REQUEST FOR AUTHORIZATION TO IMPLEMENT A BACHELOR OF SCIENCE IN FRESHWATER SCIENCES AT UNIVERSITY OF WISCONSIN (UW)-MILWAUKEE PREPARED BY UW-MILWAUKEE

ABSTRACT

The demand for freshwater is regarded as the greatest natural resource challenge of the 21st century. The University of Wisconsin-Milwaukee proposes to establish a Bachelor of Science in Freshwater Sciences (BSFS) in response to student and market demand for workforce development in freshwater science, to attract new students to UW-Milwaukee, and to provide undergraduate student access to the only school in the nation dedicated to freshwater sciences. The aim of the program is to train future professionals in the scientifically sound management of natural and constructed water systems for productive and equitable use while sustaining natural biota, diversity and freshwater availability. Graduates will be equipped to generate solutions to the problems facing freshwater through a complete understanding of water resources, the social systems in which they operate, and the application of technology, conservation, and sustainable management practices. The BSFS major requires students to choose from two options (Aquatic Science or Water Policy).

PROGRAM IDENTIFICATION

Institution Name
University of Wisconsin-Milwaukee

Title of Proposed Program
Freshwater Sciences

Degree/Major Designations
B.S. in Freshwater Sciences

Mode of Delivery
Single institution. Most courses will be delivered face-to-face, with some hybrid offerings.

Projected Enrollments and Graduates by Year Five
Table 1 represents enrollment and graduation projections for students entering the program over the next five years. By the end of Year 5, it is expected 130 students will have enrolled in the program and 23 students will have graduated from the program.

Student retention and graduation and projections were calculated using the latest average annual retention (80%) and graduation (40%) rates from UWM for engaged undergraduates as reported by the Provost at the Academic Planning and Budget Committee (12 September 2019). New students are expected to include both freshman and transfer students (see below). It is expected that by year five, 30 students (including 25 freshmen and 5 transfer students) will enroll in the program annually.

Table 1: Five-Year Degree Program Enrollment Projections

Students/Year	Year 1	Year 2	Year 3	Year 4	Year 5
New Students	15	25	30	30	30
Continuing Students	0	12	32	56	68
Total Enrollment	15	37	62	86	98
Graduating			2	6	15

Tuition Structure
The BSFS program will use the tuition structure currently in place for undergraduate students at UW-Milwaukee. For 2019-20, tuition for full-time students per semester is $4,799.20 for residents, $10,584.17 for non-residents, $6,850.61 for Minnesota residents, and $6,822.05 for residents eligible for the Midwest Student Exchange rate. These figures include segregated fees of $753.65 per semester. The BSFS may offer a few online and hybrid courses that will charge an additional distance education fee (currently set at $275 per course). Several courses are experiential based and may include a fee for field trips or research vessel use.

Department or Functional Equivalent
The proposed Freshwater Sciences program will reside within the School of Freshwater Sciences, which is a non-departmentalized unit.

College, School, or Functional Equivalent
School of Freshwater Sciences

Proposed Date of Implementation
Fall 2021

DESCRIPTION OF PROGRAM

Overview of the Program

This Freshwater Sciences academic program will provide comprehensive undergraduate studies in ecological/environmental sciences, technology, and policy relevant to freshwater systems and resources to:

- Maintain a scholarly, productive environment for the education and training of next generation professionals in the field of freshwater sciences.
- Provide state, regional and national leadership to solve current and impending environmental issues.
- Fulfill our mission of Great Lakes research excellence, and societal relevance.
- Complete the School of Freshwater Sciences' ambition as an institution of higher learning by including undergraduates, in addition to our graduate student program.
- Stimulate compatible and synergistic economic growth and environmental sustainability.
- Facilitate undergraduate career success through forward-thinking academic preparation (SFS has a 97% employment rate for its graduate students).
- Participate fully in the Freshwater Collaborative concept across UW System.

Student Learning Outcomes and Program Objectives
In the School of Freshwaters Sciences, the undergraduate program will emphasize the unique opportunities for hands-on learning through intensive laboratory and field experiences that span the interdisciplinary breadth of freshwater studies and scientific inquiry. As such, we are requiring all students in the program to complete and defend an undergraduate thesis or capstone project to support the development of critical thinking, problem solving, and research capabilities through independent research. Our curriculum is designed around the following competencies for the next generation of freshwater scientists:

PROGRAM OBJECTIVES
- Discovery—the requisite knowledge to understand the nature of these problems, which requires basic biology, chemistry, physics, geoscience, and mathematics. These basics provide the foundation for more advanced competencies in specific focus areas of freshwater systems where complex interactions drive the dynamics of the entire hydrologic cycle (streams, lakes, groundwater and atmosphere).
- Analysis/Assessment—the ability to identify, analyze, and anticipate problems, then develop solutions in the context of the multidimensional implications in the policy, economic, and social/cultural setting.
- Design—the integrative ability to devise solutions to complex problems and challenges using a suite of solutions informed by ecology, socio-politics, and technology in an integrative, holistic framework.
- Technology—the proficient use of the latest technology for data collection and analysis, and the ability to match the sophistication of the technology with the problem at hand.
- Communication—the ability to effectively convey written, oral, and visual concepts, data, and arguments to diverse strata of audiences; and develop skills in two-way communication with experts, stakeholders, and the community.

LEARNING OUTCOMES
1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)
2. Understand the nexus between biological, ecological, physical, climate and economic systems as they relate to water. (Discovery, Analysis/Assessment)
3. Understand the hydrologic cycle and the processes and interactions among atmospheric, surface and ground water components and the issues and processes related to the quality of these waters. (Discovery, Analysis/Assessment, Design)
4. Demonstrate understanding of the chemical and biogeochemical interactions of both natural and anthropogenic substances and their importance within global earth system dynamics, natural freshwater resources, and water/wastewater management systems. (Discovery, Analysis/Assessment, Design, Technology, Communication)
5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)

6. Develop the computer literacy and skills to apply big data to environmental problems. Implement models as analytical and forecasting tools. (Analysis/Assessment, Design, Technology)
7. Understand the application of monitoring and smart sensor systems in creating built and natural environmental intelligence to enhance systems management. (Discovery, Analysis/Assessment, Design, Technology)
8. Understand the application of environmental laws, regulatory and management frameworks; and the economics of water resource use and allocation. (Analysis/Assessment, Design, Technology)

Program Curriculum

Table 2 illustrates the program curriculum for the proposed program. The program requirements are comprised of 120 credits, of which 42 are UWM general education requirements. We also require 35 credits in Foundational natural sciences, mathematics, economics, and computer science courses; 32 credits of Core courses of which 29 are in Freshwater; and 27 credits of program Option Requirements (Water Policy or Aquatic Sciences) and Elective courses. We understand the need to offer undergraduate courses on the main campus. In support of the activities of SFS Faculty on campus, we will need 3-4 offices, a meeting room, and 3-4 parking spaces reserved for SFS Faculty visiting campus. The office spaces are needed for an Advisor, and shared spaces for Faculty while they are on campus for office hours, meeting with other Faculty, and facilitating productivity while SFS Faculty are on the main campus.

Table 2: Bachelor of Science in Freshwater Sciences Program Curriculum

2A. General education courses required for graduation	
Oral and Written Communication levels A and B	6 credits
Quantitative Literacy levels A and B (B satisfied by MTHSTAT 215)	6 credits
Foreign language	6 credits
Arts	3 credits
Humanities	6 credits
Social Sciences (partially satisfied by ECON 103)	6 credits
Natural Sciences (satisfied by BIOSCI 150, 152)	6 credits
Cultural Diversity	3 credits
Total GER credits *12 credits are included in the Foundational courses	**42/30***

2B. Required Foundational courses		**Learning outcomes**
BIOSCI 150 Foundations of Biological Sciences I (NS)	4 credits	1
BIOSCI 152 Foundations of Biological Sciences II (NS)	4 credits	1
CHEM 102 General Chemistry	5 credits	4
CHEM 104 General Chemistry and Qualitative Analysis	5 credits	4
COMPSCI 250 Introductory Computer Programming	3 credits	5,6
ECON 103 Principles of Microeconomics (SS)	3 credits	8
MTHSTAT 215 Elementary Statistical Analysis (QLB)	3 credits	5
MATH 231 Calculus and Analytic Geometry I	4 credits	5
Total Foundational credits	**31**	

2C. Required Core courses

FRSHWTR 101 Elements of Water	3 credits	1,2,3,8
FRSHWTR 120 Preparing for a Career in Freshwater Sciences	1 credit	
FRSHWTR 201 The Water Environment	3 credits	3,4
FRSHWTR 202 Life in Water	4 credits	1
FRSHWTR 392 Water-Energy-Food-Climate	3 credits	6,2
FRSHWTR 391 Water and Natural Resource Economics	3 credits	8
FRSHWTR 361 Intro to Environmental Data Systems	3 credits	6,7
FRSHWTR 464 Chemical Hydrogeology	4 credits	3,4
FRSHWTR 660 Undergraduate Capstone	3 credits	5
OR FRSHWTR 662 Undergraduate Research and Thesis		
FRSHWTR 661 Professional and Capstone Planning	1 credit	5
OR FRSHWTR 663 Thesis Research Planning and Proposal Development		5
FRSHWTR 690 Undergraduate Seminar in Freshwater Sciences	1 credit	
GEOG 215 Intro to GIS	3 credits	5
Total Core credits	**32**	

2D. Aquatic Science Option – 27 credits

Required Courses - 7 credits	
PHYSICS 120 or PHYSICS 209	4 credits
BIOSCI 512 Limnology	3 credits
Electives – Choose at least 9 credits from the following list, including at least 3 FRSHWTR credits	9 credits
FRSHWTR 321 Exploration of Inland Seas	3 credits
FRSHWTR 341 Sanitation and Sustainability	3 credits
FRSHWTR 322 Ecology and Evolution of Freshwater Organisms	3 credits
FRSHWTR 362 Calculating Nature	3 credits
FRSHWTR 342 Water Pollution Solutions: Water Technology and Management	3 credits
FRSHWTR 471 Introduction to Sensing Networks	3 credits
FRSHWTR 421 Molecular Level Tools to Understand Larger Scale Change	3 credits
FRSHWTR 511 Ichthyology	3 credits
FRSHWTR 512(Topic) Brew City Aquaponics	3 credits
FRSHWTR 513 Field Experimentation and Analysis in Freshwater Science	3 credits
FRSHWTR 514 Analytical Techniques in Freshwater Sciences	3 credits
FRSHWTR 522 Aquatic Organic Biogeochemistry	3 credits
FRSHWTR 524 Aquatic Isotope Biogeochemistry	3 credits
FRSHWTR 562 Principles of Aquaculture Systems	3 credits
FRSHWTR 563 Finfish Aquaculture and Nutrition Principles	3 credits
FRSHWTR 564 Water Quality in Aquaculture	3 credits
FRSHWTR 565 Fish Health	3 credits
FRSHWTR 621 Benthic Ecology	3 credits
ATM SCI 240 Introduction to Meteorology	3 credits
BIOSCI 310 General Ecology	4 credits
BIOSCI 406 Marine Biology	3 credits
BIOSCI 505 Conservation Biology	3 credits
CES 651 Principles of Stream Management and Restoration	3 credits
CIVIL 311 Intro to Energy Environment and Sustainability	3 credits
GEOG 403 Remote Sensing: Environmental and Land Use Analysis	4 credits
GEOG 411 Physical Climatology	3 credits
GEOG 415 Hydrogeography	3 credits
GEOG 455 Applied Climatology	3 credits
GEOG 515 Watershed Analysis and Modeling	3 credits
GEOG 525 Geographic Information Systems	4 credits
GEOSCI 400 Water Quality	4 credits
GEOSCI 463 Physical Hydrogeology	4 credits
MATH 305 Introduction to Mathematical and Computational Modeling	3 credits
PH 303 Climate Change, the Environment and Human Health	3 credits
Additional Electives – 11 credits - chosen in consultation with your advisor	11 credits

2E. Water Policy Option – 27 credits

Required Courses – 6 credits	
FRSHWTR 393 Water Law, Policy and the Environment	3 credits
FRSHWTR 510 Economics, Policy and Management of Water	3 credits
Electives – Choose at least 9 credits from the following list, including at least 3 FRSHWTR credits	9 credits
FRSHWTR 584 Aquatic Ecosystem Valuation	3 credits
FRSHWTR 583 Cost-Benefit Analysis for Environmental Resource Decision	3 credits
FRSHWTR 461 Politics and Policy of Sustainability	3 credits
FRSHWTR 585 Applied Water Statistics and Data Manipulation	3 credits
POLISCI 216 Environmental Politics	3 credits
GEOG 525 Geographic Information Science	4 credits
GEOG 625 Intermediate Geographic Information Science	4 credits
ECON 210 Economic Statistics	3 credits
ECON 301 Intermediate Microeconomics	3 credits
ECON 310 Research Methods for Economics	3 credits
HIST 432 North American Environmental History	3 credits
Additional Electives – 12 credits - chosen in consultation with your advisor	12 credits

Example pathway through BSFS program, Aquatic Sciences focus

SEMESTER 1	**title**	**credits**	**SEMESTER 2**	**title**	**credits**
FRSHWTR 101	Elements of Water (Req)	3	FRSHWTR 120	Preparing for a career in Freshwater Sciences (Req)	1
BIOSCI 150	Foundations of Biological Sciences I (NS)(Req)	4	CHEM 104	General Chemistry and Qualitative Analysis (Req)	5
CHEM 102	General Chemistry (NS)(Req)	5	FRSHWTR 201	The Water Environment (Req)	3
MATH 115	College Algebra	3	BIOSCI 152	Foundations of Biological Sciences II(Req)	4
			ENG 102	College Writing and Research (OWCA)	3
total		**15**			**16**
SEMESTER 3			**SEMESTER 4**		
FRSHWTR 202	Life in Water (Req)	4	FRSHWTR 392	Water, energy, food, climate (Req)	3
COMPSCI 202	Intro Programming Using Python (OWCB)	3	ECON 103	Principles of Microeconomics (Req) (SS)	3
MATH 115	Precalculus	4	ART 150	Multicultural America (SS, CD)	3
Language I	Foreign language requirement	4	Language II	Foreign language requirement	4
			PHILOS 213	Intro to Philosophy of Science (HU)	3
total		**15**	**total**		**16**
SEMESTER 5			**SEMESTER 6**		
COMPSCI 250	Introductory Computer Programming (Req)	3	FRSHWTR 464	Chemical Hydrogeology (Req)	4
MATH 231	Calculus and Analytic Geometry I (QLB)(Req)	4	FRSHWTR 391	Water and natural resource economics	3
BIOSCI 512	Limnology	3	MTHSTAT 215	Elementary Statistical Analysis (QLB)	3
THEATRE 260	Storytelling (A)	3	PHYSICS 120	General Physics I	4
BIOSCI 310	General Ecology	3			
total		**16**	**total**		**14**
SEMESTER 7			**SEMESTER 8**		
FRSHWTR 661	Professional and Capstone Planning (Req)	1	FRSHWTR 660	Undergraduate Capstone (Req)	3
FRSHWTR 361	Intro to Environ Data Systems	3	FRSHWTR 690	Undergraduate Seminar in Freshwater Sciences (Req)	1
FRSHWTR 699	Independent Study for Undergraduates	2	FRSHWTR 524	Aquatic Isotope Biogeochemistry	
FRSHWTR 522	Aquatic Chemistry		PHILOS 237	Technology, Values, and Society (HU)	3
GEOG 215	Intro to GIS (Req)	3	BIOSCI 511	Ichthyology	3
BIOSCI 505	Conservation Biology	3			
total		**15**	**total**		**13**

Example pathway through the BSFS program, Water Policy focus

SEMESTER 1	title	credits	SEMESTER 2	title	credits
FRSHWTR 101	Elements of Water (Req)	3	FRSHWTR 120	Preparing for a career in Freshwater Sciences (Req)	1
BIOSCI 150	Foundations of Biological Sciences I (NS)(Req)	4	FRSHWTR 201	The Water Environment (Req)	3
CHEM 102	General Chemistry (NS)(Req)	5	BIOSCI 152	Foundations of Biological Sciences II(Req)	4
MATH 115	College Algebra	3	CHEM 104	General Chemistry and Qualitative Analysis (Req)	5
			ENG 102	College Writing and Research (OWCA)	3
total		**15**			**16**

SEMESTER 3			**SEMESTER 4**		
FRSHWTR 202	Life in water (Req)	4	FRSHWTR 392	Water, energy, food, climate (Req)	3
ECON 103	Principles of Microeconomics (Req) (SS)	3	ECON 104	Principles of Macroeconomics	3
MATH 115	Precalculus (QLB)	4	Language 102	Foreign language requirement	4
Language 101	Foreign language requirement	4	ART 150	Multicultural America (SS, CD)	3
			PHILOS 213	Intro to Philosophy of Science (HU)	3
total		**15**	**total**		**16**

SEMESTER 5			**SEMESTER 6**		
MATH 231	Calculus and Analytic Geometry I (Req)	4	FRSHWTR 464 (Req)	Chemical Hydrogeology	4
COMPSCI 250	Introductory Computer Programming (Req)	3	FRSHWTR 391	Water and Natural Resource Economics	3
COMPSCI 202	Introductory Programming Using Python (OWCB)	3	GEOG 215 (Req)	Intro to GIS	3
THEATRE 260	Storytelling (A)	3	MATH 215	Elementary Statistical Analysis (QLB)	3
ECON 328	Environmental Economics	3	FRSHWTR 393	Water Law and the Environment	3
total		**16**	**total**		**16**

SEMESTER 7			**SEMESTER 8**		
FRSHWTR 510	Economics, Policy and Management of Water	3	FRSHWTR 660	Undergraduate Capstone (Req)	3
FRSHWTR 661	Professional and Capstone Planning (Req)	1	FRSHWTR 690	Undergraduate Seminar in Freshwater Sciences (Req)	1
FRSHWTR 361	Intro to Environ Data Systems	3	FRSHWTR 584	Aquatic Ecosystem Valuation	3
FRSHWTR 461	Politics and Policy of Sustainability	3	PHILOS 237	Technology, Values, and Society	3
ECON 351	Introduction to International Economic Relations	3	ECON 353	Economic Development	3
total		**13**	**total**		**13**

Assessment of Outcomes and Objectives
The BSFS will continuously assess student learning at the course and program levels. At the course level, instructors will develop learning objectives that align with BSFS outcomes. Instructors will engage in ongoing course improvement and revisions based on review of course assignments, course evaluations, and course content to ensure that the concepts presented are up-to-date and consistent with effective teaching methods. Students admitted to the program will provide a self-assessment of competencies achieved upon entry and again each spring. The School of Freshwater Sciences will administer an alumni self-assessment survey one-year post-graduation.

Diversity
Consistent with UW-Milwaukee's Mission statement that includes: "To develop and maintain high quality undergraduate, graduate and continuing education programs appropriate to a major urban doctoral university, to attract highly qualified students who demonstrate the potential for intellectual development, innovation, and leadership for their communities," the School of Freshwater Sciences is committed to increasing diversity in the student population, and to recruit and retain underrepresented, first-generation, and low income students in STEM disciplines.

UWM's TRIO programs engage diverse populations of students who complete their high school education and attend and graduate with an undergraduate degree. In addition, programs such as the Lake Sturgeon Bowl and Water Sys-STEM, coordinated through the School of Freshwater Sciences, provide an important connection with high schools and technical colleges in the area.

In curricular efforts, the proposed BSFS will train students to integrate the interdisciplinary and multidisciplinary aspects of the freshwater needs in the world. BSFS students will take courses that meet the Cultural Diversity general education requirement and broaden participation in Freshwater Sciences. We will work with transfer students to count their credits toward this major.

Collaborative Nature of the Program
The School of Freshwater Sciences actively collaborates on research and academic endeavors with government agencies and non-profit organizations. The following entities share space in our facilities: U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, U.S. Geological Survey, U.S. Department of Agriculture, Wisconsin Sea Grant, Harbor District, Inc., Milwaukee Riverkeeper, and Southeast Wisconsin Watershed Trust.

This program will interact with other UW campuses through the Freshwater Collaborative designed to foster undergraduate educational collaboration across the UW System. The Freshwater Collaborative will solidify Wisconsin's competitive advantages represented by our expanding water economy, our unparalleled water wealth and geography, and the diversity of intellectual strengths within our system of public universities.

The School of Freshwater Sciences has collaborated with multiple UWM Schools and Colleges throughout its short history. The multidisciplinary nature of student focus areas in environmental health, technology development, aquaculture and fisheries, and policy provides an opportunity to incorporate courses as part of our required courses and electives. Partners may include Zilber School of Public Health, College of Engineering and Applied Science, School of Architecture and Urban Planning, College of Health Sciences, School of Information Studies, and the College of Letters and Sciences departments of Biological Sciences, Geosciences, Geography, Economics, Physics, Communication, Mathematics, and Chemistry.

Projected Time to Degree
The projected time to completion of the BSFS is 4 years or 120 credit hours.

Program Review
All undergraduate degrees at UW-Milwaukee are subject to a 10-year program review process. The initial review of the BSFS will occur during the 5th year. After the initial review, there will be a 10-year cycle.

Accreditation
There is no accreditation process for this program.

JUSTIFICATION
Rationale and Relation to Mission
The freshwater research enterprise at UWM is over 50 years old. The Center for Great Lakes Studies was founded in 1966 as a UW System Center of Excellence and was housed as an organized research unit within the graduate school until 2009, when the School of Freshwater Sciences was inaugurated, becoming the first graduate school in the United States devoted entirely to graduate freshwater research and education. The goal is broad and forward looking -- to create a global freshwater center located on the shores of the world's most valuable freshwater resource, and to promote the University of Wisconsin System and the State of Wisconsin, building on their history and past investment, as leaders in the stewardship and preservation of freshwater for future generations.

The School of Freshwater Sciences is a unique confluence of water disciplines, housing toxicologists, microbiologists, aquaculture and fisheries biologists, biogeochemists, oceanographers, groundwater specialists, economists and policy experts in a single location and in one academic program. UWM has identified Water Science and Technology as one of the key initiatives for growth on our campus. As such, UWM has a solid base of capabilities and resources on which to build this program.

The formation of this degree program fits well with the mission of UWM as outlined in the Select Mission Statement (UWM Chancellor Strategic Directions). As a major doctoral university, UWM has a critical role to play in offering a high quality undergraduate program appropriate to a major urban university; to attract highly qualified students who demonstrate the potential for intellectual development, innovation, and leadership for their communities; and to promote public service and research efforts directed toward meeting the social, economic and cultural needs of the state of Wisconsin and its metropolitan area. The BSFS is designed to be rigorous and research-immersive to support student success and research excellence. The program includes critical communication and outreach components to support community engagement. The program will increase visibility by leveraging UWM branding as a water-focused knowledge generator and its linkage with Lake Michigan.

The BSFS also represents one of UWM's key contributions to the UW System wide initiative: the Freshwater Collaborative of Wisconsin (FCW). Built upon the broad expertise, world-class facilities, research acumen, and commitment to undergraduate and graduate student training across all 13 campuses, the FCW is designed to unleash the collective assets of the UWS and place them into an elite, one-of-a-kind program of training and research, while launching a talent development program in which students fully engage a diverse, multidisciplinary course of study across UW campuses. The BSFS will be a key collaborating program within the FCW matrix of programs and will provide opportunities for undergraduate training for students throughout System interested in the unique aspects that UWM's program will offer. Likewise, once implemented, UWM students within the BSFS degree program will have the opportunity to participate in instructional and training programs in water studies throughout System campuses. Many of these opportunities were highlighted by each campus at the June 2019 Board of Regents meeting. [1]

[1] (https://www.wisconsin.edu/regents/download/meeting_materials/2019/june_6-7,_2019/Board-of-Regents-Thursday-Materials-(June-6,-2019).pdf; https://www.youtube.com/watch?v=0DWJh_PCGE4&list=PL8mza1HK_WkJmtIgjS6bDVPF1ii3jfqBQ&index=11 [@1:15:30-2:33:00]

Institutional Program Array

The School of Freshwater Sciences currently offers a Doctor of Philosophy in Freshwater Sciences, a Master of Science in Freshwater Sciences and Technology-Thesis track and a Master of Science in Freshwater Sciences and Technology-Professional Science track. The current program fills a need at the University of Wisconsin-Milwaukee, and it is expected that this program will provide a population of well-trained graduates from which to recruit graduate students.

Other Programs in the University of Wisconsin System

Within UW System there are a variety of degree and non-degree programs with aspects that relate to freshwater sciences. A search of the Major Mania system for "water" found little duplication of other programs in the UW System. UW-Stevens Point offers majors in both Fisheries and Water Resources, and Soil and Waste Resources. UW-Green Bay has a major in Water Science. UW-Stout offers an Aquatic Biology concentration under the Environmental Science major. UW-Whitewater has a Marine and Freshwater Ecology emphasis in their biological sciences major, where students spend one year in collaboration with their sister institution, Deakin University, in Australia. Students completing the Integrated Science/Business major at UW-Whitewater have the option to add a Water Emphasis. UW-Milwaukee offers a concentration in Water Resources through the Conservation and Environmental Sciences major, but does not require the level of math, chemistry, and biology that this program does.

The BSFS focuses on water as the center of the curriculum and offers students a water policy option or an aquatic science option. In addition to the study of the whole hydrological cycle, water policy and economics is integrated into the curriculum, giving our students a breadth of knowledge vital for meeting workforce needs. This broad focus is also the driving force behind the Freshwater Collaborative.

The State has similar programs, but the market demand for jobs in freshwater, and Milwaukee, as the largest metropolitan area of the state is a particularly good place to center a degree of this type. Market demand suggests that all UWS programs should be able to thrive. Therefore, the Freshwater Science major at UWM will complement, not conflict with these programs.

Need as Suggested by Current Student Demand
Located in the state's major metropolitan area, UW-Milwaukee appeals to and serves a unique population of undergraduate students. Establishing a new degree option for these students will provide them with access and the opportunity to acquire the training and expertise needed for careers in water, many of which are located throughout Wisconsin with a particular concentration in the Milwaukee greater metropolitan region.

In March 2020, the School of Freshwater Sciences (SFS) conducted a short survey of current and prior graduate students of the School of Freshwater Sciences at UWM. A response rate of 26.8% was obtained from 59 complete surveys out of 220 students. When asked if they would have considered an undergraduate major in Freshwater Sciences when choosing an undergraduate program, 88.2% responded "Yes" (39.0%) or "Maybe" (49.2%). Of those students who attended undergraduate programs outside of Wisconsin, 83% who attended out of state private schools responded to the same question as "maybe" or "yes" (n=6) and 100% of students who attended an out of state public or land grant school indicated they may have considered the undergrad degree (n=2). While this pool of current and former students is drawn from those who have self-selected for a graduate degree in Freshwater Sciences, it indicates that had this major been available, these students would have shown demand for an undergraduate degree. One student stated, "I went into my undergrad degree knowing that I would be applying for the SFS graduate program upon completion of it. I think there would be about as much demand for an undergrad degree as there is for the graduate program (maybe a bit more demand though as not everyone wants to do graduate school)." These results show that there is strong student interest in the development of an undergraduate degree in freshwater.

Offered for 25 years at the Great Lakes Water Institute/School of Freshwater Sciences, the National Science Foundation funded Research Experience for Undergraduates in Aquatic Sciences consistently attracted 100 applicants per year, showing evidence of a strong and sustainable student demand for water-based education. In addition, technical college students participating in the Water SYS-STEM (See Yourself Succeeding in STEM) program[1] have expressed a strong interest in transferring into a Freshwater Sciences or Engineering bachelor's program. SFS staff, faculty, and students have developed educational programming with Bradley Tech, Escuela Verde, Carmen High School, Pulaski, Tenor, and Greendale high schools. These strong relationships will continue to generate interest and demand for opportunities in freshwater undergraduate education.

The school is uniquely visible to talented high school students interested in freshwater sciences education. The school's outreach specialist provides research focused tours and presentations to community groups, hands-on K-12th grade classroom activities, hosts the Wisconsin Regional Remotely Operated Vehicle (ROV) Competition through the Marine Advanced Technology Education (MATE) International Competition, hosts the Lake Sturgeon Bowl (the regional National Ocean Sciences Bowl competition), and leads professional development opportunities for teachers, connecting scientists to their research stakeholders.

According to a Burning Glass Technologies report[2], of all the Wisconsin bachelor's programs offering degrees most closely related to Freshwater Sciences, (e.g., Environmental Sciences, Natural Resources Management and Policy) conferrals of BS degrees increased by 79% from 2014 to 2018. This upward trajectory demonstrates an increasing demand for students in these disciplines, which freshwater sciences can help fill. Lack of trained talent threatens the success of our water and water-dependent industries, hampers their growth and drives these industries to look for skills, ideas, and investment outside our state. The Burning Glass report shows that eighteen of the 29 most common occupations in these fields that require a BA/BS or higher had fewer Wisconsin graduates in 2016 than the estimated number of water sector job openings available.

Water resources technicians, as defined by the U.S. Bureau of Labor Statistics (BLS)[3], are expected to experience a faster-than-average increase in employment opportunities during the 2018-2028 decade, due in part to the need to protect the environment from the increasing demands of population growth. Freshwater biologists, or limnologists, as defined by the BLS, are expected to experience a 5% growth rate from 2018-2028, also due to the increasing demands of human populations on wildlife and habitats.

The BSFS will be working through and with the collaboration, coordination and partnership among Milwaukee Public Schools, Milwaukee Area Technical College, and the University of Wisconsin-Milwaukee (M^3) to increase the retention, graduation, and career success of our

[1] Business-Higher Education Forum. (2019). Creating Purposeful Partnerships: Business and Higher Education Working Together to Build Regional Talent Ecosystems for the Digital Economy. Washington, DC. Retrieved from https://www.bhef.com/sites/default/files/BHEF_2018_CEO_playbook_0.pdf

[2] Burning Glass Technologies report (2019), commissioned by Laura Pedrick 12/19/2019

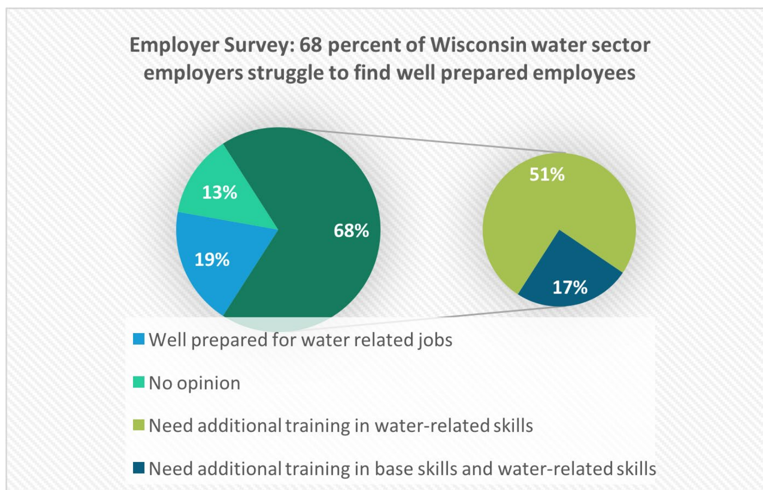
[3] https://study.com/articles/Freshwater_Biology_Jobs_Career_Options_and_Requirements.html

students and provide a prepared workforce. The program includes boosting student achievement, ensuring students have necessary resources to advance to college and into the workforce, and closing the equity gap in educational attainment.

The BSFS will be promoted through social media and email marketing campaigns by expanding the current activities of the graduate program marketing campaign. Finally, the demand will be sustained by having both a dedicated advisor and marketing/recruiter position to work with undergraduate admissions.

Need as Suggested by Market Demand

Wisconsin industries are facing significant workforce shortages particularly in the water sector. Water is the fastest growing sector of the world's economy, (about $800 billion annually by 2035), and is fueling a growing demand for hydrologists, ecologists, engineers, modelers, data scientists, aquatic toxicologists, policy analysts, business leaders and others who can understand and anticipate water issues and problems, and who can devise, implement and manage solutions. In June of 2018, the Brookings Institute identified 1.7 million workers that were directly involved in designing, constructing, operating, and governing U.S. water infrastructure alone. This represents 1 to 2 percent of total employment in the country's metro and rural areas. According to the same Brookings report, water occupations pay well, and consistently exceed the average national average for all occupations. This matches up with a UW-Milwaukee analysis of workforce data, which suggests a Wisconsin water workforce of more than 60,000, or about 2% of the State's total employment.



The 2017 "Initial Report on UWM's Exploratory Study of Water-related Workforce Needs Survey" revealed a substantial need for extensive training in water related issues. This survey of water sector industries revealed that, while almost half saw water-focused positions as growth areas, most could not find new employees with adequate training in water-related issues, technologies or processes. It was reported that the following majors/degrees need additional water resource training: Engineering, Environmental Science, Chemistry, and Biology. The proposed Freshwater Sciences undergraduate major will directly fill this need.

University of Wisconsin - [Milwaukee]
Cost and Revenue Projections For Newly Proposed Program - B.S. in Freshwater Sciences

	Items	Projections				
		2021	2022	2023	2024	2025
		Year 1	Year 2	Year 3	Year 4	Year 5
I	**Enrollment (New Student) Headcount**	15	25	30	30	30
	Enrollment (Continuing Student) Headcount	0	12	32	56	68
	Enrollment (New Student) FTE	12	20	24	24	24
	Enrollment (Continuing Student) FTE	0	9.6	25.6	44.8	54.4
	Total New Credit Hours					
II	(10 new course sections x 3 credits per section) x FTE	360	888	1488	2064	2352
	Existing Credit Hours (cur. 2 sections/semester,30 students/section)	90	90	90	90	90
III	**FTE of New Faculty/Instructional Staff**	0	1	1	2	2
	FTE of Current Fac/IAS	0.25	0.25	0.25	0.25	0.25
	FTE of New Admin Staff	1	1	1	1	1
	FTE Current Admin Staff					
IV	**New Revenues**					
	From Tuition (total student FTE x tuition cost 8091.12)	$97,093	$239,497	$401,320	$556,669	$634,344
	From Fees					
	Program Revenue - Grants					
	Program Revenue - Other					
	Reallocation of tuition (Campus 20%)	-$19,419	-$47,899	-$80,264	-$111,334	-$126,869
	Total New Revenue	$77,675	$191,598	$321,056	$445,335	$507,475
V	**New Expenses** (*plus existing costs to be shifted to new program*)					
	Salaries plus Fringes (35% + 0.5% annual increase)					
	Faculty/Instructional Staff	$0	$108,400	$109,344	$220,584	$222,488
	Other Staff (Coordinator, technical support)	$97,200	$98,102	$99,008	$99,918	$100,832
	Other Expenses					
	Facilities					
	Equipment					
	Other:Marketing & Recruitment	$20,000	$20,000	$20,000	$20,000	$20,000
	Other: 2 TAs (33% Doctoral Academic Year)			$43,800	$43,800	$43,800
	Total Expenses	$117,200	$226,502	$272,152	$384,302	$387,120
VI	**Net Revenue**	-$39,525	-$34,904	$48,904	$61,033	$120,355

Narrative: Explanation of the Numbers and Other Ongoing Commitments that will Benefit the Proposed Program

a - Number of students enrolled
b - To be based on 12 credits at the undergraduate level and 7 credits at the graduate level
c - Number of faculty/instructional staff providing significant teaching and advising for the program
d - Number of other staff providing significant services for the program

Provost's Signature:	**Date:**

COST AND REVENUE PROJECTIONS NARRATIVE – Additional Document #2

Introduction
The University of Wisconsin-Milwaukee proposes to establish a Bachelor of Science in Freshwater Sciences (BSFS). The development of the program responds to the rapidly growing student and market demand for undergraduate education in freshwater sciences and will attract a new cadre of students to UW-Milwaukee. Establishing the BSFS at UW-Milwaukee will create an educational platform to elevate broad societal understanding of linkages between resource utility, human activity, and resource sustainability directed at furthering general human wellbeing. This program will provide students access to the only school in the nation whose primary focus is on research and education in freshwater sciences. Graduates will be equipped to face the challenge of dealing with a severely limited vital resource with reason, fairness and a transdisciplinary view to sustainability through development of critical thinking, problem solving, and research capabilities. Demand for freshwater will continue to exceed supply, expanding in temporal utilization and geographic scope well into the next century. The program will be comprised of 120 credits, including a minimum of 42 credits of general education; 55 credits in the Freshwater Sciences major with at least 32 in FRSHWTR; a minimum of 35 credits in the natural sciences, economics, mathematics, and computer science; required undergraduate thesis/capstone project; and sufficient electives to complete the required minor or double major in a natural science, mathematics, engineering or a policy-relevant program.

Section I – Enrollment
By the end of year five, it is expected a total of 130 new students (headcount) will have enrolled in the program and 23 students will have graduated from the program. These figures include students entering UW-Milwaukee as new freshmen, as well as those who will transfer into the program from partner institutions including Gateway Technical College, Milwaukee Area Technical College, Alverno, Carthage, and others using articulation agreements. Each projected student headcount equals 0.8 student FTE, as it is typical for some students to enroll part-time at UW-Milwaukee.

Section II – Credit Hours
It is estimated that, by year 5, the program will offer 15 sections of courses required for the major each year—none of these is currently offered. New credit hours represent the product of the number of new course sections and the credit hours per course, multiplied by the number of FTE students projected to enroll in the major.

Section III – Faculty and Staff Appointments
We anticipate hiring 1 FTE administrative staff in year 1 that will continue to support the program as needed—e.g. recruiter, advisor, retention specialist. We anticipate having an existing faculty member spend 0.25 FTE to act as a direct student contact, perform limited advising, and represent the program within UWM and UWS as needed. We anticipate hiring 1.0 FTE faculty in year 2, and another in year 4, resulting in 2.0 FTE in years 4 onward.

Section IV – Program Revenues
Tuition Revenues:
New revenues include tuition revenue attributable to total FTE student enrollments, based on the residential tuition rate of $8,091.12 per academic year. These expected revenues include tuition attributable to general university credit requirements. We anticipate that a significant percentage of students will pay out-of-state, non-resident tuition, raising the actual per student revenue rate.

Section V – Program Expenses
In addition to the personnel expenses outlined in Section III, we anticipate program expenses for marketing and recruitment. Out of necessity, the undergraduate courses will be primarily taught on the

main campus, so it will be the main place in which we will have contact with students in the program. As such, will need space for one office for the Administrative Assistant and more for faculty to hold office hours and work in between teaching classes. It would be best to have a central open space with at least 3-4 offices adjacent.

Section VI – Net Revenue
It is anticipated that the BS program in Freshwater Sciences will yield an increase in net revenue for UWM and the School of Freshwater Sciences. Growth will be monitored carefully by the SFS administrators, and adjustments to teaching, coordination, and marketing/recruitment investments will be made accordingly. The projected temporary financial deficits that may occur in the first years of this program will be offset over time by the financial growth in the Department.

March 26, 2020

ADDENDUM TO: REQUEST FOR AUTHORIZATION TO IMPLEMENT A DEGREE BACHELOR OF SCIENCE IN FRESHWATER SCIENCES AT UNIVERSITY OF WISCONSIN (UW)-MILWAUKEE

Student Learning Outcomes and Program Objectives

In the School of Freshwaters Sciences, the undergraduate program will emphasize the unique opportunities for hands-on learning through intensive laboratory and field experiences that span the interdisciplinary breadth of freshwater studies and scientific inquiry. As such, we are requiring all students in the program to complete and defend an undergraduate thesis or capstone project to support the development of critical thinking, problem solving, and research capabilities through independent research. Our curriculum is designed around the following competencies for the next generation of freshwater scientists:

PROGRAM OBJECTIVES

- Discovery—the requisite knowledge to understand the nature of these problems, which requires basic biology, chemistry, physics, geoscience, and mathematics. These basics provide the foundation for more advanced competencies in specific focus areas of freshwater systems where complex interactions drive the dynamics of the entire hydrologic cycle (streams, lakes, groundwater and atmosphere).
- Analysis/Assessment—the ability to identify, analyze, and anticipate problems, then develop solutions in the context of the multidimensional implications in the policy, economic, and social/cultural setting.
- Design—the integrative ability to devise solutions to complex problems and challenges using a suite of solutions informed by ecology, socio-politics, and technology in an integrative, holistic framework.
- Technology—the proficient use of the latest technology for data collection and analysis, and the ability to match the sophistication of the technology with the problem at hand.
- Communication—the ability to effectively convey written, oral, and visual concepts, data, and arguments to diverse strata of audiences; and develop skills in two-way communication with experts, stakeholders, and the community.

LEARNING OUTCOMES

1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)
2. Understand the nexus between biological, ecological, physical, climate and economic systems as they relate to water. (Discovery, Analysis/Assessment)
3. Understand the hydrologic cycle and the processes and interactions among atmospheric, surface and ground water components and the issues and processes related to the quality of these waters. (Discovery, Analysis/Assessment, Design)
4. Demonstrate understanding of the chemical and biogeochemical interactions of both natural and anthropogenic substances and their importance within global earth system dynamics, natural freshwater resources, and water/wastewater management systems. (Discovery, Analysis/Assessment, Design, Technology, Communication)
5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)

6. Develop the computer literacy and skills to apply big data to environmental problems. Implement models as analytical and forecasting tools. (Analysis/Assessment, Design, Technology)
7. Understand the application of monitoring and smart sensor systems in creating built and natural environmental intelligence to enhance systems management. (Discovery, Analysis/Assessment, Design, Technology)
8. Understand the application of environmental laws, regulatory and management frameworks; and the economics of water resource use and allocation. (Analysis/Assessment, Design, Technology)

DESCRIPTION OF PROPOSED NEW COURSES

COURSE NAME
FRSHWTR 101 Elements of Water

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)
2. Understand the nexus between biological, ecological, physical, climate and economic systems as they relate to water. (Discovery, Analysis/Assessment)
3. Understand the hydrologic cycle and the processes and interactions among atmospheric, surface and ground water components and the issues and processes related to the quality of these waters. (Discovery, Analysis/Assessment, Design)
8. Understand the application of environmental laws, regulatory and management frameworks; and the economics of water resource use and allocation. (Analysis/Assessment, Design, Technology)

CREDITS 3

DESCRIPTION
This course is an introduction to water as it relates to humanity and its interaction with the environment. The physics, chemistry, and biota of freshwater combine to produce an ecological infrastructure that provides ecosystem services that all humans rely on. Socially relevant issues and the exploration of human dimensions of water use will be covered in this class. This course provides a foundation sufficient for a citizen to understand contemporary issues as well as preparation for advanced courses.

COURSE NAME
FRSHWTR 120: Preparing for a Career in Freshwater Sciences

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
Setting students on the course to meet all learning outcomes.

CREDITS 1

DESCRIPTION
This course will introduce students to the skill sets they will need for a successful career. In addition to competency in your field, employers seek skills in communication, teamwork, interpersonal relationships, administration, and leadership. Other important skills include networking capability, taking initiative, fostering mentorship, and maintenance of work-life balance.
Course Objectives:

Develop a better understanding of their career aspirations;
Create an individual development plan (IDP) which can be expanded throughout their degree program
Understand job markets and workplace culture;
Learn to communicate in professional settings both orally and via written material;

Possible Textbook:
"What Color is Your Parachute?" by Richard N. Bolles or
"Now What? The Young Person's Guide to Choosing the Perfect Career" by Nicholas Lore

COURSE NAME
FRSHWTR 201 The Water Environment

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
3. Understand the hydrologic cycle and the processes and interactions among atmospheric, surface and ground water components and the issues and processes related to the quality of these waters. (Discovery, Analysis/Assessment, Design)
4. Demonstrate understanding of the chemical and biogeochemical interactions of both natural and anthropogenic substances and their importance within global earth system dynamics, natural freshwater resources, and water/wastewater management systems. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 3

DESCRIPTION

1	The Hydrologic cycle - global view - reservoirs, residence times, rates of transport
	The atmosphere, river, lake, ocean continuum, weathering & why the ocean is salty and lakes vary
2	Properties of water I: physics of gas, liquid, ice; density, weight & pressure, buoyancy
	Properties of water I (cont.) - viscosity, diffusion, evaporation
3	Properties of water II: optics & light attenuation, sound in water -
	Properties of water II: Boundary layers - turbulence, diffusion, air-water, sediment-water, thermoclines, fish gills, etc.
4	Properties of water II: Boundary layers (cont.) -living at scales from um-km
	Dynamics of flow I: measuring velocity, waves and currents
5	Dynamics of flow I (cont.): waves and currents, basic equations
	Dynamics of flow II: flow in pipes and channels
6	Chemistry of water I: composition, solubility
	Chemistry of water II: chemistry of carbon & the global carbon cycle
7	Chemistry of water III: biogeochemistry, nutrients, stoichiometry of life, tracers
	Chemistry of water III (cont.): models
8	lab/field week
	lab/field week
9	midterm review
	midterm
10	The basics of changing Global water scarcity & security
	Dynamics of groundwater I
11	Dynamics of groundwater II
	Watershed Dynamics I: flow in rivers & streams
12	Watershed Dynamics II: Land use and runoff
	Water contamination - chemicals of concern
13	Water contamination - biological

	Drinking water & the built hydro-cycle
14	Stormwater systems, green and grey infrastructure
	Water quality, standards and treatment - what is clean? What is legal?
15	lab/field week
	lab/field week
16	review
	final

COURSE NAME
FRSHWTR 202 Life in Water

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)

CREDITS 4

DESCRIPTION
"Life in Water" is the study of how organisms adapt to diverse physical, chemical, and interspecies interactions in water. The approach focuses on convergent and divergent aspects of evolution so that the perspective of biological diversity surveys diverse adaptive solutions to challenges rather than principles of taxonomic classification.

This course is intended to complement FRSHWTR 2XX The Water Environment by emphasizing how organisms live in and adapt to the water environment, and what it means for human dependence on water for life. The course provides a number of field exercises examining a variety of the biotic aspects of water systems, both natural and built.

These exercises will survey and provide opportunities to examine the wide variety of organisms that live in freshwater systems (rivers, lakes, beaches, bio-reactors, etc.) the habitats they occupy, and how species interact with each other and their environment. Included will be examinations of adaptations, behavior, ecology, and a discussion of local and global resource management and conservation issues.

Habitats:
- Large lakes – physical forcing at scale, the biological oceanography of inland seas
- Rivers & streams: life in a flowing environment
- Harbors and estuaries
- Ponds and lagoons
- Built systems, bioreactors, aquaculture and aquaponics

Behavior:
- reproducing, growing and thriving in a changing fluid environment
- interferences driven by human impacts

Ecology
- dynamics of food webs and exploited populations (fisheries), examples of how complex parts assemble into ecosystems

Conservation & Restoration of ecosystems:
- Reconstructing sustainable ecosystems
- Problems of diversity
- Human use and misuse

Field exercises:

- Why beaches are sometimes open and sometimes closed
- Non-indigenous species invasions - How "natural" biota and ecosystems can become dominated by non-native species
- How do we treat drinking water and wastewater?
- Life in a flowing stream
- Intro to water-dependent industries (e.g. brewing, food processing, biofuels)

COURSE NAME

FRSHWTR 392 Water-Energy-Food-Climate

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED

2. Understand the nexus between biological, ecological, physical, climate and economic systems as they relate to water. (Discovery, Analysis/Assessment)

6. Develop the computer literacy and skills to apply big data to environmental problems. Implement models as analytical and forecasting tools. (Analysis/Assessment, Design, Technology)

CREDITS 3

DESCRIPTION

Water, food, energy, and climate are central to issues of economic growth, social wellbeing, and environmental sustainability. This course introduces the main features and linkages in these complex interrelated systems. It integrates insights from biological, physical, and social sciences to build the analytic frameworks needed to conceptualize key system drivers and cross-scale relationships, and for assessing emerging challenges and potential policy options.

Part I. The climate system

1. The physics of climate, greenhouse gases and paleoclimate change
2. How do we observe climate change & weather?
3. The global carbon budget and terrestrial-ocean-atmosphere interactions, Modeling climate, uncertainties, and future projections¸ ocean acidification, sea level rise
4. Energy and climate, peak oil & fossil fuels, hydropower

Part II. The Global ecological system

1. Ecosystem energetics – energy flow, primary production
2. Basic biogeochemistry of food production - Peak phosphorus, the green revolution, pesticides
3. Population increase and urbanization – food security, how many people can the planet feed?
4. Economic changes, standards of living, moving up (or down) the food chain

Part III. Water, food, energy and climate

1. Freshwater systems and climate change - changing hydrology of the Great Lakes
2. Water scarcity and stress – causes, trends, water policy, pricing, property rights
3. Water, food, energy production and distribution
    a. Agricultural economics – food, biofuels, etc., changing agri-food systems, Farm scale operational models
    b. Aquaculture and fisheries
    c. Transportation of food, energy and water
    d. Environmental and health issues arising from food and energy production
    e. Interaction between food, energy, water markets

Part IV. Technology and policy

1. Climate policy: The Paris Climate Accords, the IPCC,
2. US Farm policies

3. Urban water systems, water supply & treatment, pricing
4. Mitigation, adaptation, carbon sequestration
5. Water management, conservation, alternative energy, desalinization
6. Market failures and their potential solutions (e.g., externalities, public goods)
7. Tools for evaluating policy (cost benefit analysis, cost effectiveness analysis, multi-criteria analysis, life cycle assessment)
8. Case studies

COURSE NAME
FRSHWTR 393 Water Law, Policy, and the Environment

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
8. Understand the application of environmental laws, regulatory and management frameworks; and the economics of water resource use and allocation. (Analysis/Assessment, Design, Technology)

CREDITS 3

DESCRIPTION
Statutory law, case law, and administrative practices relating to regulation of the water and environment resources including clean water act, environmental impact statements, pollution, public lands, and preservation law.
Potential Text: Vig and Kraft, 2018, Environmental Policy or Durant and Fiorino. 2017 .Environmental Governance Reconsidered: Challenges, Choices and Opportunities.

Understanding of institutions and regulatory framework for water and the environment in WI and federal government
Understanding of main water law doctrines adopted by US states
Understanding of the Great Lakes Compact
Understanding of Waters of the United States
Understanding of Agricultural Environmental Support programs such as CRP, WHIP, FSA and federal oversight
Understanding of Clean Water Act, NEPA, Clean Air Act and their synergies
Familiarize students with the history of the environmental movement
Familiarize student with the public policy process related to water laws, politics, and policy

COURSE NAME
FRSHWTR 391 Water and Natural Resource Economics

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
8. Understand the application of environmental laws, regulatory and management frameworks; and the economics of water resource use and allocation. (Analysis/Assessment, Design, Technology)

CREDITS 3

DESCRIPTION
This course provides an introduction to water and natural resource economics. Using microeconomic theory and tools, a framework for analyzing environmental management decisions is developed and applied to water and other natural resources. Topics include the efficient allocation of resources, market failures, rights of ownership, non-market valuation, and the institutions that impact management opportunities.
Potential Text: Hacket and Dissanayake, Environmental and Natural Resources

Application of supply and demand to water
Understanding of market and non-market values for water
Understanding and theoretical application of effects of market failure on water and natural resource quantity, quality, and protection
Understanding of institutions and market tool effects on resource use
Understanding of basic regulatory institutions and laws for water and natural resources at state and federal levels
Introductory understanding of economic decision tools including pareto optimality and cost-benefit analysis

COURSE NAME
FRSHWTR 361 Intro to Environmental Data Systems

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED

6. Develop the computer literacy and skills to apply big data to environmental problems. Implement models as analytical and forecasting tools. (Analysis/Assessment, Design, Technology)
7. Understand the application of monitoring and smart sensor systems in creating built and natural environmental intelligence to enhance systems management. (Discovery, Analysis/Assessment, Design, Technology)

CREDITS 3

DESCRIPTION
This course provides an introduction to how data systems are integrated and applied in freshwater sciences. Approaches to acquire, manage, and process data and use analysis outcomes to inform social-environmental problems will be discussed.

Learning Outcomes:
Understand and apply the data science lifecycle
Provide examples of opportunities and challenges in applying data systems to freshwater sciences
Describe database technologies and identify their strengths and weaknesses
Identify, access, and query databases containing information on freshwater systems
Assess the validity and quality of data
Understand key theoretical and statistical concepts to analyze complex data
Use computer resources to apply big data to environmental problems
Implement models as analytical and forecasting tools
Explain best practices for data system management

COURSE NAME
FRSHWTR 321 Exploration of Inland Seas

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED

1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)
2. Understand the nexus between biological, ecological, physical, climate and economic systems as they relate to water. (Discovery, Analysis/Assessment)
3. Understand the hydrologic cycle and the processes and interactions among atmospheric, surface and ground water components and the issues and processes related to the quality of these waters. (Discovery, Analysis/Assessment, Design)
4. Demonstrate understanding of the chemical and biogeochemical interactions of both natural and anthropogenic substances and their importance within global earth system dynamics, natural freshwater resources, and water/wastewater management systems. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 3

DESCRIPTION
The worlds large lakes, which include the Laurentian Great Lakes, African Great Lakes, and Lake Baikal (Siberia), have hydrodynamic physical properties not found for common lakes. Some of these hydrodynamic properties are related to size and are found in marine systems, but, being freshwater, there are properties due to large size that are not found in marine systems. The challenges to large lakes biota are different from those for both common lakes and marine systems, so ecosystem dynamics have properties that make these ecosystems distinctively different from common lakes and marine systems, and from each other. Topics are considered from a historical perspective, focusing on how science, management and policy have responded to fishing pressure, changes in water quality, weather conditions, and invasive species.

COURSE NAME
FRSHWTR 362 Calculating Nature

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED

6. Develop the computer literacy and skills to apply big data to environmental problems. Implement models as analytical and forecasting tools. (Analysis/Assessment, Design, Technology)
7. Understand the application of monitoring and smart sensor systems in creating built and natural environmental intelligence to enhance systems management. (Discovery, Analysis/Assessment, Design, Technology)

CREDITS 3

DESCRIPTION
The study of any environmental resource or contaminant is ultimately concerned with three questions: How much is there? Where is it going? And, how long will it last? Answering these questions requires good environmental data and the math skills needed to turn raw numbers into inventories, fluxes, and residence times. This course will examine the fundamentals of quantitative environmental analysis, including dimensional analysis, approximation, visualization, and box modeling.

COURSE NAME

FRSHWTR 341 Sanitation and Sustainability

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED

1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)

4. Demonstrate understanding of the chemical and biogeochemical interactions of both natural and anthropogenic substances and their importance within global earth system dynamics, natural freshwater resources, and water/wastewater management systems. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 3

DESCRIPTION

Microbes are integral to the integrity of water and sustainable urban centers. Topic of exploration and discussion will highlight how microbes interface with health, ecosystems and society. The Seminar will be divided up into three parts. The first weeks, we'll focus on understanding microbes in general, and how they contribute to ecosystem processes and health, particularly in urban water systems. To cover these topics, we will use chalk talks and a book club format. Important concepts such as pathogen host relationships and water quality monitoring will be covered. The second portion of the course will explore important societal issues through directed readings. Cholera and Cryptosporidium outbreaks, dead zone formation in the Gulf of Mexico and Green Bay, and Legionella and Leptospira and the link to climate change are examples of case studies for discussion and writing assignments. The last part will consist of field trips and labs, and watershed exploration (i.e. EPA surf your watershed) to directly measure some of the microbes we learned about. We will focus primarily on urban infrastructure (stormwater, wastewater, green infrastructure).

Learning Objectives:

Students will be able to recognize significant events in history shaped by infectious disease and the important contributions of renowned microbiologists

Students will understand the basic biology of microorganisms and in particular, pathogens that affect humans. Students will be able to cite examples of waterborne disease outbreaks and convey the environmental and manmade causes

Students will be able to describe different types of urban water infrastructure, how it works, types of failure, and be able to explain the long term costs and investments needed to maintain these systems to protect public health

Students will understand components of the urban water cycle, including natural and built aspects and gain hands on experience sampling urban water sites

Students will be able to describe different types of indicator bacteria used to assess water quality, and the most important attributes of an indicator organism

Students will be able to assess and interpret water quality data for rivers, beaches, and Lake Michigan and recognize causes of impairments to swimming and other recreational activities

Students will demonstrate proficiency in organizing and communicating observations, experimental findings, and interpretations through lab and field reports.

Students will demonstrate an understanding of ecosystem services offered by freshwater and explain the complex interconnected impacts urbanization has on freshwater systems

Students will be able to describe different types of green (and blue) infrastructure and explain the value of these systems to protecting water resources and enhancing the urban environment

COURSE NAME
FRSHWTR 322 Ecology and Evolution of Freshwater Organisms

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)

CREDITS 3

DESCRIPTION
This course describes the fundamental concepts of ecology and evolution in aquatic systems. Examples of population, community and ecosystem dynamics will be discussed in relationship to the physical environment. The course will discuss how populations of aquatic organisms change and evolve over time due to natural and human induced influences on aquatic systems.

Learning outcomes:
Explain ecological processes important for freshwater populations, communities and ecosystems
Describe human impacts on freshwater systems at the population, community and ecosystem level of measurement
Understand how ecological processes limit and contribute to population growth and how this is measured
Be able to describe adaptations of aquatic species that contribute to their success in the freshwater environment
Understand the concepts of biogeography and factors that impact conservation
Understand microevolution in aquatic organisms and how population genetics can change over time (mutation, natural selection, drift)
Understand quantitative genetics in freshwater organisms
Macroevolution of freshwater organisms (e.g. speciation over time)

COURSE NAME FRSHWTR 342 Water Pollution Solutions: Water Technology and Management	
PROGRAMMATIC LEARNING OUTCOMES ADDRESSED 1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication) 4. Demonstrate understanding of the chemical and biogeochemical interactions of both natural and anthropogenic substances and their importance within global earth system dynamics, natural freshwater resources, and water/wastewater management systems. (Discovery, Analysis/Assessment, Design, Technology, Communication)	
CREDITS	3
DESCRIPTION This course will provide an overview of the types of pollutants found in freshwater systems (surface and groundwater), their origin and movement. Various approaches to cleanup, water and wastewater treatment will also be discussed. **Learning outcomes:** Understand dominant urban versus agricultural pollution sources and pollutants Understanding the concepts of point-source and non-point source pollution Understand transport of the pollution into freshwater systems Understand the role of atmospheric deposition and cycling in contaminant exposures Understand dominant urban versus agricultural pollution sources and pollutants Understand concepts of transformation of pollutants Understand the mechanics of water treatment and wastewater treatment technologies Understand strategies for removal and prevention	

COURSE NAME FRSHWTR 471 Introduction to Sensing Networks	
PROGRAMMATIC LEARNING OUTCOMES ADDRESSED 5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication) 6. Develop the computer literacy and skills to apply big data to environmental problems. Implement models as analytical and forecasting tools. (Analysis/Assessment, Design, Technology)	
CREDITS	3
DESCRIPTION This course focuses on understanding of the basic principles and applications of sensing networks and big data. Topics to be covered include the introduction to sensing networks, including in-situ sensors, remote sensing, sensor network and ground-truth, principles and applications of in-situ physical, optical, chemical, and biological sensors in freshwater systems, data uncertainty, and data collection, synthesis and interpretation. Students will apply skills in programing, data formatting, and statistics to deal with visualization, uncertainties, and data report. Students will learn skills to efficiently process, integrate, analyze and visualize sensed data in freshwater environments, to link collected data with hydrological/biogeochemical/environmental processes and climate and environmental changes over different time scales, and to reveal patterns, trends, and associations relating to human-environment interactions and interactions between ecosystem components.	

COURSE NAME
FRSHWTR 421 Molecular Level Tools to Understand Larger Scale Change

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED

1. Demonstrate understanding of the complexities of life in water, the interactions with the physical surroundings and the ecological relationships between organisms and their environment. (Discovery, Communication)
2. Understand the nexus between biological, ecological, physical, climate and economic systems as they relate to water. (Discovery, Analysis/Assessment)
4. Demonstrate understanding of the chemical and biogeochemical interactions of both natural and anthropogenic substances and their importance within global earth system dynamics, natural freshwater resources, and water/wastewater management systems. (Discovery, Analysis/Assessment, Design, Technology, Communication)
5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)
7. Understand the application of monitoring and smart sensor systems in creating built and natural environmental intelligence to enhance systems management. (Discovery, Analysis/Assessment, Design, Technology)

CREDITS 3

DESCRIPTION

Scientists often use measurements of phenomena at very small scales and extrapolate to much larger scales, and vice versa. It is critical to make linkages between observations at different scales to understand systems and their complexity.

Topics will include:

Molecular scale indicators (strengths and weaknesses)
Small scale indicators (strengths and weaknesses)
Medium scale indicators (strengths and weaknesses)
Large scale indicators (strengths and weaknesses)
What is a system?
System principles and archetypes
Complex adaptive systems
Simulation and experimentation
Freshwater system influences: biological, chemical, geological, physical
Interactions between natural and anthropogenic systems
System scalability
Uncertainty

COURSE NAME
FRSHWTR 585 Applied Water Statistics and Data Manipulation

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 3

DESCRIPTION
This course offers introductory-level instruction on descriptive and inferential statistics. Students will engage with the theory and practical application of statistical concepts essential to scientific inquiry, including data distributions, correlation, random variables, confidence intervals, and hypothesis testing. Students will be exposed to real-world applications of statistics and taught to conduct analyses in the R software environment, with an emphasis on data pertaining to freshwater resources.

Learning Objectives:
Understanding of descriptive statistics, representation of information, and exploratory data analysis
Introductory understanding of experimental design
Understanding of probability theory, discrete and continuous random variables, and sampling distributions
Understanding of institutions and market tool effects on resource use
Understanding and application of hypothesis testing, one- and two-way ANOVA, simple linear regression analysis, and chi-square tests
Understanding of data management and analysis in the R software environment

COURSE NAME
FRSHWTR 661 Professional and Capstone Planning

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 1

DESCRIPTION
Description: Preparation to work and communicate with environmental professionals, agencies, or clients and develop a written proposal to solve an environmental application or problem. Leads into the Spring capstone, but will allow students to form groups along similar interests, plan any data sampling or background research and develop a proposal to conduct spring project as a team.

COURSE NAME
FRSHWTR 663 Thesis Research Planning and Proposal Development

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 1

DESCRIPTION
Description: Preparation for scientific research to be completed as part of the undergraduate thesis. This will include identifying a relevant problem, understanding appropriate approaches for data collection and analysis specific to this problem, and developing a written proposal to address this important freshwater issue. Will include review of experimental design principles including replication, randomization, and control. Leads into thesis research activities (generally in the Spring semester. Will allow students to learn as a group, as well as provide comments as part of peer review critiques during proposal development

COURSE NAME
FRSHWTR 660 Undergraduate Capstone

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 6

DESCRIPTION
The capstone project allows students to demonstrate mastery of both a specific topic and the relationship of this topic to the broader subject of Freshwater Sciences in collaboration with fellow students and professionals. The capstone project should develop analytic solutions and communicate them in both written and oral form to professionals. The capstone project serves to demonstrate and apply the multidisciplinary skills students have learned in the program.

COURSE NAME
FRSHWTR 662 Undergraduate Research and Thesis

PROGRAMMATIC LEARNING OUTCOMES ADDRESSED
5. Develop the skills to collect, analyze, interpret and communicate data and findings at multiple scales and across disciplines. This may include the ability to apply geographic information systems, systems modeling, environmental sampling, and genomics. (Discovery, Analysis/Assessment, Design, Technology, Communication)

CREDITS 6

DESCRIPTION
The thesis serves to allow a student to demonstrate mastery of both a specific topic or laboratory experiment skills in relationship to the broader subject of Freshwater Sciences. The thesis or capstone project should demonstrate the student's analytic and interpretive skills. The thesis should serve as a summative expression of a student’s ability to form, answer, and communication research on an aspect of freshwater science in depth or from a variety of disciplines.