Connections

Department of Civil and Environmental Engineering

MICHIGAN STATE UNIVERSITY

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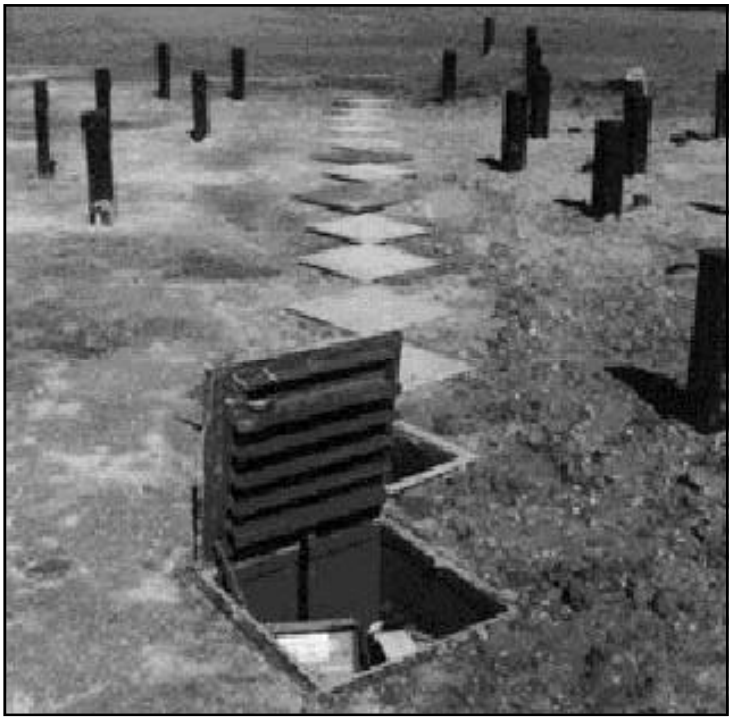
The Schoolcraft Project–Bioremediation Makes an Impact in Michigan

Most Americans still take for granted the safety of their drinking water supply. The case of Schoolcraft, Michigan reveals how vulnerable are those supplies and how environmental engineers, through hard work and good fortune, can fashion the technology to clean up a polluted aquifer. Schoolcraft is a small town about ten miles south of Kalamazoo, and it sits above the St. Joseph Aquifer from which it draws its drinking water. The discovery in 1986 of a toxic plume of carbon tetrachloride (CCl_4) in the aquifer set off a chain of events that generated a new technique for bioremediation at such sites. Apparently a quantity of carbon tetrachloride (a known human carcinogen) was used to fumigate corn in storage and subsequently leaked into the aquifer, creating a contamination plume approximately 1.6 km long and 60 m wide. Contamination was measured as high as 150 parts per billion (ppb), far above the maximum contaminant level of 5 ppb set by the EPA. Beginning in 1992, researchers from several universities, industry and public officials came together to launch the Schoolcraft Project, in which environmental engineers at Michigan State University played a central role.

Perhaps the real story of success at Schoolcraft began in 1988. At that point former MSU faculty member Craig Criddle was studying aquifer materials from various Department of Energy sites to search for microorganisms that might degrade carbon tetrachloride. As an afterthought, Criddle tested some material sitting in a bucket in the laboratory. Within two days there was no detectable carbon tetrachloride in the bottle containing this material. Nor was there any chloroform, normally an undesirable byproduct of degrading carbon tetrachloride. He had isolated a new strain of *Pseudomonas stutzeri*, which he named *Pseudomonas stutzeri KC*. This discovery proved

(continued on page 2)

Also in this issue...



This photo captures a surface view of the biocurtain, with a line of extraction and injection wells flanked by monitoring wells. (Courtesy of Mike Dybas)

The Schoolcraft Project (continued from page 1)

to be the key to a major advance in using bioaugmentation to clean up a polluted site. Ironically, Criddle did not think his discovery would have much practical use. He felt it would not be able to compete with native microorganisms.

Enter Mike Dybas, a microbiologist and current project manager. Mike demonstrated that maintaining the pH around 8 also improved the ability of *Pseudomonas stutzeri KC* to compete with native microorganisms.That discovery raised the possibility of creating and sustaining a zone in which *KC* could work its magic. Mike, along with Greg Tatara, identified a molecule secreted by *KC* that actually transformed carbon tetrachloride. So these researchers had developed a good understanding of the basic conditions necessary for *KC* to work.

It was about this time that Tim Mayotte, of Golder Associates, made the MSU researchers aware of the problem at Schoolcraft. Bench-scale studies proved that strain *KC* could colonize Schoolcraft sediments. State regulators approved a pilot-scale project, and, despite some problems, the results suggested that *KC* might work.

The key issue at this point was how to design an efficient delivery system for placing *KC* across the plume and maintaining its activity over time. The answers came from professors David Hyndman and David Wiggert, whose computer modeling suggested that a gallery of injection and extraction wells spaced about one meter apart would do the job. This design was called a "biocurtain."

Some Helpful Definitions

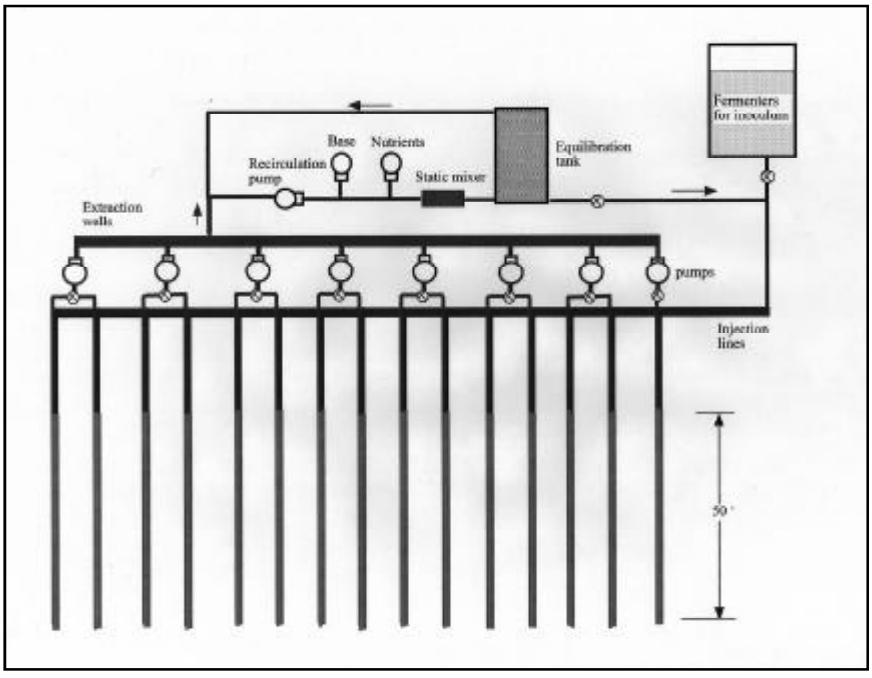
aquifer–an underground formation saturated with water.
bioaugmentation–a type of bioremediation that uses nonnative microbes to clean up toxic wastes.
biocurtain–a series of closely spaced wells designed to span an aquifer and intercept polluted water with a colonized zone of biodegrading microbes.
bioremediation–the process of cleaning up toxic waste by adding microbes that remove or neutralize the toxic substances.
carbon tetrachloride (CCl_4)–a hazardous compound used in manufacturing, cleaning and fumigation. The current regulatory limit for carbon tetrachloride is 5 parts per billion (ppb).
pump and treat–a conventional process for cleaning polluted aquifers by non-biological methods, such as air stripping or chemical treatment, and returning water to the aquifer. (Adapted from http://www.egr.msu.edu/schoolcraft/glossary.htm)

The Schoolcraft project is now in its full-scale remediation phase, and it is proving more efficient than conventional pump and treat processes at reducing contamination levels to <5 ppb. Schoolcraft Project researchers are now studying the application of this technology to recently discovered plumes contaminated with arsenic and with chromium. For more information on the Schoolcraft Project, contact *schoolcraft@egr.msu.edu.*

A Schematic of the Biocurtain Used in the Schoolcraft Project (Courtesy of Mike Dybas).

The search for a feasible method of delivering *Pseudomonas stutzeri KC* to the contamination plume led to the design of the biocurtain seen in this schematic.The gallery of extraction and injection wells comprise the structure of the biocurtain—along with the recirculation pumps and tanks used in the effort to control pH and nutrient levels and to maintain the population of *Pseudomonas stutzeri KC* within the active area of the biocurtain.

The wells were spaced about one meter apart across the advancing edge of the carbon tetrachloride plume. A series of upstream and downstream monitoring wells complete the design. Computer models had predicted that this design would be effective in the field, and it proved to be exactly that.



Civil Infrastructure Laboratory Receives Major Gift from the Granger Family.

Alton and Janice Granger (c) receive a plaque marking their induction into the Frank S. Kedzie Society. MSU President Peter McPherson (l) and Dean of the College of Engineering Janie Fouke (r) represent the university. (Photo by Bruce Fox).

The Civil Infrastructure Laboratory received a major boost recently through an unrestricted gift of $500,000 from Alton L. Granger (B.S. '54) and Janice M. Granger (B.S. '90). Mr. Granger is Chairman and CEO of Granger Construction Company, a full-service construction enterprise with headquarters in Lansing, Michigan.

Begun as Granger Brothers Construction in the 1930s, the company has witnessed some of the most dramatic changes in the construction industry. Mr. Granger feels that a number of forces highlight the importance of the work to be undertaken in the Civil Infrastructure Laboratory. The trend toward "design and build" and the competitive nature of the industry have pressed the need for ever more efficient uses of materials. In addition, he feels that student engineers need a facility that will better prepare them to understand the properties of the materials they will employ on the job.

The Granger family has a distinguished history of support for Michigan State University. The Grangers recently pledged $500,000 to MSU's College of Nursing, where Janice Granger is a member of the Board of Visitors.

Department News

Professor Mackenzie Davis was recently featured in an *MSU Today* article anouncing a major water research facility in Grand Rapids. Michigan State University is part of a consortium of entrepreneurs, scientists, academic institutions and the community that will convert Clearwater Plaza (the former Monroe Avenue Water Filtration Plant) into the Global Enterprise for Water Technology (GEWT). This facility will fill a global need for a place to test new water treatment technologies, as well as ways to redesign existing treatment plants.

The CEE department participated in a college-wide external review of graduate and research programs. Fifteen distinguished reviewers visited the college on October 1-3, 2000. These individuals received self-studies and strategic plans for each department, met with faculty and graduate students, and wrote a report that should assist departments in improving their research and graduate programs. CEE department reviewers were: Professor Debbie A. Niemeyer, Department of Civil and Environmental Engineering, University of California-Davis; Professor Robert L. Smith, Department of Civil Engineering, University of Wisconsin-Madison; and Professor Kenneth J. Williamson, Head, Department of Civil, Construction and Environmental Engineering, Oregon State University. More details on the review will be published in the spring newsletter.

Lab Notes

- In August the MSU Board of Trustees approved construction of the Civil Infrastructure Laboratory. S&J Enterprises, Ltd. received the contract for construction and began work in September. Site preparation and pouring of the foundation were completed before winter set in. The estimated completion date is early fall in 2001. A ribbon-cutting ceremony is planned when the laboratory is ready for use.

- In recognition of the substantial gift provided by Mark Young (BS '75, MS '77), the conference room of the laboratory will be named the Ferrantino-Young Conference Room.The department deeply appreciates Mark Young's gift and hopes it will stimulate others to consider naming opportunities through gifts of $25,000 or more. In addition, gifts of $10,000 or more will be prominently recognized on a plaque placed at the entrance to the laboratory. Alumni, associations, companies and friends are invited to participate in this program. For more information please contact Kris Bradley, senior director of development, College of Engineering at (517) 355-8339.

Alumni News

Alumni Profile: Mark Young, P.E.

Mark (BS '75, MS '77) is a project manager with Seiber, Keast & Associates, Inc. of Novi, Michigan. Seiber, Keast & Associates is an engineering design firm, providing civil engineering and permitting services to residential, commercial and industrial developers in the private sector. As project manager, Mark coordinates the preparation and timely delivery of design documents, and serves as the client's representative in matters concerning public agencies. Mark joined Seiber, Keast & Associates in August 1996, following 22 years as a geotechnical/environmental engineer and engineering manager. He is a licensed professional engineer in California, Illinois, Michigan and Ohio.

Beginning with this issue, we will feature alumni who have been especially active in supporting the department. Mark Young is past chairperson of the department's Professional Advisory Board and has been a notable contributor to the department on many fronts.

Q: What motivated you to become a member of the department's Professional Advisory Board?

In 1992, I served on the Alumni Board for the College of Engineering, which led to the creation of department-level boards of visitors. Over the years we have worked with CEE staff, faculty and students to see how we can be most helpful to the department. In the end, I wanted to serve on the CEE-PAB because department members sincerely wanted our assistance on a variety of matters, and I wanted to help in any way I could.

Q: What do you envision as the PAB's role in the future?

I believe the CEE-PAB can increase CEE alumni participation in helping the department achieve its goals. We have made significant progress in understanding the challenges facing the department, and in conceiving action plans which can bring CEE alumni to bear on these problems. The Professional Advisory Board envisions an "alumni network" through which information about department issues and needs can be swiftly disseminated. We want alumni to know that their involvement and support mean a great deal to the success of the department. Small contributions of opinion, time and money–when multiplied–can have a huge effect on the ability of the department to fulfill its various objectives.

Q: What issues do you see as being crucial in engineering education? How have these issues changed since you were a student at MSU?

I believe keeping students current with emerging technology is critical. Michigan State must strive to offer its students an education utilizing the latest technologies. The alumni network can assist by providing information to the department and its students concerning the professional environment, the tools and skills currently utilized or needed by engineers, and the direction of the profession. Perhaps most startling from the standpoint of change is computing. As a student, many of my assignments involved card punching; however, it was only a few years after graduation that I had punched my last card. Conversely, a particularly strong aspect of my education at Michigan State has not changed very much at all: collaboration. Spartan engineers always seem to distinguish themselves by their ability to work well with others. This skill is in demand now as much as ever. There is nothing that we undertake which is not done for or through other people. Indeed, it is our calling—civil engineering.

Q: What is the most rewarding aspect of your career in civil engineering?

Managing civil projects gives me a chance to learn more about the development process, and to facilitate accommodation and cooperation among concerned parties. There is a lot of satisfaction in watching a project come to fruition, particularly when you've participated from an early stage and appreciate how much difficult ground was covered to arrive at the approved project. Best of all is getting to the conclusion with the parties feeling good about the result.

Q: What advice would you give students who are preparing for careers in civil engineering?

I would remind students that much of what they will learn in their studies is our technical craft, but engineering practice involves much more than mastery of this realm. Engineering is a service profession. It's important to remember the business, communication and people skills needed to optimize the value of our work. I suggest that students complement their engineering studies with courses from these areas. I would also remind students that engineers have many roles to play in design and construction. If possible, they should try to get some cooperative education experience in engineering, which offers students a glimpse of the professional world and helps them discern more satisfying positions within it.

We've Heard From...

James D. Richey, P.E. (BS '84) is currently vice president of the Texas Division with Petsche & Associates, Inc., an engineering consulting firm specializing in large master-planned communities. *Email: jdrichey@aol.com*

Michael J. Thelen, P.E. (BS '91, MS '92) is an Associate of Soils and Materials Engineers, Inc. in Lansing, MI. He recently co-authored a paper entitled "High Capacity Drilled Cast-in-Place Piles," which was presented at the Deep Foundation Institute 2000 conference. *Email: michaeljth@aol.com*

Jim Grant, P.E. (BS '92, MS '94) is senior project engineer/ associate at NTH Consultants, Ltd. He specializes in environmental issues related to property transactions, investigations and redevelopments. Jim was named Young Engineer of the Year by the Michigan Section of the American Society of Civil Engineers (ASCE). *Email: jgrant@nthconsultants.com*

Mohammed Jamal Khattak (MS '95, PhD '99) has joined the Dept. of Civil Engineering at the University of Louisiana at Lafayette as an assistant professor. *Email: mxk0940@louisiana.edu*

Kyong-Ku Yun (PhD '95) is an assistant professor at Kangwon National University in Chunchon, South Korea. *Email: kkyun@cc.kangwon.ac.kr*

Jeremy M. Rasmussen (BS '96, MS '98) is a project engineer at SECOR International, Inc. Jeremy was married in August 1999. *Email: jrasmussen@secor.com*

Scott Greene (BS '99) is a bituminous mixtures and materials engineer at the Michigan Department of Transportation (MDOT). Scott is involved with all hot mix asphalt projects in the state at some point. He also serves on advisory committees for MDOT funded research. *Email: greenesgc@netzero.net*

Events Calendar

–**West Michigan CEE Alumni Gathering,** February 8, 2001, 5:30 p.m., Grand Rapids, location to be annouced.

–**South-East Michigan CEE Alumni Gathering**, March 22, 2001, 5:30 p.m., NTH Consultants Office, 38955 Hills Tech Drive, Farmington Hills.

–**CEE Alumni Dinner,** May 11, 2001, 6:00 p.m., Kellogg Center, MSU.

For reservations or information, please contact Linda Steinman at (517) 355-5107 or steinman@egr.msu.edu

A Gathering of Geotechs....

Tom Wolff, Glen Anderson, Gilbert Baladi, Bill Marcuson III, and Orlando Andersland gather prior to Bill's ASCE Terzaghi lecture at MSU this fall.

Share Your News

Throughout *Connections* you will read about what faculty, students, and other alumni are doing. We want to hear YOUR news as well. Fill out the form below and send it to us—we'll include your news in the next issue.

Name

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City, State, Zip

Home Phone Business Phone

Degree(s) and Year(s) of Graduation

Job Title

Employer

News about your work, family, achievements

You can also complete this form on the department's Web Site at http://www.egr.msu.edu/cee/alumni/alumniup.html

Focus on Research

Dr. Syed Hashsham joined the department in August of 1999 as an assistant professor working in the environmental engineering group. He had previously been a research associate at MSU (1996-98).

Q: How would you define the specific subject of your research? Where does it fit within the larger scheme of related research?

The emerging field I am interested in may be called "environmental genomics." It is the area of genomic research that is targeted to solve environmental problems—from assessing the rate of natural attenuation of a contaminated aquifer to detecting all known air and waterborne pathogens in a single test. The field is driven by recent advancements in the field of sequencing and in high-throughput analytical techniques such as microarrays.

Environmental genomics reaches across the research community. Researchers interested in developing human gene therapy, increasing plant and animal productivity, managing microbial ecosystems and reactors depend on it. Environmental scientists and engineers will find it to be one of their main tools in the near future. I depend heavily on these techniques in my proposals on biocomplexity (submitted to NSF) and natural attenuation (funded by EPA). Other researchers are using it to develop strategies for maintaining water quality and to combat bioterrorism.

Q: What are the implications of your research for your area of engineering? What might be the practical payoffs?

It means that engineers working with microorganisms will need to develop a deeper understanding of molecular microbiology and bioinformatic tools. There will be many more interactions with mainstream researchers in these areas (microbiologists, geneticists, and computer scientists). There are practical payoffs from this research. For example, determining the rate of natural attenuation in contaminated groundwaters is critical to determine risk and to decide remedial actions. If successful, my research may help to reduce cleanup costs and health risks by providing decision-makers with better information. Another payoff (from research being done elsewhere) will affect the techniques used to detect pathogens. At present, a test for a single pathogen in drinking water may cost hundreds of dollars. When developed, these techniques may be useful to detect thousands of pathogens (and non-pathogens) in a single test at a fraction of the cost!

Q: What drew you to this subject and why is it attractive to you personally? Are you pursuing this research with colleagues?

This subject entices researchers in many different fields because of its power for study of gene expression that previously would have taken years—and that with limited potential of success. For example, it is now possible to know the expression levels of all the four or five thousand genes that a bacterium has just by conducting a single test. This was not possible before. Personally, I find it exciting to observe the ongoing merger of biology, computer science, ethics, health sciences, and the environment.

My colleagues include James Tiedje at the Center for Microbial Ecology, Craig Criddle at Stanford University, Daphne Stoner at Idaho National Engineering and Environmental Laboratory, and Lutgarde Raskin at the University of Ilinois at Urbana.

Q: How long have you studied this subject and what is the current status of your research? What special or interesting problems have you encountered?

I started working in this area during my post-doctoral work at Stanford University in 1999. I have established a cDNA microarray facility at the Engineering Research Complex here. One post-doctoral student, two doctoral students, and two undergraduates are currently studying environmental problems—including proof of gene expression during bioremediation, quantification of single population biomass in mixed microbial systems, whole genome expression of methane- and ammonia-oxidizing bacteria, etc.

From the experimental results obtained until now, I would say that the presence of mixed microbial populations and lower mRNA signals are the two key issues for environmental applications. The microarray technique was originally developed for *pure* cultures. I am now working on approaches to modify the technique to make it suitable for *mixed* cultures.

Q: What might be the future direction of your research?

Once the technique is modified to be useful for mixed cultures, it has many applications involving mixed microbial populations. Environmental engineers have their hands full with mixed microbial populations and the problems encountered in mixed communities are also well known: filamentous bulking in activated sludge, anaerobic digester failures, phosphorous removal, bioremediation, mixed community management are some of them.

Focus on Outreach

Highway Traffic Safety Programs (HTSP) – A Continuing Education Opportunity

HTSP will offer six new classes/workshops during the 2000-2001 outreach training cycle. An Introduction to the Michigan Vehicle Code will be offered in mid-March. This class will provide a basic understanding of the vehicle code, especially as it relates to Michigan's traffic laws. It will also discuss the relation of the vehicle code to the *Michigan Manual of Uniform Traffic Control Devices* and the *Uniform Traffic Code for Cities, Townships, and Villages.*

A class/workshop on roadside design/safety will be held twice during May. An Introduction to Roadside Design/ Safety will cover topics based on the *American Association of State Highway and Transportation Officials' Roadside Design Guide*. This class will examine an assessment and design of roadside conditions; the selection, location and design of roadside and median barriers/guardrails; and crash cushions and bridge railings. Other topics include clear zone concepts, unsafe roadside features (along with appropriate recommendations to address them), and the appropriate selection and placement of different types of traffic barriers. In the workshop that follows participants will apply the principles learned in the class.

An Introduction to Traffic Signal Design will be offered once in May. This class will examine how traffic signals are designed and placed and will include hands-on exercises.

Two hands-on computer classes on capacity analysis will be offered: An Introduction to Capacity Analysis and More Capacity Analysis Applications. These classes will be offered back-to-back in early June. The first class will concentrate on the three most popular models of highway capacity software: basic freeway segments; signalized intersections; and weaving areas. The second class will extend the knowledge gained in the first by covering the theory and applications for multi-lane highways, unsignalized intersections, and ramps/ramp junctions.

The two capacity classes will be held in a computer lab at Calvin College. All other classes will be held in the greater Lansing area. To learn more about our specialty classes or on-site training programs, please contact Tom Krycinski at 517-353-9782 or Laura Taylor at 517-353-1790.

Technical Outreach Services for Communities (TOSC) Assists Detroit-Area Citizens

At the request of southwest Detroit-area citizens groups, TOSC is reviewing an air emissions permit for a glass aggregate production/sewage sludge incineration facility to be built in Delray—a poor, largely minority community—on the old Detroit Coke site. The facility will replace several large, out-of-compliance incinerators, which burn waste generated by more than 4.5 million people (the largest such operation in the U.S.). University of Toledo Professor emeritus Gary Bennet leads TOSC's review, assisted by Diane Lickfelt and Jason Killian. Chief among citizen concerns is whether the plant will achieve its promised 95% reductions in particulates and air toxics. The Michigan Department of Environmental Quality has expressed strong support for this effort, including TOSC participation in a cumulative air risk assessment that the agency may conduct.

TOSC is also producing a manual: *Air Quality in Southwest Detroit, 1970-Present.* This manual will examine permitted facilities, air quality enforcement actions, air monitoring data (including trends in air quality), and ways that citizens can participate in state and federal air quality issues.

Student News

The Environmental Engineering Student Society (EESS) provides students with an opportunity to participate in various activities related to the environment. EESS also gives members access to professional organizations and contacts, service opportunities and field trips.

EESS offers its 40 members a chance to meet with faculty in the civil and environmental fields. Students in MSU's chapter also receive discounted memberships in the Air and Waste Management Association and the Water and Environment Federation.

Current members participated in the semi-annual community project known as Girl Scout Day, in which EESS members reach out into the surrounding communities and educate young girls about different aspects of water to assist them in earning their water wonders badge.

EESS members traveled to the Muskegon River to do water sampling and to Mason to learn about the recycling process of foam products at Dart Container Corporation. For more information about EESS activites, contact EESS president Therese Sutphen at sutphent@msu.edu.

How to Find Us

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