2009 VIRGINIA WATER RESEARCH CONFERENCE

Poster Session

(1) Contamination & Climate Change: Examining the Relationship Between Virginia's Hazardous Waste Sites & Public Health -- Emily Russell, *Environmental Stewardship Concepts* and Martha Ellen Wingfield, *Environmental Stewardship Concepts*

(2) Adsorption of Fluorine on Limestone-derived Apatite: Equilibrium and Kinetics -- Cyprian Murutu, *Department of Chemical and Metallurgical Engineering, Tshwane University of Technology*

(3) The Impact of Environmental Water Pollution on Pre-metamorphic Tadpole Development -- Cherelle J. Johnson, *Department of Biology, Norfolk State University* and Lawrence O. Garnett, *Department of Biology, Norfolk State University*

(4) Bacterial Community Diversity and Metabolic Activity in the James River -- Catherine M. Luria, *Virginia Commonwealth University*

(5) Perchlorate Concentrations in Commercially Available Sparklers and Post Burn Residues -- Jennifer L. Gundersen, *U.S. Environmental Protection Agency - Region 3*

(6) Application of Molecular Techniques for Assessment of Marine Recreational Waters -- Corinne Audemard, *Department of Environmental and Aquatic Animal Health, VIMS, College of William and Mary*

(7) Dye Tracing to Fay and Sempeles Springs in Winchester, Virginia -- Nathaniel C. Farrar, *Department of Environmental Science, University of Virginia*

(8) Interim Measures of Water Quality Change: A Standardized Non-parametric Characterization -- Roger E. Stewart, *Virginia Department of Environmental Quality*

(9) Using a GIS Approach to Analyze Blue-green Interactions -- Jennifer Ciminelli, *Center for Environmental Studies, Virginia Commonwealth University*

(10) Using *Galdieria sulphuraria* Oxidative Enzymes as a Water Quality Biosensor -- Camellia M. Okpodu, *Department of Biology, Norfolk State University*

(11) Saltwater Intrusion Effects on Soil Organic Carbon in Tidal Freshwater Wetland Soils -- Lindsey M. Koren, *Virginia Commonwealth University*

(12) Plant Community and Soil Saturation Effects on the Structure and Function of Microbial Communities in an Emerging Freshwater Wetland -- Christine E. Prasse, *Virginia Commonwealth University*

(13) Seasonal Dynamics of Microbial Communities in an Emergent Freshwater Marsh -- Amy Jenkins, *Virginia Commonwealth University*

(14) Reedy Creek: A Prime Example of Urbanization's Detrimental Effects on Streams and Watersheds -- Tammy E. Parece, *Department of Geography, Virginia Tech*

(15) Challenging Assumptions: Physical Contributions to Water Quality Variation in Stormwater Retention Ponds -- Melissa Montagna, *Keck Environmental Lab, College of William and Mary*

(16) Effectiveness of Amendments in Reducing Nutrients and Mercury Release from Green Roofs -- Lan M. Tran, *Virginia Wesleyan College*

(17) Impact of Heated Runoff from Parking Lots During Summer Storms on Stream and Wetland Temperatures -- Kalen Bauman, *Department of Civil and Environmental Engineering, Virginia Tech*

(18) Stormwater Management: Discharge, Turbidity, and Nutrient Concentrations During Storm Events -- Robert S. Arthur, *Department of Civil and Environmental Engineering, University of Virginia* and Kate E. Abshire, *Department of Environmental Sciences, University of Virginia*

(19) Validating Water Quality and Quantity Outcomes for an Innovative Stormwater-management Design -- Michael J. Downey, *Department of Environmental Sciences, University of Virginia* and Kate E. Abshire, *Department of Environmental Sciences, University of Virginia*

(20) Space-efficient Enhancement of Phosphorus Removal for Urban Stormwater Practices Through Supplemental Wetland Filtration -- Shawn Rosenquist, *Department of Biological Systems Engineering, Virginia Tech*

(21) Reevaluating Irreducible Concentration Limits Based on Filterra® System Performance Monitoring in Washington State -- Mindy Ruby, *Filterra Bioretention Systems*

(22) Advanced Bioretention Media for Enhanced Bacteria Removal from Stormwater Runoff -- Mindy Ruby, *Filterra Bioretention Systems*

(23) Filterra® Advanced Bioretention System: Discussion of the Benefits, Mechanisms, and Efficiencies -- Glen Payton, *Filterra Bioretention Systems*

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CONTAMINATION & CLIMATE CHANGE: EXAMINING THE RELATIONSHIP BETWEEN VIRGINIA'S HAZARDOUS WASTE SITES & PUBLIC HEALTH

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Climate change presents a myriad of challenges to the maintenance of human and ecological health in the Commonwealth of Virginia. The loss of coastal and inland wetlands, an increased frequency of extreme weather events and precipitation, as well as a rise in sea levels all threaten the state's water resources. We will focus specifically on the effect of climate change on chemically contaminated sites and what that will mean to our water supply. We examined the EPA and DEQ databases to investigate the relationship between hazardous waste sites and water bodies. In addition, we reviewed federal and state investigations on anticipated changes in extreme weather events for Virginia.

Two-thirds of Virginia's hazardous waste sites named to the National Priorities List are located near or immediately on bodies of water. In the event of extreme storm surges and increased sea level rise, this translates into the possible spread of chemicals into surface and ground waters, leading to long-term economic and environmental damage. Heavy rainfall can compromise the efficiency and efficacy of treatment plants, meaning that contamination is likely to spread to drinking water. Communities near military bases, such as Hampton Roads, with groundwater contamination have been shown in studies to have a greater frequency of negative health effects such as cancer and developmental problems.

We conclude that the solution to these threats lies in prioritizing the remediation of hazardous waste sites. Preparation for severe storm events is also key, including storm surge prediction and securing or relocation of sites that contain these threats. By doing so, the water resources that are so dear to communities throughout Virginia will be protected in the face of our changing climate.

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ADSORPTION OF FLUORIDE ON LIMESTONE-DERIVED APATITE: EQUILIBRIUM AND KINETICS.

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Fluoride in drinking water above permissible levels is responsible for human dental and skeletal fluorosis. Adsorptive based defluoridation is probably the most popular technique with several end-user applications. Consequently, the current study describes the fluoride removal potential of a novel sorbent, limestone-derived apatite from drinking water. The adsorbent was prepared by calcining limestone followed by reacting with orthophosphoric acid. Batch sorption studies were performed as a function of contact time, pH, initial fluoride concentration, particle size, temperature and adsorbent dose. Sorption of fluoride was found to be pH dependent with a maximum occurring in the pH range of 5-9. It was also observed that the material had a buffering effect on the same pH range. Meanwhile, the adsorption capacity was found to increase with temperature, depicting the endothermic nature of the adsorption process and decreases in adsorbent mass and particle size. The equilibrium data was well described by the conventional Langmuir isotherm, from which isotherm the maximum adsorption capacity was determined as 22.2 mg/g. From the kinetic perspective, the fluoride adsorptive reaction followed the pusedo-second order mechanism.

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THE IMPACT OF ENVIRONMENTAL WATER POLLUTION ON PRE-METAMORPHIC TADPOLE DEVELOPMENT

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Environmental water pollution has devastating effects on the development and vitality of marine organisms. The importance of this study is to investigate the influence of pharmaceutical and agricultural water pollutants acting as developmental disrupters of pre morphogenic tadpoles. This research determines morphological disruptions in the development of marine species, frogs, *Rana sylvatica* and *Rana pipiens* exposed to an estrogen and nitrate polluted environment. A leading source of pharmaceutical water pollution is waste containing birth control pills, antidepressants and other compounds that are finding their way into the nation's water ways. A major source of agricultural water pollution is artificial fertilizers, pesticides and farmyard waste polluting water through cultivation runoff. Previous studies have examined the impact of estrogen and ammonium nitrate pollution on the developmental patterns of marine organisms. It is vital to understand the potential dangers of developmental disruptors on marine organisms caused by environmental pollutants.

This is a continuous study of the effects of environmental water pollution. *Rana pipiens* tadpoles were placed in a polluted ammonium nitrate environment and an unpolluted environment on April 19, 2009. A similar study was conducted April 18, 2008 in the same laboratory using estrogen as the pollutant. *Rana sylvatica* tadpoles were placed in an estrogen polluted water environment and an unpolluted environment. The aquatic environments were monitored daily and the developmental stages were recorded. The amount of beta estradiol and ammonium nitrate used in this study was based on the Environmental Protection Agency standards for human water consumption and toxicity reports for marine species. The effects of estrogen and ammonium nitrate water pollution were studied independently and the data was correlated in this investigation. This research determined ammonium nitrate and estrogen water pollution act as developmental disruptors of *Rana sylvatica* and *Rana pipiens* during the pre metamorphosis stages of tadpole to frog development. This research establishes the effects of pharmaceutical and agricultural water pollution as developmental disruptors on the metamorphosis of amphibians.

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BACTERIAL COMMUNITY DIVERSITY AND METABOLIC ACTIVITY IN THE JAMES RIVER

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Bacterial communities are diverse assemblages comprised of thousands of species that differ in their physiological capacities, levels of metabolic activity and preferred growing conditions. Because they play an essential role in material and energy cycles, a deeper understanding of these communities, and particularly of how they function, may provide valuable insights into ecosystem processes. This project aims to describe how bacterial communities in the James River respond to key environmental gradients including light, nutrient, and dissolved organic carbon (DOC) availability. Toward this goal, water samples were collected on a monthly basis from the tidal freshwater segment of the James River (between Richmond and Hopewell). Measurement parameters included nutrients, DOC, phytoplankton biomass (as CHLa) and production, community respiration and bacterial abundance and metabolic activity. Experiments were performed wherein water from James River was incubated under varying light, nutrient and DOC (glucose) treatments: Preliminary results show a strong coupling between algal and bacterial activity with enhanced light and nutrient availability leading to increased bacterial abundance and metabolism. The conclusions from this research will enhance our understanding of factors that regulate bacterial diversity and function in river and estuarine environments.

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PERCHLORATE CONCENTRATIONS IN COMMERCIALLY AVAILABLE SPARKLERS AND POST BURN RESIDUES

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Perchlorate (ClO4-) is one of the most commonly used oxidizers in sparkler manufacturing where its use is not regulated, except in shipping. A review of labeling on several varieties of sparklers revealed that some claimed to contain no perchlorates while others made no statement regarding perchlorate content. Perchlorate is believed to interfere with thyroid hormone function. It is highly water soluble and mobile in groundwater. Most occurrences in the environment are from rocket fuel, fireworks, road flares and explosives. While not a regulated pollutant, EPA recently issued an interim health advisory level of 15 ppb for drinking water.

Given the widespread use of sparklers throughout the country, and the solubility and mobility of ClO4-, there is a potential for sparklers to be a source of ClO4- contamination in groundwater.

In this study, burned and unburned sparklers from various sources were analyzed for ClO4- by HPLC/MS (EPA Method 6850). Concentrations varied from non-detectable to several mg in unburned sparklers. Perchlorate concentrations in the residues from burned, perchlorate-containing sparklers were much lower than the corresponding unburned sparkler, but ClO4- was never completely consumed. In this sample set, product labeling was not an accurate indicator of perchlorate content.

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APPLICATION OF MOLECULAR TECHNIQUES FOR ASSESSMENT OF MARINE RECREATIONAL WATERS

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A variety of cultural and molecular-based methods for detection and quantification of selected indicators of enteric pollution were applied to samples collected at Fairview Beach, a recreational bathing beach on the Potomac River in Virginia. Currently, assessment of health risk for closure of marine bathing waters is based on the 1986 USEPA enterococcus criterion that uses a 24 hour culture technique. We developed, evaluated and validated molecular-based methods for rapid detection and quantification of the enterococci that could provide more timely information for managers. Evaluation of different DNA extraction methods for enterococci-spiked samples revealed maximum recovery using a bead beating method described by Haugland et al. (2005). Using genus-specific enterococcus primers, spiked water samples yielded a sensitivity of 100 enterococci 100 ml^{-1}. qPCR results of water samples tracked closely with enterococci enumerated by both IDEXX and membrane filtration on mEI agar. Shallow bathing area sediments (0.25-0.5m) analyzed using a cultural method were determined not to be potential reservoirs of enterococci at the study site. The enterococcal *esp* gene, proposed as a specific indicator of human fecal pollution, was detected in mEI enrichments from beach waters as well as in dog feces and stormwater samples. In addition to enterococci, beach samples were also tested for male-specific FRNA coliphage by culture and qPCR using genogroup-specific primers. Although FRNA coliphage densities were below the detection limit of the qPCR method (>1000 coliphages per sample), the primers were used to genotype FRNA coliphages recovered by culture and results supported the presence of human fecal inputs to beach waters. Our results demonstrate the potential use of the enterococcal qPCR assay in the rapid assessment of beach water quality and discrimination of human fecal contributions using phage genotyping.

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DYE TRACING TO FAY AND SEMPELES SPRINGS IN WINCHESTER, VIRGINIA

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Fay Spring and Sempeles Spring are located within the karst of the Great Valley physiographic province in northern Virginia. In this region, surface water and groundwater interactions are complex and largely influenced by local geologic structures. Fay Spring is owned by the city of Winchester; although the spring was once used as a water supply for the city, it is no longer within the supply line. The springs are 300 m apart and lie along a common fault. A quantitative dye trace was conducted from a sink point along Sunnyside Run located approximately 1 km west of Fay and Sempeles Springs in an attempt to understand the degree of impact of sinking stormwater runoff on these springs.

Two kg of Rhodamine WT dye was injected on June 30, 2009 at 4 pm. The dye breakthrough occurred at both springs less than 3 days after injection. The dye was more concentrated at Sempeles Spring than at Fay Spring, reaching a peak value of 0.35 ppb at Sempeles compared to 0.24 ppb at Fay. An estimate of mass recovery indicated approximately 34 g of the dye was recovered at the two springs within the first two weeks, or 1.7% of the amount injected. A lesser amount of dye was also positively recovered within Redbud Run, a surface stream that receives groundwater discharge, however mass recovery estimation is not possible. Subsequent rainfall events caused peaks in dye concentrations more than 2 weeks after injection, indicating that dye is retained within more stagnant zones of the groundwater system.

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INTERIM MEASURES OF WATER QUALITY CHANGE: A STANDARDIZED NON PARAMETRIC CHARACTERIZATION

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A novel methodology, “interim measures” has been developed to track annual changes in key water quality parameters. Using the interim measures approach we are able to evaluate water quality trends over broad geographic regions which may include data from numerous collecting organizations, projects, and testing laboratories. Furthermore we will present a comparison between our interim measures results and our formal Kendall test for trends. We have introduced a scoring system to the interim measures similar to an index of biological integrity (IBI) to summarize each annual water quality distribution. Individual observed values in the most

desirable water quality quartile receive a score of 5, those in the least desirable quartile receive a score of 1, and values in the intermediate (inter quartile range - moderate) water quality class receive a score of three. The Integrated Water Quality score (IWQ score) for the year consists of the average of the individual scores for that year. A linear regression line is included only to indicate the general trend. Any effort to estimate the statistical significance of the regression line, or to estimate confidence intervals, would be inappropriate since it is based on integrated, non-parametric ordinal scale measures.

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POSTER TITLE: USING A GIS APPROACH TO ANALYZE BLUE-GREEN INTERACTIONS.

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GIS (Geographic Information Systems) and statistical analyses were used to determine the presence of blue-green relationships by analyzing terrestrial and aquatic models at different spatial scales. The VA Department of Conservation Division of Natural Heritage, in collaboration with VCU Center for Environmental Studies, VA Department of Forestry and VA DEQ Coastal Zone Management Program developed a geospatial model of important terrestrial areas that contribute to watershed integrity as part of the Virginia Conservation Lands Needs Assessment, an approach for mapping green infrastructure in Virginia. VCU Center for Environmental Studies, in collaboration with the VA Department of Conservation and Recreation and VA DEQ Coastal Zone Management Program have developed a dynamic and interactive mapping and data visualization application called INSTAR *(*INteractive ***ST***ream ***A***ssessment ***R***esource*)*. INSTAR allows users to access and manipulate a comprehensive (and growing) database representing over 2,000 aquatic (stream and river) collections statewide. Data represent fish and macroinvertebrate assemblages, instream habitat, and stream health assessment, based on integrative, multimetric indices at the watershed scale and a stream reach scale and serves as the blue infrastructure component of the study. The watershed integrity model and INSTAR data were analyzed to assess if "blue-green" relationships could be determined using GIS techniques; and, the limitations associated with the spatial scale of the approach.

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USING *GALDIERIA SULPHURARIA* OXIDATIVE ENZYMES AS A WATER QUALITY BIOSENSOR

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Galdieria sulphuraria, a thermoacidophile red alga, is fast becoming a model system for understanding the process of eukaryotic organelle genesis and evolution. Its bio-complexity makes it a preferred model that can be studied from a number of perspectives, which could provide a better understanding of the genetics and biochemistry of eukaryotic organisms. *G. sulphuraria* can survive at temperatures above 50^{o}C and very low pH's (less than 2) – conditions under which most eukaryotic cellular proteins become denatured. *Galdieria* can grow in complete darkness on a wide variety of organic compounds, including sorbitol, glycerol and mannitol. These polyols have to be converted to sugars or sugar phosphate in order to be useful to metabolism. *G. sulphuraria* grows on most of these substrates by having very active hydrogenases that convert these intermediates to highly active and useful biologically active metabolites. The high adaptability of this organism to extreme environments (i.e., elevated temperature and extremes with pH) that causes oxidative stress makes it an interesting organism to study the regulation of the active oxygen species (AOS) and antioxidant scavenging systems.

G. sulphuraria has been shown to have enzymes and products of the inositol signaling pathway, which change after stress. Although our long-term objective is to understand the antioxidant mechanism in this alga, because high concentrations of AOS generated in oxidative burst have direct cytotoxic effects in defense mechanisms, we are interested to investigate what role *G. sulphuraria* oxidative enzymes can be used a biosensor to detect contaminants in the environment, specifically in aquatic systems.

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SALTWATER INTRUSION EFFECTS ON SOIL ORGANIC CARBON IN TIDAL FRESHWATER WETLAND SOILS

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Tidal freshwater wetlands (TFWs) are unique ecosystems that bridge the gap between terrestrial and aquatic ecosystems and are important in the sequestration of soil organic carbon. With the ever changing global climate, TFWs are left vulnerable to downstream effects of rising sea level and saltwater intrusion due to increase in precipitation and flooding. These changes often act over large spatial scales, but the scale can vary over local and regional scales resulting in significant impacts. This multidisciplinary study assessed the amount, lability and optical characteristics of desorbed organic carbon in tidal freshwater wetland soils from the Waccamaw River, South Carolina ("organic" soils, 50-65% organic content) and Pamunkey River, Virginia, ("mineral" soils, 13% organic content). Soils from each TFW were extracted at salinities 0-35 and the dissolved organic carbon (DOC) concentration, carbon lability, and excitation-emission fluorescence spectroscopic signatures (EEM), of the leachates were measured. Based on the resulting parameters, the soil desorption shows an increase in the amount, rate and percentage of DOC in the organic soil in comparison to the mineral soil. These measurements also indicate as salinity increases, there is a positive correlation in respect to the amount, rate and percentage of DOC. EEM fluorescence spectra of the DOC was used to characterize the organic carbon into autochthonous and allochthonous components. By understanding how saltwater intrusion affects desorption and lability of soil organic carbon, it can demonstrate how climate change will play on regional carbon storage and the global carbon cycle.

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PLANT COMMUNITY AND SOIL SATURATION EFFECTS ON THE STRUCTURE AND FUNCTION OF MICROBIAL COMMUNITES IN AN EMERGING FRESHWATER WETLAND

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Wetlands are ecologically important habitats that are responsible for a variety of functions including cleansing polluted water, ameliorating floods, and recharging groundwater aquifers. More notably, the characteristic wetting/drying cycles of wetlands sustain a diverse population of microorganisms responsible for mobilizing and recycling nutrients. This project aims to describe how plant communities and soil saturation contribute to the maintenance and selection of bacterial function and diversity. To achieve this goal, soil cores were collected from two treatments (vegetated and de-vegetated plots) within three different hydrological regimes. Data collected from the early growing season has confirmed differences in soil physiochemical properties (pH, redox, organic matter content, C:N), microbial community function (assessed as extracellular enzyme activity), and microbial community composition (T-RFLP) between the three hydrological regimes and soil depth profiles. As of yet, there is little evidence that the presence/absence of vegetation is significant; however it may take several months for the effects of manipulation to develop in the treatment plots. As we collect further into the growing season, we expect to see extreme differences in microbial community composition and function between the two vegetation treatments since soil saturation, organic matter content, and oxygen availability are all influenced by the presence/absence of plants. The conclusions presented from this research will enhance our understanding of factors that regulate bacterial diversity, function, and soil quality in dynamic environments.

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SEASONAL DYNAMICS OF MICROBIAL COMMUNITIES IN AN EMERGENT FRESHWATER MARSH

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Sediment microbial communities are important contributors to biogeochemical processes in freshwater marshes, though relatively little research has been conducted to determine the environmental parameters that constrain the distribution and function of these organisms. This long-term study examined temporal patterns in microbial community structure, function, and soil environment in a freshwater marsh along the James River (USA), and considered the effects of sampling depth, moisture availability, and plant community composition and biomass on the bacterial communities. Strong seasonal patterns were observed for both the environmental parameters (soil pH, redox, and moisture) and the wetland vegetation, and both types of data

correlated with successional changes in the soil microbial community. However, depending on sampling depth and location within the marsh, this relationship differed. For example, at the wettest site, microbial community composition was strongly correlated to changes in the diversity of the aboveground vegetation, while the microbial community at the drier sites seems to vary primarily in response to soil moisture and redox status. This study reinforces the importance of understanding temporal patterns and environmental controls on microbial community structure and function, which are essential to preservation of overall ecosystem function in marsh habitats.

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REEDY CREEK: A PRIME EXAMPLE OF URBANIZATION'S DETRIMENTAL EFFECTS ON STREAMS AND WATERSHEDS

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The Reedy Creek watershed is a watershed located entirely within the political boundaries of the City of Richmond, Virginia. From its headwaters, the stream flows 3.68 miles through residential areas, commercial areas, Forest Hill Park and then the James River Park where it empties into the James River. The James River Watershed is one of the major watersheds composing the Chesapeake Bay Watershed and, as such urbanization's influences on Reedy Creek affect the Chesapeake Bay Watershed. Reedy Creek and its watershed are prime examples of urbanization's detrimental effects on streams and watersheds. These effects include sedimentation, channel degradation, stream bank erosion, pollution and changing physical parameters. Reedy Creek was placed on the TMDL list in 2002 due to high levels of e-coli. Macro-invertebrates present in the stream represent pollution tolerant species. The City has undertaken sixteen separate improvement projects to correct flooding issues in various parts of the watershed. Reedy Creek continues to degrade. This poster presentation will demonstrate urbanization's effects on Reedy Creek and its watershed.

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CHALLENGING ASSUMPTION: PHYSICAL CONTRIBUTIONS TO WATER QUALITY VARIATION IN STORMWATER RETENTION PONDS

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Retention ponds are widely used as management structures (BMPs) to control the volume of water discharged during storms, but they may also retain sediment and nutrients draining into larger bodies of water. This "water quality enhancement" function is based largely on the assumption that greater retention time leads to better water quality, but no research to date has determined which, if any, physical characteristics of these ponds contribute to the quality of water released. To address this information gap, we sampled and measured water quality in 96 stormwater retention ponds in James City County, VA. Using ArcGIS software, the James City County code of each BMP was identified and available physical data on the ponds and surrounding watersheds were extracted; additional data are being generated from direct measurements. Once complete, we will run separate factor analyses on water quality and physical data to generate eigenvalues and then discern how variation in water quality correlates with variation in physical characteristics. Ultimately, we hope the relationships we identify canthen be used to help developers, planners, and managers design stormwater control structures that also enhance water quality.

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EFFECTIVENESS OF AMENDMENTS IN REDUCING NUTRIENTS AND MERCURY RELEASE FROM GREEN ROOFS

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Vegetated green roofs are effective in reducing storm water runoff. However, recent literature and experiments at Virginia Wesleyan College have found that green roofs leach higher concentrations of nutrients and mercury than typical gravel roofs due to added fertilizer or compost in the growing media, which can impact eutrophication and human health. Preliminary laboratory studies indicated that alum and Ultra-Phos Filter showed promise at reducing nutrient runoff. Fifteen experimental green roof plots and two real green roofs were used to evaluate 1) the difference in nutrient and mercury runoff from green versus traditional gravel roofs, and 2) the effectiveness of alum and Ultra-Phos Filter in reducing nutrients and mercury in the runoff. The experimental plots were divided among the following treatments: standard green roof, green roof plus alum, green roof plus Ultra-Phos Filter, and standard gravel roof. A dormitory roof was divided into four sections: green with slow release fertilizer, green with no fertilizer, green with fertilizer and Ultra-Phos Filter, and gravel. The roof of a commercial building in downtown

Portsmouth, VA, was divided into two sections: green with Ultra-Phos Filter and gravel. Two to three rainstorms were sampled for each of the roof types. These initial results indicate that the green roofs continued to leach higher concentrations of nutrients than the gravel roofs, even three years after installation. The mean concentrations of nitrogen and phosphorus were not significantly lower in the treatments with added alum or Ultra-Phos Filter. Plans for ongoing studies to confirm these results will be discussed.

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IMPACT OF HEATED RUNOFF FROM PARKING LOTS DURING SUMMER STORMS ON STREAM AND WETLAND TEMPERATURES

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Abstract: Runoff from hot parking lots during summer thunderstorms injects pulses of hot water into receiving water bodies. If the magnitude of these thermal perturbations is sufficiently large, aquatic organisms downstream can be impacted. Such concerns are heightened because aquatic organisms are particularly sensitive above their thermal optima, and climate change will likely both raise the temperature and reduce the magnitude of baseflow in aquatic systems. While previous studies have determined that the impact of summer storm thermal pulses on stream temperatures can be significant, none have fully resolved the spatial extent and magnitude of these impacts in space or time in receiving streams nor evaluated impacts in other types of water bodies (e.g., wetlands). Here we present preliminary temperature timeseries data collected using arrays of wireless temperature sensors in two example waterbodies (a stream with directional flow and a wetland with minimal current) immediately downstream of the outlet of storm sewers draining large nearby parking lots on the Virginia Tech campus in Blacksburg, VA. These data are useful to quantify the magnitude, duration, and evolution of thermal perturbations from individual storms and how these vary with current velocity, weather conditions, and time of year. We will compare the magnitude, extent and frequency of measured perturbations in the receiving water body to thermal tolerance data for both representative and sensitive species to evaluate the expected ecological impacts. We also outline future research planned on this topic.

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STORMWATER MANAGEMENT: DISCHARGE, TURBIDITY, AND NUTRIENT CONCENTRATIONS DURING STORM EVENTS

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The dynamic interaction of precipitation, runoff, streamflow, and Pond residence determines the outcome of the stormwater management structures designed and constructed at University of Virginia in 2004. Time-course sampling during and following storms in which 0.2-1.0 inches of rain were received over the course of several hours determined discharge, turbidity, and nutrient concentrations at locations (1) upstream of the engineered channel, (2) at the end of the vegetated, sinuous channel with reconstructed floodplain, and (3) at the outlet of the Pond. A sharp peak in discharge, turbidity, and phosphate upstream of the stormwater-management system occurs with every rainfall. Peak storm turbidity can reach 800 NTU. High discharge is maintained, but turbidity drops quickly during flow along the vegetated channel, so that water entering the Pond is rarely greater than 50 NTU. The Pond acts to dampen the flood peak, and retention time is adequate to reduce the turbidity to values of 5-8 NTU. Approximately 2 feet of loose sediment has already accumulated on the bottom of the 6-foot deep forebay of the Pond. Upstream phosphate levels reach 3 mg/L at peak turbidity and range 0.05-0.1 mg/L at the Pond outfall. Upstream nitrate concentrations are 0.4-0.6 mg/L as N, and the Pond outfall is commonly 0.2-0.3 mg/L as N. The decrease in phosphate levels mirrors the turbidity decrease, but the nitrate concentrations are lowered to a lesser degree. The greatest water quality improvement is seen in the turbidity, and distribution on reconstructed floodplain and deposition in the Pond are critical factors in determining what is passed further downstream.

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VALIDATING WATER QUALITY AND QUANTITY OUTCOMES FOR AN INNOVATIVE STORMWATER-MANAGEMENT DESIGN

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University of Virginia is set at the headwaters of Meadow Creek, an impaired tributary of the Rivanna River. Urban development provides significant coverage by impervious surfaces in this small watershed, resulting in high peak runoff with elevated turbidity and nutrient content. In 2004, 1100 feet of Meadow Creek were daylighted into an engineered channel, reconstructed flood plain, and detention basin (Dell Pond). Assessment of stormwater quantity and quality provided data to determine regulatory compliance and to validate the success of the design. Measurements were made (1) upstream of the engineered channel, (2) at the end of the vegetated, sinuous channel, (3) at the outlet of the Pond, (4) at the entrance to the new John Paul Jones Arena, and (5) at the exit from University property. Large reductions in turbidity and phosphate concentration are achieved as water flows along the vegetated channel and is detained in the Dell Pond. The Pond further acts to dampen peak discharge, and turbidity is reduced to nearly baseline levels by retention in the Pond. The decrease in phosphate levels mirrors the turbidity decrease, but retention in the Pond is too short to significantly reduce the nitrate concentrations. The outlet of the Pond is water of good quality, but further inputs of stormwater occur downstream. The final construction of the stormwater-management features at the Arena did not follow the original design. The result is a missed opportunity to positively influence stormwater quality and quantity derived from large expanses of parking areas and arena roof at the downstream terminus of University property.

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SPACE-EFFICIENT ENHANCEMENT OF PHOSPHORUS REMOVAL FOR URBAN STORMWATER PRACTICES THROUGH SUPPLEMENTAL WETLAND FILTRATION

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Anthropogenic eutrophication of surface waters caused by excess nutrient loads is a major environmental and economic problem in the US. Phosphorous, typically the limiting nutrient for algal growth in freshwater, is often targeted to prevent eutrophication. While agricultural sources are often a primary target for phosphorus reduction, urban landscapes are also a major contributor of phosphorus and must be addressed. Constructed wetlands (CW) have demonstrated significant promise in reducing phosphorous in stormwater, but challenges exist for implementing traditional CW in urban areas, such as high land value and flashy storm events. The objective of this research is to investigate a novel approach to CW filtration in urban stormwater, which addresses the specific constraints of the urban setting. Land use and associated cost is decreased by regularly rejuvenating the removal capacity of a much smaller CW. Limitations associated with flashy storm events are overcome by pairing the CW with existing retention ponds, thereby utilizing existing infrastructure and further decreasing cost. This paired treatment strategy allows the CW to be optimized for removing dissolved phosphorus. Bench-scale studies have provided promising results, leading to validation at field-scale. Field-scale evaluation for the filtration and rejuvenation processes includes several 30L filters receiving source water from a eutrophic retention pond. The filters are scaled to limit sorption sites and accelerate the degradation in removal performance, allowing a much shorter study period. Results presented include the quantification under field conditions of filter performance, performance degradation, and the effectiveness of the rejuvenation process in regaining original removal performance.

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REEVALUATING IRREDUCIBLE CONCENTRATION LIMITS BASED ON FILTERRA® SYSTEM PERFORMANCE MONITORING IN WASHINGTON STATE

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A Technology Evaluation Report (TER) for the Filterra® Bioretention System was submitted to the Washington State Department of Ecology for approval through the Technology Assessment Protocol – Ecology (TAPE) in the summer of 2009. The Filterra® system was tested at the Port

of Tacoma in Tacoma, Washington from May 2008 through May 2009. The Filterra® system is a self-contained stormwater bioretention treatment system manufactured by Americast, Inc. The Filterra® system is a flow-through stormwater treatment device intended for removal of suspended sediments, nutrients, heavy metals, and oil & grease from stormwater flows within small-scale catchments such as parking lots and streetscapes. During the 2008-2009 monitoring period, a total of 27 storm events were sampled to characterize the water quality treatment performance of two Filterra® test systems at the Port of Tacoma.

During the 2008-2009 monitoring period, the Filterra® test systems at the Port of Tacoma demonstrated significant reductions in total suspended solids (TSS), dissolved zinc, dissolved copper, and total petroleum hydrocarbons (TPH). TSS removal ranged from 79 to 90 percent for influent TSS concentrations 20 milligrams per liter (mg/L) or greater. The irreducible TSS concentration is commonly considered to be 20-40 mg/L TSS; however, the sampling conducted at the Port of Tacoma demonstrated that TSS reduction beyond this threshold are possible with effluent concentrations from the monitored systems ranging from 2.0 to 7.8 mg/L. This presentation will demonstrate how the Filterra® Bioretention System pushes the limit of typical stormwater effluent irreducible concentrations and raises the bar for stormwater treatment system performance.

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ADVANCED BIORETENTION MEDIA FOR ENHANCED BACTERIA REMOVAL FROM STORMWATER RUNOFF

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Bioretention filters stormwater runoff through a terrestrial aerobic plant / soil / microbe complex to remove pollutants through a variety of physical, chemical and biological processes. The goal of Filterra®, division of Americast Inc., is to advance and optimize bioretention media through the use of bioretention's physical, chemical and biological pollutant removal mechanisms.

With the growing concern about bacterial impairment of recreational waters associated with stormwater runoff, extensive laboratory and field studies were conducted by Filterra®, to determine an optimum blend for bacteria removal. The Filterra® bioretention BMP blend is currently designed to utilize pollutant mechanisms to remove typical stormwater pollutants such as TSS, phosphorus, nitrogen and heavy metals. Filterra® has developed a specialized treatment media to remove fecal coliform and other pathogens from urban stormwater runoff. This new media blend has been trade marked Bacterra.

Laboratory tests have shown bacteria removal rates between 77% and 99%, with field results showing removal between 93% and 99%. It is believed that the media goes through a maturation process where it develops a complex microbiological ecosystem that enhances predation, capture

and destruction of fecal coliform. Physical, chemical and biological processes are all believed to contribute to the removal process, but sorption is believed to be the primary removal mechanism.

This study demonstrates that a high flow through rate can achieve high bacteria removal efficiencies. This presentation will summarize the history and advancements in bioretention and the research effort and findings of Filterra® in the development of their Bacterra™ high flow bioretention media treatment technology.

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FILTERRA® ADVANCED BIORETENTION SYSTEM
DISCUSSION OF THE BENEFITS, MECHANISMS AND EFFICIENCIES

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Filterra® represents the latest advancement in bioretention technology for urban stormwater runoff treatment. Filterra's® bioretention plant / soil / microbe treatment complex utilizes physical, chemical and biological pollutant mechanisms to remove nutrients, heavy metals, TSS, bacteria and other constituents found in urban runoff. It is essentially "bioretention in a box" combining a high flow rate filter media, with an attractive tree or shrub, in a concrete container. Filterra® also provides many added values such as enhanced aesthetics, improved habitat, and easy safety inspection. Filterra can be designed as a filter and / or to infiltrate / recharge runoff and can be used for any type of develop (new or retrofit applications) in any soil conditions to achieve multiple stormwater management goals. Maintenance is easy, safe and the first year is free.

Filterra's® high pollutant removal efficiency is primarily due the multiple treatment systems inherent in a plant / soil / media filter system. This presentation will outline the wide array of pollutant removal mechanisms, design strategy and benefits provided by Filterra® that allow it to perform and operate in such an exceptional manner.