Restoration in the Coastal Plain: Stream and Wetland Processes

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The Dilemma of Bedload Transport Prediction in the Coastal Plain Geomorphic Setting

Ellen McClure, Biohabitats, Inc., Timonium, MD

Stream restoration practitioners generally include channel cross-sectional geometry, planform pattern, and profile in the development of a natural channel design. While there is considerable effort made in defining appropriate *morphologic* parameters via reference reach evaluation, regional relationships, and channel classification guidelines, we often fall short in terms of *process-based* thinking.

Bedload transport is a geomorphic process that is central to the development and maintenance of channel morphology. While practitioners of stream restoration acknowledge the importance of sediment transport, rarely is it fully integrated into natural channel design to establish proper channel stability.

The bed surface of Coastal Plain streams is dominated by mixed grain sizes, most of which are sand or finer (<2mm). As opposed to uniform sediments, the transport mechanics of these non-uniform mixtures are extremely complex. Furthermore, sediment supply to Coastal Plain streams is highly variable both spatially and temporally. These aspects present an additional layer of complexity in the natural channel design of Coastal Plain streams.

A poor estimate of the relationship between bedload transport with respect to sediment supply can reduce project success. If transport exceeds sediment supply, a restoration project may experience accelerated bed scour and channel degradation. If sediment supply exceeds transport, a design channel may unexpectedly aggrade and undergo bank erosion.

Despite a half century of intensive theoretical, empirical, and probabilistic approaches to the prediction of sediment transport, our ability to apply sediment transport models to these stream restoration problems is tenuous at best. Practitioners must continue to accept large uncertainty inherent to any sediment transport analysis. However, there are simple ways in which we can improve our thinking and reduce uncertainty in natural channel design.

- **Practitioners must understand the assumptions inherent in sediment transport modeling before selecting an appropriate model**. There is no “magic” sediment transport model, but some approaches are more appropriate than others to the Coastal Plain setting.

- **There’s more to sediment transport than incipient motion**. If sediment is mobilized, how do we know there is sufficient sediment supply to replace it? Evaluating the geomorphic setting can provide a meaningful framework for estimation of sediment supply. Relatively simple quantitative models can be used to predict any net adverse channel change for a given set of design conditions.

- **Large uncertainties with existing models can be reduced with some additional data collection**. Even if found generally appropriate to mixed, sandy bed material in the Coastal Plain, a sediment transport model will provide little guidance in the absence of any field data. However, by fitting a transport model to some field data, transport rates can be extrapolated to a broader range of events.

About the speaker:

Ellen McClure is a geomorphologist at Biohabitats, Inc. in Timonium, MD. Her responsibilities include watershed and stream channel assessment, hydrologic and hydraulic modeling, and preparation of stream restoration designs.

Ms. McClure received a B.S. in Geological Sciences from the University of Washington and a M.S. in Geology and Civil Engineering at Oregon State University. Before joining Biohabitats in 2000, Ms. McClure worked as a hydrology and geomorphology consultant at PWA, Inc. in San Francisco.

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A Comparison of Soil Properties and Processes in Natural and Mitigation Wetlands of the Southeastern Coastal Plain

Greg Bruland, Duke University Wetland Center, Durham, NC

Mitigation involves the creation or restoration of wetland structure and function that were lost during development. As mandated by Section 404 of the CWA, the Army Corps of Engineers (ACoE) requires that the hydrology and vegetation of mitigation wetlands meet hydrologic and vegetative success criteria during a 5 year monitoring period following creation or restoration. However, the ACoE monitoring process does not require any monitoring of soil properties or processes. This is a cause for concern for various reasons because: (1) soil forms the foundation of these developing ecosystems, (2) soil properties can be limiting to vegetative growth and survival due to lack of nutrients and compaction, and (3) soil is the medium for biogeochemical processes that transform and retain nutrients. Furthermore, very little research has been attempted to examine how differences in soil properties leads to differences in critical wetland soil processes such as phosphorus (P) sorption, and denitrification. Thus, the objectives of this study are to: (1) quantify differences in soil properties (bulk density, texture, moisture, organic matter, pH, and microbial biomass) of mitigation and natural wetlands, (2) examine how differences in soil properties lead to differences in soil process (P sorption, denitrification). Results to date indicate that the soils of mitigation wetlands generally have higher bulk density and sand content, and lower moisture, organic matter, and microbial biomass than their natural counterparts. This is turn can lead to lower P sorption capacity and denitrification rates in mitigation wetlands. Thus, while mitigation wetlands may meet the ACoE's hydrologic and vegetative success criteria in the early years of development, soil properties and processes in certain types of mitigation sites may not functionally replace those of the natural wetlands that were lost due to development.

About the speaker:

Greg Bruland is a Ph.D. candidate with the Duke University Wetland Center in Durham, NC. His current research involves the comparison of soil properties and processes of natural and mitigation wetlands in the southeastern coastal plain. His first publication is currently in press with the journal *Wetlands Ecology and Management*. This paper describes some of his initial graduate research investigating the effects of restoration on the hydrology, soils and water quality of a Carolina Bay complex in Cumberland Co., NC.

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Reference Reach and Gage Survey Data Analyses for Coastal North Carolina

Barbara A. Doll, PE and Angela D. Moreland

Restoration and stabilization of degraded streams is a priority focus for many federal, state and local government agencies and nonprofit groups. Many restoration practitioners strive to restore stability to disturbed streams by using a natural channel design approach. This approach transitions degraded channels to more stable forms by restoring and/or adjusting natural stream characteristics, including a properly sized bankfull channel, adequate floodplain width, meanders, riffles, and pools. Stability is achieved when the stream has developed a stable dimension, pattern, and profile such that, over time, channel features are maintained and the stream system neither aggrades nor degrades (Rosgen, 1996). Successful stream restoration requires an understanding of the causes of degradation; specific knowledge of the stream's present state; and understanding of the stream's most stable dimension, pattern and profile based on its present valley type and flow regime. In addition, quantitative knowledge of stable streams is necessary to determine the stable dimension, pattern and profile that can be applied in a restoration design.

A reference reach is a stable river segment that represents a stable channel within a particular valley morphology (Rosgen, 1998). Reference reaches provide the numerical template that can be applied to unstable reaches. Reference stream-channel morphology relationships are valuable tools for stream-restoration professionals. Designers and reviewers should use references reaches to determine appropriate stream-channel dimension, pattern and profile for various stream types and watershed conditions. The reference stream is not necessarily pristine (completely unimpaired). It instead is a reach that characterizes a stable morphology within its setting.

Channel-morphology relationships on reference streams are valuable tools for engineers, hydrologists and biologists involved in stream restoration and protection. Dimensionless ratios are useful tools for comparing the data from multiple reference streams, which have a different bankfull dimensions and discharges. Dimensionless ratios are also essential design tools for scaling the reference reach dimension, pattern and profile data to the design stream, which likely has a different bankfull dimension and discharge. In addition, channel morphology relationships can be used to evaluate the relative stability of a stream channel.

The natural channel design approach also relies on the accurate identification of the bankfull channel dimension and discharge. Hydraulic geometry relationships that relate bankfull stream channel dimensions and discharge to watershed drainage area are therefore useful tools for stream restoration design. Dunne and Leopold (1978) first developed hydraulic geometry relationships for the bankfull stage, also called regional curves.

This presentation will include preliminary regional curve and morphological reference reach relationships for 7 reference reach and 7 USGS gaged streams in the Coastal Plain. Reference and gaged streams included in the presentation represent the major physiographic regions within the Coastal Plain: Upper, Middle, Lower and Sandhills regions.

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About the speaker:

Barbara Doll is water quality specialist for N.C. Sea Grant, which is a federal/state program that promotes the wise use of coastal resources. Based at NC State University, Barbara provides information to the public and local governments about water quality status, research and regulations. Much of Barbara's current work is focused on repairing degraded stream systems and reducing the impacts of stormwater runoff and nonpoint source pollution. With grant funding from both state and federal agencies, she is currently working on several restoration projects. Projects include repair of a highly degraded urban stream located on the NC State University campus; restoration of a small tributary of Hewlett's Creek on Pine Valley Golf Course in Wilmington; and restoration of a tributary of Yates Mill Pond in Raleigh.

Ms. Doll has bachelors and master's degrees in civil engineering from N.C. State University. Before joining Sea Grant in 1992, she specialized in water resources and surface water quality in consulting work and graduate school.

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The Emergency Watershed Protection Program and Its Implementation Following Hurricane Floyd

Michael J. Hinton, USDA Natural Resources Conservation Service, Raleigh, NC

The Emergency Watershed Protection (EWP) Program is administered by the USDA Natural Resources Conservation Service (NRCS) to assist local sponsors address hazards to life and property created by natural disasters that cause a sudden impairment of watershed functions. Hurricane Floyd brought unprecedented rainfall to most of North Carolina's coastal plain region resulting in record flooding. All of the major river basins east of Raleigh experienced flows in excess of the 500-year event. Fifty-two lives were lost and damages exceeded $6.0 billion. Flooding killed over 3 million turkeys and chickens, and 40,000 swine. Wind and flood flows resulted in the placement of a large numbers of trees and other debris into stream and river channels. High flows also contributed to significant streambank erosion in many locations.

The EWP Program was used to provide technical and financial assistance for the disposal of over 2 million dead animals. Disposal methods included burial, composting and incineration.

Debris removal from streams and rivers was completed in 24 eastern North Carolina counties. Debris was removed from channels where it created an increased threat to life and property due to a greater risk of flooding. The EWP program was not used to address pre-existing problems such as poor drainage or beaver damage. Debris was removed from over 1,800 miles of streams and rivers using EWP Program technical and financial assistance.

Because of the potential adverse impacts associated with debris removal, NRCS worked closely with federal and state resource management agencies, sponsors, and contractors to ensure that work was completed without significant adverse impacts to water quality, aquatic habitat, or riparian areas. Guidelines for debris removal were developed in cooperation with state and federal agencies following Hurricane Fran (1996) and were used in Floyd debris removal projects. The guidelines were incorporated into NRCS contract documents. In most cases, section 404/401 permits were not required. Navigable waters were subject to Section 10 regulations, and permits were acquired prior to any work.

Additionally, NRCS provided state and federal review agencies a copy of quad maps showing the location of all proposed work. When there were potential impacts to endangered species, water quality, cultural resources, aquatic habitat, or other environmental concerns, NRCS worked with the appropriate resource agencies to modify the proposed work to avoid impacts. NRCS and Soil and Water Conservation District inspectors monitored the debris removal contracts to ensure that contract specifications were followed and that adverse impacts were avoided.

As a result of the cooperation of state and federal agencies, contract provisions, and inspection, debris removal contracts were completed in a manner that met program objectives regarding the protection of life and property without adverse impacts to the environment. Debris removal was limited to that which posed a threat to life and property. Significant woody debris was left in the streams and rivers when it was sufficiently anchored and positioned where it posed no threat. Inspection of completed work revealed a good distribution of both large and small woody debris.

While most of the EWP effort focused on debris removal, streambank stabilization and stream restoration was completed as well. Record storm flows combined with high velocities caused significant bank erosion in a number of locations. NRCS completed 9,800 feet of streambank stabilization and stream restoration. Principles of natural channel design were used to evaluate stream conditions and to determine the type of restoration appropriate for the site. Priority 1 or 2 restoration was implemented where possible. Priority 4 restoration (stabilization in place) was implemented where roads, utilities, or buildings limited access to the floodplain.

About the speaker:

Mike Hinton is the EWP Program Manager for the Natural Resources Conservation Service in North Carolina. He has been with NRCS for 22 years and has worked in South Carolina, Mississippi, and North Carolina.

Mr. Hinton received a B.S. in Zoology and a M.S. in Wildlife Biology from Clemson University.

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Bankfull Regional Curves for the Coastal Plain Physiographic Province of North Carolina

William V. Sweet and Jens W. Geratz, EcoScience Corporation, Raleigh, NC

Bankfull regional curves relate stream-channel geometrics to watershed size for specific physiographic regions. This paper presents bankfull-curve information and bankfull recurrence intervals for North Carolina's Coastal Plain physiographic province. Cross-sectional and longitudinal survey data from stream reaches with gage stations and un-gaged, stable reference reaches were used to compute bankfull-channel dimension and profile information. Power-function regression analysis generated watershed size-dependent relationships for bankfull discharge, cross-sectional area, width and mean depth. Recurrence intervals of bankfull events were estimated by Log-Pearson Type III distribution of peak-annual data to average 0.61 years, ranging from 0.21 to 1.09 years. Partial-duration series methods, which utilize average daily discharge values at gage sites, determined that recurrence intervals for bankfull events ranged from 0.11 to 0.31 year, with an average 0.18-year period. In any case, certain bottomland regions of the Coastal Plain province appear to have unique bankfull-hydraulic geometrics.

About the speaker:

Jens Geratz is a restoration ecologist with EcoScience Corporation located in Raleigh, N.C. His responsibilities include staff management, project oversight and review, and development of technical studies. Mr. Geratz' specialties includes stream and wetland mitigation planning, geomorphological stream surveys, and plant ecology.

Mr. Geratz received a B.S. degree in Horticultural Science and a M.S. degree in Forestry (Ecological Restoration Program) from North Carolina State University. Since joining EcoScience in 1998, Mr. Geratz has designed and implemented multiple stream and wetland restoration projects located throughout the Piedmont and Coastal Plain of North Carolina.

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The Development of Bankfull Hydraulic Geometry Relationships for Streams of the Georgia Coastal Plain

Steve Bevington, William A. Harman, John Hutton

Bankfull hydraulic geometry relationships, also known as regional curves, relate bankfull stream channel dimensions to watershed drainage area. Established regional curves are important to channel assessment and stream restoration efforts as they can confirm identification of bankfull stage and channel dimension in un-gaged watersheds and help estimate the appropriate bankfull dimension and discharge for natural channel designs. This paper describes results of bankfull hydraulic geometry relationships developed for streams of Georgia's Coastal Plain. Ten USGS gage stations were identified that had a minimum of 10 years of continuous or peak discharge measurements, no major impoundments, no significant change in land use over the past 10 years, and less than 10% impervious cover over the watershed area. To supplement data collected in these gaged watersheds, eleven stable reference reaches in un-gaged watersheds meeting the same criteria were also included in the study for a total of 20 sites. Drainage areas of the selected sites ranged from 0.32 to 93.4 square miles. Sites from both the Upper and Lower Coastal Plain of Georgia were included. Cross-sectional and longitudinal surveys were conducted at each study reach to determine channel dimension, pattern, and profile information. Sediment samples were also collected to assess bed material. Log-Pearson Type III distributions were used to analyze annual peak discharge data for USGS gage station sites. Estimated return intervals for bankfull discharge at the selected sites ranged from 1.0 to 1.3 years. Power function relationships were developed using regression analyses for bankfull discharge, channel cross-sectional area, mean depth, and width as functions of watershed drainage area. Contrary to pre-study expectations, no significant differences were observed between regional curves estimated for the Upper and Lower Coastal Plain hydro-physiographic regions. These relationships based on Georgia streams will be compared to relations from other Southeastern State coastal plains, including North Carolina, in an effort to compliment and extend regional relationships. Results of this study will be discussed with particular attention given to issues relevant to coastal stream processes including multi-thread channels, non-fluvial channel formation in wetlands and the stability of sand bed streams.

About the speaker:

Mr. Bevington has 17 years experience in water quality and natural resource science. He has provided technical assistance for basinwide water quality planning efforts and the development of watershed management strategies. His background includes experience and formal training in stream and habitat restoration, riparian and wetland ecology and hydrology. Mr. Bevington has extensive experience with restoration project evaluation and selection, and management of GIS implementation. Mr. Bevington holds a Masters in Environmental Management from Duke University and a BS in Zoology from the University of Wisconsin, Madison.

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An Assessment of the Effectiveness of Cross-Vane Structures Used on Shawneehaw Creek and Clark Creek in North Carolina

Amanda J. Todd, Stantec Consulting

The primary purpose of this research was to monitor and assess the effectiveness of cross-vane structures used at Shawneehaw Creek in Avery County, North Carolina and on Clark Creek in Watauga County, North Carolina. This thesis was designed to monitor these projects for six months after construction, to establish baseline data for future research on the two sites, and to provide a foundation for a monitoring protocol that could be used for other projects on cross-vane stability in the region. One important gap in the knowledge base about stream restoration structures this study addressed is the lack of published data of the success or failures of cross-vane structures used with Natural Channel Design.

The six cross-vanes at Shawneehaw Creek and four cross-vanes at Clark Creek were monitored for a six month period beginning June 2001. Data were collected on the stream pattern, profile, and dimension before construction in May and four times after construction at both sites. Two cross sections were established at each cross-vane immediately after construction. One cross-section for each cross-vane was established over the invert of the structure and one cross-section was established over the location of the scour hole immediately after construction. Longitudinal Surveys, Cross-Sectional Surveys, Cross-Vane Measurements, Pebble Counts, and Visual Assessments were completed at each site on multiple occasions. These data allowed for precise documentation of the short-term changes in stream channel conditions and provided valuable insights into why cross-vane structures might fail in these and similar streams in the region.

Four out of the ten Cross-Vane structures failed to meet the objectives of protecting the stream banks and streambed within the first six months. The primary reasons for the failures are: 1) the cross-vane angles were not designed according to the design specifications, 2) the cross-vane slopes were too steep or too flat, and 3) the type of streambed material. The study concludes by suggesting there is a need for continued efforts by scientists to study and refine the structures and techniques used for stream restoration within different geographic settings. While this thesis has provided a foundation for a monitoring protocol of cross-vane structures used in the Appalachian region, the protocol needs to be expanded and refined for long-term monitoring in this region and other geographic settings.

About the speaker:

Amanda Todd is an Environmental Scientist with Stantec Consulting in Raleigh, North Carolina. Her responsibilities include: writing mitigation and feasibility reports, surveying existing and reference reach stream sites, and construction oversight.

Ms. Todd holds a B.S. degree in Natural Resource Management from North Carolina State University. She worked for the NCSU Water Quality Group while she was an undergraduate student and continued to work for them while in graduate school. Ms. Todd joined Stantec Consulting in 2002 after completing her Master's in Geography from Appalachian State University.

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A Comparison of Natural and Design Plunge Pool Morphology in Urban Stream Systems

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In 1997 The City of Charlotte began investigating the implications of its current maintenance practices for natural channels at road culvert crossings. The investigations were initiated after it became apparent that certain implications from these practices could result in extreme instability of the receiving natural channels with the possibility of reinitiating a cycle of instability in an otherwise stable built out watershed.

Naturally formed plunge pools are a common morphologic feature in many urban stream systems where the transition between pipe and natural stream systems occur. Initially road culvert crossings will result in scour at natural channel transition points. In streams that have not been modified for a period of time and that have adapted to the urban watershed display geomorphic characteristics of stability. It is in these streams where plunge pools serve as significant stream energy dissipaters, increasing flow resistance and enhancing stream channel stability. Such features may also provide habitat diversity and serve as refugia for stream biota during low flow periods.

We present the morphologic characteristics of naturally formed plunge pools associated with culvert outlets in the metropolitan Charlotte area. Plunge pool dimensions surveyed include maximum depth, length and width, longitudinal and side slopes as well as bed material. Culvert outlet dimensions and hydraulic characteristics of the scouring jet for each study site are also reported. These data are compared to plunge pool dimensions predicted for both free fall and submerged culvert hydraulic conditions as determined from laboratory flume studies. Comparisons between collected field data and the laboratory produced methodologies suggest sharp contrast between individual design methodologies themselves and apparent inadequacies of common design standards.

The implementation costs for constructed plunge pools are compared to those for armored riprap aprons that are traditionally employed at culvert outlets.

The end result of this research is recommended design standards to achieve designed natural plunge pools.

About the speaker:

Christopher J. Estes is president of Estes Design Inc. an environmental design and consulting company that specializes in stream restoration services. These services include stream assessment, classification, design, construction administration, monitoring and wetlands assessment / design.

Mr. Estes received a B.A. in Landscape Architecture from the School of Environmental Design at the University of Georgia in 1988. Before starting Estes Design Inc. Mr. Estes worked for the City of Charlotte Engineering Department for eleven years. Mr. Estes has initiated and managed the Charlotte's stream bioengineering program for 8 years with over 60 stream projects and 15,000 feet of urban stream stabilized using bioengineering techniques. During this time Mr. Estes has also been a designated City resource for stream and wetlands restoration design as well as permitting, training and research. Mr. Estes initiated and managed the City of Charlotte's four collaborative natural channel research projects with UNCC.

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Use of Rock for Natural Stream Restoration in Coastal Plain Settings

Vince Sortman, Biohabitats. Inc.

Natural stream restoration design utilizes principles of fluvial geomorphology to obtain channel cross section, profile, and plan-form dimensions that will allow the restored channel to function in a state of dynamic equilibrium – that is, the channel neither aggrades nor degrades and maintains its plan, profile, and section. Even in a state of dynamic equilibrium, a newly graded channel needs stabilization (preferably in the form of woody vegetation) to hinder bank erosion. In urban settings, where utilities or private property need to be protected from channel adjustment, stabilization may need to be in the form of native rock.

Stream channels in coastal plain regions are usually flowing in sandy substrate with no naturally occurring rock outcrops. The lack of naturally occurring rock presents a dilemma for stream restoration, especially in urban areas. Should rock be used to stabilize outside meander bends, step/pools, or grade control structures? These are typical uses for rock in type B and C channels in piedmont and mountain regions. But should rock be used in the same scenarios in the coastal plain? If the goal of the project is to restore a natural channel, and no rock is found in the degraded channel or in the reference reach, then it would make sense not to use rock in the restoration. But if the channel and its floodplain have been altered and affected by development and urbanization, is there anything wrong with using rock to create a natural-looking, stable channel.

A number of stream restoration projects have been chosen to demonstrate the use of rock for stream restoration in the coastal plain. All of the projects are on urban streams that have been altered and/or degraded by an urban hydrology. Some of these projects have been very successful in creating natural, stable channels. Others have been only partially successful.

About the speaker:

Mr. Sortman is a fluvial geomorphologist with Biohabitats, Inc. in Timonium, Maryland. He received his Bachelor of Science degree in Geological Sciences from the Pennsylvania State University and his Master of Science degree in Geology from the Colorado State University. At CSU he studied fluvial geomorphology under Dr. Stanley Schumm. At Biohabitats, Mr. Sortman is the lead stream restoration specialist, responsible for the design and construction supervision of all stream restoration projects. He has designed dozens of stream restorations throughout the eastern United States based on fluvial geomorphic principles and natural channel processes. He has also taught fluvial geomorphic principles and channel restoration techniques at numerous seminars throughout the country.

Incremental Tree Ring Growth as a Tool to Evaluate the Influence of Regulated River Flow on a Floodplain Swamp

Joe Berg, Biohabitats, Inc.

A detailed assessment of the effect of river regulation on bottomland forest resources in the Oconee River was undertaken to address permit requirements for the relicensing of a dam associated with an existing hydroelectric facility. The project area is in central Georgia and extends from the city of Milledgeville 60 river miles downstream to the town of Dublin. The floodplain near Milledgeville is relatively narrow and largely in agricultural cover. However, once the river traverses the fall zone and enters the Coastal Plain province, the floodplain dramatically widens, with widths of up to 6-miles, and an average width of 2 ½ miles. Tree growth ring data from large specimen trees representative of the species inhabiting wetter portions of the floodplain were collected using increment coring techniques (Fritts 1969, Phipps 1985). These data were evaluated for evidence of any relationship with patterns of river discharge and the onset of river regulation. While a number of species were evaluated, most data was collected for water tupelo (*Nyssa aquatica*) and laurel oak (*Quercus laurifolia*). The results of the tree ring study indicated that there was no statistically measurable reduction in tree growth between the 40-yr period prior to the construction and operation of the dam and the 40 year period of time following dam operation. Similarly, tree ring width data did not evidence a reduction in growth of water tupelo or laurel oak from the pre- to post-dam period, and although correlations with river discharge for wet and dry periods were significant, the correlation coefficients never explained a large proportion of the observed variability in ring width.

Conclusions

The results of these studies indicate that even though high frequency inundation events have decreased, and areas of the floodplain subject to frequent inundation have decreased, no adverse effects are evident or are predicted to result to the BLH wetland resource. One reason may relate to the relatively long duration of flooding present in the study area. The floodwater enters the floodplain more quickly than it exits, so that even when the river is above bankfull for hours to days, the floodplain may be inundated for days to weeks and sloughs and other depressions in the floodplain may be ponded for months. As a result, the effect of river regulation on duration of floodplain inundation is not expected to be important as long as the floodplain is inundated by the less frequent but larger annual flood events. In addition, many recognize the robust nature of the BLH forest community. Natural variations in precipitation, levee breeches, exceptionally wet or dry periods, etc. are commonplace in these systems, so the species present typically are able to tolerate a broad range of hydrologic regimes, as long as less robust species are periodically excluded by events beyond their range of tolerance. This floodplain remains one of the better examples of the typical BLH swamp in the southeast.

About the speaker:

Joe Berg is an ecosystems ecologist with Biohabitats, a consulting firm specializing in restoration of natural resources.

Mr. Berg has a M.S. in Marine, Estuarine and Environmental Sciences from the University of Maryland, and has been working in the resource assessment and restoration field for the past 20 years.

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Stream Bank Revegetation: Options for the Coastal Plain

Ellen Colodney, Coastal Plain Conservation Nursery, Edenton, NC

Revegetation of disturbed stream banks is an integral part of stream restoration. Stream bank vegetation can greatly improve aquatic, terrestrial, and aerial wildlife habitat, absorb excess nutrients, soften the blows of heavy rainfall, provide aesthetic pleasure to us humans, and keep all that dirt we move from washing away.

The fact that stream restoration plantings often do survive is a small miracle, given that they are typically placed into compacted clay devoid of macropores, oxygen, humus, and reliable moisture. Only plant species that are fast, strong growers, tolerant of poorly drained soil, drought, flood and clay have a chance of becoming established under these conditions. Luckily, North Carolina's coastal plain is the home of at least 10 woody species that meet the challenge. The second most important function of most stream restoration plants is to produce extensive root masses for bank stabilization. Most woody plants, native perennial grasses, and even some perennial forbs have the deep and extensive root systems that can really stabilize soil. Stoloniferous plants, are particularly beneficial since they provide full cover relatively quickly. Beware of planting trees on steeply sloping stream banks - and remember that black and Carolina willows (*Salix nigra* and *caroliniana*) are trees.

All woody vegetation will provide the debris that is the basis of the aquatic food chain. All riparian trees, and many shrubs, will provide critical shade. Terrestrial and aerial wildlife, however, will derive the greatest benefit from your stream restoration if you plant a variety of woody species, and even throw in a few herbaceous plants if your local seed source is poor. For urban or high visibility areas, maximizing aesthetic value for humans can be critical. Luckily, many of our locally native species are extraordinarily beautiful, and are beloved as ornamentals. With some species, you truly can have it all.

Live stakes are pieces of stem from living but dormant plants, stuck into the ground on site. This technique became classic for two main reasons 1) willows and some of the shrub dogwoods are very easy to propagate this way, and these are the most common riparian plants of two important cradles of stream restoration technology - the Alps, and the Rocky Mountains and 2) if one has a vast supply of dormant cuttings, one can build actual structures out of the cuttings that stabilize the stream both before and after the plants develop roots. On the downside is the fact that most plant species cannot be grown from live stakes reliably, and that live stakes should only be planted between the time the parent plant goes dormant until one month before the average last frost date. Bare root plants must be planted in a similar time frame, and often require a fairly large hole dug into the stream bank to contain their roots. Plants in 1, 3, and 5 gallon containers can be planted in all but the hottest weather. When planted in a stream restoration, which is doubling as a landscaped greenway, these plants can reduce maintenance costs. Plants grown in small containers (perhaps 2” in diameter) are the latest trend. All species can be grown in these containers and planted throughout much of the year, although availability tends to be limited in the spring. Planting is quick and easy and requires little disturbance of the stream bank while survival rates are high.

About the speaker:

Ellen J. Colodney, MD is the owner of Coastal Plain Conservation Nursery, Edenton, North Carolina.

She received her Bachelor of Science from Rutgers University, Medical Doctorate from Rutgers Medical School, and became board certified in Physical Medicine and Rehabilitation.

Five years ago she abandoned the practice of medicine to pursue her true love, helping to restore the magnificent wetlands and waterways of North Carolina by propagating the native plants needed for ecological restoration and conservation projects.

Tidal Salt Marsh Restoration, Creation, and Mitigation

Stephen W. Broome

Tidal marshes are productive ecosystems that provide important life support, water quality and hydrologic functions. Severe impacts or losses of tidal marshes occur as a result of dredging, filling, tidal restrictions, subsidence, and erosion. To mitigate those losses, techniques have been developed to restore and create marshes that provide habitats similar in structure and function to natural systems. Establishing a fringe of marsh vegetation is also an effective method of erosion control for some shorelines. Along shorelines where exposure to waves is too severe for plants to persist, offshore breakwaters may be used to protect the vegetation. Important site-related factors that must be considered to insure successful marsh establishment is elevation, slope and tidal regime, wave climate, currents, salinity, and soil physicochemical properties. Agronomic practices that are important to establishment of vegetation include selection of native plant species adapted to the site, seed collection and storage, seedling production, site preparation, soil testing, fertilization, handling of transplants, timing of planting, plant spacing, control of undesirable invasive plants, and maintenance until the marsh is self sustaining. The criteria used to define acceptable restoration or creation are often controversial. The plant communities usually achieve structural and functional equivalence in a few years, while other characteristics, such as soil organic matter and numbers and species of benthic invertebrates, require much longer to reach equivalence. When restoration or creation technology is properly applied tidal marshes with many of the same attributes and values as natural systems can be provided to replace marsh habitats that were lost in the past, or to mitigate current losses and impacts.

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Priority I Restoration: The Effects on Groundwater Levels

Angela D. Moreland, Dani E. Wise, Karen R. Hall, and Barbara A. Doll PE

When restoring incised, degraded, or straightened channels using natural channel design, there are four priorities or options available to the designer (Rosgen, 1996). The Priority I option involves returning the elevation of an entrenched and incised channel to the elevation of the original, pre-impacted bed so that bankfull discharge will access the historical flood plain. Priority I restoration aims at restoring the natural channel morphology as well as developing a healthy riparian buffer. A properly functioning riparian area may provide many water quality and stream stability benefits. Benefits that can and often do result from Priority I stream restoration are: in-stream stability, increased nutrient removal from the surface and subsurface flows, interception of sediment from overland flow, decreased stress on riparian vegetation, and improved terrestrial and aquatic habitat.

Groundwater levels have a significant influence on the biotic and biogeochemical functions of the stream corridor ecosystem. A potential byproduct of Priority I stream restoration is a raised groundwater elevation. The ultimate groundwater recovery goal for Priority I stream restoration is to bring the groundwater level closer to the surface while increasing the vegetative coverage in order to increase the subsurface filtration capacity within the riparian area. The combination of groundwater rise and dense vegetation will increase the retention time of groundwater pollutants within the vegetated zone, therefore increasing the chances of pollutant interception and removal before entering the stream system.

Although collection of groundwater measurements can be costly and time-consuming, studies are needed to determine the actual groundwater response rates resulting from Priority I restorations in North Carolina. A series of groundwater monitoring wells has documented a rise in the water table at a Priority I stream restoration project in Raleigh, North Carolina. This paper presents the conditions of the restoration, post-construction groundwater monitoring results, the benefits of this change in watertable, and future monitoring considerations.

About the speaker:

Angela D. Moreland, Water Quality Extension Associate, NCSU Water Quality Group, Department of Biological and Agricultural Engineering, North Carolina State University. Ms. Moreland has been with the North Carolina Cooperative Extension Service since April 2000. She obtained her Bachelor of Science at Greensboro College in 1999 and Master of Forestry in 2001 at North Carolina State University. Ms. Moreland supports water quality monitoring and stream restoration project initiatives in North Carolina through GIS manipulation, stream restoration field survey and classification, water quality sample collections and data analysis.

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Permeable Pavement Effectiveness in Eastern North Carolina

Bill Hunt, PE

Two types of permeable pavement were installed in Eastern North Carolina and tested for runoff reduction. The first installation (Kinston, NC) is a block paver with approximately 40% open space overlying a bedding layer of sand and washed marl. The second (Wilmington, NC) is a 150-mm (six-inch) thick porous concrete installation. Each site was constructed on sandy soil, which would provide little impediment to infiltration. The first site was tested from 1999 through 2001 and was found to substantially decrease runoff. Runoff coefficients for this installation of block paver were found to range from 0.20 to 0.50. The porous (or permeable) concrete parking lot was constructed in late 2001 and has just begun to be monitored. Visual inspection indicates a reduction in runoff, but no substantive numerical results are available as of May 2002. Results from this research may indicate an effective means of surface flow reduction into urban streams and thereby decreasing in-stream erosion.

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Pre-Restoration Water Quality of an Urban and Suburban Stream in the Central Coastal Plain of North Carolina

Erin Crawley and Terri Woods, Geology Department, East Carolina University

Over the past decade, there has been a focus on improving the quality of degraded surface waters through stream restoration projects. Many of these projects are begun because of obvious problems, such as bank erosion, excessive sedimentation, and agricultural runoff, however, very few data are available on pre-restoration water quality. These pre-restoration data are invaluable for evaluating effectiveness of stream restoration projects.

Two streams in Greenville, North Carolina were sampled for one year (July2001 – June 2002) as part of a baseline-monitoring program for the City. Greens Mill Run runs throughout the city of Greenville and discharges into the Tar River. It captures runoff from residential, commercial, and industrial areas, and in some areas is deeply incised. Meeting House Branch runs through residential areas and a golf course in the eastern part of Greenville. This stream shows significant lateral bank erosion and channel incision due recent installation of two new 36-inch culverts that replaced a single 36-inch culvert.

The baseline-monitoring program included collection of surface water samples approximately every 3 weeks, and in response to significant precipitation events. Many of the samples were taken downstream of urban storm water structures, such as culverts, storm drains, and small dams. The goal of the monitoring program was to assess the overall water quality of the two streams including nutrients (NH_4^+, PO_4^{3-}, PP, TDP, NO_3^-, PN, and TKN), sediment (TSS, volatile solids, and fixed solids), and major ions (HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, and K^+).

From the database of chemical data, spatial and temporal variability will be examined. Additionally, the effects of stream discharge and stage, groundwater influx, and precipitation will be evaluated as influences on data trends. Multivariate statistical analysis will also be applied to the data to extract statistically significant trends and relationships.

Overall, the results and conclusions of the baseline-monitoring program will provide the City of Greenville with thorough understanding of the pre-restoration water quality in both an urban and a suburban watershed.

Stream Name	Station #	$NH4^+$ (ppm)	$PO4^{3-}$ (ppm)	$NO3^-$ (ppm)	$HCO3^-$ (ppm)	Cl^- (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Na^+ (ppm)	K^+ (ppm)
Greens Mill Run	1	.0116-.2187	.0170-.0990	.0074-.2249	7.3-165.9	1.0-26.3	6.0-15.2	.9-2.6	2.2-10.6	3.2-4.6
	2	.0095-.7802	.0100-.2200	.0097-.5639	17.1-48.8	1.0-8.4	7.4-32.1	.9-3.1	3.4-9.8	2.7-14.7
	3	.0074-1.0090	.0500-.7500	.1568-1.1104	17.1-63.4	1.0-5.2	6.2-35.3	.9-2.5	3.1-10.8	2.2-4.0
Meeting House Branch	4	.0103-.0844	.0013-.0191	.0091-1.2850	17.1-61.0	1.0-59.9	11.1-18.1	1.5-3.7	5.0-8.6	3.2-4.4
	5	.0291-.1154	.0062-.0412	.0032-.8713	9.8-29.3	.09-28.2	6.2-13.5	1.1-2.5	4.8-9.7	2.5-3.9
	6	.0107-.0612	.0098-.0349	1.0505-2.9799	9.8-31.7	1.0-19.6	5.1-28.7	1.1-2.2	7.4-9.0	2.7-4.1
	7	.0124-.1197	.0062-.0365	.1382-2.6139	11.0-41.5	1.0-19.6	6.6-11.4	1.1-2.1	7.5-10.3	2.5-3.9
	8	.0332-.1480	.0078-.0507	.3780-.7395	7.3-29.3	.4-26.4	5.1-20.3	1.1-1.9	4.7-8.1	2.4-3.7
	9	.0107-.1046	.0239-.0712	.2235-.8447	19.5-43.9	.3-16.6	11.1-21.7	.9-1.7	5.3-7.3	2.9-4.0

About the speaker:

Erin Crawley is currently pursuing a M.S. in Geology from East Carolina University. Her thesis is titled: "Water quality of an urban, suburban, and rural stream in Pitt County, North Carolina" and is in progress. Ms. Crawley also received a B.S. from Purdue University in 1999. She has had one year of work experience as field geologist with ATC Associates, Inc. in Indianapolis, Indiana.

The Restoration of the Tuckasegee River Following the Possible Removal of the Dillsboro Dam

Brad Fairley B.Sc., MES, Kevin Williams BS, PE, PLS, Katie McKeithan BS, EI, Stantec Consulting, Raleigh, NC

The Dillsboro Dam is a small hydroelectric project located on the Tuckasegee River in Dillsboro, Jackson County, NC. As part of a relicensing package involving several hydro projects in the area, Duke Power developed a trial balloon involving more than 30 items including fish and wildlife habitat enhancement, recreational fishing, and boating. One of the items on the list is the possible removal of the Dillsboro Dam and the restoration of the Tuckasegee River to its natural condition. Stantec was hired to determine the feasibility of restoring the river and to answer two questions raised by stakeholders: How would it look?" and "How would it sound?"

Stantec carried out a Level I assessment of the Tuckasegee River and developed a conceptual plan for restoration. The conceptual plan involves narrowing the river channel, stabilizing the new banks, and installing a "W" weir. In order to help the locals understand what the site would look like following dam removal and restoration, Stantec prepared photo renderings of the site. Stantec answered the question of how it sound, by taking noise readings at the dam and at riffles similar to what would be created at the site of the dam. The sound analysis showed that the newly created riffle would be as loud as the dam and would generate a more constant sound.

About the speaker:

Brad Fairley has a Bachelors Degree in Biology from McMaster University and a Master Degree in Environmental Science from York University. He has more than 20 years experience in water resources management involving both the public and private sector. He moved to the Raleigh area from Canada 2½ years ago and is currently Manager of the Natural Systems Unit at Stantec Consulting, where his work focuses on environmental restoration.

Longstreet Drainage Way Flood Control Improvement Project: A Case Study for Urban Watershed Improvements

Jim Eisenhardt, Scott Brookhart, and Will Wilhelm, Kimley-Horn and Associates, Inc., and
Dave Mayes and Matt Hayes, City of Wilmington Storm Water Services

The project targets flood control issues in the Longstreet Drainage Way area in the developed Hewlett's Creek Watershed, Wilmington, NC. The objective is to address flood control issues through natural channel design and to provide overall water quality benefits to the watershed. Lessons learned from this holistic approach to watershed management in the urban setting includes: natural channel design versus traditional hard stabilization techniques in the Coastal Plain, function versus aesthetics and public involvement, and mitigation and permitting issues.

The City of Wilmington is pro-active in its approach to storm water management and seeks to use both traditional and non-traditional quantity control measures as well as potential measures for controlling water quality to resolve storm water management issues in the City's urban/developed areas. The City has developed a substantial list of future drainage improvement projects through its Storm Water Drainage Master Plan (1977, 1990), and initiated a storm water utility for the purpose of generating revenues to address all aspects of the storm water management issue.

The project segment of the Longstreet Drainage Way Project extends from Shipyard Boulevard to the upper reaches of Hewlett's Creek adjacent to the Pine Valley Country Club. The stream segment is approximately 3,500 feet in length, of which approximately 2,300 feet is located in the single-family residential neighborhood of Pine Valley. There is an existing easement (approximately 30 feet from the channel) intended for maintenance along the entire channel in this location, however, encroachments (i.e. fences, sheds, etc.) have hampered maintenance of the channel. The drainage way terminates at (and discharges to) the Pine Valley main channel. The drainage way is channelized, likely established this way when the development was constructed in what was once a pocosin wetland area. The drainage way is manmade and jurisdictional (Section 404) as an open water channel. However, the drainage way functions as a stream, including developing bed and bank features.

The drainage way is fed by channelized ditches in the Pine Valley neighborhood, a large stormwater pond, and by a large, wooded area (currently being developed), north of Shipyard Boulevard and the area between Shipyard Boulevard, South Seventeenth Street, and Independence Boulevard. Anticipated future development in the headwaters of this area adds to concerns regarding the drainage way's ability to handle the additional runoff created by new development.

Other keys to this project are working with the regulatory agencies for permitting issues, and the local community/property owners to address specific concerns within the residential community.

For a successful project, the Longstreet Drainage Way Flood Control Improvement Project depends upon proactive and diligent coordination, communication, and cooperation with individual property owners, local business owners, the City, its consultants, the agencies and the Contractor.

The project has gone through an alternative analysis, and a Value Engineering Report was produced. The alternative analysis included the evaluation of no improvements, relocating the channel, piping the channel in culverts, hard stabilization, biostabilization, and natural channel design. Ultimately, it was preferred to pursue a solution that included natural channel design and enhance the ecological/biological function of the channel.

Lessons learned from the project include: Cost benefits of traditional stabilization techniques (hard stabilization) versus natural channel design in the Coastal Plain (comparison with Long Leaf Creek stabilization project, 1996), Technical solutions for flood control issues considering water quality benefits for a watershed approach, Permitting issues, Public involvement.

NC Wetlands Restoration Program's New Hanover County Local Watershed Planning Initiative

Christy Perrin, Agricultural and Resources Economics, NC State University and Bonnie Duncan, NC Wetlands Restoration Program

The NC Wetlands Restoration Program (NCWRP) has embarked on a new watershed restoration strategy called Local Watershed Planning within several Local Watersheds statewide. Local Watershed Plans are developed for small, local watersheds to identify all factors contributing to water quality degradation within the watershed and provide voluntary strategies to address nonpoint sources of pollution. Local stakeholders who represent numerous interests across the watershed generally drive the Planning Process, with local resource professionals assisting as technical advisors. This process has been initiated and is still going on in a New Hanover County watershed that includes Burnt Mill Creek, a 303(d) listed stream, Smith Creek, and Prince Georges Creek. The planning process started in September 2000 and is driven by a local stakeholders team that includes local governments, environmentalists, foresters, developers, CP&L, as well as other interested citizens. The NCWRP has contracted and partnered with NC State University's Watershed Education for Communities and Local Officials (WECO) Program to help build and facilitate the stakeholder process for this Local Watershed Plan. The Local Watershed Planning Process provides an important opportunity for local stakeholders including residents, community groups, businesses, and industry to play a role in shaping the future of their watershed. Through the Local Watershed Planning process, these groups work cooperatively to identify issues, set priorities, develop strategies, secure funding, and implement protection and restoration projects within their communities. By encouraging stakeholders to participate in identifying solutions to address water quality, habitat, flooding, and recreational needs, the Local Watershed Plans become blueprints for strategically implementing local projects through partnerships between local governments, citizens, non-profit organizations, and state and federal agencies.

Technical Assessment

To help support this process, and provide a technical framework for stakeholder input, the NCWRP contracted with a private consulting firm, KCI, Inc., to develop a technical watershed assessment for the New Hanover County Watershed. This assessment entailed a compilation of all available data and information developed into a Watershed Characterization. The Characterization provided a baseline for what the status of the watershed was, and an indication of what information gaps existed. The second key component was a prioritization of subcatchments within the watershed for the purposes of monitoring, fieldwork and visual assessment of stream reaches. The University of North Carolina at Wilmington, Lower Cape Fear River Program conducted monitoring efforts and coordinated with KCI to develop baseline and first flush data for the watershed. Finally, KCI identified specific projects and ranked them according to stakeholder identified issues and with relevance to the project's impact on improving water quality, wildlife habitat and flooding within the watershed. Stakeholders provided pertinent local information to finalize the rankings. Since this work has been completed in March 2002, stakeholders have been assisting with landowner contacts and pursuing funding options for implementing projects.

Benefits of the Planning Process

- The process promotes locally driven, interactive restoration planning that can address the specific watershed concerns of local communities.
- The process enables local knowledge to be combined with technical support and resources to identify specific sources of water quality degradation and develop appropriate solutions.
- The process enables local communities to guide implementation of strategies developed through the planning process cooperatively with the NCWRP.

Benefits of the Plans

- Local Watershed Plans describe the conditions of local watersheds, issues of importance to local communities, objectives set by local plan participants, and the necessary measures needed to achieve those objectives.
- Local Watershed Plans describe the tools to be utilized to address watershed issues. These tools are identified by local plan participants and may include voluntary landowner assistance programs, education and outreach, drinking water supply protection measures, stormwater best management practices, model ordinances, water quality improvement projects, and habitat protection plans.
- Local Watershed Plans identify the funding sources needed to implement each component of the plan. Funding identification is made more effective by the cooperative nature of the process which brings together public and private organizations and local community members to work as a watershed team.

About the speaker:

Christy Perrin is the Program Coordinator for Watershed Education for Communities and Local Officials (WECO), a program of the N.C. Cooperative Extension Service at N.C. State. WECO's goal is to involve the public in local watershed planning and management. In 1998 Christy earned her Masters in Public Administration with an Environmental Policy focus, then worked for the Natural Resources Leadership Institute at NCSU before becoming WECO's Program Coordinator in 2000.

GIS Mapping and Evaluation of Wetland Restoration Sites in Coastal North Carolina

Kelly Williams, P.W.S.

In order to accomplish its mission of management and protection of valuable natural resources, the North Carolina Division of Coastal Management (DCM) has developed wetland inventory and assessment tools that should greatly improve wetland resource management and planning in the coastal area. Specifically, DCM has developed a wetland Geographic Information System (GIS) that effectively inventories the type, amount, location and functional significance of wetland restoration and enhancement sites located in coastal North Carolina. DCM's wetland restoration type maps use DCM's GIS wetland type maps, the US Fish and Wildlife Service's National Wetland Inventory (NWI) maps, the Natural Resources Conservation Service's soil surveys, 1:24K hydrology data, and 1989 and 1994 Landsat TM satellite imagery as well as field reconnaissance data to locate and evaluate potential wetland restoration and enhancement sites. By using multiple data sources, DCM has attempted to maximize the strengths of each source, while minimizing its weaknesses. The resulting data show the location, size and type of wetland restoration and enhancement sites more accurately, clearly and comprehensively than previously accomplished in North Carolina. In addition to identifying the location and extent of wetland restoration and enhancement sites, DCM's challenge has been to develop a functional assessment procedure that would provide a meaningful evaluation of the ecological significance of potential restoration and enhancement sites. Consequently, DCM developed a GIS functional assessment model commonly known as Restoration Functional Assessment Procedure or R-FAP. The R-FAP functions in a hierarchical manner and evaluates three major wetland functions (Hydrology, Water Quality and Wildlife Habitat), eight wetland sub-functions and 42 landscape and wetland parameters. Potential restoration and enhancement sites are assigned ratings of Beneficial Significance, Substantial Significance or Exceptional Significance, depending on how well they are likely to perform the various wetland functions once restored.

Currently, DCM has completed restoration type mapping for 37 Coastal Plain counties in North Carolina. The R-FAP is currently being tested in selected watersheds in the coastal counties of NC. Practical uses for these datasets include mitigation site search and planning, mitigation site functional assessment, and watershed restoration planning. DCM staff has also used the GIS restoration data to perform a limited evaluation of existing mitigation sites in coastal North Carolina. Of the over 100 sites contained in DCM's mitigation and wetland restoration site database, many sites were found on our restoration site maps with similar characteristics to those found on the ground. Based on field truthing conducted for mapping of potential restoration sites in the coastal counties, an accuracy assessment found our mapping to be approximately 90% accurate depending on wetland type.

About the speaker:

Kelly Williams is a Wetland Specialist for the NC Division of Coastal Management (DCM) in Raleigh, NC. At DCM she reviews wetland mitigation plans and is a project manager for DCM's GIS wetland and restoration site mapping tools.

Ms. Williams received a B.A. in Biology at UNC-Greensboro and a M.S. in Forestry from NC State University. Before coming to work for DCM in 1998, she was a Wetland Mitigation Specialist at the NC Department of Transportation.

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Restoration Site Selection: A Stepwise Watershed Approach

Mark T. Southerland, Steven P. Harriott, Nancy E. Roth, and Donald E. Strebel

Selecting sites for restoration has historically been an ad hoc process, driven by political, economic, and technical considerations particular to each situation. Unfortunately, this approach often leads to restorations that are less successful than hoped for or that have only minimal benefits for the larger ecosystem. We have developed a stepwise watershed approach to restoration site selection that identifies restoration opportunities most likely to succeed and most likely to improve the condition of the ecosystem. This restoration site selection approach was developed for the U.S. Army Corps of Engineers and has been implemented in two large watersheds of the Mid-Atlantic. It has also been applied to state and local government restoration planning in Maryland. The most important aspect of our approach is its focus on the watershed. Without a comprehensive assessment of watershed conditions, sites may be selected where cumulative watershed stressors will overwhelm restoration actions. The focus of the watershed assessment is to identify the most important site problems that can be fixed with available resources (sometimes in combination with watershed-wide best management practices that are expected to be implemented). Because the natural resources involved and the stressors affecting them vary across the watershed, our approach is systematic, involving both qualitative and quantitative metrics that allow comparison across potential restoration sites. It draws on the best scientific knowledge of the species and natural communities of concern, and involves collecting information on the biological, hydrological, geomorphological, and water quality components of the ecosystem. The steps in our restoration site selection approach refer to screening steps that use successively more accurate environmental information. Recognizing that assessment resources are limited and that the extent and quality of available data are variable, the first step in our approach is to analyze relevant watershed-wide information in a geographic information system (GIS). This step typically identifies approximately 100 candidate restoration sites. The second step is to conduct rapid field reconnaissance of these candidate sites. These field data are then analyzed to identify the 10% to 20% of sites that provide the best restoration opportunities. These sites are then studied in more detailed as part of the feasibility step. Our talk will describe the development of this approach in the freshwater Buffalo Creek watershed of Pennsylvania (134 mi^2) and its transfer to the coastal Barnegat Bay estuary of New Jersey (328 mi^2). Application of this approach to smaller watersheds (10 mi^2) in Maryland and Virginia will also be discussed. The types of restoration opportunities identified in these projects include stream, freshwater wetland, tidal marsh, and submerged aquatic vegetation restoration; flood control and historic building protection; and restoration of abandoned lagoons, bird nesting islands, and fish passage.

About the speaker:

Dr. Mark. Southerland is a senior ecologist with Versar, Inc., who has more than 20 years of experience in the monitoring, assessment, and restoration of freshwater and terrestrial ecosystems. He was a coauthor of the U.S. EPA guidance on developing biological criteria for water resource programs and currently supports the ongoing Maryland Biological Stream Survey (MBSS). Since 1993, Dr. Southerland has been involved in U.S. Army Corps of Engineers reconnaissance and feasibility studies for environmental restoration of watersheds from North Carolina to New Jersey. Dr. Southerland received his doctorate in ecology at the University of North Carolina at Chapel Hill and has diverse field experience ranging from the rain forests of Costa Rica to the grasslands of Africa.

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A Riparian Corridor Assessment Protocol

James M. Halley, North Carolina State University, N.C. Stream Restoration Institute
Julia Elmore, Surry County Soil and Water Conservation District

The Mitchell River, located in Surry County, lies within a 108 square mile watershed. The upper third of the watershed is classified as Outstanding Resource Waters (ORW)/Trout Waters and maintains this classification until the confluence of the South Fork Mitchell River. The South Fork's 25 square mile watershed experiences a significant increase in agricultural land use when compared to the Mitchell River. The South Fork Mitchell River is primarily impacted by sediment and is the Mitchell River's main tributary.

In March 2001, Piedmont Land Conservancy (PLC) completed the Mitchell River Watershed Protection Plan for the entire 108 square mile basin. As part of the plan, PLC compiled all existing data on the watershed including a detailed inventory of aerial photographs enhanced with various GIS layers. The South Fork Watershed Assessment was conducted to further investigate the source(s) of impairment within the South Fork watershed and builds on the information presented in the Mitchell River Watershed Protection Plan. The primary objectives of the South Fork Watershed Assessment were to 1) identify areas within the watershed whose restoration will improve the water quality and 2) provide a means to prioritize potential restoration sites.

The Riparian Corridor Assessment (RCA) protocol, implemented as part of the South Fork Watershed Assessment, provided an expedient means to collect site-specific data at the watershed scale. Several data parameters were collected during the assessment, which were then used in a scoring system to identify and prioritize potential restoration sites. A weighting system was available within the RCA framework to allow managers the flexibility to rank sites based on specific assessment criteria. The data collected during the RCA was geo-referenced for straightforward incorporation into a GIS. Field parameters include, but are not limited to: riparian vegetation (width and side slope), adjacent land use, exotic vegetation, debris jams, stream classification (Rosgen Level 1), and bank erosion hazard index (BEHI) per foot of stream. Habitat quality indicators such as bed material, undercut root banks, canopy shade were also evaluated as part of the assessment.

Site-specific data was collected along approximately 20 miles of the South Fork's main stem and tributaries. This data provided Surry County Soil and Water Conservation District (SWCD) with information that will be used to educate landowners about the impact their property is having on water quality in the South Fork River. The assessment also provided Surry SWCD the necessary data to identify potential restoration sites, plan restoration activities, and pursue future funding opportunities for specific project sites.

About the speakers:

James M. Halley is an Extension Assistant in the Department of Biological and Agricultural Engineering at North Carolina State University. Mr. Halley joined the NCSU Water Quality Group in 2001. His responsibilities include stream restoration construction management, stream restoration feasibility assessment, watershed-scale riparian conditions assessment, and flood modeling associated with stream restoration projects. Prior to working for the Water Quality Group, Mr. Halley designed stormwater wetlands and also developed remediation plans for hazardous waste sites. Mr. Halley completed his M.S. in Civil Engineering at North Carolina State University this year, and holds a B.S. degree in Biological Systems Engineering from Virginia Tech.

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Julie Elmore is a District Watershed Conservationist. Miss Elmore has been working for Surry SWCD for 3 years as the county's watershed manager. She is involved with water quality improvement projects, which include stream restoration, agricultural BMPs, aquatic and flood plain habitat restoration, public education, conservation easement negotiation, and continual seeking of grant funding for water quality. She has a B.S. in Biology from Elon College.

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A Preliminary Analysis of Stream Restoration Costs in the North Carolina Wetlands Restoration Program

D. M. Haupt, J. Jurek, L. Hobbs, C. Smith and J. Guidry, NC Wetlands Restoration Program

The North Carolina Wetlands Restoration Program (NCWRP) is an innovative program charged with the restoration of wetlands, streams, and riparian buffers for the protection and improvement of water quality and habitat in each of the seventeen river basins in the state. Payment to the NCWRP is an option for applicants who must provide compensatory mitigation as a condition to receive a Section 404 Permit or 401 Water Quality Certification for impacts to streams, wetlands, and riparian buffers. Currently, applicants pay the NCWRP $125 per linear foot for stream impacts. The Program is responsible for using this money to implement stream restoration projects that are both ecologically functional and cost efficient. The purpose of this study is to track costs of natural stream restoration and to determine whether the $125 per linear foot fee is adequate to meet NCWRP goals.

The NCWRP analyzed twenty-five stream restoration projects (104,494 total linear feet) that are either under construction or constructed. The stream restoration projects were divided into urban and rural groupings. The restoration costs were divided into categories: site identification, site acquisition, project assessment, project design, construction management, site restoration, monitoring, and long-term management. Costs analyses were performed on a per linear foot basis and a percentage of total cost for each of the categories.

The thirteen urban stream projects averaged $214.20 per linear foot for restoration while the twelve rural stream projects averaged $105.78 per linear foot. The average for all twenty-five stream projects was $143.32 per linear foot, $18 more than the $125 per linear foot fee charged for mitigation.

The eight project categories were analyzed for cost per linear foot of restoration and percentage of total project cost. Project assessment, which includes watershed assessment, data collection and assimilation, averaged $21.86 per linear foot and was 15.25% of the total project cost. Design averaged $10.77 per linear foot and 7.52% of total cost, while Construction Management was $10.58 and 7.38%, respectively. Finally, Site restoration, which includes all construction, planting, and fencing, averaged $79.20 per linear foot and 55.26% of total project cost. Site Identification, Site acquisition, monitoring, and long-term maintenance combined to average $20.92 per linear foot and the final 14.59% of total stream restoration project cost.

NCWRP collected stream restoration cost data from other NC state agencies and from other eastern states. These collected stream costs (urban and rural) were compared to NCWRP stream costs to determine if our projects are in line with similar stream projects in similar geographic areas.

- The analysis of the current fee schedule of $125 per linear foot shows that the NCWRP can implement projects in rural areas within this budget. On the other hand, the total cost for urban stream restoration projects is significantly higher. The average cost of the completed stream projects is $143 linear foot. The urban stream projects showed a significantly higher cost as compared to the rural projects ($214 per linear foot as compared to $106 per linear foot, respectively). The NCWRP anticipates the need to restore more urban streams since most of the mitigation payments accepted are from urban areas.

About the speaker:

Jeff Jurek works in the implementation section for the NC Wetlands Restoration Program. Responsibilities include restoration project management, project design and construction plan review, and stream/wetlands project cost assessment.

Mr. Jurek did his undergraduate work at Wake Forest University and NC State University. He has a M.S. in Natural Resources-Hydrology from NC State.

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Stream Restoration: Land the Job by Preparing a Winning Proposal

Andrew Burg, Mecklenburg County Storm Water Services, Charlotte, NC

- So when was the last time you got a job with no effort?
- When was the last time you bothered to contact a potential client when you didn't get a job?
- When was the last time you knew you had the job before the RFP was ever advertised?

These questions should concern you. They do your boss. You know he looks at how much time you spent "getting the job." He worries about why you didn't get the job. Then he worries about how much time you'll spend "doing the job." But first things first.

The successful businessperson knows one simple rule. You're going after a relationship --- not a project. And in that spirit, this presentation shares with you some secrets of success. There are three elements to successfully securing a project --- relationships, process and content.

RELATIONSHIPS

Before you ever talk about a project, learn about your client and their needs. Listen. Ask questions. This is the last place you want to talk about yourself or your company. The client will ask you the questions pertinent to their needs. Listen. Everyone knows why you're at lunch or why you requested the meeting or what your relationships are. There are no big secrets here. They have a need and you can fill that need. Maybe. Maybe not. Do you really hear what they are saying? Do you really know the issues? Are you listening between the lines?

MECHANICS

Make it easy on your client. They like to think they're your only client. Treat them that way. Provide exactly what you're asked for --- no more and no less. Unless it enhances the request or sheds some new light on the project, they only have so much time for review. In the end clients are people too. Individuals. Peer review your work just as you would any other professional document. This is a reflection on your capabilities and attention to detail much as your personal resume is to yourself. Ask yourself, would I want to review this when I know I have to do this 8-12 times? (Do the math, 8 x 20 pages = 160 pages of "why we're great"). Is it enjoyable to review? Check dates, times, etc. Is there an error? Promptly notify the requestor. Check again.

You cannot do all of the following for every client or every RFQ. Pick your battles carefully and allocate your marketing resources towards the opportunities that are best-suited to your set of skills; in other words, be selective. Don't be afraid to decline a submittal verbally and then follow up with a written letter to the client stating why … "it would not be in your best interests, etc."

CONTENT

In a well-prepared RFQ, everything you need should be in front of you. Before bothering the potential client with basic questions, be sure it's not anywhere in the RFP. Have someone else look. Look again. Then make the phone call. Don't assume anything. Otherwise, just like in college, state your assumptions. If it says 23 pages max, then don't assume it excludes the cover letter. The client is not only looking for the most qualified consultant, they are seeking to minimize review time. Therefore, chances are they have carefully prepared the RFQ for both those goals. An RFQ is not a re-formatted version of the corporate resume. It is tailored to what the client wants. As such, be prepared to spend a fair amount of time on eliminated unnecessary material that doesn't apply.

About the speaker:

Andrew Burg, P.E., L.S. currently works as a project developer for Mecklenburg County Storm Water Services, a division of the Land Use and Environmental Services Agency. As a project developer, Mr. Burg is responsible for formulating and implementing successful environmental restoration projects. Selection of qualified restoration professionals is an integral daily activity.

Mr. Burg is a licensed civil engineer in six states and a licensed land surveyor in California. He received his undergraduate degree in civil engineering from Lehigh University in Bethlehem, Pennsylvania in 1981. After graduation, he became a staff engineer for the Los Angeles County Department of Public Works in the mountain road design section. Mr. Burg also spent many years working as a consultant in Southern California, designing both subdivisions and various municipal projects. Preparing proposals for clients was a routine part of his job. Mr. Burg and his wife have been living in Charlotte, NC since 1994.

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City of Charlotte, Mitigation Banking for Municipal Projects

Mary Murray, City of Charlotte Stormwater Services

The City of Charlotte is in the process of developing a mitigation bank to provide compensatory mitigation for municipal projects. The City is working with the USACE and DWQ toward developing a local umbrella bank program that will provide a mechanism for utilizing stream restoration, watershed improvement and other projects to obtain compensatory mitigation credits. These credits will be used to offset losses associated with other municipal projects that have unavoidable impacts to waters of the US. The City will provide an overview of the efforts and experience associated with the development of the bank and the initial process of getting the bank approved through the MBRT process. Bank program efforts include: establishment of a Stream Restoration Ranking process to populated the bank, development of a permit/mitigation tracking system, development of a banking ledger, monitoring program, and project specific mitigation credit proposals.

About the speaker:

Mary C. Murray is a Water Quality Program Administrator with the City of Charlotte. She is responsible for Section 404/401 Permitting and Mitigation Programs. Ms. Murray received a B.S. in Biology with a minor in Chemistry from Old Dominion University and a M.S. in Environmental Science from Johns Hopkins University. Ms. Murray is a Professional Wetland Scientist and has more than 10 years of professional experience in her field. She has recently joined the Stream Restoration Institute Advisory Committee.

Monitoring Mitigation Projects: What Are We Looking For?

Dani E. Wise, Karen R. Hall, Angela D. Moreland, and James M. Halley

Mitigation is currently required in North Carolina for stream impacts over 150 linear feet. Along with the requirement for mitigation, comes the responsibility of determining if the project meets the designated goals and results in a stable, restored stream. In North Carolina, this mitigation program has resulted in a deluge of restoration projects throughout the State. The main driving forces behind these projects are the NC Department of Transportation (NCDOT) and the NC mitigation in-lieu fee program, NC Wetlands Restoration Program (NCWRP). Between these two entities, many projects have already been constructed, and there are many more to follow. The regulating entities, NC Division of Water Quality, US Army Corps of Engineers, and NC Wildlife Resources Commission, have determined restoration as the most effective and/or efficient means of mitigating the impacts of channel alterations such as culverts and channel relocation. Enhancement of degraded channels and preservation of pristine streams is also included in the mitigation program, but with a much higher credit ratio (up to 10:1 for preservation). There are many challenges associated with mitigation of stream impacts. Some of these challenges include: determining the ratio of restoration credits required for each project based on the nature of the impacts and the streams that are affected; identifying an appropriate reach to be restored; ensuring accurate and effective design of the project, as well as construction; proper monitoring of the project for a lengthy period of time post-construction; and finally, determination of the project success or failure. In regards to the last challenge listed above, the regulating agencies in NC have developed a preliminary "success criteria" for determining whether or not the project credits may be released, after five years of monitoring, as mitigation for the pre-determined impacted reach. North Carolina State University (NCSU) installed one of the first restoration projects to be used for mitigation by the NCWRP. The restoration of the East Prong Roaring River was completed in November 2000. By November 2002, two full years of post-construction monitoring data will have been collected and analyzed for indications of stability and/or instability of the project. The field data collected to date, as well as the analyses, are included in this presentation. The results of the analyses of the monitoring data are being used to test the existing "success criteria". As this and future projects are evaluated, alterations may be made to the current mitigation monitoring guidelines to more accurately determine project success or failure.

About the speaker:

Dani E. Wise is a Water Quality Extension Associate with the Department of Biological and Agricultural Engineering at North Carolina State University. Ms. Wise joined the Water Quality Group in 1998 after completing her Masters in

Natural Resource Administration, Hydrology from the School of Forestry at North Carolina State University. Her responsibilities include working with research and extension faculty to demonstrate and evaluate watershed management and stream restoration systems for protecting water quality across the state. Ms. Wise also holds a B.S. degree in Environmental Science from the College of William and Mary.

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Characterization of Three Carolina Bays in Bladen County, North Carolina

Britta Lees, Jon M. Stucky, and Thomas R. Wentworth, North Carolina State University

Carolina Bays are unique ovoid depressions that dot the landscape from Florida to Virginia, with high concentrations in North Carolina. A large percentage of these bays have been ditched, drained, filled, logged or otherwise severely impacted by humans in the past 50 years. The North Carolina Department of Transportation (DOT) is in the process of restoring a Carolina Bay that was converted to farmland 30 years ago. This project aims to characterize three intact Carolina Bays in order to: 1) assess plant communities typically found in Carolina Bays of this region; 2) identify target communities for the DOT restoration site; 3) understand the ecosystem requirements of Carolina Bay communities; and 4) supply resources for identifying the natural communities located in other Carolina Bays through the use of GIS. Soil sampling, hydrology monitoring, and assessment of the shrub and tree communities will be conducted within the mineral, histic, shallow, organic, and deep organic soils of each bay. In addition, sample plots will be located using a geographic positioning system, georeferenced to current aerial photographs, and analyzed for the purpose of developing remote sensing techniques that can be used to map vegetation communities within Carolina Bays. The data collected will be used to characterize each bay individually and to develop restoration objectives that are applicable to Carolina Bays of this region.

Restoration of Coastal Headwater Stream and Wetland Systems

Kevin L. Tweedy, Buck Engineering

This presentation will focus on the restoration of headwater wetland systems within the Coastal Plain of North Carolina. Headwater systems (typically defined as first or second order streams) make up the vast majority of stream miles within a given watershed. Headwater wetland systems are especially susceptible to alteration, due to their small size, productive soils, and the ability to provide increased drainage easily. Land-use changes resulting from agricultural practices and increased development within the Coastal Plain of North Carolina have led to the impairment of many natural headwater wetland systems. As a result, it is estimated that less than 1% of the headwater ecosystems remain intact.

In this presentation, several case studies of headwater wetland restoration projects will be presented, with emphasis on the Westbrook Lowgrounds Wetland and Stream Mitigation Project. The project is scheduled to go to construction in mid-summer, and involves the restoration of approximately 65 acres of wetland and 5,500 feet of Priority Level I stream restoration. The presentation will focus on the technical design and construction aspects of the projects, including existing site assessment, reference sites, hydrologic considerations, vegetation considerations, managing construction, and post-construction monitoring.

About the speaker:

Kevin Tweedy, PE is currently a Water Resources Engineer at Buck Engineering. Mr. Tweedy has 7 years of experience in wetland and stream restoration, watershed management, water quality monitoring and data analyses, and environmental education. He currently works as a water resources engineer for Buck Engineering in Cary, North Carolina. Environmental education experience includes conducting numerous conference presentations, workshops, and training sessions aimed at educating participants about natural channel design concepts and natural systems. His current projects with Buck Engineering focus primarily on the design of stream and wetland systems, with emphasis on the restoration of site hydrology. He has a MS in Biological and Agricultural Engineering from North Carolina State University and a BS in Agricultural Engineering from Virginia Tech.

Edward’s Branch Watershed Improvement Project: Case Study for Urban Watershed Improvements

Tony Dudley, City of Charlotte Storm Water Services and Jim Eisenhardt, Chad Evenhouse, and Will Wilhelm Kimley-Horn and Associates, Inc.

The Edward’s Branch Watershed Improvement Project is a holistic watershed approach to improve flood control and water quality in a developed, urban watershed. Phase I construction is nearing completion, with Phase II scheduled for construction in the fall of 2002. This presentation is intended to provide an update on the project, and to present “lessons learned” from this proactive/holistic approach to watershed management in the urban setting.

To reduce surface water pollution, flooding, and erosion of stream banks in the headwaters of the Edward's Branch watershed, the City of Charlotte and Mecklenburg County are working together on the Edward's Branch Watershed Improvement Project. The subject watershed encompasses an approximately one square mile area containing approximately 7,500 feet of perennial/intermittent stream channel in a densely urbanized (industrial, multi- and single-family residential, commercial, parks, schools, churches and a cemetery) portion of the City.

Charlotte Storm Water Services (CSWS), Mecklenburg County Department of Environmental Protection (MCDEP) and the North Carolina Clean Water Management Trust Fund are funding this project. Stakeholders include property owners who are directly affected by Edward's Branch and its tributaries, residents of the Edward's Branch watershed, the US Army Corps of Engineers, the North Carolina Division of Water Quality, Mecklenburg County Storm Water Services, Mecklenburg County Department of Environmental Protection and Mecklenburg County Parks and Recreation.

The project aims to address and improve degraded stream habitat, observed sources of stream bank erosion and channel instability, physical constraints typical of a fully developed watershed (utilities, culverts, fences, etc.), pollutant removal, flood control, and enhanced public use/aesthetics. To address the multiple water quality and flood control issues within the watershed, the Edward’s Branch Watershed Improvement Project will utilize a number of localized, sub-basin and systematic improvements (including BMPs, and stream restoration of 5,000+ linear feet of stream channel) to be implemented to address the over-all environmental health of the watershed.

This presentation will provide an update on the project and discuss lessons learned (successes and failures) regarding implementation of the project for others to include when conducting similar “holistic” urban watershed improvement projects. Some focused topics include:

- The Balancing Act in Urban Watershed Restoration: Traditional Flood Control and “Natural” Channel Restoration Techniques
- Technical Considerations/Opportunities
- Regulatory (Permitting) Strategies/Opportunities
- Construction
- Contract Alternatives

Crescent Road Stream Restoration

Ed Lewis, NC Department of Transportation

Oil and water does not mix, but sand and water mix very well. The North Carolina Department of Transportation (Department) has built several streams in the Piedmont in clay soil where soil stability was not a major concern. The Department has completed two streams in the upper Coastal Plain, Speight and Abbott, where the stability of sand was an issue. The Department's first foray deep into the coastal plain with stream restoration is associated with the Crescent Road project in Lenoir County just north of Kinston (Transportation Improvement Program project R-2719BA). During the avoidance and minimization stage of this highway project, Department staff identified a mitigation opportunity which included a channelized and degraded sandbed stream running through a prior converted wetland farm field that would be crossed by three proposed roadways of the Crescent Road project. The Department acquired a permanent drainage easement for the stream, and it was able to purchase the remaining farm field as well.

The stream restoration project involves restoring 500 meters of G5c stream adjacent to the proposed highway project. The stream, with a drainage area of 65 hectares (161 acres), is an unnamed tributary of Briery Run that had been straightened during past agricultural uses. The downstream two-thirds of the project reach had no forested buffer, with cultivated field extended to the top of both banks. A narrow forested buffer exists on the right bank over the upstream third of the reach. The roadway project required the construction of three new culverts, which set the profile grade at the upstream end, mid-reach and downstream end.

The Department requested that Buck Engineering develop a design that would maximize belt width, increase stream length, increase riverine wetland and buffer areas, and improve floodplain functionality. The design stream pattern, with a sinuosity of 1.3, increased restored stream length by about 200 meters. Relatively deep culvert inverts necessitated a Priority 2 restoration (A Priority 1 restoration would have been proposed if the stream restoration had been identified early enough in the highway design process to set culvert inverts at a higher elevation). An excavated floodplain extending 15 meters on both banks provided about 2.2 hectares of restored buffer and about 1.9 hectares of riverine wetland. Several shallow vernal pools were excavated on the floodplain and brush mats were anchored into the floodplain soils to enhance habitat.

Construction began in November 2001. Channel excavation and floodplain grading lasted about 10 weeks. Root wads and erosion control matting were installed during the grading operations. Rock cross vanes were constructed over a one-week period in late February 2002. Cross vane grades were set about 0.30 meter above the adjacent culvert inverts to promote deposition within the culverts. Preventing downstream migration of backfill behind the rock cross vanes was a concern in the sand bed system. Gaps between boulders were filled with small riprap and washed stone, and each structure incorporated geotextile filter fabric on its upstream face. Seeding and planting was completed in March 2002.

Between the times the floodplain was excavated and temporary seed was established, small rills formed in the floodplain. Runoff concentrated in the rills, which carried sediment into portions of the channel, most commonly in pools at the outside of bends where root wads were installed. Berms were constructed along the top of the slope above the floodplain to divert some runoff from adjacent ground, but runoff from the floodplain itself was sufficient to cause continued rill development. The problems were attributed mainly to loosely compacted backfill on top of root wad trenches and a lack of erosion control matting on the floodplain behind the root wads. The rill problem will be addressed during the final construction phase by building small floodplain berms and adding erosion control matting behind each outside bend or by providing a shallow depression behind the rootwads. Sediment that washed into the channel will be removed.

Earthwork and structure construction was performed in the dry. Flow over the downstream two-thirds of the reach was diverted to an excavated ditch. Flow through the upstream third of the reach was maintained in the existing channel. The new channel alignment intersects the existing channel in several locations at the outside of new meander bends over this upstream third of the project. To prevent sediment from reaching the existing channel, a berm was left around the perimeter of the new floodplain in this area. The lower end of this bermed area has a sediment filter outlet to allow the floodplain to drain.

Final construction will resume once roadway grading is complete and traffic is re-routed to the new alignment. The final phase of construction will involve making tie-ins from the new channel to the existing channel and re-routing flow from the diversion ditch to the new channel. Channel plugs with root wad reinforcement will be constructed in areas where the new and existing channels meet, and the remainder of the existing channel will be backfilled.

A major issue for the Department has been when to turn the water into the restored stream. The concern is will too much sand be transported downstream if you turn it too soon. If it is not turned quickly enough does the channel become choked with vegetation and\or is your thalweg location compromised.

Sand is mobile with the help of water. Stream restoration of sandbed systems is a challenging opportunity that the Department will continue to pursue in the Coastal plain.

Site Owner: North Carolina Department of Transportation
Consultant: Buck Engineering
Contractor: North State Environmental

About the speaker:

Ed Lewis is a natural systems engineer with the Office of the Natural Environment, Project Development and Environmental Analysis Branch, Division of Highways, North Carolina Department of Transportation in Raleigh, NC. His responsibilities include managing consultants, reviewing natural systems restoration plans and designs, and implementing construction projects.

Mr. Lewis received a B.S. in Civil Engineering from North Carolina State University. Mr. Lewis' previous experience with the Department includes work in traffic engineering, NEPA planning, and permitting. Before joining the Department, Mr. Lewis worked in the construction industry as a surveyor and inspector.

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Hewletts Creek Restoration Plan for Recreational and Shellfish Waters - A Local Management Model

Andrew McDaniel, EIT, Dewberry & Davis, Inc., Raleigh, NC
David Mayes, PE, City of Wilmington Stormwater Services
Matt Hayes, AICP, City of Wilmington Stormwater Services
Ken Carper, PE, Dewberry & Davis, Inc., Raleigh, NC

Hewletts Creek is one of several ecologically important tidal creeks in eastern New Hanover County. The watershed has a drainage area of approximately 10 square miles and drains the eastern portion of the City of Wilmington. The NC Department of Environment and Natural Resources (DENR) has designated that the best intended use of Hewletts Creek is the harvesting of shellfish for market purposes. Other important designated uses include primary recreation such as swimming, and secondary recreational activities such as boating. In addition to these uses the NC Division of Marine Fisheries recognizes the estuary as a Primary Nursery Area with important habitat for the development of juvenile fin fish.

For many years however, the upper half of Hewletts Creek has been closed to shellfish harvesting due to excessive bacterial contamination. Sources associated with development in the watershed are believed to be major contributors to the contamination problem. In recognition of the loss of the harvesting use the NC Division of Water Quality has placed approximately 66 acres of the upper estuary on its 2000 303(d) List of Impaired waters. Water quality sampling has been conducted in the watershed since 1993 by the UNC-W Center for Marine Science Research as part of the New Hanover County Tidal Creeks Program. Data collected through this program suggests that bacterial contamination in the upper reaches of the estuary and feeder tributaries is reaching a point where recreational uses may also be threatened due to potential human health concerns.

In response to a declining trend in water quality, Wilmington's Stormwater Services has developed a plan to restore and protect the shellfishing and recreational waters in the Hewletts Creek watershed. At the heart of the plan is a tiered set of goals designed to guide and prioritize management actions:

Goal #1: Protect and enhance the health of existing shellfish populations. This goal, which serves as a foundation for objectives to follow, was crafted in recognition of the ecological importance shellfish populations have by providing habitat and improving water quality.

Goal #2: Restore partial shellfish harvesting use of the estuary during extended dry weather conditions. This goal is the first in a series of three goals designed to address the best use of the estuary as designated by DENR.

Strategies to meet this goal are also intended to protect public health during periods when recreational use of the estuary is at its greatest.

Goal #3: Maintain the shellfish harvesting use of the estuary after small rainfall events (approximately <1"). Stormwater runoff is believed to be a major vehicle for bacteria to reach the estuary. Controlling sources of bacteria subject to transport by stormwater runoff, as well as treating runoff once it becomes contaminated, is the biggest challenge local managers face. Attaining this goal will require implementation of a comprehensive suite of structural and non-structural best management practices.

Goal #4: Complete restoration of the harvesting use of the estuary with infrequent restrictions after rainfall events. This goal is designed to be consistent with local long-term comprehensive planning objectives, as well as state and federal mandates to restore the designated uses of Impaired waters. Attaining this goal will require sweeping changes in the way we develop and use coastal land, as well as improvements in stormwater treatment technology. While reaching this goal is likely to be far off into the future, it does serve to set the course for long range management of the watershed.

The restoration plan includes recommendations for a variety of structural BMPs and programmatic initiatives. Appropriately sited stream and wetland restoration projects, such as the Pine Valley project in the upper watershed, can play an important role in minimizing the delivery of bacterial loads to the estuary. However, in order to reach the outlined goals controlling sources of bacteria must also be a significant component of the management effort. The plan's management model recommends initially focusing on dry weather sources first, as these are typically more feasible to control. Special emphasis should be placed on minimizing human sources of bacterial contamination as these sources generally represent the highest risk to human health. Tackling wet weather source control should be second. Management of these sources will require a much wider array of strategies ranging from public education to development and land use controls.

About the speakers:

Andy McDaniel is an environmental engineer with the Raleigh office of Dewberry & Davis, Inc. His responsibilities include stormwater management planning, watershed assessments, water quality modeling, and stormwater BMP evaluations. Before joining Dewberry in 2001, Mr. McDaniel worked for 6 years as a water quality modeler with the NC Division of Water Quality. While with DWQ Mr. McDaniel was involved with a wide variety of point and nonpoint source water quality issues in the Cape Fear, Yadkin, Tar-Pamlico, and White Oak River basins.

Education: B.S degrees in Biology and Environmental Engineering, and M.S. in Plant Pathology from North Carolina State University.

Dave Mayes has been employed with the City of Wilmington for 7 years. Initial responsibilities included technical review of plans for new development within the City and issuing permits for compliance with the storm water management ordinance. Mr. Mayes led efforts to implement a stormwater utility for the City in 1998. Current responsibilities include administrative management of the stormwater program for the City. The stormwater program encompasses capital improvements, water quality, regulations, maintenance, and administration. Mr. Mayes serves as director for numerous capital drainage improvement projects within the City. Previous professional experience included 6 years with the consulting firm of Law Engineering in both Raleigh and Wilmington. His responsibilities at Law included construction material analysis, quality assurance engineer for a major site characterization project and environmental assessment and remediation projects.

Mr. Mayes received a Bachelor of Science in Civil Engineering from North Carolina State University in 1988. He also participated in the Natural Resources Leadership Institute at North Carolina State University in 2000.

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Marks Creek Dam Removal and Stream Restoration

Katie McKeithan, EI and Kevin Williams, PE, PLS, Stantec Consulting, Raleigh, NC
LeiLani Paugh, NCDOT, Raleigh, NC

Small dams are abundant in Eastern North Carolina providing benefits in the form of recreation, irrigation, hydro-electric power production and flood risk reduction. However, these dams have some negatives. They alter the natural flow, create greater water temperature variation and represent a barrier to fish migration. In some cases, these dams have served their purpose. When the dams are no longer needed, they represent an opportunity to remove a safety hazard, improve habitat and restore the watershed to its original configuration. This opportunity is offered to us by the continuously evolving science of natural stream restoration. This paper focuses on the issues associated with removing a dam and restoring a pond bed back to a natural stream and wetland system.

In the early 1970's, a 400-foot long and 20-foot high earth dam was constructed on an unnamed tributary to Marks Creek in Wake County North Carolina creating a 10 acre pond. The project involves draining the pond, removing the dam and restoring the stream and riverine wetland. The design calls for Priority 1 restoration of 3,244 feet of stream and 12 acres of wetland restoration and creation. Challenges for the project include: unconsolidated materials on the pond bed, three incoming streams merging together to form one outgoing stream, a sand bed stream system, a steep slope and minimum amounts of existing vegetation for transplanting.

About the speaker:

Katie McKeithan is an engineering intern with Stantec Consulting in Raleigh, NC. She specializes in environmental restoration including: assessment of watershed and stream channels; natural channel design, hydraulic modeling; preparation of mitigation plans, stream restoration designs, and construction plans.

Ms. McKeithan received a B.S. in Biological Engineering from North Carolina State University. Prior to joining Stantec Consulting, Ms. McKeithan worked with the North Carolina Department of Transportation Roadside Environmental Unit on wetland and stream mitigation projects.

Clayhill Farms Stream and Wetland Mitigation Bank

Robert P. Kerr, Kerr Environmental Corp., and Phillip Todd, NCDOT

In conjunction with the North Carolina Department of Transportation's Project Development and Environmental Assessment Branch, LandMark Design Group identified and provided technical services related to the site search, feasibility and final design of the Clayhill Farms wetland and stream restoration bank, a 355-acre site in Jones County, North Carolina. This bank is located in the interstream divides down gradient of pocosin habitats, a typical environment of headwater stream systems. The Croatan National Forest also surrounds this site on three sides. Clayhill Farms was harvested of timber and converted to agricultural use in the early 1980's. The owner had secured all permits for a swine operation and construction had begun before the NCDOT purchased the property. The site contained roughly 6,200 linear feet of channelized stream, Billy's Branch, as well as 142 acres of ditched and drained Prior Converted Cropland.

The absence of regional curves for stream hydraulic geometry relationships in the Coastal Plain, together with the lack of a gaged stream sites in the local region, required the development of a simplified set of regional curves from two gage stations found to be suitable. An off-site reference site for stream and wetland restoration was inventoried within the lands of the Croatan National Forest. Additional wetland restoration target communities were sought. The conversion of much of the wetland habitats in this region to pine plantations limited the value of data collected from surrounding areas in similar landscape positions. As such coordination with the Mitigation Banking Review Team proved to be critical.

The project design includes 8,200 linear feet of Priority I stream restoration to a C6 stream type. Much of the construction of the stream restoration will be performed "in the dry" to maximize stability of the new channel, created in loamy silt-clay soils. Raising the stream bottom of Billy's Branch and reconnecting the bankfull flood event to the original floodplain on-site are enhancing bottomland hardwood wetlands. Four wetland habitats are being restored or enhanced including: headwater swamp forest (bald cypress dominated), mesic pine flatwood, mixed mesic hardwood and bottomland hardwood forest.

About the speakers:

Bob Kerr founded Kerr Environmental in Virginia Beach, Virginia in July 2002. The firm focuses on wetland and stream restoration, watershed studies and environmental consulting. Previously he was an owner at LandMark Design Group, where he was the Deputy Director of the Environmental Services Section, responsible for the Natural Resources Section and staff in Raleigh, North Carolina, Virginia Beach and Williamsburg, Virginia. While at LandMark, Mr. Kerr managed and supervised successive contracts with the NCDOT between 1996 and 2002 and led their wetland and stream assessment and restoration programs. Mr. Kerr has a Bachelors Degree in Biology, with a concentration in Aquatic Biology and a Masters Degree in Marine Environmental Sciences.

Phillip C. Todd is a mitigation supervisor with the North Carolina Department of Transportation in Raleigh, North Carolina. His responsibilities include overseeing wetland and stream searches, feasibility studies and mitigation planning as well as training and supervising mitigation staff.

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Application of a Coupled Surface-Groundwater Hydrologic Model In a Barrier Island Setting: A MIKESHE Case Study

Johnny D. Martin, P.E., Robert G. Moresi, P.G., and Timothy R. Reid, P.E.

The Town of Emerald Isle is a highly developed community located on a barrier island along the coast of North Carolina. The island has high topographic relief due to parallel sand dunes that run the length of the island. Historically, the Town has used an ocean outfall as its primary means of removing floodwaters. However, recent decisions by the State of North Carolina require the Town to find an alternative solution to severe flooding problems that occur even under normal rain events. The flooding problems have also recently been compounded by the loss of many pine trees on the island due to hurricanes and a pine beetle infestation.

To help solve this complex problem, the MIKESHE model is being used. The MIKESHE model offers a full hydrologic solution, dynamically coupling surface and groundwater behaviors. The surface water model includes overland and channel flow components, and the groundwater model includes both saturated and unsaturated zone components. The model also accounts for evapotranspiration losses as well with detailed modeling of vegetative water use.

The project assessed many flood management options including land acquisition, wetland uptake, aquifer storage, inground storage, and flood proofing. After evaluating each of the alternatives using various criteria and discussions with state and federal agencies, a land/based infiltration/treatment system was chosen for as the optimum solution.

As for preliminary design concerns, the proposed project was designed to temporarily store runoff in shallow, vegetated pools that allow for uptake and removal of urban pollutants washing from the adjacent landscape. The infiltration area also had to be large enough to accept large quantities of water without adversely affecting nearby property owners (through surface flooding or amplification of groundwater levels). The treatment area would also need to be high enough to eliminate the possibility of a direct discharge during a storm surge. Another important consideration during preliminary design was to quantify the effects of the project on the existing plant and wildlife community structure by the altered hydroperiod. An overriding design goal of the project was then to minimize this effect by limiting the depth and duration of flooding allowed. The fully coupled MIKESHE model allowed for detailed investigations of all of these and other complex issues surrounding this project.

About the speaker:

Johnny Martin Johnny Martin has been serving as a Water Resources/Coastal Engineer with Moffatt & Nichol Engineers for over 8 years. He received both a

Bachelor of Science degree in Civil Engineering and a Master of Science degree in Civil Engineering with a concentration in Water Resources from North Carolina State University. During his tenure at M&N, he has spent a majority of his time involved in both hydrologic and hydraulic modeling for wetland restoration projects on both US coasts.

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Pine Valley Stream Restoration: A Coastal Case Study for Natural Channel Design

Barbara A. Doll, Gregory D. Jennings, David B. Mayes, and Carolyn M. Buckner

Urban development takes a heavy toll on creeks, streams and rivers throughout the nation. A broadening landscape of impervious surfaces - parking lots, roads and rooftops - causes excess stormwater to course through stream channels. Urban development also frequently consumes floodplain area, severely restricting space for stream channels. The increase in impervious surface combined with channel constriction can result in streambank erosion each time it rains. Thousands of miles of streams in North Carolina are unstable and eroding, contributing large volumes of sediment to many stream systems. Traditionally, culvert pipe, concrete and riprap have been used to armor eroding urban streams. However, these approaches are costly and can destroy aquatic habitats along with the natural beauty of the stream. In contrast, natural channel design, a more recent technology, works to establish a stable dimension, pattern and profile based on fluvial geomorphology principles.

This presentation will feature a natural channel design restoration project on an urban stream in the coastal plain of North Carolina. Pine Valley is a first-order tributary on a golf course in Wilmington, N.C. This previously ditched channel has been re-meandered through the golf course, increasing stream length by 15%. This project represents the first natural channel design restoration for coastal North Carolina and will serve as a model for further restoration on the golf course. The design addressed adjustments to morphologic features, including riffle-pool sequence, bankfull channel dimension, floodplain width, meander geometry, sinuosity and slope.

PROJECT SUMMARY

The Pine Valley project involved the demonstration of natural channel design based restoration along 800 linear feet of degraded stream running through the Pine Valley Golf Course in Wilmington, N.C. While there are several successful demonstrations of natural channel design throughout the North Carolina Piedmont and Mountains, Pine Valley represents one of few stream restoration projects that have been implemented in the Coastal Plain of North Carolina.

New Hanover County Tidal Creeks Program, the City of Wilmington, the Cape Fear Resource and Conservation District, the North Carolina Cooperative Extension Service, North Carolina State University, NC Sea Grant and Pine Valley Country Club worked together to plan and implement this project. This stream restoration project is also intended to serve as a pilot for a larger restoration on the golf course to be implemented by the NC Wetlands Restoration Program. This coastal stream, a tributary to the main stem of Hewlett’s Creek, drains a 0.5 square mile watershed comprised of the golf course and single-family residential development. Historically, the stream was channelized through the golf course and more recently piped through the residential area upstream of the golf course. As a result, the stream was entrenched, meaning it could no longer rise out of its banks and spread out on a floodplain during high flows. The resulting narrow, deep trench of water flows significantly faster than a stream spread out across a wide flood plain, causing erosion through lateral migration. In an attempt to create a balance between the flow of water, the sediment load and the changing slope and size of the channel, the stream was in the process of developing an adequate floodplain through lateral migration.

The removal of woody vegetation from the streamside accelerated erosion on this stream. The resistance to erosion provided by soil depends on its cohesiveness and texture. The sandy soils found at Pine Valley have low cohesion and are comprised of particles small enough to be moved by relatively low flows and velocities. Deeply rooted bank vegetation, especially woody material, both lessens the impact of rain directly on the soil and holds the soil in place through the development of a root network or root mat that stabilizes and reinforces the soil on the streambank. The loss of this vegetation at Pine Valley reduced the resisting forces and helped accelerate erosion.
The goal of this project was to demonstrate the successful use of natural channel design techniques to restore a degraded coastal stream. The objectives are to reduce the rate of erosion by restoring the stream to a natural balance or dynamic equilibrium, and to improve the aquatic and streamside habitats. Rosgen priority 2 was selected for the restoration design, as the historic floodplain area needed for a priority 1 was not available to construct a new channel. Also, the culvert at the beginning of the project pre-empted the need to maintain the stream at its existing elevation. The natural channel design process included identification of bankfull channel dimension and discharge and the identification and analyses of a stable reference reach to be used as a “blueprint” in the restoration design.

The stream restoration included the construction of a narrow and deep bankfull channel to improve stream efficiency and aquatic habitat. The floodplain was widened to slow the water and reduce erosive forces at high flow. The stream was re-meandered through the new floodplain to dissipate energy, restore natural bed features, and improve the aesthetics of the stream. To prevent future erosion, improve streamside habitat, and provide shade, the floodplain and banks were planted with a mix of native wetland plants, grasses, low growing shrubs, and trees that can survive periodic inundation. The vegetation was located keeping the golf course in mind with taller trees being placed on the edge of fairways. Log cross vanes and root wads were installed for grade control, to help prevent future erosion in meander bends, improve aquatic habitat, and protect two concrete cart bridges. Log floodplain sills were installed in tight radius meander bends to prevent potential short-circuiting of flow during flooding events. In addition, two small bioretention areas were constructed to intercept existing drainage depressions, prevent slope failure, and provide minor stormwater retention and infiltration.

About the speaker:

Barbara Doll is water quality specialist for N.C. Sea Grant, which is a federal/state program that promotes the wise use of coastal resources. Based at NC State University, Barbara provides information to the public and local governments about water quality status, research and regulations. Much of Barbara's current work is focused on repairing degraded stream systems and reducing the impacts of stormwater runoff and nonpoint source pollution. With grant funding from both state and federal agencies, she is currently working on several restoration projects. Projects include repair of a highly degraded urban stream located on the NC State University campus; restoration of a small tributary of Hewlett's Creek on Pine Valley Golf Course in Wilmington; and restoration of a tributary of Yates Mill Pond in Raleigh.

Ms. Doll has bachelors and master's degrees in civil engineering from N.C. State University. Before joining Sea Grant in 1992, she specialized in water resources and surface water quality in consulting work and graduate school.

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