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ENVIRONMENTAL *Engineer*

Environmental Sustainability: A New AAEE Certification

Environmental Engineer: Applied Research & Practice

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by Cecil Lue-Hing, D.Sc., P.E., DEE, Hon.M.ASCE, NAE

Am I Good Enough?

As you turn to the next issue, I will give a hint on why I joined, what I have gained, why I feel enriched, my thoughts for the organization and some comments about the Class of 2009.

The pride of being elected President and the privilege to serve AAEE as its President for the year 2010 is at once humbling, rewarding, and challenging. Humbling because of the honor it bestows, rewarding because of the opportunity it offers to contribute, and challenging because of the important work that lies ahead.

The Academy has just completed a successful and productive year which, in no short measure, is the result of the efforts and dedication of a large number of individuals. First, thanks are due to outgoing President Debbie Reinhart for her amiable, efficient, and effective style of governance of the organization this past year. Her leadership was firm, but always courteous and mission oriented, and we will treasure the lessons learned from her approach to governance. Thanks are also due to outgoing Past President Bill Dee for his sage advice and counsel throughout the year, and to the committee chairs and their contingent of motivated committee members and volunteers, whose personal donation of time and resources contribute so much to the proper functioning of the Academy. Finally, no professional organization such as AAEE can operate effectively without a competent and dedicated staff, and the Academy is very fortunate to be served by such a group of individuals headed by Executive Director Joe Cavarretta, and ably supported by staffers Sammi Olmo, Joyce Dowen, Yolanda Moulden, and Pat Violette. Our thanks to them also; we very much appreciate their service.

I was first introduced to AAEE in the Summer of 1980 by the only colleague that I then knew who was an AAEE "Diplomate," today, an AAEE Board Certified Environmental Engineer. After some additional discussion with my colleague, he persuaded me to take a look at the roster of Diplomates, and I was most impressed by the lineup which represented the giants of the profession in academia – Dan Okun, Gerry Rolich, Earnie Gloyna, Ray Loehr, Fred Pohland, and in practice – Roy Weston, Bill Carroll, Joe Ling, Wes Eckenfelder, Paul Busch, and including also the founding Diplomates.

"You should join up" he said, and I muttered, "I will think about it." However, having said that, a few questions immediately surfaced in my mind, e.g., "Am I good enough to be in the company of the really big boys on the roster?" "Why should I join?" "Will I benefit personally?" "Will I benefit professionally?" (My career is already on the fast track – so I figured), and "Will joining improve my situation?" "How do I measure the benefits?" While I respected my colleague, and took some comfort in the fact that we both held important and equivalent positions in our organization, both being department heads, I was still haunted by the question – "am I good enough?" Not being one to shy away from joining professional groups – WEF, AWWA etc., I decided to pursue the idea of joining AAEE, and began my research into what it would take for me to join.

Not far into my research, I realized that I needed to show proof of graduation from a reputable engineering program, proof of a P.E., in active status, many years of relevant experience in the practice of Environmental Engineering, and even a record of good character. And to add insult to injury, I also had to sit for an examination. This was near devastating, and it slowly began to dawn on me that this was not any simple "joining" but rather a critical evaluation of me and my professional experience and skills, or a professional gauntlet that I would be voluntarily committing to run. This caused me to quickly reflect on the events of my joining other professional organizations, and I found those experiences by comparison to be hardly memorable. This, "joining" I concluded, was punishment that I can very well do without. Notwithstanding all of this anxiety, uncertainty, and fatigue, my colleague would not give up, would not leave me alone, would not go away, and finally persuaded to me to "join" up. After all, what was so bad about a little "exam?" As you turn to the next issue, I will give a hint on why I joined, what I have gained, why I feel enriched, my thoughts for the organization and some comments about the Class of 2009. EE

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Membership Growth

134 new Board Certified individuals were approved at the Annual Board of Trustees Meeting. The 127 new Board Certified Environmental Engineers (BCEEs) and 7 Board Certified Environmental Engineering Members (BCEEMs) are profiled in this issue of *Environmental Engineer.*

We would like to thank all of our members who take the time to recruit new applicants. Word of mouth and personal encouragement are still our best tools for recruiting new members. If you have a colleague who is not yet Board Certified, encourage them to apply for Specialty Certification. The next AAEE application cycle ends on March 31, 2010.

New Officers and Trustees

Congratulations to the new Officers and Trustees for 2010 who were installed during the Annual Meeting on October 15 and will take office January 1, 2010. They are:

Cecil Lue-Hing .... President
Brian P. Flynn ....President-Elect
Michael W. Selna ....Vice President
Howard B. LaFever .... Treasurer
Debra R. Reinhart .... Past President
Gary S. Gasperino ....A&WMA Trustee
Pasquale S. Canzano........ AIChE Trustee
Edward Butts.................... APHA Trustee
Lamont W. Curtis .... APWA Trustee
Paul A. Bizier.....................ASCE Trustee
Jason C. Lynch ....ASEE Trustee
Richard S. Magee..............ASME Trustee
Steven J. Quail................AWWA Trustee
Hector R. Fuentes............AEESP Trustee
Dan Wittliff ....NSPE Trustee
Stephen G. Lippy ....SWANA Trustee
Richard D. Kuchenrither ....WEF Trustee
C. Robert Baillod ....Trustee-at-Large
Gary S. Logsdon ....Trustee-at-Large
Otis J. Sproul.................Trustee-at-Large
Sandra L. Tripp..............Trustee-at-Large
R. Tim Haug..................Trustee-at-Large
James F. Stahl.................Trustee-at-Large

Invitation to All Members

AAEE is seeking volunteers to serve on its many committees and work groups. Gain valuable industry-wide perspective, build your network, and be recognized. The required commitment varies, depending on specific activities. Committees include:

- Bylaws/POP,
- Admissions,
- Eminence,
- Membership/Development & Outreach,
- Recertification,
- Air Pollution Control,
- Environmental Sustainability,
- General Environmental Engineering,
- Hazardous Waste Management,
- Industrial Hygiene,
- Radiation Protection,
- Solid Waste Management,
- Water Supply/Wastewater,
- Engineering Education,
- Excellence in Environmental Engineering Award,
- International Relations,
- K-12 & Beyond,
- Planning, and
- Publications.

Work Groups include Workshops & Seminars, and Web Site/Social Media.

For more information, email JSOlmo at aaee.net. Volunteer, and help AAEE carry out its mission and reach its goals!

2010 Excellence In Environmental Engineering (E3 Awards)

The Excellence in Environmental Engineering Awards Committee of the American Academy of Environmental Engineers is pleased to announce a new category for 2010: Environmental Sustainability. Entries for the Excellence in Environmental Engineering Competition may now be submitted in eight categories: Research, Planning, Design, Operations/Management, University Research, Small Projects, Small Firms, and Environmental Sustainability.

For complete entry guidelines, go to www.aaee.net. Remember, the entry deadline is February 1, 2010. EE

AAEE Calendar of Events

Please mark your calendar now with these important AAEE dates:

February 1, 2010
Excellence in Environmental Engineering Entries are due

March 1, 2010
Petitions for Officer Nominees

April 1, 2010
Mid-year Committee Reports are due

April 28, 2010
AAEE Awards Luncheon

April 28-29, 2010
Board of Trustees Spring Meeting

November 3-4, 2010
Board of Trustees Annual Meeting

by Joseph S. Cavarretta, CAE

The Make a Difference Challenge

My former association CEO and good friend Elissa M. Myers, CAE, is presently on a gutsy consulting engagement in the Republic of Georgia, which is bordered by Russia, Armenia and Turkey, Azerbaijan, and the Black Sea (N.S.E.W.,respectively). Two of her tasks are to help municipalities organize and to set the stage for effective environmentally sustainable waste management and water supply strategies. At some point, she will turn to USAID or other agencies for funding to finance environmental engineering expertise. All around the world, nations, states, regions, cities, and villages are in dire need of qualified environmental engineers and sustainable practices. Ladies and gentlemen, there is a call out there and here, in the United States of America, for environmental engineering experts.

The Good News

Based on my experience with AAEE members, you, the practitioners, are rising to the challenges with fierce passion, dedication, and enthusiasm to ensure the health of this planet and its inhabitants. What a career and a reward, to know that your work and research are so important to humankind. Thanks to those founders of AAEE who saw the need for a national focus on environmental engineering to advance the practice and to provide the nation with qualified environmental engineers.

The Bad News

The bad news is there are NOT ENOUGH of you to go around. According to the U.S. Bureau of Labor Statistics, demand for environmental engineers is expected to surpass 25% annually in the next 10 years. According to Anil Mehrotra, director of the Centre for Environmental Engineering Research and Education at the University of Calgary's Schulich School of Engineering, demand for environmental engineers in Canada is outstripping supply. It's the same in many parts of the world. Given this global shortage, identifying and engaging experts such as BCEEs and BCEEMs will be difficult at best. What keeps me up at night is how urgent this matter is of building a sustainable world for future generations. The only role I can play is to motivate AAEE members to **Make A Difference** in the world by building the Academy, the profession, and the practice.

"Make A Difference"

"Make a Difference" is our rallying cry for this membership drive. The deadline is March 31! I believe that each and every member knows at least one qualified environmental engineer or engineering practitioner who will apply for certification if encouraged. Many more of you have great networks to get the word out.

Goal: 320 New Members

If only one of every seven Board Certified Environmental Engineers and Board Certified Environmental Engineering Members brings in one new applicant, AAEE will reach its goal. It will also build the Academy's ability to initiate more activities that assist you in your career and practice. The AAEE Membership Committee has designed a Membership Stimulus Package to further encourage your participation.

Join the Campaign

I am asking for your help on several levels to stimulate colleagues to join the Academy. There are three ways you can help **Make a Difference**:

1. **Spread the word** in your professional associations. Use your contacts to provide notices about the Academy's membership drive. Contact me at ***jcava@aaee.net*** to receive flyers, ads, or notices that could be placed in a newsletter or magazine.
2. **Persuade colleagues individually**. Take five minutes each week to call a colleague between now and March 1, 2010. Here are five points to discuss:
   - Tell your colleague why you decided to become certified.
   - Share with them the names of other BCEEs and BCEEMs who you know.
   - Relate how board certification enhances your career and the profession.
   - Explain the application process and offer to be a referral. Follow up with your colleague often, and offer assistance with applying.
   - Use the Membership Drive at www.AAEE.net to download information you can forward to colleagues.
3. **Encourage groups via e-mail**. Construct an e-mail that has your touch, and distribute it to people in your workplace and your professional organization who you think would be good candidates. Attach the Membership Drive information from AAEE.net. EE

AAEE's Make A Difference Stimulus Package

Beyond improving the profession and practice, this is where AAEE rewards you for your efforts.

Membership Drive Rewards

- Five new members: 50 AAEE dollars*
- Ten new members: 100 AAEE dollars*
- Grand Prize: Highest total above 20 new members: $500 (cash)*

If we work together to help grow the Academy, we can **Make a Difference** in the profession, the practice, and ultimately in the lives of millions of people, including our own families, who increasingly depend on a sustainable world.

* AAEE dollars may be used for AAEE merchandise, specialty certification, dues, and workshops. Rewards apply for new BCEEs, BCEEMs, or regular Members.

Awards & Honors

Glen T. Daigger, Ph.D., P.E., BCEE, has been elected President-Elect of the International Water Association. He will take the office as President in September 2010 at the IWA World Water Congress. Dr. Daigger, Senior Vice President of CH2M Hill (Englewood, CO), has been board certified since 1995 in Water Supply & Wastewater Engineering.

Johannes van Leeuwen, D.Eng., P.E., BCEE, has been named as the 2009 R&D Innovator of the Year for his Mycofuel Process. Within the Mycofuel process, van Leeuwen uses a two-stage bioconversion process with diverse fungal species to make bio-oil or biofuel. Dr. van Leeuwen, Professor of Environmental Engineering at Iowa State University, has been board certified in Water Supply and Wastewater Engineering since 2003. He has also previously won AAEE's Excellence in Environmental Engineering (E3) Grand Prize Award in University Research (2007, 2008, and 2009) for his innovative projects.

Specialty Certification

Makson A. Esan, P.E., BCEE, was recently board certified in a second specialty. Mr. Makson, Project Manager for Georgia-Pacific Corporation (Atlanta, GA), has been board certified in Water Supply & Wastewater Engineering since 1995. His second specialty is Air Pollution Control.

David E. Schaad, Ph.D., P.E., BCEE, was recently board certified in a second specialty. Dr. Schaad, Associate Professor and Chair for Duke University (Durham, NC), has been board certified in Hazardous Waste Management since 2005. His second specialty is in Water Supply & Wastewater Engineering.

In Memoriam

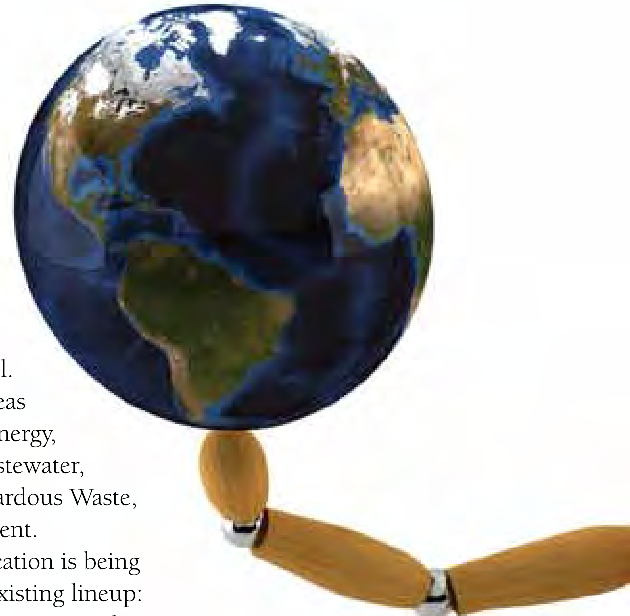
Jack Kroop, P.E., BCEE, of New York, NY, passed away on March 23, 2009. Mr. Kroop was a Life Member of AAEE. He had been board certified in Sanitary Engineering since 1965.

DID YOU KNOW?

LeRoy C. Feusner, P.E., BCEE, was AAEE's first board certified Hazardous Waste Management Engineer, a specialty which was first made available in 1987. Mr. Feusner, who is currently Administrator, Waste Management, of the Wyoming Department of Environmental Quality, was first certified in 1983 in Water Supply/Wastewater Engineering.

Environmental Sustainability: A New AAEE Certification

Brian P. Flynn, P.E., BCEE, Mario G. Cora, P.E., BCEE, and Phillip Dixon



Background

The sustainable use of the Earth's resources has become an extremely important concern for engineers, corporations, governmental agencies, and policy makers. This is driven by the multiplier effect of simultaneous population increase and economic development. Environmental engineers have assumed a huge role in conceptualizing, designing, operating, and trouble-shooting environmental facilities that make it possible to live in harmony with nature in our only home: earth.

Realizing this, the Board of Trustees of the American Academy of Environmental Engineers authorized the creation of a Sustainability Workgroup in November of 2008 with the charge of exploring the need for a new specialty certification in Environmental Sustainability. Based on the Workgroup's findings, the BOT authorized it in May 2009 to develop the certification and make it available to individuals practicing Environmental Engineering. It has done so. An application for the upcoming exam cycle is available at ***www.aaee.net***; hit the button "How to Apply" in the upper right area of the home page and download an application form.

What is It?

For the purpose of the Academy's certification purposes, sustainability is defined as:

Sustainability is the supporting of the quality of life while living within the carrying capacity of all systems. A long term balance of environmental stewardship, economic development, and social well being must be achieved.

To add some detail to this definition, the Academy has added a short mission statement:

Environmental engineers work transparently with stakeholders towards the following sustainability goals:

1. *Renewable resources are not consumed faster than they regenerate*
2. *Non-renewable resources are replaced by renewable substitutes faster than they are depleted, and*
3. *Harmful substances are not released faster than they can be absorbed or rendered harmless.*

The Sustainability Workgroup developed a list of 94 competencies to serve as the basis for developing a 100 question written multiple choice exam and 6 complex oral questions.

The workgroup also decided that the application of sustainability to environmental engineering is so broad that the written exam will have two parts: a general section that every applicant must take, and a set of optional sections (by subject area) that will round out the exam to 100 questions for each individual. The subject areas include: Air, Energy, Water and Wastewater, Solid and Hazardous Waste, and Development.

This certification is being added to the existing lineup:

- Air Pollution Control
- General Environmental Engineering
- Hazardous Waste Management
- Industrial Hygiene
- Radiation Protection
- Solid Waste Management
- Water Supply and Wastewater Engineering

The Exam

The written portion of the exam is a closed book examination consisting of multiple choice questions with 4 or 5 possible answers, only one of which is correct. Questions were developed consistent with the types of knowledge that a specialist in the practice area would possess. Most of the questions try to assess specific knowledge of facts, the application and use of information, or insight into basic relationships. The oral portion of the test involves a question and answer session in which the candidate sits before a small panel of BCEEs. Each examinee is given two fairly complex questions involving realistic situations related to sustainability concepts. The objective of this portion of the test is to evaluate the professional maturity and experience of the candidate. The answers are somewhat open ended: there is no one correct response.

In developing the written questions, the normal characteristics for Academy exams were used:

1. Questions must be clear, such that if there were no choices offered, someone could answer the question correctly.
2. The closed book format required that relevant facts and data be included, so that memorization is not required.
3. Questions were structured to avoid negatives and double-negatives (no "trick" questions).

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4. Some questions involve calculations; they must be simple enough to allow completion of the written exam within three hours.
5. The correct answer to each question should be documented such that it would be accepted by competent authorities in the sustainability field.

Draft questions (written and oral) were developed, edited, and then transmitted to a small army of field test volunteers (approximately 4 dozen). Each field tester was given only a small section of the exam. They provided valuable feedback on the validity, wording, and correctness of answers to questions. Based on this feedback, the written and oral exams were modified and turned over to Academy staff for use in the next examination cycle, beginning March 31, 2010.

Basic Qualifications

Just a reminder of the Academy's major basic qualifications to become a Board Certified Environmental Engineer (BCEE) or Board Certified Environmental Engineering Member (BCEEM):

- Possess a Baccalaureate degree or higher in engineering (or related field acceptable to the Board) from a college or university of recognized standing.
- Hold a validate P.E. license (US) or valid certificate of registration or license issued by a foreign country, provided it meets standards established by the Board of Trustees of AAEE.
- Be professionally engaged in environmental engineering activities on a full-time basis.
- Have at least eight years of engineering experience, at least four of which are in responsible charge. If more than 16 years, the Academy's written exam may be waived, providing there are at least 12 years in responsible charge.

The second requirement does not apply to the BCEEM category. You should consult the Academy's website and the annual *Who's Who* for more details about certification requirements.

It should be noted that a member of AAEE can hold more than one specialty certification. So, if you are already certified but want to add Environmental Sustainability, make an application! And remember that many environmental engineers have been practicing sustainability but not classifying it as such.

Potential Users

The need for engineers with a unique set of skills to plan, organize, implement, and control projects with sustainable components is increasing. One only needs to take a look at message boards, career search engines, magazines, and newspapers to see this. It is evident that sustainability concepts will be used in the development of new projects, ideas, and products across all sectors of the economy.

Environmental consulting firms are increasingly being asked to consider, develop, and implement more sustainable approaches in their projects for their clients. The requested scope of services ranges from design and construction projects to regulatory compliance. Many of them involve energy efficiency and renewable energy concepts, involving the creation, banking, and selling of carbon credits and renewable energy credits. Many organizations are involved in projects aimed to determine their carbon footprint and other energy minimization strategies.

Consulting firms with engineers who possess AAEE's Environmental Sustainability board certification will be in a great position to attain and execute engagements in this field. Until now, the lack of an available certification for environmental engineers has even led some clients to specifying LEEDS certification in RFPs for sustainability projects outside the scope of LEEDS – because it is perceived as the only game in town!

There are many drivers in the Sustainability marketplace. They include such things as:

- The "Regional Greenhouse Gas Initiative (RGGI)". This is an agreement signed by 10 Northeastern and Mid-Atlantic states with the aim of capping and then reducing CO2 emissions from the power sector by 10% by 2018. This is the first mandatory, market-based effort in the United States to reduce greenhouse gas emissions.
- Efforts are being taken also by the local governments. Recently, the City of Cleveland held a conference entitled, "Sustainable Cleveland 2019 Summit: Building an Economic Engine to Empower a Green City on a Blue Lake." The City's commitment to creating a sustainable city and economy is being highlighted by the appointment of a new Chief of Sustainability position and a 25-person Sustainable Cleveland 2019 Council.
- At present, more financial management companies are using or implementing a wide variety of products in which environmental sustainability concepts are included.
- Educational institutions are also expanding their offerings and rethinking their engineering programs. James Madison University is developing a unique engineering program focused on sustainable societies. Researchers at the Center for Sustainable Engineering, a consortium consisting of Arizona State University, Carnegie Mellon University, and the University of Texas at Austin, has been exploring the idea of sustainable engineering as rigorous methodology so that it can be applied by professionals and taught to engineering students (Allen, Murphy, Allen, and Davidson, 2009). In another article by Ashford (2004), the author discusses major challenges to engineering education for sustainable development in relation to creativity, effectiveness, and acceptability to the established disciplines.

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- A significant number of states are now taking the lead and forming initiatives that will require reduced emissions and an increase in the use of more renewable energy.

As stated in an article by Crittenden et al. (2003), "Perhaps the most critical endeavors that must be undertaken in ensuring the viability of the sustainability metadiscipline are in the area of education and human resource development." The profession of environmental engineering and the American Academy of Environmental Engineers will be in the leading edge of this change.

What's in it for Me?

Everyone's time and resources are limited. The Academy's Environmental Sustainability certification has to pass the "What's In It For Me?" test. Here is how:

- It demonstrates to others your expertise in this new discipline.
- It provides a competitive advantage over non-certified practitioners. This applies to competing for consulting engagements and for employment.
- It provides personal credibility with the public and outside organizations with which you have built a relationship.
- It is another distinction of personal professionalism.

Environmental sustainability is a fundamental requirement in the design, construction, and operation of virtually all industrial and non-industrial facilities. The marketplace is looking for environmental professionals who can demonstrate their expertise in this area. Be one of them. Apply today at ***www.aaee.net*** (Go to *How To Apply* and download an application). If you get your application in by March 31, 2010, you will be in the first class to be tested, and if successful, certified.

Many thanks to the two dozen members of the Sustainability Workgroup who developed this new certification and the additional four dozen volunteer field testers. Without the eager and effective participation of both groups, this certification would not be possible. **EE**

About the Authors

Mr. Flynn is the President Elect of AAEE and chair of the Environmental Sustainability Workgroup. Mr. Cora is a member of the workgroup and serves as a public health engineer with ARMA-MDE. Philip Dixon is also a member of the workgroup employed by CDM.

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The 2010 Kappe Lecturer

Morton A. Barlaz, Ph.D., P.E., BCEE
Professor, Civil Engineering, North Carolina State University

Education

University of Michigan-Ann Arbor	1978	BS	Chemical Engineering
University of Wisconsin-Madison	1985	MS	Civil & Environmental Engineering
University of Wisconsin-Madison	1988	Ph.D.	Civil & Environmental Engineering

Professional Credentials

Registered Professional Engineer in North Carolina
Board Certified Environmental Engineer, American Academy of Environmental Engineers

Professional Associations

American Society of Civil Engineers
American Society for Microbiology
American Chemical Society
Sigma Xi
Association of Environmental Engineering and Science Professors
International Solid Waste Management Association
Solid Waste Association of North America

Professional Awards

Distinguished Service Award, AEESP, 2003 & 2009
Distinguished Individual Achievement Award, SWANA, 2004
Outstanding Paper, 7th International Waste Management & Landfill Symposium, Cagliari, Italy, 1999
Samuel Arnold Greeley Award, ASCE, 1997
National Science Foundation Presidential Faculty Fellow, 1992-1997
Department of Energy Junior Faculty Enhancement Award, 1992
American Chemical Society Graduate Student Award, 1987

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Dr. Morton A. Barlaz is a Professor in the Department of Civil, Construction, and Environmental Engineering at North Carolina State University. He received a B.S. in Chemical Engineering from the University of Michigan and an M.S. and Ph.D. in Civil and Environmental Engineering from the University of Wisconsin. He has been involved in research on various aspects of solid waste since 1983. Over this time, he has conducted research on biological refuse decomposition, methane production, and the biodegradation of hazardous wastes in landfills. He has participated in two state-of-the-practice reviews of bioreactor landfills. His research forms the basis for much of the work done to assess the impact of landfills on methane emissions inventories.

Dr. Barlaz also conducts research on the use of life-cycle analysis to evaluate environmental emissions associated with alternate solid waste management strategies. Dr. Barlaz is the author of over 75 peer-reviewed publications and has made over 150 presentations at conferences throughout the world. In 1992, he was awarded a Presidential Faculty Fellowship from the National Science Foundation.

Dr. Barlaz has been active in service throughout his career. He is an Associate Editor for two journals (*Waste Management* and *Journal of Environmental Engineering*) and serves as co-chair of the bi-annual Intercontinental Landfill Research Symposium. He has served as chair of the Government Affairs Committee and the Lectures Committee for the Association of Environmental Engineering and Science Professors. Finally, he serves on the Science Advisory Committee for the International Waste Working Group.

Abstracts of Lectures Offered

Development of a Carbon Footprint Model for Landfill Disposal of Solid Waste

Over half of all solid waste generated in the U.S. is disposed of in landfills, and landfills are likely to be a dominant factor in solid waste management for the foreseeable future. Landfills are an anaerobic ecosystem in which biogenic carbon decomposes to methane and carbon dioxide. As a result, landfills are scrutinized as a leading source of anthropogenic methane emissions in the U.S. and globally. A landfill carbon balance includes gas production and collection, the biological oxidation of methane in landfill cover soils, fugitive emissions, carbon sequestration and avoided emissions when methane is recovered for beneficial reuse. The state-of-knowledge for each aspect of a landfill carbon balance will be presented, including the results of current research and how this information can be utilized in practice. Methane production modeling is uncertain, in part due to the difficulty in obtaining reliable field data for model verification. This uncertainty is exacerbated by the lack of detailed information on waste composition and field-scale biodegradability. While numerous methods are available for measurement of fugitive emissions, each method has its own limitations and here, too, there remains uncertainty in the measured values. A fraction of landfill methane that is not collected is oxidized by methanotrophic bacteria in landfill cover soils and this fraction will vary as a function of both climatic factors and the methane flux. Thus, there is also uncertainty in the appropriate oxidation factor for a landfill carbon balance. Biogenic carbon that does not decompose is said to be sequestered, and landfills represent a sink for some biogenic carbon. Finally, methane is utilized as an energy source at about 500 landfills in the U.S., and it is estimated that there are an additional 500 landfills at which energy recovery is viable. Energy recovery results in avoided emissions. A spreadsheet model was developed to explore the sensitivity of various input parameters to the overall carbon footprint. Realistic ranges for key inputs will be presented along with the results of model simulations.

The Use of Life-Cycle Analysis for the Study of Alternatives for End of Life Materials Management

Solid waste management (SWM) is an integral component of civil infrastructure. The cost and environmental implications (e.g., energy consumption, greenhouse gas (GHG) emissions) of SWM are important societal issues. SWM costs are borne by the public, either through use fees or taxes. SWM has environmental impacts resulting from waste collection, separation, treatment processes such as composting and waste-to-energy combustion, and landfill disposal. The beneficial use of waste, either for energy recovery or material recovery, can result in both revenue and avoided emissions. Thus, policymakers face the challenge of developing and implementing integrated SWM programs that represent an appropriate use of public funds in consideration of emissions and energy consumption. Mathematical models of integrated SWM are important planning tools given the complexity of the solid waste system, the interactions among the numerous components that constitute the system, and the number of potential SWM alternatives. Over the past decade, we have used an integrated solid waste management life-cycle model to evaluate waste management alternatives for a variety of cases. In one application, alternative plans for integrated SWM in the State of Delaware were evaluated considering cost and environmental performance, particularly GHG emissions. In a second study, three alternatives for the management of commercial food waste were evaluated including aerobic composting, landfill disposal, and in-vessel anaerobic digestion. Each case study presents unique challenges due to constraints associated with the solid waste system under study. This presentation will describe the SWM life-cycle model and present key results from two case studies. Model results will be put into the context of SWM practice. EE

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The Class of 2009

These individuals were Board Certified in October 2009.

From the first applicants in 1956 to the 134 Board Certified Environmental Engineers and Board Certified Environmental Engineering Members listed on the following pages, the Academy has undergone growth and changes, but has never wavered from its core objective to "identify and credential persons with special capabilities in environmental engineering."

Today, there are nearly 2,500 Board Certified Environmental Engineers and Board Certified Environmental Engineering Members in the Academy and interest continues to grow on an annual basis.

A brief description of the specialty certification process follows: To be included in an annual class, the application for specialty certification must be submitted to the Academy by March 31. Any application received after that date is held over to the next class. The applications received by March 31 are then reviewed by the Admissions Committee for adequacy of education and qualifying experience in April and May. Examinations are administered to the qualified applicants during July and August at convenient locations throughout the country. The examination results are reviewed by the Admissions Committee in September and recommendations for each candidate are presented to the Board of Trustees. Each person's history is reviewed by the Board members at the Academy's Annual Meeting and decisions made to certify or not.

The Academy announces the issuance of specialty certificates and Board Certified Environmental Engineers and Board Certified Environmental Engineering Members status to those individuals portrayed in this special section of the Environmental Engineer®. These persons have demonstrated to their peers that they possess the requisite formal education and environmental engineering practical experience and have successfully completed the Academy's examinations to be Board-Certified environmental engineering specialists. The special capability of each person is shown after their name using the following codes:

AP	Air Pollution Control,
GE	General Environmental Engineering,
HW	Hazardous Waste Management,
IH	Industrial Hygiene,
RP	Radiation Protection,
SW	Solid Waste Management,
WW	Water Supply and Wastewater Engineering.

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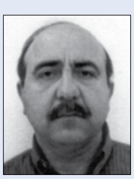

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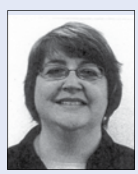

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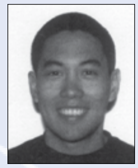

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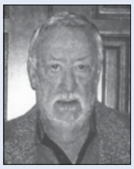

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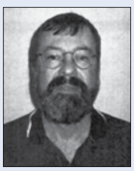

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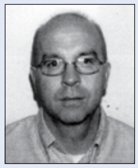

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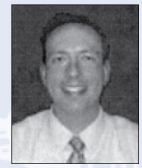

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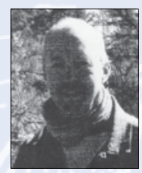

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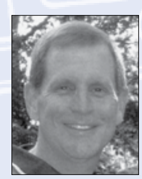

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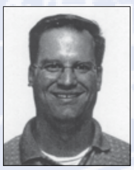

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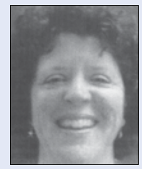

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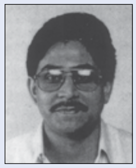

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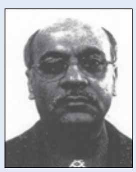

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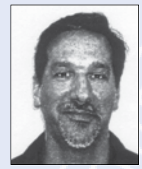

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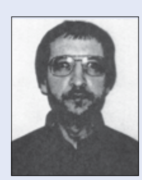

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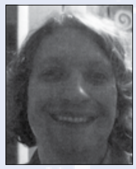

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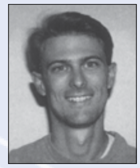

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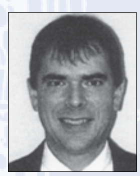

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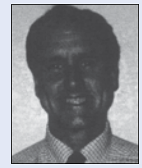

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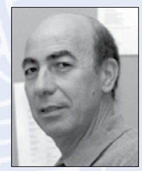

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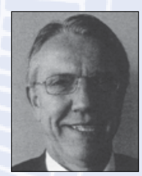

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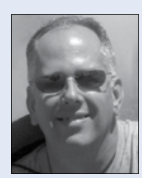

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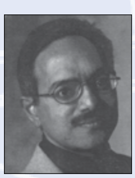

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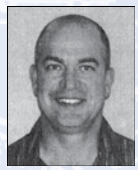

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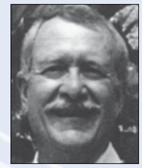

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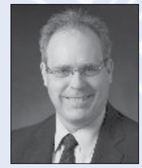

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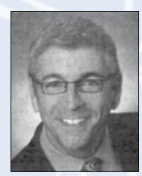

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GROWTH FOR DESIGN AND CONSTRUCTION MARKETS STOPS IN 2009

By Alan L. Farkas & Christopher S. Frangione

Design and construction markets related to environment, infrastructure, and facilities chalked up another growth year in 2008, in spite of deteriorating market conditions during the second half of the year. Most of these markets will not grow in 2009.

Designers for transportation, power and water infrastructure, as well as remediation, and facilities in the U.S. saw billings increase by 9 percent in 2008, and construction firms serving those same markets enjoyed a 10 percent increase in aggregate revenues. Although some of these markets began to weaken in the first half of 2008, all of them were slowing considerably by the last quarter of 2008. For engineers and architects, growth has slowed from 15 percent in 2006 to 12 percent in 2007 to 9 percent in 2008, and we project that these markets, in aggregate, are unlikely to grow at all in 2009. Our growth rate estimates and forecasts do not account for inflation. Exhibit 1 shows the growth of the U.S. engineering market. Exhibit 2 shows the distribution of the engineering market among the major segments.

For all of the hype surrounding the infrastructure funding in the American Recovery and Reinvestment Act (ARRA), only highway and bridge contractors will see a boost to their top lines in 2009. Highway/bridge engineers should see some stimulus dollars in 2010. Based on our analysis of ARRA, architects, engineers, and contractors have a potential claim on as much as $150 billion of the stimulus bill's $789 billion in authorizations. In addition to the funding provided for transportation contractors and engineers, some large engineering firms will realize windfalls from the acceleration of cleanup programs at the Department of Energy (DOE), but most stimulus dollars should benefit smaller engineering and construction firms that serve small to medium sized municipal water and wastewater utilities or that have the capability to renovate government buildings.

We expect to see growth return to most design and construction markets during 2010, but we will likely have to wait several years for a return to double digit design and construction growth across environment, infrastructure, and facilities markets.

WATER INFRASTRUCTURE ENGINEERING AND CONSTRUCTION

The water infrastructure market consists of two principal segments and two client groups. The two segments include water and wastewater treatment facilities and associated infrastructure and water resources projects. Water resources includes such projects as flood control, habitat restoration, and the development of new water supplies. The two major client groups are municipalities and the federal government, which is a major client for water resources projects. Water resources management is included in the estimated market size.

The water infrastructure engineering market grew 10 percent in 2008, while the value of construction put in place for water and wastewater increased by 6 percent. We have seen double digit growth in the water infrastructure engineering market for the last six years except for 2007. That growth was slightly less than 7 percent.

The surprisingly strong 10 percent growth rate for engineers in 2008 masks a slowing of the market during the second half of the year. We forecast a declining market this year and next, with recovery not likely until 2011.

Engineers enjoyed a strong market until the third quarter of 2008. A confluence of variables weakened the market by the fourth quarter of last year. These variables all impacted funding sources. Funding of most water infrastructure design and construction comes from a mix of federal and state and local government sources including user rates, hookup fees, municipal bonds, and State Revolving Funds. The market was negatively impacted by the U.S. recession. Multiple effects of the recession led to cancelled or delayed projects. These drivers included:

The housing crisis: The housing crisis led to lower population growth in the Sunbelt states. These were the states that reported the fastest market growth in recent years. Many projects were delayed or cancelled because the expansion of water and wastewater services was no longer urgently needed.

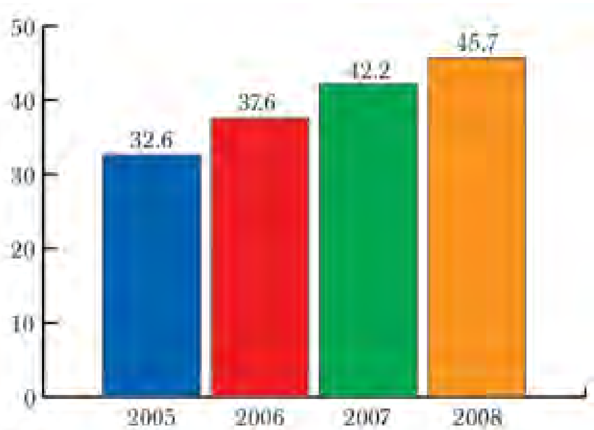
The reduction in tax revenue: Along with the housing crisis, tax revenue and hook-up fees decreased for municipalities. This further limited their ability to invest in water and wastewater infrastructure.

The meltdown of the municipal bond market: Municipalities float municipal bonds to fund water and wastewater infrastructure. A confluence of factors depressed the bond market in late 2008. These factors included: the lack of availability of bond insurance, hedge funds and insurance companies selling their stake in long-term bonds therefore increasing the interest rates municipalities have to pay on their bonds, and shrinking tax revenue at the state and local levels increasing the credit risks. In fact, in the fourth quarter of 2008, we saw the lowest sales of new bonds by dollar value in a single quarter since before 2006. And, looking at the number of new bonds being issued, we saw 35 percent fewer bonds being issued in the fourth quarter of 2008 than in the fourth quarter of 2007.

The hope for stimulus dollars: Once the rumors began flying about the stimulus bill, many municipalities delayed their projects in hope that they would get "free" money.

EXHIBIT 1: U.S. Engineering Market 2005-2008

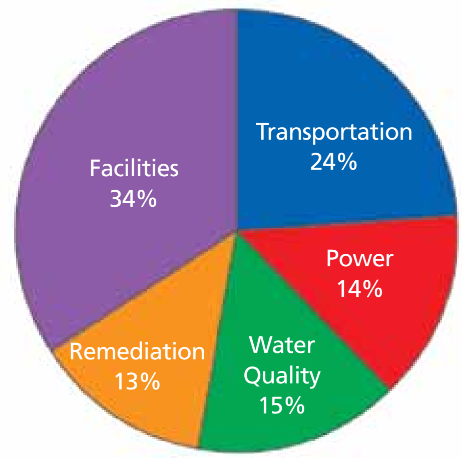
U.S. Engineering Market for Environment, Infrastructure and Non-residential Facilities ($ Billions)



Source: Farkas Berkowitz, based on ENR Top 500 Design Firm Survey for 2008 (Net Revenues)

EXHIBIT 2: Distribution of U.S. Design Market in 2008

Distribution of $45.7 Billion U.S. Design Market in 2008



Source: Farkas Berkowitz, based on ENR Top 500 Design Firm Survey for 2008

Municipalities even delayed projects for which they had the funding. Market participants believe this delay negatively impacted the market in late 2008.

While the stimulus bill provides $6 billion to state revolving loan fund programs, few large municipalities are sufficiently motivated to tap that source of funding.

The competitive landscape seems to be changing in the marketplace, but most of the big players remain the same. AECOM is new to the "big player" list as a result of its acquisitions of Earth Tech and Boyle Engineering in 2008. Looking at worldwide gross revenues, the top five firms in this market grew more quickly in 2008 than the other firms in the market. The top five firms grew 15 percent, while the next ten firms grew at a 6 percent rate. All other firms in the water segment grew at 9 percent. The top five firms in 2008, including revenue from U.S. and foreign projects, in order of market share, are: CH2M HILL, Tetra Tech, MWH Global, AECOM, and URS.

Market participants see more competitors going after each opportunity. Participants report seeing both major engineering and construction firms bidding on smaller projects than they would have in the past. These larger firms are lowering their fee threshold because of a lack of opportunities. In addition, participants report seeing small local civil engineers and contractors bidding on projects. In many cases, these firms have never done a water or wastewater project. Again, they are bidding because of a lack of opportunities in their own core markets. These smaller firms seem to be bidding on the projects in the $25 million to $100 million range. Some report seeing the number of competitors for projects in this value range increase from about 10 to 30.

Engineering led design-build projects chalked up sales in excess of $2.2 billion in 2008 according to data collected by the Water Design-Build Council. Unfortunately for many design-builders, many of the projects sold were later postponed or cancelled. However, interest at all levels of government in quickly stimulating the economy will increase the percentage of water and wastewater projects that will go to design-build.

Four states account for 65 percent of the $6.4 billion in engineer-led design-build sales value from 2005–2008. These states are Florida (26 percent), Arizona (15 percent), California (14 percent), and Texas (10 percent). These top states are driven by population growth and requirements to meet new standards for drinking and wastewater. Even states like Florida and Arizona that have a housing crisis will still be good markets for design-build because they will continue to need to meet regulations and will have water resources challenges. They are not, however, great markets for traditional water/wastewater engineering. One participant believes that California has over $1.5 billion in opportunities.

We see fewer competitors on larger projects because the cost of bidding is so high, but we are seeing more competitors for smaller projects due to the depressed conditions in other markets.

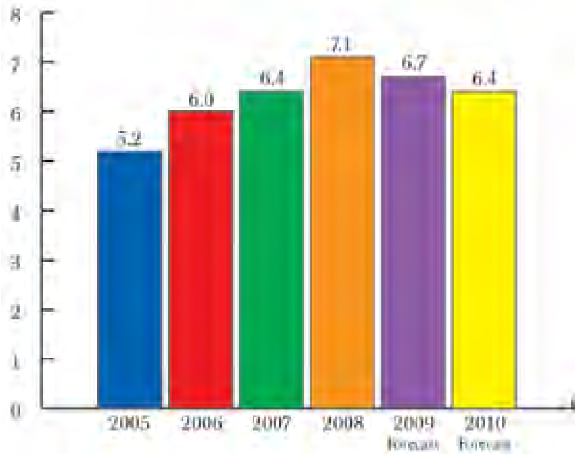
We see a trend towards CM@Risk over traditional and progressive design-build. CM@Risk allows the municipality to choose both their engineer and contractor on a qualifications basis and allows the contractor and engineer to work together early in the process. However, the municipalities get to choose the engineer and contractor independently of each other and contract separately with each. From 2005 – 2008, CM@Risk only accounted for 34 percent of the $6.4 billion in engineer-led design-build sales value. In 2008 alone, it accounted for 68 percent of the $2.2 billion in engineer-led design-build sales value.

WATER PUBLIC PRIVATE PARTNERSHIPS

Based on a survey recently reported in Public Works Financing magazine, we find that the water public-private partnership market has remained essentially constant since

EXHIBIT 3: U.S. Water Infrastructure Engineering Market

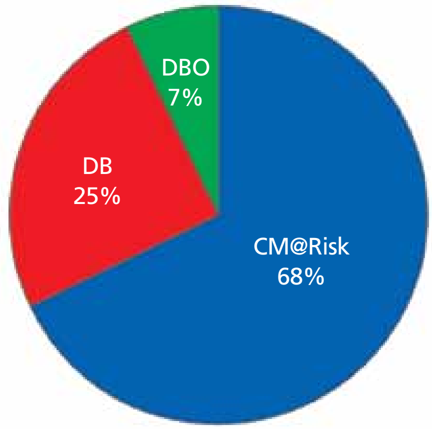
U.S. Water Infrastructure Engineering Market ($ Billions)



Actuals developed by Farkas Berkowitz, based on ENR Top 500 Design Firm Survey for 2008 (Net Revenues); Forecasts by Farkas Berkowitz

EXHIBIT 4: Distribution of Engineering-Led Design-Build Projects by Delivery Type

Distribution of $2.2 Billion Sales Value in 2008 by Type of Project Delivery



Based on survey conducted by the Water Design-Build Council

2005, at just under $1.3 billion. Renewal rates have also remained constant at around 95 percent.

Inquiries seem to have increased significantly in 2009. Market participants report seeing the greatest activity in the first quarter of 2009 than they have seen in the last two years. Some municipalities are looking at O&M to help them reduce financial burdens including health insurance and pensions. Municipalities are also short on staff. Some of these opportunities are just for short-term or the replacement of an operator. At the same time, participants have reported to us that they are increasing their business development budgets. Between renewed interest and a focus on marketing, the partnership market could restart this year. In the meantime, competitors are broadening the scope of services they offer. Most participants are interested in DBOs and offering additional municipal services, although the number of these opportunities is decreasing as a result of slower population growth. Less population growth means fewer new cities that will need the support.

REMEDIATION CONSULTING AND ENGINEERING

The remediation consulting market grew 12 percent in 2008 after contracting 2 percent in 2007. This is the strongest remediation consulting and engineering market that we have seen in a very long time. The strong growth can be explained principally by the substantial pick up in Department of Defense (DOD) spending on remediation. The industrial market was also strong through the third quarter of 2008, but tanked in the fourth quarter. We forecast a steady DOD market over the next two years but a weakening industrial market. Overall we project a contraction in the remediation market of 5 percent in 2009 and again in 2010.

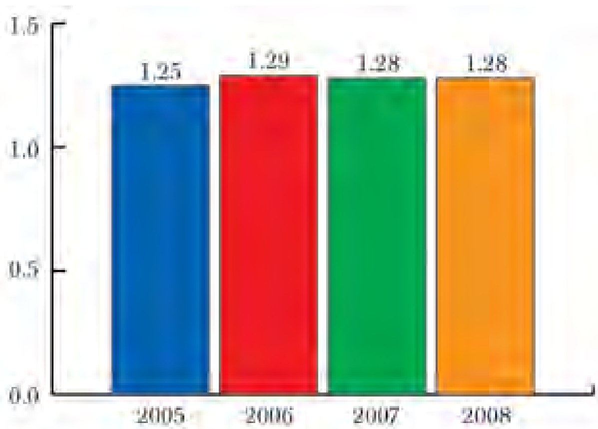
The industrial market was hit hard at the end of 2008. Cost cutting among nearly all industries, the collapse of the brownfields market, and a sharp reduction in merger and acquisition activity all contributed to a sudden down-turn in the industrial remediation market in the fourth quarter. For example, most industries, especially manufacturing, chemical, and mining, stopped most discretionary spending on cleanup.

The DOD remediation market grew approximately 10 percent in 2008 and is still growing in 2009. After appropriations of approximately $1.3 billion per year during federal fiscal years 2003-2006, the Defense Environmental Restoration Account (DERA) dipped by 20 percent in 2007 and then increased 33 percent in FY2008. Emphasis on low price continues to pervade the contracting practices of the Army, Air Force, and Navy. At the same time performance-based design-build contracts are favored. A combination of the increased risks of performance contracts, fixed-price against approved site closure, and greater emphasis on price rather than relationships and past performance has driven some successful competitors to shun this market. Those firms that have stayed in the market report that competition has become less fierce. We see the Army Corps of Engineers lead in new contracting. In addition, we see small businesses continue to increase share. For example, the Navy and the Air Force Center for Environmental Excellence (AFCEE) target 50 percent of work to small businesses. In addition, DOD is pushing for 75 percent of subcontracts to go to small businesses or 30 percent of contract values. Unlike in the past, with more work to go around, complaints about the small business focus are less.

The Department of Energy (DOE) clean-up market was extremely active in 2008, with over 50 percent of the environmental management budget at stake in a series of re-competes. More contracts were awarded in 2008 than in the last 10 years. The five firms that have dominated this market for the last 10 years or more successfully protected their turf. Fluor, URS, and CH2M Hill led teams to major wins, with Bechtel and Babcock & Wilcox playing important supporting roles on winning teams. URS was the most successful of

EXHIBIT 5: Water Public-Private Partnership O&M Market

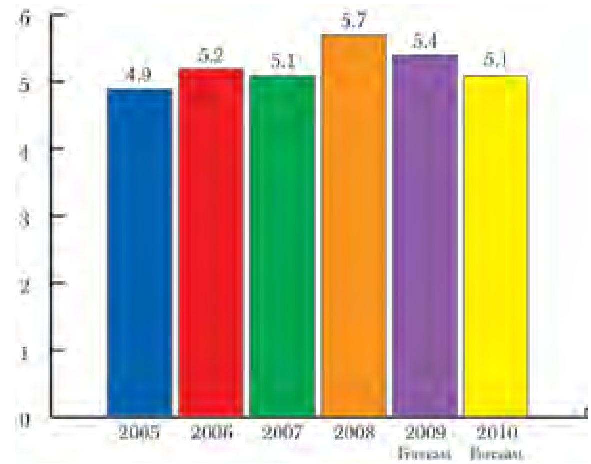
Government O&M Market in U.S. ($ Billions)



Based on survey conducted by Public Water Financing

EXHIBIT 6: Remediation Consulting and Engineering Market

Remediation Consulting and Engineering Market ($ Billions)



Source: Farkas Berkowitz, based on ENR Top 500 Design Firm Survey for 2008 (Net Revenues)

all, winning three of six major DOE contracts and walking away with the coveted $9.6 billion clean-up of the Sellafield complex for the United Kingdom Nuclear Decommissioning Authority.

The stimulus will pump $6 billion into cleanup over FY 2010 and 2011 increasing the Office of Environmental Management budget by 50 percent each year. These funds will go to existing contract vehicles, with $1.6 billion to the Savannah River Site and $1.9 billion to Hanford. URS and CH2M are the major beneficiaries of this windfall. An additional $7.5 billion will go into energy R&D. DOE will use these funds directly for projects and service providers to advance clean coal, renewable energy, energy efficiency, and study climate change.

About the Authors

Farkas Berkowitz & Company is a management consult\ing firm serving companies that provide design, construction, and operational services for government and industry. Established in 1983, the firm assists clients with strategy, mergers and acquisitions, and organizational development. Inquires should be addressed to Alan Farkas at 202-833-7530 or farkas@farkasberkowitz.com or visit their website: www.farkasberkowitz.com. EE

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Environmental Engineer: Applied Research and Practice

SUSTAINABILITY AND THE ENVIRONMENTAL ENGINEER: IMPLICATIONS FOR EDUCATION, RESEARCH, AND PRACTICE
James R. Mihelcic, Ph.D., BCEEM, and Maya A. Trotz, Ph.D. 27

Instructions to Contributors

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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.

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Papers may be submitted in the following areas:

Applied Research

Original work presented with careful attention to objectives, experimental design, objective data analysis, and reference to the literature. Practical implications should be discussed.

Review

Broad coverage of an environmental engineering application or a related practice with critical summary of other investigators' or practitioners' work.

Practical Notes

Novel methods that the author(s) have found to be sufficiently successful and worth recommending.

Case Studies

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

Design/Operation

Conceptual or physical design or operation of engineering systems based on new models or techniques.

Management

Papers describing novel approaches to problems in environmental management, or to the global, sustainability or business asects of environmental engineering.

ABSTRACT

An abstract of up to 200 words should be provided, including a statement of the problem, method of study, results, and conclusions. References, tables, and figures should not be cited in the abstract. Up to six key words or terms should be included for use by referencing sources.

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SUSTAINABILITY AND THE ENVIRONMENTAL ENGINEER: IMPLICATIONS FOR EDUCATION, RESEARCH, AND PRACTICE

James R. Mihelcic, Ph.D., BCEEM, and Maya A. Trotz, Ph.D.

ABSTRACT

Three case studies (Bolivia, Guyana, Florida) are presented that demonstrate how sustainability can be incorporated into environmental engineering education, research, and practice. They demonstrate how traditional measures of performance (e.g., function, economics, and safety) can be enhanced with additional measures of performance that integrate societal needs and a global perspective. The case studies also show how engineering practice can apply sustainability to an "engineering project" to transcend beyond the physical structure and include the social setting in which the project is located and importantly, the people who will operate, manage, and benefit from the project. This fits with the vision of the Environmental Engineering Body of Knowledge that "environmental engineering problem formulation and solution must be accomplished in the context of sustainability, must meet societal needs and must be sensitive to global implications." Furthermore, adding the learning outcomes of caring and a human dimension to education is critical if sustainability is to become inherent in all environmental engineering practice.

INTRODUCTION

Since the release of *Limits to Growth* (Meadows et al., 1972) there has been increased global discussion on issues relating to sustainability. One definition of sustainable engineering is ***"the design of human and industrial systems to ensure that humankind's use of natural resources and cycles do not lead to diminished quality of life due either to losses in future economic opportunities or to adverse impacts on social conditions, human health, and the environment***" (Mihelcic et al., 2003). This is often practically interpreted as mutually advancing the long-terms goals of environmental protection, societal prosperity, and economic growth (Mihelcic and Zimmerman, 2010).

The Environmental Engineering Body of Knowledge (BOK) (AAEE, 2009) describes the knowledge and core competencies important for the understanding and practice of environmental engineering and recognizes sustainability as an essential competence for environmental engineers. The BOK further asserts that "***environmental engineering problem formulation and solution must be accomplished in the context of sustainability, must meet societal needs and must be sensitive to global implications.***" To recognize this competence, AAEE has created a new certification category in sustainability.

Unfortunately, sustainability has been a difficult concept for many engineering educators, researchers, and practitioners to integrate into their professional activities. One problem is that an Internet search performed on the words "sustainability" or "sustainable development" will result in hundreds of definitions. Additionally, many challenges to implementing engineering solutions such as providing safe drinking water around the world are not technical, but instead relate to social, economic, and environmental limitations that have geographical and cultural context (Hokanson et al., 2007).

Most can agree that definitions of sustainability seek some type of balance between environmental, social, and economic components. However, traditional environmental engineering education, research, and practice have not always emphasized the social and global implications of a specific engineering solution. Another problem has been that many engineers gravitate towards solutions that arise from an educational system that emphasizes learning fundamental knowledge and applications of fundamental skills. This can lead to an overemphasis to substitute technology and economic considerations at the expense of other innovative solutions that may be more economically competitive and better integrated with societal and environmental concerns.

Application of sustainability to engineering projects thus requires more emphasis on integrating and balancing human and societal considerations with technological and economic considerations. In this view, the word *project* transcends beyond the physical structure and includes the social setting of people who will operate, manage, and benefit from the project and includes long term life cycle implications (Mihelcic et al., 2009). Importantly, community participation (Selener et al., 1999; Chambers, 2002; Ratner and Gutierrez, 2004) and gender considerations are often critical to project success (Coles and Wallace, 2005; Fisher, 2006).

OBJECTIVES

The objective of this paper is to demonstrate, through three case studies, how sustainability can be incorporated into environmental engineering education, research, and practice. In some cases, readers will readily see how their current approach to projects already fits into the overarching theme of sustainability. Others will see how to expand their existing approach to incorporate sustainability. All the case studies expand the list of additional measures of performance which have historically focused on quality and cost of environmental emissions. They also demonstrate how the project fits the BOK vision of meeting societal needs and is sensitive to global implications.

The case studies engage undergraduate and graduate students, with engineering practitioners to design and implement projects for municipalities or nongovernmental organizations (NGOs). Common to all the case studies is development of partnerships that connect the environmental engineer with households, neighborhoods, and institutions of governance. Another commonality is demonstrating that integrating a caring and human dimension (Catalano and Baillie, 2006) with technical competence is important for project success.

Two case studies are located outside of North America, in Bolivia and Guyana. Bolivia and Guyana rank 113th and 114th respectively on the Human Development Index (HDI) with values of 0.729 and GDP per capita of $4,206 and $2,782 respectively (UNDP, 2009). The concepts presented in these case studies are still applicable to engineering problems encountered in more developed parts of the world. In addition, though the scale of the problems addressed here are at the community level, we believe that incorporating sustainability into a particular problem's unique context is scalable to more complex and larger situations. The manuscript concludes with observations on how environmental engineering education and practice needs to go beyond learning outcomes of foundational knowledge and application by adding a human dimension and empathy.

Case Study # 1: Bolivia

We identified six rural communities (population of < 2,700) in the eastern La Paz Department of Bolivia (Figure 1) where there are different sanitation technologies, levels of social organization, and economic capacities to support a particular system (Table 1). In these six communities, water and sanitation systems are typically managed together by local community water committees.

One question we are attempting to answer is "what is the appropriate sanitation expansion path for a community beyond a simple pit latrine?" (Fuchs and Mihelcic, 2009). Appropriate technology

FIGURE 1: Country of Bolivia Showing the La Paz Deartment and the Locations of the Six Study Communities (illustration provided by Valerie J. Fuchs).

Table 1: Sanitation Technologies used by Six Communities in Bolivia Case Study

	San Antonio	Sararia	Sapecho	Arapata	Coripata	Palos Blanchos
Population served	420	546	1039	1950	2680	2691
Sanitation Technology	Sewer to Facultative and Maturation Lagoons	Household Septic Tank connected to Absorption Pits	Sewer to Upflow Anaerobic Reactor followed by Maturation Lagoons	Six Condominial Sewers to Septic tank followed by Biofilter	Seven Condominial Sewers to Septic tank followed by Biofilter	One Sewer to Septic Tank followed by Biofilter
Number of Connections	150	91	206	401	546	700

Table 2: Traditional Measures and Sustainable Measures of Performance for the Bolivia Case Study

Project Objectives	Traditional Measure(s) of Performance	Additional Measures of Sustainable Performance
Assess operation and maintenance of appropriate technology to treat wastewater	Performance of technology in protecting human health and water quality	• Appropriateness, in communities where average income is less than 1 USD per day. • Carbon neutrality of technology. Adaptability to urbanization and seasonal movement of beneficiaries. • Compatibility with community based management systems.
Assess sanitation pathway for advancement from latrine technology	Economics and effectiveness in protecting human health	• Community training costs. • Minimization of water and energy use. • User/technology interface, and modularity. • Community knowledge about project, compatibility of technology with existing community management structures, seasonal and long term changes in population.

is defined here as the use of materials and technology that are culturally, economically, and socially suitable to the area in which they are implemented (Mihelcic et al., 2009). Through user and water committee surveys and detailed analysis of engineering reports, we have determined that the successful operation and maintenance of a particular technology is related to how well community members understand the operation and maintenance of a particular technology, and that is in turn related to how much funds were allocated for training of beneficiaries during the pre- and post-construction phases. In this setting, an appropriate sanitation technology also has characteristics of the decentralized absorption pits found in the community of Sararia. The modularity of this particular technology allows it to adjust to dynamic changes occurring in the area related to population growth, urbanization, land use changes on water availability, and seasonal employment activities that are influenced by country and global policies. Here, an appropriate sanitation technology also has minimal demands for human/financial/natural resources, and does not overburden local water committees with excessive management requirements (Fuchs and Mihelcic, 2009).

The technologies employed in all six communities have very low water and energy footprints over their life cycle (ongoing research). Recovery of water, energy, and nutrients is a key consideration in any discussion of what makes a particular wastewater treatment technology sustainable (Guest et al., 2009). The water requirements of specific sanitation technologies ranges from 0 L/capita-day for a double vault urine diversion composting latrine to 2-10 L/capita-day for a pour flush toilet, to over 70 L/capita-day for a traditional flush toilet connected to a sewer (Fry et al., 2008). In Sapecho, the low level of water usage has limited the sewer's ability to transport solids. Thus, a second gravity flow water supply system that consists of a mountain springbox connected to a several km long transmission line is being considered to improve operation of the existing sanitation technology. In this case, the low population density combined with the reality of financial and human resources required to construct and manage an additional water supply system cause the sanitation technology in Sapecho to be less appropriate. Importantly, because the majority of community residents work long hours as subsistence farmers in fields that can be far from their primary residence, the additional financial and human resources required of the community to support the existing technology, may be beyond their collective capacity.

Table 2 shows the project objectives along with traditional measures of performance, and additional measures of performance that integrate sustainability concepts into the project. In a typical case, the traditional measures of performance for environmental engineering might be focused on effluent quality of a particular treatment technology, the associated cost of treatment, and issues of worker safety. The additional measures of performance presented in Table 2 take into consideration social issues, e.g., specific measures of health, interface of humans with technology, community management and issues of governance.

Interestingly, if one was to base an assessment of the technology primarily on environmental indicators of improved water quality, nutrient recovery, and lowering the technology's energy footprint, the Sapecho sanitation technology would rate very well. It does an excellent job of improving human health, protecting water quality, and sludge from the anaerobic reactor is recovered and applied to a small garden located on the plant's property. In terms of energy use, facultative wastewater lagoons use wind mixing and photosynthetic algae to provide oxygen to the wastewater and our field measurements indicate the upflow anaerobic reactor produces gas which is 66% methane and has an average flow rate of 30.8 L/min, resulting in a potential energy content of 9.33×10^3 kJ/day.

In Bolivia, the student teams consist of U.S. and Bolivian engineering students. The U.S. students include doctoral students integrating the international experience with their dissertation research. They in turn mentor a group that consists of one U.S. undergraduate researcher and several undergraduate Bolivian students majoring in ecological engineering.
The U.S. undergraduate researchers are combining their research experience with an International Capstone Design course situated in Bolivia that takes place the following summer (Trotz et al., 2009).

Student feedback was solicited through a survey consisting of three parts, including multiple choice questions and two essay type questions (Trotz et al., 2009). Besides these topics, the last day assessment included additional questions to further evaluate the impacts of this research experience. Out of the 18 U.S. and Bolivian engineering students participating in the 2009 Bolivia Research Project: 89% believe that their understanding of sustainability issues related to household/community level increased over the course of the research program; 89% believe that their understanding of sustainability issues related to regional (e.g. watershed) level increased over the course of the research program; 78% believe that their understanding of sustainability issues related to global level increased over the course of the research program; 94% believe they have increased their research skills to solve sustainability problems; 83% believe their understanding of career options have increased; and 100% said they are more likely to continue their education because of this experience.

In terms of gaining a global perspective, one doctoral student commented that "for sustainable development to be a global partnership, it must include developed and developing people/communities, and the partnership should ensure mutual knowledge transfer." They went on to comment that they were "truly beginning to see a positive-impact cycle in the concepts of education, sustainability and diversity" because this research program "formally ties these concepts together, so students learn to do sustainable development in diverse environments."

A second doctoral student commented that "direct, practical learning deeply impacts students' thinking. Because they are immersed in the research projects, they are forced to understand the issues holistically. The emotional connections forged with their international team members, the work region, and the information they seek provokes both analytical and emotional analysis of the experience. Because of the significant time, energy and emotion invested in the project, students are more likely to view this as a formative experience and to apply what they have learned in the future."

FIGURE 2: Map of Guyana Showing Locations Where Research is Underway with WWF (Mahdia), Iwokrama International Center for Rainforest Conservation (Iwokrama), and Guyana Citizen's Initiative (Georgetown).

Table 3: Water quality in storage tanks (n = 42) sampled in April 2009 in 5 different coastal neighborhoods in Guyana.
Main water sources were: piped from main (64%), rain (31%).

pH	pH	Temperature (°C)	DO (mg/L)	Turbidity (NTU)	% with Total Coliforms	% with Fecal Coliforms
Range	5.1-9.5	27.1-41.8	1.0-7.0	10.3-20.2	48	12
Average	6.9	30.8	5.0	13.6		
Stdev	1.2	2.7	1.9	3.6		

Table 2: Traditional Measures and Sustainable Measures of Performance for the Bolivia Case Study

Project Objectives	Traditional Measure(s) of Performance	Additional Measures of Sustainable Performance
Assess water quality in household water storage containers	Water quality at end of treatment plant	• Impact of household water storage containers and storage practices on human health and water quality. • Economics of home treatment systems. • Effect of educational campaigns on household habits that influence health. Determine gender roles in household storage, treatment, and use. • Compare funding mechanisms for centralized government run water projects versus decentralized small scale community/household based projects.
Evaluate the impact of mercury use in small and medium scale gold mining	Quantity and environmental fate of mercury releases	• Compare mercury releases from human activities (mining and non-mining) that occur in two distinct geographical settings (Guyana and Florida). • Evaluate mercury releases related to regional and global issues of consumption and trade. • Assess reduction in human exposure to mercury through educational campaigns, workshops, and public policy. • Use Geographic Information Systems to evaluate land use changes that have resulted from mining and investigate best approaches to land restoration and recovery.

Case Study #2: Guyana

Guyana is situated between Suriname, Brazil and Venezuela on the northeastern coast of South America. We have been working along the densely populated low lying coastal region around the capital, Georgetown, as well as in the forested interior near Mahdia where small to medium scale gold mining is rampant (Figure 2). With a population of roughly 770,000, the major exports are sugar, gold, bauxite, rice, shrimp, rum, and timber. The country currently faces several environmental issues; for example, water pollution from untreated sewage and agricultural and industrial chemicals, improper solid waste management, and deforestation.

In developing countries like Guyana where democracy and governance remain focal points for agencies like USAID, partnerships with NGOs and civic organizations are crucial and seen as essential for local development (Trotz, 2008). Since 2005, we have developed education and research projects with several NGOs on projects that center around mercury use in gold mining communities (with WWF-Guianas and Conservation International-Guyana) and household water storage tanks (with Guyana Citizen's Initiative (GCI)).

Based on a 2002 census, 66% of Guyana's population receives water piped into their homes, dwellings or yard from either a public or private supply or from rainwater (Guyana Bureau of Statistics, 2009). This piped water is received primarily from the country's water authority, Guyana Water Incorporated (GWI). Inconsistent supply from GWI has led many people to invest in black 450-gallon polyethylene storage tanks which, if operated correctly, can provide water throughout the day even when the supply from the water main is low or zero. In general, ground level tanks are filled when water pressure is high and that water is pumped to an elevated tank where it is then distributed to the household. While these individual systems help to guarantee a more constant supply of water (and thus improve health through sanitation and hygiene), they increase the residence time of the water supply and may adversely impact water quality at the household tap. If not properly maintained and cleaned, these tanks could become breeding grounds for vectors that cause disease (Chadee and Rahaman, 2000). They may also affect the concentration of bacteria, heavy metals, and organics in the water supply (see references in Mihelcic et al., 2009).

In 2006, GCI received a grant from the Pan American Health Organization (PAHO) to implement community water projects in Guyana. This resulted in the construction of a tank system to collect city water when it was available and share it among households. Through a graduate research project, we partnered with GCI to determine water quality changes resulting from storage tanks and household practices. The goal of this ongoing project is to develop improved maintenance and treatment routines such as tank cleaning and disinfection and to improve the human interface with this technology. Student research includes water quality measurements,

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accessing public health records, and household surveys on water use, treatment, time and money spent on systems, hygiene practices, gender roles and access to information.

Table 3 summarizes water quality data from tanks in five coastal neighborhoods in Guyana. Twelve percent of tanks tested positive for fecal coliform, and 48% tested positive for total coliform with all of the fecal coliform cases coming from tanks filled with piped water supplied by GWI. Household surveys show that water from these tanks is used for various purposes, including drinking, and that point of use treatment varies by household and includes the addition of bleach, boiling and nothing. High tank temperatures, combined with very little cleaning over the tank lifetime (up to 20 years in some cases) could contribute to unwanted microbiological and chemical water quality with implications for human health (Batté et al., 2006). These tank systems (of varying composition and style) can be seen throughout the Caribbean and Latin America, and the concept of household intervention is similar to commercial point of use filters common in US households. Traditionally, engineers have been concerned with water quality at the treatment plant, however, studies from large scale distribution systems show that water quality changes are influenced by a variety of factors like residence time in the distribution system, water chemistry, disinfection processes used, breaks in the system, piping materials, and flowrate (LeChevallier et al., 1996; Bessner et al, 2002). This Guyana project shows that in addition to these very technical areas, engineers must also consider household practices and assess member roles in communicating information and setting habits. A recent example of this in the US is captured by Edwards et al. (2009) where a change in the utility's disinfectant resulted in increased lead levels seen in some Washington D.C. households, and this was followed by the widespread distribution of filters and campaigns encouraging residents to flush tap water for 10 minutes prior to use for drinking or cooking.

Interdisciplinary teaming is critically important for implementation of sustainable projects. We formed interdisciplinary teams of graduate students from several disciplines: environmental and civil engineering, public health and geography. This led to a two-course sequence of graduate level classes that integrate teaching of sustainability with research using inquiry-based and experiential learning (Trotz et al., 2009). In Spring 2008, the course focused on "Mercury Issues in Tampa Bay" and, in Spring 2009, the course was "Mercury Issues in Guyana." The second course included a one-week field experience in Guyana for 10 students, two of whom also included the active gold mining area visited (Mahdia) for their graduate research. Students also visited a biodiversity conservation area whilst in Guyana.

In both classes, students gathered data needed to model this complex human/environmental system through population surveys to evaluate perceived risks from mercury exposure, the sampling and analysis of water quality and sediment samples for mercury loadings, and the collection of social and economic data related to mercury flows into and out of the study areas. In Guyana, previously funded efforts have been undertaken to improve mercury handling at mining sites and WWF-Guianas had recently initiated a vegetation recovery project at a mined out area. When we visited, land recovery efforts were minimal and there was evidence of releases of mine water to local waterways. Survey results are currently being analyzed for separate publication, however they indicate varying degrees of management and worker awareness and attention to handling of mercury at the five mines visited, though the mine managers and/or owners interviewed all stated that retorts were used during recovery to minimize mercury releases. Sediment and surface soil mercury loadings around the five mining sites studied ranged from 29 to 601 ng/g with differences seen between mines which could be attributed to mineralogy of ore and/or management practices. No significant differences were seen between average loadings in mining areas and conservation areas. Continuing work will look at appropriate interventions for improving health and reducing environmental impact of both mining activities and activities of forest communities in conservation areas.

Table 4 shows the project objectives, the traditional measures of performance and additional measures of performance that integrate measures of sustainability into the Guyana projects. For the water supply aspect, the traditional measure of performance is the water quality as the water leaves the treatment plant. Additional measures of performance include impact of storage, cost, education, funding and gender roles. For the mercury project, the traditional measure is the quantity and environmental fate of mercury released. Additional measures compare mercury releases in different areas, assess reduction in human exposure, and evaluate land use changes from mining and other activities given naturally high background levels.

In terms of educational value, one student commented during the assessment that "working [in] interdisciplinary teams did contribute to the learning of sustainability as it allowed for different perspectives to be highlighted that might have ordinarily been missed in a typical Geography, Public Health, or Engineering class. It also allowed [me] to see how different disciplines assess the same issue of sustainability."

Case Study #3: East Tampa, Florida

East Tampa is a diverse, historically African-American neighborhood located northeast of downtown Tampa (Florida). It encompasses approximately seven square miles, and has approximately 30,000 residents. Primarily residential, it is surrounded by interstate highways and has thirteen neighborhood associations, more than a dozen nonprofit organizations, several hundred small businesses and over a hundred churches. Thirty three percent of the population lies below the poverty line and 48.8% have less than a high school education. In 2004, the City established the East Tampa Community Redevelopment Area (CRA), a tax-increment district created to fund redevelopment of blighted areas and improve the community. Community leaders who serve on the East Tampa Community Revitalization Partnership (ETCRP) recommend ways to invest these funds and are personally involved in improving the quality of life for residents and businesses in the neighborhood.

One of the projects selected for fund-

FIGURE 3: Map of Florida Showing East Tampa and its Proximity to the Hillsborough River and McKay Bay.

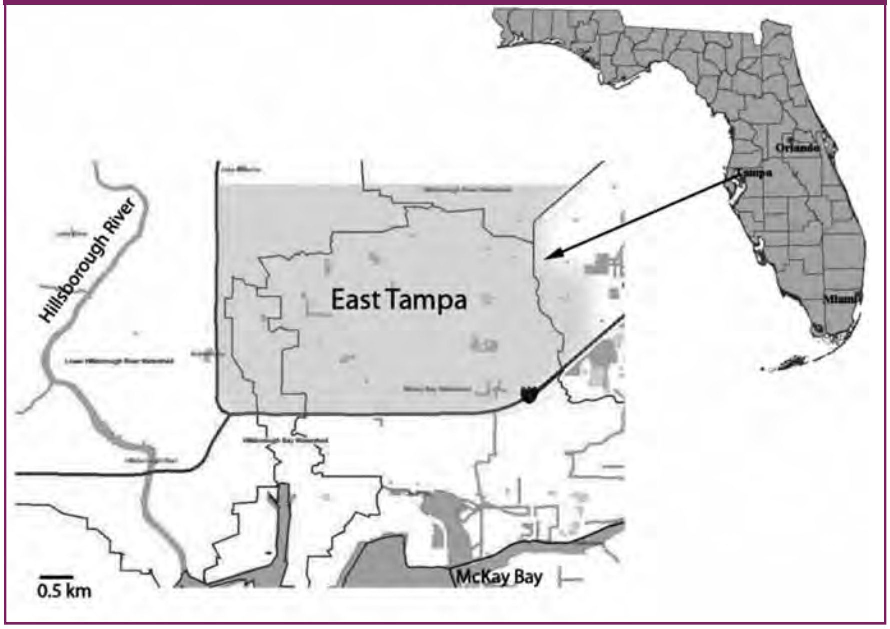

Table 5: Traditional Measures and Sustainable Measures of Performance for the East Tampa (Florida) Case Study.

Project Objectives	Traditional Measure(s) of Performance	Additional Measures of Sustainable Performance
Assess water quality in stormwater ponds	Performance of stormwater ponds in protecting water quality and dampening flooding	• Engage community in project development and implementation. • Monitor the effect of the stormwater beautification project on community health and happiness due to the use of new exercise paths and social gathering areas. • Mitigate effect of stormwater ponds on unforeseen habits like fishing and potential exposure to contaminated food sources. • Link project to students' own community and personal actions.
Investigate the impact of low impact development (LID) on stormwater runoff	Performance of LID in affecting quantity of runoff and resulting water quality	• Enhance technology diffusion associated with adoption of LID by low-income community Measure impact of LID on community health and happiness.

ing includes the beautification of 3 of the 31 stormwater ponds in the community. Many of the ponds were constructed in the 1970's for flood control with outfalls that drain either into McKay Bay or the Hillsborough River (see Figure 3). The beautification project was designed to address social issues, creating community friendly open spaces with exercise paths and seating areas. Stormwater ponds are vital for the control of floodwaters and reducing pollution loads reaching larger water bodies and many community awareness programs strive to reduce pollution in runoff from the built environment (Lehner et al., 1999). Through EPA-funded People, Prosperity and the Planet (P3) Phase I and Phase II grants, Water Awareness Research and Education in East Tampa (WARE) has helped to create a mechanism for building environmental awareness in East Tampa using the stormwater ponds as focal points for K-12, community, and university science and engineering curricula.

WARE includes educational, research and outreach components for both undergraduate and graduate students. Stormwater pond monitoring is integrated into a required upper level undergraduate environmental engineering laboratory each semester and involves the testing of water quality parameters of ponds in East Tampa and on the university campus (Thomas and Trotz, 2009). The data are used to explain various phenomena related to aquatic systems. In order to tie in issues of sustainability, students are placed in the context of the larger project which addresses community engagement and awareness of a local asset – something that all students can personalize given the widespread use of stormwater ponds in Florida and increased interest of students in their immediate surroundings.

Undergraduate and graduate research examines the effectiveness of the ponds in East Tampa on stormwater quantity and quality and the ultimate impact on Tampa Bay, and their data uses and extends the information collected by the undergraduate class. Dissolved orthophosphate concentrations have ranged from 0.8 – 1.7 mg/L and DO levels below 2 mg/L have been observed in some ponds. While connections between high nutrient loads and low DO are well understood, translating that into household practices that reduce nutrient inputs remains a challenge. Dissolved total mercury and copper concentrations were found to be less than 3 ppt and less than 5 ppb respectively, with up to an order of magnitude difference seen in copper concentrations between some ponds. Mercury loadings in sediments of the three East Tampa ponds ranged from 317 to 512 ng/g which is higher than loadings observed for sediments of the Hillsborough river (68 ± 18 ng/g for 18 different sample points) and could have implications for fish concentrations though this has not been measured in the ponds to date. The beautification process has increased access to the ponds and renamed them as community lakes which could encourage residents to fish there. The research students also interact with the local community through attendance at monthly community meetings, weekly classroom visits at elementary schools, local workshops, meetings with government agencies and annual outreach events. Finally, with the assistance of the community and university students, school science teachers are

Table 6: Fink's Taxonomy of Significant Learning (Fink, 2009)		
Category of Significant Learning	Description	Special Values
Foundational Knowledge	Understanding and remembering information and ideas	Provides the basic understanding that is necessary for other kinds of learning.
Applications	Skills, thinking (critical, creative, and practical thinking), managing projects	Allows other kinds of learning to become useful.
Integration	Connecting ideas, people, realms of life	The act of making new connections gives learners a new form of power, especially intellectual power.
Human Dimension	Learning about oneself and others	Informs engineers about the human significance of what they are learning.
Caring	Developing new feelings, interests, values	When engineers care about something, they then have the energy they need for learning more about it and making it a part of their lives. Without the energy for learning, nothing significant happens.
Learning how to Learn	Becoming a better student, inquiring about a subject, self-directing learners	Enables engineers to continue learning in the future and to do so with greater effectiveness.

developing curricula for their classes. Hence, while a traditional outcome might be improved water quality entering the bay, this project shows that other measures include community awareness and reduced exposure to potential hazards (e.g. mercury) through personal activities (fishing for consumption).

The group is designing educational kiosks for the pond areas that will increase community awareness. Although the ponds are required for controlling stormwater, low impact development (LID) strategies like pervious pavements, green roofs, rain gardens, and rainwater collection have additional potential to reduce stormwater runoff and pollutant loads. Pilot projects testing these strategies have been proposed for future research and their success will depend on the participation of the community members.

Table 5 summarizes some of the additional measures of sustainable performance for current and potential WARE projects which expand the traditional educational and research components of university training. In this case study the traditional measures of performance are related to protecting water quality and dampening the impact of wet weather events on local flooding. Additional measures of performance include linking students involved with the projects with their own personal actions and communities, assessing creation of green space on sustainability social indicators such as community health and happiness, and integrating the community into development and implementation of the project.

The graduate students involved with the WARE project were asked how it influenced their PhD research and career plans, especially in terms of thinking about sustainability. One student said, "The WARE project has reinforced my belief for environmental justice along with the importance of environmental awareness and community involvement. By promoting and implementing sustainability initiatives at the household level, residents can collectively reduce environmental health effects seen in their community. This notion is important in my research in household water treatment and environmental health." Another student said, "When examining my career goals, I wish to encourage our youth to develop healthy lifestyles through fitness, education, and environmental stewardship. Through my participation in the WARE project, I have been able to effectively communicate concepts that may seem complex to a variety of audiences and recognize the importance of education and engagement starting from students at the primary level who effectively convey information to their home environments."

IMPLICATIONS FOR ENVIRONMENTAL ENGINEERING EDUCATION

The creation of the Environmental Engineering BOK (AAEE, 2009) is a major milestone in integration of sustainability into environmental engineering education and practice. Also important are AAEE's efforts to create a new certification category in sustainability. Importantly, the BOK identified that environmental engineering problems must meet social needs and be sensitive to global implications. The BOK asserts that the document is not static. And thus, the development of the BOK is best considered a continuous process of testing and improvement. The authors of the BOK suggested that as it was implemented, "practitioners and educators evaluate it and determine whether all issues necessary to the practice of environmental engineering have been addressed and whether the outcomes can be achieved at the level recommended at the point in professional development indicated." Though discussed in some of the case studies, our discussion of sustainability would not be complete without additional discussion of how environmental engineering education must be continuously improved to meet the challenges of local and global sustainability.

In the Environmental Engineering BOK (and other BOKs such as ASCE's, (2008)), learning outcomes are broadly classified as either: 1) fundamental (related to abilities in science, mathematics and areas of discovery and design), 2) essential to the problem-solving process, or 3) professional skills (knowledge and attributes needed to be a successful engineer). In an NSF research grant related to integrating sustainability into environmental and civil engineering curriculum, Zhang et al. (2008) propose that Fink's Taxonomy of Significant Learning (Table 6) is highly relevant to learning concepts and goals of sustainability. Fink's taxonomy asks the educator and student learner to take foundational knowledge and apply it to critical, creative problem solving while integrating social system concepts. The taxonomy also acknowledges that to learn, students must change. This emphasis on change is very important because achieving a –sustainable future will require that our discipline change how we educate, learn, and practice environmental engineering.

Typical educational learning outcomes are based on foundational knowledge; the understanding and remembering information and ideas and application of this knowledge (that is, skills, creative and practical thinking, and managing projects). Adding the learning outcomes of caring and a human dimension is critical if a balance of societal issues is to become inherent in all environmental engineering education and practice. Caring means that students develop new feelings, interests, and values. The human dimension means learning about oneself and others. To meet the need for educational resources that adopt this new method of learning, a new introductory text for environmental engineering (Mihelcic and Zimmerman, 2010) includes foundational concepts and applications of sustainability, and also includes learning objectives in each chapter that address caring and a human dimension.

Related to the case studies presented here, creating a human dimension and empathy in engineering problem solving is critical to achieving a balance of sustainability that integrates environmental, social, and economic systems. Accordingly, those engaged in sustainable design, where conditions and definition of success may change with time, geography, and culture, will have to continually adapt their designs to new information and often generate new, innovative solutions for a particular situation.

SUMMARY AND CONCLUSIONS

Sustainability is often practically interpreted as mutually advancing the long-terms goals of economic growth, societal prosperity, and environmental protection. However, traditional environmental engineering education, research, and practice has not always emphasized the *global implications* of a specific engineering solution or provided an integrated and balanced social component and human dimension with environmental and economic considerations. Three case studies (Bolivia, Guyana, East Tampa) were presented that show how traditional measures of performance (e.g., function, economics, safety) can be enhanced with integration and balance of societal needs and a global outlook. In the Bolivian case study, appropriate sanitation technology was identified to make minimal demands on human/financial/natural resources, not overburden local water committees, have a negligible energy and water footprint, and be easy to integrate with substantial training of beneficiaries and operators. In the Guyana case study, coupling water quality assessment at the household level with household dynamics and practices were identified as important initial steps to understand potential health implications and interventions needed to improve potable water quality. An interdisciplinary systems level approach was taken to understand the complex human/environmental system dynamics affecting mercury use and human exposure in a developing country and highlighted the need for further work on land use changes on human exposure to mercury. In the East Tampa case study the traditional measures of performance such as protecting water quality and controlling water quantity during storm events were linked to personal actions of students involved with the project in relation to their own communities, the assessment of urban green space creation on sustainability social indicators such as community health and happiness, and the engagement of the local community into development and implementation of the project.

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