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PROJECT SPOTLIGHT

GIS Tools to Help Manage Dynamic Urban Watersheds

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Introduction

Federal National Pollutant Discharge Elimination System (NPDES) Stormwater Regulations have mandated that urbanized municipalities develop and implement stormwater management programs to ensure that pollutants in stormwater runoff from urban non-point sources are controlled to the maximum extent practicable. As non-point pollution sources have been shown to contribute significantly to the degradation of receiving water quality, improved stormwater management programs at the local level should play an important role in protecting our nation's surface water resources. The City of Greensboro, North Carolina is developing and implementing a comprehensive and proactive urban stormwater and watershed management program to address issues in a holistic manner for optimal management of surface runoff and water resources into the 21st century.

Greensboro, with a current population of approximately 205,000, is located in Guilford County in North Carolina's Piedmont physiographic region. It is situated in the headwaters of the Cape Fear River Basin, with no major rivers flowing through or near the city. The North Buffalo Creek and South Buffalo Creek originate in and flow through the central part of Greensboro, and drain approximately

EDITOR'S NOTE

Managing stormwater to reduce flooding and protect water resources in urban areas is a daunting task. Federal NPDES Phase 1 and Phase 2 stormwater regulations now require municipalities of all sizes to control stormwater runoff from nonpoint sources. This issue of *NWQEP NOTES* features the efforts of one local government to develop and implement a proactive, holistic urban stormwater and watershed management program, incorporating GIS technology. The GIS-based modeling tool will lead to improved decision making by enabling users to evaluate the impacts of alternative land use on stormwater runoff quality and quantity, stream stability and flooding, as well as evaluate alternative mitigation measures.

As always, please feel free to contact me regarding your ideas, suggestions, and possible contributions to this newsletter.

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two-thirds of the 109 square mile area of the city. Three reservoirs, Lake Higgins, Lake Brandt, and Lake Townsend, on the Reedy Fork Creek, which flows through the northern part of the city, are the existing primary sources of drinking water supply for Greensboro. A planned water supply reservoir, Randleman Lake, which will be located south of Greensboro along the Deep River, will provide Greensboro, High Point, and other area communities with a future additional source of drinking water. Figure 1 shows the major watersheds and sub-watersheds in Greensboro, along with the existing water supply lakes and a vicinity map showing the general location of Greensboro in the Cape Fear River Basin.

Overview of Greensboro's Stormwater Management Program

The Federal NPDES Phase 1 and Phase 2 Stormwater Regulations mandate that municipalities take a comprehensive approach towards stormwater management issues within their jurisdiction and develop new programs that will prevent or minimize impacts to water quality from non-point pollution sources, such as urbanized areas. Local governments within the State of North Carolina are also required to implement watershed protection programs for designated drinking water supply watersheds, as noted above. These two regulatory mandates, along with local interest in developing an optimum stormwater management program, have served as initiatives for Greensboro to begin developing improved programs for both stormwater and watershed management. The City's developing Stormwater Management Program includes the following key components:

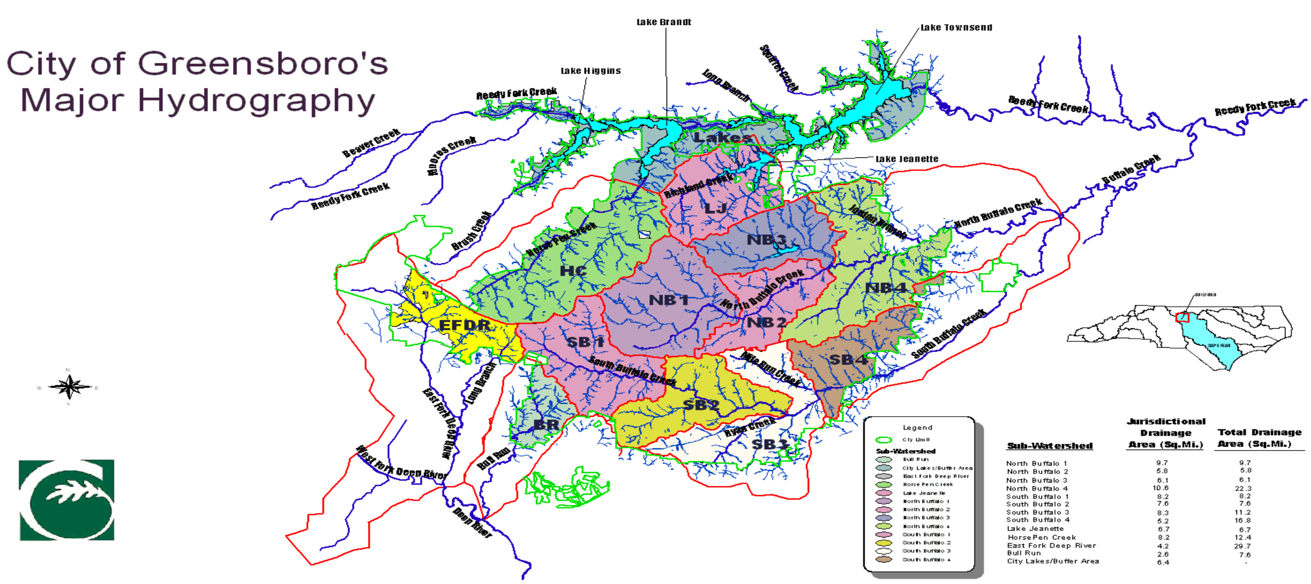

Figure 1. Major watersheds and sub-watersheds in the City of Greensboro.

- Implementation of a Stormwater Utility to serve as the dedicated funding mechanism for the new and improved stormwater management programs, including administration of the NPDES municipal stormwater permit.
- Development and implementation of a comprehensive GIS database of stormwater infrastructure and proactive stormwater infrastructure maintenance program.
- Development of a "Dynamic Stormwater and Watershed Management System," which includes interactive linkages between the GIS database and major hydrologic, hydraulic, and water quality / pollutant loading models.
- Implementation of an extensive public education and awareness program because improved watershed management begins with individual citizens and businesses, i.e.; stopping the pollution at its source is always the best approach. The City has also developed partnerships with many area businesses to promote environmental and water quality protection goals through a program called the "Environmental Business Partners."
- Implementation of a watershed-based water quality monitoring program, including wet weather land use-based monitoring, ambient and wet weather stream monitoring, structural Best Management Practice (BMP) assessment monitoring, and biological / habitat assessment and monitoring. The City is also working with the United States Geological Survey to establish a citywide network of continuous monitoring rainfall and streamflow gaging stations to provide data for the watershed modeling and management program.
- Innovative restoration projects for local degraded streams including enhancement or creation of adjacent riparian wetland areas.
- Development of a comprehensive stormwater management ordinance.

With this brief overview of Greensboro's stormwater management program, the remainder of the article will focus on the City's GIS applications development strategy, including the unique Dynamic Stormwater and Watershed Management (termed "DWM") System under development by the City.

GIS Applications Development Strategy

The Greensboro approach to GIS applications is unique in its focus on making the utilization of GIS applications central to the key tasks within the Stormwater Management Program. In most stormwater programs, the focus is to adopt those applications that easily fit within the existing structure. In the case of Greensboro, the approach has been to highlight the most critical operational tasks, and create GIS applications as tools to help solve those tasks.

The City's stormwater program is funded by a Stormwater Utility, which is levied based on the acreage of impervious area for non-residential properties and a flat fee for residential customers. This funding is used for operation and maintenance of drainage structures, proactive planning, and for monitoring of receiving streams and lakes within the City. It was noted at an early stage of the project that all these tasks could be automated fully or partially using GIS technology and it was known that tools had been developed by other organizations that partially assisted with some of this automation for specific data structures and computing environments. The challenge was to provide these tools to fit the existing data structures, computing environments and workflow that existed within the group.

The first application to be developed was for calculating impervious areas and the consequent utility fee, which provides the funding for the local program. This application was originally developed in 1993 and re-engineered in 1998 when ARC/INFO by ESRI was adopted as the citywide GIS platform.

In 1996, a pilot application was developed which included infrastructure view/query tools, stormwater modeling using simplified tools and a monitoring database for information collection and analysis. These applications were not heavily used at the time because the infrastructure inventory data collection program, which was the data source, was in its infancy. This exercise provided useful insight into what lay ahead, both in terms of the potential benefits and also the complexity and the lack of available integrated products to address stormwater and watershed management problems.

In 1998, the view/query application for the infrastructure inventory was re-engineered and a complementary work management application was added. This was to address the routine and proactive maintenance requirements of the stormwater management program, one of its primary functions, and utilize the data provided by the on-going infrastructure inventory effort. These applications were provided in an integrated form, but because of the limitations of the GIS, the transition from view/query to maintenance was not fully transparent. The goal for this stage of the development effort was to provide a very high level of integration between modules, which was facilitated by the Microsoft COM architecture. However, to accomplish this integration, it was necessary to make some compromise in the ease-of use of the user-interface.

In 1999, work commenced on the most ambitious phase of the project to date, to automate the Stormwater Modeling and Master Planning process. This development is the main focus for this article and is discussed in more detail below. This component (the Dynamic Watershed Management System) is still under development and should be complete by the end of 2000. The application incorporates interfaces to HEC-HMS, HEC-RAS XP-SWMM for closed conduit modeling, water quality modeling, and various planning tools to assist in the master planning process. The goal was to integrate these solutions in a single integrated tool to facilitate the master planning process by engineers and water quality professionals.

A further application currently being developed to aid master planning is the display and assessment of water quality monitoring data. This application will build a database for the on-going chemical and biological-monitoring program, which includes chemical monitoring of streams and lakes and biological monitoring of bugs, fish and stream habitats. The databases will facilitate the rapid calculation of water quality indices for local streams based on methodologies determined by various academic and state agencies. These indices will allow citizens to monitor the water quality in their local streams and lakes and the trends in this data. The results will feed into a live Internet application and will generate thematic maps showing the chemical indices and symbology to display the biological indices at the monitoring sites. In addition, a summary of results will be displayed for each of the watersheds within the City.

Technical Components of DWM System

The Dynamic Stormwater and Watershed Management System, or DWM, is the City's unique GIS-based modeling tool that will be used to facilitate effective stormwater and watershed management decision making. The term "dynamic" is intended to reflect the capability of the system to accommodate the changing nature of many natural and manmade systems within urban watersheds, including land areas, streams and floodplains. Importantly, the DWM System is being designed to be easily updated as conditions in the dynamic urban watershed change. With the DWM System and its integrated modeling modules, the City can efficiently evaluate the impacts of alternative land use and other watershed management decisions on stormwater runoff quality and quantity, receiving stream system stability, floodplain and floodway elevations and boundaries, as well as determine optimum site specific and/or regional measures to mitigate negative impacts of stormwater runoff and non-point source pollution.

The programming environment used for the DWM System will consist of Visual Basic, SQL, ArcView and ESRI Map Objects. The DWM Modeling Modules, which include Watershed Hydrologic Modeling Module (HEC-HMS), Floodplain Hydraulic Modeling Module (HEC-RAS), and the Water Quality Modeling Module, will be developed using primarily Avenue in an ArcView environment. In addition to ArcView, the modeling modules will require ArcView's Spatial and 3-D Analyst extensions. The DWM System is modular in design for flexibility and expandability and includes the following:

- Stormwater Infrastructure and Conveyance System Inventory Module
- Interactive Hydrologic, Hydraulic, and Water Quality Modeling Modules
- Watershed Planning and Modeling Tools
- Master Plan Manager Module

Stormwater Infrastructure and Conveyance System Inventory Module: The scope of Greensboro's Stormwater Infrastructure Inventory included going beyond development of a drainage infrastructure database to encompass the overall connectivity of the storm sewer system with various natural and manmade open channels, ponds, and lakes. The overall connectivity of the drainage system is important for stormwater modeling applications, as well as other proactive applications such as tracking and removing illicit connections to the drainage system and emergency spill response activities.

The major stormwater system features within the Greensboro database include: various types of drainage inlets, manholes or junction boxes, storm sewer pipes, drainage swales, natural and manmade open channels, energy dissipators, culverts, bridges, and waterbodies such as ponds and lakes. The stormwater inventory database is also linked to the City's bridge inspection database, a stormwater pond and BMP database, and water quality monitoring information required by the NPDES permit and for the developing watershed management program.

Example attributes for structures and features within the stormwater inventory database include: a unique tag or identification number, reference to a standard drawing for the feature (if applicable), elevation data from the survey, physical dimensions and measurements, number of incoming flow elements (generally the number of incoming pipes) to the feature, physical condition observations, observations of any obstructions to flow, a check for potential illicit connections, public or private system ownership data, date of information collection, date of future inspection, any unusual flow observations such as odor, watershed data, NPDES storm sewer outfall information, and a field for any specific comments. Digital photographs were also obtained for most drainage structures such as culverts, bridges, larger open channel segments, non-standard infrastructure elements, or features that required near term maintenance (Bryant et al., May 1998).

When completed, the stormwater inventory module will contain over 4.5 million attributes of data surveyed using GPS technologies to 3.5 cm accuracy on the size, location and condition of pipes, culverts, bridges, and open channels.

Figure 2 shows a typical area of the storm system inventory incorporated into the GIS module, with a digital orthophoto in the background.

Interactive Hydrologic, Hydraulic, and Water Quality Modeling Modules: The interactive modeling module will create the hydrologic, hydraulic, and water quality models from the City's inventory and watershed databases. The watershed databases include such GIS layers as existing land use, future zoned land uses, locations of industrial and municipal facilities, soil classifications and hydrologic soil groups, aerial photography layers such as orthophotos and planimetrics, a digital terrain model and topographic contours, and related watershed data layers.

While the GIS applications and relational databases are customized software to meet the needs of Greensboro, the DWM integrates widely-used and accepted computer models such as the U.S. Army Corps of Engineers' HEC-HMS and HEC-RAS hydrologic and hydraulic models, the EPA SWMM hydrologic, hydraulic, and water quality model, and a non-point source pollutant load estimation model based on procedures developed by Schueler (1987).

Figure 3 shows an example of watersheds imported into the DWM system for hydrologic analysis.

The Watershed Hydrology Module of the Dynamic Watershed Management (DWM) system will be used to simulate runoff hydrographs and determine peak flows for a selected subwater-shed(s). The Watershed Hydrologic Modeling Module will be used to compute design flows for use in the Hydraulic Modeling Module (HEC-RAS). Hydrologic modeling will be performed using NRCS methodologies (NRCS Unit Hydrograph and Runoff Curve Number Loss Rate) within the US Army Corps of Engineers HEC-HMS computer program (Replacement to HEC-1). HEC-HMS (referred to as HMS) will be used to simulate hydrographs for relatively large subwater-sheds that include significant open-channel flow and/or ponds. Level-pool routing procedures in HMS will be used for routing flows through lakes and ponds. The source code for the Watershed Hydrologic Modeling Module will be flexible to allow for upgrades to HEC-HMS. The HMS Module is designed to interface different GIS data layers with the HMS hydrologic model. The HMS Module will serve as a preprocessor for HMS input data. Different GIS data layers will be manipulated to derive new GIS data layers and compute several hydrologic parameters such as drainage areas, area-weighted Curve Numbers, and lag-time.

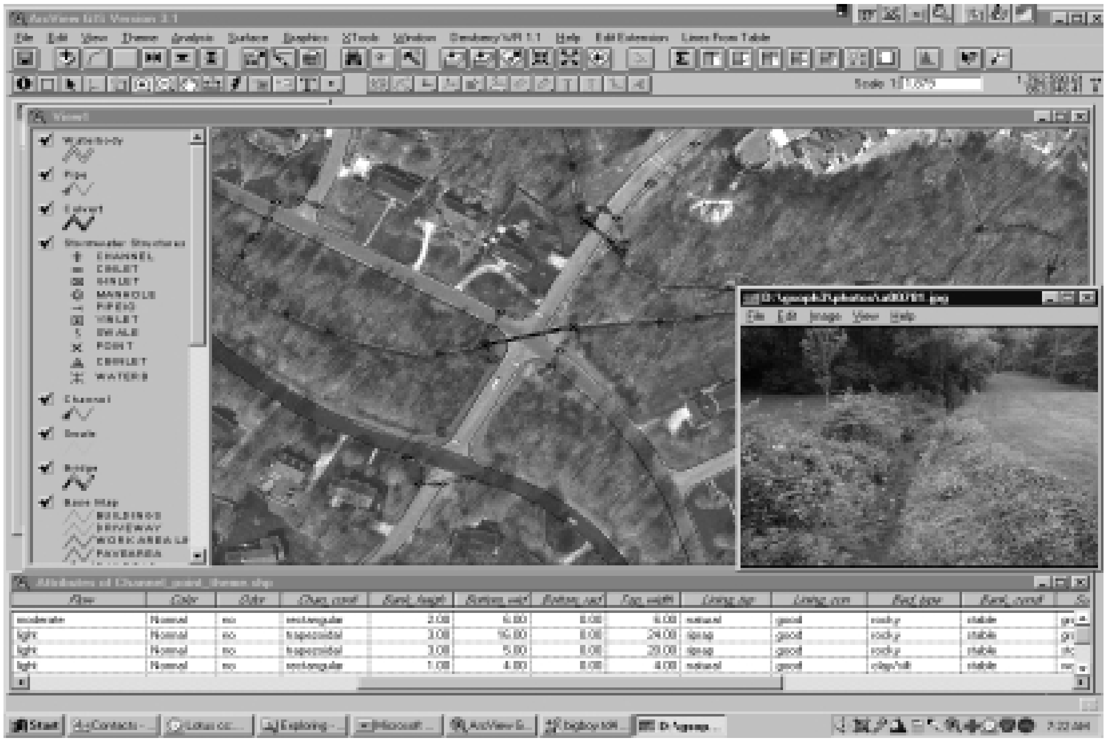

Figure 2. Stormwater system inventory module.

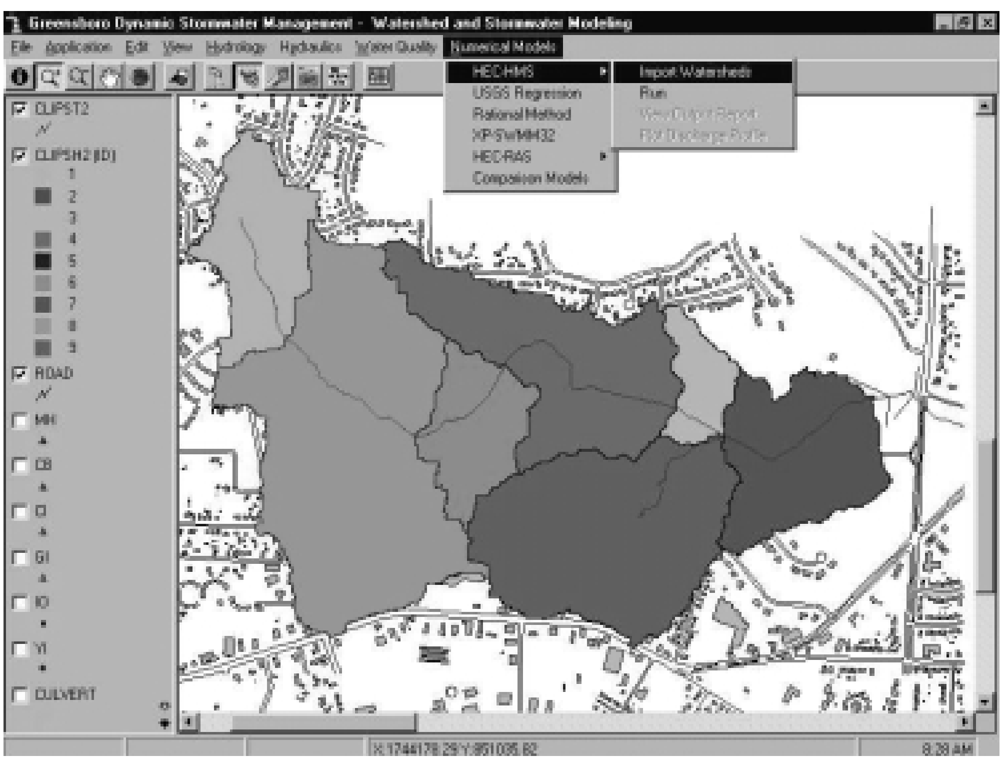

Figure 3. Watersheds imported into DWM System for analysis.

The GIS-based modeling environment will automatically create and format the HMS basin file. In addition, an HMS map file that depicts the subwatershed boundaries and streams in state plane coordinates will be created. The HMS precipitation files will be developed outside the GIS environment and stored on disk for access within the DWM system. Internal quality control checks will be performed to ensure that parameters and data are within a reasonable range. Options regarding the type of output results will be included in the input file. Automated routines will be developed within the DWM system for checking model input. These routines will ensure that input data and parameters are within reasonable ranges. The DWM system will send a warning message to the user if parameter checks show possible problems with the input data.

The Floodplain Hydraulics Modeling Module of the Dynamic Watershed Modeling (DWM) system will provide a semi-automated link to HEC-RAS to perform backwater analyses for open channel reaches. The Floodplain Hydraulics Modeling Module will accept peak discharges from the Watershed Hydrologic Modeling Module (HEC-HMS) through the use of HEC-RAS's DSS (Data Storage System) import procedures. The user will also have the ability to modify the location of changes in peak discharges within the standard HEC-RAS Graphical User Interface (GUI).

The Floodplain Hydraulics Modeling Module is designed to serve as both a pre- and post-processor for the HEC-RAS computer model. Different GIS data layers and their associated attributes will be pre-processed and formatted for input into the HEC-RAS model. HEC-RAS output such as water-surface elevations and floodway encroachments will be post-processed to produce new GIS data layers depicting the floodplain and floodway boundaries. The basis for cross sections and bridge and culvert information required by HEC-RAS will be taken from the infrastructure inventory database. Hydraulic modeling and floodplain mapping procedures will be supplemented with additional cross sections extracted from the digital terrain surface within the DWM system.

Steady state, one dimensional hydraulic modeling will be performed using the US Army Corps of Engineers HEC-RAS program (version 2.2). The source code for the Floodplain Hydraulic Module will be flexible to allow for upgrades to HEC-RAS. The DWM system will have the overall flexibility to incorporate other models in the future (such as UNET).

The purpose of the Water Quality Module is to provide planning level tools suitable for the assessment of water quality issues at a watershed scale. This Module is intended to support other more detailed applications such as an evaluation of citywide stormwater pollution prevention plans or support for future determination of Total Maximum Daily Loads (TMDLs), as these functions are developed. Water quality assessments completed in the module will be based primarily on an annual pollutant loading approach. Statistical procedures will be formulated to introduce seasonal variations into the annual loading estimates.

The basic tool for the Water Quality Module is the "Simple Method" proposed by Tom Schueler to compute annual pollutant loadings from various land uses. Basic pollutants to be included in the Module are total suspended solids, total phosphorous, total Kjeldahl nitrogen, nitrates & nitrites, COD, BOD5, lead, copper, zinc, and cadmium.

BMPs will be evaluated using techniques compatible with the loading model given by the "Simple Method." Removal efficiencies will be selected for various BMP types including wet ponds, dry ponds, extended detention, constructed wetlands, grass swales, filter strips, infiltration trenches, and bioretention facilities. The Module will be developed such that these removal efficiencies can be implemented in a number of user-defined BMP scenarios to examine their combined pollution-reduction effectiveness. The Module will also allow the user to revise BMP types and associated pollutant removal efficiencies, as new information becomes available.

Linkages will be developed between the water-quality output and the GIS to present output in tabular format, and to show loadings by sub-basin in a graphical format. Color schemes will be used to display the effectiveness of implementing various BMP scenarios. Users will be able to export the results of water-quality assessments for further analysis in spreadsheets or other software packages.

Watershed Planning and Modeling Tools: The Floodplain Management Tool within the DWM allows the user (City and stakeholders such as a developer, an engineer, or water quality professional) to interactively evaluate the impacts of development or encroachments on flood elevations throughout the watershed or to evaluate alternative flood hazard mitigation measures. Within the HEC-RAS Module, the user will be able to access the results from the hydraulic model and automatically map the floodplain boundaries for the modeled reach. The floodplain management tools will require a floodplain polygon (i.e., area of inundation) and water-surface TIN (triangulated irregular network) (i.e., flood elevations) for each recurrence interval to be investigated. Combined with digital elevation certificates for all structures located in the 100-year floodplain and tied to georeferenced address fields, the risk assessment may be performed on a structure-by-structure basis.

The buildings GIS data layer will be linked with the results from the hydraulic modeling (i.e. floodplain boundary polygons) so that flood prone structures can be identified. Tools will be provided to determine the lowest adjacent grade from a ground surface TIN for any number of structures. The user will identify the floodplain polygon associated with a given recurrence interval and the DWM will automatically determine the number of structures impacted and the maximum depth of flooding at each structure. The DWM can also be used to determine the availability of elevation certifications for individual structures. If an elevation certificate is available, the software will automatically override the approximate structure elevations obtained from the digital terrain model (DTM) with actual surveyed first floor elevations from the GPS elevation certificates. If no elevation certificates are available for the buildings, the maximum depth of flooding will be based on the difference between the computed flood elevation and the lowest adjacent grade obtained from the ground sur-

Figure 4. Floodplain Determination within DWM System.

face TIN. It is envisioned that the tools to determine maximum depth of flooding and lowest adjacent grade for the structures will be accessed through an ArcView environment.

Proactive flood hazard mitigation planning will be evaluted within the HEC-RAS Modeling Module on a watershed basis. By combining structure-by-structure risk assessment with automated modeling capabilities, the benefits and costs of proposed mitigation measures can be quickly evaluated. The flood mitigation measures to be evaluated include structural flood control measures, bridge and culvert crossing improvements, stream restoration, relocation, acquisition and floodproofing of individual or groups of structures (Bryant and Beadenkopf, May 1999). Figure 4 shows an example of 100-year and 500-year floodplains developed within the DWM System.

Master Plan Manager Module: Users will be able to click on certain GIS features and get information on proposed mitigation projects. This module will include a GIS interface showing the locations, numbering-naming system, and approximate dimensions of selected projects of the Master Drainage Plans for completed watersheds within the city. A project database will contain photographs, sizing data, cost estimates, project summary, and any preliminary grading (scanned from worksheet) if available. The supporting projects database for this Module will be populated as the master plan is completed for various watersheds throughout the city. It is envisioned that the Master Planning Module will be developed in either MapObjects or ArcView.

Summary

This article provides a brief overview of the City of Greensboro's Stormwater Management Program and an introduction to the GIS-based "DWM System" under development that will aid local officials in effective stormwater and watershed management decision making. The authors hope that this summary will be useful as an example for local government officials, consulting engineers and scientists, watershed planners, public works officials, and others involved with challenging current and future urban stormwater and watershed management issues.

The Greensboro DWM System provides a strong linkage between data, watershed modeling results, and the technical basis for management decisions. The system and local monitoring program also allows progress to be tracked and improvements to be measured.

Examples of expected positive results from improved local stormwater management programs include protection and enhancement of water quality in receiving streams and lakes, reduced flooding or mitigation of drainage problems, proactive floodplain management measures, improved aquatic and riparian biota and habitat, and optimal maintenance management of stormwater infrastructure assets. The DWM System also provides a preliminary framework for comprehensive water resources and watershed management as the City moves into the 21st century.

For Further Information

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References

Bryant, Scott D., Todd Young, and John Nicholson, May 1998, Stormwater Infrastructure Inventory and GIS Database Design, Water Environment Federation, *Proceedings of the Specialty Conference on Watershed Management: Moving from Theory to Implementation*, Denver, Colorado.

Schueler, Thomas R., July 1987, *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Metropolitan Washington Council of Governments, Washington, D.C.

Bryant, Scott D. and Edward G. Beadenkopf, May 1999, *A Model for Local Proactive Floodplain Management in the 21st Century: Development of a Dynamic Stormwater, Watershed, and Floodplain Management Program for the City of Greensboro, North Carolina*, paper presented at the Association of State Floodplain Managers Annual Conference, Portland, Oregon.

Acknowledgments

The authors wish to thank the NCSU Water Quality Group for the opportunity to share this work. Some portions of this paper appear in the proceedings of the Water Environment Federation (WEF) Watershed 2000 Specialty Conference. Thanks are also extended to our colleagues at the City of Greensboro, Dewberry & Davis, and Spatial Solutions. Portions of this paper also appear in the Proceedings of the 1999 American Water Works Association (AWWA) Water Resources Conference. Reprinted from Proceedings of the 1999 AWWA Water Resources Conference, by permission. ■

WEB RESOURCES

TMDL Information

For information on Total Maximum Daily Loads (TMDLs), check out the web site below, developed by the Agricultural Research Service, USDA. The web site includes answers to the most frequently-asked questions about TMDLs, background information, links to EPA sites, state-specific TMDL information, tools for developing TMDLs, and recent congressional hearings. **http://www.nal.usda.gov/wqic.TMDL.html** ■

INFORMATION

Effects of Animal Feeding Operations on Water Resources

A product of the USGS-Sponsored Animal Feeding Operations workshop held in Fort Collins, Colorado, in the fall of 1999 is Open-File Report 00-204, Effects of Animal Feeding Operations on Water Resources and the Environment: Proceedings of the technical meeting, Fort Collins, Colorado, August 30-September 1, 1999. The report, which includes the abstracts from all sessions of the meeting, is available on-line under the link "Proceedings" at USGS Animal Feeding Operations web site: **http://water.usgs.gov/owq/AFO/**.

Atlas of America's Polluted Waters

EPA has recently published the Atlas of America's Polluted Waters, EPA 840-B-00-002, which include maps showing waters within each state that do not meet state water quality standards. States listed these waters in their most recent submission to EPA, generally, in 1998, as required by section 303(d) of the Clean Water Act. This provision of the Clean Water Act requires a "total maximum daily load" or TMDL for each listed water. Over 20,000 waterbodies across the country are identified as not meeting water quality standards. These waterbodies include more than 300,000 miles of rivers and streams and more than 5 million lake acres. The overwhelming majority of Americans—218 million—live within 10 miles of a polluted waterbody.

A key feature of the 1998 lists of polluted waters is that, for the first time, all states provided computer-based "geo-referencing" data that allow consistent mapping of these polluted waters. In order to better illustrate the extent and seriousness of water pollution problems around the country, EPA prepared this Atlas of state maps that identify the polluted waters in each state. The maps are color coded to indicate the type of pollutant causing the pollution problem. Bar charts show the types of pollutants impairing stream/river/coastal miles, and lakes/estuary/wetland acres.

Copies of the document are available at no charge from the National Service Center for Environmental Publications (NSCEP) in Cincinnati at: Phone: (513) 489-8190; Fax: (513) 489-8695. A copy of the Atlas has also been posted on the TMDL web site for browsing and downloading at: **http://www.epa.gov/owow/tmdl/atlas/index.html** ■

ANNOUNCEMENTS

NCSU Water Quality Group Staff Changes

We would like to extend our farewell to Rachel Smith, who has worked with the NCSU Water Quality Group since the fall of 1997. Rachel had recently been serving as Coordinator of the French Broad River Training Center in the mountains of North Carolina. In her 3 years with the Group, Rachel made numerous contributions, primarily in the area of stream restoration. Effective June 2000, Rachel accepted an engineering position with an environmental consulting firm in Raleigh, NC, where she continues to work on stream restoration projects. Good luck, Rachel. We wish you the very best!

We would like to welcome Debbie Bousquet to the NCSU Water Quality Group effective June 2000. Debbie will serve as Project Engineering Technician for the Stream Restoration Institute. Her primary responsibilities include preparation of stream restoration documents and design plans as well as working with contractors to implement stream restoration construction. She will also be assisting with storm water assessment plans for the NC Department of Transportation.

Debbie comes to us from a consulting firm where she worked as a Senior Project Technician on stream restoration design plans as well as various environmental planning documents. Welcome Debbie! ■

MEETINGS

Call For Papers

WEFTEC 2001. Water Environment Federation 74th Annual Conference & Exposition: Oct 13-17, 2001, Atlanta, Georgia. Submit abstracts by **Dec 4, 2000**. To receive WEFTEC 2001 materials, call 1-800-666-0206**.** If outside the US and Canada, call 1-703-684-2471 or send an email to confinfo@wef.org. Web site: www.wef.org.

Meeting Announcements — 2000

AUGUST

Agrochemical and Nutrient Impacts on Estuaries, 220th Amer Chem Soc Natl Mtg, Aug 20-24, Washington DC. Co-Sponsored by Agrochemical and Fertilizer and Soil Chemistry Divisions. Contact Laura L. McConnell, USDA-ARS, Environmental Chemistry Laboratory, Bldg 007, Rm 225, Beltsville, MD 20705, Tel: 301-504-6298; Fax: 301-504-5048; email: mcconnel@asrr.arsusda.gov

Intl Conf on Riparian Ecology and Mgmt in Multi-Land Use Watersheds: Aug 27-31, Portland, OR. American Water Resources Assn. Contact Mike Kowalski, AWRA Director of Operations, 4 West Federal Street, PO Box 1626, Middleburg, VA 20118-1626. Tel: 540-687-8390, Fax: 540-687-8395, email: mike@awra.org, web site: http://www.awra.org/meetings/Portland/Portland.html

SEPTEMBER

Coastal Environment 2000–Environmental Problems in Coastal Regions, Third Intl Conf: Sept 18-20, Las Palmas de Gran Canaria, Spain. Contact Sally Walsh, Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK. Tel: +44(0)238 029 3223, Fax:+44(0)238 029 2853, email: slwalsh@wessex.ac.uk

National Poultry Waste Mgmt Symp: Oct 16-18, Ocean City, MD. Contact Richard Reynnells, National Program Leader, Animal Production Systems, USDA/CSREES/PAS, Room 3702 Waterfront Center; 800 9th Street, SW Washington, DC 20250-2220, Tel: 202-401-5352, Fax: 202-401-5179, email: rreynnells@reeusda.gov

OCTOBER

1st Intl Conf on Wood in World Rivers: Oct 23-27, Oregon State Univ, Corvallis, OR. Web site: http://riverwood.orst.edu

NOVEMBER

Intl Conf on Atmospheric, Surface and Subsurface Hydrology and Interactions: Nov 5-8, Research Triangle Park, NC. Sponsored by the American Institute of Hydrology. For details visit web site: http://www2.ncsu.edu/ncsu/CIL/WRRI/aihconf.html

Water Research Symposium'2000: Advances in Water and Land Monitoring Technologies and Research for Management of Water Resources. Nov 8-10, Virginia Tech, Blacksburg, VA. Contact Dr. Tamim Younos, Virginia Water Resources Research Center, 10 Sandy Hall, Virginia Tech, Blacksburg, VA 24061-0444. Phone: 450-231-8039; FAX: 540-231-6673; E-mail: tyounos@vt.edu. For additional information visit web site: http://www.vwrrc.vt.edu.

Irrigation Symposium 2000: Nov 12-16, Phoenix, AZ. Contact American Society of Agricultural Engineers at Tel: 616-429-0300; Fax: 616-429-3852; email: mcknight@asae.org

Meeting Announcements — 2001

JANUARY

Intl Symposium on Integrated Decision-Making for Watershed Mgmt: Jan 7-9, Chevy Chase, MD. Contact Dr. Darrell Bosch at Tel: 540-231-5265, email: bosch@vt.edu, web site: http//www.conted.vt.edu/watershed.htm

International Soil Erosion Symposium: Jan 15-18, Hawaii. Contact American Society of Agricultural Engineers at Tel: 616-429-0300; Fax: 616-429-3852; email: mcknight@asae.org

MARCH

9th National Symposium on Individual and Small Community Sewerage Systems: Mar 12-14, Fort Worth, TX. Contact American Society of Agricultural Engineers at Tel: 616-429-0300; Fax: 616-429-3852; email: mcknight@asae.org

8th National Nonpoint Source Monitoring Workshop

Monitoring and Modeling Nonpoint Source Pollution in the Rural-Urban Interface

September 11-14, 2000
Hartford, Connecticut

This workshop will bring together land managers and water quality specialists to share information on the effectiveness of best management practices in improving water quality, effective monitoring techniques, and statistical analysis of watershed data. The workshop will focus on the successes of Section 319 National Monitoring Program projects from throughout the United States as well as other innovative projects. Urban water quality impacts will be emphasized.

The agenda will include three days of indoor workshop sessions/presentations and a one-day field trip to view stormwater treatment sites. A half-day workshop will focus on hands-on statistical analysis of project data.

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