

My 30-year Career with the NCDOT Hydraulics Unit

By: David Chang, Ph.D., P.E., Hydraulics Unit Head

View Point

In May 1985 I received a Ph.D. degree from North Carolina State University's Civil Engineering Department. In the following month, I accepted a position as a Highway Engineer I at the NCDOT Hydrographics Unit. Later that year, the Unit was renamed as Hydraulics Unit. I asked Mr. Archie Hankins, Jr., then the State Hydraulics Engineer, why. He said he wanted to steer the Unit in a new direction, to develop the Hydrologic and Hydraulic (H&H) designs based on the science and engineering equations, rather than using charts and nomographs. The main functions of the Hydraulics Unit then were to develop the Bridge/Culvert Survey and Hydraulic Design Reports, the Permit Drawings, and provide Operations with technical assistance on all flood control and



surface drainage-related issues.

Later, I found out from the Unit's archives that in 1925 the Hydrographic Unit was formerly named

"Bridge Location and Hydrographic (BL&H) Unit" under the Bridge Department of NC State Highway Commission. The main function of

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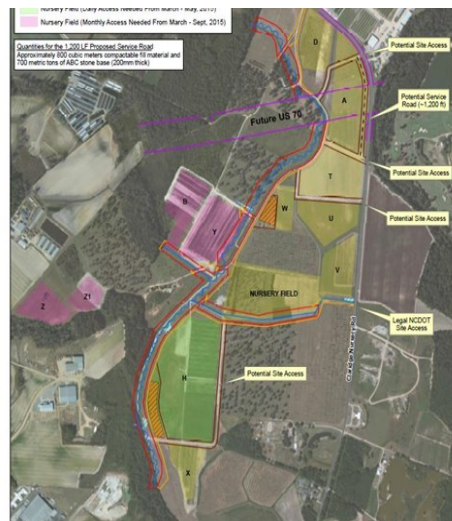
Construction of the Claridge Nursery Stream Mitigation Site, Wayne County

Project Spotlight

By: Byron Moore, P.E., NES Engineering Group

The Claridge Nursery Stream Mitigation Site is a project currently under construction in Wayne County. The site consists of 10,400 linear feet of stream mitigation as well as 23 acres of Neuse buffer mitigation, and is being constructed to offset unavoidable stream and buffer impacts associated with the Goldsboro Bypass (R-2554). The construction was let as a Division Purchase Order Contract through the NCDOT Division 4 office.

The site is located on the NC Forest Service's Claridge Nursery property,



adjacent to the newly constructed US 70 Goldsboro bypass. Planning for this project began in 2004.

Close coordination between NCDOT, NC Forest Service, state and federal resource agencies, design consultants, and contractors are essential to ensure the success of this project. North Carolina State University has also been involved with the development of this site. Under a separate research contract, stream monitoring sta-

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tions have been established to measure pre-project and post-project water quality variables. Monitoring is also occurring during construction.

The project involves restoring an existing incised “canal” into a more natural meandering stream channel with an accessible floodplain. The canal was ditched and straightened in the 1930’s as part of a Civilian Conservation Corps (CCC) project. Rosgen stream design techniques are being utilized. The design process involves gathering information on a natural stable reference stream and applying these parameters to develop a new stream design. Factors such as watershed area, channel slope, channel sinuosity, cross-sectional area, and bankful discharge are important measurements needed in order for the design to mimic the reference stream. Natural streams are subject to periodic overbank flooding. It is important to correctly design a stream section that will carry normal low flow conditions and also have a sufficient floodplain area that will handle any bankful events.

With over 150,000 cubic yards of earthwork to be excavated, temporary erosion control has been an important part of this project. Stringent erosion



NCSU Stream Monitoring Equipment



Existing Canal



New Stream Section

control measures, including turbidity measurements and standards, play an integral role in construction activities. The new floodplain and stream reach must be stabilized before “live” flow is permitted to be turned into the new section. Stabilization measures include temporary silt fence, coir fiber matting, and temporary/permanent seeding and mulching. All new stream work is performed “in the dry” by using pump-around operations. Resource agencies have the opportunity to inspect each completed reach before flow is returned to the new channel. Monthly meetings with all per-



Stream Channel Construction

sonnel involved are also scheduled to keep everyone aware of project progress.

The contractor is constructing the stream using GPS equipment and models. Sensors on the construction equipment guide the operator via a cab-mounted screen on the extents of cut and fill limits. As a check, portions of the newly constructed stream are restaked using traditional survey methods in order to make sure the GPS model matches the proposed plan layout.

The site is scheduled to be planted with a variety of appropriate tree and shrub species this winter/spring. Live stakes will be installed to help stabilize the newly con-



Completed Stream Section

structed stream channel banks. The majority of the plant material is being grown on-site by the NC Forest Service. Species such as silky dogwood, buttonbush, willow oak, overcup oak, black gum and others will be planted.

Once construction is complete, the site will be monitored for certain success criteria. Post construction monitoring will involve annual channel cross-sections and profile measurements. Vegetation monitoring is also required. Monitoring reports will be submitted to the regulatory agencies for 5 years in order to meet project permit conditions and to ensure the project has performed as planned.

NCDOT is dedicated to providing quality mitigation for unavoidable environmental impacts. There are currently over 450 sites in the NCDOT mitigation geodatabase. A link to all of NCDOT's mitigation sites can be found here.

<http://www.arcgis.com/home/item.html?id=d560dfef1ea443b299ca7fc68b2506b4>



Completed Stream Section

the BL&H Unit was to provide surveys for bridges and large culverts to be included in the contracts for construction. The BL&H Unit was later reorganized and renamed as the Hydrographic Unit.

In the mid-1980s the Hydraulics Unit was staffed with four (4) administrative positions (Unit Head, Asst. Unit Head, staff engineer and clerk), 12 engineers and 20 technicians, which was organized into five squads (consultant coordination, maintenance, and three design). There were only four (4) registered Professional Engineers in the Unit. Back then, each design squad was staffed with engineers, technicians and trainees sharing a 12 foot by 12 foot office. Since the technicians were often sent to the field to survey the drainage structures, a small office for a squad of 6-8 people seemed manageable. However, during inclement weather, the field crew struggled to find working or standing space at the office. During that time, the Unit's junior technicians were responsible for the development of Permit Drawings that were used for the 404/401/CAMA environmental permit applications. They used office windows and two light tables to hand-trace the wetland and stream impacts. Back then, the impacts to streams and wetlands were rounded to the nearest tens of feet and the tenth of an acre, respectively.

In March 1989, I was promoted to a squad leader. My primary responsibilities were to supervise a group of engineers and technicians to develop H&H Designs and Permit Drawings for TIP projects. Since the quantity and variety of projects were plentiful, the Unit's managers and supervisors selected appropriate projects for their staff for training and development purpose. Mr. Hankins provided the Unit's staff with numerous design challenges and training courses. The Federal Highway Resource Center experts were also invited to teach the latest available design tools and engineering computer models to improve the quality of H&H designs. Great efforts of training were invested by Mr. Hankins. It seemed to work



well; many young engineers received cross-training and stayed in the Unit. For example, the staff in my squad included several young engineers who ended up becoming career employees with the Department. They were: Andrew Nottingham, P.E., then a Highway Engineer I, who just retired in December 2015 as the Asst. State Hydraulics Engineer; Marshall Clawson, P.E., then a Highway Engineer I, who retired in December 2014 as an Advanced Engineer Supervisor; Philip Harris, III, P.E., then a student co-op, who is now the Head of the Natural Environment Section; Marc Clifford, P.E., then a student co-op who is now the manager of NCDOT Engineering Application Services; Dennis Jernigan, P.E., then an Engineering Associate who is now the Division Construction Engineer in Division 5; Julie Hunkins, P.E., then an Engineer Associate who is now the staff engineer for the Administrator of Technical Services Division.

In August 1995 I was promoted to the Manager of Highway Stormwater Program that was created to address Department's stormwater related issues. In July 1996 the NC General Assembly passed House Bill 515, which asked the Department of Transportation and then the Department of Environment, Health and Natural Resources (DEHNR) to develop a Statewide Stormwater Permit under EPA's National Pollutant Discharge Elimination System (NPDES) Permit. It

covers all the program activities administered by the Department, such as general roadway drainage, EPA designated impaired waters, Division maintenance facilities, maintenance of ferry terminals, construction activities, etc. I worked with Ms. Jeanette Powell of the NC Division of Water Quality in jointly developing the Department's NPDES Permit, which took effect in June 1998. This permit has proven to be successful in addressing the Department's stormwater issues in a practical and cost effective manner and has earned national recognition as an example of a statewide NPDES Permit approach. This program was later managed by Mr. Matt Lauffer, P.E. and currently, Mr. Andy McDaniel, P.E.

In August 2000 I was promoted to the Assistant to the then Unit Head, Mr. David Henderson, P.E. In and around that time, the Department experienced delays in the letting schedule of several major projects due to difficulty in obtaining 404/401/CAMA permits and riparian buffer certifications from the Army Corps of Engineers and state regulatory agencies. To improve the delivery of projects and communication with agencies prior to and during the permitting stage, the Department staff collaborated with all federal and state agencies in 2001 to develop the Merger 01 process. In this new Merger 01 process, Merger 4B and 4C meetings were created by the Merger Team and subsequently designated to the Hydraulics Unit for implementation. The Merger 4B

meeting provides a review with the agencies on preliminary hydraulic design, including stormwater BMPs; the Merger 4C meeting serves to review the final hydraulic design and quantified impacts to the wetlands, streams, riparian buffer areas. Later, I was tasked with the development of the protocols and rules for the 4B and 4C meetings. To date the 4B and 4C meetings have proven successful and earned praise from the federal and state agencies.

In August 2006 the Federal Emergency Management Agency (FEMA), the Federal Highway Administration (FHWA) Region IV and NC Floodplain Mapping Program (NCFMP) staff conducted a workshop for the Unit's design engineers on compliance to the National Flood Insurance Program (NFIP). A federal regulatory program, NFIP requires all land developers including NCDOT to strictly adhere to its regulations to avoid or minimize impacts to floodplains. It directs the design engineers to notify the local community floodplain managers of the proposed projects and obtain their approval. In North Carolina, there are over 650 community floodplain managers who enforce the communities' flood damage prevention ordinances. However, many of them don't have the required knowledge and experience in hydraulic

design to review and approve the engineering plans. More than 85% of the NCDOT bridges that cross streams are regulated by FEMA. While understanding the concerns on the potential delay of project delivery, the FHWA staff reiterated that NCDOT shall follow FEMA's guidance for all federally-funded road and bridge projects that cross over FEMA regulated streams. To ensure and streamline the NFIP compliance, the Department entered a Memorandum of Agreement (MOA) with NC Floodplain Mapping Program in June 2008. I was tasked with the development of the MOA, and its subsequent modifications. To date, the Unit's design engineers have successfully submitted over 1,300 projects and received approvals from NCFMP without any let delay. It has reduced the process time from 10 months to 3. It also has moved the approval of the NFIP compliance out of the critical path of project delivery.

In August 2011, I was promoted to Unit Head. Exactly two weeks later Hurricane Irene hit and breached NC 12 at Pea Island and Rodanthe in Dare County. Contractors and a renowned tidal hydraulic consultant engineer were quickly retained for repair of the breaches and bridge designs. I realized the lack of and the dire need for in-house tidal hydraulics expertise in the Unit. I also saw the op-

portunity for further streamlining NFIP compliance by modifying the MOA.

In September 2012 I began work on the Department's two H&H design manuals: Handbook of Design for Highway Surface Drainage Structures, published in 1973, and Guidelines for Drainage Studies and Hydraulic Design, published in January 1999. Both the Handbook and Guidelines are widely used by the consultants Unit's design staff and consultants for all of the Department's projects. To accomplish this task more effectively, I enlisted Mr. Jerry Snead, P.E., to assist me with the collection, review, and edit of the past and current engineering principles and practices that are available in and out of the state. These two manuals will be consolidated into one with the addition of two new chapters covering the federal programs of NFIP and NPDES. We anticipate this manual will be completed this year.

In February 2014 I redefined and expanded the H&H design needs to four Tiers. Tier I is to prepare basic H&H Designs and Drainage Investigations; Tier II is to prepare H&H Designs and NFIP/MOA Floodplain Analysis packages for TIP projects; Tier III is to prepare complex H&H Designs over sounds or large rivers; Tier IV is to prepare unique Hydraulic Engineering Designs including Tidal Hydraulic Analysis, NFIP Contract Coordination and NPDES Program Management. The Unit's new 4-tier H&H design structure has been well received by the consultant engineering community. More than 60 firms have submitted their pre-qualification applications to the Unit based on their unique H&H design expertise.

Since my arrival in the Unit 30 years ago, the Hydraulics Unit has remained a small and closely-knit group. Currently, the Unit is staffed with two clerks and 51 engineers and technicians, of which 31 are registered Professional Engineers. Over the last 30 years, we have been challenged with many pressing issues, such as, bridge structure deficiency, stringent environmental regulations,



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Infusion of LiDAR-based Modelling into the NEPA Process

By: Morgan Weatherford, NES ICI/ On-site Mitigation

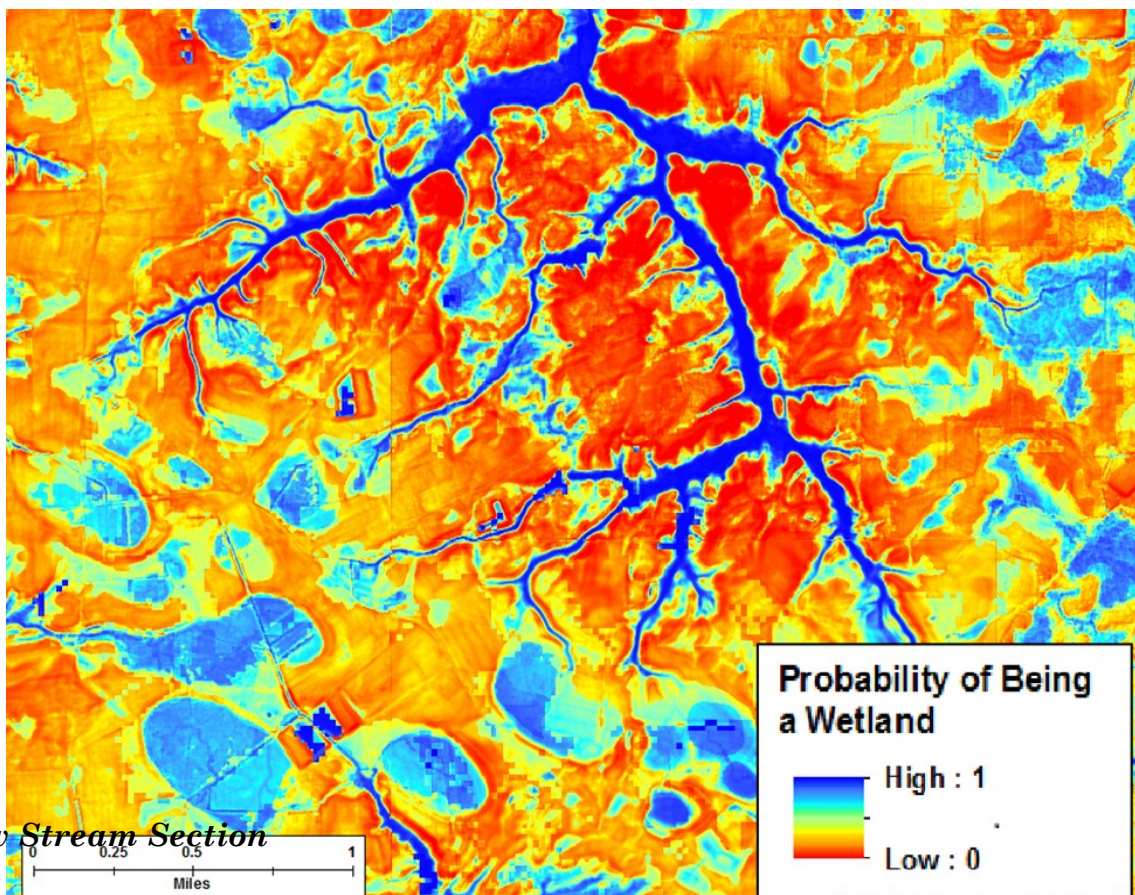
NES Technical Article

Streamlining the National Environmental Policy Act (NEPA) process for infrastructure projects has become a priority on the state and federal level as costs and project delivery times have steadily risen. In response, NCDOT identified three pilot projects to implement streamlining initiatives during the planning process. One of the major goals of these pilot projects was to rely more heavily on Geographic Information System (GIS) to reduce the amount of field work and provide more data earlier in the Merger Process leading to better and more timely decisions by the Merger Team. The location of jurisdiction resources such as streams and wetlands are key features when determining potential impacts of road projects.

As many GIS users know, any GIS analysis is only as good as the data. Much of the environmental data that we use is comprehensive, however, it hasn't been updated in many years and lacks sufficient accuracy to adequately compare impacts among alternatives for the Least Environmentally Damaging Practical Alternative (LEDPA) selection. The task of updating wetland locations fell into the hands of the ICI/OSM Group while the NC Division of Water Resources is responsible for mapping headwater streams. NCDOT's wetland models rely on Light Detecting And Ranging (LiDAR) data to create different variables explaining the presence or absence of wetlands. Models are created by using a sample of field delineated wetland boundaries along with the LiDAR-based variables as input data. The information is then analyzed with Statistical Analysis System (SAS) software. The resulting model can be run for a given study area in ArcGIS to predict wetland locations. Another round of field delineations is then needed to validate the model and quantify its level of accuracy. The advantage of using a prediction model is not only in saving time and money, but it also provides wetland locations for an entire study area, not just within the corridors. However, the modeling process is time-consuming primarily due to creating the variables from LiDAR, and it requires a large capacity of computing resources.

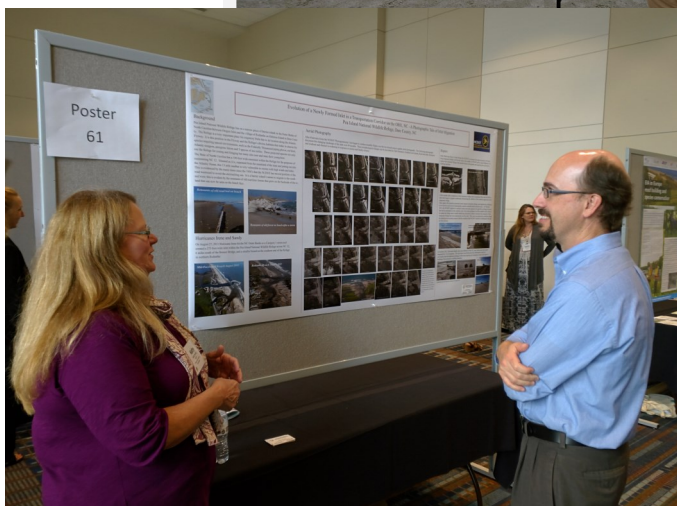
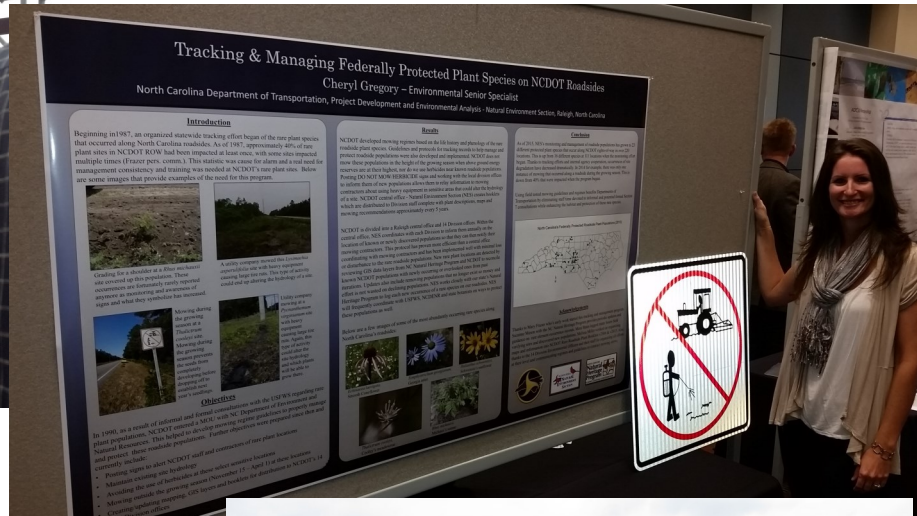
NCDOT funded a research project through the Research and Development Unit in the spring of 2013, tasking a team from UNC-Charlotte to improve the modeling process. They developed Wetland Assessment Method Automation Tools (WAMAT), a set of GIS tools that automated and improved the modeling process saving time and money. Version 4.0 of the WAMAT tools will be delivered in February with testing following soon after. This version of the tools will provide more flexibility and is capable of one-click predictions for an entire county. What took several weeks will now take hours. The project won the American Association of State Highway and Transportation Officials (AASHTO) 2015 Sweet Sixteen Award for being a High-Value Research Project, and the tools are patent-pending.

The same research team from UNCC was awarded two additional research projects in the spring of 2015. One project will develop coastal wetland prediction models using the next generation LiDAR data that are currently being captured across the state. The other project aims to assign a wetland type based on the North Carolina Wetland Assessment Method as well as provide a high-level functional assessment for predicted wetlands.



2015 ICOET

The NCDOT PDEA—Natural Environment Section recently hosted the 2015 International Conference on Ecology and Transportation (ICOET) and it was a huge success!!! The conference ran from September 20-24 and included over 500 participants representing over 20 different countries! A BIG THANKS to the NES staff that volunteered in a support role by moderating sessions and planning and executing the three separate field trips across the state. Also, thanks again to our co-sponsor, the Center for Transportation and the Environment at NC State University, and our many private sponsors. This same conference will be jointly sponsored in 2017 by Utah and Wyoming. Below are just a few pictures from ICOET 2015!!!



more detailed design analysis required by FHWA, etc. With moderate increase in personnel, the Unit has been successful in undertaking many new Department-wide programs, such as Bridge Scour, NFIP and NPDES.

It has been my privilege to get to know so many “hydro folks” over the years, whether they stayed with the Department, or moved on to other opportunities. Many of them demonstrate the highest integrity and professionalism in their day-to-day duties. They take pride in their work, unselfishly sharing with each other their knowledge and experience. I am very fortunate to have the opportunity to work with them to serve the Department over the last 30 years. It is my greatest honor to lead the Hydraulics Unit staff to use the latest engineering tools and techniques to deliver the H&H designs for the TIP Projects, provide the Operations staff with required services, and to deliver and maintain safe transportation infrastructure to the citizens of North Carolina.

NES Promotions

NES RIBBON CUTTINGS



Congratulations to Cheryl Gregory and Jim Mason for their recent promotions within the NES. Cheryl was promoted within the Biosurveys Group where she is the consultant coordinator and the new Northern Long-eared Bat expert. Jim was promoted within the Environmental Coordination and Permitting Group where he will continue his work in permit acquisition, natural resource investigations and consultant coordination. Congratulations!!!



LiDAR Modeler Graduates

Morgan Weatherford received his graduate certification in Applied Statistics and Data Management in December 2015. The curriculum emphasized statistical programming and analysis and will advance the Natural Environment Section (NES) capabilities as it relates to LiDAR (Light Detecting And Ranging) modelling. There is great interest in this emerging modelling technique, and Morgan is making efforts to spread his knowledge to other transportation departments across the Southeast. Congratulations Morgan!!!



NCDOT Receives the “Sweet Sixteen” Research Award

At the AASHTO annual meeting last September in Chicago, NCDOT Chief Engineer Michael Holder, P.E. accepted the Sweet Sixteen Award for the Department’s ground breaking work on the Wetlands Prediction Model research project and the improvements made on the model since its inception.

NCDOT developed the LiDAR-based wetland prediction models as part of the Lenoir County GIS Pilot Study. Some of the benefits of the original wetland model were that it allowed for evaluation of a large number of initial alternatives while reducing fieldwork costs and it could easily quantify impacts of new or revised alternatives for comparisons to improve project delivery. This model also allowed for design revisions “outside the corridor” without the need for additional fieldwork, and it provided more information earlier in the process for quicker decision making, reducing the risk of future delays.

The goals for the new research project were to automate the wetland prediction models with highly automated, reliable, and user-friendly tools based on ArcGIS. Some of the benefits of these improvements to the wetland model include:

- An automated and simplified modeling effort by

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way of a “one-click” modeling process instead of using multiple tools and GIS software packages,

- A user-friendly map generation with validations,
- A user’s guide created to improve replication and application to other areas of the state,
- Time and cost savings provided by these innovative models and automation process, resulting in a more efficient project planning process.

Staffs from both the NCDOT Research and Development Unit and the Natural Environment Section were recognized at the October Board of Transportation Meeting.



Employee Spotlight



Jim Mason is currently an Environmental Program Consultant with the Western Region of the Environmental Coordination and Permitting Group (ECAP) in the Natural Environment

Section (NES). He has been with NCDOT for almost 10 years, all within NES. Prior to his current position, he was an Environmental Specialist in the Central Region of ECAP.

His current duties include performing and overseeing natural resource work, obtaining environmental permits for both bridge and linear projects, and providing support to both internal and external partners.

Prior to working for NCDOT, Jim spent his early professional career working in the field of ornithology, with most positions focusing on shorebird research. He has held seasonal positions monitoring shorebirds with both the U.S. Fish and Wildlife Service in Chincoteague, VA and the Massachusetts Audubon Society in both Westport, MA and throughout Cape Cod, MA, and studied ospreys on Martha’s Vineyard, MA.

Jim was born in Honolulu, HI, but spent a large majority of his childhood and early adulthood in New England. He grew up in Little Comp-

ton, RI, which is a small coastal town of only about 3,000 people. He is half-Vietnamese, with his father meeting his mother while serving in the U.S. Army during the Vietnam Conflict.

Jim graduated from Colby College with a Bachelor of Arts in Biology and earned a Master of Science degree in Biology/Ecology from the University of North Carolina at Charlotte.

Outside of work, Jim enjoys spending most of his free time outdoors with his family. That love of the outdoors has led him to become the president and treasurer of the Friends of Hemlock Bluffs, which is a small non-profit organization that supports Hemlock Bluffs Nature Preserve in Cary, NC. He also enjoys helping his son practice his Taekwondo and spending time with the crazy family dog.

NCDOT

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