creeks discharging into the inlet had consistently elevated levels of fecal indicator bacteria. These findings galvanized the local community, which describes itself as the seafood capital of South Carolina, to take action.

USEPA Section 319 funding was obtained to develop a watershed-based plan. Work began using data from the state shellfish and volunteer monitoring programs to elucidate spatial and temporal trends in bacteria levels and their causative drivers, including rain, tidal flushing, and land-use change. Coastal Carolina University's Waccamaw Watershed Academy (WWA) was engaged to lead this effort. The 319 project's steering committee participated in selection of appropriate statistical tests, reasonable assumptions, and modes of data presentation including GIS mapping. A technical advisory committee provided peer review. Additional data collection has included efforts by the volunteers to track upstream sources and by the WWA to identify host animal sources using genotypic and chemical markers. The most important bacterial sources identified thus far are urbanized wildlife and canines.

Results from the data analyses were used to prioritize subwatersheds for remediation. This has led to proposed treatment strategies that focus on volume reduction of stormwater runoff, dredging of tidal creek sediments, and outreach education for pet waste control.