

Recycled Materials Resource Center

Final Proposal

Submitted by

The University of New Hampshire
and
The University of Wisconsin-Madison

In Response to RFP:
DTFH61-07-RA-00102

Part 1 – Technical Application

INTRODUCTION

Recycled materials and industrial byproducts are being used in transportation applications with increasing frequency. However, these materials still remain under-utilized due to technical and institutional barriers. The proposed Recycled Materials Resource Center (RMRC) described herein has been designed to provide the resources and activities needed to breakdown these barriers and increase utilization of recycled materials and industrial byproducts. This will be done through carefully integrated and orchestrated activities that include basic and applied research in key areas relevant to transportation applications combined with outreach programs that provide the educational and technical resources needed to maximize the rate at which recycled materials and industrial byproducts are used in transportation applications.

Success of the proposed RMRC hinges directly on the ability of its leadership to *define* and *tackle* the most pressing barriers affecting use of recycled materials in highway applications. The leadership of the existing RMRC has relied heavily on input from primary stakeholders, such as the FHWA and state DOTs, to identify these barriers and to define the research needed to break down the barriers. The team in this proposal believes that the ability to *define* and *tackle* the most pressing barriers remains the single most important factor that will affect the success of the new RMRC. Thus, the RMRC proposed by this team has been designed from this perspective.

Many changes have occurred since the original RMRC was conceived. Thus, the team offering this proposal believes that the new RMRC must begin by defining a clear vision of the most important barriers affecting the use of recycled materials *today*, and in the *future*. This visioning effort will be followed by development and implementation of an integrated strategic plan focused on developing and providing the technical information and educational resources necessary to break down the barriers. The ultimate objective will be *to increase the wise use of recycled materials in roadway construction and maintenance*. Thus, the strategic plan will include activities to:

- systematically testing evaluating, and developing standards and guidelines and demonstrating environmentally acceptable and occupationally safe technologies and techniques for the increased use of recycled materials in highway construction and maintenance;
- making information available to state transportation departments, the Federal Highway Administration, the construction industry, local and municipal agencies, and other interested parties to assist in evaluating proposals to use recycled materials in transportation infrastructure construction;
- encouraging the increased use of traditional and non-traditional recycled materials by using *scientific principles* to analyze thoroughly all potential long-term considerations that affect the physical and environmental performance of recycled and secondary materials; and
- working cooperatively with federal, state and local officials to reduce institutional barriers that limit widespread use of recycled materials and to ensure that increased use is consistent with the sustained environmental and physical integrity of the infrastructure in which the materials are used.

These activities will ensure that:

- policymakers at the federal, state, and local levels have the education and technical information needed to formulate policy permitting recycled materials to be considered on equal footing with conventional construction materials,
- a voice dedicated to advocating recycled materials exists in each of the technical organizations associated with transportation infrastructure,
- existing information on recycled materials is organized and structured into standards, specifications, and typical engineering properties that can be used directly by the design and construction community,

- new and innovative applications of recycled materials are continuously developed, and
- industries and transportation agencies have the logistical tools needed to connect sources of recycled materials, applications in the transportation infrastructure, and entities involved in supply/delivery.

The unique team described in this proposal consists of experts from the University of New Hampshire (UNH) and the University of Wisconsin-Madison (UW) that provide all of the skills and expertise necessary to accomplish the overarching objective of the RMRC. Moreover, the UNH-UW team has the experience, leadership qualities, and connections necessary to ensure that the RMRC's impact is maximized. The complementary aspects of the team members provide a number of distinct advantages. For example, the combined team couples the existing relationships between UNH, FHWA, and state DOTs with the long-standing relationships between UW and industry (producers and contractors), which will permit the RMRC to effectively address all aspects of barriers to recycled materials use. The expertise of the team is also complementary, which increases the depth of knowledge and breadth of research experience that can be accomplished ranging from laboratory experimentation to full-scale field validation. The team also provides liaisons with many different centers involved in transportation research and outreach, which provides tremendous potential for leveraging expertise and resources. The UNH-UW team also provides greater geographical coverage in two critical areas for recycled materials use: the industrial Midwest and the Northeast corridor. Finally, past successes in outreach will be built upon with the expertise of UW's Department of Engineering Professional Development (EPD) to advance a much more aggressive outreach agenda that reaches a wider audience inclusive of the private sector.

TECHNICAL AND MANAGEMENT APPROACH

Center Operation

The RMRC will be organized under the auspices of the Federal Highway Administration (FHWA), with the Directors and an Advisory Board directly interacting with FHWA to set directions and policy, as shown in Fig. 1. The RMRC will be directed by Dr. Kevin Gardner (current RMRC director) and Dr. Craig Benson. Operation of the RMRC will be divided into three areas, Administration, Research and Development, and Outreach and Technology Transfer. Dr. Gardner will serve as Leader for Administration, Dr. Tuncer Edil will serve as Leader for Research and Development, and Dr. Jeffrey Melton will serve as Leader for Outreach and Technology Transfer. Gardner, Benson, Edil, and Melton will serve as the RMRC *Executive Committee*, which will work with an Advisory Board (described subsequently) and AOTR to define strategy and policy.

Each of the three areas has foci that are intended to maximize the RMRC's impact and address specific barriers to recycled materials use (Fig. 1). Coordinators of these foci have been selected based on their expertise, experience, and leadership skills (see *Staffing* section). Foci in the Center Administration area are intended to produce links with other state, regional and national research centers at UNH and UW through which the RMRC's efforts can be leveraged. The Research and Development area has four foci (Asphalt and Concrete, Structural Fill and Unbound Materials, Environmental Issues, and Recycling Markets) that address each of the key areas where barriers exist and technological development is necessary. Similarly, the Outreach and Technology Transfer area has foci to address training, information and communications, and development of standards and specifications.

The structure in Fig. 1 reflects the team's experience and perception of the major initiatives needed to breakdown the existing technical and institutional barriers. However, the team is cognizant that this structure may be optimized using input from others. Thus, one of the first activities of the proposed RMRC will be a visioning workshop where *perspectives and guidance from a broad community of stakeholders will be solicited with the objective of identifying the significant barriers that still exist to widespread adoption of recycled materials in transportation applications*. Refinements will be made based on this input as well as feedback from the Advisory Board.

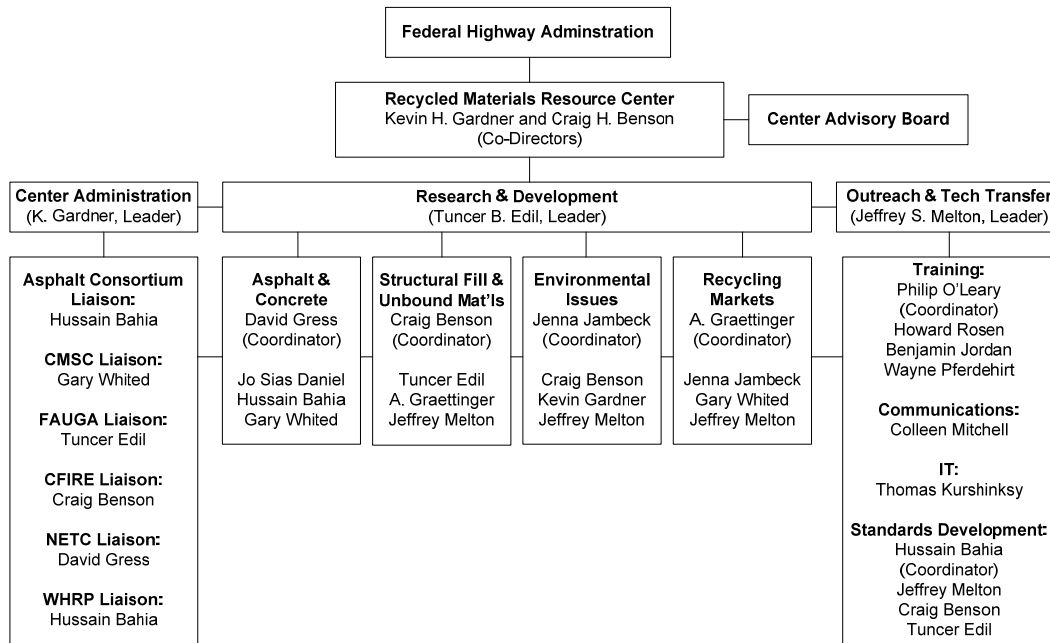


Fig. 1. Structure for the proposed RMRC.

The RMRC will be operated in a manner that maximizes coordination of effort between institutions, provides effective leadership, ensures seamless integration of operations, and provides for continuous opportunities for feedback and input from FHWA and other stakeholders. One of the primary tools used by the RMRC administration will be regularly scheduled, monthly IP videoconferencing to coordinate the efforts at the different institutions. All members of the Executive Committee will participate in these meetings, while the RMRC co-directors will schedule a weekly teleconference to maintain communication. Every fourth monthly meeting will include coordinators of the research thrusts to summarize the content of research activities in the different areas in a longer videoconference meeting. The FHWA AOTR will be apprised of the video conferencing schedule and will be encouraged to participate in these meetings. Videoconferencing is an enabling technology, allowing the creation of an RMRC that is built on the best individuals and best institutions, providing optimal service and functionality to FHWA.

Advisory Board - An Advisory Board will be established within the first month and will be comprised of individuals nominated by the Executive Committee and approved by the AOTR. The Advisory Board will play a critical role in guiding the new RMRC, and will be expected to attend the visioning workshop that will be instrumental in setting the direction for research and outreach. The Advisory Board will be engaged by the Executive Committee and will make recommendations regarding the strategic plan, annual work plans, financial plans, and self evaluation plans. The Advisory Board will also act as a conduit to the stakeholders, including FHWA. The Advisory Board will also make recommendations regarding selection and prioritization of research topics and will provide assistance in identifying sites for field demonstration of research. Advisory Board meetings will be held annually.

Strategic Plan - A Strategic Plan will be prepared for the 4-year period, along with a Policy and Operational Procedures Manual, based on information gleaned from the visioning workshop, experience with the existing RMRC, and advice and recommendations from the Advisory Board. Concurrence will be obtained from the AOTR. The Strategic Plan will be designed so that the RMRC's impact and use of resources is optimized.

Annual Work Plans - Annual Work Plans (AWPs) will be prepared at the beginning of each year, with advice and recommendations from the Advisory Board and concurrence from the AOTR. The AWP will identify the activities needed to implement the Strategic Plan and meet the four primary objectives of the RMRC. Each AWP will include a list of desired outcomes and provide a mapping of these outcomes to the overall RMRC objectives and the Strategic Plan. Development of research topics and projects will be part of the annual work plan preparation, and will be a collaborative effort between the RMRC Executive Committee, the research foci leaders, and the Advisory Board. Outreach topics and schedules (discussed further below) will be developed in a similar fashion and be included in the AWP.

Self-Evaluation – A system for on-going self-evaluation and improvement will be developed collaboratively by the Executive Committee, the Advisory Board, and AOTR. The structure of the anticipated evaluation process is illustrated in Fig. 2. The process includes definition of objectives and outcomes in the Strategic Plan and each AWP, collection of performance data, evaluation of the performance data in context of the objectives and outcomes, and implementing adjustments and future plans annually based on the data collected.

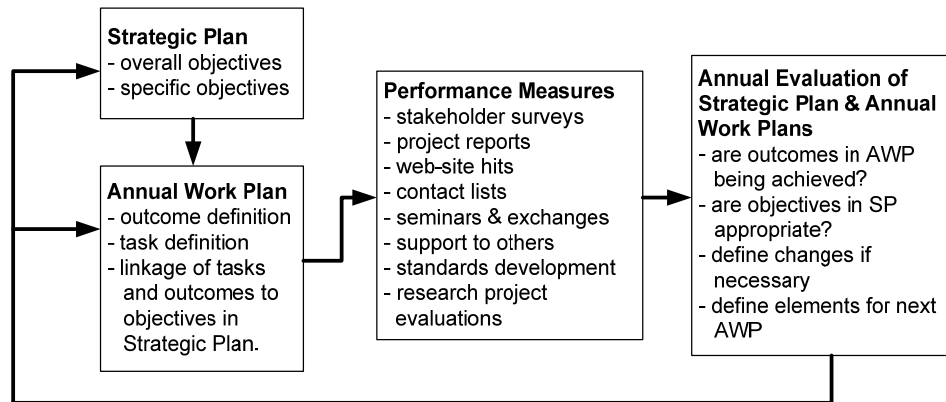


Fig. 2. Structured of evaluation process for proposed RMRC. Annual evaluations conducted by Executive Committee in Collaboration with the Advisory Board and the AOTR.

Qualitative and quantitative performance measures will be used to determine whether the outcomes have been attained and the objectives are being satisfied. Many of the quantitative performance measures employed at the current RMRC, which were developed collaboratively with FHWA and the original Board, will be retained in the new system (e.g., number of website hits, number of clients, number of data requests, number of people presented to by the RMRC, and number of websites linked to the RMRC website). Additional performance measures that will be tracked include number of reports and publications, standards/specifications/guidelines developed and adopted, and research projects completed. Data will also be collected by surveying stakeholders interacting with the research and outreach components of the RMRC. For example, surveys will be sent to persons making information requests, participants in learning activities (webinars, workshops, conferences), and FHWA and DOT personnel interacting with the RMRC. The surveys will request quantitative performance scoring, but will also include a section where written comments can be provided. Progress of research projects will also be tracked and an annual evaluation of research projects will be conducted by the Executive Committee in the context of anticipated outcomes.

Reasonable and achievable targets for each performance measure will be identified at the start of each year by the Executive Committee with input from the Advisory Board and the AOTR. The evaluation will include a comparison of actual performance relative to the targets. Results of this self-evaluation will be used when developing each AWP and to update the Strategic Plan as needed. Input from the Advisory

Board and AOTR will be used when making changes to the Strategic Plan and when formulating the AWP. Results of the evaluation will be included in the annual report to FHWA and the Advisory Board. Summaries of the performance data will also be included in quarterly reports to FHWA. The Board and AOTR will provide recommendations to the RMRC Executive Committee regarding adjustments to the AWP and the Strategic Plan based on their review of this report.

Timeline - The timeline for the proposed RMRC is illustrated in Fig. 3. The RMRC will begin by assembling the advisory board and conducting the visioning workshop shortly after being established. Immediately after the visioning workshop, the Executive Committee will develop a Strategic Plan and an AWP for the first year of operation with assistance provided by RMRC participants and the advisory board. This Annual Work Plan will include formulation of research projects that will provide the technical information needed for the Strategic Plan and outreach activities to provide information to stakeholders. A similar approach will be followed in each year, with the elements of the work plan modified based on feedback from the self evaluation process.

Task	Year 1				Year 2				Year 3				Year 4			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Vision Meeting	■															
Info Center Established ¹	■															
Establish Advisory Board	■															
Board Meeting		■			■				■				■			
Annual Report				■				■				■				■
Conference								■								■

Fig. 3. Timeline for activities in the proposed RMRC

Center Annual Financial Plan - An annual plan will be developed to maximize leveraging of RMRC funds through a variety of mechanisms such as (i) an industrial partners program, (ii) in-kind and collaborative assistance with field research, (iii) state DOT or local partners co-sponsoring specific projects, (iv) in-kind institutional contributions, and (v) revenues from registration fees for seminars, conferences, etc. The Advisory Board will be engaged in selecting and developing these sources of leveraging. Each of the potential sources is described in the following.

An industrial partners program will be modeled after the existing Consortium for Fly Ash Utilization in Geotechnical Applications (FAUGA) at UW. Members of FAUGA include electric utilities that produce coal combustion products (CCP), distributors of CCPs, and contractors that specialize in CCP applications. FAUGA has committed to focus its research efforts through the proposed RMRC and to provide at least \$55,000 annually to support undergraduate students and a graduate student to participate in RMRC projects. If the RMRC is awarded to the UNH-UW team, FAUGA has committed to increasing the number of partners in the consortium so as to provide an even larger potential for leveraging efforts by the RMRC. A similar effort will be undertaken to develop industrial partnerships with other industries, such as the cast metals industry, the paper industry, the scrap tire industry, and the construction debris industry. The Executive Committee of the proposed RMRC has long-standing relationships with these industries and will use these relationships to build an industrial partners program with each industry.

The proposed RMRC will also leverage resources by participation in demonstration projects conducted by local, state, and private entities where recycled materials are being used in transportation applications. At least \$120,000 of this type of in-kind support will be available annually to the RMRC. However, greater leveraging is likely to occur. The Executive Committee of the proposed RMRC has been participating in

similar projects for many years with entities across the US where recycled materials are being used in transportation applications. Over the last five years, the portion of these projects that will be considered leveraging in the context of the proposed RMRC has had an average annual value exceeding \$400,000. Additional leveraging will also be available from (i) State Planning and Research (SP&R) funds, (ii) pool funds for recycling demonstration projects and other project co-sponsorship, (iii) in-kind state funds, and (iv) other FHWA and federal project funds. Each of these sources will be used to the extent possible by the proposed RMRC.

UNH and UW are also committed to provide in-kind support for the RMRC as documented in the budget section of this proposal. This in-kind support includes salary for the directors, area leaders, academic staff, and students as well as indirect costs. The total value of this support is over \$1.6 million. Additional institutional leveraging is also anticipated through affiliations with other research centers at UNH and UW focused on transportation research (see Fig. 1, Administration area). These centers are described in the *Staffing* section.

The proposed RMRC will include a series of webinars and workshops as part of its outreach effort. Fees associated with these outreach activities will be modest so as to maximum participation and technology transfer. Nevertheless, revenues from these efforts are anticipated to be at least \$15,000 annually. These revenues will be available to the proposed RMRC.

Research Projects and Collaboration with Federal, State, Local, and Private Sector Partners

The proposed RMRC will conduct research projects in each of the foci shown in Fig. 1 to address technical barriers to recycled materials use. The content of these projects will be developed in coordination with the Advisory Board and AOTR. Feedback from the visioning workshop will also be used to define the research projects.

Some of these projects will involve field applications. The RMRC will coordinate with federal, state, and municipal officials and other stakeholders to identify test sites and demonstration projects where applications of recycled materials can be evaluated under field conditions and can benefit from the expertise and resources available at the RMRC. Collecting performance data describing the long-term physical and environmental performance of recycled materials in the transportation applications will be a key objective of the proposed RMRC. Existing sites as well as newly constructed sites will be considered. For example, eight instrumented highways and embankments constructed using industrial byproducts are currently being monitored for long-term performance by participants in the proposed RMRC. These highways, which are located in Wisconsin, Minnesota, and New Hampshire, will be available for research and data collection by the RMRC. The field monitoring has to be corroborated with laboratory experiments and analytical investigations to derive generalized conclusions and recommendations, which is an important function of the RMRC.

A variety of opportunities for participation in demonstration and full-scale projects from a broad set of stakeholders is anticipated. Thus, the proposed RMRC will develop a consistent methodology for evaluating the merits of potential projects and for selecting projects for RMRC collaboration. This methodology will include a formal application available to stakeholders on the RMRC website. This application will include a series of questions related to the type and potential impact of project to be considered, such as technical characteristics of project (recycled materials to be used, highway design, monitoring strategies, type of application, etc.), the long-term availability of the site to the RMRC and other researchers, and the potential for leveraging. The application form and evaluation procedure will be developed by the RMRC's Executive Committee with input from the Board. Projects in which the proposed RMRC participates will be consistent with the Strategic Plan and themes of existing research efforts being conducted in each of the research thrusts. The intent will be to add value to a planned or on-going demonstration project (rather than fund the total cost of the demonstration) that could provide data or other information contributing to the mission of the RMRC. For example, the RMRC could provide assistance with data collection, long-term performance monitoring, data interpretation, and analysis

needed to develop general conclusions and recommendations. Projects in which the proposed RMRC participates will need to be approved by the RMRC's Executive Committee and will need a positive recommendation from the Advisory Board.

The availability of the RMRC for participation in projects will be advertised to the stakeholders by several mechanisms. These mechanisms will include a solicitation on the RMRC website, notices in electronic newsletters and related communications distributed by the RMRC, and announcements at meetings and conferences where stakeholders participate (e.g., TRB Annual Meeting, TRB committee summer meetings, ASTM semi-annual meetings, the Byproducts Summit).

Outreach and Technology Transfer

The proposed RMRC will have an outreach program that promotes adoption of research products developed by the RMRC and disseminates information on using recycled materials in transportation applications. The outreach program will consist of electronic resources (website, information clearinghouse, electronic databases,), training sessions (webinars, short courses), two international conferences, participation in conferences, seminars, and other scientific exchanges, and standards development. Each of these elements is described below. The outreach components that involve face-to-face participation are particularly important. For example, frank and open discussion amongst RMRC members, researchers, and stakeholders ultimately led to the adoption of the RMRC-sponsored AASHTO standards on use of post-consumer shingles in hot mix asphalt.

The outreach program will involve the University of Wisconsin's Department of Engineering Professional Development (EPD), the nation's largest and most diverse provider of continuing engineering education. In 2006, EPD offered 56 continuing education courses on transportation engineering topics to 3065 participants. EPD is also recognized as a leader in distance education, with the EPD Master of Engineering in Professional Practice (MEPP) receiving every major national and international award in recognition of quality. EPD is also a leader in distance training through an extensive series of webinars. In addition to the specific tasks proposed for the RMRC, EPD will integrate recycled materials into its training courses in geotechnics and pavement design, construction, and maintenance.

Web Site - The existing RMRC web site will be extensively updated with input from the RMRC participants, the Advisory Board, and AOTR. The updated web site will take advantage of the many technological and security innovations that have become available since the original website was created, and will serve as one of the principal information and outreach mechanisms available to the stakeholders. The website will also serve as a portal to other State, Federal, and Association web sites that have related content as well as the electronic portion of the information clearinghouse and database (described in the next section). In addition, the renewed site and all electronic documents will comply with all appropriate accessibility regulations (e.g. section 508 of the Rehabilitation Act). The updated web site will be a living electronic resource that is continually updated as new information becomes available and feedback is provided by stakeholders. Major functions of the RMRC, such as standards development and outreach schedules, will have dedicated space on the web site.

Information Clearinghouse - The RMRC will maintain an interactive electronic information clearinghouse to keep the transportation community abreast of technical advances, developments, and activities pertaining to recycled materials use in transportation applications. The Clearinghouse will be coordinated with other state, federal, and related international information systems including the Transportation Research Information Services (TRIS) and the Netherlands' clearinghouse on waste reuse. The Information Clearinghouse will be designed to be comprehensive, easy to use, and meets the overarching goal of the RMRC. The following elements will be included:

- **Online Information Guide.** This guide will direct users to the type of information they are seeking and provide the informational resources that are appropriate. Links to TRIS and the Netherlands' clearinghouse will be provided, along with guidance for using these resources. Other resources that

will be available include AASHTO specifications, state specifications related to recycled materials use, and FHWA, USEPA, and industry guidance documents (e.g., *Fly Ash Facts for Engineers*). Final reports for research projects, bibliographies of research topics, and contact information for experts are other types of information that will be provided depending on the type of information being sought.

- **Contact Databases.** Searchable contact databases will be developed that include contacts at state DOT and environmental agencies as well as contacts at regional FHWA, regional EPA, and other federal agencies. Contacts lists compiled by industry trade groups will also be included. These databases will allow users seeking information about a particular material, application, or location to receive specific information and appropriate contacts.
- **Toll-Free Resource Line.** A toll-free (“800”) number will be established that will connect information seekers to RMRC staff that can answer questions and provide direction to other information sources. The RMRC staff will also find answers to questions that are not easily answered. The toll-free number will be established within the first month of operation and will be available from 8 AM – 4 PM EST.
- **Electronic Newsletter.** An electronic newsletter will be distributed quarterly that provides news related to Center activities as well as announces conferences, seminars, and meetings of interest to stakeholders. The newsletter will also be posted on the website, and printed versions of the newsletter will be available to stakeholders on request. Each newsletter will include a featured research project and a featured outreach opportunity, with links to obtain more information.
- **Learning Groups.** Electronic learning groups will be established in which stakeholders can share information and communicate ideas on various themes. Initial themes for the electronic groups will be identified based on information gathered from the visioning meeting and from recommendations by the Advisory Board. The learning groups will be interactive and will be accessible through the website. An RMRC staff member will be assigned to each learning group as a facilitator.

Databases - Electronic databases will be developed and maintained in coordination with other State, Federal, and International partners to provide the highway community with access to up-to-date information (data, technical information, specification, and performance issues, etc.) on using recycled materials in the highway environment. A liaison will also be maintained with other agencies sponsoring technical information databases and technical support will be provided. Links to these databases will be included through the Information Clearinghouse, so that users seeking this type of specific information can be guided to the databases.

Webinar Training – Webinars are on-line training programs that can be accessed by anyone that has access to a computer with a high-speed internet connection. They generally last 90-120 minutes and are lead by an instructor. Webinars reach a large group of stakeholders and deliver a focused presentation on a particular topic. The proposed RMRC will have three series of webinars (one series per year in each of the first three years), with four to six webinars offered in each series at two to three month intervals. Each webinar series will cover a particular theme (e.g., assessing environmental impacts associated with recycled materials, writing specifications for recycled material applications, etc.). A series of questions will be posed at the end of each webinar to evaluate the participant’s understanding and the effectiveness of the instructor. Faculty involved in the RMRC will serve as webinar instructors/leaders. Webinar offerings will be advertised via the RMRC website, list servers of technical organizations interacting with the RMRC, and through EPD’s sophisticated marketing system.

The webinars will be prepared and presented by EPD in collaboration with the RMRC. EPD will follow the successful model employed in their MEPP program when preparing each webinar series. Topical certification will be provided by EPD to participants on completion of a webinar series. Professional development credits (PDHs or CEUs) will also be provided by EPD to participants after completing each webinar. The availability of certification and professional development credits is expected to enhance participation, as many professionals are required to accumulate these credentials to maintain professional

licensure. Content from these training seminars will also be incorporated into the NHI Highway Materials Engineering course. Preliminary discussions between Dr. Melton and personnel from FHWA and US DOT indicate that a two-day section on recycled materials will fit into the NHI course.

Short Course Training – A series of four regional short courses will be offered in the third year of the RMRC to convey research findings of the RMRC and the latest methods regarding the use of recycled materials in highway applications. They will be offered in locations that are easily accessed and will also include remote involvement of participants by IP video teleconferencing. These short courses will follow a similar format as those previously offered by the existing RMRC, but will be broader in scope and will reflect the latest findings of research conducted during the first three years of the RMRC. EPD will provide continuing education credits to all participants in the short courses. Faculty involved in the RMRC will serve as short course instructors. Short course offerings will be advertised via the RMRC website, list servers of technical organizations interacting with the RMRC, and through EPD’s marketing system.

International Conferences - A goal of the proposed RMRC is to develop a self-sustaining bi-annual specialty conference that focuses on the use of recycled materials in the transportation applications. Having a regularly scheduled conference of this sort is key to a maturing and accepted technology. Getting these conferences into a routine will help acceptance of recycled materials in highway applications. These conferences ultimately might be coupled with the TRB annual meeting, as was done with *Geosynthetics 2007*. During the first year, the RMRC will develop a follow-up to the “Beneficial Use of Recycled Materials Transportation Applications Conference” organized by the RMRC in 2001. This international conference will attract scholars, regulators, DOT personnel, and industry representatives and will cover all aspects of recycled materials use in the highway environment. The conference proceedings will be peer-reviewed and will be published in a bound volume. A second international conference will follow in the fourth year. The RMRC will take a lead role in organizing both conferences. Logistical and organizational support will be provided by UW’s EPD. RMRC personnel will be responsible for selecting co-sponsors and will have leadership roles in the steering and technical committees.

Conference Co-sponsorship – The proposed RMRC will also support smaller conferences through sponsorship and logistical support. These conferences will follow the example of the New England Rubber Modified Asphalt & Civil Engineering Workshop held in October 2005, which was co-sponsored and supported by the RMRC under the direction of Dr. Melton.

Conferences to be sponsored will be identified based on the priorities established collaboratively with the Advisory Board. Sponsoring and/or supporting certain regular conferences is anticipated, such as the WASCON International Conference on the Environmental and Technical Implications of Construction with Alternative Materials, the annual summer meeting of TRB ADC60 Committee for Waste Management and Resource Efficiency in Transportation, and ASTM symposia focused on recycled materials testing and standards.

Conference Participation – Personnel involved in the proposed RMRC are active in a broad variety of technical organizations (TRB, AASHTO, ASCE, ASTM, ACI, ISCOWA) and many of the personnel in the proposed RMRC have leadership roles in these organizations. The breadth of organizations and the leadership positions of the participants will allow the RMRC to become engaged in a broad variety of conferences and reach a large and diverse audience, thereby maximizing the impact of the RMRC’s research findings. RMRC personnel will take an active role in requesting, organizing, managing, promoting, and speaking at sessions on recycled materials in highway applications at conferences in their professional organizations. The RMRC will also have an exhibit booth at conferences when appropriate.

Participants in the RMRC will also become involved with conferences associated with trade organizations (e.g., organizations for suppliers of recycled materials and contractors for transportation facilities) and regulatory organizations. For example, the RMRC will participate in meetings and conferences of the American Coal Ash Association, the American Foundry Society, the American Road and Transportation Builders Association, and the Association of State and Territorial Solid Waste Management Officials. The intent is to remain in close contact with the key organizations affecting the use of recycled materials so that the RMRC remains at the forefront of key issues.

One of the most important conferences is the TRB Annual Meeting in Washington, DC. Many of the personnel of the proposed RMRC are active in TRB and will therefore attend and present at the TRB annual meeting on behalf of the RMRC. In the current TRB committee structure, responsibility for recycled materials is dispersed through five or more committees (e.g., ADC60, AFK30, AFN40, AFS80, AFS90, AFS 70). RMRC personnel will work through the TRB committee structure to provide a focal point and greater visibility to recycled materials. The committee chair for AFN10 (Basic Research and Emerging Technologies Related to Concrete) has agreed to sponsor a TRB Task Force on Recycled Materials, and committee sponsors from Planning and Environment, Bituminous Materials, and Geology and Properties of Earth Materials will be sought to establish a widely represented Task Force on Recycled Materials in the first year of the RMRC. The RMRC will also continue to have an exhibit booth at the TRB Annual meeting, as has been done for the past nine years.

Standards/Specifications/Guidelines Development and Coordination with AASHTO, ASTM, and Other Standardization Organizations - Staff from the RMRC will be engaged in AASHTO, ASTM, Transportation Research Board (TRB), ASCE, ACI, and the International Society for the Environmental and Technical Implications of Construction with Alternative Materials (ISCOWA) committees on behalf of the RMRC. Liaisons with other standards-setting committees or organizations will be developed as appropriate. The primary objectives of this activity will be (1) to develop and publish standards regarding tests, methods, and procedures for using recycled materials in highway applications, (2) to define practices for scientifically measuring, recording, and documenting the long-term physical and environmental performance of recycled materials used in highway applications, and (3) to enhance understanding and visibility of recycled materials in these important organizations. Members of the proposed RMRC currently have leadership roles in each of these organizations. As members of the RMRC, they will use them on behalf of RMRC to proactively advance standards on mature topics. Assignments to each of these organizations are described in the *Staffing* section.

RMRC personnel will also work closely with state DOT materials/soils engineers and local and municipal transportation agencies and develop acceptable construction specifications. These are referred as “implementation” projects and are largely based on completed research and demonstration projects but sometimes require additional specific research to support the specification language. The proposed RMRC will be particularly focused on promoting such highly cost-effective efforts.

STAFFING

Organization. The structure shown in Fig. 1 (previous section) also serves as the organizational chart for the proposed RMRC. Staffing for the various parts of this structure is described in this section.

Direction. Kevin Gardner and Craig Benson will serve as co-directors of the RMRC. They will have primary responsibility for interacting with the Federal Highway Administration, the Center Advisory Board, and byproducts stakeholders as well as developing and implementing the Strategic Plan. Gardner and Benson will also provide direct oversight of activities at UNH and UW, respectively. Both have extensive experience in administering large groups and have a strong background in research related to recycled materials. Gardner is Director of the existing RMRC at UNH as well as the UNH Environmental Research Group (ERG). ERG is a formal entity organized under the Vice President for Research and consists of some 30 faculty and senior research staff and 30 graduate students at UNH. Gardner manages ERG, with annual research expenditures of over \$4.5 million, and coordinates staffing, the capital plant,

proposals and research initiatives. Gardner has directed the RMRC since 2004 and has been responsible for the RMRC's continued success. Benson is Associate Chairman of the Dept. of Civil and Environmental Engineering at UW. In this capacity, he manages 14 full-time faculty and three professional staff in the Environmental Science and Engineering Division and oversees an annual academic budget of approximately \$1.4 million and an annual research budget of approximately \$7 million. Benson also manages a research group consisting of 12 persons with an annual budget of approximately \$1 million. He also recently completed a three-year appointment as Editor-in-Chief of the *ASCE J. of Geotechnical and Geoenvironmental Engineering*. As Editor-in-Chief, Benson managed four editors and 45 associate editors that were responsible for 600 manuscripts annually. Gardner and Benson will be allocated two months of effort per year for their responsibilities as co-directors.

Center Administration. Gardner will also serve as Center Administration Leader and will be responsible for day-to-day administrative issues. Gardner will be allocated one month per year for effort associated with Center Administration. As Center Administration Leader, Gardner will also oversee collaborative relationships between the RMRC and other research centers at UNH and UW shown in Fig. 1. These centers include the Asphalt Research Consortium (ARC), the Construction Materials Support Center (CMSC), the Consortium for Fly Ash Use in Geotechnical Applications (FAUGA), the National Center for Freight and Infrastructure Research and Education (CFIRE), the New England Transportation Consortium (NETC), and the Wisconsin Highway Research Program (WHRP). Each of these affiliated centers is associated with state or federal transportation departments (ARC, CMSC, CFIRE, NETC, and WHRP) or byproducts producers (FAUGA), and will provide strategic interactions and leveraging of resources. An RMRC Liaison will be assigned to each affiliated center (see section Liaison Assignments below) to provide a direct pathway for communication with the RMRC.

Research and Development. The Research and Development Discipline will be lead by Tuncer Edil (Fig. 1). He has been working in recycled materials for more than 20 years and has experience in all four of the research thrust areas. He has published more than 60 articles and reports on methods to use recycled materials in transportation applications and has directed 22 research projects in the area. Edil has been instrumental in establishing the use of recycled materials and industrial byproducts in highway construction in the upper Midwest. For example, he played a key role in developing engineering criteria and design methods for using tire chips as lightweight fill in highway embankments. He also conducted the first full-scale study of industrial byproducts as unbound pavement materials in Wisconsin highways and is responsible for developing the methodology used in the Midwest for stabilizing soft subgrades with fly ash. Edil's research contributions have been incorporated into the Wisconsin DOT's (WisDOT) Facilities Development Manual, which is used by WisDOT designers. Edil has been allocated two months per year for effort associated with leading the Research and Development focus area of the RMRC.

The Research and Development Thrusts will be lead by David Gress (Asphalt and Concrete), Craig Benson (Structural Fill and Unbound Materials), Jenna Jambeck (Environmental Issues), and Andrew Graettinger (Recycling Markets). These leaders will oversee research projects conducted in each of the thrust areas and will be assisted by other experts in each thrust (see listings in Fig. 1). Each leader has been allocated one month of effort per year for leading the thrust areas. Participants in the thrust areas have also been allocated time for their efforts on individual research projects and participation in outreach and technology transfer functions.

The leaders for the thrust areas have been selected based on their expertise in the themes associated with each thrust. Gress has conducted laboratory and full scale demonstration projects using MSW bottom ash substitution in hot-mix asphalt, high volume use of out of specification coal fly ash for freeze-thaw resistant flowable fill, stabilization and solidification of waste materials for use as a construction material, cement substitution using pulverized E-glass and window glass to mitigate alkali silica reaction in Portland cement concrete, and has monitored and evaluated full scale Portland cement kiln test burns using hazardous waste materials for raw materials in the production of Portland cement. Benson has

conducted laboratory and field research on the engineering properties (modulus, strength, compressibility, and hydraulic properties) and long-term behavior of a variety of recycled materials and industrial byproducts including foundry sands and slags, coal combustion byproducts, paper residuals, tire chips, and shredded plastics. Jambeck has extensive experience in the environmental characterization of materials for beneficial use, contaminant fate and transport, sustainable and innovative waste and materials management practices, and life-cycle approaches to waste and materials management. Graettinger's expertise is related to site characterization and GIS applications in civil engineering, and has experience in developing mapping applications that connect byproducts generators with applications.

Outreach and Technology Transfer. Jeffrey S. Melton will serve as Leader of the Outreach and Technology Transfer discipline. He serves in this capacity for the existing RMRC and will assume a similar role in the proposed RMRC. Melton will oversee all activities associated with outreach, technology transfer, and standards development. In addition, he will personally manage the 800-hotline, the information clearinghouse, and the electronic databases. He will also be the primary contact for stakeholders (e.g., government officials, byproducts generators, contractors, etc.) seeking applications information from the RMRC. Melton will also serve as the official RMRC liaison to the Transportation Research Board (TRB), the American Association of State Highway and Transportation Officials (AASHTO), and the International Society for the Environmental and Technical Implications of Construction with Alternative Materials (ISCOWA). He will take an active role in each of these organizations on behalf of the RMRC. Melton will also have primary responsibility for preparing and delivering annual reports, and creating and maintaining the RMRC website. Colleen Mitchell will assist Melton with reporting and communications and Thomas Kurshinsky will provide support for databases and the website. Melton has been allocated five months per year for his effort as Outreach and Technology Transfer Leader. Mitchell and Kurshinsky have been allocated four months per year for their effort. These levels of effort are consistent with the effort required for the existing RMRC.

Development and implementation of training materials for the RMRC workshops and the webinars will be done by Phillip O'Leary, Benjamin Jordan, Howard Rosen, and Wayne Pferderhirt of the Dept. of Engineering Professional Development (EPD) at UW. Each has extensive experience in training and technology transfer in the recycling and transportation industries. O'Leary, who will serve as training coordinator, has more than 30 yr experience in outreach and continuing education and is acknowledged as one of the nation's leaders in the discipline. As Chairman of EPD, O'Leary manages 20 program directors that are dedicated to outreach and continuing education. Benjamin Jordan is a program director in EPD and provides training and technical assistance focused on pavement construction, rehabilitation, and maintenance to public works, highway, and transportation departments at the municipal and state level. He is a civil engineer and formerly was employed by the Illinois DOT and served as a municipal public works director. Howard Rosen, PhD is a program director in EPD and specializes in continuing education related to public works infrastructure, dynamics of technological development, and organizational change. Before coming to UW, Rosen served as the Assistant Director of Education of the American Public Works Association and Administrative Officer of the Canadian Public Works Association. Wayne Pferdehirt, PE is a faculty associate in EPD that has extensive experience in design of recycling programs and facilities, planning and design of transportation facilities, and development and delivery of web-based education. Pferdehirt also directs the development and delivery of UW's web-based engineering graduate degree programs. His Master of Engineering in Professional Practice (MEPP) has been honored as the top distance degree program by the Sloan Foundation, the University Continuing Education Association, and the US Distance Learning Association.

Standards/specifications development will be undertaken by Hussain Bahia (Coordinator), Jeffery Melton, Craig Benson, and Tuncer Edil. Each has extensive experience in the development and approval of standards in ASTM and AASHTO. For example, Bahia and Melton have developed AASHTO standards related to hot-mix asphalt and use of recycled material in highway construction. Similarly, Benson and Edil have developed ASTM standards related to the engineering properties of structural fill and unbound

materials. Benson currently serves on the Executive Committee of ASTM Committee D18 and is developing a subcommittee in D18 that will publish standards for using recycled materials and industrial byproducts as construction materials. Edil will chair this new subcommittee.

Liaison Assignments. The Center will designate individual members as liaisons to the organizations discussed in the section on Center Operation. The assignments will be: AASHTO - Melton; TRB - Edil (AF30, AFS70), Daniel (AFK50, AFK30), Gardner (ADC60, ADD40), Bahia (AFK20, AFK30, AFK40), Gress (AFN10, AFN30); ASTM - Benson (D18 Executive Committee, D18.04, D18.14, D18.20), Edil (D18.04, D18.14 - new committee on recycled materials in geotechnical construction, Edil chair); ACI - Gress (Committee 555). Assignments to other centers and organizations are shown in Fig. 1. Gardner will serve as the liaison to the International Society for the Environmental and Technical Implications of Construction with Alternative Materials. Liaisons will maintain regular contact with their organizations, actively participate as committee members, accept leadership roles, regularly attend organization meetings, report RMRC activities to the organizations, and report organizational activity to the RMRC.

Biographical Sketches of Leadership and Key Participants

Kevin H. Gardner, PhD, PE (Center Co-Director and Administration Leader) is Associate Professor of Civil Engineering, the Robert C. Davison Professor of Environmental Engineering, and Director of the existing Recycled Materials Resource Center and the Environmental Research Group at the University of New Hampshire (UNH). Prior to joining UNH in 1999, he was on the faculty of Case Western Reserve University. Dr. Gardner has a BS from Union College (NY) and MS and PhD degrees from Clarkson University (all in Civil and Environmental Engineering). He conducts experimental and numerical modeling research on topics related to environmental aspects of recycled material use. Dr. Gardner has conducted more than \$7 million in research projects for a number of federal agencies (e.g. National Science Foundation, EPA, FHWA, National Oceanic and Atmospheric Administration), industry associations, and corporations. His research projects have included laboratory investigations of fundamental environmental processes, pilot-scale and full-scale field demonstrations, development of numerical fate and transport models, and investigation of life-cycle and other industrial ecological analyses related to recycled materials use. Dr. Gardner has published more than 60 articles and reports on his work, including more than 35 articles in refereed journals and one patent related to recycled materials use. Dr. Gardner is a member of TRB, ASCE, the ASCE Committee on Sustainability, the International Society for the Environmental and Technical Implications of Construction with Alternative Materials (ISCOWA), the American Society for Engineering Education, the Association of Environmental Engineering and Science Professors, and is the Research Subcommittee Chair and a member of TRB ADC60 Committee for Waste Management and Resource Efficiency in Transportation.

Craig H. Benson, PhD, PE (Center Co-Director and Structural Fill and Unbound Materials Thrust Coordinator) is Professor of Civil and Environmental Engineering, Professor of Geological Engineering, and Kellet Fellow at the University of Wisconsin-Madison (UW). He has been on the faculty at UW since January 1990. Dr. Benson has a BS from Lehigh University and MSE and PhD degrees from the University of Texas at Austin (all in Civil Engineering). He conducts experimental and analytical research on topics related to the environment, including the reuse of industrial byproducts in civil, geotechnical, and transportation engineering. He has conducted more than \$15,000,000 in research projects for a variety of federal agencies (e.g., National Science Foundation, EPA, USDOT, Dept. of Energy, Dept. of Homeland Security), state agencies (e.g., Minnesota Dept. of Transportation, Wisconsin Solid Waste Research Program, Wisconsin Dept. of Transportation, Wisconsin Dept. of Natural Resources), and corporations. These research projects have included laboratory studies, large-scale field experiments and demonstrations, and development of predictive computer models regarding the use coal combustion byproducts, foundry byproducts, and paper industry residuals in construction applications. Dr. Benson has published more than 300 articles and reports on his work, including more than 100 articles in refereed journals and 5 ASTM standards. He is Director of the UW Geotechnics Laboratory and Co-Director of the UW Consortium for Fly Ash Utilization in Geotechnical Engineering. Dr. Benson

has received several awards for his work, including the Presidential Young Investigator Award from the National Science Foundation and the Distinguished Young Faculty Award from the US Dept. of Energy. Dr. Benson has also received the Huber Research Prize as well as the Croes, Middlebrooks, Collingwood, and Casagrande Awards from the American Society of Civil Engineers, and the Kellet Mid-Career Research Award from the UW Graduate School. Dr. Benson is a member of ASTM, ASCE, and the ASCE Geo-Institute and is the immediate past Editor-in-Chief of the *ASCE/GI Journal of Geotechnical and Geoenvironmental Engineering* (2004-2006). He holds two US patents on test methods to evaluate the hydraulic properties of construction materials.

Tuncer B. Edil, PhD, PE (Research and Development Leader) is Professor of Civil and Environmental Engineering, Professor and Chair of Geological Engineering at the University of Wisconsin-Madison (UW). He has been on the faculty at UW since November 1973. Dr. Edil has a BS and MS from Robert College and PhD degrees from Northwestern University (all in Civil Engineering). He conducts experimental and analytical research on topics related to geotechnical construction and environment, including the reuse of industrial byproducts in civil, geotechnical, and transportation engineering. He has conducted more than \$20 million in research projects for a variety of federal agencies (e.g., National Science Foundation, Dept. of Energy, EPA, USDOT, NOAA, USGS), state agencies (e.g., Minnesota Dept. of Transportation, Wisconsin Solid Waste Research Program, Wisconsin Dept. of Transportation, Wisconsin Dept. of Natural Resources, Wisconsin Department of Administration, Wisconsin Groundwater Research Program, Wisconsin Sea Grant Program), and corporations. These research projects have included laboratory studies, large-scale field experiments and demonstrations, and development of predictive computer models regarding the use coal combustion byproducts, foundry byproducts, scrap tires, and scrap asphalt shingles in construction applications. Dr. Edil has published more than 260 articles and 100 reports on his work and book chapters, including more than 140 articles in refereed journals and 2 ASTM standards. He is Co-Director of the UW Consortium for Fly Ash Utilization in Geotechnical Engineering. Dr. Edil has received several individual and team awards for his work, including the Dow Outstanding Young Faculty Award from the American Society of Engineering Education, Young Civil Engineer of the Year, Merit for Individual Achievement as an Engineer in Education, and Outstanding Civil Engineer in SW Branch awards from the ASCE Wisconsin Section, and *Journal of Cold Regions Engineering* Best Paper Award from ASCE. Dr. Edil has also received the International Achievement Award from the Industrial Fabrics Association International and Blue Pencil Award for Professional Paper Award from National Association of Government Communicators. Dr. Edil is a member of TRB, ASTM, ASCE, and the ASCE Geo-Institute and is the past Editor-in-Chief of the *ASCE/GI Journal of Geotechnical and Geoenvironmental Engineering* (1984-1988) and the current Editor-in-Chief of the *Geotechnical and Geological Engineering* journal published by Springer.

Jeffrey S. Melton, PhD (Outreach and Technology Transfer Leader) is a Research Assistant Professor of Civil and Environmental Engineering at the University of New Hampshire (UNH). He has been on the faculty at UNH since February 2002. Dr. Melton has BA in Physics from Hamilton College, an MS in Ocean Engineering from UNH and a PhD in Engineering Sciences from the Thayer School of Engineering, Dartmouth College. His research is focused on the remediation of contaminated soils and sediments, and on the beneficial use of industrial byproduct materials in geotechnical and infrastructure engineering projects. He has conducted more than \$1,000,000 in research projects for federal agencies such as the DOT, the EPA and the National Oceanic and Atmospheric Administration, and for corporations. His research seeks to characterize the mechanical and environmental properties of recycled materials at both the laboratory and field scale, and then use the resulting data to predict their long term performance through numerical modeling. He is currently evaluating recycled materials for use in unbound pavement layers within the context of the FHWA Mechanistic-Empirical Design Guide. Dr. Melton is also the Director of the Outreach Program at the Recycled Materials Resource Center. In this capacity he has given 17 presentations on behalf of the RMRC, co-organized a session on recycled materials at GeoTrans 2004, co-organized three specialty workshops on recycled materials, and organized two of the RMRC's regional recycled materials workshops.

David L. Gress, PhD, PE (Asphalt and Concrete Coordinator) is Professor of Civil Engineering and Associate Director of the existing RMRC. Dr. Gress has been on the faculty at UNH since September 1974 and was chair of the department for 9 years. He teaches courses in materials and pavement design. Dr. Gress has a PhD from Purdue University in Civil Engineering with emphasis in Materials. He conducts experimental and analytical research on topics related to transportation materials, including recycled materials and industrial byproducts used when renewing the civil infrastructure. He has been involved with more than \$14,000,000 in projects funded from a variety of federal agencies (e.g., Department of the Army, Department of the Navy, National Science Foundation, EPA, DOT Federal Highway Administration, Department of Transportation Federal Aviation Administration, various State Agencies (e.g., Connecticut DOT, Maine DOT, Massachusetts Highway Department, New Hampshire DOT, Rhode Island DOT and Vermont Highway Department), and corporations (e.g., Public Service of New Hampshire and Wheelabrator Technologies). These research projects have included laboratory studies, full scale field experiments, and demonstrations. Dr. Gress has published in a variety of referred journals and conference proceedings associated with the transportation industry and is a member of and the Official University Representative to the Transportation Research Board (TRB), American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), American Society of Testing and Materials (ASTM), and the American Ceramic Society (ASC). He is a member of the Policy Committee of the University Transportation Center (MIT, Harvard, and all New England State Universities), Advisory Committee of the New England Transportation Consortium (all New England State Universities), and is a member of the following national committees: ACI 555 Concrete with Recycled Materials, TRB AFN10 Basic Research Emerging Technologies Related to Concrete, TRB AFN30 Durability of Concrete, and ASCE Highway Research.

Jenna R. Jambeck, PhD (Environmental Thrust Coordinator) is a Research Assistant Professor of Civil and Environmental Engineering at the University of New Hampshire (UNH). She has been on the faculty at UNH and a part of the existing RMRC since August 2005. Dr. Jambeck has BS, MSE, and PhD degrees from the University of Florida in Environmental Engineering. She has eight years of experience in solid waste, recycled material beneficial use, and construction and demolition (C&D) debris issues. Relevant research she has participated in includes an investigation of recycled materials to attenuate hydrogen sulfide from the beneficial use of C&D debris fines, environmental and economic issues with recycling C&D debris, beneficial use and characterization of abrasive blasting media, and leaching of mine waste aggregates. Her research at UNH has been funded by various entities including the FHWA (RMRC), USEPA, and Waste Management of Massachusetts. She is currently updating the FHWA/USEPA [User Guidelines for Waste and Byproduct Materials in Pavement Construction](#) for coal combustion products, foundry sand, and C&D debris. Her past work also includes an evaluation of economic and industry impacts from various policy options for increasing recycling of C&D debris and assisting with sampling and characterizing Florida's C&D debris fines for inorganic contaminants. She previously worked for URS Corp. in Minnesota where one of her major clients was the Minnesota DOT. After leaving URS to pursue her PhD, she consulted with URS for the Solid Waste Management Coordinating Board in the Minnesota Twin Cities metro area on construction debris reduction and recycling. Jambeck assisted in developing www.shinglerecycling.org at UF in partnership with USEPA Region V and the Construction Materials Recycling Association. Before joining the Environmental Research Group at UNH, she was an Oak Ridge Institute for Science and Education post-doctoral associate at the USEPA Office of Research and Development in Research Triangle Park, NC. At USEPA, Jambeck assisted with research on life-cycle approaches to waste and materials management and exploring the affect of increased air pollution controls on current recycling or disposal of coal combustion byproducts.

Andrew J. Graettinger, PhD (Recycling Markets Coordinator) is Visiting Professor of Civil and Environmental Engineering at the University of Wisconsin-Madison (UW) and is Associate Professor of Civil, Construction, and Environmental Engineering at The University of Alabama (UA), having started at UA in August 1998. Dr. Graettinger received his PhD in Civil Engineering from Northwestern

University and his MS and BS degrees from the University of Wisconsin–Milwaukee. Dr. Graettinger’s research interests are in geotechnical engineering, specifically the use of recycled materials in geotechnical applications, reliability-based geotechnical site characterization, and geographic information systems applied to civil engineering. Within these research interests, he has been involved in 16 research projects totaling over \$1.5 million, including field and laboratory research on employing recycled plastics as a high-value lightweight geotechnical fill. Dr. Graettinger has published over 50 articles and reports including 15 refereed journal articles. He received the 2003 Donald H. McClean Civil Engineering Professor of the Year Award at UA and is a member of the American Society of Civil Engineers (ASCE), American Society for Engineering Education (ASEE), and the Urban & Regional Information Systems Association (URISA). Dr. Graettinger also holds a provisional patent for a nanoscale waterjet device. Graettinger is currently updating the FHWA/USEPA User Guidelines for Waste and Byproduct Materials in Pavement Construction for coal combustion products, foundry sand, and C&D debris.

Philip R. O’Leary, PhD, PE (Training Coordinator) is Professor and Chair of the Department of Engineering Professional Development at the University of Wisconsin-Madison. He has BS, MS, and PhD degrees in engineering and land resources from the University of Wisconsin-Madison. Dr. O’Leary directs the technical outreach program for the College of Engineering at the University of Wisconsin-Madison. In this capacity he oversees the delivery of over 400 continuing education courses each year in a wide range of technical specialties. The program, which serves national and international audiences, delivers training at multiple locations throughout the US and also over the internet. Dr. O’Leary’s area of expertise is solid waste management, hazardous waste control, groundwater quality protection, and related environmental topics. In this capacity he organizes training programs for practicing professionals. His landfill design course has been attended by thousands of professionals who are responsible for developing, permitting and operating landfills throughout the US and Canada. O’Leary co-founded the highly successful Solid and Hazardous Waste Education Center (SHWEC) at the University of Wisconsin in 1991. SHWEC conducts practical studies, outreach programs, and training on all aspects of waste management for industries throughout the US.

Hussain U. Bahia, PhD (Standards Development Coordinator) is Professor of Civil and Environmental Engineering, at the University of Wisconsin-Madison (UW). He also serves as Technical Director of the Wisconsin Highway Research Program (WHRP), a joint program between UW and the Wisconsin DOT, and is coordinator of the Materials for Constructed Facilities Graduate Program. He joined the faculty at the University of Wisconsin-Madison in 1996, prior to which he served at the Asphalt Institute and Penn State University. He completed his PhD at Penn State University in 1991. He currently teaches and conducts research in construction materials and design, with emphasis on asphalt materials. One of his main research interests is reuse of industrial by-products, particularly recycled rubber and foundry sands. He has completed a number of studies on the re-use of crumb rubber in asphalt pavements and studies on the characterization and best practices for use of foundry sands in hot-mix asphalt. His research activities include experimental laboratory and field work as well as modeling and interpretation of experimental results. Bahia has advised more than 30 graduate students. He has contributed significantly to continuing education activities and has been active in ASTM for many years. He has published more than 50 technical publications in refereed journals in the area of paving materials and pavement performance, and has authored a large number of technical reports for various public and private agencies. He holds three US patents on test methods to evaluate the properties of asphalts binders. Dr. Bahia is an elected member of TRB committees AFK20, AFK30, and AFK40. He is also a member of the American Society for Engineering Education, the Association of Asphalt Paving Technologists, American Society of Civil Engineers, the Society of Rheology, and the American Society for Testing and Materials. He served as a member of the Expert Task Group (ETG) of the Federal Highway Administration on asphalt binders from 1993 to 2005. He has also served as a member of two of the NCHRP project panels related to Superpave technology. He is an associate editor of the *International Journal of Road Materials and Pavement Design*.

Jo Sias Daniel, PhD, PE (Asphalt and Concrete Thrust researcher) is an Assistant Professor in the Civil Engineering Department at the University of New Hampshire (UNH). Dr. Daniel received her BS in Civil Engineering from UNH in 1994, and her MS and PhD from North Carolina State University in 1996 and 2001, respectively. Dr. Daniel has been a faculty member at UNH since 2001. She conducts experimental and analytical research on asphalt mixtures and pavements, including the use of recycled asphalt pavement (RAP) in new asphalt mixtures. She has conducted more than \$1,200,000 in research projects for a variety of federal agencies (e.g., National Science Foundation, National Cooperative Highway Research Program), state agencies (e.g., New Hampshire DOT, New England Transportation Consortium), and corporations. These research projects have included material characterization in the laboratory, application of constitutive models for fatigue, field experiments, accelerated load testing in the laboratory, evaluation of pavement maintenance treatments, analysis of RAP mixtures using the Mechanistic Empirical Pavement Design Guide (MEPDG) and implementation of the MEPDG. Dr. Daniel has published more than 20 articles and reports on her work, and regularly presents her work at the Transportation Research Board (TRB) and Association of Asphalt Paving Technologists (AAPT) annual meetings, among other regional, national, and international conferences. Dr. Daniel received the UNH Outstanding Assistant Professor Award and was runner-up for the AAPT Walter J. Emmons Best Paper Award. Dr. Daniel is a member of TRB, AAPT, ISAP, ASCE, the FHWA Models Expert Task Group, and is on the Editorial Board of the *International Journal of Road Materials and Pavement Design*. She is currently a member of TRB committees AFK50 and AFK30 and is chair of AFK50(1) subcommittee on Advanced Models to Understand Behavior and Performance of Asphalt Mixtures.

Gary C. Whited, PE (Asphalt and Concrete Thrust & Unbound Materials researcher) is Program Manager of the Construction and Materials Support Center (CMSC) in the Department of Civil and Environmental Engineering, University of Wisconsin-Madison. Mr. Whited is responsible for managing operations of the Center, conducting research activities, performing engineering studies for federal, state, and local transportation agencies, consulting on materials engineering and construction management projects, and classroom teaching. Mr. Whited has 35 years of experience in managing transportation programs and providing technical expertise in highway construction management and materials use/testing for the Wisconsin DOT (WisDOT). At WisDOT he held positions of Administrator - Headquarters Division and State Highway Engineer, State Construction Engineer, State Materials Engineer, Chief Regional Road Design Engineer, Assistant State Geotechnical Engineer, and Soils Engineer. He has a BS from Iowa State University and a MS (geotechnical) from the University of Wisconsin – Madison. Mr. Whited has served on a number of National Cooperative Highway Research Program (NCHRP) project oversight committees dealing with construction, pavements, and geotechnical engineering. He has served on a variety of TRB committees on soils, materials, pavement and construction topics. He was a member of the American Association of Transportation Officials (AASHTO) European Scanning Tour on Construction Contract Administration and chair of the AASHTO European Asphalt Pavement Warranties Scanning Tour. Mr. Whited has authored papers published in the *ASTM Geotechnical Testing Journal* and *Transportation Research Record*. He is a professional engineer in Wisconsin and is a member of ASCE, the Association of Asphalt Paving Technologists, and Midwest Concrete Consortium.

EXPERIENCE

This section describes UNH experience followed by UW experience; the experience of each institution is divided into sections describing experience in Research and Development followed by Outreach and Technology Transfer.

UNH Research and Development Experience

The RMRC at UNH has been a leader in advancing recycled materials-related research, not only conducting research at UNH but working with states, private companies, and other universities to find the best people to conduct needed research and leverage resources associated with related initiatives. The

success of the RMRC at UNH can be measured in many ways, but perhaps most significant has been the strong support received from AASHTO. The Subcommittee on Materials (SOM) of AASHTO has endorsed the work of the Center by passing a resolution in favor of continued support for the RMRC. The resolution was subsequently passed by the AASHTO Board of Directors. The resolution points out that *the product-driven research supported and conducted by the RMRC has resulted in materials specifications and practices, which are items of interest to the SOM*. In addition, the resolution notes the *productive collaboration between the SOM Recycled Materials Task Force and the RMRC that has resulted in the RMRC Recycled Materials Workshops for DOT personnel and the Survey on Recycled Materials*. The resolution ends with a call to support the RMRC so that these activities will continue.

Since the inception of the RMRC, 39 individual research projects have been conducted at UNH and at Universities, private companies, and State DOTs across the country. The common theme among the projects are that they serve a need expressed by the highway community, are applied in nature, and result in research products that are useful to road construction and maintenance stakeholders. Projects have developed novel products and uses for recycled materials in the highway environment, developed protocols for environmental testing and compliance, developed and demonstrated a lifecycle costing and analysis tools to better understand the full range of cost and environmental benefits stemming from recycled materials use, developed cold in place recycling mixture design, developed guidance for structural layer coefficients for foamed asphalt pavement layers, and assessed thermal and mechanical response of tire treads, whole tires, and soil/tire shred mixtures in embankments. From the research projects, the RMRC has developed 10 standards that have been adopted (7) or are under consideration for adoption (3) by AASHTO. The standards that have been developed are detailed below in the section UNH Outreach Experience. Other products include computer programs, design guidelines and procedures, and data. A brief review of research topics conducted by the RMRC and its contractors is provided below, divided by material or research focus into seven sections.

Recycled Asphalt Pavement - Several RMRC projects have investigated the effect of including RAP on the overall properties of the asphalt concrete mixture. Projects have investigated how the mixture properties changed as different percentages of RAP were added. Rheological properties such as dynamic modulus, phase angle and creep compliance were measured at various temperatures and testing frequencies to develop master curves. The results of this project indicate that as the percentage of RAP increases, the RAP begins to act more like a black rock and changes the volumetric properties of the mixture, which in turn affects the performance. Other projects have addressed the use of RAP mixtures in the framework of the new Mechanistic-Empirical Pavement Design Guide (MEPDG). The effect of different PG binder grade assumptions on the performance prediction for several pavement structures have been demonstrated, and results of the Level 2 & 3 assumptions with Level 1 analysis, which uses actual properties measured from the RAP mixtures, have been compared. This work is being leveraged by work being performed under an NETC project that is developing a method for determining the effective PG grade of RAP mixtures.

Additional research has investigated the susceptibility of RAP mixtures to moisture damage under accelerated loading conditions in the laboratory. Various RAP mixtures have been tested in the wet and dry conditions under the Model Mobile Load Simulator to evaluate differences in rutting performance. The results of this research will provide the state agencies a method to select correct percentages of RAP to be used with virgin materials to produce moisture resistant HMA. Other RMRC projects have focused on using nondestructive testing equipment to better design and construct recycled pavement layers (plant mix recycled asphalt pavement and foamed asphalt full depth reclamation), development of a rational and practical mix design for full depth reclamation, evaluation of cement-stabilized full-Depth reclamation bases with regard to performance in frost areas and under early traffic, and development of a protocol for determination of compactive effort necessary for cold in-place recycling.

Recycled Concrete Aggregate - RMRC research has shown Recycled Concrete Aggregate (RCA) can be effectively utilized as an aggregate substitute for highway infrastructure projects. These efforts have

successfully shown the use of RCA in transportation structures to be economically and environmentally feasible. From a sustainability perspective, research has demonstrated significant reduction in CO₂ production and the use of hydrocarbon fuels; related laboratory and field-scale research has demonstrated the CO₂ sequestration capacity of recycled concrete leading to a pending patent on the technology. These features unquestionably make recycled concrete a material of choice. One significant RMRC effort was the participation with FHWA in a national review of the practice of using recycled concrete aggregate in transportation applications. Use of RCA as unbound base material has been addressed by a White paper and the development of guideline specifications. AASHTO is anticipated to approve and print these guideline specifications as provisional standards this coming summer. Little knowledge was available on using RCA that has been distressed by alkali silica reactivity (ASR) prior to the work done by the RMRC. This work has shown that ASR RCA can be used in recycled concrete if properly mitigated. Procedures for determining the remaining ASR expansion potential in RCA have been developed and are available for use. Performance of concrete pavements made with RCA has been studied by the RMRC and preliminary data show these pavements after 25 years of traffic have performed as well as if not better than the control pavements. This research has also shown that recycled concrete pavements can be rehabilitated using standard dowel bar replacement and diamond grinding techniques used on conventional pavements.

Environmental and Life Cycle Research - One of the significant barriers to the more widespread adoption of recycled materials use is concern over the risk to human health and the environment posed by their use. This barrier was clearly identified in the 2000 AASHTO survey, and continues to be a major concern based on feedback during the RMRC during workshops. For this reason, a significant component of research conducted by the RMRC focused on evaluation of environmental aspects. A number of different types of research have been conducted in this area, ranging from development of numerical models to laboratory experiments to collection of data from a field demonstration of recycled material use.

A number of research projects investigated fundamental leaching behavior to provide a more complete understanding of how to estimate long-term environmental performance. These projects included research focused on the long-term geochemical weathering reactions that significantly alter materials characteristics over time, the influence of freezing and thawing on contaminant release from recycled materials, and understanding contaminant release under more realistic conditions of wetting and drying and unsaturated conditions. These projects not only provided important data on environmental performance of materials but also evaluated the suitability of the simple test methods that are being used for estimating release and risk. Two other projects focused on providing data on two types of materials for which accurate environmental performance data did not exist: slags and mine waste materials.

Other RMRC research has focused on the use of models to predict the fate and transport of released contaminants through a highway structure. This work has provided a detailed research-grade model that provided critical information on the rates of water movement through pavements, cracks and base layers; this was coupled with contaminant transport to provide a means to accurately predict risk associated with recycled material use. One of the products from this is a technical paper that provides “look-up” graphs for any contaminant/sub-base/road condition, such that regulators can quickly and easily provide an approximation of groundwater impact from a proposed recycled material application. RMRC research has also provided a robust evaluation of the US EPA Industrial Waste Management Evaluation Model, originally designed for landfill and impoundment evaluation; this evaluation led to a new EPA effort to incorporate changes to better enable the model to be useful for state agency personnel in evaluating proposed applications of recycled materials.

Research has also focused on understanding life cycle costs and life cycle impacts of recycled materials use. One project developed a life cycle costing tool, useful for understanding the full cost of different roadway construction and maintenance options, including the use of recycled materials. The second project intended to provide a holistic view of the benefits and risks associated with recycled materials use.

The project has convincingly demonstrated that use of recycled materials has a wide range of environmental and economic benefits. A hybrid model is currently under development that permits precise calculation of site-specific risk associated with recycled materials use as well as environmental and economic benefits.

Environmental and life cycle research has provided information for an AASHTO standard of practice (provisional), has produced a freely available model, data on environmental performance, and useful look-up tables and graphs for environmental impact assessment.

Tires and Tire Shreds - The RMRC has collaborated on research on the evaluation of tire-rubber anti-vegetation tiles, recycled tire spacer blocks and a full-scale evaluation of mechanical and exothermal response of tire-soil embankments.

Plastics - Research has developed and evaluated a novel lightweight aggregate made from waste plastics mixed with fly ash, evaluated the performance of a cement stabilized pavement base course material consisting of recycled concrete aggregate, ASTM Class C fly ash, and waste plastic (high-density poly ethylene) strips obtained from post-consumer water and milk containers, and evaluated the suitability of recycled plastics use for stabilization of earth slopes (“Recycled Plastic Pins Used to Stabilize Slopes” standard submitted to AASHTO).

Composted Products - RMRC research has developed products and specifications for the use of composted and other similar materials in erosion and sediment control (Compost Blankets and Filter Berms/Socks accepted as two provisional AASHTO standards).

Asphalt Shingles - Research was conducted to overcome barriers to asphalt shingle recycling and develop standards for materials and recommended practices (both accepted by AASHTO).

Construction and Demolition Debris - The RMRC has developed “User Guidelines” on the use of C&D debris for roadway construction. A full-scale embankment was constructed using C&D debris to investigate leaching and hydrogen sulfide formation. Monitoring of this embankment continues.

UNH Outreach Experience

Since the inception of the RMRC in 1998, the UNH staff has made the RMRC a leader in technology transfer with regard to recycled materials in the highway environment. The RMRC’s Outreach Program has consistently produced tangible research products and then has worked to disseminate these products to end users via conferences, workshops, through its website and through professional bodies. The following section documents past outreach activities conducted by the UNH staff and demonstrates the experience that the UNH researchers have with outreach and technology transfer.

Standards. National standards have been a priority outreach product for the RMRC at UNH because these standards provide guidance to end users interested in recycled materials, and also make effective teaching tools at workshops. Working with the AASHTO Subcommittee on Materials and RMRC sponsored researchers, the staff at UNH has developed seven regular or provisional AASHTO standards, with three additional draft standards submitted to the SOM. Standards developed by UNH and UW researchers are shown in Table 1.

Conferences. The UNH investigators have shown leadership in promoting the use of recycled materials by organizing and hosting a number of conferences, forums and seminars through the outreach program of the RMRC. In 1999 UNH staff hosted a one-and-a-half day regional workshop on recycled materials in Albany, NY that was attended by more than 100 people from the Northeast. This was followed in 2001 by the “Beneficial Use of Recycled Materials Transportation Applications” conference held in Arlington, VA. The conference attracted more than 160 experts from 15 countries. The conference resulted in 97 papers being published in proceedings by the Air and Waste Management Association. In 2004 UNH hosted a forum on “Water Movement and Reactive Transport Modeling in Roads,” a two-and-a-half day event that brought together an international group of experts to discuss modeling of water in the highway

environment. UNH staff have worked with federal agencies to provide forums as well. In 2003 UNH hosted and co-organized the TRB ADC60 Summer Meeting in Portsmouth, NH. The theme of the meeting was “Beneficial Use, Sustainability, and Pollution Prevention in Transportation Infrastructure,” and resulted in seven technical papers and an editorial in a special issue of *Resources, Conservation and Recycling*. In 2006, UNH and the US EPA co-sponsored a forum on water modeling that served to follow up on the work done during the 2004 modeling workshop.

Table 1. AASHTO and ASTM standards developed by UNH and UW researchers.

Number	AASHTO Standards	Developer
M 318-02	Glass Cullet Use for Soil-Aggregate Base Course	UNH
M 319-02	Reclaimed Concrete Aggregate for Unbound Soil-Aggregate Base Course	UNH
MP 9-06	Compost for Erosion/Sediment Control (Filter Berms and Filter Socks)	UNH
MP 10-03	Compost for Erosion/Sediment Control (Compost Blankets)	UNH
MP 15-06	Use of Reclaimed Asphalt Shingles as an Additive in Hot-Mix Asphalt	UNH
PP 53-06	Design Considerations When Using Reclaimed Asphalt Shingles in New Hot-Mix Asphalt	UNH
PP 56-06	Evaluating the Engineering and Environmental Suitability of Recycled Materials	UNH
MP XX-XX	Reclaimed Concrete Aggregate for Use As Coarse Aggregate in Portland Cement Concrete	UNH
MP XX-XX	Coal Combustion Fly Ash for Embankments	UNH
MP XX-XX	Recycled Plastic Pins Used to Stabilize Slopes	UNH
R 26	Certifying Suppliers of Performance-Graded Asphalt Binders	UW
T 313	Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)	UW
R 28	Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)	UW
T 315	Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)	UW
	ASTM Standards	
D 1997	Standard Test Method for Laboratory Determination of the Fiber Content of Peat Samples by Dry Mass	UW
D 5084	Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter	UW
D 5715	Standard Test Method for Estimating the Degree of Humification of Peat and Other Organic Soils	UW
D 5856	Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall Compaction Mold Permeameter	UW
D 6836	Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using a Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, and/or Centrifuge	UW
D 7100	Standard Test Method for Hydraulic Conductivity Compatibility Testing of Soils with Aqueous Solutions that may Alter Hydraulic Conductivity	UW
D 7243	Standard Guide for Measuring the Saturated Hydraulic Conductivity of Paper Industry Sludges	UW

In addition to sponsoring workshops, UNH staff are very active with regard to making presentations about their research and presentations on the RMRC. Dr. Melton has made 17 presentations about the

RMRC over the past five years, and the staff average three presentations on RMRC sponsored research per quarter. UNH staff have presented information about the RMRC or RMRC sponsored work to more than 9,000 people since the Center became active. The staff are active in the Transportation Research Board, attending the TRB Annual Meeting in Washington, DC and their respective annual committee meetings both as representatives of the RMRC and to present RMRC sponsored research. UNH has had a booth on behalf of the RMRC at the TRB Annual meeting for the past nine years and has the experience and equipment to continue preparing a booth at Annual Meeting for the proposed project period. In addition, Dr. Melton has attended the AASHTO Subcommittee on Materials (SOM) Annual Summer Meeting for the past five years as a plenary session speaker and to provide support for proposed AASHTO standards developed with the support of the RMRC at UNH.

Recycled Materials Regional Workshops. The staff from UNH have organized and hosted four Regional Recycled Materials Workshops that covered the Northeast, Southeast, Midwest and Western regions of the United States. The workshops brought together State DOT Materials Engineers, State DOT Environmental Specialists, State EPA Beneficial Use Specialists, and FHWA Divisional Office personnel and US EPA personnel to learn about appropriate recycled materials use for each region of the country. Each workshop was the same in that attendees were given a “tool box” of information so as to allow them to develop their own recycling expertise within their state. The toolbox was made up of research products developed by UNH for the RMRC as well as guidance documents developed by FHWA and industrial associations. Each workshop had four recycled material modules that focused on material/application combinations that were of specific interest to that region of the country. The RMRC had experts develop and present these modules so that the attendees will get timely information and will be able to gain from the experience of the presenters. The workshops also had talks about the environmental aspects of using recycled materials, and about how different state DOTs have developed successful programs for incorporating recycled materials. Each member of the UNH staff attended at least two of the workshops. Follow-up surveys were sent to workshop participants to get their feedback regarding the effectiveness of the workshop as well as suggestions for how to improve it. These suggestions were incorporated to improve each subsequent workshop.

Additional Performance Measures. There are a number of additional performance measures that show the breadth of the UNH outreach efforts with regard to recycled materials. The UNH staff host the RMRC website, which is a valuable tool that allows potential end users to learn about the RMRC and to request information. The RMRC website at UNH has received over 90,000 hits to date, and 278 other websites have linked to the RMRC website. The RMRC newsletter is delivered to roughly 2,500 clients via email and through is downloadable from the website. The UNH staff has responded to more than 400 formal information requests. UNH has surveyed the people requesting information and asked them to rate the staff on five different aspects of answer to their info request. The staff have an average of 92% approval on their performance.

UW Research and Development Experience

The UW group has been conducting research on using recycled materials and industrial byproducts in unbound and bound materials for more than 20 yr. In all cases, a holistic research approach has been followed that includes fundamental study of material behavior (e.g., strength, compressibility, modulus, and hydraulic conductivity), definition of engineering properties and methods of measurement, field demonstrations and validation, and evaluation of environmental issues.

Scrap Tires – The UW group conducted the first studies on using mixtures of soil and chipped scrap tires as lightweight fill for embankments and retaining structures. This research program was conducted over a 10-yr period and included an evaluation of how chip content, chip size, and soil type affected the strength, compressibility, and hydraulic conductivity of soil-tire chip mixtures. Large-scale tests for determining leaching characteristics and sorptive capacity of shredded tires for contaminants were also conducted. A test embankment overlain by a roadway was constructed and monitored. The embankment was

instrumented to monitor for total and differential settlements and the roadway was evaluated for pavement distress over a two-year period. Lysimeters were placed within the embankment to monitor leaching of contaminants. A geogrid-reinforced segmental block retaining wall was also constructed using a soil-tire chip backfill. The wall was instrumented for vertical and horizontal deformations and was loaded to near failure to evaluate the design method. Products of this research program include a method to predict the strength of soil-tire chip mixtures, a procedure to predict short-term settlements of soil-tire chip embankments due to static and cyclic loading, a procedure to predict long-term creep settlements, modeling and field verification of mass behavior, and a procedure to design geosynthetic-reinforced structures using soil-tire chip backfill. This research program was sponsored by US EPA, the Wisconsin DOT, the Wisconsin Department of Natural Resources, the Wisconsin Solid Waste Research Program, and the Wisconsin Recycling Market Development Board.

Paper Residuals – The UW group conducted a research program on civil engineering applications of paper residuals for a period of 8 years. The emphasis was on using the paper residuals as a hydraulic barrier. Laboratory experiments were conducted to determine how the hydraulic conductivity, shear strength, and compressibility of paper residuals depend on the fiber content and ash content of the residual, the water content, and the compaction condition. Test cells were used to evaluate the field performance of compacted paper residuals and a full-scale paper sludge fill was instrumented to monitor long-term creep settlements. Products of this research effort include a method to evaluate the field hydraulic conductivity of paper residuals, a method to predict creep settlements, an ASTM standard (D 7243, *Standard Guide for Measuring the Saturated Hydraulic Conductivity of Paper Industry Sludges*) on hydraulic conductivity test procedures, and acceptance of the material in Michigan. This research program was sponsored by US EPA, the Wisconsin Solid Waste Research Program, the National Council for Air and Stream Improvement (NCASI), Mead Paper Company, and Manistee Paper Company.

Foundry Byproducts – The UW group has been conducting research on reuse of byproducts from the iron foundry industry since 1994. This research has included laboratory studies to define how the strength, resilient modulus, and hydraulic conductivity of foundry sands depend on the bentonite fraction of the sand, the compaction energy, and water content. Similar experiments were conducted to determine how the strength, resilient modulus, and hydraulic conductivity of foundry slag depend on the type of slag and the crushing method. The interaction characteristics of geosynthetic-reinforced foundry sands were also investigated for use as backfill in mechanically stabilized earth applications. Leaching experiments were conducted to evaluate the potential environmental impacts of using foundry sands in highway applications. Test fills were constructed to compare laboratory and field measured engineering properties of compacted foundry sands. Test sections using foundry sand and foundry slag as subbase and base were constructed as part of Wisconsin State Highway 60 in 2000. These test sections include lysimeters for monitoring leaching from the foundry byproducts and instruments for monitoring temperature and water content within the pavement profile. Falling weight deflectometer and pavement distress surveys have been conducted semi-annually since construction. Products of this research program include a methodology to predict the resilient modulus and CBR of foundry sands based on index properties, a methodology to determine field-scale resilient moduli of foundry sands and foundry slags using laboratory test results, a methodology to determine the thickness of foundry sand or foundry slag to be equivalent to a base layer of crushed stone, and the only full-scale long-term data set on the field performance and leaching characteristics of foundry sand and foundry slag used in a pavement application. Use of foundry sands in flowable fill applications was also investigated and specifications were developed based on foundry sand bentonite content. Findings from this research program have been incorporated into the Facilities Development Manual of the Wisconsin DOT. Sponsors of this research program include the Wisconsin DOT, the Wisconsin Recycling Market Development Board, the Wisconsin Solid Waste Research Program, the Wisconsin Groundwater Research Advisory Council, Richland Center Foundry, and Grede Foundries, Inc.

The UW Asphalt Research Group has been conducting research on reuse of foundry sand in asphalt paving mixtures since 1998. This research has included laboratory studies to define how the workability, strength, modulus, and resistance to moisture damage is affected by replacing fine aggregates in typical asphalt mixtures with foundry sand. The research included defining the critical properties of the foundry sands that could affect asphalt mixture behavior. Angularity, organic content, active clay content, and sodium silicate content were found to be the most critical properties that need to be measured and controlled in using recycled foundry sands. Methods for measurements of each of these properties and limits for control of quality were developed. The research also addressed the blending of recycled sands from various types of foundries and the steps that should be taken to ensure uniformity and consistency of properties. Field trials using the recycled sands in several sections in Wisconsin were monitored and documented. A literature database was developed and a set of lectures for training and education about best practices for use of these sands in asphalt mixtures were developed. In the latest study, funded by DOE, a database for critical properties of sands taken from 17 foundries selected to include various regions and types of metals was developed. The database was used to describe general trends of effect of sands on critical asphalt mixture design and performance variables. The database give typical percentages of recycled sands that can be used to achieve optimum use and performance of mixtures.

Coal Combustion Products – The UW group has been conducting research on civil engineering applications of coal combustion products (CCPs) for more than two decades. The more recent research has focused on using CCPs in highway applications such as a subgrade stabilizer or as base or subbase. The most recent research has focused on using CCPs to reduce the cost of rehabilitating or upgrading secondary highways. Laboratory studies were conducted to determine how the strength, resilient modulus, and CBR of soil-fly ash, recycled pavement materials-fly ash, and road surface gravel-fly ash mixtures depend on the properties of the fly ash, the properties of the base material being stabilized, and fly ash content. Seven test sections were constructed as part of highways in Wisconsin and Minnesota for full-scale evaluation of bottom ash and mixtures of various geomaterials and fly ash in pavement structures. Falling weight deflectometer and pavement distress surveys have been conducted semi-annually on these test sections since construction to evaluate long-term performance. Leaching tests were also conducted on soil-fly ash mixtures and the bottom ash and a leaching model was developed for evaluating potential environmental risks associated with using CCPs in highways. The leaching model was validated using data collected from lysimeters installed beneath the highway test sections. Products from this research program include a design method for subgrade stabilization with fly ash, a method to predict field-scale resilient moduli from laboratory-measured moduli, a detailed data set on field performance, and public-domain software for evaluating the environmental impacts associated with CCPs in highways. Results of the research have been incorporated into the Facilities Development Manual of the Wisconsin DOT. Sponsors of this research program include the US Department of Energy, the National Science Foundation, the Wisconsin DOT, the Minnesota DOT, the Minnesota Local Roads Research Board, the Wisconsin Department of Natural Resources, the Wisconsin Solid Waste Research Program, the Wisconsin Consortium for Fly Ash Utilization in Geotechnical Applications, Alliant Energy, Great River Energy, Xcel Energy, and Lafarge Inc.

UW Outreach and Technology Transfer Experience

The Department of Engineering Professional Development (EPD) at the University of Wisconsin-Madison is the nation's largest and most diverse provider of continuing engineering education. Each year, EPD presents nearly 400 short courses annually to over 12,000 practicing professional engineers in a wide variety of technical fields. Nearly 100 of these courses are offered outside of Wisconsin. In 2006, EPD offered 56 continuing education courses on transportation engineering topics to 3065 participants. EPD is also home to the Wisconsin Transportation Information Center.

EPD is recognized as a leader in distance education. EPD's Master of Engineering in Professional Practice (MEPP) has received every major national and international award on engineering education and distance learning organization in recognition of its quality. This two-year program provides full-time

employed engineers with an opportunity to earn a Master's Degree from the UW-Madison College of Engineering by taking courses offered at a distance. EPD's extensive experience in developing and providing transportation-focused training programs enables it to contribute to the success of the RMRC. EPD has organized and managed conferences and other training programs for AASHTO committees and state DOT personnel, and regularly offers a series of short courses on pavement design, evaluation, and rehabilitation. EPD has recently organized and managed successful large conferences such as Transportation Asset Management, Maintenance Quality Assurance, and the Mid-Continent Transportation Research Forum 2006: Making Research Pay Off. In 2007, EPD is managing the annual meetings of the AASHTO Subcommittees on Maintenance (SCOM) and systems operations & management (SSOM).

The UW group has been active in standards development in geotechnics and pavement materials through ASTM and AASHTO. These standards shown above in Table 1.

Past Performance

Past performance questionnaires have been supplied and sent under separate cover from the following individuals:

Sarah Tarpgaard, FHWA
William Turley, Construction Materials Recycling Association
David Goss, American Coal Ash Association
Claudio Manissero, FMC Corp., Lithium Division
Alan Rawson, NH DOT
John Siekmeier, MN DOT
Edward Harrington, TRB
Rick Fragaszy, National Science Foundation
Eileen Norby, Wisconsin Solid Waste Research Program
David Carson, US EPA
Robert Morgan, ASTM

Part II – Budget Application Detail

BUDGET SHEETS

Center Budget

Project Director: Kevin Gardner

Start and End Dates: June 1, 2007 - May 31, 2011

		Year 1	Year 2	Year 3	Year 4	Total	
A. Faculty							
PI - Gardner	Base 87,568	0.11 Acad 9,730	10,119	10,524	10,945	41,318	
		1.00 Summer 9,730	10,119	10,524	10,945	41,318	
		0.00 Cal 0	0	0	0	0	
Co-PI - Melton	82,524	0.56 Acad 45,847	47,681	49,588	51,572	194,688	
		0.00 Summer 0	0	0	0	0	
		0.00 Cal 0	0	0	0	0	
Co-PI - Jambeck	74,651	0.39 Acad 29,031	30,192	31,400	32,656	123,279	
		0.00 Summer 0	0	0	0	0	
		0.00 Cal 0	0	0	0	0	
Co-PI - Gress	100,000	0.00 Acad 0	0	0	0	0	
		1.00 Summer 11,111	11,556	12,018	12,499	47,184	
		0.00 Cal 0	0	0	0	0	
Co-PI - Daniel	76,578	0.00 Acad 0	0	0	0	0	
		1.00 Summer 8,509	8,849	9,203	9,571	36,132	
		0.00 Cal 0	0	0	0	0	
Total Faculty			113,958	118,516	123,257	128,188	483,919
B. Other Personnel							
Grad Students AY		0.0% 613NZO 41,715	42,966	44,256	45,585	174,522	
Grad Students SU (Partial Fringe)		7.9% 613NZO 19,253	19,830	20,406	21,039	80,529	
Subtotal Grad Students			60,968	62,796	64,662	66,624	255,051
Post Doctoral Assoc		25.9% 611Q90 0	0	0	0	0	
Pat Staff		41.1% 615NZO 34,861	36,256	37,706	39,214	148,037	
OS Staff		41.1% 617NZO 0	0	0	0	0	
Labor (incl student)		7.9% 61SNZO 4,000	4,160	0	0	8,160	
Labor (Partial Fringe exempt)		0.0% 61SNZO 0	0	0	0	0	
Total Salaries & Wages (A+B)			213,787	221,728	225,625	234,026	895,166
C. Fringe Benefits							
	289,417	7.9% 65YF10 3,257	3,351	3,130	3,241	12,979	
	507,322	41.1% 65YF10 49,102	50,942	52,979	55,099	208,122	
	0	25.9% 65YF10 0	0	0	0	0	
Subtotal			52,359	54,293	56,109	58,340	221,101
Total Salaries, Wages & FB (A+B+C)			266,146	276,021	281,734	292,366	1,116,267
D. Tuition		721100	32,520	33,014	34,376	36,095	136,005
E. Equipment		740000	0	0	0	0	0
F. Travel		710000	20,000	22,000	15,000	24,000	81,000
G. Other Direct Costs							
Materials & Supplies		711200	40,566	39,899	29,689	31,668	141,822
Publications Cost		711200	5,000	5,000	5,000	5,000	20,000
Kickoff Meeting		717000	10,000	0	0	0	10,000
Computer Services		711200	4,000	3,000	2,000	2,000	11,000
Subcontracts		730001	519,948	530,401	547,160	514,106	2,111,615
Service Providers		717200	0	0	0	0	0
Other (F&A Exempt)		722200	0	0	0	0	0
Other			0	0	0	0	0
Other			0	0	0	0	0
Total Direct Costs			898,180	909,335	914,959	905,235	3,627,709
MTDC Base			370,711	345,920	333,422	355,033	1,405,087
H. Facilities & Administrative		0.00 760300	166,820	155,664	150,040	159,765	632,289
Total Direct + F&A			1,065,000	1,064,999	1,064,999	1,065,000	4,259,998
I. Cost Sharing (if any)			504,488	515,752	543,315	496,878	2,060,433
J. Program Income (if any)			0	0	0	0	0
Total Project Costs			1,569,488	1,580,751	1,608,314	1,561,878	6,320,431

UNH Cost-Sharing Detail

Project Director: Kevin Gardner Start and End Dates: June 1, 2007 - August 31, 2010

This is a cost-sharing sheet, not a budget

			Year 1	Year 2	Year 3	Year 4	Total	
A. Faculty								
	Base	Mos or %						
PI - Gardner	87,568	0.28	Acad	24,324	25,297	26,309	27,361	103,291
		0.00	Summer	0	0	0	0	0
		0.00	Cal	0	0	0	0	0
Co-PI - Melton	82,524	0.00	Acad	0	0	0	0	0
		0.00	Summer	0	0	0	0	0
		0.00	Cal	0	0	0	0	0
Co-PI - Jambeck	74,651	0.00	Acad	0	0	0	0	0
		0.00	Summer	0	0	0	0	0
		0.00	Cal	0	0	0	0	0
Co-PI - Gress	118,089	0.17	Acad	19,682	20,469	21,288	22,140	83,579
		0.00	Summer	0	0	0	0	0
		0.00	Cal	0	0	0	0	0
Co-PI - Daniel	85,000	0.11	Acad	9,444	9,822	10,215	10,624	40,105
		0.00	Summer	0	0	0	0	0
		0.00	Cal	0	0	0	0	0
Total Faculty				53,450	55,588	57,812	60,125	226,975
B. Other Personnel								
			Fringes					
1 TA, 1 PhD fellow - Grad Stud AY		0.0%	613NZ0	27,810	28,644	29,504	30,390	116,348
Grad Students SU (Partial Fringe)		7.9%	613NZ0	13,905	14,322	14,752	0	42,979
Subtotal Grad Students				41,715	42,966	44,256	30,390	159,327
Post Doctoral Assoc		25.8%	611Q90	0	0	0	0	0
Pat Staff		41.1%	615NZ0	0	0	0	0	0
OS Staff		41.1%	617NZ0	0	0	0	0	0
Labor (incl student)		7.9%	61SNZ0	0	0	0	0	0
Labor (Partial Fringe exempt)		0.0%	61SNZ0	0	0	0	0	0
Total Salaries & Wages (A+B)				95,165	98,554	102,068	90,515	386,302
C. Fringe Benefits								
	42,979	7.9%	65YF10	1,092	1,117	1,151	0	3,360
	143,396	41.1%	65YF10	13,879	14,399	14,975	15,574	58,827
	0	25.8%	65YF10	0	0	0	0	0
Subtotal				14,971	15,516	16,126	15,574	62,187
Total Salaries, Wages & FB (A+B+C)				110,136	114,070	118,194	106,089	448,489
D. Tuition								
			721100	32,520	33,014	34,376	30,079	129,989
E. Equipment								
			740000	0	0	0	0	0
F. Travel								
			710000	0	0	0	0	0
G. Other Direct Costs								
Materials & Supplies			711200	0	0	0	0	0
Publications Cost			711200	0	0	0	0	0
Consultants			717000	0	0	0	0	0
Computer Services			711200	0	0	0	0	0
Subcontracts			730001	0	0	0	0	0
Service Providers			717200	0	0	0	0	0
Other (F&A Exempt)			722200	0	0	0	0	0
Other				0	0	0	0	0
Other				0	0	0	0	0
Total Direct Costs				142,656	147,084	152,570	136,168	578,478
MTDC Base				110,136	114,071	118,193	106,089	448,489
H. Facilities & Administrative								
		0.00	760300	49,561	51,332	53,187	47,740	201,820
Total Direct + F&A				192,217	198,416	205,757	183,908	780,298
I. Cost Sharing (if any)								
				0	0	0	0	0
J. Program Income (if any)								
				70,000	70,000	70,000	70,000	280,000
Total Project Costs				262,217	268,416	275,757	253,908	1,060,298

UW Budget Detail

Proposed Budget
Agency: FHWA/UNH

		Year 1	Year 1	Year 2	Year 2	Year 3	Year 3	Year 4	Year 4	Total	Total	Grand Total
		UW	Match	UW	Match	UW	Match	UW	Match	UW	Match	
A. Senior Personnel												
1. Craig Benson	2.5	\$ 34,316	\$ 25,737	\$ 35,345	\$ 26,509	\$ 36,406	\$ 27,304	\$ 37,498	\$ 28,123	\$ 143,565	\$ 107,674	\$ 251,238
2. Tuncer Edil	2	\$ 30,576	\$ 22,932	\$ 31,494	\$ 23,620	\$ 32,438	\$ 24,329	\$ 33,412	\$ 25,059	\$ 127,920	\$ 95,940	\$ 223,860
3. Andrew Graettinger	1.25	\$ 12,500	\$ -	\$ 12,875	\$ -	\$ 13,261	\$ -	\$ 13,659	\$ -	\$ 52,295	\$ -	\$ 52,295
4. Hussain Bahia	1	\$ 11,581	\$ -	\$ 11,929	\$ -	\$ 12,287	\$ -	\$ 12,655	\$ -	\$ 48,452	\$ -	\$ 48,452
5 Gary Whited	0.5	\$ 2,792	\$ -	\$ 2,875	\$ -	\$ 2,962	\$ -	\$ 3,051	\$ -	\$ 11,679	\$ -	\$ 11,679
6 Phil O'Leary	0.25	\$ -	\$ 3,690	\$ -	\$ 3,800	\$ -	\$ 3,914	\$ -	\$ 4,032	\$ -	\$ 15,437	\$ 15,437
7 W. Pferdehirt	0.6	\$ 6,796	\$ -	\$ 7,000	\$ -	\$ 7,210	\$ -	\$ 6,188	\$ -	\$ 27,194	\$ -	\$ 27,194
8 B. Jordan	0.4	\$ 3,459	\$ -	\$ 3,563	\$ -	\$ 3,670	\$ -	\$ 3,780	\$ -	\$ 14,471	\$ -	\$ 14,471
9 H. Rosen	0.2	\$ 1,911	\$ -	\$ 1,968	\$ -	\$ 2,027	\$ -	\$ 2,088	\$ -	\$ 7,993	\$ -	\$ 7,993
Total Senior Personnel		\$ 103,931	\$ 52,359	\$ 107,049	\$ 53,930	\$ 110,260	\$ 55,548	\$ 112,330	\$ 57,214	\$ 433,570	\$ 219,050	\$ 652,621
B. Other Personnel												
1. Post Doctoral Associates		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
2. Other Professionals		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
3. Graduate Student	4 0.5	\$ 76,877	\$ 19,219	\$ 79,952	\$ 19,988	\$ 83,150	\$ 20,787	\$ 86,476	\$ 21,619	\$ 326,455	\$ 81,614	\$ 408,068
4. Project Asst		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
5. Undergraduate Students		\$ -	\$ 10,000	\$ -	\$ 10,000	\$ -	\$ 10,000	\$ -	\$ 10,000	\$ -	\$ 40,000	\$ 40,000
6. Lab Manager		\$ -	\$ 7,303	\$ -	\$ 7,559	\$ -	\$ 7,823	\$ -	\$ 8,097	\$ -	\$ 30,782	\$ 30,782
7. Other - LTE		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Total Salaries		\$ 180,808	\$ 88,881	\$ 187,001	\$ 91,476	\$ 193,410	\$ 94,158	\$ 198,806	\$ 96,930	\$ 760,025	\$ 371,445	\$ 1,131,470
C. Fringe Benefits												
35.0% *A		\$ 57,130	\$ 26,270	\$ 59,050	\$ 27,120	\$ 61,040	\$ 27,990	\$ 62,660	\$ 28,900	\$ 239,880	\$ 110,280	\$ 350,160
24.0% *B1&B4	2% *B5											
27.0% *B3	35.0% *B6											
	20.0% *B7											
Total S&W + FB		\$ 237,938	\$ 115,151	\$ 246,051	\$ 118,596	\$ 254,450	\$ 122,148	\$ 261,466	\$ 125,830	\$ 999,905	\$ 481,725	\$ 1,481,630
D. Equipment												
1.		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
2.		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
3.		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
4.		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
5.		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
6.		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Total Equipment		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
E. Travel												
1. Domestic		\$ 13,000	\$ -	\$ 22,000	\$ -	\$ 25,000	\$ -	\$ 22,000	\$ -	\$ 82,000	\$ -	\$ 82,000
2. Foreign		\$ 3,000	\$ -	\$ 3,000	\$ -	\$ 3,000	\$ -	\$ 3,000	\$ -	\$ -	\$ -	\$ 12,000
F. Other Direct Costs												
1. Materials & Supplies		\$ 40,000	\$ -	\$ 40,000	\$ -	\$ 40,000	\$ -	\$ 40,000	\$ -	\$ 160,000	\$ -	\$ 160,000
1 In-Kind Field Services		\$ -	\$ 50,000	\$ -	\$ 50,000	\$ -	\$ 50,000	\$ -	\$ 50,000	\$ -	\$ 200,000	\$ 200,000
2. Webinar/Wkhp Production		\$ 26,500	\$ -	\$ 26,500	\$ -	\$ 26,500	\$ -	\$ -	\$ -	\$ 79,500	\$ -	\$ 79,500
2 Webinar/Wkshp Fees		\$ -	\$ 15,000	\$ -	\$ 15,000	\$ -	\$ 30,000	\$ -	\$ -	\$ -	\$ 60,000	\$ 60,000
3. Computer Services		\$ 1,500	\$ -	\$ 1,500	\$ -	\$ 1,500	\$ -	\$ 1,500	\$ -	\$ 6,000	\$ -	\$ 6,000
4. Kickoff Meeting		\$ 10,000	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 10,000	\$ -	\$ 10,000
5.		\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
6. Tuition Remission 8000/student		\$ 32,000	\$ 8,000	\$ 32,000	\$ 8,000	\$ 32,000	\$ 8,000	\$ 32,000	\$ 8,000	\$ 128,000	\$ 32,000	\$ 160,000
Total Other Direct Costs		\$ 110,000	\$ 73,000	\$ 100,000	\$ 73,000	\$ 100,000	\$ 88,000	\$ 73,500	\$ 58,000	\$ 383,500	\$ 292,000	\$ 675,500
G. Total Direct Costs		\$ 363,938	\$ 188,151	\$ 371,051	\$ 191,596	\$ 382,450	\$ 210,148	\$ 359,966	\$ 183,830	\$ 1,477,405	\$ 773,725	\$ 2,251,130
H. Indirect Costs												
47.0% of G-D-F5-F6		\$ 156,010	\$ 54,120	\$ 159,350	\$ 55,740	\$ 164,710	\$ 57,410	\$ 154,140	\$ 59,140	\$ 634,210	\$ 226,410	\$ 860,620
I. Total Costs		\$ 519,948	\$ 242,271	\$ 530,401	\$ 247,336	\$ 547,160	\$ 267,558	\$ 514,106	\$ 242,970	\$ 2,111,615	\$ 1,000,135	\$ 3,111,750

BUDGET EXPLANATION – UNIVERSITY OF NEW HAMPSHIRE

Salaries:

Salaries are included for all of the primary participants from the University of New Hampshire. All salaries are budgeted based on UNH rates currently in place or anticipated for future years of the study.

Professor Gardner is allocated 2 months of salary per year for directorship of the center (1 month), coordination of Center Administration (0.5 month) per year, and participation in research projects (0.5 months per year). 2.5 additional months of time through cost-sharing will be devoted to directing the Center (1.5 months) and participation in outreach (1 month).

Professor Melton is allocated 5 months of salary per year. 1 month is for leadership of the Outreach and Technology Transfer initiatives, 1 month for participation in research projects and 3 months for outreach (participation in workshops, conferences, and standardization organizations).

Professor Jambeck is allocated 3.5 months of salary per year for leadership of the Environmental Issues (1 month), participation in outreach and technology transfer (1.5 months) and participation in research projects and (1 month).

Professor Daniel is allocated 1 month of salary per year for participation in research (0.5 months) and outreach and technology transfer (0.5 months). 1 month of additional effort is provided by the University as cost-sharing for participation in research (0.5 months) and outreach (0.5 months).

Professor Gress is allocated 1 month of salary per year for participation in research (0.5 months) and outreach and technology transfer (0.5 months). 1.5 months of additional effort is provided by the University as cost-sharing for participation in research (1 month) and outreach (0.5 months).

Three graduate students at the PhD level are included with a conventional research appointment on an annual basis. Three additional graduate students are included in years 1-3 and two students in year 4 through cost-sharing from UNH, bringing the total number of graduate students working on RMRC research to 6 per year (5 in year 4).

Travel:

Travel costs were computed based on average costs associated with domestic trips (\$1500 each) and international trips (\$3000 each) by UNH faculty.

Kickoff Meeting (Year 1): Five UNH faculty will attend the RMRC kickoff meeting at \$1500 each (\$7500 total).

Domestic Conferences (annual): UNH faculty and graduate students will attend domestic conferences on behalf of the RMRC (\$1500/person). At least one conference will include a booth displaying attributes of the RMRC (\$1000/yr). Year 1: 5 conference trips, Year 2: 2 conference trips, Year 3: 2 conference trips, Year 4: 3 conference trips.

International Conferences (annual): One UNH faculty member will attend one international conference in years 1, 2, and 4 on behalf of the RMRC (\$3000/yr).

RMRC Conferences (Years 2 and 4): Five UNH faculty and five graduate students will attend and conduct both RMRC conferences in collaboration with UW. The total cost for 10 attendees is \$15,000 per conference (\$1500/participant).

Workshops (Year 3): Two UNH faculty will participate in each of the four workshops to be held in year 3 of the center at a cost of \$1500/person/workshop (\$12000 total)

Supplies:

Materials and supplies have been budgeted at approximately \$40,000/yr for the first 2 years, and approximately \$30,000 per year for years 3 and 4. The requirements of each research project will differ, however, the average project cost is expected to be similar to costs of similar projects that the UNH RMRC has conducted in the past.

Computer Services:

Computer services have been budgeted at \$4,000 for the first year, \$3,000 for year 2, and \$2,000 for years 3 and 4. It is expected that higher costs will occur in the initial phases of setting up new servers to house the electronic databases, information clearinghouse and revised web site.

Kickoff Meeting:

Costs associated with the kick-off meeting are estimated to be \$20,000, of which \$10,000 is included in the UNH budget for activities associated with the preparation and delivery of the meeting. This cost was estimated based on the cost associated with a similar meeting recently conducted by UW's Dept. of Civil and Environmental Engineering and includes \$500 for printing of display items, \$1200 for meeting room rental, \$500 for audio and visual services, \$1800 for guest refreshments, and \$6000 for travel supplements (6 @ \$1000 each) to support participation.

Tuition:

Tuition costs are in accordance with UNH current projections for each year of the project. The budget is for 3 students/year.

Fringe Benefits and Indirect Costs:

Fringe benefits are allocated at standard rates stipulated by UNH: faculty and staff academic year – 41.1% in 2007-2008, 41% years 2-4; faculty and staff summer rate: 7.85% in year 1, 7.8% in years 2-4; graduate and undergraduate students – 7.85% in Year 1, 7.8% in years 2-4,.

Indirect costs are budgeted at standard rates stipulated by UNH. The indirect cost is equal to 45% of modified total direct costs.

MATCHING BUDGET EXPLANATION – UNIVERSITY OF NEW HAMPSHIRE

Faculty Salaries:

2.5 months of AY salary for Gardner, and 1.5 month each for Daniel and Gress will be cost-shared. Total includes fringe benefits and indirect costs.

Student Salaries:

One PhD Fellowship per year for three years will be associated with the RMRC and the AY salary and summer salary and tuition will be cost-shared. Two graduate students per year will conduct research for the RMRC and will be supported by Teaching Assistantships (2.5 teaching assistantships in Year 4). Support includes academic year salary and tuition.

In-Kind Support

In-kind support of at least \$70,000/yr is anticipated. Although the specific type and amount of support cannot be known with certainty at this time, the support most likely will involve a field application of recycling in a transportation project conducted by a municipal or state agency that is synergistic with work being conducted in the research thrusts. UNH RMRC faculty have been involved in similar types of research, and have successfully matched over \$3 million during the operation of the existing RMRC, including a significant fraction of in-kind support that have allowed major field-scale research to be conducted. No indirect costs are included in the in-kind support.

BUDGET EXPLANATION – UNIVERSITY OF WISCONSIN-MADISON

Salaries:

Salaries are included for all of the primary participants from the University of Wisconsin-Madison (UW). All salaries are budgeted based on UW rates currently in place or anticipated for future years of the study.

Professor Benson is allocated 2.5 months of salary per year for directorship of the center (1 mo), coordination of the Structural Fill and Unbound Materials research thrust (1 month) per year, and participation in research projects (0.5 months per year).

Professor Edil is allocated 2 months of salary per year. One month is for leadership of the Research and Development discipline and 1 month for participation in research projects and outreach (participation in workshops, conferences, and standardization organizations).

Professor Andrew Graettinger is allocated 1.5 months of salary per year for coordination of the research thrust on Recycling Markets (1.0 months) and participation in research projects and outreach (webinars, workshops) (0.5 months).

One month of salary is allocated per year for Professor Hussain Bahia for coordination of Standards Development (0.5 months) and participation in research projects and outreach (webinars, workshops) (0.5 months).

Mr. Gary Whited is allocated 0.5 months per year to serve as CMSC Liaison and to participate in research projects.

Dr. Howard Rosen, Mr. Wayne Pferdehirt, and Mr. Benjamin Jordan are budgeted at 0.6, 0.4, and 0.2 months per year, respectively, for development and production of the webinars in Years 1-3 and the workshop in Year 3. A similar budget is provided in Year 4 for assistance with the second RMRC conference, except Pferdehirt's effort will be 0.5 month/yr. This level of effort is based on past experience at UW's Engineering Professional Development.

Four graduate students at the PhD level are included with a conventional 50% research appointment on an annual basis. One student will working in each of the four primary areas of research and development.

Travel:

Travel costs were computed based on average costs associated with domestic trips (\$1500 each) and international trips (\$3000 each) by UW faculty on federal contracts over the last five years. Only previous trips meeting the federal requirements stipulated in Sec. IV.A.3 of the RFA were used when making the travel cost estimate.

Kickoff Meeting (Year 1): Four UW faculty will attend the RMRC kickoff meeting at \$1500 each (\$6000 total).

Domestic Conferences (annual): Four UW faculty will attend one domestic conference per year on behalf of the RMRC (\$1500/person/yr; \$6000/yr total). At least one conference will include a booth displaying attributes of the RMRC (\$1000/yr).

International Conferences (annual): One UW faculty member will attend one international conference each year on behalf of the RMRC (\$3000/yr).

RMRC Conference (Years 2 and 4): Six UW faculty and four graduate students will attend and conduct both RMRC conferences in collaboration with UNH. The total cost for 10 attendees is \$15,000 per conference (\$1500/participant).

Workshops (Year 3): Two UW faculty and one staff member from UW's Dept. of Engineering Professional Development (EPD) will participate in each of the four workshops to be held in the third year of the center at a cost of \$1500/person/workshop (\$18,000 total)

Supplies:

Materials and supplies have been budgeted at \$10,000/yr for four research projects (one per thrust area). This estimate corresponds to the average supply budget for past projects conducted within the Dept. of Civil and Environmental Engineering at UW over the last five years. The requirements of each research project will differ. Thus, some projects may require more than \$10,000 and others less. However, the average project cost is expected to be similar to that expended over the past five years in similar research efforts.

Webinar and Workshop Costs:

Webinar costs were estimated based on past costs for webinar development and production by UW's EPD. On a per webinar basis, these costs include \$1000 for audio-visual services, \$2000 for preparation of the electronic medium, and \$1500 for marketing fees.

Workshop costs were estimated based on past costs for workshop development and production by UW's EPD. These costs include \$1000 for audio-visual services, \$2875 for participant refreshments, and \$2500 for marketing fees.

Costs for the webinar and workshop development are distributed over Years 1-3.

Computer Services:

Computer services have been budget at \$1500/yr. These services were budgeted based on previous records in UW's Dept. of Civil and Environmental Engineering and include computer installation, networking, etc. The total estimate is based on a \$1000/yr for the Research and Development discipline, \$250/yr for administration, and \$250/yr for outreach/training efforts.

Kickoff Meeting:

Costs associated with the kick-off meeting are estimated to be \$20,000, of which \$10,000 is included in the UW budget for activities associated with the preparation and delivery of the meeting. This cost was estimated based on the cost associated with a similar meeting recently conducted by UW's Dept. of Civil and Environmental Engineering and includes \$500 for printing of display items, \$1200 for meeting room rental, \$500 for audio and visual services, \$1800 for guest refreshments, and \$6000 for travel supplements (6 @ \$1000 each) to support participation.

Tuition Remission:

Tuition remission is set at \$8000/student/year as required by UW.

Fringe Benefits and Indirect Costs:

Fringe benefits are allocated at standard rates stipulated by UW: senior personnel – 35%, graduate students – 27%, undergraduate students – 2%, and secretarial staff – 50%.

Indirect costs are budgeted at standard rates stipulated by UW. The indirect cost is equal to 47% of total direct costs less tuition remission.

MATCHING BUDGET EXPLANATION – UNIVERSITY OF WISCONSIN-MADISON

Faculty Salaries:

Salaries for Professors Benson, Edil, and O’Leary are included in the matching budget. Professors Benson and Edil will provide 0.5 month per year of salary for participation in research projects, 0.5 months per year for standards development, and 0.5 months per year for outreach and as center liaisons (total of 1.5 months/year each). Professor O’Leary will provide 0.25 months/yr for outreach. Fringe benefits and indirect costs are included in this match at the rates stipulated in the previous section.

Staff Salaries:

Xiaodong Wang, Geoengineering Laboratory Manager at UW, will provide technical support to the research projects. His effort will be provided as in-kind support (11% time per year) by UW’s Department of Civil and Environmental Engineering. Fringe benefits and indirect costs are included in this match at the rates stipulated in the previous section.

Student Salaries:

Funding will be obtained from the UW Consortium for Fly Ash Utilization in Geotechnical Applications (FAUGA) to support an additional PhD student conducting research in the Structural Fill and Unbound Materials Research Thrust. FAUGA will also provide support for undergraduate research assistants. In particular, each UW PhD student participating in the RMRC will be provided with 200 hrs per year of assistance by an undergraduate research student (5 students x 200/hr-yr x \$10/hr = \$10,000/yr). Tuition remission and fringe benefits are included in this match at the rates stipulated in the previous section. Indirect costs are also included at the previously stipulated rates, but will be provided as in-kind support by UW.

Webinar and Workshop Fees

Modest fees will be charged for participation in the webinars and the workshops. These fee is anticipated to be \$75 per participant per event and 50 participants are expected for each event (i.e., 4 events/yr x 50 participants x \$75/participant-event = \$15,000/yr for Years 1-2; 8 events/yr = \$30,000 in Year 3). Indirect costs are excluded from this match.

In-Kind Support

In-kind support of at least \$50,000/yr is anticipated. Although the specific type and amount of support cannot be known with certainty at this time, the support most likely will involve a field application of recycling in a transportation project conducted by a municipal or state agency that is synergistic with work being conducted in the research thrusts. UW faculty have been involved in similar types of synergistic research with a variety of city, county, and state agencies for the last decade, and have previously received comparable in-kind support from those being assisted. No indirect costs are included in the in-kind support.