A Vision for the Future –

Summary from the Colloquium to Celebrate Fifty Years of Environmental Engineering

By

C. Joseph Touhill, Ph.D., P.E., DEE
President, Touhill Technology Management
Jamison, PA
and
Nicholas L. Clesceri, Ph.D., P.E., F.ASCE
Professor Emeritus of Environmental Engineering
Rensselaer Polytechnic Institute
Troy, NY

Introduction

On March 29, 2005, "A Colloquium to Celebrate Fifty Years of Environmental Engineering" was held at Rensselaer Polytechnic Institute (RPI). In addition to RPI, the Colloquium was co-sponsored by the American Academy of Environmental Engineers (AAEE) and the Association of Environmental Engineering and Science Professors (AEESP). The date was chosen to coincide with the fiftieth anniversary of the day that RPI's Committee on Environmental Engineering submitted their report to the Dean of Engineering recommending initiation of a curriculum in a new discipline termed "environmental engineering". Later that year on October 21, 1955, the American Academy of Sanitary Engineers was incorporated. In 1973, the Academy became the American Academy of Environmental Engineers. The purpose of the Colloquium was to celebrate these two milestone events, and to recognize the leadership and dedication of Professor Edward J. Kilcawley in founding the new discipline.

A number of presentations were made that focused upon how the discipline was formulated and evolved in the early years of development. Some of the topics covered were:

- A chronicle of the efforts of RPI Professor Edward J. Kilcawley and his Committee on Environmental Engineering as they developed and implemented a bold curriculum to educate this new type of engineer.

- An explanation of the formation of AAEE and how it has reacted over the years to growing public awareness of the environment and the need to meet professional demands for technical excellence.

- A description of how other universities reacted to RPI's lead in developing the new discipline.

- A recounting of how the New York State Department of Health helped meet student needs at RPI and the role that these Department employees played in implementing New York State's Pure Waters Bond Act. These actions influenced establishment of the Department of Environmental Conservation – a model for environmental regulatory agencies in many other states.

- A discussion of the evolution of federal activities that led to the founding of the U. S. Environmental Protection Agency (EPA).

- A description of how professional societies addressed the changing role of engineers in other disciplines performing work to solve environmental problems.

- An examination of how sanitary engineering consulting firms reacted to the development and evolution of environmental engineering and science in meeting the changing needs of industry and government.

- An exploration of how industry moved from a reactive mode to a proactive one in addressing emerging environmental issues.

The Colloquium was concluded by complementing the retrospective views with some visions of where the profession may be headed as it begins the next fifty years. A conscious attempt was made to anticipate the AEESP education conference at Clarkson University in July 2005, the theme of which is "***Pushing the Boundaries: Making research and education in environmental engineering and science count***."

Dr. Charles R. O'Melia, Department Chair and Abel Wolman Professor of Environmental Engineering, The Johns Hopkins University, led a discussion of attendees to obtain a sense of some of the major issues that will capture the attention of environmental engineering professionals over the next ten to twenty years.

A panel provided ideas upon which the attendees could focus in order to help stimulate discussion. The presentations were made by:

- **Dr. Jong-In Han**, Assistant Professor of Environmental Engineering, RPI, who explored the emerging multidisciplinary approach to environmental biotechnology.

- **Dr. James Kilduff**, Associate Professor of Environmental Engineering, RPI, who presented issues to be addressed in an examination of environmental engineering curriculum reform to better serve future needs of the profession.

- **Dr. Patrick Brezonik**, Program Director, Environmental Engineering and Technology, National Science Foundation (NSF), who presented a view of environmental engineering research and education programs at NSF, with emphasis on **CL*EAN*ER** (Collaborative Large-Scale Engineering Analysis Network for Environmental Research).

After the panel presentations, Dr. O'Melia gave a vision statement of issues that he believed would guide the research, education, and engineering practice of the profession in the future.

This paper briefly highlights the presentations and associated discussions, and enumerates a number of thoughtful ideas on what areas will dominate the work of environmental engineers in both the near-term and long-term future. A summary statement that captures the sense of attendees and presenters is found at the conclusion of this paper.

Kilcawley's Vision

One way to test whether an idea truly is visionary is to examine the original concept in the context of current thought. Certainly the elapse of fifty years is a sufficiently long period to apply the test. The essence of Professor Kilcawley's vision is encapsulated by the definition of environmental engineering that he developed in 1955, together with Sol Pincus, a consultant and member of the founding RPI Committee on Environmental Engineering, and Dr. Robert Burden, The Rockefeller Foundation. This definition follows:

"Environmental Engineering is defined as that portion of the science of environmental control in which engineering is used to conserve and develop world's resources for the general well-being of man as measured by such indices as the absence of disease, comfort, convenience and productivity."

There can be no doubt that this definition is just as cogent today as it was more than fifty years ago when Kilcawley and his colleagues articulated it.

Good ideas that are implemented and have profound effects upon the world's resources and man's well-being are rare. This, perhaps, was Kilcawley's greatest accomplishment. He made it happen.

What's Past is Prologue

Professor Kilcawley saw a number of compelling needs that prompted him to visualize the new discipline. Among these needs were:

- The need to establish linkages between public health, natural resource conservation, and ecology.
- The need for a coordinated approach to mitigate the adverse impact of human actions on various environmental media.
- The need to react to the ability to detect contaminants at very low levels.
- The need to address growing public awareness and concern about the environment.

Not only were these crucial issues that led to the founding of environmental engineering, but also they were amongst the key issues that the Colloquium attendees cited in their present day look into the future.

Matter, Energy, and Waste

We saw it clearly for the first time in 1973, and even more so recently. Energy resources are crucial to the sustenance of developed nations and to the emergence of lesser developed ones. Only recently has the linkage between energy and materials as vital global resources been realized fully. When the public was asked in conjunction with millennium celebrations to cite the greatest accomplishments of engineers, they placed the diminishment of water-borne disease and the provision of reliable, safe water supplies very high on their list.[1] It is not unreasonable to believe that the provision of reliable, safe energy supplies will be high on the public's list over the next ten to twenty years.

Moreover, just as it is important to conserve and use water wisely, it is equally important to conserve and use energy judiciously. To sanitary engineers, their focus was oriented strongly toward water and wastewater management. And this is rightly so because these were the resources that required attention at the time. Now the job of an environmental engineer is to husband all resources; that is, matter and energy.

So how does waste enter into this equation? Here is an excellent definition of waste: **it is matter or energy that is not seen to have beneficial use**. The Second Law of Thermodynamics insures us that waste is inevitable. Our job as environmental engineers (short of repealing the Second Law) is to **modify** the form that waste takes, and to **distribute** the impacts so as to minimize adverse effects.

The modifications can be: 1) ***to make the waste more valuable***, 2) ***to make it more useful***, and 3) ***to make it easier to deal with environmentally***.

The distribution aspect is trickier, because adverse effects can depend upon who you are and where you are. For example, the question "Is incineration or landfilling better?", depends upon whether you live near the landfill or the incinerator; what the air quality is where you live; what your health situation is; and many other very good questions. Is it possible that we could make a case that incineration leads to an irretrievable loss of resources if you consider that someday landfills may be mined? We must recognize that in devising solutions to complex problems, we may conjure up very sophisticated, costly, and wrong answers.

The discussion above provides one framework under which environmental engineers can work in addressing critical issues of the future.

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[1] The National Academy of Engineering in publishing the twenty most important engineering contributions in the twentieth century noted that water supply and distribution was the fourth most important engineering contribution to society's well-being (http://www.greatachievements.org).

Global Water Needs

Population growth in developed countries has decelerated dramatically. For example, demographic studies have projected that in fifty years population will decline in Western Europe, with some countries having population in 2050 about half what it is today. Conversely, in Asia, Africa, and the Middle East major growth is expected. Water requirements for agriculture to feed these shifting population centers will be great. Moreover, based upon where population growth will occur, water supplies will not satisfy projected needs because many of the people will be in arid areas. Thus, water resource management will take on much greater importance in the future. Additionally, water quality and quantity concerns will be considerable, and the need to focus upon more rigorous water reuse will emerge. Desalting technology is expected to surge as water resources become constrained.

Global Communications

The ability to communicate almost instantaneously with any place in the world already has a huge effect upon how environmental engineers interact and accomplish work. Designs can be conceived on one continent and committed to plans and specifications on another in order to execute projects on yet a third continent.

A key challenge of the Internet will be to sort out useful information from that which is without foundation.

Use of the Internet to monitor and control environmental treatment facility operations remotely already is taking place. How to protect the security of these operations still is a question to be pondered.

Information management, decision sciences, and cyberinfrastructure will be foci for environmental engineers who intend to use powerful tools for communicating electronically.

Biotechnology

It seems odd to older environmental engineers that biotechnology is becoming recognized as a major growth area. Activated sludge treatment plants and composting have been utilized for a long time in environmental engineering. However, the fundamental knowledge base and the tools to expand this knowledge have been evolving dramatically in recent times. The outcome likely will be more refined use of biotreatment such as composting, anaerobic digestion, and other new techniques, to generate valuable biochemical products. Likewise, innovative bioremediation and phytoremediation methods will help to cure legacy waste problems.

Genetic manipulation, advanced biosensors, and microbial fuel cells were mentioned as potential fruitful areas for environmental research.

Nanotechnology

The great promise of nanotechnology applied to solution of environmental problems was cited by several Colloquium attendees. They also suggested that potential downsides of this technology have yet to be explored fully, and that there are concerns that need to be addressed.

Toxicity and Very Low Level Detection Methods

Detection of exotic chemicals and biota at very low levels does not necessarily make the discovered species dangerous; it simply permits us to have more information about their presence. Colloquium attendees suggested that models be developed to assess chronic low-level exposures to potentially harmful contaminants. It was observed that industry probably will form research cooperatives in order to do better risk assessments. Several people pointed out that efforts should be made to help the public and media understand the context and extent of risk from various levels of materials. Specific mention was made of the appearance of residual pharmaceuticals in public wastewater treatment facilities, and the implications of these residuals potentially appearing in drinking water supply sources.

Membrane Separation Technology

There seemed to be universal agreement amongst Colloquium presenters that membrane separation technology will have a very positive impact on environmental pollution control in the near future. It was acknowledged that great strides have been made recently in applying new technology, but there was optimism that new developments will be made at an accelerating pace. Membranes will play an important role in desalting.

Natural Organic Matter (NOM) in Water

Several people cited the need to work on NOM source reductions in water supplies and their removal and destruction in treatment systems. Specifically mentioned was the growing need to improve treatment technology for this purpose.

Safety and Security

Some participants pointed out the need to improve environmental designs by formally incorporating rigorous examination of process safety. There was an opinion that safety is an aspect of design that falls within the purview of the environmental engineer.

Statements were made that environmental facilities should be given the same kind of security scrutiny as that focused upon electric utilities and mass transportation.

Interaction with Others

A few commenters encouraged development of better techniques for academic and governmental interactions and cooperation, particularly at the state level. Others mentioned the need to work more closely with professionals from the social sciences, urban planning, sociology, resource economics, and information management and decision sciences.

CL*EAN*ER

CL*EAN*ER (**C**ollaborative **L**arge-Scale ***E***ngineering ***A***nalysis ***N***etwork for **E**nvironmental **R**esearch) was cited as an example of how to develop the scientific and engineering knowledge base for human-dominated large-scale problems in terms of complexity and spatiotemporal scale. Moreover, **CL*EAN*ER** could help to provide a model for developing comprehensive solutions to multimedia problems.

Curriculum Reform

There was an extended discussion of the need for environmental engineering curriculum reform. Two issues that have been discussed at length over the years continued to be warmly debated: 1) increasing the number of credit hours required for graduation, and 2) making the first professional environmental engineering degree at the Master's level. There was a strong discussion about the merits of cross-departmental curricula.

The Business of Environmental Engineering

Last year (2004), more than half of the environmental work in the United States was done by eleven firms, and nearly 80 percent was performed by the 50 largest firms. The past fifty years have seen a dramatic consolidation of consulting engineering firms. The regional "giants" of fifty years ago have been swallowed by international firms, and recently, multinational companies like General Electric and Siemens have begun acquiring water-related and other environmental firms. Therefore, it is reasonable to expect that the mix of entities hiring new environmental engineering graduates will be very different than it was just a few years ago.

Summary Statement

The following statement represents the authors' view of the consensus opinion of attendees at the Colloquium relative to some of the future directions of the profession as it enters its next fifty years.

- **In the future, environmental engineers must regard our responsibility as conservators of resources – both energy and matter. Additionally, we must see waste as matter and energy that is not used beneficially. Our job is to *modify* the form that waste takes, and to *distribute* the impacts so as to minimize adverse effects.**

- **Environmental engineers will be obliged to address the shifting requirements of water quality and quantity for all essential uses, especially agriculture. Water reuse and treatment for contaminant removal will be issues of increasing concern, and use of desalting technology will increase.**

- **A key task of environmental engineers in the future will be to learn how to plan and use a growing array of communication and computational tools. The Internet will continue to be a vital link for professionals in the field.**

- **Great advances in biotechnology are anticipated in the near-term and long-term future. Environmental engineers have an advantage of a sound base of prior knowledge, but must be alert to the rapid strides being made in new tools and techniques that will result in breakthroughs in innovative technologies.**

- **Emerging nanotechnology developments must be studied carefully to understand fully their potential and dangers.**

- **Study of the fate and effects of contaminants is expected to continue, aided by increasingly sophisticated modeling techniques. Risk management will become recognized more as it is apparent that priorities need to be established in the face of limited financial resources.**

- **There was a strong consensus among attendees that membrane separation technology will be an important treatment method in the future, including use in desalting technology to produce water in arid regions.**

- **Several people cited the need to work on NOM (natural organic matter) source reductions in water supplies and their removal and destruction in treatment systems.**

- **Process safety and environmental facility security are expected to become increasingly important to environmental engineers.**

- **Attendees encouraged better interactions between academia and government, and between technical and non-scientific disciplines.**

- **The National Science Foundation's CL*EAN*ER initiative likely will dominate environmental science and engineering research well into the future.**

- **Curriculum reform was the subject of a lively discussion. Colloquium consensus was that extensive commentary needs to be encouraged at the AEESP education conference at Clarkson University in July 2005.**

- **The trend toward consolidation of environmental engineering companies very likely will continue.**

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Colloquium Proceedings

The Colloquium program and formal presentations may be accessed through the Rensselaer School of Engineering Website:

http://www.eng.rpi.edu/50enve/