Final Report

Department of Civil and Environmental Engineering Equipment Grant

W.M. Keck Foundation

December, 2000

WPI

EXECUTIVE SUMMARY

The Keck Equipment grant, received by the CEE Department at WPI on July 1999 is clearly instrumental to a number of significant advancements. Physical renovations supported through WPI's Capital Campaign at a cost of $ 1.12 M for both the Highway Infrastructure Program laboratories and the Environmental Infrastructure Program laboratory have been completed. Two new equipment grants have been awarded to the HIP laboratory facilities totaling $ 131,500. Faculty members in both the HIP and EIP programs have submitted $ 2.4 M in research proposals and have received $ 0.8 M to date.

Two new positions have been added to the CEE Department staff for laboratory support (Laboratory Manager and a Part Time Secretary). A third position has been added to the CEE Department staff for research activity support (Asphalt Research Engineer). Two new tenure track faculty members with laboratory-based research experience have been added to the EIP group (Professors Plummer and Bergendahl). WPI seed money supplied with these new faculty is supplementing the Keck equipment grant and helping to further establish a state-of-the-art environmental research and teaching facility.

Faculty members in both the HIP and EIP groups are actively working to meet this new challenge and will continue to contribute to their respective fields for many years to come. Peer reviewed research papers and presentations at research conferences have been made as a result of equipment now available in these laboratories. A listing of these papers is presented in the body of this report. These new teaching and research facilities provide hands-on training and state-of-the-art research projects that were not possible before. New teaching programs (an asphalt training program and a unit operations environmental engineering course) have also been established as a result of this new equipment.

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PROGRESS

This document is the final report for the Keck Foundation equipment grant received by the Department of Civil and Environmental Engineering on July 1999. A summary of all equipment purchased is presented.

Along with the $ 0.5 M supplied through the Keck Foundation equipment grant, additional WPI start-up money totaling $ 129,730 has been supplied to the CEE Department for laboratory equipment that is now installed in the highway and environmental infrastructure laboratories. Recent equipment grants totaling $ 131,500 have been awarded by outside agencies to support these laboratories.

Related activities that are a direct result of the Keck Foundation equipment grant are outlined in this report. These activities include new staff additions, undergraduate and graduate student project plans, research proposal submissions and awards, and publications.

Equipment Purchased

As shown by Appendix I, the total purchases at the close of this grant period account for 100 % of the $ 0.5M awarded. Final delivery of one major piece of equipment (the Axial Servohydraulic testor) is being delayed until laboratory renovation details in the structural analysis area are complete. All other equipment is in the process of final shakedown operations or is actively being used for research projects. Both undergraduate and graduate research projects are in progress during this academic year to make full use of this equipment.

Other equipment purchases have been financed through new faculty seed money and other equipment grants. Appendix II summarizes these purchases.

As can be seen from Appendices I & II, the total equipment purchases over the last twelve months total to about $ 782,000.

Personnel Hired

Two WPI staff positions (one secretary and one laboratory manager) have been added to the Civil Engineering Department team to support new activities related to the EIP and HIP laboratories. A research staff position (supported through outside funding sources) has also been added. Table 1 lists these positions. Job descriptions and resumes of each person hired to fill these positions are presented in Appendix III and IV respectively.
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Table 1 - New Staff Positions for CEE Department

Name	Date Hired	Brief Job Description
Brenda May	Nov-99	Assist Faculty with Research Activities
Don Pelligrano	Jan-00	Oversee All Laboratory Operations
Matthew Teto	Jan-00	Asphalt Laboratory Research

Faculty Members Appointed

The Environmental Infrastructure Program has added two new faculty to their group. Both faculty are full time tenure track assistant professors. They are Professors Jeanine Plummer and John Bergendahl. Resumes of these new faculty members are shown in Appendix V.

Laboratory Renovations

The Civil Engineering Department Infrastructure Laboratories (HIP and EIP) have been completely renovated. The cost for this renovation significantly exceed the original estimate of $ 0.5 M by about $ 0.6 M, bringing the total cost to more than $ 1.12 M. Photos of these new renovations are shown in Appendix VI. Table 2 summarizes the costs for these renovations.

Table 2 – Summary of Renovation Costs

Description	Cost
General (supervision, clean-up, permits …)	$ 100,258
Architecture and Engineering Fees	$ 65,000
HIP Lab	$ 437,575
EIP Lab	$ 415,053
Common areas (hallway, bathrooms, shop …)	$ 106,510
TOTAL	$ 1,124,396

The original estimate for physical renovations was expected to match the Keck Foundation equipment grant. Spiraling construction costs and unforseen needs for building infrastructure upgrades, however, increased the total renovation costs. The final laboratory renovation cost is about 212 % of the Keck Foundation support. WPI,

therefore, has significantly exceeded the original projection to match the Keck Grant with renovation money.

PROBLEMS ENCOUNTERED AND HINDSIGHT

In most areas, this grant functioned smoothly and had minimal impact on the normal operations of the department. Laboratory renovation during the summer period when student populations and teaching activities were low was successful. Weekly meetings with the architect and the contractor throughout the renovation period were very useful and avoided many unforseen problems. During the renovation periods, new equipment was received and set-up at other areas with little difficulty. Large equipment such as the Atomic Absorption Spectrophotometer and the Instron Testor could not be set-up in temporary locations however. Late installations of these devices could not be avoided.

Early estimates of infrastructure support needs for much of this new equipment were underestimated or not well known during the proposal writing stage of this project. This is a main reason for the delay in final installation of the Instron Testor – which was found to require a cooling unit for long term operation. Initial plans were to use water for this cooling, but it was later discovered that discharging cooling water to the city sewer system was not allowed (although this practice is still used by many facilities, new installations must comply with new regulations). Likewise, the Atomic Absorption Spectrophotometer was also found to require a separate cooler device for the same reasons. Luckily, the cooler was supplied with the analyzer by the supplier as a new introductory offer.

ADDITIONAL SUPPORT RECEIVED

Appendix VII lists recent proposals that are directly related to laboratory facility use that have been submitted by the EIP and HIP Faculty since the Keck Grant award As can be seen, the total proposal submissions this period is about $ 2.4 M.

Table 3 lists recent grants directly related to laboratory facility use that have been awarded to the HIP and EIP Faculty since the Keck Grant award. The total grants awarded during this period is about $ 0.8 M.

It is expected that this level of support will continue or will increase (with increased EIP activities) in the future.

Table 3 – Funded Projects

Project Title	Faculty	Sponsor	Amount
Oxidation Reduction Potential Versus Residual Control of Chlorine	J. Bergendahl	D.Williams Assoc	$30,000
Evaluation of Properties of Subsurface Soils and Reclaim Base Material	R. Mallick	MEDOT	$26,000
Lab & Field Experience Based Course in Asphalt Tech.	R. Mallick	NSF	$31,479
Evaluation of Use of Manufactured Waste Asphalt Shingles Hot Mix Asphalt	R. Mallick	UMA	$40,749
Development of a Rational and Practical Mix Design System for Full Depth Reclamation	R. Mallick	UNH	$141.50
Evaluation of Permeability of Superpave Mixes	R. Mallick	UMA Dartmouth	$49,723
Design Alternatives for the Weak Post W-Beam	M. Ray	Bucknell	$43,929
Center of Excellence in Dyna3d Analysis	M. Ray	DOT	$50,000
Recommended Guidelines for Curbs and Curb-Barrier Combinations	M. Ray	NAS	$300,000
Acquisition of Structural Mechanics Testers	M. Ray	NSF	$100,000
Development of an Improved Roadside Barrier System	M. Ray	UWVA	$60,792
Side Impact, Finalizing the Test Procedures and Preliminary Countermeasures	M. Ray	Uiowa	$68,291
Waste Minimization in Food Production	J.O'Shaughnessy	Decas.Cranb.	$6,000
		TOTAL	$807,105

IMPACTS OF THIS GRANT

As noted in the above sections, both the EIP and the HIP faculty groups have been very active in their teaching and scholarship activities since the start of this grant. The new equipment supplied from this grant and the newly renovated laboratory facilities supported by WPI as a matching investment to the grant, are significant reasons for this level of activity. Specific scholarship capabilities resulting from these new facilities are as follows:

- Dynamic structural analysis capabilities, including fatigue testing and impact testing
- Organic measurements in water and wastewater at low concentrations
- Inorganic measurements in water and wastewater at low concentrations
- Microbiological testing in water and wastewater
- Asphalt production testing
- Dynamic testing of asphalt materials
- Environmental impact testing of asphalt materials

The two new teaching initives noted above are also only now possible because of these new facilities. Both of these new teaching initiatives require use of the measurement testing capabilities listed above.

At a wider scale, these new facilities impact prospective students and their parents, accrediation reviewers, prospective faculty and staff and the entire undergraduate and graduate student population. Influences range from a non-tangible sense of pride to the tangible improved analytical capabilities which will open opportunities for scholarship and teaching activities that have not be available before.

RELATED ACTIVITIES

Publications and Presentations

Appendices VIII and IX list publication and presentations made since July 1999 by faculty in the HIP and EIP groups. As can be seen, the topic matter in these listings is closely related to laboratory based studies. With the addition of equipment supplied through this grant, these type of studies will clearly continue and expand.

New Teaching Initiatives

Two new teaching initiatives have developed as a result of new equipment added to the EIP and HIP laboratory facilities.

- An Asphalt Technology Course
- A Unit Operations/Process Environmental Laboratory Course

A field and laboratory based coursework in asphalt technology was developed with the help of a grant from the National Science Foundation. The objectives of this project are to provide the undergraduate students with tools for field experience in asphalt pavement construction, including quality control techniques, and to teach concepts of statistical quality control through analysis of real time quality control test data. As part of the field and laboratory work for this newly developed course, students used testing equipment in the field and analyzed data with portable computers and data analysis software. The students participated in the fieldwork to gain experience in operation of equipment, understand techniques of proper interpretation of test results and making decisions based on test results.

A new unit operations laboratory course is presently being developed by Professors Bergendahl and Plummer for the EIP graduate program. This course will focus on environmental laboratory experiments that demonstrate the use of analytical instruments for analysis of environmental samples. Substantial time will be spent on development, testing and optimization of an environmentally-based design project.

FUTURE PLANS

Both the EIP and HIP faculty groups will continue making strives in teaching and scholarship areas and will continue to support these new laboratory facilities. Plans are

to integrate the new EIP laboratory facility with our new distance learning program. Appendix X contains a brochure printout of this new program. Further information on the EIP distance learning program may be found at: http://www.wpi.edu/+CEE/ADLN.

The next innitiative planed for physical upgrade of the CEE laboratory facilities will be to renovate the geotechnical engineering laboratory – which represents the remaining one-third of the total laboratory space of the department.

Appendix I

Total Listing of Keck Foundation Equipment Grant Purchases

Date	Description	Company		Paid
10/19/03	Model 8250HV Drop weight impact test instrument	Instron Corp.	$	60,741.00
2/8/04	Freight Charges	Instron Corp.	$	228.06
3/2/04	Tinius Olson Retrofit	Instron Corp.	$	21,259.00
6/28/04	Axial Servohydraulic	Instron Corp.	$	171,926.00
9/2/03	Thermolyne NCAT Asphalt content tester	Barnstead/Thermolyne	$	7,922.82
10/5/03	Zeitfuchs Viscometer ASPH Inst. Vac Viscometer	Gilson Company	$	126.00
9/29/03	Portable Mixer	Gilson Company	$	406.00
9/29/03	Deluxe Paddle/M-66	Gilson Company	$	42.70
9/29/03	Pail & Cover/M-66	Gilson Company	$	23.60
11/5/03	Quantitative EXT & Rec of ASPH Binder/RHE TSTG	Gilson Company	$	14,300.00
9/2/03	Asphalt Pavement Analyzer	Pavement Technology	$	84,325.00
10/8/03	Electric Penetrometer	Gilson Company	$	2,701.00
10/8/03	Wax Penetration needle for penetrometer	Gilson Company	$	115.00
10/8/03	Motorized liquid limit machine	Gilson Company	$	606.00
10/22/03	Constant Tem. Bath Economy	Gilson Company	$	2,544.00
10/22/03	Neoprene Holder for AI VacViscom	Gilson Company	$	14.15
10/21/03	Electric Penetrometer	Gilson Company	$	42.00
10/21/03	Support Shelf for MA-72	Gilson Company	$	41.00
10/21/03	Plastic Transfer Disk	Gilson Company	$	38.00
10/21/03	3Oz. Tinned steel can 2.1"	Gilson Company	$	9.00
10/21/03	6 oz Tinned steel can 2.8"	Gilson Company	$	12.00
10/21/03	Stopwatch, Digital	Gilson Company	$	34.50
10/21/03	Sand equivalent shaker	Gilson Company	$	2,160.00
10/21/03	Sand equivalent test set	Gilson Company	$	305.00
10/21/03	Accessory set for liquid & plastic limits	Gilson Company	$	145.00
10/21/03	Grooving tool, AASHTO	Gilson Company	$	30.00
10/21/03	Plastic Limit roller	Gilson Company	$	130.00
10/21/03	SS wire baslet fpr SG-6	Gilson Company	$	75.50
11/13/03	Dig Recirc.HTG/Cool Bath	Gilson Company	$	2,825.00
12/22/03	Rechrgeable battery pack Vio F Series Sony CPU	PC Mall	$	249.99
12/15/03	Sony Viao - S0130072277	PC Mall	$	3,479.00
1/21/04	Mouse for Notebook	PC Mall	$	49.99
1/26/04	DANAHER Controls	PC Mall	$	351.75
1/26/04	Labview Base Pkg. for Windows NT	National Instruments	$	664.95
1/29/04	Linksys PCMPC200	PC Connection,Inc.	$	3,896.08
2/8/04	Lab. Equipment	Artech/Teto	$	303.33
2/23/04	Carrying Case	PC Mall	$	136.39
3/9/04	Plex	Plastic Unlimited	$	117.62
3/9/04	1-Port,Windows NT	National Instruments	$	230.90
4/13/04	Wall Steel Tubing	Peterson Steel Corp.	$	384.00
4/28/04	HM-2	Gilson Company	$	2,148.00
4/28/04	Cable	Gilson Company	$	19.91
3/22/04	Ethernet Cart	Staples	$	52.47
3/22/04	Danaher Controls RS485	Staples	$	83.50
3/2/8/00	150 MM Mold Assembly Perf.	Pine Instrument Co.	$	3,208.12
4/13/04	Computer Equip./Lab Photos	Matt Teto	$	131.77
4/13/04	Wall Steel Tubing	Peterson Steel Corp.	$	384.00
4/13/04	HM-2	Gilson Company	$	2,148.00
5/5/04	1 1/2"x7"x14 PVC	Plastic Unlimited	$	58.33
5/11/04	Nylon Type 6 Cast 8"Dia x 39" L	Plastic Unlimited	$	667.81
5/13/04	1 1/2"x7"x14 PVC 2 4" Dia	Plastic Unlimited	$	55.78
5/18.00	4oz. Plextic &#33	Plastic Unlimited	$	10.39
6/7/04	Centrifuge Exractor	Gilson Company	$	2,183.12
7/26/04	Trap Inlet Chemical ITC20K	BOC Edwards	$	481.67
8/8/04	E-LAB2 Pump	BOC Edwards	$	1,515.57
8/3/04	Lab. Supplies	Cole-Parmer	$	218.03
9/2/04	Lab. Supplies	Cole-Parmer	$	189.39
9/26/04	Valve	Cambridge Valve	$	321.68
10/18/04	Steel Flat	Peterson Steel Corp.	$	58.00
7/14/04	10_AU-005 Field Fluorometer	Turner Design, Inc.	$	3,500.00
7/26/04	GPS Beacon	Maine Tech. Sci.	$	15,707.66
3/23/04	Carry 50 Scanning	Varian	$	9,417.80
5/5/04	ALS Interface Board	Agilent Tech.	$	30,391.17
9/14/04	Atomic Absorption	Perkin Elmer	$	41,388.83
12/10/00	Environmental Centrifuge	VWR	$	2,665.00
				$ 499,997.33

Appendix II

Additional Equipment Purchases

Equipment Name	Vendor		Cost	Date
TOC Analyzer	Shimadzu	$	28,000	Jan-00
Particle Counter	Chemtrac	$	8,500	Jul-00
Water Purification System	Millipore	$	12,000	Jul-00
Tenius Olsen Retrofit (partial)	Instrom	$	20,000	Jan-00
Environmental Refrigerator Unit	Fisher	$	1,496	Oct-00
GC (partial)	Agilent Tech.	$	12,178	Mar-00
Incubator	Fisher	$	2,594	Feb-00
Laminar Flow Cleanbench	Cleanroom Filters	$	2,898	Aug-00
Water Purification System	Barnstead	$	4,500	Oct-00
Model Module Load Simulator	MLS Test Systems Co.	$	85,000	Dec-00
Pavement Quality Indicator	Transtech Systems	$	6,000	Mar-00
Computers for field work	PC Mall	$	9,530	Mar-00
Software for statistical analysis	SAS Institute	$	1,750	Mar-00
Triaxial testing equipment	Shetworks Inc.	$	51,678	Mar-00
10-AU-005 Fluorometer	Turner Design	$	7,500	Jul-00
Vetronix.Com Corp.	CDR kit	$	2,495	Oct-04
Cole-Parmer Instrument Co.	18X24 reconditioned cart	$	109	Nov-04
Worcester County Welding	cut 8 holes in plates	$	96	Nov-04
Instron	general purpose TUP	$	4,386	Nov-04
Plastics Unlimited	1" sch 40 pipe, OD ID	$	39	Nov-04
Grainger, Inc.	115V AC electric winch	$	323	Nov-04
Peterson Steel Corp.	3" sch 40 carbon steel pipe 120"	$	218	Nov-04
Peterson Steel Corp.	3" sch 40 carbon steel pipe 120"	$	73	Nov-04
TechImaging Serv	MotionScope PCI 8000 Video Sys	$	20,736	Nov-04
	TOTAL	$	282,098	

Appendix III

Positions Added to CEE Department

Research Secretary

Basic Function: Assist active researchers in the civil engineering department with report and proposal writing as well as budget and administrative record keeping. Perform a wide range of secretarial and administrative duties with limited supervision for a department head/director of a small department or second secretary in a department which has many faculty members or students. Perform/be able to perform most or all of the duties and responsibilities of the Administrative Secretary II level.

Principal Duties: Provide word processing of complex manuscripts, materials, reports, office forms and use several business software packages. Compose correspondence requiring exercising judgment and originality. Maintain complex calendars; screen calls; make appointments; handle arrangements for travel, meetings, conferences, etc. Review mail for content, taking initiative to answer some independently as appropriate. Assist with budget preparation and/or accounts maintenance; perform some bookkeeping and billing; reconcile discrepancies; process vouchers and personnel forms. Maintain and compile statistical data; prepare and format general spreadsheets, etc.; perform minor research or statistical analysis.

Qualifications: Existing skills, or the ability to learn skills in word processing (Word and Word Perfect), basic spread sheet operations (Excel), e-mail communication (file transfer ... etc), and web page maintainance. Previous office experience and appropriate education.

Laboratory Manager

Basic Function: Responsible for the overall efficient operation of all labs and stockrooms within the building. This manager works closely with all faculty, staff and students to help facilitate the academic and research goals of the Civil Engineering Department. The Civil Engineering Department presently has laboratory facilities for structures, geotechnical, impact, asphalt, environmental and material engineering testing. Much of this laboratory space had undergone major renovations during the summer of 2000, and has received over $ 0.5M of new equipment plus $ 0.5M in physical renovations.

Principal Duties:: Coordinate all purchase order activity for all laboratories; maintain vendor files and contacts; solicit cost quotations, as necessary. Assist Department Head with financial management issues; monitor and report monthly budget activity; recommend and manage appropriate cost control methods. Act as the building liaison with Plant Services tradesmen and project managers for building repairs and renovations. Supervise all workstudy students, research assistants and teaching assistants involved with laboratory teaching and research activities. Perform all duties as assigned by the

Department Head. The lab manager will also support the academic interests of the department through the following activities. He/she will:

Assume responsibility for care and maintenance of instrumentation in the civil engineering laboratories.

Participate in proposal preparation, particularly for the upgrading of facilities.

Supervise and/or instruct in the undergraduate laboratory program.

Qualifications: Bachelors degree in science relate field preferred. Two to four years business systems experience, preferably in higher education preferred. Must be able to clearly recognize his/her role as a staff resource for the academic and research programs in Kaven Hall and the entire campus community. Must be an effective communicator to a very diverse community, and possess an adequate level of computer skills to support this level of service.

Asphalt Research Engineer

Basic Function: The basic function is coordination of laboratory work for sponsored highway materials research and development of new test methods and equipment for highway materials related problems in conjunction with Material Science and Engineering department. The person will work with state Departments of Transportation, aggregate suppliers, asphalt suppliers, HMA contractors, Federal Highway Administration and others to identify materials related problems, work towards implementation of a plan for accreditation of Highway Materials Laboratory by the American Association of State Highway and Transportation Officials (AASHTO), and oversee research work of a group of undergraduate students.

Principal Duties: Principal duties include procurement of materials, laboratory work with asphalt materials, and supervision of laboratory work, data collection, and upgrading/modification of existing and fabrication of new equipment in the asphalt laboratory.

Qualifications: The minimum qualification required is a Bachelor's degree in Civil Engineering with relevant coursework in highway materials, especially asphalt materials, and experience of work in a highway materials production plant and highway construction/research related fieldwork.

Appendix IV

Resumes of New Hires

Appendix V

Resumes of New Faculty

John Bergendahl, Ph.D, P.E.
Department of Civil and Environmental Engineering
Worcester Polytechnic Institute, Worcester, MA
Phone: (508) 831-5772; email: jberg@wpi.edu

Education

Doctor of Philosophy in Chemical Engineering, February 1999; University of Connecticut, Storrs, CT

- Dissertation: *Modeling the Mechanics of Colloid Detachment in Environmental Systems*
- Research in colloid and surface chemistry; application to physicochemical processes

Master of Science in Environmental Engineering, August 1996; University of Connecticut, Storrs, CT

Bachelor of Science in Mechanical Engineering, December 1985; University of Connecticut, Storrs, CT

Professional Experience

Assistant Professor, January 2000 – present; Department of Civil and Environmental Engineering, Worcester Polytechnic Institute, Worcester, MA

Courses Taught:

- Spring 2000, CE590F, *Physical and Chemical Treatment Processes*, Advanced Distance Learning Network course
- Fall 2000, CE561, *Advanced Principles of Wastewater Treatment*, Advanced Distance Learning Network course

Postdoctoral Research Fellow, March 1999 – December 1999; Environmental and Water Resources Engineering Program, Department of Civil Engineering, University of Texas, Austin, TX

- Research project: *Stability and Mobility of Plutonium Colloids*

Research Associate, 1995 - February 1999; University of Connecticut, Storrs, CT

Research Projects:

- *Colloid Generation During Batch Leaching Tests*. Quantification of increase in colloid concentrations during agitated batch tests, and exploration of detachment mechanisms
- *Colloid Detachment Mechanisms in Porous Media*. Investigation on colloid detachment from porous media due to solution chemistry and hydrodynamic perturbations
- *Site Closure Criteria For Coal-Tar Contaminated Sites*. Evaluation of the acceptability of EPA's Toxicity Characteristic Leaching Procedure for hydrophobic organic contaminated soil

- *Fenton's Oxidation of Chlorinated Solvents*. Study to evaluate the feasibility of using Fenton's reagent oxidation to treat solvent contaminated groundwater at a Superfund site.
- *Evaluation of Zero Valent Iron Reactive Wall at Dover Air Force Base, Dover Delaware – Study of Inorganic Colloids*.

Teaching Fellow, 1993 – February 1999; University of Connecticut, Storrs, CT

- Instructor for Environmental Engineering Chemistry (Graduate), Fall 1998
- Provide guidance to students in the following classes: Introduction to Engineering, Unit Operations in Water Quality Engineering, Chemical Engineering Laboratory, Water Purification Principles, and Environmental Engineering Chemistry
- Lectured in: Environmental Engineering Chemistry, Introduction to Engineering, Water Quality Engineering, and Environmental Engineering Laboratory

Intern, September 1994 - May 1995; Connecticut Hazardous Waste Management Service, Technical Assistance Program, Hartford, CT

- Conducted site audits and suggestions on pollution prevention opportunities for industry
- Evaluated process changes to reduce hazardous material generation

Senior Engineer, Engineer, Associate Engineer, 1985 - 1992; General Dynamics, Electric Boat Div., Groton, CT

- Fluid system and component design projects
- Responsibilities included: conceptual development, design calculations, material and component selection, presenting customer design reviews, and engineering support for manufacturing
- Cognizant engineer for: seawater systems, freshwater systems, lube and fuel oil systems, miscellaneous pumps, hoses, filters, etc.

Publications

Journal Articles

"The Toxicity Characteristic Leaching Procedure: Colloid Release and PAH Leachability," *Environmental Toxicology and Chemistry*, with D. Grasso & J. Pignatello, in preparation.

"Prediction of Colloid Detachment in a Model Porous Media: Hydrodynamics," *Chemical Engineering Science*, with D. Grasso, **55**, 1523-1532, 2000 (refereed).

"Prediction of Colloid Detachment in a Model Porous Media: Thermodynamics," *American Institute of Chemical Engineers Journal*, with D. Grasso, **45**, 475-484, 1999 (refereed).

"Colloid Generation During Batch Leaching Tests: Mechanics of Disaggregation," *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, with D. Grasso, **135**, 193-206, 1998 (refereed).

Discussion Article: "Role of Short-Range Forces in Particle Detachment During Filter Backwashing," *Journal of Environmental Engineering*, with M. Butkus & D. Grasso, **123**, 726-728, 1997 (non-refereed).

"Case Study: A Cardboard Box Manufacturer," *Pollution Prevention Review*, **5**, 15-19, 1995 (non-refereed).

Presentations

Thermodynamics and Hydrodynamics of Colloid Detachment in a Model Porous Media, American Institute of Chemical Engineers Annual Meeting, Interfacial Aspects of Remediation Technology, Dallas, Texas, November 5, 1999, with D. Grasso.

Poster Presentation: *Plutonium Colloid Mobility and Stability*, Environmental Solutions Program, University of Texas, Austin, TX, November 4, 1999, with S. Aghara, L. Katz, D. Lawler, and S. Landsberger.

Colloid Detachment in Porous Media, Advancing Filtration and Separation Solutions for the Millennium, The American Filtration and Separations Society, Boston, MA, April 6 – 9, 1999, with D. Grasso.

Mechanisms of Colloid Detachment in Porous Media, Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, November 23, 1998.

Implications of Colloid Generation for Coal-Tar Contaminated Soil Leach Testing, 30th Mid-Atlantic Industrial and Hazardous Waste Conference, July 12 - 15, 1998, Villanova University, Villanova, PA, with D. Grasso.

Poster Presentation: *Mechanisms of Colloid Detachment in Environmental Systems*, 72nd ACS Colloid and Surface Science Symposium, Pennsylvania State University, University Park, PA, July 21 - 24, 1998, with D. Grasso.

Poster Presentation *Colloid Detachment in Porous Media*, University Consortium Solvents-in-Groundwater Research Program, Spring 1998 Meeting, Farmington, CT, May 5 - 7, 1998.

Mechanisms of Colloid Detachment in Environmental Systems, Northeast Regional Student Environmental Conference, University of Massachusetts, April 18, 1998.

Mechanisms of Colloid Detachment in Porous Media, 71st ACS Colloid and Surface Science Symposium, University of Delaware, Newark, DE, July 1, 1997, with D. Grasso.

Quantification of PAH Concentrations During the Toxicity Characteristic Leaching Procedure, Department of Civil and Environmental Engineering, University of Connecticut, Storrs, CT, November 1, 1996.

Reports

Stability and Mobility of Plutonium Colloids – Phase I, prepared for the Amarillo National Resource Center for Plutonium, Research and Education Program, with L. Katz and D. Lawler, February 2000.

SRSNE Non-Time Critical Removal Action Treatment System: Fenton's Oxidation prepared for Handex Corporation and *de maximis*, inc., with D. Grasso and M. Engwall, January 7, 1999.

Study of Filtration Sand From the SRSNE Non-Time Critical Removal Action Treatment System, prepared for Handex Corporation and *de maximis*, inc., with D. Grasso and M. Engwall, October 24, 1997.

Patent

Centrifugal Method to Separate Particles from Granular Media; patent applied for: application #09/671968, dated 9/29/2000

Funding

Oxidation Reduction Potential versus Residual Control of Chlorine, Damon S. Williams Associates / Water Environment Research Foundation, $29,279

Field Testing Fenton's Oxidation at SRSNE, de maximis, inc., $59,007 (with D. Grasso, Smith College, verbally accepted)

Effect of Hydrogeology and Water Quality on Inorganic and Protozoan Particle Mobilization in Riverbank Filtration, U.S. Environmental Protection Agency, $518,632 (with D. Grasso, Smith College, pending)

Colloid-Facilitated Leaching of Hydrophobic Contaminants, American Chemical Society Petroleum Research Fund, $25,000 (pending)

Reviewer

Prentice Hall, College Division (Textbook)

Environmental Toxicology and Chemistry

Water Research

Environmental Science and Technology

Journal of Soil and Sediment Contamination

19th Biennial International Conference, International Association of Water Quality, Paper Referee.

1st World Congress of the International Water Association (IWA): Paris 2000, Paper Referee

Professional Licensure

Professional Engineer, State of Connecticut

Honors and Fellowships

U.S. Department of Defense Fellowship, 1997 - 1998, Environmental Fellowship Program

Inducted member *Chi Epsilon*, National Civil Engineering Honor Society

Inducted member of the Honor Society of *Phi Kappa Phi*

University of Connecticut, Summer 1996 Fellowship for Advanced Graduate Students

University of Connecticut, Pollution Prevention Research and Development Center Fellowship, 1993 - 1994

Service

ASCE Hazardous Waste Committee member (Environmental Engineering Division), 1998 - present

Resident Assistant for Graduate Residences; January 1997 - January 1999, University of Connecticut

University of Connecticut Resident Assistant Advisory Committee, 1998

UCONN CONNECTS Facilitator; 1997 - 1999, Mentor for academic intervention program at the University of Connecticut for students on probation

Connecticut Science Fair Judge, 1998

Professional Affiliation

American Chemical Society; American Institute of Chemical Engineers; American Society of Civil Engineers; Association of Environmental Engineering Professors

JEANINE D. PLUMMER
Assistant Professor
Department of Civil and Environmental Engineering
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PROFESSIONAL PREPARATION

Cornell University	Civil and Environmental Engineering	B.S., 1993
University of Massachusetts	Environmental Engineering	M.S., 1995
University of Massachusetts	Civil and Environmental Engineering	Ph.D., 1999

APPOINTMENTS

Worcester Polytechnic Institute Assistant Professor 8/99 – present

Teaching undergraduate and graduate courses in environmental engineering, water treatment processes, and water chemistry. Research interests include control of algae in water supplies; disinfection byproduct production from algae; microbial contamination of water supplies; and physical and chemical treatment processes.

PUBLICATIONS

Plummer, J. D. 1999. Control of Algae in Drinking Waters by Coagulation and Oxidation. Ph.D. Dissertation, Department of Civil and Environmental Engineering, University of Massachusetts at Amherst, MA.

Plummer, J. D. and J. K. Edzwald. 1998. Effect of Ozone on Disinfection By-product Formation of Algae. *Water Science and Technology*, 37:2:49-55.

Plummer, J. D.; J. K. Edzwald; and M. B. Kelley. 1995. Removing *Cryptosporidium* by Dissolved-Air Flotation. *J. American Water Works Association*, 87:9: 85-95.

Plummer, J. D. 1995. Removal of *Cryptosporidium parvum* from Drinking Water by Dissolved Air Flotation. Master's Thesis, Department of Civil and Environmental Engineering, University of Massachusetts at Amherst, MA.

PRESENTATIONS/PROCEEDINGS PUBLICATIONS

Plummer, J. D. and J. K. Edzwald. 2000. Impacts of Ozone on Coagulation of Algal-Laden Waters. *Proc. of the AWWA Water Quality Technology Conference*, Salt Lake City, Utah, Nov. 5-8, 2000.

Plummer, J. D. and J. K. Edzwald. 2000. THM and HAA Production from Algae in Drinking Waters. *Proc. of the AWWA Annual Conference*, Denver, Colorado, June 11-15, 2000

Plummer, J. D. and J. K. Edzwald. 1998. Control of Algae in Drinking Waters by Coagulation and Oxidation. *Proc. of the AWWA Annual Conference*, Dallas, Texas, June 21-25, 1998.

Plummer, J. D. and J. K. Edzwald. 1997. Effect of Ozone on Disinfection By-product Formation of Algae. *Proc. of the IAWQ-IWSA Joint Specialist Conference: Reservoir Management and Water Supply - an Integrated System*, Prague, Czech Republic, May 19-23, 1997.

Kelley, M. B.; J. K. Edzwald; and J. D. Plummer. 1996. *Cryptosporidium* Removals by Dissolved Air Flotation and Sedimentation - An Evaluation of Coagulants and Operating Conditions. Paper presented at the AWWA Annual Conference, Toronto, Ontario, June 23-27, 1996.

Edzwald, J. K.; J. D. Plummer; and M. B. Kelley. 1995. *Cryptosporidium*: Coagulation, Clarification and Filtration. Paper presented at the IAWQ-IWSA Workshop on Separation of Microorganisms from Water and Wastewater, Amsterdam, The Netherlands, Oct. 31 - Nov. 1, 1995.

Plummer, J. D. and J. K. Edzwald. 1995. Removal of *Cryptosporidium parvum* from Drinking Waters by Dissolved Air Flotation. *Proc. of the AWWA Annual Conference, Anaheim*, California, June 18-22, 1995.

AWARDS , HONORS and FELLOWSHIPS

U.S. Environmental Protection Agency STAR Graduate Fellowship 1996-1999

United Technologies Outstanding Graduate Woman in Engineering Award 1996

Association of Environmental Engineering Professors/Montgomery-Watson Master's Thesis Award: First Place 1995

National Science Foundation Graduate Research Fellowship 1993-1996

PROFESSIONAL EXPERIENCE

Institute Assistant *Dr. J. K. Edzwald, Institute Director* 1995-1998

Institute in Drinking Water Treatment, sponsored by the Environmental Engineering Program at the University of Massachusetts. Assisted Institute Director with institute management, logistics and laboratory demonstrations.

Research Assistant *Dr. C. A. Shoemaker, Cornell University* 6/92 - 5/93

Investigated method to correct groundwater remediation strategies given model prediction errors. Performed computer simulations of contaminant movement in

aquifers undergoing clean-up and analyzed results. Developed FORTRAN programs.

Technician *Sverdrup Corporation, Boston, MA* 9/91 - 1/92
Designed and evaluated seventy culverts for drainage beneath commuter railroad. Provided quantity estimates for ten-pier railroad bridge. Edited five technical reports and specifications for submittal to clients.

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers
American Water Works Association
Member, Particulate Contaminants Research Committee (AWWA), 2000
Association of Environmental Engineering and Science Professors
International Water Association
New England Water Works Association

JOURNAL REVIEWER

Ozone Science and Engineering - The Journal of the International Ozone Association
Journal of Water Supply: Research and Technology - AQUA

Appendix VI

Photos of New Lab Facilities

Appendix VII

Recent Proposals

Project Title	Faculty	Sponsor	Amount
Theoretical Investigation of Colloid Detachment Using Molecular Dynamics Simulations	J. Bergendahl	ACS	$25,000
Effect of Hydrogeology and Water Quality on Inorganic and Protozgan Particle Mobilization in Riverbank Filtration	J. Bergendahl	EPA	$5l8,632
Field Testing of Fenton's Oxidation at SRSNE	J. Bergendahl	de maximis	$51,000
Non-Destructive Measurement of Pavement Layer Thickness	R. Mallick	Infrasense	$20,04l
Evaluation of Permeability of Superpave Mixes In ME	R. Mallick	MEDOT	$3,317
Development of Energy-saving Economic & Environment Friendly Cold Asphalt Mixes for NY	R. Mallick	NY State Energy	$151,427
Development of a Fast and Effective Method for Evaluation of Aggregate Properties	R. Mallick	NAS	$97,342
Development of Warm Mix Asphalt	R. Mallick	NAS	$93,765
Development of Warm Mix Asphalt	R. Mallick	NAS	$86,474
Career:Understanding the Effect of Materials and Mix Properties on Long-Term Performance of Full Depth Reclam	R. Mallick	NSF	$375,000
Development of a Non-Destructive Testing System for Evaluation of Foundation Soil	R. Mallick	NSF	$177,843
Relationships of HMA In-Place Air Voids, Lift Thickness, and Permeability	R. Mallick	Purdue	$111,773
Field Evaluation of Use of Manufactured Waste Asphalt Shingles in Hot Mix Asphalt	R. Mallick	UMA Amherst	$45,971
Evaluation of Asphaltic Expansion Joints	R. Mallick	UMA Dartmouth	$29,943
Evaluation of Permeability of Superpave Mixes	R. Mallick	UMA Dartmouth	$49,723
Hydrology of the Jones River Watershed	P. Mathisen	ARL	$24,661
Modeling the Bacteriological Impact of Livestock on Water Quality Using GIS	P. Mathisen	USDA	$206,977
Career: Rational Strategies for Control of Algae in Drink Waters	J. Plummer	NSF	$375,000
Powre: Removal of Algal DBP Precursors by Coagulation	J. Plummer	NSF	$69,247
Modeling the Bacteriological Impact of Livestock on Water Quality Using GIS	J. Plummer	USDA	$206,977
Application Context-Sensitive Design Principles	M. Ray	NAS	$125,000
CCLI: Prototype Educational Materials Development for an Impact Mechanics Course	M. Ray	NSF	$73,009
		TOTAL	$2,379,449

Appendix VIII

Recent Publications

Refereed

John Bergendahl and Domenico Grasso, “Prediction of Colloid Detachment in a Model Porous Media: Hydrodynamics,” *Chemical Engineering Science*, Vol. 55, No. 9, pp. 1523-1532, May 2000.

C. A. Plaxico and M. H. Ray, "Comparison of the Impact Performance of the G4(1W) and G4(2W) Guardrail Systems Under NCHRP Report 350 Test 3-11 Conditions," In Roadside Safety Features, Transportation Research Record No. (in press), Transportation Research Board, Washington, D.C., 2000.

M. H. Ray and K. Hiranmayee, "Evaluating Human Risk in Side Impact Collisions with Roadside Objects," In Roadside Safety Features, Transportation Research Record No. (in press), Transportation Research Board, Washington, D.C., 2000.

M. H. Ray and J. A. Hopp, "In-Service Performance Evaluation of the BCT and MELT Guardrail Terminals in Iowa and North Carolina," In Roadside Safety Features, Transportation Research Record No. (in press), Transportation Research Board, Washington, D.C., 2000.

M. H. Ray, "Safety Effectiveness of Upgrading Guardrail Terminals to Report 350 Standards," In Roadside Safety Features, Transportation Research Record No. (in press), Transportation Research Board, Washington, D.C., 2000.

M. H. Ray, K. Hiranmayee and S. Kirkpatrick, "Performance Validation of Two Side Impact Dummies," In International Journal of Crashworthiness, Vol. 4 No. 3, Woodhead Publishing Limited, London, UK, 1999.

G. S. Patzner, C. A. Plaxico and M. H. Ray, "Effect of Post and Soil Strength on the Performance of the Modified Eccentric Loader Breakaway Cable Terminal," In Roadside Safety Features, Transportation Research Record No. 1690, Transportation Research Board, Washington, D.C., 1999.

M. S. Fitzpatrick, K. L. Hancock and M. H. Ray, "Videolog Assessment of the Vehicle Collision Frequency with Concrete Median Barriers on an Urban Highway in Connecticut," In Roadside Safety Features, Transportation Research Record No. 1690, Transportation Research Board, Washington, D.C., 1999.

M. H. Ray, "Impact Conditions In Side Impact Collisions With Fixed Roadside Objects," In Accident Analysis and Prevention, Vol. 31, No. 1, Pergamon Press, 1999.

M. H. Ray, M. W. Hargrave, J. F. Carney III and K. Hiranmayee, "Side Impact Test and Evaluation Criteria for Roadside Safety Hardware," In General Design and Roadside

Safety Features, Transportation Research Record No. 1647, Transportation Research Board, Washington, D.C., 1999.

Mallick,R., , and Ray Brown, "A Comparison of Laboratory and In-Place Aging of Binders," International Journal of Pavement Engineering, December 1999.

Mallick,R., Ken Kandhal and Mike Huner "Development of a new Test Method for Measuring Bulk Specific Gravity of Fine Aggregates," Transportation Research Record, January 2000.

Mallick,R., Ken Kandhal , Shane Buchanan and Rick Bradbury, "A Rational Approach of Specifying Voids in Mineral Aggregate in Dense Graded Hot Mix Asphalt," International Journal of Pavement Engineering, January, 2000.

Mallick,R., Ken Kandhal, Allen Cooley, Jr. and Don Watson "Design, Construction and Performance of New-Generation Open-Graded Friction Courses," Journal of Association of Asphalt Paving Technologists, March, 2000.

Mallick, Rajib B., L. Allen Cooley, Jr., Matthew R. Teto, Richard L. Bradbury, Dale Peabody. An Evaluation of Factors Affecting Permeability of Superpave Designed Pavements , Paper submitted for presentation and publication at the 80th Annual Meeting of the Transportation Research Board (TRB) in Washington, D.C, 2001.

Mallick,R., Chapter on Emerging Materials in Asphalt, in *Emerging Materials in Construction Materials*, Published by ASCE in Spring, 2000.

Mathisen, P. and O.S. Madsen "Waves And Currents Over A Fixed Rippled Bed III. Bottom And Apparent Roughness For Spectral Waves And Currents," Journal of Geophysical Research.

Mathisen, P., "Use Of A Graduate-Level Distance Learning Course To Enhance Undergraduate Education In Civil Engineering: A Combined Graduate/Undergraduate Course In Hydrology" *Proceedings of the 1999 Annual Meeting of the American Society of Engineering Education (ASEE)*, June 1999 in Charlotte, NC.

Roberge, J and P. Mathisen, "Sensitivity Analyses To Assess The Use Of CFD For Predicting The Occurrence Of Swirl In Pump Intakes," *Proceedings of the Symposium on Industrial Application of Swirling Flows, 1999 ASME/JSME Conference on Fluids Engineering*, July, 1999 in San Francisco, CA

Bates, W.A., and O'Shaughnessy, J.C., "Development of a Life Cycle Assessment Screening Model," *Proceedings of the Purdue / WEF Industrial Waste Conferences*, Indianapolis, IN., June., 1999.

O'Shaughnessy, J.C., and Blanc, F. C., "Aqueous Solvent Removal of Contaminants from Soils," *Engineering Considerations and Remediation Stratagies*: Volume 1., Marcel Decker Publisher. pp. 617 – 638., Spring 2000.

Kandhal, P. S and Rajib B. Mallick. "An Evaluation of Effect of Aggregate Gradation of Rutting Potential of Hot Mix Asphalt (HMA)," Paper submitted for presentation and publication at the 80th Annual Meeting of the Transportation Research Board (TRB) in Washington, D.C, 2001

Mallick, Rajib B., Kandhal, P. S., Matthew. R. Teto, Richard L. Bradbury and Ed. Kearney. "Development of a Rational and Practical Mix Design System for Full Depth Reclamation (FDR)," Submitted for publication in the Journal of Asphalt Paving Technologists, March 2001.

Mallick, Rajib B., Elton Ray Brown, Matthew R. Teto, John E. Haddock and Frank Dalton. "Development of a Tool for Predicting Rutting Potential of Asphalt Paving Mixes," To be published by National; Center for Asphalt Technology, Auburn University, in winter 2001.

Mallick, Rajib B., Matthew R. Teto and John E. Haddock. "Use of the Concept of Pore Pressure in Unsaturated Soils for Evaluation of Rutting Potential of Asphalt Paving Mixes," Paper submitted for presentation and publication at the Ninth International Conference on Asphalt Pavements in Copenhagen, 2002.

Mallick, Rajib B. "Development of A Field And Laboratory Based Coursework in Asphalt Technology," Paper accepted for presentation and publication at the 2001 American Society for Engineering Education (ASEE) Annual Conference in Albuquerque, 2001.

Non-refereed

John Bergendahl, Lynn Katz, and Desmond Lawler, "Stability and Mobility of Plutonium Colloids – Phase I," Amarillo National Resource Center for Plutonium, Research and Education Program, February 2000.

T. Elkorchi, J. Bacon, M. Turo, M. Ecmecian **,** "Correlation Study of Ride Quality Assessment Using Pavement Profiling Devices," Transportation Research Board, Washinton D.C. Jan 2000.

Plummer, J. D. and James K. Edzwald. "THM and HAA Production from Algae in Drinking Waters," Proceedings of the AWWA Annual Conference, Denver, Colorado, June 11-15, 2000.

Plummer, J. D. and J. K. Edzwald. 2000. "Impacts of Ozone on Coagulation of Algal-laden Waters," Proceedings of the AWWA Water Quality Technology Conference, Salt Lake City, UT, November 5-8, 2000.

M. H. Ray, Cutting the High-Cost of Crash Testing, *In Civil Engineering*, American Society of Civil Engineering (ASCE), August 1999.

C. A. Plaxico and M. H. Ray, Using LS-DYNA to Simulate Collisions with Guardrails, 6th International LS-DYNA User s Conference: Simulation 2000, 9-11 April 2000.

Mallick,R., Prithvi S. Kandhal "Testing of Hot Mix Asphalt (HMA) with the Asphalt Pavement Analyzer", Presented And Published at the International Conference on Accelerated Pavement Testing in Reno, October, 1999.

Walsh, J., O'Shaughnessy, J.C., "Bioremediation of an Oil Contaminated Soil," *Proc. of the Fifth International Conf. On Bioremedation*, San Diego, CA., April, 1999.

Nardini, C.A., O'Shaughnessy, J.C., and Manz, R.D, "Remediation of Coal Tar, PCB and Chlorinated Solvent Contaminated Soils using Thermal Desorption," *Proc. of the 15th International Conference on Contaminated Soils, Sediments & Water*," Amherest, MA., Oct., 1999.

Appendix IX

Recent Presentations

John Bergendahl and Domenico Grasso, “Thermodynamics and Hydrodynamics of Colloid Detachment in a Model Porous Media,” American Institute of Chemical Engineers Annual Meeting, Interfacial Aspects of Remediation Technology, Dallas, Texas, November 5, 1999.

John Bergendahl, Sukesh Aghara, Lynn Katz, Desmond Lawler, and Sheldon Landsberger, Poster: “Plutonium Colloid Mobility and Stability,” Environmental Solutions Program, University of Texas, Austin, TX, November 4, 1999.

El-Korchi, T., J. Bacon, M. Turo, M. Ecmecian , “MassHighway Ride Quality Correlation Study,” NESMEA Meeting, Atlantic City, N.J., Oct. 1999.

El-Korchi, T., J. Bacon, M. Turo, M. Ecmecian. “MassHighway Ride Quality Study,” RPUG Meeting, Pheonix, AZ, Nov.,1999.

El-Korchi, T., J. Bacon, M. Turo, M. Ecmecian ", “MassHighway Ride Quality Correlation Study,” NorthEast Pavement Managment Meeting, Killington, VT, Nov. 1999.

El-Korchi, T., NCHRP 20-46 “Systems Approach to Evaluatin Innovations for Integration into Highway Practice,” TRB RACK Meeting Harrisburg, PA, July 1999.

El-Korchi, T., “Assessment of Leachability and Porosity of Cement Solidified Heavy Metal Waste in Seawater,” Materials Research Society, Boston, MA 1999.

El-Korchi, T., “Modelling Leachability of Cement Solidified Metal Wastes,” Materials Research Society, Boston, MA,1999.

Mallick, R., Asphalt Materials Research and Education program at WPI, TransTech Industries, Schenectady, New York, August, 1999.

Mallick, R., “Development of density specifications for permeability of asphalt pavement,” Advanced Asphalt Testing, Campbell Hall, NY, September, 1999

Mallick, R., “An Evaluation of permeability of coarse graded Superpave mixes,” New York Department of Transportation, Albany, NY, September, 1999

Mallick, R., “Use of APA and SMA for preventing rutting in hot mix asphalt pavements,” Massachusetts Port Authority, Logan International Airport, Boston, MA, September, 1999

Mallick, R., “Use of shingles in hot mix asphalt,” Bardon Trimount Inc., Saugus, MA, September, 1999

Mallick, R., “Evaluation of rutting potential of mixes with the APA,” Pike Industries, Belmont, NH, September, 1999

Mallick, R., “Cooperation Of Industry And Academic Institutions For Building A Research And Education Program On Asphalt Materials,” Massachusetts Aggregate and Asphalt Pavement Association (MAAPA) Board Meeting, Marlboro, MA, October, 1999

Mallick, R., “Opportunities of research at WPI,” New Hampshire Department of Transportation, Concord, NH, October, 1999

Mallick, R., “Development Of In-Place Permeameter For Hot Mix Asphalt,” Maine Department of Transportation, Augusta, ME, October, 1999.

Mallick, R., “Compaction Of Hot Mix Asphalt Pavements,” National Center for Asphalt Technology, Auburn, Alabama, November, 1999.

Mallick, R., “Use Of APA To Prevent Rutting In Hot Mix Asphalt,” Maine Department of Transportation, Augusta, ME, December, 1999.

Mallick, R., “Development Of A Rational Method To Specify VMA In Dense Graded Hot Mix Asphalt,” Transportation Research Board Meeting, January, 2000

Mallick, R., “Building An Education Program On Asphalt Materials,” Worcester Department of Public Works, January, 2000.

Mallick, R., “Evaluation Of Use Of Shingles In Hot Mix Asphalt,” Worcester Department of Public Works, March, 2000.

Mallick, R., “Development Of A Tool To Predict Rutting In Hot Mix Asphalt,” Expert Task Group, Federal Highway Administration, March, 2000.

Plummer, J. D. and J. K. Edzwald. 2000. "THM and HAA Production from Algae in Drinking Waters," Presented at the AWWA Annual Conference, Denver, Colorado, June 11-15, 2000.

Mathisen, P., “Use Of A Graduate-Level Distance Learning Course To Enhance Undergraduate Education In Civil Engineering: A Combined Graduate/Undergraduate Course In Hydrology,” Presented At The *1999 Annual Meeting of the American Society of Engineering Education (ASEE)*, scheduled for June 1999 in Charlotte, NC.

Roberge, J and P. Mathisen, “Sensitivity Analyses To Assess The Use Of CFD For Predicting The Occurrence Of Swirl In Pump Intakes,” Presented At *The Symposium on*

Industrial Application of Swirling Flows, 1999 ASME/JSME Conference on Fluids Engineering, July, 1999 in San Francisco, CA

Walsh, J., O'Shaughnessy, J.C., "Bioremediation of an Oil Contaminated Soil," *Proc. of the Fifth International Conf. On Bioremedation*, San Diego, CA., April, 1999.

Nardini, C.A., O'Shaughnessy, J.C., and Manz, R.D, "Remediation of Coal Tar, PCB and Chlorinated Solvent Contaminated Soils using Thermal Desorption," *Proc. of the 15th International Conference on Contaminated Soils, Sediments & Water*", Amherest, MA., Oct., 1999.

Bates, W.A., and O'Shaughnessy, J.C., "Development of a Life Cycle Assessment Screening Model," *Proceedings of the Purdue / WEF Industrial Waste Conferences*, Indianapolis, IN., June., 1999

Ray, M. H., Invited Speaker, In-Service Performance of Traffic Barriers, Transportation Research Board, Roadside Safety Features Committee Summer Meeting, Estes Park, CO,

Ray, M. H., Paper Presentation, In-Service Performance of Traffic Barriers, Traffic Safety on Two Continents, Malmo, Sweden, 20-22 September 1999.

Ray, M. H., Interview, Traffic Safety, NBC Nightly News with Tom Brokaw, 27 September 1999.

Ray, M. H., Presentation to Transportation Engineering Seminar, In-Service Evaluation of Traffic Barriers, University of Massachusetts, Amherst, MA, 14 October 1999.

Ray, M. H., Presentation to WPI Advisory Boards, Computation Modeling Thrust Area, WPI Advisory Board Meetings, Worcester, MA, 15 October 1999.

Ray, M. H., Presentation to WPI Board of Trustees, Crashworthiness and Impact Analysis, WPI Advisory Board Meetings, Worcester, MA, 28 October 1999.

Ray, M. H., Invited Speaker, NCHRP Project 22-13: In-Service Performance Evaluation of Roadside Safety Features, Ohio Transportation Engineering Conference, Ohio Department of Transportation, Columbus, OH, 16-17 November 1999.

Ray, M. H., Invited Speaker, Crashworthiness of Weak-Post W-Beam Guiderails, Pennsylvannia Transportation Engineering and Safety Conference, State College, PA, 8-9 December 1999.

Ray, M. H., Paper Presentation, Evaluating Human Risk in Side Impact Collisions with Roadside Objects, Transportation Research Board Annual Meeting, Washington, D.C., 9-13 January 2000.

Ray, M. H., Paper Presentation, In-Service Performance Evaluation of the BCT and MELT Guardrail Terminals in Iowa and North Carolina, Transportation Research Board Annual Meeting, Washington, D.C., 9-13 January 2000.

Ray, M. H., Paper Presentation, Safety Effectiveness of Upgrading Guardrail Terminals to Report 350 Standards, Transportation Research Board Annual Meeting, Washington, D.C., 9-13 January 2000.

Ray, M. H., Status Report, Quality Assurance Standards for Full-Scale Crash Tests, Transportation Research Board Annual Meeting, Roadside Safety Features Subcommittee on International Activities, 9-13 January 2000.

Ray, M. H., Status Report, Progress in Establishing Quality Assurance Standards for Full-Scale Crash Tests, AASHTO-ARTBA-AGC Joint Committee on New Matierials, Task Force 13, Savanah, GA, 13-14 April 2000.

Ray, M. H., Paper Presentation, Using LS-DYNA to Simulate Collisions with Guardrails, 6th International LS-DYNA User s Conference: Simulation 2000, Dearborn, MI, 9-11 April 2000.

Appendix X

EIP Distance Learning Program