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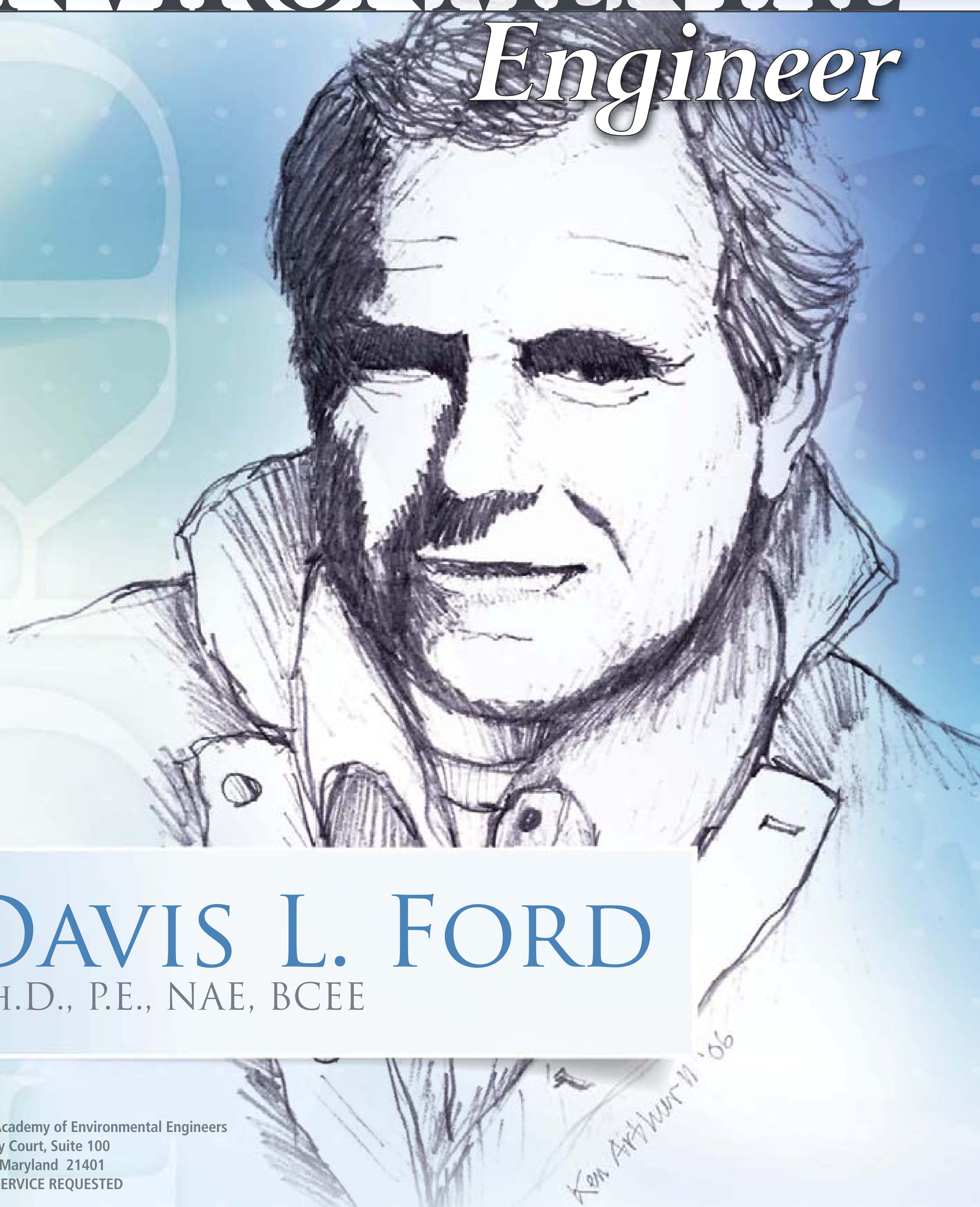
ENVIRONMENTAL *Engineer*



DAVIS L. FORD
PH.D., P.E., NAE, BCEE

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Annapolis, Maryland 21401
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Professor and Director of the Environmental Institute

The University of Alabama is experiencing unparalleled growth and prosperity. The College of Engineering is a leading contributor to this success with unprecedented growth in its undergraduate, graduate, and research programs. As a consequence, the University is constructing several new engineering buildings, and the College is adding multiple new faculty positions, including positions that support the University's emphasis on water resources and the environment. We invite applications and nominations for Director of the University's Environmental Institute (ei.ua.edu). The Director of the Environmental Institute (EI) will hold an academic appointment at the rank of full professor within the College of Engineering.

The EI's primary mission is to be a national leader in research on environmental issues related to water, air, and land resources. The College and University are committed to furthering the success of the EI and advancing it into an internationally recognized center of excellence. In addition to seeking a new director, the University will be adding six additional faculty in the area of environmental and water resource engineering this year. These faculty and the new director will join an existing dynamic and collegial group of faculty from multiple departments across the University, including Civil, Construction and Environmental Engineering, Chemical and Biological Engineering, Electrical and Computer Engineering, Geology, and Biology. These faculty members are dedicated to undergraduate and graduate education and to conducting leading-edge fundamental and applied research in the broad area of environmental and water resource engineering.

The EI director will be expected to lead the Institute to further advance the College and University's research profile. The University of Alabama offers many opportunities to work within an integrated research community of on-campus centers, including the Center for Freshwater Studies and the Aging Infrastructure Systems Center of Excellence. Additionally, the College is adding significant new research laboratory facilities to support a full spectrum of research activities.

Applicants must have an earned doctorate in engineering or a closely related field. The appointment will be at the full professor level in one or more of the engineering departments active in the environmental and water resource engineering thrust area. A January 2012 start date is desirable, but a later date is possible. Applicants are strongly encouraged to submit a resume, a research vision statement for environmental and water resource engineering, and a list of at least three references as soon as possible. Review of applications will begin immediately and continue until the position is filled. Electronic submission of application materials via the University of Alabama employment website is required (facultyjobs.ua.edu, requisition number 0805076).

For additional information regarding the University of Alabama, the College of Engineering, or this search, please contact the search committee at ei-search@eng.ua.edu.

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FEATURES

DEPARTMENTS

by Brian P. Flynn, P.E., BCEE, *BFlynn4290@aol.com*

Governance and Organization

Q. ***What do you mean by governance and organization?***

A. It is what makes the Academy run. By this I mean the staff, the Board of Trustees, the Officers of the Academy, the various committees, and the representatives that we have to other organizations.

Q. ***How do they fit together?***

A. Kind of like a state government. The Officers are analogous to the leadership of an executive branch, the governor, and cabinet. The Board is like a legislature. The staff is like the governor's office, charged with running the entire enterprise. Because the Academy has a small staff, the committees are like regulatory agencies, working on the nuts and bolts of Academy operation. Fortunately, in our case, we have little need for a judicial branch.

Q. ***Do you think that the Academy suffers from too much government, similar to the United States?***

A. You've been watching too much TV. The answer is no. And we don't run deficits either, although we would be tempted if we could print our own money. Who wouldn't?

Q. ***Who is on the Board of Trustees?***

A. The elected Officers (President, President-Elect, Past-President, Vice President), a single appointed officer (Treasurer), six Trustees–At–Large (elected by the members), and Trustees that have been lent to us by our Sponsoring organizations, for a total of 23 people.

Q. ***What do they consider at a typical Board meeting?***

A. A whole host of things. The Board meets in person twice a year and discusses budget control and development, staff performance, progress of committee activities, joint activities with sponsoring and allied organizations, elections, and most important: Board certification!

Q. ***What do you mean?***

A. The Academy's Board is the Board in the terms *Board* Certified Environmental Engineer and *Board* Certified Environmental Engineering Member. The Board oversees the process for assessing the qualifications of applicants to the Academy and votes on whether or not to admit individuals to the Academy. The Board relies heavily on the Admissions Committee to evaluate applications.

Q. ***What does the Academy staff do?***

A. A lot. They answer questions from the membership, keep the books, pay the bills, handle certification fees, do the arrangements for events (E3 competition, annual awards luncheon, Board meetings), take care of our various publications (*Environmental Engineer*, *Who's Who*, *Selection Guide*), help out with various Academy seminars around the country, stay in contact with our Sponsoring Organizations, arrange for the administering of exams, etc.

Q. ***What about the committees?***

A. They do tremendous work, all of it on a volunteer basis. They also serve as an incubator for future trustees and officers. Their work includes assessing and updating each exam, developing and implementing technical seminars, recruiting new members, educating the public on environmental engineering, certification activities (including eminence candidates), evaluation of academic programs through ABET, evaluation and recommendation of awards, student outreach, operation of the project competition program, long range planning, production of materials for publication etc.

Q. ***What about our representatives to other organizations?***

A. We have representatives to ABET (university program evaluations), CESB (the governing body that accredits our certification system), and NCEES (PE exams). They keep us plugged into these important functions for our organization.

Q. ***Did I forget anything?***

A. Yes! Our State Representatives – they arrange for the on-site examination of certification candidates and help with recruiting new members. Also, depending on their inclinations, they organize local AAEE activities.

Q. ***Thank you.***

A. You are welcome. One other thing – if anyone wants to volunteer for any of our committees, simply contact Joe Cavarretta, the Executive Director of the Academy at *jcava@aaee.net* and let him know. All of the Committees are listed in the front of *Who's Who* and on the AAEE website. **EE**

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Have You Renewed?

The 2012 certification renewal process is underway. It is important that you complete your renewals as soon as possible. Current certifications expire December 31, and payment is expected by that date. Members may log in to the AAEE Center and renew (or update your contact information) online.

Any BCEE or BCEEM not having completed the certification renewal process by January 31, 2012, will lose his or her specialty certification and listing in the 2012 edition of *Who's Who in Environmental Engineer*. A 10% late fee is also assessed as of February 1. Please make sure that you have renewed before the deadline.

If you have not received an electronic or hard notice of renewal, please contact Joyce at Academy headquarters immediately.

Kappe Lecturer for 2012 Announced

The 2012 Kappe Lecturer is Dr. Vladimir Novotny, P.E., BCEE. Dr. Novotny is CDM Chair & Professor & Director with Northeastern University. He has been board certified in General Environmental Engineering since 2005. A full profile and abstracts of his lectures will appear in the Winter 2012 issue of *Environmental Engineer.*

Call for Entries: 2012 E3 Competition

The deadline for entering the 2012 Excellence in Environmental Engineering Competition is February 1. Begin planning your entries now. As noted in the Summer issue's Executive Director's Page, starting the entry process four to five months in advance is not too early! Winning entries are submitted to the IWA PIA Awards North American category.

A new category has been added: *Industrial Waste Practice*. Not only will the top winner in this category receive their E3 Award, but they will also be presented with the W. Wesley Eckenfelder Industrial Waste Management Medal. For entry guidelines and additional information, visit *www.aaee.net* and go to *E3 Competition*.

2012 Application Cycle

Don't let your colleagues miss their chance to be part of the Academy's next class of Board Certified Environmental Engineers or Board Certified Environmental Engineering Members. Encourage them to apply for Specialty Certification. Completed applications must be submitted to AAEE no later than March 31. Go to *www.aaee.net* and click on *Apply Now*. EE

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– Kevin Murphy, AVT President and 35-year piping professional
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by Joseph S. Cavarretta, CAE

The Story of Dimas

This column usually calls on you, the Academy's stakeholders, to recruit new certificants, attend Academy events, and compete in the Academy's Excellence in Environmental Engineering Awards. While they are more important than ever, this article attempts to provide the context for why advancing the practice of environmental engineering is essential both here and abroad.

My marriage to the best woman on earth, a lady from Peru, came with a whole new family tree. It was through my wife's Uncle Mario that I hired Dimas, an affable jack-of-all-trades, to do some work at our home. Not more than five-feet tall, a bit on the roly-poly side, religious, respectful, always smiling, Dimas worked with his father, an uncle, and two cousins in a small, insured, tax-paying contracting business specializing in home improvement and repair. They always wore white khakis and treated our home with more deference than most large home-improvement centers we had used in the past. They spent three days in June, patching and painting, refurbishing shower ceramics, and upgrading a garage door. Meanwhile, Dimas added value to their work by identifying and repairing other small items free-of-charge.

Dimas had a secret: he was an illegal immigrant. In July, he was deported to his native land of El Salvador. In mid-September, Dimas, a 32-year-old father of a 5-year-old girl and 3-year old boy, both born here, was beaten to death in El Salvador by a street gang for refusing to give up his Nike sneakers.

Sometimes it takes a sad, sad tragedy like this to remind one of how fortunate we are in the United States of America.

> "This column usually calls on you, the Academy's stakeholders, to recruit new certificants, attend Academy events, and compete in the Academy's Excellence in Environmental Engineering Awards."

What are the root causes that incite adolescents to kill someone over a pair of sneakers? America is largely immune to incidents like this because of our system of government and rule of law; our multi-tiered criminal justice system, socio-economic system, and our infrastructure. It's far from perfect, but it beats anything on the planet.

Core Conditions

It doesn't take a political scientist or sociologist to understand the core conditions that can create a total disregard for life: gross social inequality, lack of jobs, lack of nutritious food, disease, and no prospects for a meaningful future. Those conditions fuel rage and despair. Those conditions make it easy for drug cartels and terrorists to recruit human resources. According to the United Nations Development Programme, "El Salvador is among the 20% of countries with the highest levels of social inequality in the world." (Benitez, 2007).

Key Drivers

What is NOT abundantly obvious is the role of insufficient clean water and inadequate sanitation systems (wastewater, solid and hazardous waste, etc.). They are a key driver of those core conditions. As Major General Jeffrey Talley, Ph.D., P.E., BCEE, made clear in his keynote address at the 2010 Annual AAEE Excellence in Environmental Engineering Awards Luncheon & Conference, the lack of clean water and sanitation was being used by terrorists to demoralize and control the Iraqi people. Improving those systems caused Iraqi citizens to rally. Some risked (and lost) their lives to thwart terrorist attempts to destroy the new and rebuilt systems.

Water supply and sanitation systems are a keystone of the United States and other culturally advanced societies – historically. Only recently did the United Nations declare sanitation a basic human right. The lack of sanitation creates the kind of inhumane conditions by which Dimas met his untimely death. Those conditions – especially near our borders, and the environmental disasters U.S. citizens and others have suffered this year and years past, underscore the need to expand investment in sustainable water, storm water, and sanitary infrastructure here and abroad. That includes devoting resources to the education and growth of environmental engineering professionals who "improve the practice, elevate the standards, and advance the cause of environmental engineering" and the education thereof.

Benitez, I. (2007, August 7). Poverty and violence in times of peace. Inter Press Service News Agency. Retrieved online September 21, 2011, from http://ipsnews.net/news.asp?idnews=38822. **EE**

Awards & Honors

Dr. James L. Barnard, Pr.Eng. was presented with the Lee Kuan Yew Water Prize 2011. Presented by Singapore's Former Prime Minister Mentor Lee Kuan Yew, this prestigious award was given as part of the Singapore International Water Week (July 4 - 8, 2011). Dr. Barnard was presented with AAEE Honorary Membership in 2006.

Paul Freedman, P.E., BCEE, was honored by WEF as part of its inaugural WEF Fellow Recognition Program. The new program honors the professional achievements, stature, and contributions of WEF members. Mr. Freedman is one of only 17 professionals approved. A former WEF President, he is currently President and founder of LimnoTech and has been board certified in Water Supply and Wastewater Engineering since 1989.

AEESP has established the Perry L. McCarty-AEESP Founder's Award. **Dr. Perry L. McCarty** was presented with AAEE Honorary Membership in 2009. The McCarty Award will be given annually in recognition of Dr. McCarty's "sustained and outstanding contributions to environmental engineering education, research, and practice." Dr. McCarty is Silas H. Palmer Professor Emeritus of Stanford University.

Dr. John T. Novak, P.E., BCEE, is the 2011 recipient of the Frederick George Pohland Medal. The Pohland Medal, established by AEESP, AAEE and The Pohland Family, honors individuals who have made sustained and outstanding efforts to bridge environmental engineering research, education, and practice. Dr. Novak, The Nick Prillaman Professor of Civil and Environmental Engineering at Virginia Tech, has been board certified in Water Supply and Wastewater Engineering since 2006.

Dr. Mark R. Wiesner, P.E., BCEE, was selected as the 2011 NWRI Athalie Richardson Irvine Clarke Prize recipient. The Clarke Prize is given annually to recognize research accomplishments solving real-world water problems. He also presented his Clark Prize Lecture, *Nanomaterials, Water, and the Directed Self-Assembly of Environmentally Responsible Industries*. Dr. Wiesner, James L. Meriam Professor of Civil and Environmental Engineering at Duke University, has been board certified in Water Supply and Wastewater Engineering since 2011.

In Memoriam

Dr. John F. Andrews of Springdale, Arkansas, passed away on April 10, 2011. Dr. Andrews, an Emeritus Member, had been board certified in Sanitary Engineering since 1967.

Dr. Dade W. Moeller, P.E., BCEE, of New Bern, North Carolina, passed away on September 26, 2011. Dr. Moeller was founder and President Emeritus of Dade Moeller & Associates, Inc. He was a Life Member of AAEE, board certified in 1961, with a dual certification in Sanitary Engineering and Radiation Protection.

William Wallace "Bill" Cameron, Jr., of Venice, Florida, passed away on February 25, 2011. Mr. Cameron had been board certified in Water Supply and Wastewater Engineering in 1980.

John E. Waters, P.E., BCEE, of Harrisburg, Pennsylvania, passed away on February 14, 2011. Mr. Waters, a Life Member, had been board certified in General Environmental Engineering since 1975.

Letters to the Editor

Environmental Research in Cincinnati: A Century of Federal Partnership

I would like to extend my deep compliments to each of you for your preparation of this excellent retrospective article, published in the AAEE *Environmental Engineer*, Volume 47:3. I enjoyed the article immensely, and believe that it should be essential reading for anyone aspiring to become an environmental engineer.

To start, my first year as a graduate student was made much easier with a USPHS grant, which included a trip to the San Francisco Regional Office and a personal meeting with Paul Eastman.

Eventually, I finished graduate school and migrated eastward. I will long remember arriving in Cincinnati in June 1971, awaiting the delivery of an in-depth filtration pilot plant funded from Jim's program. It finally arrived from California on a rail siding one day, much to my relief and I am sure to Jim's as well!

I also remember doing a project for Ed Barth on the C-N-P content of sidestreams in solids processing. Then there was the project for Dr. Joe Farrell on a high-pressure sludge pipeline in Morgantown, WV. Then there was the trip to Russia with Jim Kreissl and Ben Lykens in 1993. Somehow Jim and I were paired up because we liked vodka! There was a revolution the Monday after we departed.

Perhaps the forthcoming publication of the *Solids Processing Design and Management Manual*, with a huge amount of inspiration and guidance from Jim, will be the finale in a long relationship with Cincinnati and the talented folks like you that made the USEPA programs so great over the years.

All I can say is many thanks – the memories are great!

- Timothy G. Shea, Ph.D., P.E., BCEE

I just opened *Environmental Engineer* and read the article that all of you had been preparing. It's really quite a legacy that you have captured in just a few pages. It brings to mind what was a part of our education in sanitary engineering and the continuing contributions from the Taft Center during my career (from 1965). For example, I recall attending a two-week short course in 1966 on solid wastes management (I think the theme was *Mission 66*, meaning the goal was to close open dumps by 1966). A lot of such recollections were brought to mind. Also, the article should be quite readable by someone who is new to the field.

Thanks to all of you for doing something really valuable to our field. We certainly would not be at our present state of accomplishments in wastewater and drinking water without the federal leadership at Cincinnati.
- David W. Hendricks,
Professor (Emeritus), P.E., BCEE

Your article on page 33 of the Summer 2011 issue of *Environmental Engineer* about the history of the Robert A. Taft Sanitary Engineering Center brought back memories for me. I attended several short courses there between 1955 and 1959 while working for the then Delaware Water Pollution Commission. The courses were of one or two 5-day weeks, with classes all day and homework to do overnight.

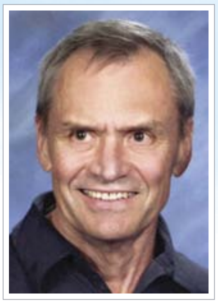
I usually stayed in the Sinton Hotel (since torn down). A feature of the Sinton was the lounge called The Coal Hole. Everything in the room was black: walls, ceiling, tablecloths, and the piano. The only light was a miniature spotlight on the piano. Waitresses had to carry flashlights in order to take your order for snacks or drinks. Lighting a cigarette with a match was looked down upon. It was a unique place to wind down after a day of classes and an evening of studying.

My courses were all in radiological health, an opportunity to learn about control of radioactivity, a relatively new concern at that time. The leader of the program was Dade Moeller. I understand why no mention was made in the article about this program because the article emphasized water. However, radioactivity in water is an important aspect. How novel it was that public funding was available for education in these fields. We might take a lesson in solving the shortage of engineers by providing financial support for engineering education.

My training there was useful for setting up a radiation control program for the State of Delaware. It was also useful in setting up a more inclusive environmental engineering curriculum at Rensselaer Polytechnic Institute, where I taught for 30 years.

The article was also interesting in showing how politics influenced the Taft Center programs and the establishment of similar programs throughout the nation. Your coverage of the Center was excellent and informative.

As an aside, your mention of Streeter and Phelps recalled to mind solving the Streeter-Phelps equation on my slide rule. When I got my HP35, one of my first accomplishments was to enter that equation into the calculator. Now there is an equation for everything. Kids today don't know how easy they have it.
- Donald B. Aulenbach, Ph.D., P.E., F.NSPE, BCEE, P.H. EE



In Memoriam

LARRY A. ESVELT, PH.D., P.E., BCEE

1938 - 2011

By Mark H. Esvelt, P.E., BCEE

As the saying goes "words cannot express…", which is certainly true when trying to summarize the life of Larry Esvelt. It has been five months since his unexpected death, and family, friends and colleagues are still mourning the loss. But his life has been celebrated, and people will continue to remember what an outstanding man he was.

Born on October 19, 1938, and raised on a dairy farm outside of Daisy, WA, Larry was the eldest of six brothers. Hard work, dedication, education and above all, family were the cornerstones of his life even from the beginning.

Larry began his lifelong Cougar pride as a student at Washington State University and graduated with honors in Civil Engineering in 1961. After marrying his partner and the love of his life, Sherry Kay Maize, Larry led studies of surface water quality in southern Colorado as a Commissioned Officer for the US Public Health Service in the Water Supply and Pollution Control Department until 1963.

Continuing his education, Larry studied at the University of California at Berkeley and received his Masters in 1964 while working in the Sanitary Engineering Research Lab as a Research Assistant. Then following several years as a consulting engineer, Larry returned to Cal in 1971, and earned his Ph.D. for his thesis "Toxicity Removal From Municipal Wastewaters," working under notable legends such as Warren J. Kaufman, Robert E. Selleck, and Robert C. Cooper. This was also the time and place where Larry began his lifelong professional and personal relationships with leaders in the field of environmental engineering. He was proud of his association with Cal and his status as an alumnus.

In 1976, Larry opened the doors of Esvelt Environmental Engineering in Spokane, WA, and became known throughout the region and eventually, throughout parts of the world for his expertise. His professional practice included work involving surface and groundwater quality, wastewater facilities planning and wastewater treatment plant design (advanced biological, biological and chemical nutrient removal), biosolids treatment, industrial wastewater management and treatment design, water and wastewater facilities in cold regions, and other reuse and reclamation water issues. Larry was a registered professional engineer in Alaska, California, Idaho, Montana, New Mexico, Oregon, and Washington. As well, he was a Licensed Wastewater Treatment Plant operator, Grade IV – Washington.

Larry continued to contribute to the environmental engineering field through research, publications, and effective presentations in his 40 plus years of work. He was on Washington State Department of Health and Department of Ecology Water Reuse Advisory Committees and received the Spokane County Aquifer Protection Award for his work to protect the region's sole source aquifer. Pioneering publications such as Treatment of Fruit Processing Waste by Aeration and Cannery Waste Biological Sludge Disposal as Cattle Feed were later presented at several association conferences, and decades later, were still being referred to and used in the field.

Professional societies in the civil and environmental engineering industries continually benefited from Larry's active participation. He was a Life Member and was Board Certified with AAEE since 1969. Along with being a member with WEF, IWA, and AWWA, Larry was a past President and recipient of the Engineer of the Year Award for 1981 with ASCE, Inland Empire Section. In the early and mid-1990s, through Volunteer Overseas Cooperative Assistance (VOCA), he assisted agricultural-associated agencies and cooperatives in Poland in water pollution control planning, coordinated through a branch of Solidarity in Warsaw.

Education and mentorship had always been a passion for Larry. He represented AAEE on the Board of Directors for ABET as well as being a member of ABET's Engineering Accreditation Commission. He greatly enjoyed his accreditation consultation visits to engineering schools throughout the U.S., and internationally to Mexico, Turkey, The Philippines, and Qatar. He shared his knowledge regarding engineering education with enthusiasm and generosity to several northwest institutions, serving Washington State University as a Member and Chairman of the Department of Civil and Environmental Engineering Advisory Board, where in 1999 he was given the Alumni Achievement Award. Larry was also on the Gonzaga University Engineering Design Advisory Board and Seattle University Civil & Environmental Engineering Advisory Board.

At the time of his death, Larry was extremely proud to be the father of three children and grandfather to seven grandchildren, as well as being a dedicated and loving brother, nephew, uncle and cousin to a large and extended family. In his spare time, he was a civic leader in the Rotary Club, The National Federation of Independent Businesses, The Aircraft Owners and Pilots Association, and Millwood Community Presbyterian Church. His name and the memory of his accomplishments will live on, as will Esvelt Environmental Engineering, which was re-formed as an LLC with his partners, son Mark Esvelt, P.E., BCEE and Mark's wife, Allison Esvelt, P.E. in 2006. EE

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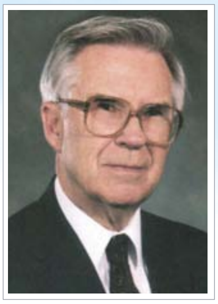

In Memoriam

DR. LINVIL GENE RICH, P.E., DEE

1921 - 2011

Linvil Gene Rich, of 117 Victoria Circle, Anderson, SC died Thursday, September 29, 2011 after a brief illness.

Born March 10, 1921 in Pana, IL, he was the son of the late Orvil C. and Lillian W. Rich. After graduating from Pana High School, he attended University of Illinois, West Virginia University and Stanford University.

Gene was drafted by the Army and served as an infantry squad leader in Europe during World War II under General George Patton. After the war, he returned to school at Virginia Tech where he earned a B.S. in Civil Engineering, M.S. in Sanitary Engineering, and a Ph.D. in Biochemistry.

After graduating, he performed research at the University of California-Berkeley. He subsequently taught at Virginia Tech for five years while he also served in the U.S. Navy Reserves.

After joining the U.S. Public Health Service, Gene and his family moved to Bolivia for a year, assisting the Bolivian government in establishing water and wastewater systems. Upon his return to the U.S., Gene taught six years at Illinois Institute of Technology (IIT) in Chicago. While at IIT, he authored two groundbreaking textbooks that radically changed how Environmental Engineering was taught. In 1961, Gene was appointed as the Department Head of Civil Engineering at Clemson University. One year later he was appointed Dean of Engineering, a position he held for 11 years before returning to the classroom to teach.

During his tenure as Dean, he expanded the Engineering graduate program and helped establish the first Ph.D. programs. In addition, he created the nationally recognized Environmental Systems Engineering graduate program, one of the first interdisciplinary environmental engineering programs in the country.

For the next 15 years, Gene taught undergraduate and graduate environmental engineering courses while performing research in aerated lagoon wastewater treatment processes. This research led to three additional books and numerous technical papers. He also taught one summer in China. After retiring in 1986, Gene continued to do research and write technical papers on wastewater treatment while also doing genealogy research. In 1991, the L.G. Rich Environmental Engineering Research Laboratory at Clemson University was dedicated to him.

Awards and recognitions over his distinguished career include:

- Charter Member, Distinguished Alumni at Virginia Tech Civil Engineering Dept.
- Charter Member, Thomas Green Clemson Academy of Distinguished Engineers
- American Society of Civil Engineers, Rudolph Hering Medal
- Exceptional Service Award, National Wildlife Federation
- Faculty Excellence Award, Clemson Board of Trustees
- South Carolina Order of the Palmetto
- Alumni Professor Emeritus, Clemson University

Gene also was a member of numerous honor societies such as Chi Epsilon, Tau Beta Pi, and Phi Kappa Phi. Moreover, he was a registered Professional Engineer and a Diplomate (Board Certified Environmental Engineer) of the American Academy of Environmental Engineers.

Gene was predeceased by his parents, his first wife Peggy, a son Linvil Burton, and a sister, Gloria. He is survived by his wife Molly of Anderson, SC; a son Graham (Karen) of Little Rock, AR; a granddaughter, Diana (Ben) Hall of Atlanta, GA; two great grandchildren, Mason Linvil and Anna Claire Hall of Atlanta; and a daughter-in-law Margaret Roper Rich of Seneca, SC.

Editor's Note: Our thanks to Graham W. Rich, P.E., BCEE, and the Rich Family for allowing *Environmental Engineer* to reprint Dr. Rich's obituary. Dr. Rich had been board certified by AAEE in Sanitary Engineering since 1958. He was profiled in *Environmental Engineer* (April 1992, Volume 28, Number 2) as part of our Profiles in History series, *Linvil G. "Gene" Rich: A Rich Legacy in Environmental Engineering*, and authored the AAEE-published *High Performance Aerated Lagoon Systems* (1999). EE

AEESP and AAEE Collaborations for Educating Environmental Engineers and Scientists of the Future

By Joel G. Burken, Professor and Associate Chair, Missouri University of Science and Technology, President, AEESP

The partnership of AEESP and AAEE has continued to advance over the past year and recent months. We share so many common goals and objectives and have worked hard to coordinate efforts to advance the profession we all appreciate so much. Some of the topics AAEE and AEESP are collaborating on now and in the near future are outlined below. We would greatly appreciate input from the AAEE membership on these specific activities. We also look forward to identifying more areas where we can collectively advance the education of environmental engineers (and scientists!) and work together to enhance the professional advancement long after graduation.

STRATEGIC PLANNING

AEESP had looked ahead and set long-term strategic planning areas. The AEESP Board of Directors gathered for a couple of days to examine what AEESP has done for members and for the profession in the nearly 50 years since it was formed as the American Association of Professors in Sanitary Engineering (AAPSE) in 1963. The evolving name of this organization reveals much about the evolving state of our profession, first in its transition from "Sanitary Engineering" to the much broader "Environmental Engineering" of AEEP, and then, in 1998, to the even broader "Environmental Engineering and Science" current core of AEESP. The addition of 'Science' to our name and focus is something that AAEE is currently considering as well (more discussion below). As a result of their meeting, the AEESP Board identified the following action items that will advance the goals of AEESP:

1. Expand AEESP's Global Influence
2. Define the Scope and Direction for Environmental Engineering & Science Curricula
3. Facilitate Expanded Research Activity
4. Promote the Environmental Engineering & Science Community

I am certain that these topics reflect the AAEE's future plans at the professional level and will promote academic advancements in these areas. We have identified some specific potential actions or activities that will help to advance these strategic areas, many of which could benefit from cooperative efforts with AAEE. In fact, a few activities are already underway. Included below are a few of the activities that AEESP is undertaking, some examples of current collaborations, and some suggestions for future efforts.

In addressing the plans to *Expand AEESP's Global Influence*, we are already working with AAEE to share notes in each other's member publications (like this one) to increase the awareness, exposure and impact of our efforts and activities. We also hope that more AEESP members will pursue certification through AAEE. I am personally awaiting the results of my evaluation and hope to add "BCEE" to my signature block later this year. AEESP is also currently investigating the adoption of an official AEESP journal to serve as an outlet for research and educational articles by AEESP members and to increase the global exposure through affiliation with an international journal. Along the same lines, we hope to increase our international membership and foster a two-way exchange of knowledge and ideas about how best to educate the next generation of environmental engineers, so they will have greater global connections and more awareness of cultures and engineering methods in other countries.

In efforts to advance *Environmental Engineering and Science Curricula*, AEESP and AAEE are actively collaborating to advance and evaluate the adoption of the Environmental Engineering Body of Knowledge (BOK). The BOK discussion comprised a large portion of the workshop "Frontiers in Environmental Engineering Education" at the 2011 AEESP conference this past July in Tampa, Florida. The workshop included talks by Dr. Debbie Reinhart, former President of AAEE, and Michael Selna, current AAEE President-Elect. I was fortunate to lead the workshop of talented participants, and as a result of the meeting, we are well on our way to holding a follow-up multi-day workshop on the same topics with a much larger audience from across the country and representing most environmental engineering degree programs. We also plan to launch an annual Environmental Engineering Department and Program Chairs meeting that will bring together the leaders of educational units from across the country with AAEE members to better align and continually improve the education of future environmental engineers and scientists. AEESP is leading this effort with great collaboration from AAEE at every step. I am working with Mike Selna to ensure we have a great inaugural meeting in 2012.

In efforts to *Facilitate Expanded Research Activity*, AEESP plans to help articulate the needs of the profession to federal agencies and to policymakers in Washington. We hope that by working with AAEE, we can identify areas that are lacking in the knowledge necessary to protect human health and the environment in efficient ways, particularly considering the constraints of energy efficiency, capital investment, and materials utilization. We particularly welcome ideas on how to identify such areas of national need in environmental engineering research.

The final strategic area is to better *Promote the Environmental Engineering & Science Community*. The AEESP continues to work on this area, and the fact that you are reading this article in an AAEE publication certainly exemplifies the current efforts of these two organizations to work together. The future of AEESP efforts absolutely includes ongoing, productive collaborations with AAEE.

One other notable area of collaborative effort relates to the recent AEESP support of the sustainability certification and the pending environmental certification. Many professors in AEESP have been active in incorporating 'sustainability' into the educations of our environmental engineers and scientists. However, 'sustainability' has so many branches that programs or efforts of seemingly similar focus may actually be quite dissimilar in the ways they look at sustainability of our public infrastructure or sustainability of energy resources and related impacts such as greenhouse gasses. Other programs focus on underdeveloped areas of the world and hope to aid their sustainable development by diverging from the infrastructure and energy intensive practices of western civilizations. AEESP has been working to help members consider a variety of approaches and sustainability-oriented programs, and then develop programs that: 1) best fit their institute and resources and, 2) share some common threads with other programs in the nation.

From these educational programs and activities, we hope that future professionals will be well prepared to operate in a world where 'sustainability' is integrated into all engineering design, and that they will seek continued professional development and certification through AAEE. The need for all environmental engineers to integrate sustainability and interface with the natural world makes understanding of earth sciences essential to our efforts to engineer better environmental infrastructure systems, and to understand how engineering and stewardship can ensure a better world for future generations.

I welcome any feedback and other ideas that can advance AAEE and AEESP collaborations as we continue to strengthen the education of environmental engineers and scientists of the future. **EE**

- Joel G. Burken, *Burken@mst.edu*

SIDE TRACKS *NEW**

Interested in knowing about the extracurricular activities of your fellow Academy members? Or do you have fun (or possibly funny) interests you'd like to share? This new section, **Side Tracks**, is intended to provide a vehicle for learning about the outside interests of our members. Email your submissions to Yolanda Moulden, Editor, News, Currents, & Careers, at *YMoulden@aaee.net*. Thanks to Michael Selna for his assistance in creating this new section.

This Illinois license plate caught our attention. AAEE Illinois State Representative **Allan L. Poole, P.E., BCEE**, is the proud owner of the plate. Allan has served the Academy as Illinois State Rep and Chief Examiner for 10 years and is a Life Member of AAEE, having been board certified in 1976 in Water Supply and Wastewater Engineering. He is also a Fellow and Life Member of the American Society of Civil Engineers and a Life Member of the American Water Works Association and the Water Environment Federation. Allan retired in 2010 after 38 years as the Director of Public Utilities for the City of Naperville responsible for their water, wastewater, and electric utilities

with the City's population increasing from 23,000 to 150,000 during his tenure. Allan enjoys kayaking, trail bike riding, nature photography, and rooting for his University of Iowa Hawkeyes.

DAVIS L. FORD
PH.D., P.E., NAE, BCEE

By Pam Arthur, *Special Assistant to Dr. Ford (1985-present)*

IT SEEMS SAFE to suggest that Isaac Newton had foreknowledge of Davis Ford – and, for that reason, developed the second part of his First Law of Motion: "…an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force." Davis and that "unbalanced force," though, have not yet come face to face. He is still in full motion, moving forward at top speed at nearly 74 years of age – full of energy and enthusiasm. Dr. Thomas M. Hatfield, Director, Military History Institute and former Dean of Continuing Education, University of Texas at Austin, in March of this year, 2011, said, "If you do not know, you should be apprised that when Davis attacks a project…it's the equivalent of being struck by a great tsunami."

Davis has used his boundless energy very capably, resulting in his becoming a worldwide renowned expert and consultant in the problems associated with special water pollution control issues. But, what began his path in engineering over 50 years ago was another type of water problem – the lack of it, the extensive and ruthless drought of the 1950s.

Davis was born in West Texas in 1937 to an agriculturally-educated father and a literarily-intellectual mother. Once his father switched from county agent to rancher and farmer in the mid-1940s, he tried to raise Davis to follow in his footsteps.

He recalls, "My dad would get in the pickup and drive me around what we called the farm (several sections of dry land farm and pasture in Deaf Smith County on the *Llano Estacado*). We'd drive around to every mother cow, all were registered Herefords, and he'd tell me about this cow and that cow. And then, he would put me to work. At that time, I was too young to get on a tractor or a cutting horse; so, my dad figured out work for me to do, like digging fence-post holes, chopping weeds, flanking calves, and other menial tasks. He worked me to death, and that's where I learned the work ethic – from my father.

"When I was in my early teens, Dad tried to make a cowboy out of me, putting me on our feisty cutting horse, Blanco, and having me cut mother cows out of a herd. This became a routine chore for me. I was amazed Blanco knew to target the cow. When he did, I simply would hold onto the saddle horn and let him do all the work[1]. I loved being in the saddle, and I still do. Up until the terrible drought of the '50s and the collapse of the cattle market, all I wanted to do was be a rancher and raise cattle and horses. But, I watched my father work the dry, hard soil – working with all his heart to make it yield what it could not. He did not get a return for his steadfast efforts, and I thought then I would look elsewhere to make my way in life."

A childhood friend of Davis, Jim McLaughlin, says this about growing up in West Texas and Lubbock:

We grew up on the plains, with cactus and sand,
Dirt roads and bar ditches scarred the land.
Glare ice in winter, floods every spring
Sand storms in summer, critters that sting
Cactus to stick you, rattlesnakes that bite
Wind in the daytime, tornados at night.
Our crops were taken by the seven-year drought
We just couldn't wait to get ourselves out!
The worldview in Lubbock is downright plain
A man's only asset is his good name
Work hard and honest, be faithful and true
Good things will always come back to you.

Because of the advice of another friend's engineering father, Davis turned to engineering and, because of his own father, entered Texas A&M University. He has never regretted either of those decisions. His graduate work took him to The University of Texas at Austin where he had the privilege of learning from and working with two engineering giants: Earnest F. Gloyna and Wes Eckenfelder.

1. This was a good lesson that Davis learned early — not to micro-manage the competent, talented people he would select for a project team. Dr. Gloyna pointed out, "Davis had the ability to bring in specialists in engineering, in science, in management. He would bring all these thoughts together to solve the problems of the day." Davis knew how to handle these experts.

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Again, he is very appreciative of his mentors and the opportunities they provided. They prepared him for an engineering career mixed with academic teaching and private entrepreneurship, designing water and wastewater treatment facilities, project development and management, team development, grant and research development, business and financial administration, national and international lecturing of complex environmental engineering issues, interaction and communication with specialist of diverse scientific fields, accrediting higher education engineering programs, extensive publishing, and effectual participation in many professional organizations.

Many, many times Davis has said, "Time is irreplaceable and precious, and I don't like to waste it." Well, that is obvious, and today, he is a highly respected and sought-after consulting engineer. In an interview in March of 2011 with Dr. Gloyna, the conversation included what constitutes a consulting engineer. "Many people can solve difficult issues but not everyone is able to solve the issues and also communicate with other professionals in different disciplines. The consultant has to have had the experience in solving difficult issues, and people must respect his professional competency. There is a difference between an ordinary individual who might be able to work a problem with some assistance and an individual who has the foresight of knowing that he has complete understanding, competence, and the ability to resolve the issues. Davis has all of this – and the drive and the deep-seeded interest in resolving broad issues. Besides, he's intelligent and an effective communicator."

Davis (right), his dad and sister at the farm, 1949

Davis and Wes Eckenfelder, 1968. Water Pollution Control (beginning their first book together)

Senior in the Texas A&M Corps of Cadets (just before Commission in the U.S. Army)

Graduate work and the following years

In 1965, Wes Eckenfelder asked Davis to remain at The University of Texas at Austin to be his first Ph.D. student. Davis, with a Masters in Environmental Health Engineering, was on his way to Dallas to join the firm of Forrest & Cotton and begin his engineering career. He changed his plans "Maybe my mother's penchant for learning finally kicked in. It was hard work; the doctoral dissertation was consuming, but it was a thrilling venture."

Davis' Dissertation Topic (January 1967) was *The Effect of Process Variables on Sludge Floc – Formation and Settling Characteristics*. The objectives of Davis' work: (1) to evaluate (in a laboratory scale investigation) the effects of the variables which affect the operation of the activated sludge treatment of municipal and industrial wastes, and (2) to correlate the information with field data and refine predicting models where possible. While many of the methods and findings of his work are still relevant today and still part of his teachings[2], such as refining mathematical modeling to insure that modeling inputs are more accurate, the very important aspect of his dissertation was that Eckenfelder taught him predictive modeling and practical application for wastewater processes.

2. Recently (April, 2011), Davis presented a lecture at Oklahoma State University that included some of his relevant doctoral material. This lecture was endowed by Wes Eckenfelder's former graduate students and others.

Peer Comments

"When Davis Ford was president of The American Academy of Environmental Engineers in 2001, he had to face a situation that no other president, to my knowledge, had to address. A long-time staff member was dismissed, and he promptly sued the Academy for wrongful dismissal. If the court ruled in his favor, which by all accounts had merit, it would have severely crippled the Academy's financial position. Dr. Ford spent most of his presidential year dealing with this serious problem, which was successfully resolved."

– **Earnest F. Gloyna, Ph.D., P.E., NAE**
President of AAEE, 1983, Former Dean, College President of AAEE, 1983
Former Dean, College of Engineering, University of Texas at Austin

"Davis and I immediately bonded – socially and professionally. We had good chemistry, and still do.

At no time did Davis try to influence me nor at any time did I try to influence him. As a result, we came up with a good answer for things. Communication is the key. There are a lot of brilliant people who cannot communicate their ideas to others – and Davis has the ability to be clear with an idea."

– **W. Wesley Eckenfelder, Jr.**
(Interview, 2010) (1926-2010)

"I have known Davis Ford since graduate school. We were, then and now, very good friends. Both of us were honored to work under Wes Eckenfelder, and both of us had lots of great experiences with him all over the world. It is a pleasure for me to acknowledge Davis in this AAEE publication."

– **Carl Adams, Jr., Ph.D., P.E.**
Doctoral Classmate of Davis

Upon completion of his doctoral work, Davis once again changed his plans. He was ready to accept a position at the University of Florida in Gainesville to begin an academic career when Dr. Gloyna offered him the position of Assistant Director of the Center of Research for Water Resources[3]. This was a great start for Davis' specialization in industrial pollution control because of the Center's grant money from chemical and petroleum refining industries for environmental-related research. Moreover, it kept him in his native state – Texas.

In 1968, Dr. Gloyna offered Davis the chance to become an adjunct professor at UT-Austin. This was a great opportunity. Indirectly, it allowed Davis to get into the private sector. Dr. Harvey Ludwig noticed the young adjunct professor's talents and asked him to open an Austin office for Engineering Science, Inc. This was a new company on the leading edge of advanced environmental consulting worldwide, founded by Dr. Ludwig in Arcadia, California. Davis accepted, developed the Austin office with aplomb, and has no regrets about the changes in his career plans over the years. As Dr. Ludwig said before his recent death, "Davis is one of those rare engineers with both down-to-earth engineering capabilities combined with high level R&D talent. He is personable, dynamic, and 100% Texas...He proceeded to organize ES as a Davis Ford Dukedom," or as Dr. Hatfield would say, "Davis attacked it like a great tsunami." And then, a friend from West Texas might say that Davis simply knew how to "cowboy up[4]."

Davis and Gwen on their Wedding Day, 1960

Davis L. Ford & Associates

In 1985, Davis formed his own consulting engineering firm. Over the next 26 years, up to today, over 300 clients have walked through his doors and hired his expertise – unsolicited by him. Davis' reputation was and is the magnet. The problem solving that was required was applied to a wide-range of environmental issues beginning with his first client, the City of Austin and its underperforming, out-of-compliance water and wastewater facilities, to a current client, Formosa Plastics of Taiwan (as well as of Point Comfort, Texas), for whom he is overseeing its compliance with environmental standards on a par with EPA in the United States.

Dr. Gloyna pointed out, "Davis could have retired but he has chosen

3. Earnest Gloyna founded the Center of Research for Water Resources in the 1960s and developed it by inviting industry to bring its environmental issues for analysis and resolution. Industry accepted, bringing interesting, complex issues and the necessary funds for the required research. The Center put the College of Engineering at The University of Texas at Austin at the top of the list for excellence in engineering programs in the U.S.

4. *"cowboy up"* means to take courage, to go ahead and tackle the job despite the risk and pain. It is an integral part of the cowboy code.

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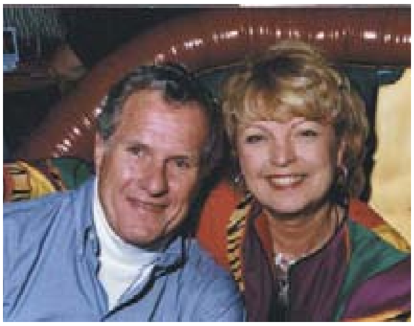
Young family with 3 girls, 1976



Traveling Couple, 1990s

Celebrating their 50th Wedding Anniversary

Cimarron Rodeo, New Mexico, 2006.
All* the Family Attending the Oldest Standing Rodeo in the Southwest (*4 grandchildren yet to come)

to continue contributing to the professional aspects of environmental engineering; thus, he is now internationally recognized as one of the outstanding contributors of the science of engineering."

Family Life

As outstanding as Davis is as an engineer, he is equally outstanding as a family man. "Your family is your tap root," says Davis. "Nothing is more important."

In 1960, after a three-year courtship, he married Gwen Andrews (born and raised in Texas) in Bryan, next door to Texas A&M. Davis recalls, "I was driving back home from my Army time on the East Coast at Aberdeen Proving Ground near Baltimore, and when I crossed the Red River I knew…I knew I was ready for the next step – and that meant getting married, especially to a Texas gal who shared my values and came from my background. And that meant Gwen, so I called her." For over 50 years, Gwen and Davis have lived their strong sense of family and created an outstanding, loving family community of three daughters, three sons-in-law and 10 grandchildren.

The wife of a busy, sought-after man has to be talented in her own right. Gwen is a graduate of the University of Texas at Austin with highly developed personal and social skills, organizational skills, and spiritual and nurturing skills. After raising Kelly, Kristy and Katy, Gwen applied her skills and her compassionate generosity to The Settlement Home, a home for abandoned and/or abused girls. In 2006, Gwen was elected President of the organization, as well as honored by Austin Ballet as one of Austin's outstanding volunteers of the year – a "Woman on Her Toes."

"In Germany we say: 'good engineers always (and only) get daughters.'" (Detlef Albrecht, 2011). None of Davis' daughters followed his footsteps to become engineers, but they all graduated from Texas A&M University!

Peer Comments

"Davis has so much energy – and almost 74 years old. He spent the night here in Fredericksburg last week and left that next morning because he had to give a lecture that afternoon in Austin – and then he flew to Corpus Christi to give a lecture the next morning – and the next day he flew to Taiwan to consult with a client. And he's 74!"

– James Collins
Retired CEO, Bell Dairies (Dean Foods)
Childhood Friend since 1945

"In the Fall of 1977, I came to Texas from Nepal as a graduate student. My first semester at UT, I took a course from Davis in the design of water and wastewater systems. We had instant bonding. Davis was never a full-time professor, always part-time because he practiced, and that is why he was so different from the other professors who taught mainly theory. Davis taught more of the practical aspects of engineering. It was rare to have a professor who had designed what he taught. At this time, he was with Engineering-Science – lucky for us students because he opened up its library and equipment to us – and we would talk to the engineers. He gave us exposure to a working engineering firm. Besides all this, Davis had a wonderful style of lecturing and grabbing your attention."

– Raj Bhattarai, P.E., BCEE
Water & Wastewater Utilities, City of Austin

"Davis is one of the finest men I have met in my life. He has been an outstanding father and husband. He has a reputation for being straightforward and honest, very professional as a businessman, representing the conservative side. He is a loyal and hard-working Texas Aggie. I am privileged to have him on my Board of Directors and more so to have him as a friend."

– Clayton W. Williams, Jr.
CEO, CWEI (NASDQ), Midland, Texas

Peer Comments

"(Davis was one of Engineering-Science's) younger officers who substantially contributed to the growth of the company...a brilliant engineer who was later to become nationally recognized as an expert in the treatment of industrial wastes. He proceeded to build up a large and talented professional staff as head of the Southwest Region and secured and worked on many projects during that period of time. He became a senior member on our Board of Directors, and then with two others arranged our merger with the Parsons Corporation. He was also a pleasure to have as a colleague... and widely recognized in the company for his contributions to many of ES's national projects, and also for his engineering and management expertise."

– Robert L. White
Former CEO, Engineering-Science, VP of The Parsons Corp.
Excerpt from his memoirs, "An Engineering Odyssey: Over Fifty Years of Practice in an Interesting Profession," October (2007)

"Davis is the epitome of the friendly, open, welcoming Texan. I first met him on a groundbreaking PACT project at DuPont in the early '70s. We have stayed in touch every since. When I moved to Austin a few years ago, he was the first one in the environmental engineering community to welcome me and get me plugged into the local environmental scene.

"Davis has had a long and illustrious career, and is still contributing to environmental engineering and education. I have always enjoyed hearing him speak and have learned something new from him every time. And when you need help with an activity, he is the first to put his tremendous energy to work with you."

– Brian Flynn, P.E., BCEE
President, AAEE

The Daughters – Kelly, Kristy (standing), Katy

Katy, Kelly, Kristy – all grown up

Grandparents Gwen and Davis and the first 6 grandchildren (more to follow)

Awards and Honorary Affiliations

- Sigma Xi
- Tau Beta Pi
- Chi Epsilon
- Phi Kappa Phi
- Marine Board, National Academy of Sciences, National Research Council
- Environmental Engineering Committee of the Science Advisory Board of the U.S. Environmental Protection Agency
- Distinguished Engineering Alumnus, Texas A&M University, 1985
- President - 130,000 member Texas A&M Alumni Association of Former Students, National and International, 1985
- Chairman - Water Pollution Control Federation Program Committee, 1986-1989
- Distinguished Alumnus - Texas A&M University, 1990
- Chairman - President's Advisory Council, Texas A&M University, 1991
- American Academy of Environmental Engineers Kappe Lecturer, 1994
- Distinguished Engineering Graduate, University of Texas at Austin, 1995
- President - American Academy of Environmental Engineers, 2001
- Chrmn., Ethics Committee - American Academy of Environmental Engineers
- Elected to the National Academy of Engineering, 1997
- Distinguished Civil Engineering Graduate, Texas A&M University, 2000
- Inducted into the Civil and Architectural Engineering Academy of Distinguished Graduates, University of Texas at Austin, November 2003
- Lifetime Achievement Award, Water Environment Federation, 2009

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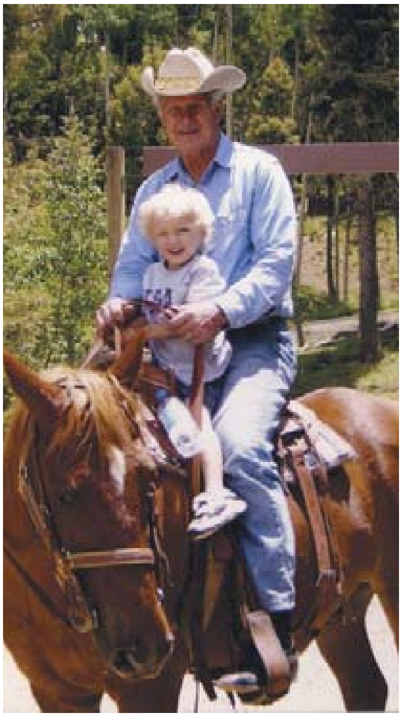


Maybe – A Grandson Cowboy?

Happy Times: Gloyna, Ford, Eckenfelder.

Davis Ford, Klaus Imhoff, Detlef Albrecht. Essen, Germany 1998.

Books Published

- *Water Pollution Control*, with W. W. Eckenfelder, The Pemberton Press, Jenkins Publishing Co., Austin (1970)
- *Development of Design and Operational Criteria*, with W. W. Eckenfelder and C. Adams, CBI Publishing Co., Boston (1981)
- *Industrial Wastewater Management Handbook*, Edited by H. S. Azad, McGraw Hill, New York (1976)
- *Carbon Adsorption Handbook*, Edited by P.N. Cheremisinoff and F. Ellerbusch, Ann Arbor Science, Ann Arbor (1978)
- *Activated Carbon Adsorption for Wastewater Treatment*, Edited by J.R. Perrick, CRC Press, Boca Raton (1981)
- *Toxicity Reduction Evaluation*, Edited by D. L. Ford, Technomics, Inc. (1993)
- *Industrial Water Pollution Control, Fourth Edition*, W. Wesley Eckenfelder, Davis L. Ford, and A.J. Englande, McGraw Hill (2008)

Books Published Outside Field

- *The Last Cowboy*, A biography of Leroy Webb, Eakin Press (2002)
- *Leroy the Cowboy: Children & Horses*, co-authored with Pam Arthur, LastCowboy Press (2006)
- *Reflections of a Soldier & Scholar: The Life of Earnest F. Gloyna*, Morgan Printing (2009) EE

5. These sculptures were unveiled at both Texas A&M and in Berlin, commemorating the anniversary of the Fall of the Berlin Wall in 1989. The sculptures symbolize the kind of passion horses have in seeking freedom.

6. Davis authored a biography (2002) on a champion cowboy, Leroy Webb, who is still in the saddle from sun up to sunset or as Leroy would say, "can't see to can't see" – working cattle, horses, and the land like the cowboys of yesterday did.

Peer Comments

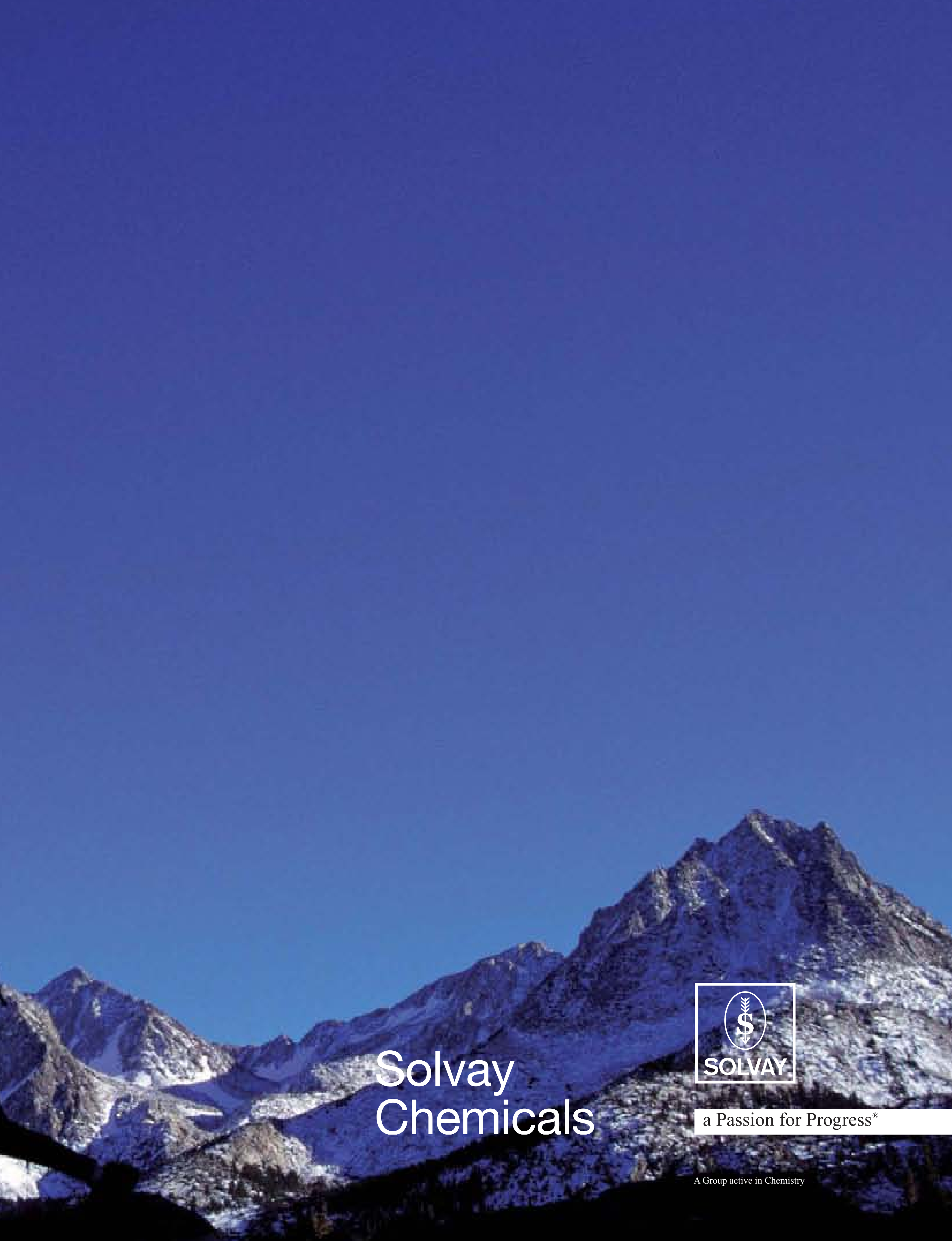
"I met Davis for the first time almost 40 years ago in Jerusalem at the IAWPR Conference in 1972. Over the years our contacts developed due to our technical discussions and additional activities of friendship. In 1980 and 1981 we exchanged our daughters. Kelly Ford came to Germany, and the next year our Katy went to Austin. I include one photograph of our traditional water engineer revivals in Essen, Germany, taken in 1998 with Davis and Professor Klaus R. Imhoff… outstanding engineers and honest men."

– Ing. Detlef R. Albrecht
Former Department Chief Ruhrverband Essen, Germany

"I met Davis L. Ford first in June, 1969. The occasion was a training course in sanitary engineering in Poland. The Polish people were very hospitable, and every evening we were invited somewhere together. (That is how) we became friends. Later that year, I traveled to USA and visited with Davis. He introduced me to Earnest F. Gloyna. We met many times during International Conferences.

In 2000, Davis was President of The American Academy of Environmental Engineers. He invited me to Washington to give a speech at the National Press Club and later to Austin. We spent an evening at his ranch and went to Texas A&M the next day. He showed us The George Bush Library where one of the sculptures of *Horses Jumping Over the Berlin Wall* is located.[5] I like Davis' wide spread interest — The Last Cowboy[6] as well as Industrial Water Quality, his book with the late Wes Eckenfelder."

– Professor Dr.-Ing. Klaus R. Imhoff
Former Director, Ruhrverband Essen, Germany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OUR CONCERN FOR **THE ENVIRONMENT** IS MORE THAN JUST TALK

As we continue to deliver valuable information through the pages of this magazine, in a printed format that is appealing, reader-friendly and not lost in the proliferation of electronic messages that are bombarding our senses, we are also well aware of the need to be respectful of our environment. That is why we are committed to publishing the magazine in the most environmentally-friendly process possible. Here is what we mean:

- We use lighter publication stock that consists of recycled paper. This paper has been certified to meet the environmental and social standards of the Forest Stewardship Council™ (FSC®) and comes from responsibly managed forests, and verified recycled sources making this a RENEWABLE and SUSTAINABLE resource.
- Our computer-to-plate technology reduces the amount of chemistry required to create plates for the printing process. The resulting chemistry is neutralized to the extent that it can be safely discharged to the drain.
- We use vegetable oil-based inks to print the magazine. This means that we are not using resource-depleting petroleum-based ink products and that the subsequent recycling of the paper in this magazine is much more environment friendly.
- During the printing process, we use a solvent recycling system that separates the water from the recovered solvents and leaves only about 5% residue. This results in reduced solvent usage, handling and hazardous hauling.
- We ensure that an efficient recycling program is used for all printing plates and all waste paper.
- Within the pages of each issue, we actively encourage our readers to REUSE and RECYCLE.
- In order to reduce our carbon footprint on the planet, we utilize a carbon offset program in conjunction with any air travel we undertake related to our publishing responsibilities for the magazine.

So enjoy this magazine...and KEEP THINKING GREEN.

Editor's Note: AAEE Contributors

Contributors to the Kappe Lecture Fund were inadvertently omitted from the Summer 2011 (V 47, Number 3) issue of *Environmental Engineer* under Academy Contributors (page 10). It is an honor to recognize the following individuals for their donation to the Kappe Lecture Fund in 2010:

Carns, Keith - Oakhurst, CA
Chen, Jeffrey - Palo Alto, CA
Corson, John - Kingsford, MA
Dombrowski, Paul M. - Holyoke, MA
Hungerford, Michael - Hungerford, PA
Kane, Donald - San Antonio, TX
Lindmark, Ulf M. - Marine Del Rey, CA
Loven, Andrew - Kennesaw, GA
Lue-Hing, Cecil - Burr Ridge, IL
Mohanka, Shyam - Schenectady, NY
Monroe, Edward - Pittsburgh, PA
Rueck, John - Silver Lake, KS
Touhill, Joseph - Jamison, PA
Vasuki, N.C. - Dover, DE
Wendle, Jeffrey - Harrisburg, PA
Whitman, Ira - East Brunswick, NJ
Xie, Yuefang - Middletown, PA

The 2012 Membership Renewal process is now underway. If you have not already done so, log in to The AAEE Center to renew your membership and donate to AAEE's programs today!

Did You Know?

The AAEE Center

Since launched in 2010, The AAEE Center has been used primarily for membership renewals. That is only one of its many valuable functions. When you log in to The AAEE Center, you may also:

- Purchase AAEE apparel and lapel pins.
- Order member certificates.
- Purchase AAEE publications.
- Register for AAEE events.
- Apply for specialty certification (or additional specialties for current members).
- Search the online membership directory (members only benefit).
- View AAEE Committee leadership.
- Donate to AAEE Programs.

The **My Information** tab is perhaps the most useful function for users of the AAEE Center. With it, users are in direct control of how AAEE communicates with them and how often. Under the **My Information** tab, users may:

- Update contact information, including email addresses.
- Change primary mode of contact between work and home address.
- Opt in (or opt out) of various AAEE email communications, including Highpoints and Membership Renewals.

Visit the AAEE Center at:
https://netforum.avectra.com/eWeb/StartPage.aspx?Site=AAEE

Benefits of AAEE Membership

There is still time to submit a response to the Benefits of AAEE Membership contest from the **Did You Know?** published in the Summer 2011 *Environmental Engineer*. The first five correct responses will receive an exclusive AAEE notebook tablet.

Volume 14, Fall 2011

Environmental Engineer: Applied Research and Practice

Instructions to Contributors

PURPOSE AND SCOPE

Environmental Engineer: Applied Research and Practice, is a peer-reviewed journal focused on practical research and useful case studies related to the multi-disciplinary field of environmental engineering. The journal strives to publish useful papers emphasizing technical, real-world detail. Practical reports, interesting designs and evaluations of engineering processes and systems are examples of appropriate topics. Papers relating to all environmental engineering specialties will be considered.

MANUSCRIPT REQUIREMENTS:

Manuscripts should follow the general requirements of the ASCE authors' guide (*http://www.pubs.asce.org/authors/index.html#1*) and should be submitted electronically in WORD format to the Editor and Assistant Editor.

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Recently completed projects or studies in progress that emphasize novel approaches or significant results.

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ABSTRACT

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Potential Impacts of Extensive Stormwater Infiltration in Philadelphia

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ABSTRACT

There is an emerging trend in urban stormwater management, as more and more major U.S. cities are considering green stormwater infrastructure to reduce stormwater impacts to their separate and combined sewers. "Green stormwater infrastructure" (GSI) is a term used to refer to a number of strategies for handling storm precipitation at its source, rather than after it has entered a sewer system. It often relies heavily on systems designed to infiltrate stormwater. The Philadelphia Water Department's (PWD) proposed Long Term Control Plan Update for Combined Sewer Overflow control calls for "greening" more than 40 percent of the city's impervious cover in the coming 25 years. This is the most ambitious use of GSI being proposed to date by a major U.S. city. Although GSI is being widely tested and implemented, urban applications at the scale at which Philadelphia proposes is unprecedented. One of the key concerns associated with urban GSI is the long-term impact of enhanced recharge on the groundwater table. PWD has examined rising groundwater table concerns using groundwater models. Models have been developed on the local level nearby proposed infiltration structures to assess groundwater mounding, as well as on a city-wide scale to assess the long-term impacts of the GSI program. Modeling shows that the water table could mound beneath the trench up to about 1 m following significant rain events; however, the mounding drops off quickly at distances of several meters from the infiltration facility and dissipates over several days. Keeping infiltration facilities more than 3 meters from nearby structures should avoid any problems with basement flooding. At full implementation of PWD's program, the groundwater table could eventually stabilize up to 1.5 meters higher than its current level in some areas of the city, but this would occur in areas where the groundwater table is more than 3 meters deep.

INTRODUCTION

Major U.S. cities are considering green stormwater infrastructure to reduce stormwater impacts to their separate and combined sewers (Civic Federation 2007). "Green stormwater infrastructure" (GSI) is a term used to refer to a number of strategies for handling storm precipitation before it has entered a sewer system. It employs natural systems, such as vegetation, wetlands, and open space to handle stormwater in populated areas. It can also involve manufactured solutions, such as rain barrels or permeable pavement.

The Philadelphia Water Department's (PWD) proposed Long Term Control Plan Update for Combined Sewer Overflow (CSO) control calls for "greening" more than 40% of the city's impervious cover in the coming 25 years. This is the most ambitious use of GSI being proposed to date by a major U.S. city (Civic Federation 2007). The concept of greening an acre of impervious cover in the city means that at least the first inch of runoff from every storm must be managed by the green stormwater infrastructure. Managing can be infiltrating stormwater into the ground, using trees and plants to enhance evapotranspiration of captured stormwater, or retention and slow release of captured stormwater back into the sewer system to prevent overflows. The exact balance between these mechanisms will depend on the mix of GSI projects implemented and the designs applied to these projects.

Although GSI is being widely tested and implemented, urban applications at the scale at which Philadelphia proposes to implement its GSI program are unprecedented. One of the key concerns associated with urban GSI is the long-term impact of enhanced recharge on the groundwater table. In particular, the concern is that higher groundwater levels may intersect existing basements, causing flooding, or even contributing to foundation instability where rubble masonry foundations are common. Although this appears to be an obvious concern related to intensive urban infiltration (Coldewey and Meber 1997), a literature search on the subject turned up only two studies that addressed this potential problem (Goebel et al. 2002, 2004; and Endreny & Collins, 2009). Goebel (2004) found that infiltration facilities could restore or even exceed natural recharge rates, and potential problems with groundwater mounding are possible and must be investigated prior to large-scale infiltration programs. Endreny & Collins (2009) modeled an eight-hectare site in a residential area of Syracuse, New York, analyzing the impacts of multiple basins on groundwater mounding. Their findings were that for a two-year storm, mounding of 0.2 to 0.7 m could occur, depending on the arrangement of the basins and the hydraulic conductivity of the soils.

PWD is planning a much larger implementation of infiltration facilities within the city, and needs to address rising groundwater table concerns on two levels: on the city block level nearby each of the proposed infiltration structures (groundwater mounding), as well as on a city-wide scale to address the long-term impacts of the GSI program.

TRANSIENT CALCULATIONS OF GROUNDWATER MOUNDING

There has been significant progress in developing analytical solutions to the groundwater mounding problem (Bouwer 1962; Amoozegar et al. 1965; Bittinger and Trelease 1965; Ghavami 1970; Rao and Sarma 1981a,b; Rao and Sarma 1983; Musiake and Herath 1987; Griffen and Warrington 1988; Finnemore 1995; Swamee and Ojha 1997; Bouwer et al. 1999; Bouwer 2002; Dewberry 2002; Zomorodi 2005). Groundwater mounding is a transient process, however, and steady-state analytical solutions are likely to over-estimate the height of the groundwater mound and cannot be used to test the range of conditions in Philadelphia. Transient analytical solutions exist, but are limited in their applicability (Hantuch 1967; Marino 1974a,b; Ortiz et al. 1978a,b; Ortiz et al. 1979; Latinopoulos 1984, 1986; Morel-Seytous et al. 1989, 1990; Guo 1991; Zomorodi 1991; Rai and Singh 1995). The importance of using a transient modeling approach is indicated in a number of prior studies (Guo 1998; Bouwer 1999). Carleton (2010), Nimmer et al. (2009, 2010), and Machusick (2011) are recent, transient modeling and monitoring studies of mounding effects of individual basins; however, they are only partially applicable to the more urban GSI proposed in Philadelphia because they deal with larger, single recharge basins in a suburban setting.

To be able to investigate groundwater mounding as a result of proposed street infiltration in Philadelphia, a simplified city block scale groundwater model was developed using the groundwater flow code DYNFLOW. The DYNFLOW code is a 3-dimensional finite element groundwater modeling code, and has been evaluated and accepted for use for a wide variety of applications (IGWMC 1985).

The city block model is designed to simulate various types of soils and street and sidewalk infiltration facilities likely to be tried under the GSI program. Philadelphia intends to develop a standard street design that features tree trenches that act as stormwater control structures as one of the primary means of reducing stormwater flows to the combined sewers. Figure 1 (USEPA 2009) shows a typical tree trench layout similar to the designs being developed for a Philadelphia street. Tree trenches were used as the primary infiltration facility example in the modeling study, but most of the planned GSI facilities act in a similar fashion, infiltrating water at rates related to the size of the facility and the soil properties.

Thus the study results are applicable to a wide variety of concentrated infiltrating facilities such as rain gardens, tree pits, planters, and infiltration trenches. To model street tree trenches, a model grid was developed centered along a standard city street and block of 500 foot length, with each hypothetical block containing up to 12 tree trench infiltration beds, each trench 30-feet long, 5-feet wide, and 3-feet deep. Each simulated trench is separated by 5-feet (see Figure 2). The intent was to simulate transient recharge into multiple basins along the block, and to see if there are appreciable differences for trenches in the middle of the block versus trenches

Figure 1
Typical Tree Trench Layout (USEPA 2009)

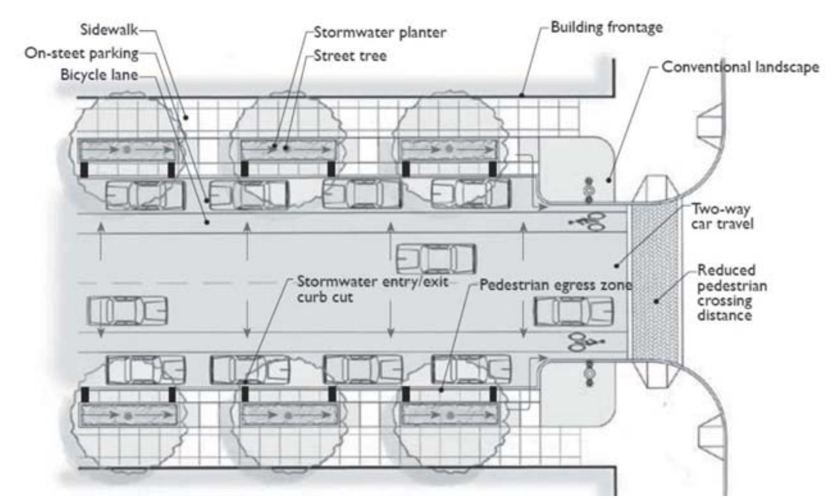
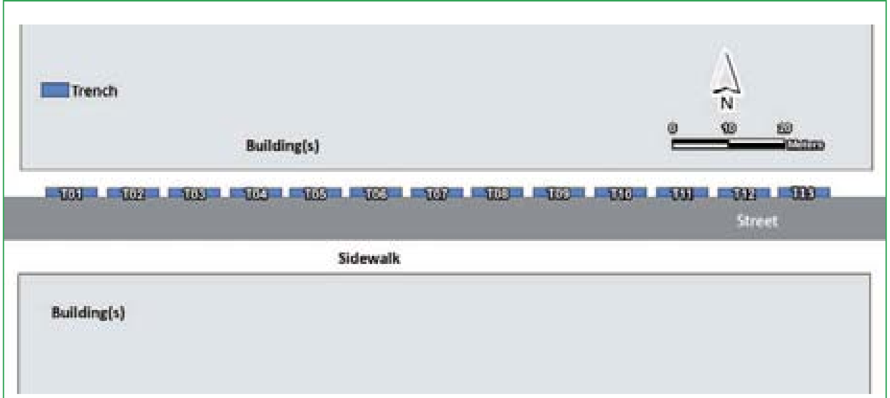


Figure 2
Hypothetical trench design for site scale model simulations.



at the end of the block. The model is also designed to simulate a variety of depths to bedrock, aquifer thicknesses, and the presence or absence of clay layers. The city block model contains 12 layers, which can be flexibly used to simulate aquifers and aquitards. The model boundaries include two no flow boundaries, and two fixed head boundaries that created a slight east to west gradient of 0.0007 and flow consistent with Philadelphia coastal plain conditions. No area-wide recharge was added to the model to isolate the impacts of recharge from the tree trenches.

The primary use of the numeric city block model was to simulate transient conditions that are reasonably realistic and representative of the way tree trenches would actually function in the city. To do this, the model needed to have a time series of infiltration through the tree trenches to carry out transient infiltration simulations. A spreadsheet model was developed to estimate the expected infiltration in each tree trench based on the following factors:

- Impervious area draining to the infiltration trench
- Area of infiltration trench
- Rainfall depth during 15-minute time step
- Soil vertical hydraulic conductivity

The infiltrating water for each trench was calculated for a 15-minute rainfall time series from the year 2005 (used by PWD as a "standard rainfall year"). The spreadsheet was designed to calculate the runoff from the total impervious area connected to the tree trench, and track the volume of water stored in the tree trench, the volume of water infiltrated, and the volume of water that spilled back to the sewer. Water entering the tree trench first fills the available volume in the soil to capacity, then slowly releases to the sewer as well as infiltrates into the groundwater. Water in excess of the available capacity of the trench is routed into the sewer directly without entering the tree trench. Because the infiltration trench receives stormwater from an area much larger than the area of the trench, a simplifying assumption was made that antecedent moisture conditions and storage in the unsaturated zone are relatively small compared to total recharge. This implies the conservative assumption that all stormwater flows directed to the infiltration trench become groundwater recharge. The calculations assume fully saturated conditions and saturated conductivity with a unit vertical gradient. The area of downward vertical flow is assumed to equal the area of the infiltration trench.

For these simulations, the effects of evapo-transpiration in the tree trenches were ignored. The infiltration volumes per 15 minutes were taken from the spreadsheet model and input into the numerical groundwater model at each of the 12 tree trench locations along the block for a 1-year, transient simulation.

For this study, simulations were run for a variety of soil conditions underlying the hypothetical tree trenches, as well as for various designs that increased or decreased the area of impervious cover draining to the tree trenches. Presenting all the results of these sensitivity simulations goes beyond the scope of this paper, and only some of the conclusions from the simulations are presented.

There are a number of factors that influence the height of the mound, how fast it rises and falls, and the distance from the trench where water table mounding occurs.

- *Storage volume of the trench:* a greater volume of storage will increase the duration and height of the mound because it will allow more water to infiltrate.
- *Area ratio:* a greater area ratio (area of impervious cover connected to the trench divided by the infiltration area of the trench itself) will create more runoff and fill the trench more frequently and faster. Whether this results in a significant increase in the mound height will depend on the trench storage volume, the soil conditions, and the frequency and duration of the storms. Often higher area ratios result in more overflow to the sewers, and thus a lower efficiency of the system.
- *Vertical hydraulic conductivity (Kv):* a lower vertical conductivity will have two, contrasting effects. It will create a higher mound for the same amount of water infiltrated. It will, however, limit the rate of infiltration, thus decreasing the height of the mound at the same time. The factor that is dominant depends on the specific combination of factors applied and cannot be easily predicted.
- *Horizontal hydraulic conductivity (Kh):* a lower hydraulic conductivity will increase the height of the mound.
- *Rainfall intensity:* a greater intensity will fill the trench faster, but since infiltration is controlled by the soil properties, will not always have much of an influence on the height or extent of the groundwater mound once the trench has been filled.
- *Rainfall duration:* the duration will affect whether the trench fills completely, and how long it remains filled. Thus, it will affect the mound height by creating a longer period of infiltration before the trench is emptied and the mound starts to recede.

Because each of these factors affects the groundwater response in different ways, it is impossible to predict exactly which set of conditions will create a higher or lower groundwater mound without simulating a time series. Several example simulations are shown below to provide insight into the response of the groundwater mound to varying soil properties and loading ratios.

Soils underlying Philadelphia streets can vary from silt to coarse sand, as well as areas of the city that are underlain by fill material. The model was used to assess the impact of soil properties ranging from silt to course sand on the groundwater mound height. Because the current tree trench designs generally have area ratios of 15:1 or less, these soil sensitivity simulations were made using an area ratio of 15:1.

Figure 3
2005 transient response of groundwater to infiltration trenches with area ratio of 15 in fine sand

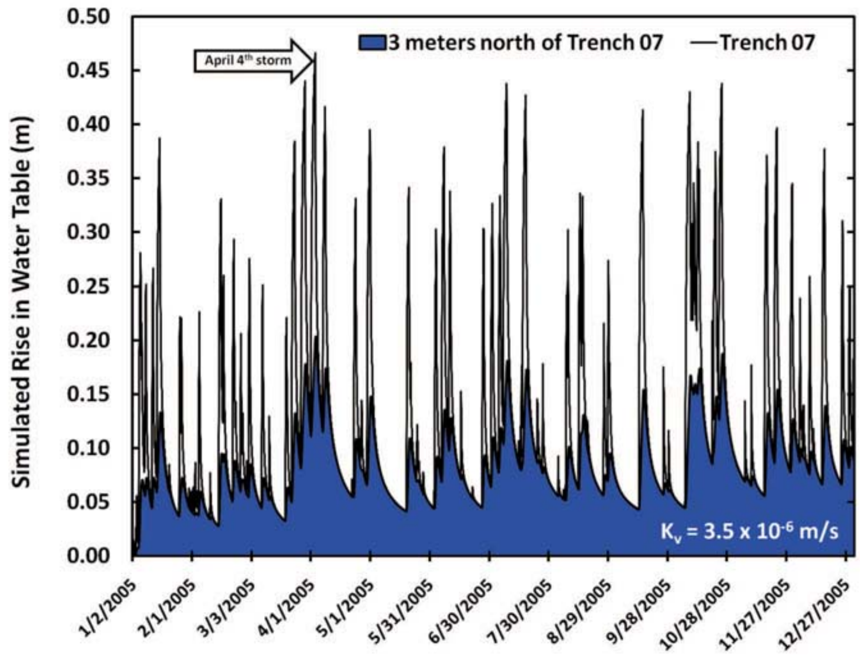


Figure 4
Cross section from center of trench - groundwater mounding from April 4, 2005 storm showing silty sand and coarse sand

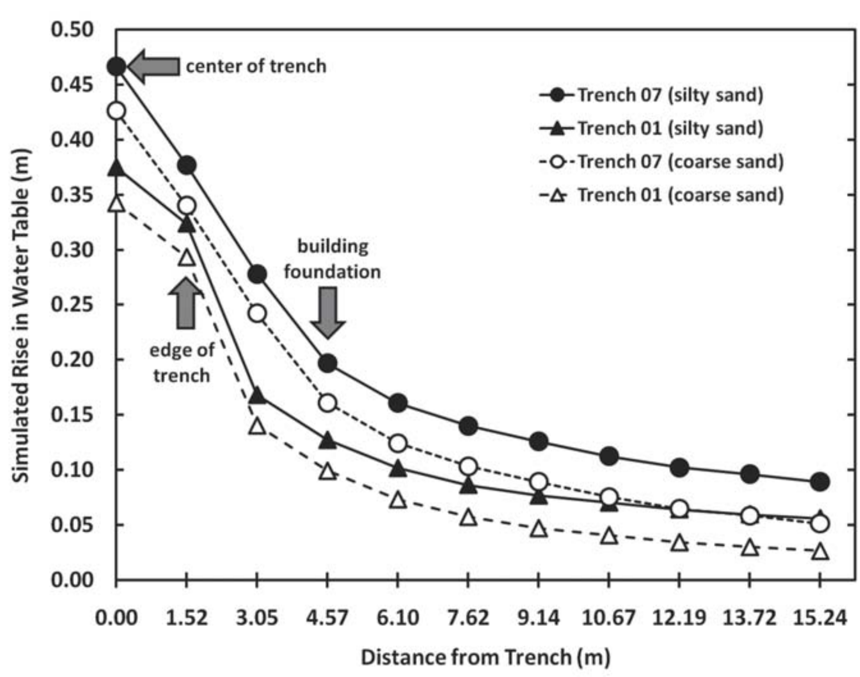


Figure 3 shows the transient nature of the simulated groundwater mound beneath tree trench 7 at the center of the block (see Figure 2) in response to rainfall in 2005, with infiltration simulated at the same time at the other trenches within the model. These results are for a silty sandy soil, with a vertical hydraulic conductivity and maximum infiltration rate of 3.5 x 10^{-6} m/s (1 ft/d), and a horizontal hydraulic conductivity of 3.5 x 10^{-5} m/s (10 ft/d). Philadelphia's stormwater regulations require storage of the first inch of rainfall if infiltration testing indicates infiltration rates of less than 3.5 x 10^{-6} m/s (1 ft/d). The simulated groundwater mound directly beneath the trench seems to hover around 5 to 7 cm, increasing occasionally to almost 0.46 m (1.5 ft) for the worst storms. At a distance of 3 m (10 ft), an assumed adjacent building, the peaks of the groundwater mound in response to storms are damped, with maximum increases of only about 15 to 20 cm (6 to 8 in).

Soil with hydraulic properties of medium to coarse sand (vertical hydraulic conductivity and maximum infiltration rate of 1.8 x 10^{-5} m/s or 5 ft/d, horizontal hydraulic conductivity of 1.8 x 10^{-4} m/s or 50 ft/d) allows greater infiltration rates but can also more effectively convey groundwater away from the trench area. Results were remarkably similar to those shown in Figure 3. The groundwater mound was only slightly lower, stabilizing around 5 cm (2 inches) directly below the trench. Short-term spikes of up to 0.42 m (1.4 ft) were also simulated, very similar to results for silty sandy soil shown in Figure 3. Figure 4 shows a cross-section drawn perpendicular to the trench from the center of the tree trench towards an adjacent building. The results are for April 4, 2005 when the simulated groundwater mound was at its highest point. Both the mid-block (trench 7) and end-of-block trench (trench 1) are shown for both silty sand and medium to coarse sand. Note that the mound drops steeply off from its highest point beneath the trench within the first 3 m (10 ft), and then gradually dissipates over a distance of about 15 m (50 ft) from the trench. The cross-section suggests that if the trench edge is more than 3 m (10 ft) from a building foundation, even using the conservative estimate for the silty sand, the groundwater rise at the building foundation is likely to be less than 25 cm (0.83 ft).

Sensitivity simulations were also made to test the response of the groundwater mound to a range of area ratios. The assumptions used to evaluate infiltration for a variety of area ratios were a silty sand [Kh = 3.5 x 10^{-5} m/s (10 ft/d), Kv = 3.5 x 10^{-6} m/s (1 ft/d)], and recharge based on 2005 annual precipitation (15-minute time steps). Figure 5 summarizes the area ratio simulations for the trench at the center of the block for the groundwater mound beneath the trench and at the nearest building 3 m away for the worst-case storm of April 4, 2005.

The results suggest that the groundwater mound does increase with increasing area ratio, from a maximum of 18 cm (0.6 ft) at the nearest building for an area ratio of 10, to about 30 cm (1 ft) for an area ratio of 25. The response is not linear to increasing area ratio because the rate of infiltration is limited by the vertical hydraulic conductivity in the trench. Thus, as the area ratio increases, more water is either held in storage for longer periods and slowly infiltrated, or is spilled through overflow to the sewers with no effect on the mound.

To get a better sense of the system response to individual storms, with the trench filling, then slowly draining down, a one-month simulation using January 2005 rainfall was conducted. Results for a variety of soil conditions using a relatively high area ratio of 20 are shown in Figure 6. At the top of the figure, the 15-minute rainfall amounts (right vertical axis) are also shown. Note how a large storm may create a rising groundwater mound for 2 to 3 days after the storm, as the trenches slowly drain down. Once drained, it can take almost a week for the mound to dissipate, and never completely returns to the initial level before another storm occurs.

Figure 5
Increase in height of groundwater mound in fine sand with increase in area ratio for trench in the middle of the block

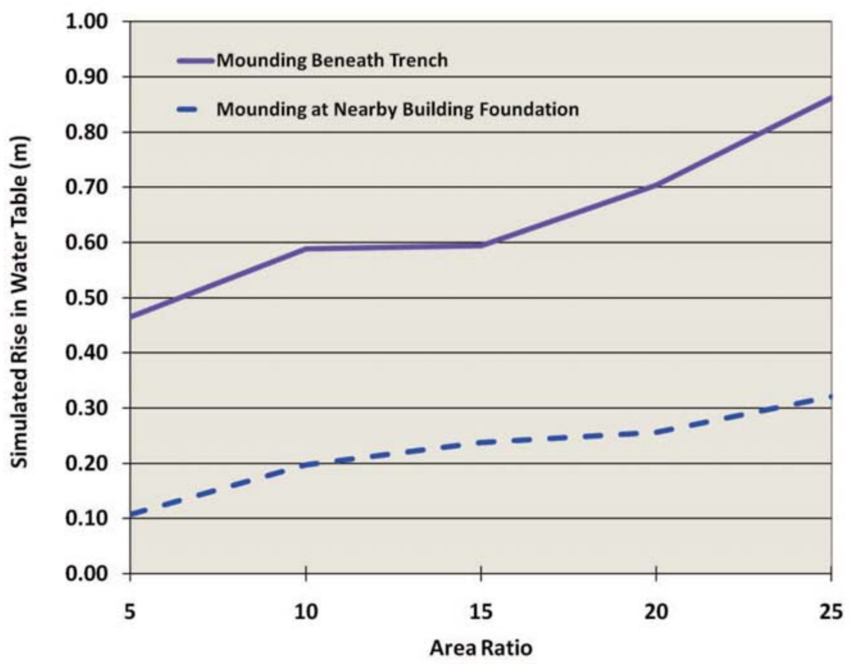


Figure 6
One month transient response of groundwater to trench 07 with area ratio of 20 at nearest building for various soil conditions (Soil Conductivity in ft/day).

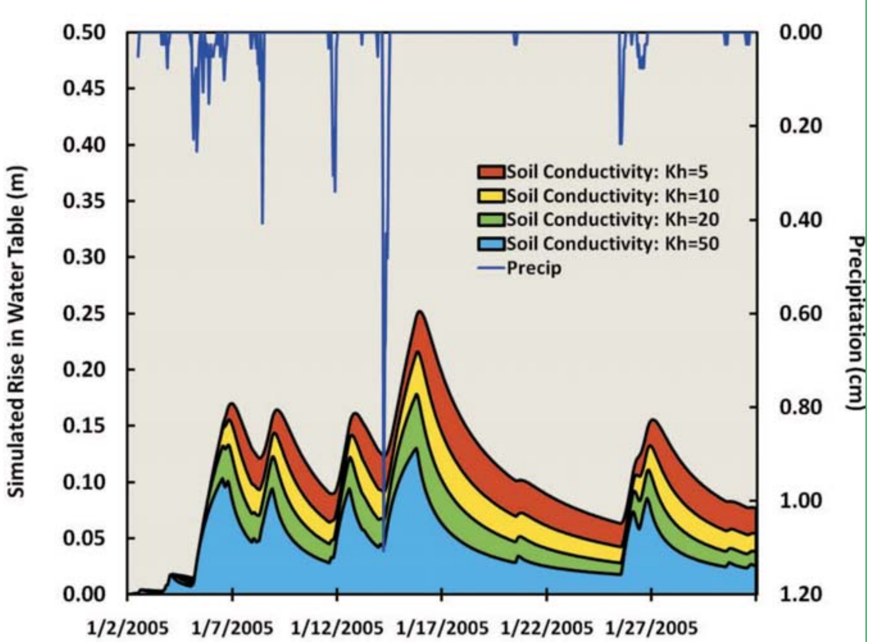


Table 1
Hydraulic Properties assigned to each stratigraphic unit in the model

Stratigraphic Unit	Model Layers	Model Kh, Kv (m/day)	Published Values[1]
Overburden (Piedmont)	4 - 11	3.05, 0.30	None identified
Fill/Sand	11	3.05, 0.30	None identified
Alluvium	11	3.05, 0.30	1.68/1.68
Trenton Gravel	10	44.19, 4.42	43.28
Upper Clay	9	0.30, 0.03	<<< 0.10 to 0.11
Upper Sand	8	30.48, 3.05	10.67 to 43.28
Middle Clay	7	0.30, 0.03	<<< 0.10 to 0.11
Middle Sand	6	38.10, 3.81	29.87 to 46.33
Lower Clay	5	0.30, 0.03	<<< 0.10 to 0.11
Lower Sand	4	60.96, 6.10	26.21 to 63.09
Saprolite	3	0.76, 0.76	None identified
Bedrock	1, 2	0.76, 0.76	Highly variable

1. Sources: USGS (1988, 1991, 2001)

Table 2
Tabulation of stratigraphic units in the Piedmont and Coastal Plain areas of Philadelphia (descriptions summarized from Paulachok, 1991).

<table>
<tr><th colspan="3">Piedmont</th><th colspan="4">Coastal Plain</th></tr>
<tr><th>Stratigraphic Unit</th><th>Description</th><th>Thickness in Model (m)</th><th>Stratigraphic Unit</th><th>Description</th><th colspan="2">Thickness in Model (m)</th></tr>
<tr><td rowspan="8">Overburden (sand, silt)</td><td rowspan="8">Sand, gravel, silt, fill</td><td rowspan="8">0 to 21</td><td>Alluvium / Fill</td><td>Fine sand and silt, some gravel</td><td colspan="2">0 to 17</td></tr>
<tr><td>Trenton Gravel/ Bridgeton Formation (combined in model)</td><td>Sand and gravel</td><td colspan="2">0 to 17</td></tr>
<tr><td>Upper Clay</td><td>Multi-colored clay, sandy in places</td><td>0 to 16</td><td rowspan="6">Potomac-Raritan-Magothy Aquifer System</td></tr>
<tr><td>Upper Sand</td><td>Medium to coarse sand. Coarser at base of unit (gravel common)</td><td>0 to 12</td></tr>
<tr><td>Middle Clay</td><td>Red and white clay, sandy in places</td><td>0 to 21</td></tr>
<tr><td>Middle Sand</td><td>Fine to coarse sand</td><td>0 to 45</td></tr>
<tr><td>Lower Clay</td><td>Generally a red clay, sandy in places</td><td>0 to 27</td></tr>
<tr><td>Lower Sand</td><td>Coarse sand and fine gravel, fines upward to fine to medium sand with silt and clay</td><td>0 to 29</td></tr>
<tr><td>Bedrock</td><td colspan="2">Primarily Wissahickon Formation (Schist)</td><td>Bedrock</td><td colspan="3">Primarily Wissahickon Formation (Schist)</td></tr>
</table>

CITY-WIDE EFFECT ON GROUNDWATER LEVELS

The initial transient simulations suggest that, although the water table will rise and fall with the filling and emptying of the tree trenches, there does appear to be some local permanent groundwater mounding around each infiltration trench, due to the fairly frequent storms that occur throughout the year in Philadelphia. If stormwater infiltration is applied to whole sections of roads or urban districts as planned, the result may be a general rise in the groundwater surface over entire portions of the city.

To assess the long-term impact of Philadelphia's proposed GSI Program on the groundwater table, a groundwater flow model of the combined sewer areas of the city was developed. The model grid was chosen to provide reasonable hydrologic boundary conditions, with a focus on capturing the two primary hydrogeologic areas within the city's borders: the Piedmont and the Coastal Plain. Horizontally, the Philadelphia model includes the area between the Delaware and Schuylkill Rivers, with a northern boundary set to represent a no flow boundary based on 1980 groundwater contours (Paulachok and Wood 1984). The finite element grid contains 7,253 nodes and 14,290 elements for each model layer/level. Node spacing ranges from approximately 75 to 300 m (250 to 1000 ft).

The model contains 11 layers (Table 1) and covers both the Coastal Plain and Piedmont physiographic provinces within the city boundaries. The Fall Line separating the two physiographic provinces runs through the middle of the model, creating two distinct stratigraphies. Table 2 illustrates the contrasting stratigraphies associated with the two primary physiographic provinces, the Piedmont and the Coastal Plain beneath Philadelphia (Paulachok 1991, U.S.G.S 2000). The stratigraphy in the coastal plain consists of a sequence of sands, gravels and clays, reaching a thickness of more than 60 m (200 ft) near the Delaware River. Beneath these aquifers and aquitards is the bedrock formation. The sequence of layers is much simpler in the Piedmont, with a relatively thin layer of sand and fill material overlying bedrock.

Aquifer properties were assigned to model layers to represent the hydraulic characteristics of the sediments in different stratigraphic layers. For each material type, a range of reasonable hydraulic property values (vertical and horizontal hydraulic conductivities) was determined based on previous modeling studies and literature values (Sloto 1988). These estimates were used to guide the hydraulic property assignments in the Philadelphia model, and were adjusted so that model simulated heads provided a reasonable visual match to the 1980 published contours of groundwater head (Paulachok and Wood 1984). No numeric calibration statistics were possible due to a lack of data. It is the intent that, as the groundwater monitoring program in Philadelphia is re-established, model calibration will be revisited. Table 1 includes the hydraulic conductivity properties that best fit the limited data available and that created the best match of simulated water table elevations with the only available groundwater contours.

BOUNDARY CONDITIONS

The boundary conditions of the Philadelphia groundwater flow model were selected to provide a reasonably realistic representation of the flow system. The boundary conditions are listed below.

- The bottom of the modeled aquifer system was assigned a no-flow boundary condition, assuming that the deeper bedrock is relatively impermeable compared to the overlying sediments.
- Inland, the top level of the model was assigned a rising water boundary condition, whereby if the water level is simulated to rise to the elevation of the ground surface, it is held fixed at that elevation and the discharge or flux (such as stream base flow) is calculated. Groundwater flow to local streams and drainage channels was represented in this way.

Figure 7
Location of brick sewers where inflow is simulated. Figure on the left shows the 1980 water table map and where brick sewers are currently installed. Figure on the right shows representation of brick sewers with model nodes

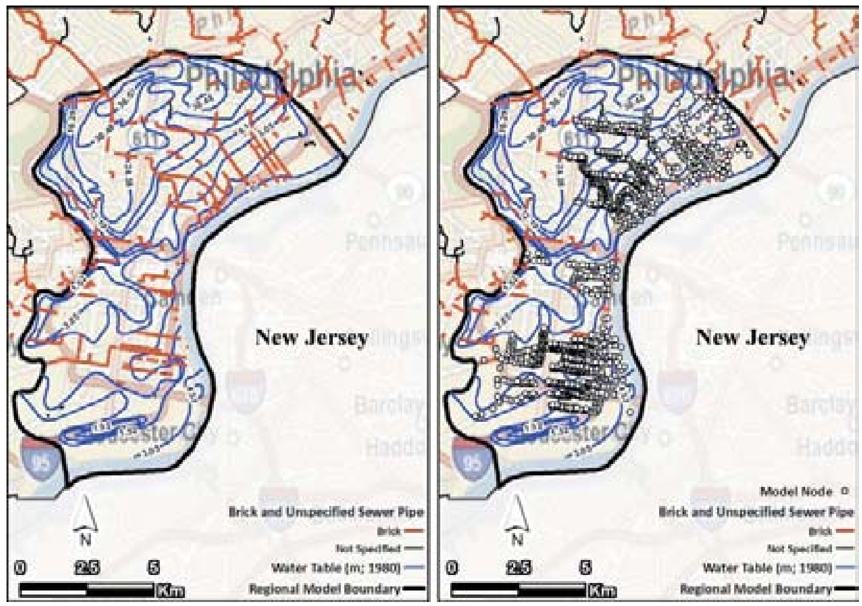


Figure 8
Comparison of simulated (right) water table with USGS 1980 estimated water table (left). Water table is shown in meters above mean sea level.

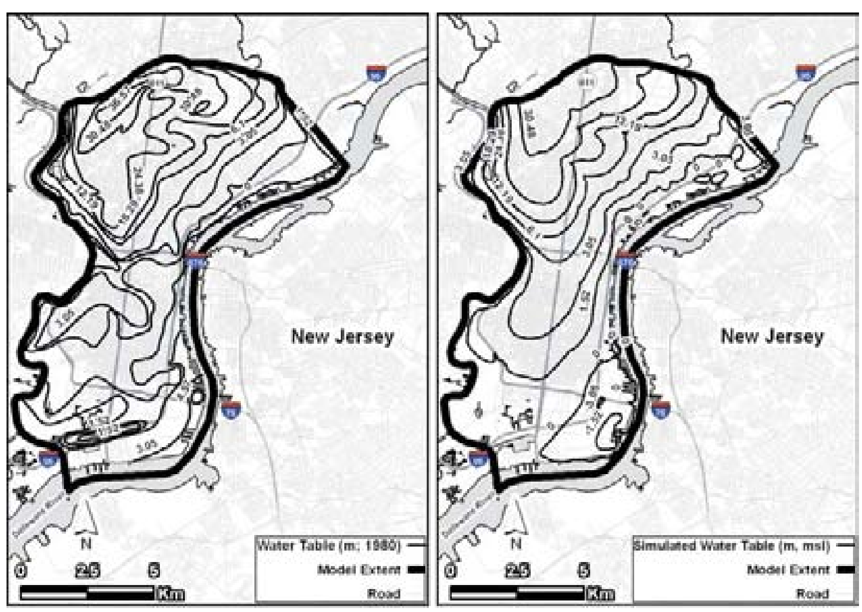
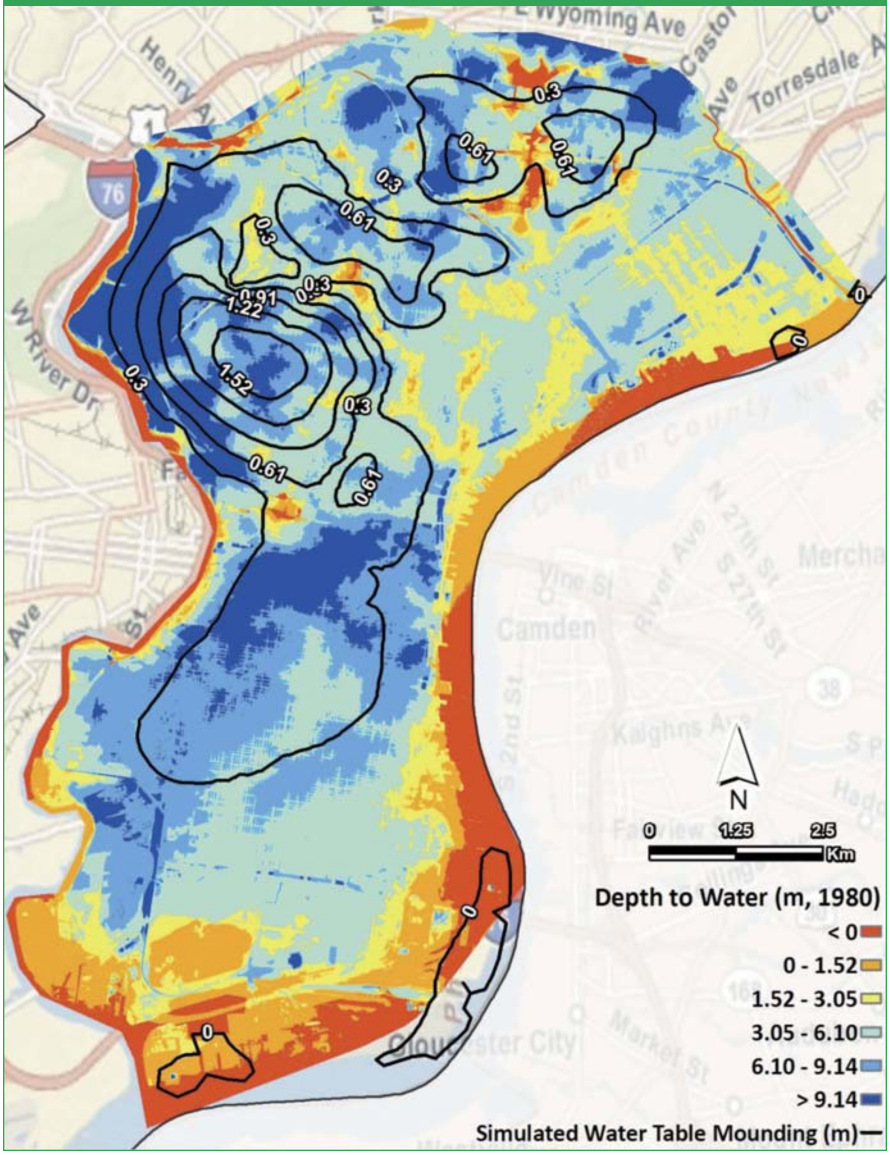


Figure 9
Estimated increase in water table after implementation of GSI program



- A specified head boundary condition, set at the mean river stage of the Schuylkill and Delaware rivers, was assigned to the eastern, western and southern edges of the model in the top model level. This simulates the connection between the groundwater system and the two main rivers in Philadelphia. Below the top level of the model, the lower model levels were no flow boundaries reflecting the tendency of groundwater to discharge to the major rivers.
- One exception was made along the southern half of the Delaware River. Along the southern half of the Delaware River, within the model domain, the deeper levels are influenced by pumping in New Jersey, and heads were specified based on recent published values (Sloto 1988; U.S.G.S 1997, Schreffler 2001). This boundary condition causes the model to represent the flow beneath Philadelphia in the deeper aquifers toward the pumping centers in New Jersey.

One other issue with boundaries was identified during the modeling simulations. It is known that the older, brick lined combined sewers in Philadelphia tend to leak, and often take in groundwater at the seams and joints. In some areas of the city, it appears from the shape of the water table contours that the combined sewers actually control the water level. This was also suggested by Paulachok (1991). In those areas of the city where combined sewers are clearly influencing the groundwater table, they were simulated as head-dependent fluxes in the model. Thus, as the water table rises above the invert of the sewer, the model allows water to enter the sewer and be discharged to the rivers. The greater the difference in head between the water table and the sewer invert elevation, the more water the model allows to flow into the sewers and leave the groundwater system. Sewer exfiltration when the water table is below the water table was implicitly modeled as part of the baseline urban infiltration rate. Figure 7 shows the areas of the city within the model area where head-dependent fluxes were assigned to represent the brick sewers.

Recharge is the primary source of water to the model, and drives the movement of water toward the rivers. Recharge in an urban environment is particularly difficult to assess because much of the land surface is impervious, sewers can either leak or drain groundwater, and leaking water lines can significantly affect the total amount of recharge applied. To estimate recharge in an urban environment, the best approach is to have a calibrated surface runoff model that can provide both average and time series breakdowns of rainfall into runoff, evapo-transpiration (ET) and infiltration. An EPA-based SWM model (James and James 2000) of the area exists, and provided most of the information needed to estimate total recharge under both baseline and future conditions associated with the GSI Program. The SWM model provided a time series of recharge estimates for an average rainfall year, 2005, accounting for spatial variation in soils and impervious cover. Infiltration time series were created for today's conditions and for the projected conditions once the proposed GSI program is fully implemented (Myers et al. 2004).

For the baseline, steady-state groundwater model, recharge was uniformly assigned to the model at the surface. The recharge for an average year of precipitation estimated by the SWM model was applied at a rate of 45 cm per year (17.6 in/year). The annual average rate of 45 cm per year is the amount of recharge from the 114 cm per year (45 in/year) of average annual rainfall that falls on Philadelphia after runoff and ET are accounted for. This rate takes into account the impacts of current impervious cover, but does not include potential leakage from water mains, much of which is reported to be collected in the underlying sewers.

The SWM model was also used to estimate the amount of stormwater runoff and recharge plus evapo-transpiration that will occur once the city is "greened." The GSI Program assumed that 2,115 ha (5,227 ac) of impervious cover within the model area was outfitted with stormwater infiltration measures such as tree trenches, infiltration trenches, or rain gardens to capture the first inch of runoff from each rain event, as required by the city's stormwater regulations. In areas of the model not affected by GSI, infiltration still averaged 45 cm per year (17.6 in/year). In areas that have been "greened," the calculation had to account for the effects of stormwater infrastructure that can detain and release, as well as infiltrate stormwater. The transient mounding model described above used an input series from a spreadsheet model that tracked infiltration, storage, and overflow in tree trenches. The spreadsheet model showed that a significant portion of the captured stormwater might not make it to the groundwater, depending on soil conditions, the trench design, and the frequency of storm events. This implies that only a portion of the 1 inch captured by the GSI would actually infiltrate, the rest either evaporating or releasing through a controlled orifice back to the combined sewer. The balance between these three pathways for the stormwater will depend on the mix of designs implemented. Because this is not yet known, a range of infiltration assumptions were tested. Space limitations allow results for only one set of simulations to be presented in this paper. Results are shown using the assumption that the mix of tree trenches, porous pavement, and rain gardens in the Philadelphia CSO control program will infiltrate 70 percent of the 1 inch of stormwater runoff captured by the GSI. Under this assumption, 63 cm per year (24.8 in/year) is assumed to infiltrate into the ground through the installed infiltration devices in areas of the city that have green stormwater infrastructure in place. This is an increase of 40% compared to the non-greened areas.

BASELINE MODEL RESULTS

A steady-state, baseline simulation was made to test the model's ability to simulate groundwater table elevations using the estimated current rates of recharge. Although no formal calibration was possible due to a lack of data, the properties of the aquifers were adjusted until the simulated water table generally resembled the estimated 1980 water table elevations from a USGS study (Paulachok 1991). Figure 8 shows that the model simulates the estimated water table in 1980 with reasonable accuracy.

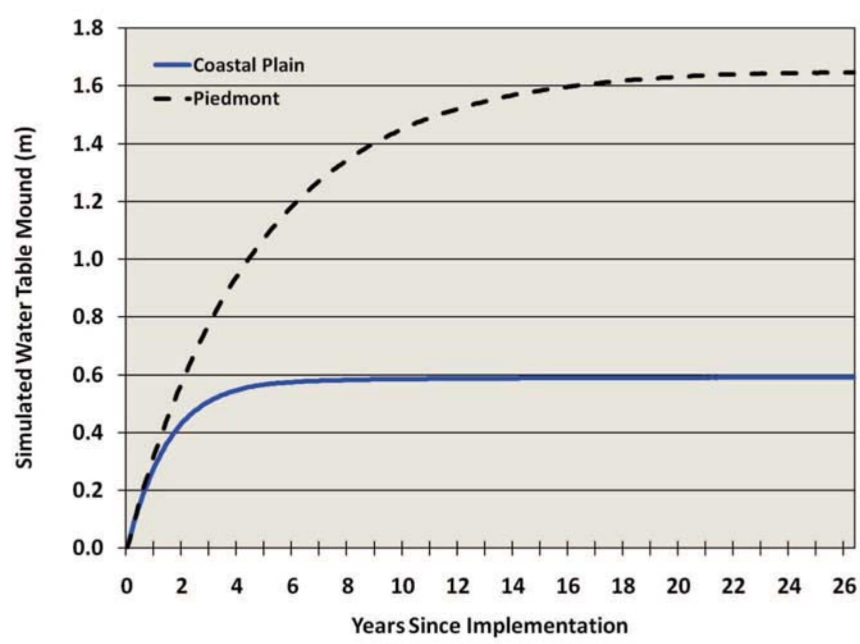
The ability of the model to capture the flow patterns and depth to groundwater suggests that by modeling a range of recharge rates, the model should provide a reasonable range of groundwater level responses that will help to identify potential areas in the city where the regional rise in groundwater due to enhanced infiltration might eventually lead to problems associated with a high groundwater table.

SIMULATING THE GSI PROGRAM

The Philadelphia GSI Program is being implemented with a variety of green stormwater infrastructure measures that combine stormwater infiltration with slow release and evapo-transpiration to reduce the volume of combined sewers overflows. The GSI Program simulation results presented here assume that up to 34 percent of the impervious cover will be "greened." The initial use of the groundwater model was to address the issue of potential long-term impacts of infiltration on the water table. This addressed the concern that over time, the water table would reach a new, higher equilibrium position that might cause basement flooding or other problems associated with a high groundwater table. The model was used to compare the steady-state water table elevation under today's conditions of recharge with the estimated increase in the water table, once the GSI Program is substantially completed and the aquifer system has reached a new state of equilibrium in response to increased recharge. The estimated increase in the water table due to the enhanced infiltration was compared to the estimated depth to water under current conditions to highlight areas where the simulated water table is less than 3 m (10 ft) below ground surface.

Figure 9 shows the maximum expected water table elevation increase. The maximum rise in the water table is shown to occur in the Piedmont, and is projected to be about 1.8 m (6 ft) in a limited area of the Piedmont. In the coastal plain, the water table increase is limited to less than about 0.5 m (less than 2 ft). Figure 9 also includes an estimate of depth to groundwater. Note that the areas of greatest increase in groundwater levels are located in areas where the depth to groundwater is currently estimated to be more than 9 m (30 ft). Thus, even the maximum rise of 1.8 m is not likely to cause any problems with basement flooding.

Figure 10
Response time of the aquifer to enhanced recharge in the Coastal Plain and Piedmont



SENSITIVITY TO ASSUMED HYDROGEOLOGIC PROPERTIES

As noted above, the model appears to simulate water table contours with reasonable accuracy when compared to USGS-estimated contours from 1980; however, the model has not been calibrated to contrasting steady-state conditions or to a transient response to changes in recharge due to a lack of data. This means that the properties of the aquifer near the surface are not well known beyond the use of literature values that match the soil descriptions of the many borings available. To test the sensitivity of the results to the assumed aquifer properties, the horizontal (Kh) and vertical (Kv) hydraulic conductivity values of the overburden and alluvium in the surface model layer were varied within ranges that did not cause significant deviation of the water table contours when compared to the 1980 measured contours. Kh was varied between 1.76×10^{-5} cm/sec and 7.1×10^{-5} cm/sec (5 and 20 ft/d), and Kv was varied between 3.5×10^{-6} cm/sec and 7.0×10^{-6} cm/sec (1 and 2 ft/d) in both the Piedmont and Coastal Plain and the difference in the water table response to the implementation of the GSI program was noted. The results of the sensitivity analysis suggest that the aquifer system responds primarily to the change in recharge once equilibrium is reached, and that the expected variety of hydraulic properties of the surficial soils is not likely to cause large differences in the equilibrium response.

Finally, the model was run in a transient mode using the baseline hydraulic properties shown in Table 1. The purpose of the simulation was to estimate the time it would take, once the GSI Program was fully implemented, to achieve the full impacts on the water table. Figure 10 indicates that the response in the Coastal Plain portion of Philadelphia is likely to achieve equilibrium within about 16 years, with most of the impacts occurring in the first 5 years. For the Piedmont, equilibrium conditions are not expected to occur for up to 22 years, with most of the impacts occurring within the first 10 years.

CONCLUSIONS

Urban infiltration through GSI is a growing trend in stormwater, as concepts of sustainability are applied to the urban hydrologic cycle. The concept of using green stormwater infrastructure to control stormwater at the source, rather than using sewers to discharge it as rapidly as possible to surface water bodies, will require considerably more investigation of potential impacts than is currently occurring. This is particularly true for cities considering more ambitious programs, such as Philadelphia's target of greening more than 40% of all impervious cover to control combined sewer overflows.

In modeling urban groundwater systems, stormwater infiltration rates, soil properties, and the design parameters of green stormwater infrastructure interact in complex ways, and transient mounding effects near infiltration facilities are impossible to predict without using numerical models with transient capabilities. Based on the initial modeling results for Philadelphia, a number of results are of importance for PWD:

- Even for a wide variety of soils, local transient water table mounds dissipate with distance from the infiltration facility, and keeping infiltration facilities more than 3 m (10 ft) from building foundations should avoid most problems.
- The water table is usually lowered by impervious cover in cities as recharge is reduced. Green stormwater infrastructure can reverse this, and create enhanced recharge in highly urban settings that can surpass recharge rates found in grassy or wooded open space.
- City-wide effects of enhanced recharge do occur over time, as the groundwater system seeks a new equilibrium. An ambitious program such as Philadelphia's can result in water table rises of up to 2 m (6 ft) in some areas.
- The modeling of GSI in Philadelphia shows that a significant percentage of the infiltrated stormwater is likely to

re-enter the sewers, but at a steadier, more controlled rate. For cities facing requirements to reduce CSOs, this can also be considered a beneficial effect of GSI infiltration.

- Groundwater mounding on a localized scale is very dependent on trench layout and design, and overlapping mounds from adjacent infiltration facilities can increase the mound height relative to a single infiltration facility.

Groundwater models need to be developed and applied at both local and city-wide scales to assess potential impacts of GSI on basement flooding, foundations, and on local streams and wetlands. The initial modeling results for the city of Philadelphia suggest that long-term increases in the groundwater elevation can be managed by avoiding infiltration in areas of shallow groundwater, and by keeping infiltration trenches more than 3 m from nearby buildings. EE

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FOOTNOTES

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