Department of Civil Engineering 2008 Strategic Plan

Mission: *To pursue and disseminate knowledge through teaching, state-of-the-art research and scholarly activities, and public service on topics critical to society while operating the Department on a sustainable basis.*

The Vision of the Civil Engineering Department is to provide:

- Programs that offer rigorous undergraduate and graduate education for students through inspired classical and innovative instruction.

- Research and scholarly activities that transform and advance the science and practice of civil engineering.

- Outreach and application of discipline expertise through collaborative initiatives to meet the evolving technical challenges to society.

- Sustainable departmental culture that provides increasing value for our stakeholders and expanding career opportunities for our faculty and staff.

Department

The Department has identified several strengths and challenges.

Strengths:

- Accessibility of faculty – open door policy
- Excellent new laboratory space
- High total undergraduate enrollment (currently 370 from 141 Fall 2000)
- Strong accreditation review by ABET for two programs; civil and environmental
- Breadth in undergraduate programs and depth in graduate programs
- Good student participation in Honors and international opportunities and programs
- Strong research programs and centers (over $6.7M in expenditures FY 07)
- Well-funded environmental, water resources, structures, and materials research programs
- Strong record of funding research assistants (30 RA and 15 TA Fall 08; 61 total grads)
- Strong Industrial Advisory Board and alumni relationships
- Integration of research and research faculty into our programs

Challenges:

- Increasing demands with flat line resources
- Physical separation (Gregg and Kingsbury)
- Small doctoral program (10 Ph.D. graduates from 2001 to 2006; currently 11 Ph.D.)
- Few 900 level graduate courses offered per year (graduate students currently take courses with undergraduates-700/800 level)
- Outdated instructional equipment even with current differential tuition funds

A review of the faculty annual reports for CEPS shows that for 2008, Civil Engineering faculty (tenure-track and research) are actively engaged in teaching, research and service. This compares very favorably with other CEPS Departments (Civil Engineering Department tenure-track faculty account for only 10.5 % of CEPS faculty):

- 28.2 % of credit hours
- 14.2 % of enrollment in courses
- 13.3 % of refereed journal articles
- 20.2 % of invited talks
- 17.3 % of total projects (for PI and co-PI)
- 14.1 % of total dollars spent (for PI and co-PI)
- 22.9 % of supported graduate students
- 24.3 % of professional service
- 21.4 % of awards

The inordinate demands on faculty are strongly tied to our large enrollment (e.g. increased student advising, projects, special programs (Honors, UROP, etc.), lab courses, grading, office hours). We have also introduced new initiatives such as the one-year MS program. Because of the nature of civil engineering, our faculty is also intimately involved with the university community and the state, serving on numerous committees outside the Department. The Department has improved efficiency by making better use of the undergraduate coordinator and the chair regarding ABET, academic petitions, curriculum and advising procedures. Tracking of students has also been streamlined but continual necessary curriculum changes add complications to the process. An external review of the departmental undergraduate and graduate programs is scheduled for AY 08-09. The results of this comprehensive effort will help us to validate our strategic goals as well as to evaluate our departmental initiatives and efficiencies.

Overall, the Department has steadily improved existing programs and strengths, but has not yet taken the necessary steps to develop transformative educational and research programs. The Department is poised to make major advances in these areas to achieve excellence. However, due to the rapidly increasing demands on faculty, we are frequently forced to manage in reactionary mode. The Department seeks to confront existing difficulties and future complex challenges in a new and visionary manner as "We cannot solve our problems by using the same kind of thinking we used when we created them." (Albert Einstein). This strategic planning document sets forth the activities needed to reach our full potential.

Undergraduate and Graduate Programs

A key aspect of the Department's mission is educating undergraduate and graduate students. Full-time faculty members' extensive engagement with students in the classroom, student programs and research is a hallmark of the UNH Civil Engineering students' educational experience.

A number of metrics provide a snapshot of our current status regarding undergraduate and graduate programs. Faculty-student contact hours (number of students in a class, taught by an FTE faculty member, times credit hours divided by number of FTE faculty) demonstrate the significant classroom educational efforts made by Civil Engineering faculty at both the undergraduate and graduate levels. (Figure 1) As evident from the instructional costs per credit hour, the Civil Engineering tenure track faculty members have a much heavier teaching load as compared to other CEPS Engineering departments (Figure 2). The graduation rates from our MS and PhD programs show strength and growth in both degree programs (Figure 3). The department also excels at supporting graduate students with its research dollars (Figure 4).

Overall these metrics demonstrate that our faculty is very much engaged in the educational mission, both at the graduate and undergraduate levels. Enrollments at the undergraduate level continue to grow in the two departmental degree programs. Record enrollments have been set in each of the last four years. The number of graduate students per faculty in the department is at a good level. Research productivity continues to be high. Based on these metrics, this department is strong.

The department has some challenges as well. Our undergraduate enrollment is currently too large to be accommodated in the facilities available for our junior-level laboratory courses (Fluid Mechanics, Engineering Materials, and Soil Mechanics) and is too large to effectively offer some of our junior and senior level courses. Upper division course enrollment routinely exceeds 80 students. Specific examples include project groups that are unwieldy in size and number in required upper division courses (e.g. Fundamentals of Environmental Engineering, Reinforced Concrete Design, Senior Design Project and Foundation Engineering Design).

Our greatest weakness in the graduate program is the lack of graduate 900 level courses. We do not have any courses taught regularly in our graduate program that are exclusively for Masters and/or Ph.D. students, save for a 1-credit course in which they are required to present their research. One reason for this is that the undergraduate level teaching commitments place excessive demands on faculty time which, in turn, hinders our ability to offer sufficient graduate level only courses and to attract greater numbers of graduate students. In addition, the department relies on teaching by research faculty and adjuncts to offer our curricula. In order to expand and improve the quality of our graduate program, particularly at the PhD level and for the non-thesis master's degree, the lack of sufficient graduate level courses is a crucial barrier that needs to be addressed.

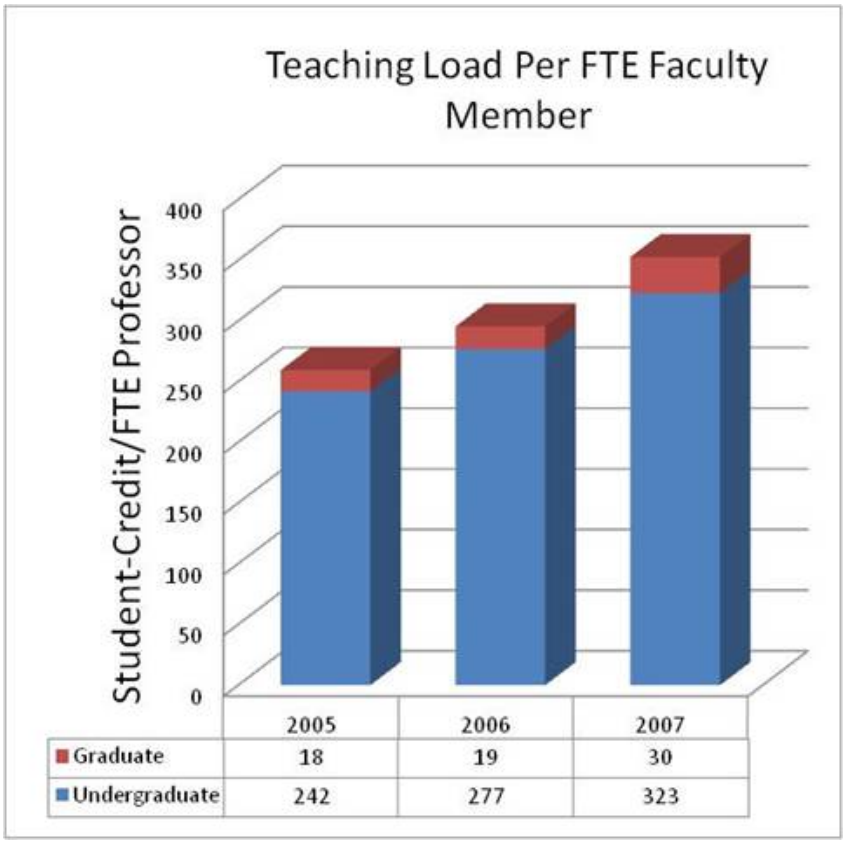


Figure 1. Teaching load per FTE faculty member in Civil Engineering. Student-credits are shown here for CIE and ENE classes taught by Department of Civil Engineering FTE professors. Student-credits are the sum of the number of students per class times the credit hours for that class for all classes taught in the indicated academic year.

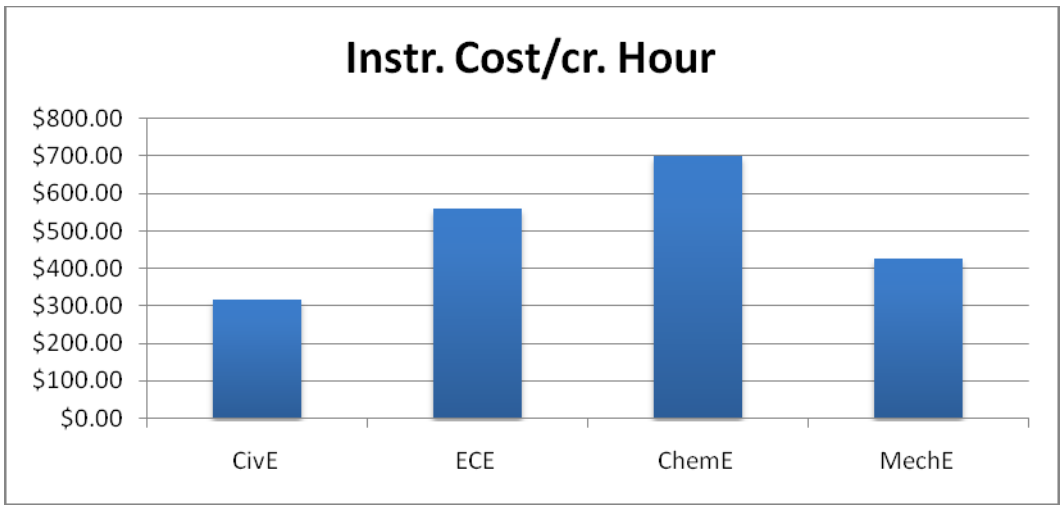
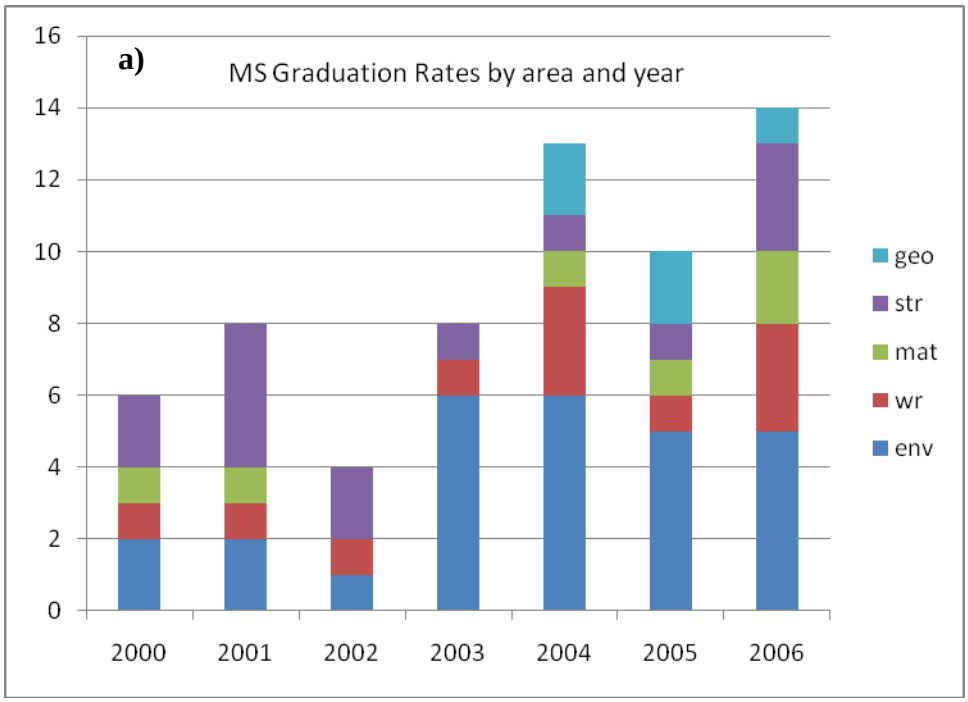


Figure 2. Instructional costs per credit hour for the four engineering Departments in CEPS.



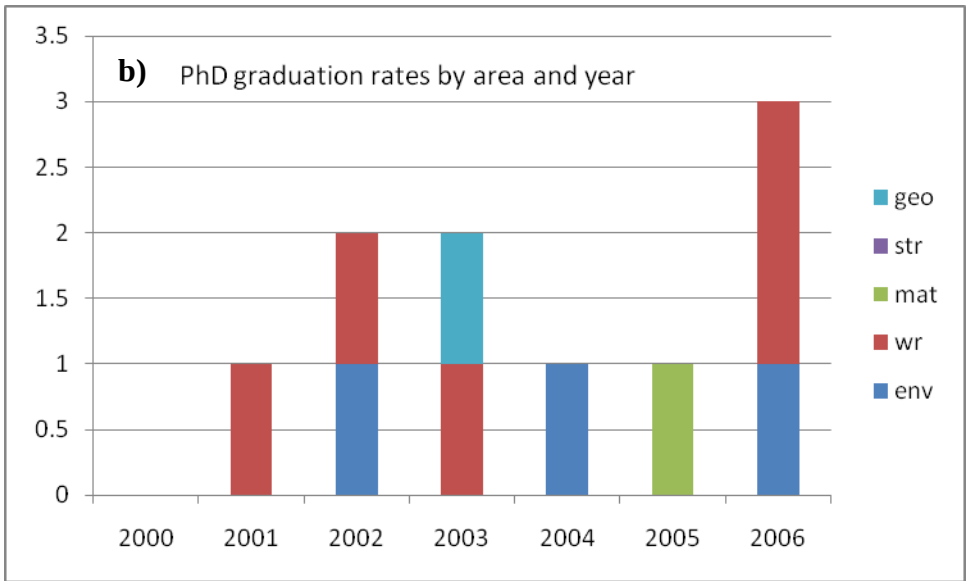


Figure 3. Graduation rates of MS (a) and PhD students (b) by area of focus and year of graduation.

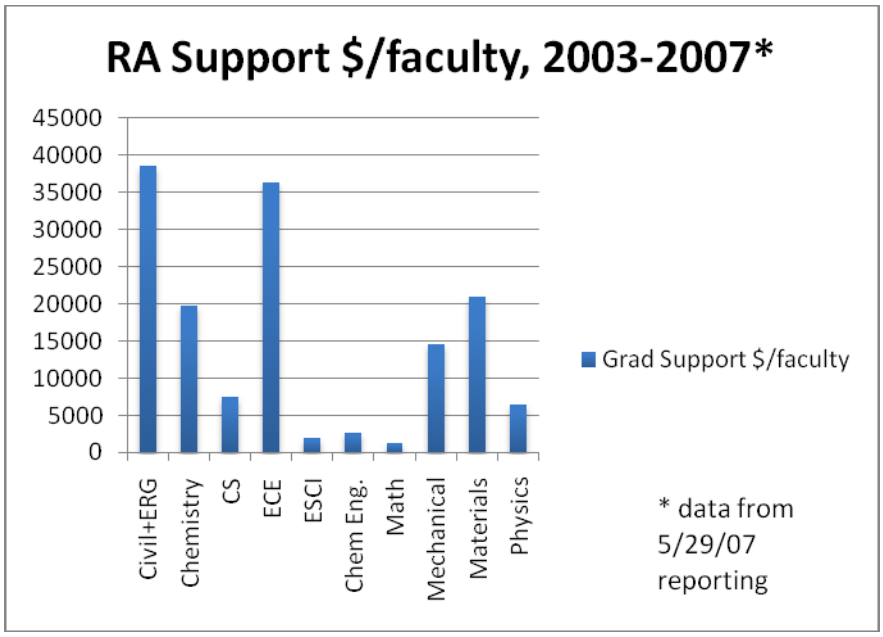


Figure 4. Average annual research assistantship support per FTE faculty from 2003-2007.

Action Items:

- Establish a committee to strategically evaluate senior-level course offerings. This committee will develop an approach to limit these offerings and, in a coordinated fashion, introduce graduate-level only courses in each civil engineering disciplines to strengthen our graduate programs.
- Establish a task force to evaluate the junior-level laboratory courses and consider alternative modes of delivery to increase efficiencies. Options that will be important to evaluate include reorganization of the curriculum and establishment of a single laboratory course (spring of Junior year, fall of Senior year). Additionally, new education technologies will be explored to permit some portion of laboratories to be offered in a virtual manner and to more efficiently deliver courses.
- Evaluate the influence that our continued efforts in raising standards has on BSCE enrollments. Monitor the effectiveness of these methods and evaluate new measures if necessary to further raise the bar.
- Work to gain approval for an instructor of Civil Engineering to relieve the teaching load for tenure-track faculty, to permit greater time for grant writing, research and offering graduate level only courses.
- Work to gain approval for hiring four new FTE faculty in order to i) increase graduate-only course offerings, ii) reduce student credit hour load of faculty in line with other departments[1], iii) expand the graduate program and research funding in strategic areas of

[1] An increase of four faculty with no change in undergraduate credit hours offered by the department would increase instruction cost per UG credit hour to $409, which is still the lowest of the CEPS engineering departments. This calculation uses instructional cost per FTE of $172,492 to calculate an increase in costs associated with additional faculty.

active research and in alignment with College and University strengths, and iv) relieve bottlenecks in large project-based courses.

Scholarly and Research Activities

The Civil Engineering Department has a sustained and successful record of scholarly activities over the last decade as judged by the research dollars and grants attained and the graduate students funded on RAs (Figure 4). In addition, Department faculty members have consistently worked together on a variety of initiatives across the civil engineering disciplines as demonstrated by the number of research centers within the Department (Table 1). For example, the Environmental Research Group (ERG) was founded in 1987 by a core of Department faculty across the disciplines (i.e., environmental, water resources, geotechnical, systems, materials engineering). Specific examples of intradepartmental research collaboration include: the Technology Transfer (T^2) Center, the Recycled Materials Resource Center (RMRC), and the Bedrock Bioremediation Center (BBC), each addressing critical national problems (e.g., building bridges rapidly and using innovative materials such as fiber reinforced plastics; sustainable use of waste materials in pavements and construction; innovative use of geotechnical drilling tools to evaluate water-bearing fractures in contaminated bedrock aquifers). Department faculty also have a substantial record of partnering with faculty in other CEPS Departments (e.g., Mechanical Engineering, Earth Sciences, Electrical Engineering) and non-UNH scholars in a variety of organizations (e.g., U.S. Geological Survey, Cold Regions Research Engineering Laboratory) and academic institutions (e.g., WPI, Tufts, University of Wisconsin), as well as international entities (e.g., Colombian geological survey (INGEOMINAS), International Atomic Energy Agency, Ecole Nationale des Ponts et Chaussées, Kyushu University). Table 2 contains information on the research foci of the Department's faculty and demonstrates a broad spectrum of civil engineering expertise in the major disciplines relating to infrastructure.

The Department is well positioned to conduct research on restoring and improving urban infrastructure, a topic which was identified by the National Academy of Engineering as one of the "grand challenges" facing the nation and the world. This research focus was brought into the national spotlight when the American Society of Civil Engineers (ASCE) issued its 2005 report card on U.S. infrastructure, assigning D as the average grade, by the catastrophic failures during Hurricanes Katrina and Rita and recent bridge collapses. Infrastructure needs span the CiE disciplines ranging from bridges and roads to water and sewer systems. This is compounded by the need to have resilient systems that can withstand impacts of natural and anthropogenic hazards (e.g., storms, terrorist attacks) and recover quickly. Further complicating the challenge is the need to build sustainable systems that have a low carbon footprint and are affordable. ASCE in its Body of Knowledge (BOK) approach to engineering education stresses research that interlinks traditional civil engineering disciplines to solve problems (e.g., flooding scenarios where water resources modeling, geotechnical approaches to river scour mitigation, and structural engineering must all be combined to avoid catastrophic bridge collapse, potential loss of life, and traffic congestion). Infrastructure will be heavily impacted by climate change; the effect on hydrology alone will make structures designed based on today's standards obsolete within their expected design life.

The Civil Engineering Department is building on its foundation of infrastructure expertise (Table 2) and more recent foci on sustainability engineering and infrastructure health monitoring (IHM) systems to address the critical research needs of urban infrastructure. In addition, the Department will continue its focus on rural infrastructure needs facing northern New England communities, with a particular interest on cold climate and water treatment issues. These foci are key to New Hampshire and the Northeast, where 21.2% of the U.S. population resides (as of 2000 census) and infrastructure needs are arguably the greatest nationally due to the relatively high density of people (343/ sq mi – the highest in the U.S.) and the long history of settlement dating back to the 1600s. These foci are not only a natural outgrowth of the Department's past research interests, but also are directly related to the strengths of our newer faculty members (Table 2). Hence, the Department believes that this is an exciting time for intradepartmental collaboration following the **total systems approach to addressing infrastructure problems through monitoring, modeling, and mitigation.**

The Department's overall research focus during the next 5-10 years will be to promote alternatives to restore and improve urban infrastructure in the Northeast through innovation and technology transfer. Many of the results and solutions will be applicable elsewhere in the U.S. and internationally. As a complement to this focus, we will also continue our work addressing rural infrastructure needs, especially in cold climates. The research mission with respect to infrastructure will adhere to the following tenets:

- Adopting a **total systems approach,** as embodied in the new ASCE Body of Knowledge.
- Building on the Department's **intradisciplinary approach to address research needs in civil engineering.**
- Addressing total infrastructure management by **interlinking infrastructure monitoring, modeling, and mitigation**, incorporating real-time data collection and synthesis, and laboratory evaluations in order to restore and improve urban infrastructure.
- Integrating sustainability, resilience, and hazard response with solutions to infrastructure problems.

An example of a total systems approach is maintaining bridge safety during flooding or ice dam conditions in rivers that threaten to scour around abutments and piers resulting in structural failure. In this situation, a total systems approach dictates that water resources, geotechnical, structural, and materials faculty work together to predict if and when river flow will increase the risk of failure to unacceptable levels. This involves flood and sediment transport monitoring linking to geotechnical evaluations of abutment and pier stability coupled with real-time monitoring of the structure to collect data useful in statistically-based predictive models of the bridge's behavior. Ultimately, this type of approach allows design of mitigation measures to minimize the risk of failure before the flood even occurs.

Flooding also damages and/or constrains vital infrastructure such as water and wastewater treatment facilities. If these systems fail, people cannot return to their homes even if the flood waters recede and buildings are deemed safe as recently exemplified by the experience in Galveston, TX after Hurricane Ike. Therefore, a total systems approach is needed to predict

conditions that will cause failure and develop innovative solutions to prevent it. Barring that, if failure is unavoidable, facilities need to be designed so that they can be repaired and restarted rapidly. Smart GIS-based systems, such as the Environmental Response Management Application (ERMA) that civil engineering faculty have already helped develop, can be used to link these approaches to response/risk management for stakeholders such as the DOT, EPA, NOAA, or DHS.

A total systems approach is also needed to find better alternatives to salt for deicing roads during winter. This involves pavements, transportation, and environmental protection, again with an emphasis on real-time monitoring of road conditions, modeling of traffic and weather conditions and innovative mitigation with environmentally acceptable materials.

The Department will continue to work collaboratively with other UNH departments/programs including: Earth Sciences (hydrology), Natural Resources (climate change and sustainability), WSBE and Sociology (human dimensions solutions to problems that address economics and behavior), Center for Coastal and Ocean Mapping (remote sensing of coastal bathymetric changes), and the EOS Data Collaborative (GIS-based rapid visualization and analysis of large data sets). Our external stakeholders will continue to be the Federal Highway Administration and state DOTs; NOAA; USGS; USEPA, and state environmental agencies; DHS and its state equivalents; and municipalities.

One of the great strengths of the Department's scholarly activity is the faculty's ability to work closely with stakeholders to rapidly inject research findings and products into practice. This emphasis on technology transfer will continue and by partnering with our external stakeholders our educational and research outreach will help the Department continue to obtain external funding.

Action Items:

- Develop and foster the Department's research initiative on urban and cold climate rural infrastructure in the Northeast with its total systems approach of monitoring, modeling, and mitigation with emphasis on hazard response, sustainability, and resilience.
- Expand intradisciplinary research among Department faculty.
- Discuss scholarly activity among faculty at regularly scheduled "brown bag lunch" meetings to maintain enthusiasm about this vital component of the Department.
- Engage our stakeholders in these discussions as part of a joint planning effort; and
- Seek new tenure track lines in priority areas of infrastructure research that align with other college (e.g. applied mathematics) and University (e.g. sustainability) priorities and are currently lacking in the Department.

Table 1: Centers affiliated with the Civil Engineering Department

Center	**Date Founded**
Technology Transfer Center	1984
Environmental Research Group	1987
Recycled Materials Resource Center	1998
Water Treatment Technology Assistance Center	1999

Bedrock Bioremediation Center	1999
Contaminated Sediments Center	1999
UNH Stormwater Center	2003
Coastal Response Research Center	2004

Table 2. Civil Engineering Department faculty research foci

Faculty Member	**Research Focus**
Thomas Ballestero	Stormwater, stream restoration, groundwater, water resources planning, development, and management
Erin Santini Bell	Structural health monitoring and condition assessment of highway bridge structures, steel design, masonry design and historic renovation
Jean Benoit	In situ testing, drilling, geoenvironmental and geological engineering
Robin Collins	Water characterization & treatability issues, drinking water treatment and sustainability, and on-site wastewater disposal
Pedro de Alba	Earthquake soil dynamics, earth structures, landslides
Raymond Cook	Concrete materials, bridges, structural design.
Jo Daniel	Infrastructure materials, asphalt, concrete, pavements, recycling
Kevin Gardner	Sustainability engineering, industrial ecology, life cycle analysis, recycling, contaminated sediments treatment and management
Charles Goodspeed	Rapid bridge construction, deployment of appropriate infrastructure technologies, development and implementation of GIS tools
David Gress	Infrastructure materials, sustainability, durability, recycling, Portland cement concrete
Jennifer Jacobs	Surface water hydrology, evapotranspiration, remote sensing and hydrology, heat and water exchange
Jenna Jambeck	Microbial fuel cells, landfill engineering, marine debris, construction and demolition debris
Nancy Kinner	Biodegradation of organic contaminants, coastal pollution response
James Malley, Jr.	Water treatment, water reuse, UV disinfection, advanced oxidation processes
Ricardo A. Medina	Structural hazard mitigation, performance-based engineering, structural collapse assessment
Jeffrey Melton	Industrial byproduct and coproduct use in infrastructure construction and maintenance, soil stabilization using byproduct materials, sustainability
Robert Roseen	Stormwater management and design, hydrology, hydraulics, and stream restoration, climate change and water resources

Facilities

Facilities in the context of this strategic plan are considered to be the building, equipment, and personnel that support the Civil Engineering Department's activities in these spaces. Well designed and maintained facilities are imperative to the Department's ability to deliver an ABET accredited curriculum with significant hands-on educational experiences as well as to propose and conduct nationally recognized and externally funded research.

Our strength in this regard is that the Kingsbury Hall and Gregg Hall offices, laboratories, and student project spaces were designed specifically for civil and environmental engineering instruction and research. The Department has recently (October 08) hired a new technician with significant laboratory experience and technical knowledge to support our facilities.

With regard to the Department's Environmental Engineering (ENE) program, Civil Engineering (CiE) and Chemical Engineering jointly provide a home for the undergraduate Environmental Engineering (ENE) program. In terms of ENE laboratory facilities, the Civil Engineering strategic plan will defer to the ENE Program strategic plan which states: "During Spring 2008 the ENE program was assigned new laboratories in Kingsbury Hall (S174 and S175). A committee consisting of the ENE faculty teaching courses and conducting undergraduate research activities will be formed to coordinate the efficient use and scheduling of these two new ENE laboratories. At the current rate of ENE enrollment growth, and the possibility that ENE-IP students will begin taking ENE 756 in place of MICRO 501, the labs are approaching their ultimate capacity."

For the Civil Engineering program, the equipment in the Kingsbury Hall undergraduate laboratories is outdated, with some units being over 30 years old. A survey of the faculty teaching the undergraduate labs has produced requests totaling over $400,000 for new instructional equipment (Table 3). This should be considered a minimum. With our current enrollment, the facilities will be overstretched even at this level of replacement, and if these student numbers are maintained in the future, some equipment should be duplicated so that $500,000 would be needed.

Action Items:

- A fundraising campaign directed towards Civil Engineering Department alumni will be conducted to obtain new equipment for undergraduate instruction. A committee of senior faculty well connected to our alumni will be formed to direct this effort.
- Identify and submit instrumentation proposals to enhance teaching laboratories. Instrumentation proposals will integrate strategic department research and education initiatives. For example, an NSF Course, Curriculum and Laboratory Improvement (CCLI) program proposal would support a new instrumentation course for senior undergraduates and graduate students. Structural health and other current civil engineering challenges require sophisticated field and laboratory instrumentation. To date, we do not offer a course in which students learn fundamental measurement techniques including stress, strain, flow, and rainfall, as well as gain the ability to design instrument packages to make the required measurements for lab and field experiments. Basics of MEMS technology, wireless

communication and other recent advances would be covered. Issues covered in the course would include instrument selection for off-the-shelf items and how to assemble them into a system, design of one-of-a-kind setups, problems of communication, survivability and data interpretation.

- To enhance its research capabilities, the Department will continue to explore the possibilities for developing interdisciplinary MRI proposals to the National Science Foundation, such as the recently-granted Digital Imaging Correlation (DIC) system proposal which involves Civil, Mechanical, Electrical and Ocean Engineering faculty.

Table 3. Equipment Needed in the Civil Engineering Laboratories

Topic Area	Equipment	Estimated Cost
Fluids	Large tilting flume	$90,000
Materials	Dynamic shear rheometer	$50,000
Materials	Asphalt mixture performance tester	$50,000
Materials	Instron upgrade	$50,000
Geotechnical	Triaxial testing system	$80,000
Geotechnical	Field drilling, sampling and testing tools	$75,000

Organization and Management

The Civil Engineering Department's research and teaching objectives can be best met when the entire faculty is engaged, working as a team, and achieving individual success. Effective infrastructure, administration, and technical support are the foundation required to promote individual strengths and encourage cooperation.

The Civil Engineering Department enjoys a collegial atmosphere. There are 13.5 FTEs including the full range of faculty ranks as well as 3.5 research faculty members who actively engage in all department activities. All faculty members have access to new and renovated facilities that provide a quality work environment. The Department recognizes that our primary assets are human resources. While the recruitment, hiring and promotion process is critical, so too is the preparation, development, and renewal of all departmental personnel. The Department has a strong mentoring program for untenured faculty members to guide and support them through the promotion and tenure process.

As the Department has broadened from an undergraduate focus to include very active research and graduate mission in line with a Research High University with aspirations of research excellence, more and more demands are being placed upon the tenure track faculty. The end result often being that following the intense sprint toward achieving tenure there is a distinct period of refocusing of energy leading to different levels of research, teaching and service productivity. A challenge is to coordinate individual refocusing to synergistically support the Department's overall mission. Initiatives are needed to provide an opportunity to post tenure faculty, on a competitive basis, to acquire new skills and competencies as well as new energies and motivation to pursue new directions in their teaching and scholarship activities in support of Department, College, and University missions. Similarly, the staff and research faculty long-term career paths need opportunities for renewal, career enhancement and reward.

The Department's educational and research needs identified in the existing plan to support the Department's mission require additional efficiencies as well as additional personnel support to enhance identified graduate program and research foci. The current organizational model offers opportunities to enhance the efficient use of department personnel. Critical needs are additional FTEs and instructors as well as administrative and technical support.

Action Items:

- Enhance department efficiency and resources. Conduct a review of the existing model of department business, including undergraduate mentoring and advising, recruiting and service to identify opportunities to grow programs, to consolidate redundant activities, and to more efficiently meet department goals through strategic realignment and focused additional personnel. For example, junior level laboratories, undergraduate advising, and upper division honors advising demands have significantly increased, but the delivery model has not changed. Hire one new permanent, full-time instructor (non-tenure track) to teach at the undergraduate level. Hire four new tenure-track faculty members to enhance the strategic plan's research and graduate education activities.
- Provide opportunities for professional development and leadership. Maintain and strengthen the early career mentoring program by actively participating in the University's Faculty Mentoring and Professional Development Program. Commence a professional development program to reward, promote, and encourage departmental mid-career to senior level professionals. We will identify means to more actively engage our alumni to support Department initiatives and envision supporting activities through dedicated CiE alumni fundraising initiatives. Specific activities to be made available to department personnel include:
    - focused nomination initiative for University and National Awards;
    - reduced teaching load to a maximum of two courses per year such that the faculty member will have one semester where they are not required to teach a course;
    - Support of travel and tuition expenses for a specialized training course or workshop that relates directly to a faculty member's professional development in teaching and scholarship activities with a focus on new skills or techniques that will position the individual to more competitively pursue externally supported research activities in a new area, and
    - Support of travel and related expenses for department member training in new skills or techniques that will position the individual to contribute to department leadership and management.
- Prioritize strategic plan action items to achieve short and long term goals. We will start by identifying what the Civil Engineering Department needs to do ***now*** to ensure the vitality of research, scholarship, and education for the next 10 years. Metrics will be developed to monitor progress with respect to enhanced visibility; continuous improvement with regard to organizational quality and performance; and improvement of stakeholder satisfaction through continuous and incremental improvements to processes including by removing inefficiencies. We will leverage our ABET and self-study activities as well as faculty meetings to advance the department. The strategic planning process has coalesced our faculty around critical challenges and a vision for the future.