DEPARTMENT OF HIGHER EDUCATION & WORKFORCE DEVELOPMENT

New Program Report

Date Submitted:
11/21/2023

Institution
University of Missouri-Columbia

Site Information

Implementation Date:
1/1/2024 12:00:00 AM

Added Site(s):

Selected Site(s):

University of Missouri-Columbia, 105 Jesse Hall, Columbia, MO, 65211

CIP Information

CIP Code:
141401

CIP Description:
A program that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of systems for controlling contained living environments and for monitoring and controlling factors in the external natural environment, including pollution control, waste and hazardous material disposal, health and safety protection, conservation, life support, and requirements for protection of special materials and related work environments.

CIP Program Title:
Environmental/Environmental Health Engineering

Institution Program Title:
Environmental Engineering

Degree Level/Type

Degree Level:
Bachelor's Degree

Degree Type:
Bachelor of Science

Options Added:

Collaborative Program**:**
N

Mode of Delivery

Current Mode of Delivery

Classroom

Student Preparation

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Special Admissions Procedure or Student Qualifications required:
The major will serve a broad population, and there will be no special admissions or student qualifications required that exceed regular university standards. There is no specific preparation recommended for students entering this program to ensure success. Additional opportunities for college readiness are also available.

Admitted students are invited to join the Mizzou Engineering Summer Bridge program and to get a head start on their college experience. The Summer Bridge Program is an eight-week summer session in which the students live in a residence hall, take a prerequisite course (if student did not place in MATH 1500), attend workshops and enjoy social activities to get familiar with Mizzou, the College of Engineering and Columbia. Courses offered in the Summer 2023 program include MATH 1160 Precalculus; CHEM 1320: College Chemistry; and CMP_SC 1050: Algorithm Design and Programming. This program is presented by Mizzou's Center for Academic Success & Excellence (CASE) and the College of Engineering.

Specific Population Characteristics to be served:
n/a

Faculty Characteristics

Special Requirements for Assignment of Teaching for this Degree/Certificate:
Full-time faculty will hold either a Ph.D., a professional engineer (P.E.) license or both.

Estimate Percentage of Credit Hours that will be assigned to full time faculty:
90%

Expectations for professional activities, special student contact, teaching/learning innovation:
n/a

Student Enrollment Projections Year One-Five

Year 1	**Full Time:** 15	**Part Time:** 0	
Year 2	**Full Time:** 35	**Part Time:** 0	
Year 3	**Full Time:** 55	**Part Time:** 0	**Number of Graduates:** 4
Year 4	**Full Time:** 80	**Part Time:** 0	
Year 5	**Full Time:** 90	**Part Time:** 0	**Number of Graduates:** 18

Percentage Statement:
n/a

Program Accreditation

Institutional Plans for Accreditation:
The department will seek accreditation from Accreditation Board for Engineering and Technology (ABET), the accreditation board that accredits other Engineering degree programs at MU, in the second year of the program.

Program Structure

Total Credits:
125

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Residency Requirements:
MU requires that 30 of a student's last 36 credits must be MU course work. Missouri Online-Self Paced courses authored by MU faculty are acceptable as are courses offered for credit through Missouri Online. Courses from a community college can account for six of the last 36 credits.

General Education Total Credits:
42

Major Requirements Total Credits:
104

Course(s) Added

COURSE NUMBER	CREDITS	COURSE TITLE
xxxxx	12	Civil Engineering Electives
xxxxx	5	Engineering Topics - General
xxxxx	30	Civil Engineering Topics
xxxxx	29	Basic Sciences
xxxxx	12	Program Electives
xxxxx	16	Math Courses

Free Elective Credits:
0

Internship or other Capstone Experience:
A capstone project will conclude Environmental Engineering education at MU. These capstone projects provide a culminating experience for students by applying the various concepts and design procedures they have learned in their classes. Students work together in teams to study real-world challenges and offer recommendations to address them. The experience gives students the hands-on preparation they need to be successful after graduation.

Assurances

I certify that the program is clearly within the institution's CBHE-approved mission. The proposed new program must be consistent with the institutional mission, as well as the principal planning priorities of the public institution, as set forth in the public institution's approved plan or plan update.

I certify that the program will be offered within the proposing institution's main campus or CBHE-approved off-site location.

I certify that the program will not unnecessarily duplicate an existing program of another Missouri institution in accordance with 6 CSR 10-4.010, subsection (9)(C) Submission of Academic Information, Data and New Programs.

I certify that the program will build upon existing programs and faculty expertise.

I certify that the program can be launched with minimal expense and falls within the institution's current operating budget.

I certify that the institution has conducted research on the feasibility of the proposal and it is likely the program will be successful. Institutions' decision to implement a program shall be based upon demand and/or need for the program in terms of meeting present and future needs of the locale, state, and nation based upon societal needs, and/or student needs.

Contact Information

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New Program Report

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Contents

Executive Summary

This proposal describes a new BS in Environmental Engineering to be offered in the Department of Civil and Environmental Engineering (CEE). The proposed program will offer three optional track areas: public health, data analytics and bio/agricultural engineering.

The recent growth in Environmental area faculty due to recent hires through the Mizzou Forward program resulted in an increase in teaching and research capacity that can now support a separate degree program targeted to students interested in the sustainability and environmental aspects of engineering.

This program is in line with campus priorities. First, it will provide Missourians with new learning and research opportunities in Environmental and Water Resources Engineering to support sustainable economic development in the state. Second, it supports the campus strategic plan's call to "magnify department strengths" by fostering collaboration with the recently formed Missouri Water Center, an interdisciplinary research center at MU. The Environmental Engineering teaching faculty are core members of the Missouri Water Center and will synergistically blend the research activities into the classroom.

The proposed program requires minimal investment (three teaching assistants to support hands-on learning and laboratories, and one adjunct instructor), and brings together currently available resources (tenure-track faculty and top-tier lab facilities) to deliver a world-class environmental engineering degree program for Missourians.

Program graduates will become licensed environmental engineers or/and continue to graduate programs in environmental or related fields. Environmental engineers can work in industrial facilities, consulting firms, research laboratories and in the public sector, mostly in government/regulatory agencies or municipal facilities.

There is currently a need for environmental engineering professionals and the demand for new graduates in this area will increase by 12.5% over the next decade, fueled by unprecedented federal and state funding that is being allocated to infrastructure and environmental projects.

1. Introduction

Academic Components and Career Paths

The environmental engineering BS program combines a solid background in science and engineering (chemistry, math, physics, thermodynamics) with core classes (water quality and treatment, air pollution, solid and hazardous waste management) and discipline-specific and interdisciplinary elective courses.

Program graduates will become licensed environmental engineers or/and continue to graduate programs in environmental or related fields. Environmental engineers can work in industrial facilities, consulting firms, research laboratories and in the public sector, mostly in government/regulatory agencies or municipal facilities.

Some of the activities that environmental engineers do are: "design, build and operate projects that lead to environmental protection, such as water reclamation facilities or air pollution control systems; prepare, review, and update environmental investigation reports; obtain, update, and maintain plans, permits, and standard operating procedures; inspect industrial and municipal facilities and programs in order to ensure compliance with environmental regulations; and advise corporations and government agencies about procedures for cleaning up contaminated sites", as identified by the U.S. Bureau of Labor Statistics.

Evolution of Concept

The program is being proposed due to the convergence of several factors: growth of the environmental area faculty at MU, merger of two campus-wide research centers to form the Missouri Water Center and the resulting increase in visibility and research activity, and the increased demand of professionals driven by the unprecedented federal and state investments in infrastructure and sustainability.

Preliminary Steps

The Department of Civil and Environmental Engineering currently offers an Environmental and Water Resources track for Civil Engineers, as well as a minor in Engineering Sustainability. The courses in the new BS Environmental Engineering curriculum already exist as part of one or both of these programs. The current Environmental Engineering Teaching laboratory used by Civil Engineering students will also serve as a teaching lab for the new program.

No changes are proposed for the existing areas in Civil Engineering (Environmental Engineering/Water Resources). The Civil Engineering degree requires a fundamental course in environmental and water resources engineering; required

courses for the BS in Environmental Engineering will be offered as electives for Civil Engineering students. No additional courses are needed in order to continue the Environmental Engineering/Water Resources emphasis area in Civil Engineering. Civil Engineering students are generally interested in enrolling in electives from more than one emphasis area to have a broader education that is appealing to future employers.

2. University Mission & Program Analysis

2.A. Alignment with University Mission & Goals

The proposed program aligns with the University of Missouri land grant mission as it provides Missouri students the benefits of learning and conducting research with internationally recognized scholars in Environmental and Water Resources Engineering. MU also offers students an excellent combination of laboratory infrastructure and scholarly research environment through the recently established Missouri Water Center, a partnership between the College of Engineering and the College of Food, Agriculture, and Natural Resources.

Alignment with Campus Strategic Plan

The proposed BS in Environmental Engineering is closely aligned with the MU strategic plan goals of "Create new degree programs and revise existing programs based on student demand, workforce needs and emerging opportunities" and "Develop new and revise existing interdisciplinary undergraduate and graduate degree programs to magnify departmental strengths." Also, core to the Strategic plan, this new program will increase undergraduate enrollment by attracting additional students to MU.

Finally, one of the areas identified in Mizzou Forward under the priority research area, New Frontiers in Science, Engineering and Technologies is "Energy, Environment & Earth Sciences". The Department of Civil and Environmental Engineering has recently hired two new tenure-track faculty through Mizzou Forward in the Environmental area.

Program Priority

The development of the environmental area has been a focus of the department, college and campus for the past several years. A campus wide Engineering Sustainability minor is housed in the Civil & Environmental Engineering department (started in 2019); two world-renowned Mizzou Forward faculty members with strong Environmental research programs joined the department in the past year, significantly increasing the research and teaching capabilities in Environmental Engineering.

The new Missouri Water Center is the result of a merger of two long standing

water related research and outreach centers at MU with the objective of creating a more streamlined research infrastructure and collaboration opportunities for faculty from various colleges, Extension, and public and private sector partners. The Center is expected to build capacity, drive workforce training, accelerate collaboration, and generate new resources to meet today's and tomorrow's water resource needs for the state of Missouri.

2.B. Duplication & Collaboration

Within UM System

The Missouri University of Science and Technology (MS&T) offers a BS in Environmental Engineering. Due to accreditation requirements, Environmental Engineering degree programs across different universities will have some similarities in the core curriculum. However, MU's proposed degree distinguishes itself in a few ways.

First, students can choose from three tracks - Public Health, Data Analytics, and Biological/Agricultural Engineering. Courses in these tracks are already offered as part of other degree programs at MU. Thus, students will have opportunities to benefit from MU's land-grant and flagship mission to offer courses in a breadth of area that are not available at other engineering schools.

Second, students in the proposed MU degree program will have unique opportunities for undergraduate research not only in the Civil and Environmental Engineering department but also in Public Health, Agriculture and Natural Resources, and Basic Sciences. Again, this is a unique advantage students will have at MU due to our charge to conduct world-class research to maintain our status as an AAU Tier 1 Research University.

Third, MU's recent investment in growing the size of Environmental faculty allows for the development of a broad variety of technical elective courses in the discipline, as well as increased research opportunities for undergraduate students. Research facilities such as the MU Materials Science and Engineering Institute and the Roy Blunt NextGen Precision Health building are examples of excellent infrastructure available on campus to support the teaching and research activities.

We expect little to no impact on MS&T's enrollment in their existing degree program. MU and MS&T have had BS in Civil Engineering degrees for over 100 years and continue to have steady enrollment in both programs. The enrollment is mainly driven by the industry need for Environmental Engineers due to the unprecedented infrastructure spending in water treatment, wastewater treatment, pollution prevention and mitigation, and other Environmental areas of national importance. MU's proposed program will grow the size of

Environmental Engineering students in the state that can be gainfully employed by the public and private sector. In addition, MU's program will be appealing to students that are interested in an interdisciplinary experience between Environmental Engineering, Public Health, Biological and Agriculture, and Natural Sciences.

The National Academy of Engineering (NAE) published a consensus report in 2019 on the future of Environmental Engineering. The report highlights that the core competencies of the traditional environmental engineering curriculum will not be enough to address current and future challenges, where more interdisciplinary approaches and non-traditional competencies will be key to developing the solutions for in the future challenges. The MU campus provides these unique opportunities for collaboration across disciplines to address this expansion of the traditional scope of the environmental engineering competencies.

The US Bureau of Labor Statistics projects a 4% increase in the employment of environmental engineers (2021-2031), mainly in the area of air and water quality. Increased public awareness is expected to contribute to further growth, in addition to the expansion of the competencies for the profession as envisioned by the NAE report.

Rationale

The BS in Environmental Engineering provides a degree option for students that are interested in the environmental aspects of civil engineering. The timing of this program is also ideal as our society faces unprecedented challenges in providing clean drinking water and preserving our environment. The National Academies has identified five grand challenges that environmental engineers will be tasked to address in the next decade. These are: 1) sustainably supply food, water, and energy, 2) curb climate change and adapt to its impacts, 3) design a future without pollution and waste, 4) create efficient, healthy, and resilient cities, and 5) foster informed decisions and actions.

The $1.2 trillion Infrastructure Investment and Jobs Act (IIJA) passed in 2021 will make significant investments in improving the civil infrastructure in our country. A sizeable portion of the funding will be devoted to upgrading our water treatment facilities, dams, levees, and flood control.

MU's Civil and Environmental Engineering department added Environmental Engineering to the department name 24 years ago in 1998 to reflect the research and education efforts conducted by the department faculty. Due to the recent growth in the department size, MU now boasts the largest group of Environmental Engineering faculty in the state (eight tenure-track faculty).

Two of the three Mizzou Forward hires in 2022 are in Environmental Engineering.

This size and diversity of research and teaching expertise makes it timely to launch this new degree program in Environmental Engineering that will attract both in-state and out-of- state students.

MU has excellent infrastructure to support lab-based instruction in Environmental Engineering. The teaching labs in the College of Engineering are top-notch with significant upgrades made in the past decade. Labs are equipped with all the necessary equipment to offer undergraduate courses in Environmental Engineering.

The proposed degree program will also benefit significantly from other existing programs on MU's flagship campus. For example, students choosing the Public Health track will take classes from the College of Health Science's Public Health program. Similarly, students interested in the Data Analytics and Big Data track will take classes from the College of Arts and Science's Department of Statistics.

The department faculty and Civil & Environmental Engineering alumni have strong relationships with both industry (e.g., Black and Veatch, Burns and McDonnell) and public sector agencies (e.g., Missouri Department of Natural Resources, US Geological Survey, EPA, US Army Corps of Engineers) which will help with student career readiness and placement outcomes.

In summary, this degree program will produce workforce to address a great societal need. The Civil and Environmental Engineering department has built up the necessary faculty expertise through strategic investments including the Mizzou Forward initiative. The department is well-positioned to take advantage of existing resources on campus to launch this new degree program with minimal additional cost.

Within the state of Missouri

Washington University in St Louis recently launched (2018-19) a BS in Environmental Engineering.

Rationale

There is an increase in demand of Environmental Engineers in the workforce and in student demand for the degree, shown by the enrollment and graduation data from Missouri S&T and testimony from employers (private and public sector) in their letters support of a new program at Mizzou.

MU offers a significant cost advantage with respect to Washington University and particularly for Missouri residents, with annual tuition and fees of $ 17,800 (resident)/ $ 38,000 (non-resident) versus $ 63,000 at WashU.

Collaboration

The new degree program is offered at the undergraduate level, and the department believes it is in the best interest of students and instructional quality for all coursework to be offered in-person and on-campus. Any partnership with S&T in delivering the program would require students to enroll in online courses, which was not deemed desirable by faculty (and students post-COVID).

Feasibility

The faculty in the Department of Civil and Environmental Engineering at Mizzou and MS&T have a long history of collaborations, both in teaching and research. For example, the environmental faculty from both departments participate and organize the Annual Mid America Environmental Engineering Conference (MAEEC), a two-day conference for graduate students in civil and environmental engineering from six regional universities (Southern Illinois University Edwardsville, Washington University in St. Louis, Missouri University of Science and Technology, University of Missouri Columbia, Southern Illinois University Carbondale and Saint Louis University) to share educational experiences and research updates. Hosting responsibilities rotate between the first four participating universities. Other attendees include faculty members, postdoctoral researchers, and keynote speakers. The conference has been held continuously for over 25 years. It is expected that the new program will enhance current collaboration and expand possibilities for the mutual benefit of both programs.

3. Business-Related Criteria & Justification

3.A. Market Analysis

3.A.1. Rationale and Workforce Demand

There is a workforce shortage and dire need for more graduates from Missouri universities. This shortfall is expected to grow because of the investments in infrastructure coming to Missouri through the Infrastructure Investment and Jobs Act (IIJA). The new degree will prepare students to be competitive for jobs in Environmental Engineering in Missouri, regionally, nationally, and internationally through strong connections to the industry, and it will meet market, societal and student demands. In addition, the proposal has received support from government agencies, federal research laboratories, municipal water treatment facilities and industry.

The BS Environmental Engineering program offered at Missouri S&T graduated 28 students in 2021, which constitutes a 33% YOY increase, and a 115% increase with respect to 2012. Historically, the MS&T program has been the only one in the state to produce graduates; Washington University launched a BS Environmental Engineering program in 2018-2019.

The current demand for Environmental Engineers in Missouri and neighboring states (Arkansas, Illinois, Iowa, Kansas, Kentucky, Nebraska, Oklahoma, Tennessee) is slightly below the national average (184 postings per month vs. 224 jobs postings national average in 2021). However, the predicted percentage growth of jobs in Missouri in the next decade exceeds the national average by more than 2 percentage points. Jobs in the Environmental Engineering sector are projected to grow 12.5 % in Missouri by 2032. Five institutions graduated Environmental Engineers in the surrounding nine state region in 2021; (Because Washington University in St Louis and Iowa State launched their programs recently, they had not produced graduates by 2021). The number of graduates (completions) showed a 115% growth for the 2017-2021 period. At the state level, MS&T saw an increase in 33% completions in the year 2021.

The current and forecasted demand do not consider the significant federal and state investments in infrastructure (e.g., renewal of aging water treatment plants), addressing Forever Chemicals, and climate change mitigation. These investments are expected to further increase the need for trained Environmental Engineers in Missouri and the region in the next decade.

According to Bureau of Labor Statistics Occupational Outlook Handbook, there are currently 44,000 Environmental Engineer jobs in the US and the field is expected to grow at 4% over the next decade. The letters of support from public and private sector further reinforce the workforce shortage and need for more environmental engineering graduates in Missouri.

3.A.2. Student Demand for Program

There is currently no pathway at MU for students interested in pursuing a degree program in Environmental Engineering. Engineering students take Environmental electives offered in the Civil & Environmental Engineering department and some enroll in the Engineering Sustainability minor. Over the past several years, Civil & Environmental Engineering students have requested the department add more elective courses in the Environmental area. Some of these courses draw students from other Engineering degree programs (e.g., Chemical Engineering, Biological Engineering), thus showing a sustained interest among current students.

The Bureau of Labor Statistics projects a 4% increase in employment (1,800 additional jobs) for environmental engineers between 2021 and 2031. To fill these jobs, many students will be seeking educational opportunities such as the BS in Environmental Engineering, to prepare them. These jobs are attractive to potential students not only due to the exciting subject matter but also by the median pay reported by the Bureau of Labor Statistics, which is $96,820 per year. The 2021 national median salary for Environmental Engineers is about $9,000 higher than the pay of Civil Engineers. Most Jobs are found in the Architectural, Engineering, and Related Services.

Table 1a. Student Enrollment Projections:

Year	1	2	3	4	5
Full-time	15	35	55	80	90
Part-time	0	0	0	0	0
Total	15	35	55	80	90

These projections are based on student demand, market demand, enrollment at other regional universities, and enrollment in related engineering degree programs at MU. MU undergraduate students are primarily enrolled in classes as full-time students, thus we do not anticipate any part time enrollment in the new degree program.

Table 1b. New Student Enrollment Projections:

Year	1	2	3	4	5
Full-time	15	20	20	25	25
Part-time	0	0	0	0	0
Total	15	20	20	25	25

Under steady state, we expect to have 25-30 new students enroll in the degree program each Fall.

Table 1c. Projected Number of Degrees/Certificates Awarded:

Year	1	2	3	4	5	6	7	8	9	10
Completions	0	0	4	13	18	22	25	25	25	25

3.B. Financial Projections

3.B.1. Additional Resources Needed

The new program will leverage existing resources and does not require significant additional funding to be successful. There are sufficient number of full-time faculty in the Environmental Engineering area to teach the required and elective courses listed in the degree program. The department has excellent lab infrastructure to support lab courses.

The program will be delivered using the current teaching capacity in the department; no new full time faculty hires are required. Three additional Graduate Teaching Assistants are requested due to the projected increase in enrollment in courses with laboratory sections as well as additional capacity in the advising/student support office at the College of Engineering.

Salary for one instructor (adjunct) is included in the estimated expenses to offer courses when full-time faculty are released from teaching assignments, in case of research leave, extraordinary service appointments, involvement in large research proposals or projects, or emergencies. Salary for advising/student support staff is included, at a rate of 1/3 person to support the additional enrollment projected at steady state (90 students). A 4% annual increase in salaries in considered for the analysis. The overall expense is estimated to be $175,000 per year. Additional resources, outlined below, are low and will be offset by new revenues.

1) Three teaching assistants (0.25 for CV ENG 3200, 0.5 for CV ENG 3700, 0.25 for CV ENG 3702, and 0.5 for CV ENG 4980)
2) Adjunct instructor for two courses
3) Additional capacity in the advising/student support office at the College of Engineering

3.B.2. Revenue

The source of revenue for this program is exclusively student tuition. Based on the enrollment projection presented above, the total revenue in year one using in-state tuition and fees will be $420,646; and increasing to $1,115,974 in year five. At the steady state, the total revenue from the BS in Environmental Engineering will be $1,161,059 per year. These estimates are new revenues to MU due to the creation of the program (not students switching from other degree programs).

In addition to revenue generated from new students, the expansion of Environmental Engineering courses that support the new degree program will also likely lead to students from other degree programs enroll in those courses. Elective courses that support the online MS program in Civil Engineering (Environmental emphasis) are also available for students from other UM campuses.

3.B.3. Net Revenue

According to the Financial Projections Spreadsheet, revenues will exceed expenses for this program from year 1, including under a 50% enrollment scenario. No new faculty lines or increase in technical personnel are requested. The program will benefit from all services and resources currently available to engineering programs at MU. These include computer services, library, marketing campaigns, etc. No additional space is requested; practical learning will use space and equipment

currently used for the Environmental Teaching lab in the Civil and Environmental Engineering department.

Table 2. Financial Projections for Proposed Program for Years 1 Through 5.

	Year 1	Year 2	Year 3	Year 4	Year 5
1. Expenses per year					
A. One-time					
New/Renovated Space	0	0	0	0	0
Equipment	0	0	0	0	0
Library	0	0	0	0	0
Consultants	0	0	0	0	0
Other	0	0	0	0	0
Total one-time	0	0	0	0	0
B. Recurring					
Faculty	0	0	0	0	0
Staff (teaching support)	178,500	182,070	185,711	189,426	193,214
Advising staff	17,000	17,340	17,687	18,041	18,401
Benefits	62335	62335	62335	62335	62335
Equipment	0	0	0	0	0
Library	0	0	0	0	0
Other(teaching lab supplies)	5000	5000	5000	5000	5000
Total recurring	$270,137	$275,440	$280,849	$286,366	$291,993
Total expenses (A+B)	$270,137	$275,440	$280,849	$286,366	$291,993
2. Revenue per year					
Tuition/Fees	667,692	1,026,459	1,526,442	1,736,654	1,771,387
Institutional Resources	(247,046)	(379,790)	(564,783)	(642,562)	(655,413)
State Aid -- CBHE					
State Aid -- Other					
Total revenue	$420,646	$646,669	$961,658	$1,094,092	$1,115,974
3. Net revenue (loss) per year	$150,509	$371,229	$680,810	$807,727	$823,981
4. Cumulative revenue (loss)	$348,747	$719,976	$1,400,786	$2,208,512	$3,032,493

3.B.4. Academic and Financial Viability

Based on the assumptions and estimates in the Financial Projections Spreadsheet, the cumulative direct margin becomes negative if total student enrollment does not reach 18 by Year 5. We estimate a minimum of 5 new students yearly for program viability. The program will be put on a hiatus if the total enrollment does not reach 20 students by the end of the initial 5- year period.

Table 3. Enrollment for Academic and Financial Viability

Enrollment	Minimum for Financial Viability	Minimum for Academic Viability
Full-time	18	40
Part-time	0	0
Total	18	40

3.C. Business Plan: Marketing, Student Success, Transition & Exit Strategies

3.C.1. Marketing Plan & Strategy

The College of Engineering recruitment and communications staff will work with campus communications teams to develop print, digital, and other marketing campaigns. This includes direct communications to prospective students, K-12 partners, STEM nonprofits, industry partners, and community members of the college and university.

The Marketing and Communications office will announce the new degree on social media, on their website using search engine optimization, through newsletters sent to prospective students, academic peers, alumni and supporters. They will also incorporate it into printed recruitment pieces and digital and other paid advertising. The college will produce a video to support the degree launch.

The Environmental Engineering degree will be integrated into the College's recruitment brochure and other printed pieces and paid digital advertising, as well as on the College's website, utilizing search engine optimization to make it easier for interested prospective students to find information. A social media campaign around the launch of a program will be tailored to prospective students including the diversity of Environmental faculty in the department, four women faculty (50% of the group), and LED advertising in the building will add to the campaign.

The Environmental Engineering program will be also integrated into recruitment activities currently managed by the College of Engineering, as well as general MU admissions and recruitment activities (e.g., campus tours, college fairs, Meet Mizzou Days, high school visits, and community college visits). There are additional, discipline-specific opportunities to recruit through existing MU events aimed at K-12 and early career undergraduate students, such as Project Lead the Way; Columbia STEM Alliance; and KC STEM Fest. Additional STEM outreach activities will be organized by the Civil & Environmental Engineering department's Water and Environmental Technologists (WET) student team and will advertise the program with various STEM alliances in Missouri (e.g., Kansas City, St. Louis, Columbia).

Marketing Costs

The college has an overall paid advertising campaign including billboards and various digital online campaigns totaling $150K. While this dollar amount is not solely focused on the new program, a portion would go to announcing it. The college has allocated $10K for printed recruiting materials which would include this program.

3.C.2. Student Success Plan

The MU College of Engineering has long-standing programs in advising, tutoring and other student services to support student retention. Early alert system through MU Connect will help advisors track student performance and initiate timely interventions. Students will also be encouraged to participate in existing student teams, such as Water and Environmental Technologists (WET) and Engineers Without Borders (EWB). Both are focused on Environmental topics and are active student teams in Engineering that would be of interest to Environmental Engineers.

Achieving Enrollment Outcomes

The Civil & Environmental Engineering department intends to pursue ABET accreditation for the new degree program, which will further enhance visibility and enrollment. The CEE department will review the enrollment each semester and take actions to address any issues that may arise. Placement outcomes will also be tracked annually as is done with other degree programs in the college.

3.C.3. Transition Plan

The Civil & Environmental Engineering Chair will be responsible for the new program, with support from the Director of Undergraduate Studies. Thus, the program responsibility is not attached to particular faculty members but instead assigned to the current department leadership. If these individuals leave the institution or assume other responsibilities, their replacements will be installed following standard procedures for Chair and Director of Undergraduate Studies

nomination in the Department/College of Engineering.

3.C.4. Exit Strategy

The department chair will meet with the Dean each year to review the enrollment, retention, and graduation data for the new degree program. The department requests a five-year period to reach steady state. We estimate total enrollment after the initial five years would reach 90 students. The program will be put on a hiatus if the total enrollment does not reach 40 students by the end of the initial 5-year period. The program will be discontinued if the total enrollment falls below 20 students after year five.

4. Institutional Capacity

The new program is expected to have minimal burden on faculty. Many of the classes that are currently taught as part of the Civil Engineering curriculum will also be offered in the new degree program. Thus, synergies between the two programs, laboratory facilities, and research opportunities for students will be fully exploited. The new program will attract students that will enrich the learning of Civil Engineering students in classes. Academic advising duties will also be overseen by staff that are familiar with other existing Engineering degree programs, thus providing a seamless advising experience for all students.

5. Program Characteristics

5.A Program Outcomes

The (BS) in Environmental Engineering will prepare students to become competitive and marketable environmental engineers licensed in the state of Missouri, nationally or internationally, and to continue to graduate programs in environmental engineering or related fields. Core courses in mathematics, chemistry, physics, biology, mass and energy balances and transport phenomena will prepare students for more advanced work in upper-level courses that include water and wastewater treatment, air pollution, hazardous management, and regulatory compliance.

Learning Objectives

The learning objectives listed below are adapted from the student outcomes and curriculum requirements proposed by American Academy of Environmental Engineers and Scientists and ABET (Accreditation Board for Engineering and Technology) as criteria for accreditation for Environmental Engineering

undergraduate programs.

Students who complete the BS in Environmental Engineering will acquire knowledge in:

a) mathematics through differential equations, probability and statistics, calculus-based physics, chemistry (including stoichiometry, equilibrium, and kinetics), earth science, biological science, and fluid mechanics;
b) material and energy balances, fate and transport of substances in and between phases in the environment (air-water-soil).
c) the design of environmental engineering systems that includes considerations of risk, uncertainty, sustainability, life-cycle principles, and environmental impacts, and
d) Concepts of professional practice and project management, and the roles and responsibilities of public institutions and private organizations pertaining to environmental policy and regulations.

Students will develop practical and critical thinking skills through hands-on laboratory experiments and analysis and interpretation of the resulting data in more than one major environmental engineering topic, e.g., air, water, land, environmental health, as well as through completion of the capstone project.

Table 4. Student Learning Objectives:

1	To identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2	To apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3	To communicate effectively with a range of audiences.
4	To recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5	To function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6	To develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7	To acquire and apply new knowledge as needed, using appropriate learning strategies.

5.B. Program Design and Content

Curriculum Design

The curriculum was initially designed by a committee formed by the Environmental faculty in the Civil & Environmental Engineering department following criteria for ABET accredited Environmental Engineering programs. The curriculum includes 16 credit hours of math, 29 credit hours of basic sciences, 26 hours of civil engineering or engineering topics, and 24 hours of electives, of which 12 should be civil engineering electives.

The designed proposal was presented to the department faculty and voted in a departmental faculty meeting. The proposal was further presented, discussed and voted at the College faculty meeting and the MU campus Undergraduate Curriculum committee meeting.

Course Sequence

The curriculum includes a sequence of courses in math (MATH 1500, MATH 1700, MATH 2300 and MATH 4100 in this order), physics (PHYSCS 2750, PHYSICS 2760), and chemistry (CHEM 1320, CHEM 1330, and CHEM 2100).

Students start the series of department courses with CV ENG 1000 Introduction to Civil Engineering, and CV ENG 1050 Foundations of Engineering, which are introductory courses part of the freshman year program in the College of Engineering designed to better prepare the incoming students for the discipline specific course sequences.

CV ENG 3010 Decision Methods in Civil Engineering is a writing intensive course that provides the student skills regarding professional registration, ethics, economics and elements of statistics. Students must pass CV ENG 3010 with a C- or better to be enrolled in CV ENG 3200 Fundamentals of Environmental Engineering. A grade of C- or better is required for the students to take the three core Environmental Engineering courses (CV ENG 4290, CV ENG 40001 Air pollution and CV ENG 4220). The C- or better requirement ensures students have a solid understanding of the fundamentals of the professional and technical aspects of environmental engineering.

A figure showing a map of how the courses are sequenced within the curriculum is attached. This is provided as merely a template for how a student might move through the curriculum. The solid lines show strict prerequisites and the dashed lines indicate co-requisite paths. Minimum grade requirements are also shown when applicable.

No new courses are proposed to be developed for this program. The core and elective courses are all existing courses (as technical electives) in the Civil

Engineering program.

The syllabi of two electives recently added to the Civil Engineering program are attached: CV ENG 4001 Data analysis/modeling in Environmental Engineering; CV ENG 4001 Air pollution control engineering. These courses have been taught for the first time as topics courses in Spring 2023 and permanent course numbers will be assigned in 2023.

5.C. Program Structure

General Description

This program requires a total of 125 credit hours for completion. The curriculum includes 16 credit hours of mathematics, 29 credit hours of basic sciences, 9 credit hours of core environmental engineering courses, 39 credit hours of civil engineering topics/electives and 9 engineering electives. A 3 credit hours course meets the capstone requirement.

Program Requirements

The BS in Environmental Engineering requires a total of 125 credit hours for completion. Students earning a Bachelor of Science in Environmental Engineering are required to complete all University general education, University undergraduate requirements, degree, and major requirements, including selected foundational courses, which may fulfill some University general education requirements.

Students are introduced to Environmental Engineering and professional engineering design practices in the CV_ENG 1000 course. Basic science and engineering courses ground the students in the fundamentals necessary for future course work: biology (BIO SCI 1500), general chemistry (CHEM 1320 and 1330), organic chemistry (CHEM 2100), physics (PHYSCS 2750 and 2760), soil science (SOIL 2100) and thermodynamics (ENG 2300).

Students are also required to complete one 3-hour cultural awareness course which is selected from an approved cultural awareness course list, created and maintained by the College of Engineering or which meets a similar Arts and Science (A&S) requirement.

Engineering topics required courses impart general engineering foundations necessary for the discipline-specific courses. Civil Engineering topics required courses in the sophomore and junior years provide students with the basic fundamentals in the areas of environmental engineering (CV ENG 3200), water resources (CV ENG 3702), data analysis and modeling (CV ENG 4001), fluid mechanics (CV ENG 3700), water (CV ENG 4290), air (CV ENG 4001) and solid waste

(CV ENG 4220) pollution and control.

Civil Engineering elective courses provide students opportunity to specialize in different aspects of environmental engineering and water resources. With the Program elective courses, students may further focus on environmental engineering or opt for one of the three tracks: public health and emerging contaminants, big data and data analysis or, biological and agricultural engineering.

Design and communication skills are integrated throughout the curriculum culminating in a capstone design project. This "final" course requires working in teams, making oral and written presentations, and completing a final design report. Oversight, interaction, and evaluation are provided by practicing engineers from industry and governmental organizations.

Major Core Requirements:

Math (16 credit hours)	
MATH 1500 Analytic Geometry and Calculus I	5
MATH 1700 Calculus II	5
MATH 2300 Calculus III	3
MATH 4100 Differential Equations	3
Basic Sciences (29 credit hours)	
CHEM 1320 College Chemistry I	4
CHEM 1330 College Chemistry II	4
CHEM 2100 Organic Chemistry I	3
PHYSCS 2750 University Physics I	5
PHYSCS 2760 University Physics II	5
BIO_SC 1500 Intr. to Biological Systems with Lab	5
SOIL 2100 Introduction to Soils	3
Engineering Topics – General (5 credit hours)	
ENGINR 1050 Foundations of Engineering	2
ENGINR 2300 Engineering Thermodynamics	3
Civil Engineering Topics (30 credit hours)	
CV_ENG 1000 Introduction to Civil Engineering	1
CV_ENG 3200 Fundamentals of Environmental Eng	4
CV_ENG 3010 Decision Methods for Civil Engineering Design	3
CV_ENG 3700 Fluid Mechanics	3
CV ENG 4001 Data Analysis and Modeling in Environmental Engineering	3
CV_ENG 3702 Fundamentals of Water Resources Engineering	4
CV ENG 4290 Water and Wastewater Treatment Engineering	3
CV ENG 4220 Hazardous Waste Management	3
CV ENG 4001 Air Pollution Control Engineering	3
CV_ENG 4980 Civil Engineering Systems Design	3
Civil Engineering Electives (12 credit hours – any four courses from the below list)	
CV ENG 4270 Environmental Engineering Microbiology	3
CV ENG 4250 Environmental Regulatory Compliance	3

CV ENG 4286 Environmental Sustainability	3
CV ENG 4230 Water Quality Analysis	3
CV ENG 4700 Hydraulics of Open Channels	3
CV ENG 4730 Hydraulic Design	3
CV ENG 4990/4995 Undergraduate research	3
CV ENG 4720 Watershed Modeling Using GIS (BIOL EN 4350)	3
CV ENG 4740 Irrigation and Drainage Engineering (BIOL EN 4250)	3

Program Electives (12 credit hours - any four courses from the below list of general electives or tracks)*

BIOL EN 4001 Observing Earth from Space	3
CV_ENG 3600 Civil Engineering Materials	4
ENGINR 2100 Circuit Theory	3
ATM_SC 3600 – Climates of the World	3

Students may choose one of the following tracks; 3 courses from the student's selected track + 1 additional elective courses from the CV ENG electives or Program electives lists

Public health and emerging contaminants
P_HLTH 4350 Principles of Environmental Health for Public Health
P_HLTH 3560: Public Health and Environmental Justice
P_HLTH 4620 Climate Change and Human Health

Data analytics and big data
STAT 4710 Intro to Math Statistics
STAT 4510/4520 Applied statistical model I and II
STAT 4870 Time series analysis

Biological and agricultural engineering (**)
CV ENG 4710 Soil and Water Conservation Engineering
CV ENG 4720 Watershed Modeling Using GIS (BIOL EN 4350)
CV ENG 4740 Irrigation and Drainage Engineering (BIOL EN 4250)

(*) any of the above listed CV ENG ELECTIVES may also be chosen, but will only count towards one requirement
(**) courses in the bio/agricultural track may change based on availability of offering

SEMESTER PLAN

First Year:

FALL : 15 credit hours

MATH 1500 Analytic Geometry and Calculus I (5)
CHEM 1320 College Chemistry I (4)
BIO_SC 1500 Intr. to Biological Systems with Lab (5)
CV_ENG 1000 Introduction to Civil Engineering (3)

SPRING: 17 credit hours

MATH 1700 Calculus II (5)
Social Behavior Science or Humanities/Fine Arts Course (3)
CHEM 1330 College Chemistry II (4)
ENGLSH 1000 Writing and Rhetoric (3)
ENGINR 1050 Foundations of Engineering (2)

Second Year:

FALL: 17 credit hours

MATH 2300 Calculus III (3)
CV_ENG 3010 Decision Methods for Civil Engineering Design (3)
Social Behavior Science or Humanities/Fine Arts Course (3)
PHYSCS 2750 University Physics I (5)
CHEM 2100 Organic Chemistry I (3)

SPRING: 18 credit hours

MATH 4100 Differential Equations (3)
CV_ENG 3200 Fundamentals of Environmental Engineering (4)
PHYSCS 2760 University Physics II (5)
CV_ENG 3700 Fluid Mechanics (3)
Social Behavior Science or Humanities/Fine Arts Course (3)

Third Year:

FALL: 15 credit hours

SOIL 2100: Introduction to Soils (3)
ENGINR 2300 Engineering Thermodynamics (3)
CV ENG 4001 Data analysis/modeling in Environmental Engineering (3)
Social Behavior Science or Humanities/Fine Arts Course (3)
CV_ENG ELECTIVE (3)

SPRING: 13 credit hours

CV_ENG ELECTIVE (3)
ELECTIVE (3)
CV ENG 4290 Water and WW treat. Eng (3)
CV_ENG 3702 Fundamentals of Water Resources Engineering (4)

Fourth Year:

FALL: 15 credit hours

CV ENG 4220 Hazardous Wast Manag (3)
CV_ENG ELECTIVE (3)
ELECTIVE (6)
Social Behavior Science or Humanities/Fine Arts Course (3)

SPRING: 15 credit hours

CV_ENG 4980 Civil Engineering Systems Design (3)
CV ENG 4001 Air pollution control engineering (3)
CV_ENG ELECTIVE (3)
ELECTIVE (3)
Social Behavior Science or Humanities/Fine Arts Course (3)

Permanent course numbers for the 4000-level courses Air Pollution Control Engineering and Data Analysis and Modeling in Environmental Engineering will be sought.

LIST OF ENGINEERING ELECTIVES

ENVIRONMENTAL	
CV ENG 4270 Env Engineering Microbiology	3
CV ENG 4250 Env Regulatory Compliance	3
CV ENG 4286 Environ. Sustainability	3
CV ENG 4230 Water Quality Analysis	3
WATER RESOURCES	
CV ENG 4700 Hydraulics of Open Channels	3
CV ENG 4730 Hydraulic Design	3
CV ENG 4720 Watershed Modeling Using GIS (BIOL EN 4350)	3
CV ENG 4740 Irrigation and Drainage Engineering (BIOL EN 4250)	3
BIOL EN 4001 Observing Earth from Space	3
CV ENG 4990/ 4995 Undergraduate Research	3
CV_ENG 3600 Civil Engineering Materials	4
ENGINR 2100 Circuit Theory	3

Residency requirements:

MU requires that 30 of a student's last 36 credits must be MU course work. Missouri Online-Self Paced courses authored by MU faculty are acceptable as are courses offered for credit through Missouri Online. Courses from a community college can account for six of the last 36 credits.

Internship, thesis or other capstone:

A capstone project will conclude Environmental Engineering education at MU. These capstone projects provide a culminating experience for students by applying the various concepts and design procedures they have learned in their classes. Students work together in teams to study real-world challenges and offer recommendations to address them. The experience gives students the hands-on preparation they need to be successful after graduation.

Unique features:

N/A

Admission Requirements:

The Office of Admissions (Admissions) specifies the requirements for admission into the University of Missouri-Columbia (MU) and is responsible for

maintaining and publishing these requirements. Admissions is also responsible for applying the published requirements to students seeking admission to the University. The published requirements can be found at https://admissions.missouri.edu/requirements/

In addition to campus admission requirements, freshmen entering in College of Engineering (COE) degree programs are expected to have completed 17 units of approved high school course work (in grades 9-12), including 4 units in English, 4 in mathematics and 3 in science with laboratory. Mathematics should include 2 units of algebra, 1 unit of plane and solid geometry (combination course), and 1/2 unit of trigonometry. Additional senior mathematics is recommended.

Students satisfying requirements to be admitted into the College of Engineering will be directly admitted into the Environmental Engineering Program. Detailed requirements for individual programs in the College of Engineering are available on the college website at: http://catalog.missouri.edu/collegeofengineering/#admissions

5.D. Program Assessment

Assessment Learning Outcomes

The process for assessing learning outcomes will use direct and indirect measurements to assess the ability of our graduates.

Direct measures include targeted course assessments every semester and the evaluation of the capstone design projects by external readers participating in the course, practitioner/client/alumni.

Indirect measurements include an exit outcome survey by graduating seniors every semester, the Fundamentals of Engineering (FE) exam result, and surveys of Alumni, Employers, and Faculty. Data for each assessment tool will be collected every semester, except for the surveys of Alumni, Employers and Faculty, that will be conducted once every three years.

Continuous improvement will be a key component of the proposed degree program. We will utilize a six-step approach which includes:

1) conducting student outcome assessments,
2) combining assessment results by outcome,
3) evaluating results with program constituents and stakeholders,
4) developing action plans and new targets,
5) implementing action plans, and
6) reviewing actions and modifying student outcome assessment approach.

This annual cycle is also critical to the ABET accreditation process that the department will seek at the end of the fifth year after program launch.

Retention and Graduation Rate Goals

The current 2-year retention rate of students in the Civil Engineering degree program is 93.8%. The initial goal for the Environmental Engineering degree program is to reach or exceed 94%. The two freshmen Engineering courses required in the program will focus on best practices and strategies to succeed in the degree program. Based on the success of Civil Engineering, which had a 4-year graduation rate of 100%, an initial goal for the 4-year graduation rate for the Environmental Engineering program will be 80%.

Another goal of the program will be to support students in acquiring licensure. While entry level Environmental Engineering jobs do not require licensure, a professional engineer license is often required for career advancement. As is the current practice for Civil Engineering students, students in the Environmental Engineering degree program will be encouraged to take the first licensure exam in their senior year. After passing the first exam, candidates must acquire five years of qualifying work experience and clear a second exam to become a licensed professional engineer.

Other Measures of Success

Other measures of success will be derived from exit interviews and outcome surveys of graduates, and alumni and employer surveys, as described in the sections below.

5.E. Student Preparation

The major will serve a broad population, and there will be no special admissions or student qualifications required that exceed regular university standards. There is no specific preparation recommended for students entering this program to ensure success. Additional opportunities for college readiness are also available.

Admitted students are invited to join the Mizzou Engineering Summer Bridge program and to get a head start on their college experience. The Summer Bridge Program is an eight-week summer session in which the students live in a residence hall, take a prerequisite course (if student did not place in MATH 1500), attend workshops and enjoy social activities to get familiar with Mizzou, the College of Engineering and Columbia. Courses offered in the Summer 2023 program include MATH 1160 Precalculus; CHEM 1320: College Chemistry; and CMP_SC 1050: Algorithm Design and Programming. This program is presented by Mizzou's Center for Academic Success & Excellence (CASE) and the College of Engineering.

5.F. Faculty and Administration

The Chair (Dr. Praveen Edara) of the Civil and Environmental Engineering department, with support from the Director of Undergraduate Studies (Dr. Sarah Orton), will be responsible for the success of this program. The CEE Chair will dedicate 25% of time to the program. Core teaching activities will be supported by eight tenured/tenure-track faculty (Table 5) and two additional instructors. In addition to the eight core Environmental faculty, elective courses taught by other Civil Engineering faculty will also be available to students . 90% of the program's credit hours will be taught by full-time faculty, who hold either a Ph.D., a professional engineer (P.E.) license or both.

Table 5: Faculty Listing

Name	Position	Percentage of Time Dedicated to Program
1) Baolin Deng, PhD	William Andrew Davidson Professor	40%
2) Maria Fidalgo, PhD	Associate Professor, Director of Graduate Studies	40%
3) Zhiqiang Hu, PhD, P.E.	William Andrew Davidson Professor	40%
4) Tim Matisziw, PhD	Professor	15%
5) Maryam Salehi, PhD	Assistant Professor	40%
6) Kathleen Trauth, PhD, P.E.	Associate Professor, IDE Fellow	40%
7) Binbin Wang, PhD	Assistant Professor	40%
8) Feng "Frank" Xiao, PhD, P.E.	Associate Professor	40%

5.G. Alumni and Employer Survey

Alumni Survey

We will conduct surveys of the graduating class, faculty, alumni and employers, following methods already established in the BS Civil Engineering program.

Each senior will be asked to fill out a survey at the end of the semester in which they graduate. Exit interviews with the Director of Undergraduate Studies will also be conducted for graduating seniors to obtain additional feedback about the program experiences and career preparedness. The results will be compiled and discussed at a faculty meeting each semester.

Employer Survey Plans

In addition to the student survey, a similar survey will be sent to faculty, alumni and employers. The survey will be administered in an approximate 2-year cycle and reviewed by the faculty after completion. Data will be collected and stored on the departmental OneDrive account for use in accreditation preparation.

5.H. Accreditation

The department will seek accreditation from Accreditation Board for Engineering and Technology (ABET), the accreditation board that accredits other Engineering degree programs at MU, in the second year of the program.

6. Appendices