



DEPARTMENT OF
HIGHER EDUCATION &
WORKFORCE DEVELOPMENT

New Program Report

Date Submitted:

02/04/2021

Institution

Missouri University of Science & Technology

Site Information

Implementation Date:

8/1/2021 12:00:00 AM

Added Site(s):

Selected Site(s):

Missouri University of Science & Technology, 206 Parker Hall, Rolla, MO, 65409-0470

CIP Information

CIP Code:

400605

CIP Description:

A program that focuses on the scientific study of the occurrence, circulation, distribution, chemical and physical properties, and environmental interaction of surface and subsurface waters, including groundwater. Includes instruction in geophysics, thermodynamics, fluid mechanics, chemical physics, geomorphology, mathematical modeling, hydrologic analysis, continental water processes, global water balance, and environmental science.

CIP Program Title:

Hydrology and Water Resources Science

Institution Program Title:

Water Science and Engineering

Degree Level/Type

Degree Level:

Master Degree

Degree Type:

Master of Science

Options Added:

Collaborative Program:

N

Mode of Delivery

Current Mode of Delivery

Classroom

Online

Student Preparation



DEPARTMENT OF HIGHER EDUCATION & WORKFORCE DEVELOPMENT

New Program Report

Special Admissions Procedure or Student Qualifications required:

Students with undergraduate degrees from one of the seven participating programs (Biology, Chemistry, Chemical Engineering, Civil Engineering, Environmental Engineering, Geology and Geophysics, and Geological Engineering) or closely related degree programs will be able to succeed within the WSE MS-degree program. Entrance requirements will be the same as the university graduate student admission standards. The GRE exam will not be required for internal degree applicants.

Specific Population Characteristics to be served:

The online, non-thesis option is intended to serve working professionals.

Faculty Characteristics

Special Requirements for Assignment of Teaching for this Degree/Certificate:

All faculty in this program are required to have their doctorate.

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

100%

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

All full-time faculty are expected to advise students.

Student Enrollment Projections Year One-Five

Year 1	Full Time: 5	Part Time: 2	
Year 2	Full Time: 12	Part Time: 4	
Year 3	Full Time: 15	Part Time: 7	Number of Graduates: 5
Year 4	Full Time: 18	Part Time: 8	
Year 5	Full Time: 20	Part Time: 9	Number of Graduates: 24

Percentage Statement:

n/a

Program Accreditation

Institutional Plans for Accreditation:

We are not seeking professional accreditation for the WSE program.

Program Structure

Total Credits:

31

Residency Requirements:

Campus research will be required for thesis students.

General Education Total Credits:

0

Major Requirements Total Credits:

31

Course(s) Added



DEPARTMENT OF
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WORKFORCE DEVELOPMENT

New Program Report

COURSE NUMBER	CREDITS	COURSE TITLE
	0	Water Infrastructure and Remediation (0-15 credits)
	0	Water Policy Track (0-15 credits)
	0	Water Resources and the Environment Track (0-15 credits)
	0	Engineering Hydrology Track (0-15 credits)

Free Elective Credits:

9

Internship or other Capstone Experience:

A written thesis and formal thesis defense are required for thesis-based MS-degree students. There are no requirements for non-thesis students.

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, CBHE-approved service region or CBHE-approved off-site location.

I certify that the program will not unnecessarily duplicate an existing program within the geographically applicable area.

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

First and Last Name: STEVEN
CHAFFIN

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Phone: 573-884-3360

5.B. Structure

A total of 31 graduate credit hours will be required beyond the B.S. degree. The curriculum structure is designed for student success. We want to provide students with maximum flexibility but also to have the opportunity to individualize their curriculum within the over-arching theme of water technology. This flexible, inter- and multi-disciplinary approach to educating graduate students is important for the development of a broad-based applied graduate degree program, but at the same time allows graduate students to gain an appreciable level of specialization that matches with their career objectives. The breakdown of course requirements is as follows:

Program Courses	18 hrs	Students must take 18 credit hours (6 courses) from the Program Course List. Students must take at least 1 course from three different course categories and also take at least 1 course from three separate departments. Course categories include Engineering Hydrology, Water Infrastructure and Remediation, Water Resources and the Environment, and Water Policy.
Additional Coursework	6 hrs	Students can take a combination of existing and newly developed graduate courses that are relevant to their degree plans. These courses must be approved by their advisor in consultation with their thesis committee and will be chosen based on their specific career goals and interests.
Graduate seminar	1 hrs	These hours will be accumulated from taking a graduate seminar course(s) offered by one of the affiliated departments.
Thesis research	6 hrs	Six credit hours in thesis research must be completed.
Total	31 hrs	

Non-thesis Option

A total of 31 graduate credit hours will be required beyond the B.S. degree. The breakdown of course requirements is as follows:

Program Courses	21 hrs	Students must take 21 credit hours (7 courses) from the Program Course List. Students must take at least 1 course from three different course categories and also take at least 1 course from three separate departments.
Additional Coursework	9 hrs	Students can take a combination of existing and newly developed graduate courses that are relevant to their degree plans. These courses must be approved by their advisor and

		will be chosen based on their specific career goals and interests.
Graduate seminar	1 hrs	These hours will be accumulated from taking a graduate seminar course(s) offered by one of the affiliated departments.
Total	31 hrs	

5.C. Program Design and Content

The curriculum was cooperatively developed by the seven participating programs to capture what we believe are the most relevant water-related graduate coursework on our campus and group it into four easily-recognizable units (Engineering Hydrology, Water Infrastructure and Remediation, Water Resources and the Environment, and Water Policy). Using this as a foundation, we developed a pathway that was flexible, but still exposes all WSE students to water-related courses of different types and in different departments. By ensuring every student has these interdisciplinary interactions, we can meet our learning goals and program outcomes.

There should be plenty of available courses for students of all backgrounds such that students will never be without a course option. By design the WSE courses will limit exclusionary pre-requisites; however, in some cases additional content may be required for a student to achieve success. In these cases, we will either provide accelerated modules with leveling assignments to prepare the student as they enter the advanced course, or we will require the student to take an additional leveling course. In general, being able to take the courses in any sequence is a huge advantage for enabling student success and limiting time to graduation.

No new courses have been added to support the WSE curriculum.

5.C.1. Program Structure Form

1. Total credits required for graduation:

31 credits are required for graduation

2. Residency requirements, if any:

None, except that campus research will be required for thesis-based students.

3. General education

Not applicable since this is a graduate degree.

4. Major requirements

One hour of graduate seminar is required for all thesis and non-thesis WSE students. The graduate seminar course is not listed below, as seminar courses can be taken in

any of the participating disciplines. Six hours of research credit are required for thesis MS students. Because we do not require specific course sequences, we include the list of program courses below. Thesis students must take 18 hours of program courses, including at least one course from three different categories and at least one course from three separate departments. Non-thesis students must take 21 hours of program courses, including at least one course from three different categories and at least one course from three separate departments.

LIST OF PROGRAM COURSES

Engineering Hydrology

1. *CIV ENG 6331 Advanced Hydraulics And Hydraulic Engineering (LEC 3.0)*
2. *CIV ENG 5338 Hydrologic Engineering (LEC 3.0)*
3. *CIV ENG 5330 Unsteady Flow Hydraulics (LEC 3.0)*
4. *CIV ENG 5331 Hydraulics Of Open Channels (LEC 3.0)*
5. *CIV ENG 5333 Intermediate Hydraulic Engineering (LEC 3.0)*
6. *CIV ENG 5337 River Mechanics And Sediment Transport (LEC 3.0)*
7. *CIV ENG 6338 Advanced Hydrology (LEC 3.0)*
8. *GEO ENG 5320 Groundwater Modeling (LEC 3.0)*
9. *GEO ENG 5331 Subsurface Hydrology (LEC 3.0)*
10. *GEO ENG 5332 Fundamentals of Groundwater Hydrology (LEC 3.0)*

Water Infrastructure and Remediation

1. *CIV ENG 5335 Water Infrastructure Engineering (LAB 1.0 and LEC 2.0)*
2. *CIV ENG 6340 Urban Hydrology (LEC 3.0)*
3. *CIV ENG 6335 Hydraulic Structures (LEC 3.0)*
4. *BIO SCI 6463 Bioremediation (LEC 3.0)*
5. *CHEM ENG 4210 Biochemical Reactors (LEC 3.0)*
6. *CHEM ENG 5110 Intermediate Chemical Reactor Design (LEC 3.0)*
7. *CIV ENG 5332 Transport Processes in Environmental Flows (LEC 3.0)*
8. *CIV ENG 5360 Water Resources And Wastewater Engineering (LEC 3.0)*
9. *ENV ENG 5630 Remediation of Contaminated Groundwater And Soil (LEC 2.0 and LAB 1.0)*
10. *ENV ENG 5635 Phytoremediation and Natural Treatment Systems (LEC 3)*
11. *ENV ENG 5619 Environmental Engineering Design (LAB 1.0 and LEC 2.0)*
12. *ENV ENG 6612 Biological Operations In Environmental Engineering Systems (LEC 3.0)*
13. *ENV ENG 6611 Physicochemical Operations In Environmental Engineering Systems (LEC 3.0)*
14. *GEO ENG 6237 Advanced Geological & Geotechnical Design For Hazardous Waste Mgt (LEC 3.0)*
15. *GEO ENG 5239 Groundwater Remediation (LEC 3.0)*
16. *GEO ENG 5381 Intermediate Subsurface Hydrology And Contaminant Transport Mechs (LEC 3.0)*

Water Resources and the Environment

1. *BIO SCI 4313 Introduction to Environmental Microbiology* (LEC 3.0)
2. *BIO SCI 6313 Environmental Microbiology* (LEC 3.0)
3. *BIO SCI 4383 Toxicology* (LEC 3.0)
4. *BIO SCI 4363 Freshwater Ecology* (LEC 3.0)
5. *BIO SCI 6363 Advanced Freshwater Ecology* (LEC 3.0)
6. *BIO SCI 6383 Advanced Toxicology* (LEC 3.0)
7. *CHEM ENG 5340 Principles Of Environmental Monitoring* (LEC 3.0)
8. *CHEM 4710 Principles Of Environmental Monitoring* (LEC 3.0)
9. *CHEM 5710 Environmental Monitoring* (LEC 3.0)
10. *ENV ENG 5605: Environmental Systems Modeling* (LEC 3.0)
11. *ENV ENG 5642 Sustainability, Population, Energy, Water, and Materials* (LEC 3.0)
12. *GEOLOGY 4431 Methods Of Karst Hydrogeology* (LEC 3.0)
13. *GEOLOGY 4411 Hydrogeology* (LEC 3.0)
14. *GEOLOGY 4451 Aqueous Geochemistry* (LEC 3.0)
15. *GEO ENG 5153 Regional Geological Engineering Problems In North America* (LEC 3.0)

Water Policy

1. *CIV ENG 5640 Environmental Law And Regulations* (LEC 3.0)
2. *CIV ENG 5650 Public Health Engineering* (LEC 3.0)
3. *POLY SCI 4500 Geopolitics and International Security* (LEC 3.0)
4. *POLY SCI 4320 Policy for Science, Technology, and Innovation* (LEC 3.0)
5. *ECON 4440 Environmental and Natural Resource Economics* (LEC 3.0)

5. Free elective credits

Thesis students must take 6 hours of additional coursework electives and Non-thesis students must take 9 hours of additional coursework electives.

6. Requirement for thesis, internship or other capstone experience:

A written thesis and formal thesis defense are required for thesis-based MS-degree students. There are no requirements for non-thesis students.

7. Any unique features such as interdepartmental cooperation:

As noted above, this is a highly unique program in that the cooperation stretches across seven separate programs and two colleges at Missouri S&T.

Executive Summary

M.S. in Water Science and Engineering

Missouri S&T aims to offer a cutting-edge, interdisciplinary master's degree program in Water Science and Engineering (WSE) that integrates the expertise of multiple departments across the University to provide new education and research opportunities for the next generation. Our students will develop an inter- and multi-disciplinary understanding to address society's grand challenges of water sustainability and water security. These are essential areas as global demand for food, energy, and water are expected to rise by 60% by 2050. On a global scale, the availability and access to clean drinking water is the single largest factor affecting human health. As a result, access to clean drinking water has been identified by the National Academy of Engineering as one of the 14 grand engineering challenges.

The objectives of the proposed degree program include preparing engineers and scientists to specialize in understanding water resources from an inter-disciplinary viewpoint, preparing students from different backgrounds for a wide variety of careers relating to water resources, and to benefit society by helping industries and government agencies manage, remediate, and secure vital water resources through the development of a highly-qualified workforce.

By relying on existing courses with additional capacities for enrollments, we are able to provide a unique but very low-cost program with a fully online option. Support for this program is strong, because the WSE degree directly addresses many aspects of our university's strategic plan, including key aspects such as building a culture with increased emphasis on high-impact research and scholarship, as well as serving industry and community needs by producing a stream of civic-minded, workforce-ready graduates.

State and national demand for WSE graduates is high. In the last year there were more than 45,000 openings nationally and almost 600 in Missouri for positions that would suit our graduates. It is expected that the state of Missouri will need 21.1% more Natural Science Managers and Water Resource Specialists over the next decade. Considering the strong national focus on inter- and multi-disciplinary research associated with water (technology, management, resources, sustainability, security, etc.) our graduates will be in a strong position to fill growth in any of these sectors.

The student demand for this program at Missouri S&T is high in that undergraduates from a wide variety of our science and engineering disciplines can feed directly into the WSE MS-degree program. A survey of students in relevant programs indicated strong interest and support for such a program. Further, the focus of the WSE degree is unique in the Midwest region, and therefore should be successful from recruiting students from the broader region. Overall, we believe this proposed program strongly aligns with Missouri S&T's mission, societal needs, and student and employer demand.

No. 3

Recommended Action – M.S. Water Science and Engineering – Missouri S&T

It was recommended by Sr. Associate Vice President Steve Graham, endorsed by President of the University of Missouri Mun Choi, recommended by the Academic, Student Affairs and Research & Economic Development Committee, moved by Curator _____, seconded by Curator _____ that the following action be approved:

that the Missouri University of Science & Technology be authorized to submit the attached proposal for a Master of Science in Water Science and Engineering to the Coordinating Board for Higher Education for approval.

Roll call vote of the Committee:

YES

NO

Curator Wenneker

Curator Hoberock

Curator Layman

Curator Snowden

The motion _____.

Roll call vote of Board:

YES

NO

Curator Brncic

Curator Chatman

Curator Graham

Curator Hoberock

Curator Layman

Curator Snowden

Curator Steelman

Curator Wenneker

Curator Williams

The motion _____.

New Degree Program Proposal:
**Master of Science in
Water Science and Engineering**
Missouri University of Science & Technology

Contents

Executive Summary	5
1. Introduction	6
2. Fit with University Mission and Other Academic Programs	7
2.A. Alignment with Mission and Goals	7
2.B. Duplication and Collaboration within Campus and Across System	9
3. Business-Related Criteria and Justification	9
3.A. Market Analysis	9
3.B. Financial Projections.....	13
3.C. Business and Marketing Plan: Recruiting and Retaining Students.....	15
4. Institutional Capacity.....	16
5. Program Characteristics.....	16
5.A. Program Outcomes	16
5.B. Structure.....	17
5.C. Program Design and Content.....	18
5.D. Program Goals and Assessment	21
5.E. Student Preparation.....	21
5.F. Faculty and Administration.....	21
5.G. Alumni and Employer Survey.....	23
5.H. Program Accreditation.....	23

(Some appendices are excluded from these materials for length and clarity and are available upon request.)

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The objectives of the proposed degree program include preparing engineers and scientists to specialize in understanding water resources from an inter-disciplinary viewpoint, preparing students from different backgrounds for a wide variety of careers relating to water resources, and to benefit society by helping industries and government agencies manage, remediate, and secure vital water resources through the development of a highly-qualified workforce.

By relying on existing courses with additional capacities for enrollments, we are able to provide a unique but very low-cost program with a fully online option. Support for this program is strong, because the WSE degree directly addresses many aspects of our university's strategic plan, including key aspects such as building a culture with increased emphasis on high-impact research and scholarship, as well as serving industry and community needs by producing a stream of civic-minded, workforce-ready graduates.

State and national demand for WSE graduates is high. In the last year there were more than 45,000 openings nationally and almost 600 in Missouri for positions that would suit our graduates. It is expected that the state of Missouri will need 21.1% more Natural Science Managers and Water Resource Specialists over the next decade. Considering the strong national focus on inter- and multi-disciplinary research associated with water (technology, management, resources, sustainability, security, etc.) our graduates will be in a strong position to fill growth in any of these sectors.

The student demand for this program at Missouri S&T is high in that undergraduates from a wide variety of our science and engineering disciplines can feed directly into the WSE MS-degree program. A survey of students in relevant programs indicated strong interest and support for such a program. Further, the focus of the WSE degree is unique in the Midwest region, and therefore should be successful from recruiting students from the broader region. Overall, we believe this proposed program strongly aligns with Missouri S&T's mission, societal needs, and student and employer demand.

1. Introduction

The proposed degree program in WSE will be interdisciplinary in its focus on water. Degree focus areas include (1) *Engineering Hydrology*, (2) *Water Infrastructure and Remediation*, (3) *Water Resources and the Environment*, and (4) *Water Policy*. A total of 31 graduate credit hours will be required beyond the B.S. degree for both thesis and non-thesis MS options.

The thesis option (31 total hours) is comprised of the following:

- Program Courses: Students will select six courses (18hrs) from the Program Course List. Students must take at least 1 course from three different course categories and also take at least 1 course from three separate departments. Course categories include *Engineering Hydrology*, *Water Infrastructure and Remediation*, *Water Resources and the Environment*, and *Water Policy*.
- Additional Courses: Students will select two courses (6 hrs) from a combination of existing and newly developed graduate courses that are relevant to their degree plans. These courses must be approved by their advisor in consultation with their thesis committee and will be chosen based on their specific career goals and interests.
- Graduate Seminar: Students will be required to take one hour of graduate seminar from any of the affiliated programs.
- Thesis Research: Students will complete six hours of research credit.

The non-thesis option is identical to the thesis option except that the research hours are replaced with six hours of additional coursework. The primary difference between the non-thesis and thesis degree option is that the non-thesis degree can be completed largely (perhaps fully depending on the desired coursework) online or using a hybrid delivery mode. Online delivery of courses will be important for attracting working professionals and other non-traditional students into the WSE program.

This flexible curriculum structure will provide students with the opportunity to individualize their curriculum within the over-arching theme of water technology. This flexible, inter- and multi-disciplinary approach to educating graduate students is important for the development of a broad-based applied graduate degree program, but at the same time allows graduate students to gain an appreciable level of specialization that matches with their career objectives. Career opportunities include a wide variety of geoenvironmental and civil engineering-focused consulting companies, state and federal regulatory agencies, NGOs, secondary education, and the growing environmental divisions of private sector mining and energy companies.

The flexible curriculum structure will also enhance student success in terms of streamlining courses and shortening time to graduation. For example, with the wide variety of potential courses that can be taken at any stage over the MS degree, students will never need to wait for course availability.

The concept for this program developed from the intersection of a clear societal need for education and research related to water resources with a critical mass of expertise in this area that is woven throughout many departments and programs at Missouri S&T. The WSE degree program brings together this multidisciplinary expertise in a way that will benefit students, fill a crucial need, and spur collaborations and innovation on our campus.

Preliminary steps toward the WSE degree include the creation of graduate certificates in *subsurface water resources* and *surface water resources*. These certificates are pathways that can lead to the WSE degree. No new coursework is required to establish the WSE degree. What makes the new degree program special is that for the first time all water-related coursework in all disciplines across the Missouri S&T campus have been linked and packaged to create a superior educational experience.

The WSE program will be run through the Department of Geosciences and Geological and Petroleum Engineering (GGPE) but will also include shared administrative responsibilities among the other participating departments and programs. The Chairs of the GGPE and CA&E Departments, currently Dr. David Borrok and Dr. Joel Burken, respectively, will be primarily responsible for the success of the program. The GGPE Department will be responsible for program-specific administrative tasks, such as admissions paperwork, program reporting, and assessment-related activities. The participating departments will jointly handle recruiting activities, admissions decisions, and student advising.

2. Fit with University Mission and Other Academic Programs

2.A. Alignment with Mission and Goals

The mission of Missouri S&T is to integrate education, research, and application to create and convey knowledge that serves our state and helps solve the world's greatest challenges. The creation of the WSE program supports this mission by positioning Missouri S&T as a state, national, and global leader in water-related research and education. The WSE program will directly benefit the state of Missouri and the Midwest where many water-related issues directly impact the public. For example, harmful cyanobacteria algal blooms have recently been occurring in Missouri's lakes and some drinking water reservoirs. *E. coli* contamination continues to be a primary human health concern for areas like the Lake of the Ozarks and Table Rock Lake. Harmful bacteria and excessive agricultural nutrients are leading causes of impairment in Missouri's rivers and streams. Much of Missouri's groundwater is particularly vulnerable to pollution because of the rapid and often unpredictable flow pathways within the bedrock impacted by karst (e.g., the development of cave forming voids). Students graduating from our program will be in a unique position to not only understand these problems but to develop sustainable solutions to address them.

In addition to supporting the mission of the university, the creation of the MS-degree in WSE directly addresses many aspects of our university's strategic plan, including the following:

Excellence in Research and Creative Works

Objective 1 (Build a culture with increased emphasis on high-impact research and scholarship)

Strategy B – Pursue the establishment of nationally-recognized, externally funded research centers

Technologies associated with water sustainability and water security are nationally and globally important, as recognized by the National Academies of Science and Engineering. The expertise we develop and catalyze as part of this new degree program will allow us to be more competitive for research centers focused on water-related research.

Excellence in Research and Creative Works

Objective 2 (Achieve highest classification in Carnegie rankings)

Strategy A – Increase annual research expenditures by 100%

Strategy B – Increase number and quality of scholarly works

The graduate students, faculty, and associated research related to the new WSE program will spur increases in research productivity.

Excellence in Engagement and Outreach

Objective 2 (Serving industry and community needs)

Strategy A – Prepare civic-minded, workforce-ready and entrepreneurial graduates

Strategy B – Increase economic impact of S&T-developed technologies

The proposed degree programs will prepare students for a variety of careers, including entrepreneurial endeavors. Technologies related to water treatment and remediation have the potential for a large economic impact.

Excellence in Engagement and Outreach

Objective 4 (National and international engagement)

Strategy A – Encourage partnerships and collaborations that promote Missouri S&T's values, enhance our regional, national, and global reputation, and increase our visibility and ranking

Water sustainability and security and associated linkages to human health are global concerns. Water-related research drives international collaboration and will provide links to collaborations and humanitarian outreach opportunities.

2.B. Duplication and Collaboration within Campus and Across System

The proposed graduate program in WSE at Missouri S&T is unique within the UM system. Currently there are no standalone graduate degree programs that focus solely on water resources and include an interdisciplinary engineering and science focus within the UM System. The closest comparators include the MS-degree in Natural Resources offered by the University of Missouri. One of the seven emphasis areas in this degree program includes Water Resources. Our proposed MS-degree in WSE is substantially different in that several of the program concentration areas required for the WSE degree (*Engineering Hydrology* and *Water Infrastructure and Remediation*) fall fully outside the requirements and scope of the Natural Resources degree.

The Civil and Environmental Engineering MS-degree program at the University of Missouri includes a specialty area in “Environmental and Water Resources” that is focused primarily on civil engineering infrastructure. Similarly, the Civil Engineering MS-degree program at UMKC offers a degree track in “Water Resources” and the CA&E Department at Missouri S&T includes a MS-degree with an emphasis area in “Water Resources Engineering”. These degrees are excellent, but all include a narrow focus on the Civil Engineering aspects of water resources, including areas such as advanced hydraulics, hydrology, fluid mechanics, and numerical modeling. This narrow focus is not comparable to the broader engineering and science focus of the proposed WSE MS-degree program. Most importantly the WSE program will be accessible to students who graduate with BS-degrees in many disciplines outside of Civil Engineering.

The potential for sharing coursework with other programs and institutions within the UM-system is high and will be pursued as the program and student numbers grow. The new degree program may also spur research collaboration among other faculty and departments within the UM system.

3. Business-Related Criteria and Justification

3.A. Market Analysis

3.A.1. Need for Program

The availability of useable freshwater is a fundamental requirement for drinking, food production, power generation, and the extraction and processing of natural resources such as oil, gas, and minerals. Global demands for food, energy, and water are expected to rise by 60% by 2050. On a global scale, the availability and access to clean drinking water is the single largest factor affecting human health. This is why providing access to clean drinking water has been identified by the National Academy of Engineering as one of the 14 grand engineering challenges.

Currently only 16 public and 1 private institution in the U.S. offer MS-degrees in “hydrology and water resources science”, and none of these are in Missouri

or adjacent states (See comparator report in the appendix). Therefore, we have an opportunity with this new degree program to fill this important niche in the Midwest.

Occupational Skills

Using Burning Glass Technologies™, we conducted an analysis of occupational skills targeted through the WSE MS-degree program that had been identified in job postings over the last year. These include, but are not limited to, areas such as hydrology, hydrologic analysis, water engineering, water conservation, water planning, groundwater evaluation, and water supply safety (see appendix for additional information). On both a national and state-level, the analysis predicted a 32.1% growth in jobs that utilize these skills over the next decade. Nationally, 3.9% of the >37,000 job postings last year required MS-degrees, and in Missouri 4.6% of the 440 job postings required a MS-degree. These numbers are particularly impressive, as recent job openings were severely limited due to the Coronavirus pandemic. Top occupations that include these job skills include Civil Engineers, Water/Wastewater Engineers, Environmental Engineers, Mechanical Engineers, Geography and GIS specialists, Environmental Planner/Scientist, Hydrologist, Geologist, Meteorologist, and Project Manager. These job titles suggest that students with a wide-variety of undergraduate degrees could enter this field and improve their marketability in these water-related career domains. Top industries that hire graduates with these water-related skills (nationally and within Missouri) include professional and technical services (i.e., consulting) companies and public administration. Top employers nationally include the U.S. Government, Natural Resources Conservation agencies, and a variety of professional consulting service companies such as Golder Associates. In Missouri, the U.S. Government is still a primary employer, as is Burns and McDonnell and similar technical services companies. The locations in Missouri where the skills associated with the WSE-degree are in the highest demand, include the Kansas City and St. Louis Metro areas, as well as Columbia, Springfield, and Cape Girardeau.

Burning Glass Technologies™ was additionally used to analyze future job demand. In an attempt to look primarily at job growth trends in fields where a multidisciplinary background would be helpful, we restricted the analysis to only jobs that are peripheral to traditional job titles such as Civil Engineering, Geology, and Biology. Note, however, this does not mean that a WSE graduate could not enhance their job prospects within these traditional domains as well. Among the jobs, shown in the table below, there were more than 45,000 openings nationally and almost 600 in Missouri in the last year. The ten-year growth projections for these careers are outstanding. National 10-year growth ranges from 6.3% to 11.1%, while state growth ranges from 1.1% to 21.1%. In fact, it is expected that the state of Missouri will need 21.1% more Natural Science Managers and Water Resource Specialists over the next decade. It is important to note that the requirement of a MS-degree is mixed for these positions, ranging from almost no requirement for preparation beyond the BS-degree in some, with others requiring more than 10% of the hires to have MS-degrees. Typically, the MS-degree will provide students in all of these job categories with a

greater salary and career mobility than a BS-degree alone, so it remains a valuable proposition to get a MS-degree even when it is not an entry-level job requirement.

Job demand table.

	Job Postings last year		Projected 10-year growth	
	National	Missouri	National	Missouri
Water/Wastewater Engineers	5,622	88	8.4%	6.2%
Environmental Scientists	7,911	109	11.1%	9.3%
Environmental Engineers	11,367	129	8.4%	6.2%
Natural Science Managers	14,823	165	9.9%	21.1%
Soil and Water Conservationists	2,216	35	6.3%	1.1%
Hydrologist	1,380	18	10.4%	13.6%
Water Resource Specialist	1,837	34	9.9%	21.1%
Total	45,156	578	NA	NA

The WSE program fills an academic need for Missouri in that we currently do not have a stand-alone MS-degree program with a primary focus on water resources and certainly not one that is this inter- and multi-disciplinary in nature. Missouri's economy will be further stimulated by the production of well-trained MS-degree students that can fill a variety of positions in the environmental and geotechnical sectors. We have included support letters from Burns and McDonnell, Black & Veatch, Golder Associates, and The Metropolitan St. Louis Sewer District indicating that these companies/organizations would be interested in hiring graduates from the WSE program (see appendix).

3.A.2. Student Demand for Program

We assessed student demand for the WSE MS-degree through an anonymous online survey sent to current undergraduate students at Missouri S&T in the programs of Chemistry, Biology, Environmental Engineering, Civil Engineering, Chemical Engineering, Geology and Geophysics, and Geological Engineering. The survey included a summary description of the proposed WSE degree program followed by a series of questions. We received 102 responses, including 69 seniors, 23 juniors, 6 sophomores, and 4 freshmen. Of these students, most (61) planned to seek full-time employment after graduation, while the others were interested in graduate degrees or had not decided. When asked how important they thought it was to create and offer the interdisciplinary WSE graduate degree program in Missouri, 80 of the 102 students indicated that they thought it was important or very important. Twenty-three of the students indicated they had a high-level of interest in enrolling in a WSE MS-degree program, and another six students indicated they would plan to enroll in the program immediately if it were established.

Based on this internal assessment of demand, we will have a consistent pool of potential undergraduate applicants on our own campus (these are students who would likely have gone out-of-state for a graduate degree). We estimate we will

receive 10 to 20 internal applications annually with this level of student interest. We also anticipate strong interest from potential students graduating from other institutions in Missouri, as well as from national and international students. The number of anticipated applications and admissions is harder to estimate in this case because there are no clear comparator degree programs. However, because of the online option for our non-thesis track degree and the existing interest in the WSE MS-degree from within our seven participating programs, we expect at least 40 applications from outside students per year.

Enrollments in the WSE MS-degree for the first five years are estimated in Table 1a. Estimates are based on a combination of the internal student demand analysis and coupled with an analysis of enrollment and graduation trends from other programs in the state that might be considered “similar”. Although it is difficult to find accurate comparator programs, we believe enrollment trends in environmental science and environmental engineering fields should provide a reasonable idea of what we can expect for enrollment for the WSE program. The MS-degree in Environmental and Urban Geosciences at UMKC had an average 5-year fall enrollment (2015 to 2019) of 17.6 students. The MS in Environmental Engineering at Missouri S&T had an average 5-year fall enrollment of 16.4 students. Based on this analysis, coupled with our broader (multiple undergraduate programs as feeders) student demand we believe the WSE program will support approximately 20 full-time students as well as 9 part-time students by year five (Table 1a). An estimate of the projected number of students enrolled in the fall semester of each year who were new to campus is shown in Table 1b. Table 1c identifies the expected number of graduates from the program over the first 10 years. We anticipate that full-time students entering the program will take, on average, 2 years to graduate. The number of annual graduates projected for the WSE degree falls within the range for similar degree programs at peer institutions in other states such as the Colorado School of Mines (CSM) and New Mexico Tech (NMT). For the five year period from 2014-2018, the Hydrologic Science and Engineering graduate degree at CSM graduated 16.4 students annually, while the Hydrologic Sciences graduate degree program at NMT graduated 4.4 students annually over the same time period (In 2017 and 2018 NMT graduated 6 and 7 students respectively).

Table 1a. Student Enrollment Projections (anticipated total number of students enrolled in program during the fall semester of given year).

Year	1	2	3	4	5
Full-Time	5	12	15	18	20
Part-Time	2	4	7	8	9
Total	7	16	22	26	29

Table 1b. Student Enrollment Projections (anticipated number of students enrolled during the fall semester of given year *who were new to campus*).

Year	1	2	3	4	5
Full-Time	5	12	15	18	20
Part-Time	2	4	7	8	9
Total	7	16	22	26	29

Table 1c. Projected Number of Degrees Awarded

Year	1	2	3	4	5	6	7	8	9	10
# of Degrees Awarded	0	0	5	9	10	12	12	12	13	13

3.B. Financial Projections

3.B.1. Additional Resources Needed

Because the MS-degree program will involve existing faculty, office space, and laboratories, additional resource needs are limited. We have budgeted for an administrative assistant position to assist with management of the program and have included modest funding for computing, marketing and recruiting expenses. See Table 2 for these financial details.

3.B.2. Revenue

All revenue for this program will be generated from student tuition and fees (Table 2).

3.B.3. Net Revenue

Total expenses in year 1 are estimated to be \$65,214 and fluctuate within 10% of this value in years 2 through 5 (Table 2). The program revenue for year 1 is estimated to be \$49,871 due to the limited number of students in the inaugural year of the program. Hence, year 1 will run at a deficit of \$15,343. The growth of the student population by year 2 will result in a projected revenue of \$111,367, which will significantly exceed expenditures for year 2, as well as make up the modest deficit incurred in year 1. Cumulative revenue should exceed cumulative expenses in year 2 by \$32,433. Cumulative revenue is projected to grow every year thereafter and by year 5 is projected to reach \$478,136 (Table 2).

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					
<i>New/Renovated Space</i>					
<i>Equipment</i>	\$3,000				\$3,000
<i>Library</i>					
<i>Consultants</i>					
<i>Other</i>	\$8,800	\$8,820	\$8,840	\$8,860	\$8,880
Total one-time	\$11,800	\$8,820	\$8,840	\$8,860	\$11,880
B. Recurring					
<i>Faculty</i>					
<i>Staff</i>	\$35,000	\$35,700	\$36,414	\$37,142	\$37,885
<i>Benefits</i>	\$18,414	\$19,072	\$19,583	\$20,098	\$20,437
<i>Equipment</i>					
<i>Library</i>					
<i>Other</i>					
Total recurring	\$53,414	\$54,772	\$55,997	\$57,240	\$58,151
Total expenses (A+B)	\$65,214	\$63,592	\$64,838	\$66,100	\$70,031
2. Revenue per year					
<i>Tuition/Fees</i>	\$49,871	\$111,367	\$171,775	\$219,400	\$255,497
<i>Institutional Resources</i>					
<i>State Aid -- CBHE</i>					
<i>State Aid -- Other</i>					
Total revenue	\$49,871	\$111,367	\$171,775	\$219,400	\$255,497
3. Net revenue (loss) per year	(\$15,343)	\$47,776	\$106,937	\$153,300	\$185,466
4. Cumulative revenue (loss)	(\$15,343)	\$32,433	\$139,370	\$292,671	\$478,136

3.B.4. Financial and Academic Viability

The WSE MS-degree program is low-cost because we are leveraging existing campus faculty, courses, and space. The projected expenses of \$70,031 in year 5 will be fully counterbalanced by the tuition and fees associated with only 12 full-time students. The number of students needed for the WSE program to remain financially viable is less than half of our projected enrollment count for year 5 (20 full-time and 9 part-time students). Therefore, we expect that the WSE MS-degree program will remain

academically viable throughout its existence, and the existing faculty and campus resources that are leveraged for this program will continually support a vibrant and active learning environment.

We will evaluate the WSE program annually to track enrollments, costs, and revenue and compare it with our initial projections. This way any needed adjustments to marketing and recruiting can be made quickly. If the program is not on track to meet minimum financial viability in year 5, we will begin to phase the program out by not enrolling new students and cutting all marketing and recruitment costs. The program could be phased out over a few years as the existing students graduate.

Table 3a. Enrollment at the End of Year 5 for the Program to Be Financially and Academically Viable.

Enrollment Status	Full-Time	Part-Time	Total
Number of Students	12	0	12
OR			
Number of Students	10	4	14

3.C. Business and Marketing Plan: Recruiting and Retaining Students

Ms. Shobi Sivadasan, our Vice Provost for Enrollment Management, will oversee the WSE marketing program. We estimate annual marketing cost at \$7,700, which includes some travel expenses. When the WSE program launches we will prepare a press release and send out an announcement to appropriate professional societies, The Chronicle of Higher Education, as well as opportunities to target corporations and government agencies through a listserv or other forms of communication.

We plan to recruit students on our own campus who receive B.S. degrees in related science and engineering fields. We will also recruit B.S. students from other universities in our state, as well as nationally and internationally. Another of our recruiting strategies will be to send out recruiting information to universities in Missouri and the surrounding states that offer B.S. degrees in related fields. We will use resources such as the GRE exam search service, GEM Consortium, the McNair Scholars Directory, and other online directories to identify potential candidates who have demonstrated graduate-level readiness for our program. In addition to these efforts, we plan to build Standard Google AdWords and social media campaigns and SEO-based recruitment initiatives. Marketing efforts will also leverage the generous scholarship allowances built into our program. These scholarships will be posted on websites such as EducationUSA to ensure the word gets out to prospective students.

Other initiatives we plan to explore include partnering with STEM-focused undergraduate institutions that do not have master's programs to create accelerated BS to WSE MS-degree pathways. Using our existing study abroad infrastructure, we

will also explore the creation of study abroad programs for students in the WSE MS-degree. This could boost international partnerships and recruiting efforts.

Each year after program launch, we will review marketing analytics and ROI from various campaigns to target a more focused audience. We will constantly monitor progress and revise our strategies during and after the recruitment/yield period.

We will leverage all campus initiatives for student success and retention, including existing efforts within each of the participating departments. This includes access to many networking and professional development opportunities. Students in the WSE MS-degree program will be engaged and encouraged by their individual academic advisors. The staff member dedicated to WSE will ensure that all the student activities available within individual programs on our campus are communicated and organized effectively.

4. Institutional Capacity

The WSE MS-degree program will leverage existing faculty, existing infrastructure, and existing course offerings. Therefore, there is little burden on existing campus resources. There will be no change in the day-to-day responsibilities for the supporting faculty in terms of teaching assignments for the WSE program, as the courses are already being taught to serve a variety of other disciplines. Participating faculty will mentor and advise additional graduate students and simply integrate these activities into their current research and service obligations. Current research and lab space is sufficient to service the projected WSE student load, as graduate students will be distributed among multiple departments and buildings on our campus.

5. Program Characteristics

5.A. Program Outcomes

Our students will be required to take courses from at least three course categories (Engineering Hydrology, Water Infrastructure and Remediation, Water Resources and the Environment, and Water Policy) as well as courses from at least three separate departments. This experience will provide them with a deep interdisciplinary knowledge of water resources that is unique to the WSE program. The learning outcomes for the WSE MS-degree program include the following:

1. Students will gain an interdisciplinary understanding of the hydrophysical, technological, and environmental aspects of water resources.
2. Students will learn to think critically about a wide variety of water resource challenges.
3. Students will learn how to design and propose multi-dimensional solutions to water-related problems.

5.B. Structure

A total of 31 graduate credit hours will be required beyond the B.S. degree. The curriculum structure is designed for student success. We want to provide students with maximum flexibility but also to have the opportunity to individualize their curriculum within the over-arching theme of water technology. This flexible, inter- and multi-disciplinary approach to educating graduate students is important for the development of a broad-based applied graduate degree program, but at the same time allows graduate students to gain an appreciable level of specialization that matches with their career objectives. The breakdown of course requirements is as follows:

Program Courses	18 hrs	Students must take 18 credit hours (6 courses) from the Program Course List. Students must take at least 1 course from three different course categories and also take at least 1 course from three separate departments. Course categories include Engineering Hydrology, Water Infrastructure and Remediation, Water Resources and the Environment, and Water Policy.
Additional Coursework	6 hrs	Students can take a combination of existing and newly developed graduate courses that are relevant to their degree plans. These courses must be approved by their advisor in consultation with their thesis committee and will be chosen based on their specific career goals and interests.
Graduate seminar	1 hrs	These hours will be accumulated from taking a graduate seminar course(s) offered by one of the affiliated departments.
Thesis research	6 hrs	Six credit hours in thesis research must be completed.
Total	31 hrs	

Non-thesis Option

A total of 31 graduate credit hours will be required beyond the B.S. degree. The breakdown of course requirements is as follows:

Program Courses	21 hrs	Students must take 21 credit hours (7 courses) from the Program Course List. Students must take at least 1 course from three different course categories and also take at least 1 course from three separate departments.
Additional Coursework	9 hrs	Students can take a combination of existing and newly developed graduate courses that are relevant to their degree plans. These courses must be approved by their advisor and

		will be chosen based on their specific career goals and interests.
Graduate seminar	1 hrs	These hours will be accumulated from taking a graduate seminar course(s) offered by one of the affiliated departments.
Total	31 hrs	

5.C. Program Design and Content

The curriculum was cooperatively developed by the seven participating programs to capture what we believe are the most relevant water-related graduate coursework on our campus and group it into four easily-recognizable units (Engineering Hydrology, Water Infrastructure and Remediation, Water Resources and the Environment, and Water Policy). Using this as a foundation, we developed a pathway that was flexible, but still exposes all WSE students to water-related courses of different types and in different departments. By ensuring every student has these interdisciplinary interactions, we can meet our learning goals and program outcomes.

There should be plenty of available courses for students of all backgrounds such that students will never be without a course option. By design the WSE courses will limit exclusionary pre-requisites; however, in some cases additional content may be required for a student to achieve success. In these cases, we will either provide accelerated modules with leveling assignments to prepare the student as they enter the advanced course, or we will require the student to take an additional leveling course. In general, being able to take the courses in any sequence is a huge advantage for enabling student success and limiting time to graduation.

No new courses have been added to support the WSE curriculum.

5.C.1. Program Structure Form

1. Total credits required for graduation:

31 credits are required for graduation

2. Residency requirements, if any:

None, except that campus research will be required for thesis-based students.

3. General education

Not applicable since this is a graduate degree.

4. Major requirements

One hour of graduate seminar is required for all thesis and non-thesis WSE students. The graduate seminar course is not listed below, as seminar courses can be taken in

any of the participating disciplines. Six hours of research credit are required for thesis MS students. Because we do not require specific course sequences, we include the list of program courses below. Thesis students must take 18 hours of program courses, including at least one course from three different categories and at least one course from three separate departments. Non-thesis students must take 21 hours of program courses, including at least one course from three different categories and at least one course from three separate departments.

LIST OF PROGRAM COURSES

Engineering Hydrology

1. *CIV ENG 6331 Advanced Hydraulics And Hydraulic Engineering (LEC 3.0)*
2. *CIV ENG 5338 Hydrologic Engineering (LEC 3.0)*
3. *CIV ENG 5330 Unsteady Flow Hydraulics (LEC 3.0)*
4. *CIV ENG 5331 Hydraulics Of Open Channels (LEC 3.0)*
5. *CIV ENG 5333 Intermediate Hydraulic Engineering (LEC 3.0)*
6. *CIV ENG 5337 River Mechanics And Sediment Transport (LEC 3.0)*
7. *CIV ENG 6338 Advanced Hydrology (LEC 3.0)*
8. *GEO ENG 5320 Groundwater Modeling (LEC 3.0)*
9. *GEO ENG 5331 Subsurface Hydrology (LEC 3.0)*
10. *GEO ENG 5332 Fundamentals of Groundwater Hydrology (LEC 3.0)*

Water Infrastructure and Remediation

1. *CIV ENG 5335 Water Infrastructure Engineering (LAB 1.0 and LEC 2.0)*
2. *CIV ENG 6340 Urban Hydrology (LEC 3.0)*
3. *CIV ENG 6335 Hydraulic Structures (LEC 3.0)*
4. *BIO SCI 6463 Bioremediation (LEC 3.0)*
5. *CHEM ENG 4210 Biochemical Reactors (LEC 3.0)*
6. *CHEM ENG 5110 Intermediate Chemical Reactor Design (LEC 3.0)*
7. *CIV ENG 5332 Transport Processes in Environmental Flows (LEC 3.0)*
8. *CIV ENG 5360 Water Resources And Wastewater Engineering (LEC 3.0)*
9. *ENV ENG 5630 Remediation of Contaminated Groundwater And Soil (LEC 2.0 and LAB 1.0)*
10. *ENV ENG 5635 Phytoremediation and Natural Treatment Systems (LEC 3)*
11. *ENV ENG 5619 Environmental Engineering Design (LAB 1.0 and LEC 2.0)*
12. *ENV ENG 6612 Biological Operations In Environmental Engineering Systems (LEC 3.0)*
13. *ENV ENG 6611 Physicochemical Operations In Environmental Engineering Systems (LEC 3.0)*
14. *GEO ENG 6237 Advanced Geological & Geotechnical Design For Hazardous Waste Mgt (LEC 3.0)*
15. *GEO ENG 5239 Groundwater Remediation (LEC 3.0)*
16. *GEO ENG 5381 Intermediate Subsurface Hydrology And Contaminant Transport Mechs (LEC 3.0)*

Water Resources and the Environment

1. *BIO SCI 4313 Introduction to Environmental Microbiology* (LEC 3.0)
2. *BIO SCI 6313 Environmental Microbiology* (LEC 3.0)
3. *BIO SCI 4383 Toxicology* (LEC 3.0)
4. *BIO SCI 4363 Freshwater Ecology* (LEC 3.0)
5. *BIO SCI 6363 Advanced Freshwater Ecology* (LEC 3.0)
6. *BIO SCI 6383 Advanced Toxicology* (LEC 3.0)
7. *CHEM ENG 5340 Principles Of Environmental Monitoring* (LEC 3.0)
8. *CHEM 4710 Principles Of Environmental Monitoring* (LEC 3.0)
9. *CHEM 5710 Environmental Monitoring* (LEC 3.0)
10. *ENV ENG 5605: Environmental Systems Modeling* (LEC 3.0)
11. *ENV ENG 5642 Sustainability, Population, Energy, Water, and Materials* (LEC 3.0)
12. *GEOLOGY 4431 Methods Of Karst Hydrogeology* (LEC 3.0)
13. *GEOLOGY 4411 Hydrogeology* (LEC 3.0)
14. *GEOLOGY 4451 Aqueous Geochemistry* (LEC 3.0)
15. *GEO ENG 5153 Regional Geological Engineering Problems In North America* (LEC 3.0)

Water Policy

1. *CIV ENG 5640 Environmental Law And Regulations* (LEC 3.0)
2. *CIV ENG 5650 Public Health Engineering* (LEC 3.0)
3. *POLY SCI 4500 Geopolitics and International Security* (LEC 3.0)
4. *POLY SCI 4320 Policy for Science, Technology, and Innovation* (LEC 3.0)
5. *ECON 4440 Environmental and Natural Resource Economics* (LEC 3.0)

5. Free elective credits

Thesis students must take 6 hours of additional coursework electives and Non-thesis students must take 9 hours of additional coursework electives.

6. Requirement for thesis, internship or other capstone experience:

A written thesis and formal thesis defense are required for thesis-based MS-degree students. There are no requirements for non-thesis students.

7. Any unique features such as interdepartmental cooperation:

As noted above, this is a highly unique program in that the cooperation stretches across seven separate programs and two colleges at Missouri S&T.

5.D. Program Goals and Assessment

We will adopt the Missouri S&T campus graduate learning outcomes (GLOs), which include the following:

1. Knowledge: An ability to apply knowledge of subject matter within their field of study
2. Communication: An ability to communicate effectively within their field of study.
3. Critical Thinking: An ability to engage in productive critical thinking within their field of study
4. Professional Development: An ability to develop professional within their field of study

These learning outcomes will be evaluated using a rubric applied to the written MS-thesis and the MS-thesis defense. The same GLOs for non-thesis students will be assessed within program coursework using existing assessment tools (quizzes, exams, presentations, etc.). Rubrics and measures will be established for several popular courses and data will be collected each semester by the administrative assistant assigned to the WSE program.

We expect to retain >90% of all WSE students who enter the program through graduation. Average graduation rates for full-time MS students will be 2 years. We project that 5 and 10 students will graduate from this program in years 3 and 5, respectively (Table 1C). The WSE program will not be relevant to achieving licensure as a professional engineer, geologist, or in other areas, as it is the undergraduate degrees that are important in these cases. Due to the high state and national demand for students with these skills, we anticipate a near 100% job placement rate.

5.E. Student Preparation

Students with undergraduate degrees from one of the seven participating programs (Biology, Chemistry, Chemical Engineering, Civil Engineering, Environmental Engineering, Geology and Geophysics, and Geological Engineering) or closely related degree programs will be able to succeed within the WSE MS-degree program. Entrance requirements will be the same as the university graduate student admission standards. The GRE exam will not be required for internal degree applicants.

5.F. Faculty and Administration

Although administered through the GGPE Department with oversight from the Department Chairs of GGPE (Borrok) and CARe (Burken), the WSE program will be independent of existing departments. Each of the participating departments will be

able to award the WSE degree. The GGPE department will handle admissions paperwork, the gathering of applications, assessments of student outcomes and learning objectives, student and employer surveys, and any internal reporting requirements. Drs. Borrok and Burken already have 50% administrative appointments and oversight of the WSE program will fall within these efforts. Additional duties will be managed with support from an additional administrative assistant who will be dedicated to the WSE program.

Other program duties will be managed by a committee of five faculty members, representing each of the five participating departments. Committee appointments will be made by the respective department chairs (or include them). This committee will meet to vote on accepting graduate students and assigning them among participating programs and advisors. The WSE committee will also decide on potential funding for MS thesis students. Graduate student assignments will be important, as credit for student numbers and advising will be distributed to the participating departments and programs. The committee will also work jointly on recruiting efforts and on any curriculum revisions.

For the MS-degree in WSE, minimum university graduate admission requirements will be adopted. Students desiring admittance to the program with insufficient engineering or scientific backgrounds will be required to take additional mathematics and/or technical electives to complete the program. Graduate student appointments will be managed by their program/department and students will be advised by the faculty within individual programs.

Instructional needs for the WSE program are not burdensome in that these courses are already taught within individual programs and can be easily co-listed to be affiliated with this new program. We anticipate only a modest (<10%) increase in existing course enrollments. All the courses will continue to be taught by full-time faculty. The names of the WSE faculty, their department and college affiliation, and expertise are presented in the table below. These are the faculty that will advise WSE students. We anticipate only modest increases in existing responsibilities, as WSE students can easily be integrated into existing research groups and labs.

List of Affiliated WSE Faculty

	Name	Department and College	Expertise
1.	Dr. David Borrok	Geosciences and Geological and Petroleum Engineering	Water quality, isotopes, aqueous geochemistry, water resources.
2.	Dr. Katherine Grote	Geosciences and Geological and Petroleum Engineering	Groundwater hydrology, agricultural systems, remote sensing and geophysics
3.	Dr. Ryan Smith	Geosciences and Geological and Petroleum Engineering	Groundwater resources and remote sensing, geophysics
4.	Dr. David Wronkiewicz	Geosciences and Geological and Petroleum Engineering	Aqueous geochemistry
5.	Dr. Cesar Mendoza	Civil, Architectural and Environmental Engineering	Hydraulics and open channel hydrology

6.	Dr. Joel Burken	Civil, Architectural and Environmental Engineering	Groundwater remediation and modeling, urban water systems
7.	Dr. Mark Fitch	Civil, Architectural and Environmental Engineering	Biological water and wastewater treatment, Sustainable water systems
8	Dr. Dev Niyogi	Biological Sciences	Aquatic ecosystem stress
9.	Dr. Melanie Mormile	Biological Sciences	Environmental microbiology
10	Dr. Honglong Shi	Chemistry	Analytical chemistry and drinking water research
11	Dr. Muthanna Al-Dahhan	Chemical and Biochemical Engineering	Water treatment
12	Dr. Fateme Rezaei	Chemical and Biochemical Engineering	Water treatment

5.G. Alumni and Employer Survey

As with our other programs, we frequently solicit feedback from graduating students and alumni and employers of our students using online survey instruments. We plan to survey all graduating WSE students. Our goal is to achieve and maintain a >90% satisfaction rate with our overall program. Surveys of employers will be done every 2 years to assess the performance of our students and to solicit feedback regarding their skills and career readiness that can be used to continually improve our program. Our goal is to achieve and maintain a >90% satisfaction rate with employers.

5.H. Program Accreditation

We are not seeking professional accreditation for the WSE program.



MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

May 21, 2020,

University of Missouri System
Academic Affairs
309 University Hall

Master's degree program in Water Science and Engineering (WSE)

The Biological Sciences Department is pleased to support a new MS degree program in WSE on the Missouri S&T campus. Water is a critical natural resource, and proper management is essential to the security and prosperity of Missouri. The Missouri S&T campus, with diversified programs in Civil, Environmental and Geological engineering, and supporting programs in Biological Sciences and Chemistry, offers an excellent diversified existing curriculum to support the comprehensive WSE program that is being proposed.

The Biological Sciences Department will support the proposed MS program with graduate curriculum in topics covering the biotic integrity and ecology of aquatic systems. A range of courses in this area are offered in support of our own MS program in Biological Sciences. These courses have capacity to support additional students, without the expenditure of additional resources. The development of a successful WSE program could support the future expansion of curriculum in Biological Sciences that could then enhance our own programs.

The Bachelor's program in Biological Sciences graduates approximately fifty to seventy students each year, about one-fourth of whom are interested in careers in natural resources management. An MS program in WSE will provide an excellent graduate degree option for matriculation of our undergraduate students. This program will also benefit our own efforts to recruit MS students to our Biological Sciences program through enhanced reputation of graduate programs in natural resources and life sciences on the S&T campus.

The Biological Sciences Faculty who initially will be affiliated with this new program, and most likely to see a direct benefit to their research programs through mentoring of MS students in WSE are Dr. Dev Niyogi (nutrient cycling and aquatic ecosystem stress) and Dr. Melanie Mormile (environmental microbiology). Other faculty members who may realize benefits of having a WSE program on the Missouri S&T campus include Dr. Robin Verble (insect ecology), Dr. Yue-Wern Huang (environmental toxicology), and Dr. David Duvernell (fish population genetics).

Sincerely,

A handwritten signature in cursive script, appearing to read "David Duvernell".

David Duvernell
Professor and Chair
Biological Sciences
Missouri S&T

Dr. Rainer Glaser
Professor and Chair

Phone: (573) 341-6805
Mobile: (573) 825-1249
Facsimile: (573) 341-6033
E-Mail: glaserr@mst.edu



**Missouri University of
Science and Technology**

Department of Chemistry
104B Schrenk Hall
400 W. 11th Street
Rolla, MO 65409-0010, USA
September 25, 2020

University of Missouri System
Academic Affairs
309 University Hall

RE: Master's degree program in Water Science and Engineering (WSE)

Dear Dr. Borrok:

I am writing this letter in strong support of the new MS degree program in *Water Science and Engineering (WSE)* at Missouri S&T.

The Department of Chemistry is participating in the new curriculum primarily with the provision of expertise in analytical chemistry. Dr. Honglan Shi has a long-standing interest in water analysis and some of her students have worked on topics in aquatic toxicity in collaboration with one of our adjunct faculty, Dr. Keith Loftin of the U.S. Geological Survey, Kansas Water Science Center, Lawrence, KS.

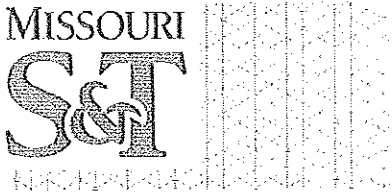
The Department of Chemistry has been offering the courses *CHEM 4710 Principles of Environmental Monitoring* (LEC 3.0) and *CHEM 5710 Environmental Monitoring* (LEC 3.0), and we welcome the opportunity to develop these courses further in this larger context and with increased enrollments.

Last Friday, we had the privilege of hosting Michael D. Stafford to present Chemistry Colloquium (<https://chem.mst.edu/seminars/colloquium/>) via zoom on the topic *Ozone Reaction Problems in Modern Aquariums*. Dr. Stafford is the Consulting Veterinarian of the *American National Fish and Wildlife Museum* in Springfield, MO. He approached us earlier this year for research support to address the problems. This Colloquium initiated a new three-way collaboration (Museum, USGS, S&T). What seemed at first as an essentially analytical problem turned out to offer interesting research questions for organic and medicinal chemists as well. Hence, there is every reason to expect synergy from the new degree program.

Sincerely,

A handwritten signature in cursive script that reads "Rainer Glaser".

Rainer Glaser
Professor and Chair
Department of Chemistry



September 18, 2020

Re: New MS Degree in Water Science and Engineering

To Whom It May Concern:

Water sustainability and security have been identified as one of the grand challenges for engineering. Chemical and biochemical engineering students are very involved in maintaining the safety of our water supply. This may be through direct applications relating to water supply, but it may also relate to the return of safe water from chemical facilities. Water quality is a primary concern of our environmental studies for our chemical plant designs. Many of our students join Engineers Without Borders as a means of applying their chemical engineering skills to the sanitation of groundwater. I believe that these students, in particular, will be very interested in the MS degree program in Water Science and Engineering. Additionally, several of our faculty have ongoing research interests that relate to this program and will welcome collaborative future opportunities.

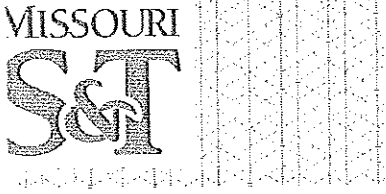
The Chemical & Biochemical Engineering Department is pleased to endorse and support this new degree program.

If you have questions about this letter, please contact me at (573) 341-4854 or via email at huyang@mst.

Sincerely,

A handwritten signature in black ink, appearing to read "Hu Yang", with a long, sweeping underline.

Hu Yang
Department Chair, Professor
Chemical & Biochemical Engineering



September 21, 2020,

University of Missouri System
Academic Affairs
309 University Hall

Master's degree program in Water Science and Engineering (WSE)

The Civil, Architectural and Environmental Department offers support of the proposed MS degree program in WSE on the Missouri S&T campus. We have core programs in surface water hydrology, hydraulic systems in water conveyance and infrastructure, and also water purification and sanitation looking at improving human health and welfare in many aspects. Water is a critical natural resource, and proper management is essential to the security and prosperity of Missouri. The Missouri S&T campus, offers an excellent diversified existing curriculum into integrating more Geological Engineering Biological Sciences and Chemistry to develop and support the comprehensive WSE program that is being proposed.

The Civil, Architectural and Environmental Engineering (CArEE) Department will support the proposed MS program with our current and expanding graduate curriculum in topics covering the water conveyance, water quality, and also laws and regulations relative to water. The breadth of courses in these areas are offered in support of our own MS programs in Civil and Environmental Engineering and also an undergraduate minor in sustainability. These courses have capacity to support additional students in the current courses, without the expenditure of additional resources. The development of a successful WSE program could support the future expansion of course offerings and curriculum in Civil, Architectural and Environmental Department that could then enhance our own programs.

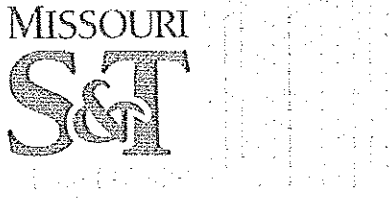
The undergraduate programs in CArEE graduate approximately 150 - 170 students each year, about 20-30% of whom are interested in careers in water resources, environmental engineering, sustainability, public health and natural resources protection. An MS program in WSE will provide an excellent graduate degree option for more diverse graduate paths our undergraduate students. This program will also benefit future MS students to our recruited to S&T through enhanced reputation of diverse, integrated graduate programs related to water resources on the S&T campus.

The CArEE Faculty who initially will be affiliated with this new program and most likely to see a direct benefit to their research programs through mentoring of MS students in WSE are Dr. Cesar Mendoza (hydraulics and hydrology), Dr. Mark Fitch (sustainable urban water and developing world drinking water), Dr. Jianmin Wang (chemical and biological water purification) and myself (Sustainable water, remediation, hazard mitigation). Other faculty members will also benefit, including adjunct faculty with the US Geological Survey Water Research Center in Rolla. The new program will have notable impact for our campus overall.

Sincerely,

A handwritten signature in cursive script that reads "Joel Burken".

Joel Burken
Distinguished Curators Professor and Chair



September 23, 2020

Dear Provost Roberts:

The College of Arts, Sciences, and Business fully supports the proposal for the creation of an interdisciplinary MS degree in Water Science and Engineering.

The new degree aligns with the University's strategic plan to raise visibility and diversity of programs, increase recruitment of students, support high-impact, interdisciplinary research, and engage in outreach activities. The creation of this degree also supports workforce development in the state of Missouri. The addition of an interdisciplinary degree that draws on S&T's strengths and prepares students for the workforce in a variety of fields strategically enhances degree offerings across the campus.

The new degree requires the addition of no new courses and does not require any additional faculty resources or hires. Instead, the degree combines existing water-related coursework into an innovative degree program that meets student and industry needs. As the proposal indicates, it also has the potential to strengthen interdisciplinary faculty connections, enhance grant opportunities, and build new government and industry partnerships. It also provides a unique option for students that draws on sciences, engineering, and the social sciences in a way that is not available at any other university in Missouri or in surrounding states.

As the proposal demonstrates, the flexible curriculum structure will provide students with the opportunity to customize their studies and prepare them for career opportunities in a wide variety of fields with demonstrated demand for trained professionals. Therefore, we support the creation of a MS in Water Science and Engineering.

Please do not hesitate to contact me if you need any additional information.

Sincerely,

A handwritten signature in cursive script that reads "Kate Drowne".

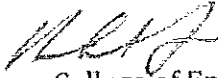
Kate Drowne
Interim Vice Provost and Dean



College of Engineering and Computing

DATE: October 12, 2020

TO: Stephen Roberts
Interim Provost and Executive Vice Chancellor for Academic Affairs

FROM: Richard Wlezien 
Vice Provost and Dean, College of Engineering and Computing

CC: David Borrok
Chair, Geosciences and Geological and Petroleum Engineering

RE: Letter of support for establishment of Water Science and Engineering Program

The National Science Foundation has recognized clean water as a global engineering grand challenge. "The provision of clean water is a global issue with societal, health, and economic implications," said NSF Deputy Assistant Director for Engineering Kesh Narayanan. "Future solutions to such far-reaching sustainability challenges will rely on cooperation, both interdisciplinary and international, to bring the right people and resources to bear." Missouri S&T is positioned to be a leader in this field and has the expertise across campus to offer a unique program addressing this need.

Currently only 16 public and 1 private institution in the U.S. offers MS-degrees in the category of "hydrology and water resources science", and none of these are in Missouri or adjacent states.

The mission of the university is to "integrate education, research, and application to convey knowledge that serves our state and helps solve the world's great challenges". We have unique capabilities across campus to address challenges related to water, and the proposed program of study integrates these capabilities into a cohesive and focused effort.

The proposed interdisciplinary Master's degree program integrates expertise across seven distinct programs:

- Civil Engineering
- Environmental Engineering
- Chemistry
- Chemical Engineering
- Geology
- Geological Engineering
- Biology

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College of Engineering and Computing

Students will learn engineering and science principles that combine characterizing water resources, managing and remediating water resources, and designing the infrastructure associated with water resources such as dams, levees, and treatment plants.

Degree focus areas are diverse and compelling:

- Engineering Hydrology
- Water Infrastructure and Remediation
- Water Resources and the Environment
- Water Policy

Students with BS-degrees in a variety of science and engineering fields will be able to obtain a graduate degree in WSE. The flexible curriculum structure will provide students with the opportunity to individualize their curriculum within the overarching theme of water technology, and will enhance student success in terms of streamlining courses and shortening time-to-graduation.

Career opportunities include a wide variety of geoenvironmental and civil engineering-focused consulting companies, state and federal regulatory agencies, NGOs, secondary education, and the growing environmental divisions of private sector mining and energy companies.

In closing, I offer my strong endorsement for the creation of this unique and valuable interdisciplinary program.





Office of the Provost

October 29, 2020

To whom it may concern,

Missouri S&T proposes the creation of an interdisciplinary Master's degree program in Water Science and Engineering. The program is built around the research and educational interests of faculty from seven academic programs in both the College of Engineering and Computing and the College of Arts, Sciences, and Business. The program will prepare students with different educational backgrounds for a wide variety of industry, business, regulatory, and academic careers in water resources, with a particular focus on technology, a strength of Missouri S&T. The program will have both thesis and non-thesis options to serve students with wide varieties of career objectives and educational options.

The program will rely on existing courses, will require no additional faculty, and will be built from existing online graduate certificates on water resources, an area of significant importance to the State of Missouri and to the nation. Indeed, our analysis of workforce needs identified almost 600 related openings in the State last year, and over 45,000 nationwide. New expenses will cover one staff member to administer the program, with small budgets to cover marketing and recruiting expenses.

The WSE program will be run through the Department of Earth, Energy, and Mineral Resources (formerly the Department of Geosciences and Geological and Petroleum Engineering), but will include shared administrative responsibilities with the other participating departments and programs, including chemistry, biological sciences, civil and environmental engineering, and chemical engineering. The interdisciplinary nature of the WSE program differentiates it from other degree programs within the UM System. For example, the engineering components of the WSE degree fall outside of the requirements of the MS program in Natural Resources, offered by the University of Missouri-Columbia, and the broader engineering and science options of the WSE program distinguish it from the water resources tracks offered by the civil engineering programs at UM-C and UM-KC, which are focused more on civil engineering infrastructure. The potential for course-sharing between the S&T WSE and related programs at UM-C and UM-KC, however, is high.

The proposed MS degree in WSE is aligned with the Missouri S&T strategic plan to promote STEM education and research. The interdisciplinary nature of the program offers expanded opportunities for students from non-engineering disciplines and limited opportunities to pursue advanced degrees. These same factors will broaden opportunities for faculty to pursue research opportunities outside of their traditional disciplines, including support

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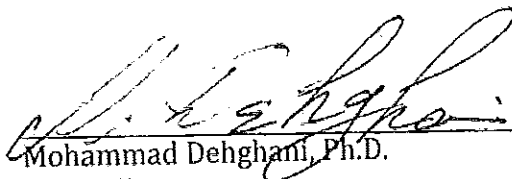
from governmental agencies, NGOs, and industry. Finally, the emphasis on cutting-edge technologies provides expanded workforce development opportunities.

This office fully supports the creation of a Master's degree program in Water Science and Engineering.

Approved By:



Stephen Roberts, Ph.D.
Interim Provost and Executive Vice Chancellor
For Academic Affairs



Mohammad Dehghani, Ph.D.
Chancellor



September 23, 2020

Dr. Stephen Roberts
Interim Provost and Executive Vice Chancellor for Academic Affairs
210 Parker Hall
300 W. 13th St.
Rolla, MO 65409

RE: Missouri S&T Water Science & Engineering degree program

Dear Interim Provost Roberts,

I am writing to express my support for the proposed Water Science and Engineering (WSE) MS-degree at Missouri S&T. This program will provide graduates with a strong foundation and increase their knowledge of multiple aspects of the complex problems associated with water resources. Layering this kind of graduate degree on top of a traditional bachelor's degree in science or engineering will provide students with a much deeper understanding of the complex relationships among engineering and science principles combining characterization of water resources, the management and remediation of water resources, and the design of infrastructure associated with water resources such as dams, levees, and treatment plants.

Burns & McDonnell is a leader in groundwater and hydrogeology and routinely designs and constructs water-related projects. For example, the Aquifer Storage and Recovery project for the City of Wichita, KS, which was a Water Project of the Year Finalist at the Global Water Summit; a tertiary, 125 million gallon per day water supply for Turkey Point Nuclear Generating Station alongside Biscayne Bay, FL; and the Sparta Aquifer recovery efforts in southeast Arkansas. As such, we frequently hire graduates trained in areas that focus on many of the individual aspects of water resources, but would welcome new hires who additionally have a more complete understanding of the intricacies of water resource management and regulatory interactions. I believe Missouri S&T graduates from the WSE program will be sought after for positions in our company (and within similar organizations).

I look forward to interviewing graduates from this program and plan to stay engaged with Missouri S&T in its development by volunteering our expertise and support.

Sincerely,

A handwritten signature in black ink, appearing to read "Paul McCormick".

Paul McCormick, P.E.
Associate Geological Engineer



BLACK & VEATCH

Black & Veatch Corporation
8400 Ward Parkway, Kansas City, MO 64114
P +1 913 458-6653 E HirnerC@bv.com

November 5, 2020

Dr. Stephen Roberts
Interim Provost and Executive Vice Chancellor for Academic Affairs
210 Parker Hall, 300 W. 13th St.
Rolla, MO 65409

RE: Missouri S&T Water Science & Engineering Degree Program

Dear Interim Provost Roberts,

I am writing to express Black & Veatch's support for the proposed Water Science and Engineering (WSE) MS-degree at Missouri S&T. To address the wide variety of water challenges we face as a state and nation, we need employees with a deep understanding of the complex relationships among water policy, water science, and engineering. We like the plans for the proposed WSE degree because it is focused on preparing students to tackle the interdisciplinary nature of water resource problems. Specifically, I see a real benefit to the diverse curriculum to supplement the geotechnical engineering expertise we require in our Heavy Civil (tunnels and dams) business lines.

Black & Veatch is a leader in the water industry and we routinely work on projects that demand geotechnical and water resource specialists. For example, we have dozens of major dams and tunnels projects that address water quality and flood control challenges in addition to the typical geotechnical engineering associated with the design and construction of these facilities. As such, we frequently hire graduates trained in areas that focus on many of the individual aspects of water resources and geotechnical engineering, but would welcome geotechnically-focused new hires who additionally have a more complete understanding of water resources. We believe Missouri S&T graduates from the WSE program will be highly-competitive for positions in our company (and within similar organizations).

Very truly yours,

Black & Veatch Corporation

Cary Hirner
Director of Tunneling, Black & Veatch



GOLDER

September 30, 2020

Dr. Stephen Roberts
Interim Provost and Executive Vice Chancellor for Academic Affairs
210 Parker Hall, 300 W. 13th St.
Rolla, MO 65409

RE: Missouri S&T Water Science & Engineering degree program

Dear Interim Provost Roberts,

I am writing to express Golder Associates' support for the proposed Water Science and Engineering MS-degree at Missouri S&T. Golder Associates is a company of over 7,500 employees (primarily scientists and engineers) that regularly recruits students from Missouri S&T. We appreciate that the proposed degree is focused on preparing students to tackle the interdisciplinary nature of water resource problems. A deep understanding of water-related challenges must include knowledge of water policy, water science and engineering. This kind of cross-disciplinary graduate training, capping a traditional science or engineering BS-degree, will provide students with a much needed multi-faceted understanding of water resources.

Golder Associates is a leader in providing engineering and environmental consulting services to the mining, oil and gas, and water resource sectors. These three sectors make up over 50% of Golder's gross revenues and involve hundreds of water-related projects per year. Including tailings dams, water and energy supply reservoirs, water restoration projects, tidal studies and others. As such, we frequently hire students trained in areas that focus on many of the individual aspects of water resources and would welcome new hires who additionally have a more complete understanding of water resources. We believe Missouri S&T graduates from the WSE program will be highly-competitive for positions in our company (and within similar organizations).

We look forward to interviewing graduates from this program and plan to stay engaged with Missouri S&T in its development by volunteering our expertise and support.

Sincerely,

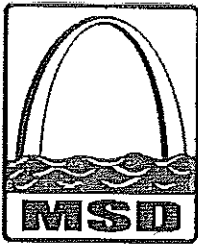
Frederick M. Booth, P.G.
Principal and Program Leader
Golder Associates Inc.

Golder Associates Inc.
2530 East Harmony, Suite 301, Fort Collins, CO 80528 USA

T: +1 314 971 2711

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golder.com



**Metropolitan St. Louis
Sewer District**

2350 Market Street
St. Louis, MO 63103
(314) 768-5200

November 9, 2020

Dr. Stephen Roberts
Interim Provost and Executive Vice Chancellor for Academic Affairs
210 Parker Hall, 300 W. 13th St.
Rolla, MO 65409

RE: Missouri S&T Water Science & Engineering degree program

Dear Interim Provost Roberts,

I am writing to express my support for the proposed Water Science and Engineering MS-degree at Missouri S&T. The Environmental Water Resources Institute (EWRI) St. Louis Section is a professional society leader in Missouri and we represent many members that work on water-related projects. As such, we all work with students trained in areas that focus on many of the individual aspects of water resources, as such we would welcome new hires who have a more complete understanding of water resources from a multi discipline approach. We believe Missouri S&T graduates from the WSE program will be highly-competitive for positions in our profession.

I appreciate that the proposed degree is focused on preparing students to tackle the interdisciplinary nature of water resource problems. This kind of cross-disciplinary graduate training, capping a traditional science or engineering BS-degree, will provide students with a much needed multi-faceted understanding of water resources.

Sincerely,

Michael T. Buechter

Michael T. Buechter, PE, D. WRE, F.EWRI
Program Manager
Engineering Department/Design