



**UNIVERSITY OF DELAWARE**

# **GRADUATE PROGRAMS IN WATER SCIENCE & POLICY**

## **ACADEMIC PROGRAM APPLICATION**

**FEBRUARY 2011**

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## EXECUTIVE SUMMARY

Global climate change, unsustainable population growth, and widespread pollution and degradation of our natural resources are threatening the quantity and quality of water resources worldwide. Addressing these challenges require solutions that are not only scientifically sound but are socially acceptable, economically viable, and environmentally sustainable. The new program in Water Science and Policy will train students to think broadly across disciplines and simultaneously possess a depth of knowledge to address important water issues.

The Water Science and Policy Program will: (a) capitalize on existing strengths and add coherence to the existing body of water science and water policy experts; (b) provide a valuable tool to enhance graduate student recruitment; (c) help attract and retain strong faculty; (d) provide opportunities for interactions among researchers from diverse disciplines; and (e) serve as a springboard/catalyst for large-scale educational funding opportunities such as the Integrative Graduate Education and Research Traineeship (IGERT).

The graduate program in Water Science and Policy will provide three degree options: 1) a PhD, with a water science concentration (36 credits total); 2) a PhD, with a water policy concentration (36 credits); and 3) a Master of Science, with thesis (30 credits).

The program will be administrated by a Faculty Director in close coordination with the Program Committee. Faculty affiliated with the program will be able to recruit and advise students and help shape the future direction of the program. The Program Committee and the affiliated faculty include representatives from the Colleges of Agriculture and Natural Resources, Arts & Sciences, Earth, Ocean & Environment, and Engineering.

Students will be able to apply to the university-wide graduate program directly through a link provided on the university Graduate Admissions homepage. The students will be required to meet the specific qualifications of the program to be admitted and awarded the degree in Water Science & Policy. The program students will be housed in the Colleges associated with their primary advisor and the degree will be awarded by the College of residence.

The graduate program in Water Science & Policy is synergistic with other programs on campus, and draws almost entirely upon existing courses. The academic deans and chairs of Colleges and Departments involved have provided enthusiastic support to the program.

The graduate program in Water Science and Policy is well aligned with the strategic priorities at the University including an emphasis on environmental research and the University's Initiative for the Planet, all within the University's Path to Prominence.

## **PART I**

### **UNIVERSITY FACULTY SENATE FORMS**

# DOCTOR OF PHILOSOPHY IN WATER SCIENCE & POLICY

## Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

**Submitted by:** Shreeram P. Inamdar      phone number 831- 8877.

**Department:** Bioresources Engineering      email address: inamdar@UDel.Edu

**Action:** Request for New Doctor of Philosophy Degree in Water Science & Policy.

(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

**Effective term** 11F  
(use format 04F, 05W)

**Current degree** N/A  
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

**Proposed change leads to the degree of:** PhD  
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

**Proposed name:** Doctor of Philosophy in Water Science & Policy  
Proposed new name for revised or new major / minor / concentration / academic unit  
(If applicable)

## Revising or Deleting:

**Undergraduate major / Concentration:** N/A  
(Example: Applied Music – Instrumental degree BMAS)

**Undergraduate minor:** N/A  
(Example: African Studies, Business Administration, English, Leadership, etc.)

**Graduate Program Policy statement change:** N/A  
(**Must attach** your Graduate Program Policy Statement)

**Graduate Program of Study:** PhD Water Science and Policy  
(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

**Graduate minor /concentration:** Water Science Concentration, Water Policy Concentration

**Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.**

**List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?**

(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter “None”)

None

**Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education:** <http://www.ugs.udel.edu/gened/>

N/A

**Identify other units affected by the proposed changes:**

(Attach permission from the affected units. If no other unit is affected, enter "None")

College of Agriculture & Natural Resources  
Department of Bioresources Engineering  
Department of Plant & Soil Sciences  
Department of Food & Resource Economics  
College of Arts & Sciences:  
Department of Chemistry & Biochemistry  
School of Public Policy & Administration  
Department of Political Science & International Relations  
College of Earth, Ocean & Environment  
Department of Geography  
Department of Geological Sciences  
School of Marine Science and Policy  
College of Engineering  
Center for Energy and Environmental Policy  
Department of Civil & Environmental Engineering  
Department of Chemical Engineering  
Department of Mechanical Engineering

**Describe the rationale for the proposed program change(s):**

(Explain your reasons for creating, revising, or deleting the curriculum or program.)

Global climate change, unsustainable population growth, and widespread pollution and degradation of our natural resources are putting immense pressure on the supply and quality of our water resources. Addressing these complex challenges and finding solutions will require a comprehensive, integrated and interdisciplinary approach. Not only do we have to address the physical, chemical and biological aspects of these problems but also make sure that the proposed solutions are socially acceptable, economically viable, and environmentally sustainable. The National Science Foundation, National Academy of Sciences, Congressional Research Service, USGS, NOAA, and USEPA have all concluded that a new interdisciplinary education and research approach is needed that integrates science and policy to address society's emerging challenges in water sustainability. An interdisciplinary graduate program in Water Science and Policy at the University of Delaware would address this challenge by training students and professionals who can think broadly across disciplines and simultaneously possess a depth of knowledge to address important water issues.

While there are many experts in the fields of water sciences and policy at the University of Delaware they are dispersed throughout several Colleges and Departments on campus. There is no coordinated body or program that unifies this group and provides a means to maximize collaborative research and education. An interdisciplinary Water Science and Policy Program would: (a) capitalize on existing strengths of the University and add coherence to the existing body of water science and water policy experts; (b) provide a valuable tool to enhance graduate student recruitment; (c) help attract and retain strong faculty; (d) provide opportunities for interactions among researchers from diverse disciplines; and (e) serve as a springboard/catalyst for large-scale educational funding opportunities such as the Integrative Graduate Education and Research Traineeship (IGERT).

A graduate program in Water Science and Policy is well aligned with the strategic priorities at the University, including an emphasis on environmental research, the plans underway to hire six to eight environmentally focused faculty, and the University's *Initiative for the Planet*, all within the University's *Path to Prominence*.

**Table 1. PhD Program Requirements: Water Science & Policy**

PhD in Water Science & Policy (36 Credits)			
Course Areas	Water Science Concentration	Water Policy Concentration	
Water Science	9 Credits	3 Credits	
Water Policy	3 Credits	9 Credits	
Research Methods	3 Credits	3 Credits	
Statistics, Analysis & Techniques	3 Credits	3 Credits	
Directed Rsch/Special Prob./Internship/Independent Study	9 Credits	9 Credits	
Dissertation	9 Credits	9 Credits	
<div>Science Courses</div> <div>Water Science Concentr. Students (9) [Select at least 3 credits from each category.]</div> <div>Water Policy Concentr. Students (3) [Select one course from physical or chemical/biological science.)</div>	a) Physical Sciences		
	BREG 623 Advanced Storm water Management		
	CIEG 698 Groundwater Flow and Contaminant Transport		
	GEOG 632 Environmental Hydrology		
	GEOG 656 Hydroclimatology		
	GEOG 651 Microclimatology (4)		
	GEOL 628 Hydrogeology		
	GEOL 611 Fluvial Geomorphology		
	PLSC 603 Soil Physics		
	b) Chemical/Biological Sciences		
	BREG 621 Nonpoint source pollution		
	BREG 667 Watershed Hydrochemistry		
	CHEM/MAST 683 Environmental Chemistry		
	CIEG 632 Chemical Aspects of Environmental Engineering		
	CIEG 636 Biological aspects of Environmental Engineering		
	CIEG 668 Principles of Water Quality Criteria		
	GEOG 631 Watershed Ecology		
	GEOG 667 Watershed Hydro-Ecology		
	PLSC 608/CHEM 608 Environmental Soil Chemistry		
		c) Policy	
	<div>Policy Courses</div> <div>Water Science Concentr. Students (3) [Select one course.]</div> <div>Water Policy Concentr. Students (9) [Select three courses.]</div>	ENEP 626 Climate Change: Science, Policy and Political Economy	
		ENEP 666 Topics in Sustainable Development	
ENEP 810 Political Economy of the Environment			
ENEP 868 Sustainable Water Policy Research			
ENEP 870 Sustainable Water Policy Readings			
GEOG 617 Seminar in Climate Change			
GEOG 649 Environment & Society			
MAST 672/ECON 670 Applied Policy Analysis			
MAST/ECON 867 Valuing the Environment			
MAST 670 US Ocean and Coastal Policy			
MAST/ECON 676 Environmental Economics			
MAST/UAPP 663 Decision Tools for Policy Analysis			
POSC 818 Environmental Politics and Policy			
UAPP 611 Regional Watershed Management			
UAPP/ENEP 617 Contemp. Issues in Environmental and Energy Policy (1)			
UAPP 628 Issues in Land Use and Environmental Planning			
UAPP 667 Field Seminar in Water Policy			
Research Methods Courses (3)		d) Research Methods	
	PLSC 667 Research Methods and Topics in Water Science & Policy (2)		
	PLSC 667 Interdisciplinary Seminar (1)		
<div>Statistics, Analysis &amp; Techniques (3) [Select three credits from the category Statistics, Analysis &amp; Techniques]</div>	e) Statistics, Analysis & Techniques:		
	CHEG 604 Probability and Statistics for Engineering Problem Solving		
	FREC/STAT 608 Statistical Research Methods		
	FREC 615 Advanced Prices and Statistics		
	FREC/STAT 674 Applied Database Management		
	FREC 807 Mathematical Programming with Economic Applications		
	GEOG 671 Advanced Geographic Information Systems		
	MAST 681 Remote Sensing of Environment		
	MEEG 690 Intermediate Engineering Mathematics		
	STAT 657 Statistics for Earth Sciences		
	STAT 675 Logistic Regression		
	UAPP 816 Advanced Social Statistics		
	UAPP 691 Quantitative Analysis in Public & NP Sectors		
	UAPP 652 Geographic Information Systems in Public Policy (1)		
Directed Research/Special Problem/Internship/Independent Study (9)			
Dissertation (9)			



## ROUTING AND AUTHORIZATION

(Please do not remove supporting documentation.)

Department Chairperson \_\_\_\_\_ Date \_\_\_\_\_

Dean of College \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, College Curriculum Committee \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, Senate Com. on UG or GR Studies \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, Senate Coordinating Com. \_\_\_\_\_ Date \_\_\_\_\_

Secretary, Faculty Senate \_\_\_\_\_ Date \_\_\_\_\_

Date of Senate Resolution \_\_\_\_\_ Date to be Effective \_\_\_\_\_

Registrar \_\_\_\_\_ Program Code \_\_\_\_\_ Date \_\_\_\_\_

Vice Provost for Academic Affairs & International Programs \_\_\_\_\_ Date \_\_\_\_\_

Provost \_\_\_\_\_ Date \_\_\_\_\_

Board of Trustee Notification \_\_\_\_\_ Date \_\_\_\_\_

# MASTER OF SCIENCE IN WATER SCIENCE & POLICY

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**Effective term** 11F  
(Use format 04F, 05W)

**Current degree** N/A  
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

**Proposed change leads to the degree of:** MS  
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

**Proposed name:** Master of Science in Water Science & Policy  
Proposed new name for revised or new major / minor / concentration / academic unit  
(If applicable)

### Revising or Deleting:

**Undergraduate major / Concentration:** N/A  
(Example: Applied Music – Instrumental degree BMAS)

**Undergraduate minor:** N/A  
(Example: African Studies, Business Administration, English, Leadership, etc.)

**Graduate Program Policy statement change:** N/A  
(**Must attach** your Graduate Program Policy Statement)

**Graduate Program of Study:** MS Water Science and Policy  
(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

**Graduate minor /concentration:** n/a

**Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.**

**List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?**

(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter “None”)

None

**Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education:** <http://www.ugs.udel.edu/gened/>

N/A

**Identify other units affected by the proposed changes:**

(Attach permission from the affected units. If no other unit is affected, enter "None")

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Department of Bioresources Engineering  
Department of Plant & Soil Sciences  
Department of Food & Resource Economics  
College of Arts & Sciences:  
Department of Chemistry & Biochemistry  
School of Public Policy & Administration  
Department of Political Science & International Relations  
College of Earth, Ocean & Environment  
Department of Geography  
Department of Geological Sciences  
School of Marine Science and Policy  
College of Engineering  
Center for Energy and Environmental Policy  
Department of Chemical Engineering  
Department of Civil & Environmental Engineering  
Department of Mechanical Engineering

**Describe the rationale for the proposed program change(s):**

(Explain your reasons for creating, revising, or deleting the curriculum or program.)

Global climate change, unsustainable population growth, and widespread pollution and degradation of our natural resources are putting immense pressure on the supply and quality of our water resources. Addressing these complex challenges and finding solutions will require a comprehensive, integrated and interdisciplinary approach. Not only do we have to address the physical, chemical and biological aspects of these problems but also make sure that the proposed solutions are socially acceptable, economically viable, and environmentally sustainable. The National Science Foundation, National Academy of Sciences, Congressional Research Service, USGS, NOAA, and USEPA have all concluded that a new interdisciplinary education and research approach is needed that integrates science and policy to address society's emerging challenges in water sustainability. An interdisciplinary graduate program in Water Science and Policy at the University of Delaware would address this challenge by training students and professionals who can think broadly across disciplines and simultaneously possess a depth of knowledge to address important water issues.

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A graduate program in Water Science and Policy is well aligned with the strategic priorities at the University, including an emphasis on environmental research, the plans underway to hire six to eight environmentally focused faculty, and the University's *Initiative for the Planet*, all within the University's *Path to Prominence*.

**Table 2. Master of Science Program Requirements: Water Science & Policy**

<b>MS in Water Science &amp; Policy (30 Credits)</b>	
Credit Hours Total	
Water Science, Policy, Statistics & Analysis	24 Credits
Thesis	6 Credits
<b>MS in Water Science &amp; Policy – Course Curriculum</b>	
Select 24 credits, with at least 3 credits from each category.	<b>a) Physical Sciences</b>
	BREG 623 Advanced Storm water Management
	CIEG 698 Groundwater Flow and Contaminant Transport
	GEOG 632 Environmental Hydrology
	GEOG 656 Hydroclimatology
	GEOG 651 Microclimatology (4)
	GEOL 628 Hydrogeology
	GEOL 611 Fluvial Geomorphology
	PLSC 603 Soil Physics
	<b>b) Chemical/Biological Sciences</b>
	BREG 621 Nonpoint source pollution
	BREG 667 Watershed Hydrochemistry
	CHEM/MAST 683 Environmental Chemistry
	CIEG 632 Chemical Aspects of Environmental Engineering
	CIEG 636: Biological aspects of environmental engineering
	CIEG 668 Principles of Water Quality Criteria
	GEOG 631 Watershed Ecology
	GEOG 667 Watershed Hydro-Ecology
	PLSC 608/CHEM 608 Environmental Soil Chemistry
	<b>c) Policy</b>
	ENEP 626 Climate Change: Science, Policy and Political Economy
	GEOG 617 – Seminar in Climate Change
	GEOG 649 – Environment & Society
	MAST 672/ECON 670 Applied Policy Analysis
	MAST/ECON 867 Valuing the Environment
	MAST 670 US Ocean and Coastal Policy
	MAST/ECON 676 Environmental Economics
	MAST/UAPP 663 Decision Tools for Policy Analysis
	POSC 818 Environmental Politics and Policy
	UAPP 611 Regional Watershed Management
	UAPP/ENEP 617 Contemp. Issues in Environmental and Energy Policy (1)
	UAPP 628 Issues in Land Use and Environmental Planning
	UAPP 667 Field Seminar in Water Policy
	<b>d) Research Methods in Water Science &amp; Policy</b>
	PLSC 667 Research Methods and Topics in Water Science & Policy (2)
	PLSC 667 Interdisciplinary Seminar (1)
	<b>e) Statistics &amp; Analysis:</b>
	CHEG 604 Probability and Statistics for Engineering Problem Solving
	FREC/STAT 608 Statistical Research Methods
	FREC 615 Advanced Prices and Statistics
	FREC/STAT 674 Applied Database Management
	FREC 807 Mathematical Programming with Economic Applications
	GEOG 671 Advanced Geographic Information Systems
	MAST 681 – Remote Sensing of Environment
	MEEG 690 Intermediate Engineering Mathematics
	STAT 657 Statistics for Earth Sciences
	STAT 675 Logistic Regression
	UAPP 816 Advanced Social Statistics
	UAPP 691 Quantitative Analysis in Public & NP Sectors
	UAPP 652 Geographic Information Systems in Public Policy (1)
<b>Directed Research Option (3)</b> With advisor approval, MS students may opt to carry out directed research, in lieu of one course, within categories a, b, or c above.	
<b>Thesis (6)</b>	

## ROUTING AND AUTHORIZATION

(Please do not remove supporting documentation.)

Department Chairperson \_\_\_\_\_ Date \_\_\_\_\_

Dean of College \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, College Curriculum Committee \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, Senate Com. on UG or GR Studies \_\_\_\_\_ Date \_\_\_\_\_

Chairperson, Senate Coordinating Com. \_\_\_\_\_ Date \_\_\_\_\_

Secretary, Faculty Senate \_\_\_\_\_ Date \_\_\_\_\_

Date of Senate Resolution \_\_\_\_\_ Date to be Effective \_\_\_\_\_

Registrar \_\_\_\_\_ Program Code \_\_\_\_\_ Date \_\_\_\_\_

Vice Provost for Academic Affairs & International Programs \_\_\_\_\_ Date \_\_\_\_\_

Provost \_\_\_\_\_ Date \_\_\_\_\_

Board of Trustee Notification \_\_\_\_\_ Date \_\_\_\_\_

## **PART II**

### **RESOLUTION STATEMENTS**

# PROVISIONAL APPROVAL OF NEW PROGRAMS -- RESOLUTION

## DOCTOR OF PHILOSOPHY IN WATER SCIENCE AND POLICY

WHEREAS, the proposed *Doctor of Philosophy in Water Science and Policy* provides a new interdisciplinary graduate course of study in a critical area of 21<sup>st</sup> century environmental science, engineering and policy and is key to our understanding of complex local, regional and national water challenges, impacting the science and technology of fields ranging from agricultural, energy and environmental sciences to social sciences and law, and

WHEREAS, the proposed *Doctor of Philosophy in Water Science and Policy* will allow students with strong environmental science, engineering or policy backgrounds to develop depth and breadth of expertise in understanding water-related challenges through research and experience in developing solutions through the study of biological, chemical, geological, social and economic systems, and

WHEREAS, the proposed program builds upon the research strength, education resources and research infrastructure from Departments across the Colleges of Agriculture & Natural Resources, Arts & Sciences, Engineering, Earth, Ocean and Environment, as well as from the Delaware Environmental Institute, and

WHEREAS, the proposed program contributes to the scholarly and educational missions of the University—to disseminate scientific, humanistic, and social knowledge for the benefit of the larger society and to produce graduates who are prepared to contribute to a global society, addressing the critical needs of the state, nation and global community, and

WHEREAS, the proposed program fosters multi- and interdisciplinary research and educational collaboration across campus, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences, and serving as a pillar of UD's *Path to Prominence*, be it therefore

RESOLVED, that the Faculty Senate approves provisionally, for five years, the establishment of a new program leading to the *Doctor of Philosophy in Water Science and Policy* effective September 1, 2011.

# PROVISIONAL APPROVAL OF NEW PROGRAMS -- RESOLUTION

## MASTER OF SCIENCE IN WATER SCIENCE AND POLICY

WHEREAS, the proposed *Master of Science in Water Science and Policy* provides a new interdisciplinary graduate course of study in a critical area of 21<sup>st</sup> century environmental science, engineering and policy and is key to our understanding of complex local, regional and national water challenges, impacting the science and technology of fields ranging from agricultural, energy and environmental sciences to social sciences and law, and

WHEREAS, the proposed *Master of Science in Water Science and Policy* will allow students with strong environmental science, engineering or policy backgrounds to develop depth and breadth of expertise in understanding water-related challenges through research and experience in developing solutions through the study of biological, chemical, geological, social and economic systems, and

WHEREAS, the proposed program builds upon the research strength, education resources and research infrastructure from Departments across the Colleges of Agriculture & Natural Resources, Arts & Sciences, Earth, Ocean and Environment, and Engineering, as well as from the Delaware Environmental Institute, and

WHEREAS, the proposed program contributes to the scholarly and educational missions of the University—to disseminate scientific, humanistic, and social knowledge for the benefit of the larger society and to produce graduates who are prepared to contribute to a global society, addressing the critical needs of the state, nation and global community, and

WHEREAS, the proposed program fosters multi- and interdisciplinary research and educational collaboration across campus, providing a critical component to University's strategic priorities in energy, environment, and life and health sciences, and serving as a pillar of UD's *Path to Prominence*, be it therefore

RESOLVED, that the Faculty Senate approves provisionally, for five years, the establishment of a new program leading to the *Master of Science in Water Science and Policy* effective September 1, 2011.



## **PART III**

### **PROGRAM POLICY STATEMENT**

## I. PROGRAM HISTORY

### A. RATIONALE

Global climate change, unsustainable population growth, and widespread pollution and degradation of our natural resources are putting immense pressure on the supply and quality of our water resources. Addressing these complex challenges and finding solutions will require a comprehensive, integrated and interdisciplinary approach. Not only must society address the physical, chemical and biological aspects of these problems; society must also ensure that the proposed solutions are socially acceptable, economically viable, and environmentally sustainable. The National Science Foundation, National Academy of Sciences, Congressional Research Service, USGS, NOAA, and USEPA have all concluded that a new interdisciplinary education and research approach is needed that integrates science and policy to address society's emerging challenges in water sustainability. The interdisciplinary graduate program in Water Science and Policy at the University of Delaware is focused on these challenges by training students and professionals who can think broadly across disciplines and simultaneously possess a depth of knowledge to address important water issues.

The graduate program in Water Science and Policy reflects the strategic priorities at the University of Delaware, including an emphasis on environmental research and sustainability, the growing number of environmentally focused faculty, and the University's *Initiative for the Planet*, all within the University's *Path to Prominence*.

The vision is a university-wide graduate program that will attract students to many departments and colleges across the campus. The students will be located within individual departments and will work with individual advisors who are affiliated with the program. The students are required to meet the specific requirements of the program to be awarded the degree in Water Science & Policy.

The graduate program in Water Science & Policy is synergistic with other programs on campus, and draws entirely upon existing courses. All students in the Water Science & Policy program take a team-taught course, entitled "Research Methods and Topics in Water Science and Policy" that involves both field and lab experiences, as well as a companion one-credit seminar series.

The academic deans and chairs of Colleges and Departments involved have provided their support to establish a cross-college program. Water Science & Policy will be administered in the College of Agriculture & Natural Resources; Dr. Shreeram Inamdar, Associate Professor of Bioresources Engineering is faculty program director.

The availability of high quality water to sustain human activities and ecosystem health is among the most critical global challenges of the 21<sup>st</sup> century, given pressures on water resources due to climate change, contaminants, population growth, hydropolitics, conservation issues and infrastructure challenges. Solutions to complex problems of water quantity and quality will require both scientific understanding and implementation through effective policy. Scientists, engineers and policy experts need to understand and predict the interactions of Earth's water system with climate change, land use, the built environment and ecosystem function and services. They will need to determine how the built water systems and our governance systems can be made more reliable, resilient and sustainable in the face of diverse and often conflicting needs.

Despite its name, the Earth is a water planet. However, pressure on water resources is growing, increasing the need for understanding water availability, quality and dynamics. The impacts of climate change and human activity have created an urgent need for experts who bring both depth and breadth of experience, and a systemic perspective to the science and policy of water at the local, regional, national, and international scales.

The program in Water Science and Policy at the University of Delaware is designed to meet this increasing national and international demand for interdisciplinary water experts and to provide students with an

educational opportunity that crosses traditional disciplinary and organizational boundaries. Due to the interdisciplinary nature of water sciences and policy, experts in these fields within the University of Delaware are housed in many Colleges and Departments and affiliated centers and institutes on campus; thus, the faculty affiliated with the program may be in one of several science, engineering or social science disciplines.

The Water Science & Policy program aims to train the next generation of researchers and professionals who will play key roles in protecting and managing a vital resource, and who will play a key role in multi- and interdisciplinary teams, bridging physical, chemical, biological and policy sciences. The program is administered through the College of Agriculture & Natural Resources, and the scientific curriculum builds upon the research and educational strengths of departments across the Colleges of Agriculture & Natural Resources, Arts & Sciences, Earth, Ocean & Environment, and Engineering. Water Science & Policy is an essential 21<sup>st</sup> century environmental thrust in academia, industry, and government, and affects public policy decisions across the globe.

## **B. DEGREES OFFERED**

Three degree options are offered: 1) the PhD in Water Science & Policy, Water Science Concentration; 2) the PhD in Water Science & Policy, Water Policy Concentration; and 3) the Master of Science in Water Science & Policy.

Doctoral students in the Water Science Concentration complete course requirements and carry out research that emphasizes science and engineering, but that provides exposure to policy tools and processes. Doctoral students in the Water Policy Concentration complete course requirements and carry out research that emphasizes economics and public policy, but that provides exposure to relevant science and engineering areas. Students in both Concentrations will have the opportunity to pursue directed research, a special problem, independent study or internship as part of required work.

The Master of Science option in Water Science and Policy prepares students to carry out advanced research at the doctoral level, or to take professional positions requiring graduate level preparation.

## **II. ADMISSION**

### **A. ADMISSION REQUIREMENTS**

Admission to graduate programs is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

To be admitted to the graduate program applicants should meet the following requirements:

1. A completed University of Delaware Graduate Studies application. In the application, prospective students should indicate clearly whether they are applying for the MS or the Ph.D. program (select the Water Science or the Water Policy concentration). Students may apply to the program prior to arranging for a faculty advisor; however, all students in the program will need the agreement of a program faculty member to serve as advisor for admission to the program.
2. A personal statement is required in the Graduate Studies application, and should discuss the following questions:
  - a. What are your specific research and educational goals?

- b. What are your long-term professional career objectives?
  - c. How do you see this program assisting you with achieving your objectives?
  - d. What is the name of the faculty member (affiliated with the program) who has agreed to be advisor?
3. Graduate Record Examination Scores are required (a minimum of 1050 on the VERBAL and QUANTITATIVE is desirable). Subject GRE scores are not required.
4. Official, up-to-date transcripts of all undergraduate and graduate programs. A minimum of 3.0/4.0 is required in the major.
5. Three letters of recommendation from individuals knowledgeable of the applicant's academic preparation and potential ability as a graduate student.
6. International students must take the Test of English as a Foreign Language (TOEFL) (Minimum Score: 550 paper test, 213 computer test or 79 on Internet-based tests.) TOEFL scores more than two years old cannot be considered official.

A graduate student applicant must, at the time of admission, have a faculty advisor who has agreed to direct and advise a program of study.

Applicants for the Ph.D. program will typically have an M.S. degree in a related field. Direct admission to the Ph.D. program immediately after a B.S. degree will only be considered for exceptionally qualified candidates, as determined by the Program Committee. These candidates will, however, have to complete all the course requirements associated with the Water Science and Policy M.S. program prior to starting the Ph.D. curriculum. Prior graduate coursework (a maximum of 9 credit hours) will be considered toward Ph.D. course requirements, with the approval of the Program Committee.

### **Change of Classification and Transfer Students**

Students that are currently matriculated in other degree programs should complete a “Change of Classification” Form to seek approval to be admitted into the Water Science and Policy Program. The Program Committee will evaluate the change in classification and transfer requests on a case-by case basis to determine if the applicant will need to complete a full application form submitted to the Office of Graduate and Professional Education. All transfer students will still have to meet the requirements listed above.

### **C. Application Deadlines**

Admission decisions are made on a rolling basis as and when applications are complete. The application deadlines are:

- Fall Semester: July 1<sup>st</sup> (regular application); March 1<sup>st</sup> (financial aid)
- Spring Semester: December 1<sup>st</sup> (regular application); October 1<sup>st</sup> (financial aid)

### III. ACADEMIC

#### A. DEGREE REQUIREMENTS

##### 1. COURSE REQUIREMENTS SUMMARY

###### a. PhD Program Requirements: Water Science & Policy

<b>PhD in Water Science &amp; Policy (36 Credits)</b>		
Course Areas	Water Science Concentration	Water Policy Concentration
Water Science	9 Credits	3 Credits
Water Policy	3 Credits	9 Credits
Research Methods	3 Credits	3 Credits
Statistics, Analysis & Techniques	3 Credits	3 Credits
Directed Research/Special Problem/Internship/Independent Study	9 Credits	9 Credits
Dissertation	9 Credits	9 Credits

###### b. Master of Science Program Requirements: Water Science & Policy

<b>MS in Water Science &amp; Policy (30 Credits)</b>	
Credit Hours Total	
Water Science, Policy, Research Methods, Statistics & Analysis	24 Credits
Thesis	6 Credits

##### 2. CURRICULUM

The tables below list the course curriculum for the major components of the graduate program in Water Science & Policy. Some courses may be offered at both the 400- and 600- levels. A student who has completed a course at the 400-level may not take the same course at the 600-level for credit toward the graduate degree.

**Table 1. PhD Program Requirements: Water Science & Policy**

PhD in Water Science & Policy (36 Credits)			
Course Areas	Water Science Concentration	Water Policy Concentration	
Water Science	9 Credits	3 Credits	
Water Policy	3 Credits	9 Credits	
Research Methods	3 Credits	3 Credits	
Statistics, Analysis & Techniques	3 Credits	3 Credits	
Directed Rsch/Special Prob./Internship/Independent Study	9 Credits	9 Credits	
Dissertation	9 Credits	9 Credits	
<div>Science Courses</div> <div>Water Science Concentr. Students (9) [Select at least 3 credits from each category.]</div> <div>Water Policy Concentr. Students (3) [Select one course from physical or chemical/biological science.)</div>	a) Physical Sciences		
	BREG 623 Advanced Storm water Management		
	CIEG 698 Groundwater Flow and Contaminant Transport		
	GEOG 632 Environmental Hydrology		
	GEOG 656 Hydroclimatology		
	GEOG 651 Microclimatology (4)		
	GEOL 628 Hydrogeology		
	GEOL 611 Fluvial Geomorphology		
	PLSC 603 Soil Physics		
	b) Chemical/Biological Sciences		
	BREG 621 Nonpoint source pollution		
	BREG 667 Watershed Hydrochemistry		
	CHEM/MAST 683 Environmental Chemistry		
	CIEG 632 Chemical Aspects of Environmental Engineering		
	CIEG 636 Biological aspects of Environmental Engineering		
	CIEG 668 Principles of Water Quality Criteria		
	GEOG 631 Watershed Ecology		
	GEOG 667 Watershed Hydro-Ecology		
	PLSC 608/CHEM 608 Environmental Soil Chemistry		
		c) Policy	
	<div>Policy Courses</div> <div>Water Science Concentr. Students (3) [Select one course.]</div> <div>Water Policy Concentr. Students (9) [Select three courses.]</div>	ENEP 626 Climate Change: Science, Policy and Political Economy	
		ENEP 666 Topics in Sustainable Development	
ENEP 810 Political Economy of the Environment			
ENEP 868 Sustainable Water Policy Research			
ENEP 870 Sustainable Water Policy Readings			
GEOG 617 Seminar in Climate Change			
GEOG 649 Environment & Society			
MAST 672/ECON 670 Applied Policy Analysis			
MAST/ECON 867 Valuing the Environment			
MAST 670 US Ocean and Coastal Policy			
MAST/ECON 676 Environmental Economics			
MAST/UAPP 663 Decision Tools for Policy Analysis			
POSC 818 Environmental Politics and Policy			
UAPP 611 Regional Watershed Management			
UAPP/ENEP 617 Contemp. Issues in Environmental and Energy Policy (1)			
UAPP 628 Issues in Land Use and Environmental Planning			
UAPP 667 Field Seminar in Water Policy			
Research Methods Courses (3)		d) Research Methods	
	PLSC 667 Research Methods and Topics in Water Science & Policy (2)		
	PLSC 667 Interdisciplinary Seminar (1)		
<div>Statistics, Analysis &amp; Techniques (3) [Select three credits from the category Statistics, Analysis &amp; Techniques]</div>	e) Statistics, Analysis & Techniques:		
	CHEG 604 Probability and Statistics for Engineering Problem Solving		
	FREC/STAT 608 Statistical Research Methods		
	FREC 615 Advanced Prices and Statistics		
	FREC/STAT 674 Applied Database Management		
	FREC 807 Mathematical Programming with Economic Applications		
	GEOG 671 Advanced Geographic Information Systems		
	MAST 681 Remote Sensing of Environment		
	MEEG 690 Intermediate Engineering Mathematics		
	STAT 657 Statistics for Earth Sciences		
	STAT 675 Logistic Regression		
	UAPP 816 Advanced Social Statistics		
	UAPP 691 Quantitative Analysis in Public & NP Sectors		
	UAPP 652 Geographic Information Systems in Public Policy (1)		
Directed Research/Special Problem/Internship/Independent Study (9)			
Dissertation (9)			

**Table 2. M.S. Requirements**

<b>MS in Water Science &amp; Policy – Course Curriculum (30 credits)</b>	
<p><b>Select 24 credits, with at least 3 credits from each category.</b></p>	<b>a) Physical Sciences</b>
	BREG 623 Advanced Storm water Management
	CIEG 698 Groundwater Flow and Contaminant Transport
	GEOG 632 Environmental Hydrology
	GEOG 656 Hydroclimatology
	GEOG 651 Microclimatology (4)
	GEOL 628 Hydrogeology
	GEOL 611 Fluvial Geomorphology
	PLSC 603 Soil Physics
	<b>b) Chemical/Biological Sciences</b>
	BREG 621 Nonpoint source pollution
	BREG 667 Watershed Hydrochemistry
	CHEM/MAST 683 Environmental Chemistry
	CIEG 632 Chemical Aspects of Environmental Engineering
	CIEG 636 Biological aspects of Environmental Engineering
	CIEG 668 Principles of Water Quality Criteria
	GEOG 631 Watershed Ecology
	GEOG 667 Watershed Hydro-Ecology
	PLSC 608/CHEM 608 Environmental Soil Chemistry
	<b>c) Policy</b>
	ENEP 626 Climate Change: Science, Policy and Political Economy
	ENEP 666 Topics in Sustainable Development
	ENEP 810 Political Economy of the Environment
	ENEP 868 Sustainable Water Policy Research
	ENEP 870 Sustainable Water Policy Readings
	GEOG 617 Seminar in Climate Change
	GEOG 649 Environment & Society
	MAST 672/ECON 670 Applied Policy Analysis
	MAST/ECON 867 Valuing the Environment
	MAST 670 US Ocean and Coastal Policy
	MAST/ECON 676 Environmental Economics
	MAST/UAPP 663 Decision Tools for Policy Analysis
	POSC 818 Environmental Politics and Policy
	UAPP 611 Regional Watershed Management
	UAPP/ENEP 617 Contemp. Issues in Environmental and Energy Policy (1)
	UAPP 628 Issues in Land Use and Environmental Planning
	UAPP 667 Field Seminar in Water Policy
	<b>d) Research Methods</b>
	PLSC 667 Research Methods and Topics in Water Science & Policy (2)
	PLSC 667 Interdisciplinary Seminar (1)
	<b>e) Statistics, Analysis &amp; Techniques:</b>
	CHEG 604 Probability and Statistics for Engineering Problem Solving
	FREC/STAT 608 Statistical Research Methods
	FREC 615 Advanced Prices and Statistics
	FREC/STAT 674 Applied Database Management
	FREC 807 Mathematical Programming with Economic Applications
	GEOG 671 Advanced Geographic Information Systems
	MAST 681 Remote Sensing of Environment
	MEEG 690 Intermediate Engineering Mathematics
	STAT 657 Statistics for Earth Sciences
<b>Directed Research Option (3)</b> With advisor approval, MS students may opt to carry out directed research, in lieu of one course, within categories a, b, or c above.	
<b>Thesis (6)</b>	

## B. COMMITTEES AND DIRECTOR

The development, administration and progress assessment of the overall graduate program in Water Science & Policy will be guided by the Program Director, Dr. Shreeram Inamdar, and the Program Committee, as outlined below.

Table 3. Water Science & Policy Program Committee

Member	College	Department	Expertise
Inamdar, Shreeram Program Director	Agriculture & Natural Resources	Bioresources Engineering	Hydrology and Biogeochemistry of watersheds; sustainable watershed management
Claessens, Luc	Earth, Ocean & Environment	Geography	Hydrology and ecosystem processes; biogeochemistry; water resources engineering
Duke, Joshua	Agriculture & Natural Resources	Food and Resource Economics	Land use, natural resource and environmental economics; law and economics; property rights
Imhoff, Paul	Engineering	Civil & Environmental Engineering	Transport of fluids and contaminants in multiphase systems; mass transfer processes in soil, groundwater, surface water, and in landfills; and mathematical modeling.
Kauffman, Gerald	Arts & Sciences	School of Public Policy & Administration	Water supply, water quality, policy, droughts and floods. Watershed planning/mgt.
Leathers, Daniel	Earth, Ocean & Environment	Geography	Meteorology, Hydrology, Water Resources, Climate Change and Variation
Levia, Delphis	Earth, Ocean & Environment	Geography	Ecohydrology, forest biogeochemistry, snow science, field methods and instrumentation.
Michael, Holly	Earth, Ocean & Environment	Geology	Groundwater-surface water interaction in dynamic coastal systems; water in developing countries; geostatistical modeling
Sparks, Donald	Agriculture & Natural Resources	Plant and Soil Sciences	How contaminants, (e.g., metals) bind to soils and move into water; remediation strategies for contaminated soils.

### B.1. WATER SCIENCE & POLICY PROGRAM COMMITTEE

The Program Committee will oversee admissions and advise the development and progress assessment of the graduate program in Water Science & Policy. The committee consists of faculty members from all participating Colleges in this degree program.

### B.2. DIRECTOR

The Director of the graduate program in Water Science & Policy will be responsible for the overall implementation, quality and progress of the degree program, advised by the Program Committee.



## **C. SATISFACTORY PROGRESS**

### **C.1. FACULTY ADVISOR**

Students are required to choose an appropriate Faculty Advisor from a list of affiliated faculty members participating in the degree program. Master of Science students may have an appropriate Faculty Advisor appointed by the Director of the graduate program in Water Science & Policy. The participating faculty members are faculty approved by the Program Committee to advise students and/or serve as research mentors or co-mentors.

The Faculty Advisor will be the primary contact of the student for questions and advice. The student will develop a plan of study for the program with the Faculty Advisor before the beginning of the second semester. The Director of the graduate program in Water Science & Policy will verify that the student has completed the requirements for the program and will approve the application for the degree upon successful completion of the requirements.

### **C.2. ACADEMIC LOAD**

Full-time students are expected to complete the MS program (30 credits) within two years. The program may be completed over a longer time frame for part-time students. Students in the Ph.D. program (36 credits) will typically complete the program in four to six years.

Students enrolled in at least 9 credit hours or in sustaining credit are considered full-time students. Those enrolled for fewer than 9 credit hours are considered part-time students, although students holding assistantships are considered full-time with six credits. Generally, a maximum load is 12 graduate credit hours; however, additional credit hours may be taken with the approval of the student's adviser and the Office of Graduate and Professional Education. A maximum course load in either summer or winter session is 7 credit hours. Permission must be obtained from the Office of Graduate and Professional Education to carry an overload in any session.

### **C.3. TRANSFERABILITY**

Previous graduate level courses (a maximum of 9 credit hours) will be considered toward completion of Ph.D. course requirements, subject to approval by the Program Committee.

### **C.4. MASTER'S DEGREE REQUIREMENTS**

#### **M.S. Requirements**

The development of a program of study will be the joint responsibility of the student in consultation with the major advisor. The student will select a three-person thesis committee that includes the student's major advisor and one other member from the Water Science and Policy program. The two program members should be from different concentrations (i.e., one each from the Water Science and Water Policy groups). The thesis committee needs to be established before the beginning of the student's second semester in the program. The names of the thesis committee members should be submitted to the Program Committee for approval.

M.S. Thesis students must complete 24 credit hours of course work and 6 credit hours of thesis (a total of 30 credits). Specific course requirements for the M.S. in Water Science and Policy are described above in Section B, Course Curriculum. All full-time MS students are required to complete the degree requirements in six semesters or fewer. Students are expected to write and successfully defend the thesis to receive the degree.

Advancement to degree candidacy is contingent upon successful completion and presentation of the thesis proposal. The thesis proposal should be presented to the Thesis Committee for approval within the first two semesters in the program. The completed thesis will be presented to the Thesis Committee in typewritten form at least two weeks before the scheduled oral defense. The oral defense of the student thesis will be publicly announced and all program members will be notified at least one week prior to the defense date.

The maximum time for the completion of the MS program is 5 years from the time of entry.

## **C.5. PH.D. REQUIREMENTS**

### **Ph.D. Requirements**

The development of a program of study will be the joint responsibility of the student in consultation with the graduate advisor. The student will select a five-person Dissertation Committee that includes the student's major advisor and at least one other faculty member from the Water Science and Policy program. The two program members should be from different disciplines (i.e., one each from the Water Science and Water Policy groups). The Dissertation Committee needs to be established within the first year of study in the program. The names of the Committee members should be submitted to the Program Committee for approval.

Ph.D. students must complete 18 credit hours of course work, plus 9 credit hours of research, and 9 credit hours of thesis (a total of 36 credits). Specific course requirements for the Water Science and the Water Policy concentrations are described above in Section B, Course Curriculum. Students must maintain a minimum of 3.0 cumulative GPA in order to receive the degree. Course with a grade below a C will not be counted towards the degree. The program of study must be submitted before the end of the first year to the graduate advisor for approval. Previous graduate-level coursework will be considered toward Ph.D. course requirements, subject to the approval of the Program Committee.

The qualifying examination will include written and oral portions. The student's graduate advisor will chair and administer the exam and the content of the exam (written and oral) will be decided jointly by the student's Dissertation Committee. The exam will be graded by the Dissertation Committee and each member of the committee will provide a single grade (including written and oral sections) of PASS or FAIL. A failure in the exam will result in dismissal from the PhD program. Upon successful completion of the qualifying exam, the student is certified as a candidate for the doctoral degree. The graduate advisor will notify the Program Committee on the result of the qualifying exam.

Upon the recommendation of the Dissertation Committee the student may be admitted to candidacy for the Ph.D. degree. The stipulations for admission to doctoral candidacy are that the student has (1) had a program of study approved, (2) completed one academic year of full-time graduate study in residence at the University, (3) passed the program's qualifying examination, (4) demonstrated the ability to do research, and (5) had a research project accepted by the Dissertation Committee.

The student must submit a research proposal prior to initiating dissertation research. A pre-proposal should be prepared within the first year and should be shared with the Dissertation Committee (preferably at the time of formation of the committee). A formal, more detailed, proposal should be developed and submitted to the Dissertation Committee for approval. After approval by the Dissertation Committee, the Program Committee will be notified and a copy of the proposal will be placed in the program records.

The final examination of the PhD degree will involve approval of the written dissertation and an oral defense of the candidate's dissertation. The written dissertation will be submitted to the Dissertation Committee and the Water Science & Policy Program office at least three weeks in advance of the oral defense date. The oral defense date will be publicly announced at least two weeks prior to the scheduled date. The oral presentation will be open to the public and all members of the Water Science and Policy program. The Dissertation

Committee will approve the candidate's dissertation. The student and graduate advisor will be responsible for making all corrections to the dissertation document and for meeting all Graduate School deadlines for submission.

The maximum time for the completion of the PhD program is 10 years from the time of entry.

#### **C.6. GRADE REQUIREMENTS**

Only graduate courses completed with a grade of B- or higher count towards the requirements of the MS and PhD program in Water Sciences and Policy. Students must obtain at least a 3.0 cumulative grade point average in the courses in the curriculum to receive the degree.

#### **C.7. CONSEQUENCES OF UNSATISFACTORY ACADEMIC PROGRESS**

The Water Science & Policy Program Committee will meet at least once each semester to evaluate each student's progress. If a student is failing to make satisfactory progress towards a degree, the committee will recommend suitable action to the Director of the graduate program in Water Science & Policy. Possible actions include (but are not limited to): (i) requirement for additional courses, (ii) suspension of financial support, and (iii) recommendation for dismissal.

#### **C.8. STANDARDS OF STUDENT CONDUCT**

All graduate students are subject to University of Delaware regulations regarding academic honesty. Violations of the UD regulations regarding academic honesty or other forms of gross misconduct may result in immediate dismissal from the Program.

#### **C.9. DISMISSAL**

The procedures for dismissal as detailed in the University Catalog will be followed. Briefly, the Graduate Committee will report its recommendation and reason for dismissal to the Director of the Water Science and Policy program. The Director will make a recommendation to the Office of Graduate Studies, who will decide whether to dismiss the student. The student may appeal this decision to the Office of Graduate Studies, following the procedure given in the University Catalog.

#### **C.10. GRADUATE STUDENT GRIEVANCE PROCEDURES**

Students who feel that they have been graded inappropriately or receive what they perceive as an unfair evaluation by a faculty member may file grievances in accordance with University of Delaware policies. Students are encouraged to contact the Director of the graduate program in Water Science & Policy prior to filing a formal grievance in an effort to resolve the situation informally.

#### **C.11. ATTENDANCE AT CONFERENCES AND PROFESSIONAL MEETINGS**

The Water Science & Policy program encourages students to attend conferences and professional meetings. They provide opportunities to meet future employers and colleagues, and can offer specialized training beyond course work.

## IV. FINANCIAL AID

### A. FINANCIAL AWARDS

Admission to the graduate program in Water Science & Policy does not automatically entitle an applicant to financial aid. Students may seek financial aid opportunities, such as fellowships or scholarships from sources within the University and from private and federal agencies. Interested students should check the Office of Graduate Studies website for the most current opportunities.

Financial aid is awarded on a competitive basis from the pool of admitted applicants. The University of Delaware's policies apply to all forms of financial aid. Please refer to the University Policies for Graduate Student Assistantships and Fellowships.

Students in the Water Science and Policy program may apply for Graduate Assistantships:

**Research Assistantships (RAs)** are generally funded by research grants and contracts provided by external funding agencies. Students may be supported as an RA through their Faculty Advisor's research funds after their first year. A research assistantship provides full tuition and a stipend. The RA's advisor is responsible for defining the student's responsibilities and for evaluating the student's performance. The amount of service or research may vary from week to week but the average is usually expected to be 20 hours per week.

**Teaching Assistantships (TAs)** are offered for graduate students to perform teaching and other instructional activities by individual departments. The amount of service may vary from week to week but the average is usually expected to be 20 hours per week. A teaching assistantship provides full tuition and a stipend. Award of TA will be decided by the primary advisor and their department.

Preference for graduate student stipends will be given to students in the PhD Program. Students receiving full stipends will be expected to work 20 hours per week on faculty projects and students are expected to maintain full-time status.

### B. CONTINUATION OF FINANCIAL AID

Students who are awarded financial aid must maintain satisfactory academic progress with satisfactory performance of assistantship duties (when applicable). Satisfactory academic progress includes registering for a minimum of 9 graduate-level credits each Fall and Spring semester, and maintaining a minimum cumulative 3.0 GPA.

The Faculty Advisor will establish the RA's responsibilities and performance standards. In the event of an unsatisfactory performance by an RA, the advisor will notify the student and the Program Committee at least four weeks prior to terminating the assistantship.

The Director of the course in which the student teaches will establish the TA's responsibilities and performance standards. In the event of an unsatisfactory performance by a TA, the Course Director will notify the student and the Program Committee of the academic department offering the course. The Committee may recommend termination of the assistantship to the Department Chair.

## **PART III**

## **PROPOSAL**

## I. DESCRIPTION

Global climate change, unsustainable population growth, and widespread pollution and degradation of our natural resources are putting immense pressure on the supply and quality of our water resources. Addressing these complex challenges and finding solutions will require a comprehensive, integrated and interdisciplinary approach. Not only do we have to address the physical, chemical and biological aspects of these problems but also make sure that the proposed solutions are socially acceptable, economically viable, and environmentally sustainable. The National Science Foundation, National Academy of Sciences, Congressional Research Service, USGS, NOAA, and USEPA have all concluded that a new interdisciplinary education and research approach is needed that integrates science and policy to address society's emerging challenges in water sustainability. An interdisciplinary graduate program in Water Science and Policy at the University of Delaware would address this challenge by training students and professionals who can think broadly across disciplines and simultaneously possess a depth of knowledge to address important water issues.

A graduate program in Water Science and Policy is well aligned with the strategic priorities at the University, including an emphasis on environmental research, the plans underway to hire six to eight environmentally focused faculty, and the University's *Initiative for the Planet*, all within the University's *Path to Prominence*.

The vision is a university-wide graduate program that will attract students to many departments across the campus. The students will be located within individual departments and will work with their individual advisors who will also be affiliated with the program. The students will be required to meet the specific qualifications of the program to be awarded the degree in Water Science & Policy.

The graduate program in Water Science & Policy is synergistic with other programs on campus, and draws almost entirely upon existing courses. An experimental, team-taught course is included, entitled "Research Methods in Water Science and Policy" that would involve field and lab experiences, as well as a companion one-credit seminar series.

The academic deans and chairs of Colleges and Departments involved have provided their enthusiastic support to establish a cross-college program. Water Science & Policy will be housed in the College of Agriculture & Natural Resources. Dr. Shreeram Inamdar, Associate Professor, Department of Bioresources Engineering, has been selected as faculty program director by the program committee. CANR will also provide administrative support to the program director to help manage day-to-day program requirements.

The availability of high quality water to sustain human activities and ecosystem health is among the most critical global challenges of the 21<sup>st</sup> century, given pressures on water resources due to climate change, contaminants, population growth, hydropolitics, conservation issues and infrastructure challenges. Solutions to complex problems of water quantity and quality will require both scientific understanding and implementation through effective policy. Scientists, engineers and policy experts need to understand and predict the interactions of Earth's water system with climate change, land use, the built environment and ecosystem function and services. They will need to determine how the built water systems and our governance systems can be made more reliable, resilient and sustainable in the face of diverse and often conflicting needs.

Despite its name, the Earth is a water planet. However, pressure on water resources is growing, increasing the need for understanding water availability, quality and dynamics. The impacts of climate change and human activity have created an urgent need for experts who bring both depth and breadth of experience, and a systemic perspective to the science and policy of water at the local, regional, national, and international scales.

The program in Water Science and Policy at the University of Delaware is designed to meet this increasing national and international demand for interdisciplinary water experts and to provide students with an educational opportunity that crosses traditional disciplinary and organizational boundaries. Due to the

interdisciplinary nature of water sciences and policy, experts in these fields within the University of Delaware are housed in many Colleges and Departments and affiliated centers and institutes on campus; thus, the faculty affiliated with the program may be in one of several science, engineering or social science disciplines.

An ensemble of three degree options is proposed; 1) the PhD in Water Science & Policy, Water Science Concentration; 2) the PhD in Water Science & Policy, Water Policy Concentration; and 3) the Master of Science in Water Science & Policy.

Doctoral students in the Water Science Concentration complete course requirements and carry out research that emphasizes science and engineering, but that provides exposure to policy tools and processes. Doctoral students in the Water Policy Concentration complete course requirements and carry out research that emphasizes economics and public policy, but that provides exposure to relevant science and engineering areas. Students in both Concentrations will have the opportunity to pursue directed research, a special problem, independent study or internship as part of required work.

Master of Science students in Water Science & Policy complete a set of course requirements involving both science and policy, and complete a thesis.

The Water Science & Policy program aims to train the next generation of researchers and professionals who will play a key role in multi- and interdisciplinary teams, bridging physical, chemical, biological and policy sciences. The program will be administered through its academic home, the College of Agriculture & Natural Resources. The scientific curriculum will build upon the research and educational strength from departments across the Colleges of Agriculture & Natural Resources, Arts & Sciences, Business and Economics, Earth, Ocean & Environment, and Engineering. The program will be synergistic with existing degree programs, providing a critical component to University's strategic priority in environmental research and education, its *Initiative for the Planet*, and serving as a pillar of UD's *Path to Prominence*.

## **II. RATIONALE AND DEMAND**

While there are many experts in the fields of water sciences and policy at the University of Delaware they are dispersed throughout several Colleges and Departments on campus. There is no coordinated body or program that unifies this group and provides a means to maximize collaborative research and education.

The University of Delaware currently does not offer a specialized graduate degree in Water Science & Policy, although related courses have been taught in several schools and departments for a number of years. We propose to develop a graduate program in Water Science & Policy, encompassing the PhD, with both a Water Science and Water Policy concentration, and a Master of Science, with thesis. The rationale for the program:

- Water Science & Policy is an essential 21<sup>st</sup> century environmental thrust in academia, industry, and government, and affects public policy decisions across the globe;
- The program will build upon research strengths and infrastructure at the University of Delaware in departments across the Colleges of Agriculture & Natural Resources, Arts & Sciences, Earth, Ocean & Environment, and Engineering. The program will capitalize on existing strengths of the University and add coherence to the existing body of water science and water policy experts.
- An interdisciplinary graduate program in Water Science & Policy will enhance graduate student recruitment and help to attract and retain strong faculty.
- A cross-college program in Water Science & Policy will provide opportunities for interactions among researchers from diverse disciplines.
- The program will provide a foundation for large-scale educational funding opportunities such as the National Science Foundation Integrative Graduate Education and Research Traineeship (IGERT).

- The program will offer graduate education in a discipline essential for UD as a major research university, providing a critical component within the University’s strategic priorities in energy, environment, and life and health sciences. Indeed the program aligns with the University strategic plan to “*engage closely with the critical issues of our day, to increase the global impact of the University, and to raise its prominence in the world.*”

## **A. INSTITUTIONAL FACTORS**

### **A.1. COMPATIBILITY WITH UNIVERSITY ACADEMIC PRIORITIES**

A strong educational program in Water Science & Policy will contribute to the scholarly and educational missions of the University—to *disseminate scientific, humanistic, and social knowledge for the benefit of the larger society* and to produce graduates who *are prepared to contribute to a global society, addressing the critical needs of the state, nation and global community.*

### **A.2. PLANNING PROCESS**

In the fall of 2010, a faculty working group requested the support of the Delaware Environmental Institute (DENIN) to develop the interdisciplinary Water Science & Policy graduate program. The faculty working group brought strong science, engineering and policy expertise, and included representatives from four colleges: Agriculture and Natural Resources, Arts & Sciences, Earth, Ocean & Environment, and Engineering. DENIN staff Jeanette Miller and Amy Broadhurst facilitated working sessions, synthesized discussion, recruited group members across colleges, coordinated with Graduate & Professional Studies and helped to develop the proposal with the Water Science & Policy group for approval by University leadership.

The working group selected Dr. Shreeram Inamdar, Associate Professor, Department of Bioresources Engineering, to serve as the Program Director, and established a Water Science & Policy Program Committee to oversee program admissions, advising and progress assessment of students.

The resulting plan offers both academic rigor as well as flexibility for students and faculty advisors to tailor the program to research interests and career objectives. The graduate program in Water Science & Policy is proposed with three degree options: 1) the PhD, with a water science concentration; 2) the PhD, with a water policy concentration; and 3) the Master of Science, with thesis.



**Table 1.** Water Science & Policy Program Committee

Member	College	Department	Expertise
Claessens, Luc	Earth, Ocean & Environment	Geography	Hydrology and ecosystem processes; biogeochemistry; water resources engineering
Duke, Joshua	Agriculture & Natural Resources	Food and Resource Economics	Land use, natural resource and environmental economics; law and economics; property rights
Imhoff, Paul	Engineering	Civil & Environmental Engineering	Transport of fluids and contaminants in multiphase systems; mass transfer processes in soil, groundwater, surface water, and in landfills; and mathematical modeling.
Inamdar, Shreeram (Program Director)	Agriculture & Natural Resources	Bioresources Engineering	Hydrology and Biogeochemistry of watersheds; sustainable watershed management
Kauffman, Gerald	Arts & Sciences	School of Public Policy & Administration	Water supply, water quality, policy, droughts and floods. Watershed planning/mgt.
Leathers, Daniel	Earth, Ocean & Environment	Geography	Meteorology, Hydrology, Water Resources, Climate Change and Variation
Levia, Delphis	Earth, Ocean & Environment	Geography	Ecohydrology, forest biogeochemistry, snow science, field methods and instrumentation.
Michael, Holly	Earth, Ocean & Environment	Geology	Groundwater-surface water interaction in dynamic coastal systems; water in developing countries; geostatistical modeling
Sparks, Donald	Agriculture & Natural Resources	Plant and Soil Sciences	How contaminants, (e.g., metals) bind to soils and move into water; remediation strategies for contaminated soils.

### **A.3. SIGNIFICANT IMPACT ON OTHER UNIVERSITY PROGRAMS**

The positive impact of the proposed Water Science & Policy Program on University research and educational programs is multi-fold:

- It will offer interdisciplinary graduate education in an area essential for the University of Delaware as a major research university.
- It capitalizes on existing strengths at the University by synergizing related areas of expertise across colleges;
- It will create a context for faculty from the various participating disciplines across-campus to articulate the interface of their research and foster research collaborations;
- It will produce graduate students with knowledge and professional expertise in water science and policy, who can play a key role in multi- and interdisciplinary teams;
- The educational program, coupled with collaborative interdisciplinary research, will provide a solid foundation for University of Delaware to compete for training grants (such as NSF's IGERT-Integrative Graduate Education and Research Traineeship Program) and research grants from multiple federal agencies;
- The graduate program in Water Science & Policy builds a foundation for a future Professional Science Master's Program, a potential source of revenue for the University.

### **A.4. UTILIZATION OF EXISTING RESOURCES**

With strong programs in engineering, environmental science, economics, and public administration the University of Delaware provides an outstanding venue for educational programs in Water Science and Policy. The proposed curricula fully leverage the course offerings from the following departments/units across Colleges. Letters of approval from contributing department/units are attached in the appendices to this document.

College of Agriculture & Natural Resources  
Department of Bioresources Engineering  
Department of Plant & Soil Sciences  
Department of Food & Resource Economics  
College of Arts & Sciences:  
Department of Chemistry & Biochemistry  
School of Public Policy & Administration  
Department of Political Science & International Relations  
College of Earth, Ocean & Environment  
Department of Geography  
Department of Geological Sciences  
School of Marine Science and Policy  
College of Engineering  
Center for Energy and Environmental Policy  
Department of Chemical Engineering  
Department of Civil & Environmental Engineering  
Department of Mechanical Engineering

## **B. STUDENT DEMAND**

### **B.1. ENROLLMENT PROJECTIONS**

We project that we will have a steady increase in new students entering the Water Science & Policy Program, and will reach 10 new students per year in the steady state.

A full-time student is expected to complete the MS program (30 credits) within two years. The MS program may be completed over a longer time frame for part-time students. Doctoral students are expected to complete the program (36 credits) in four years.

### **B.2. NEEDS OF STUDENT CLIENTELES**

The graduate program in Water Science & Policy degree addresses the needs of a range of students. The program offers both academic rigor as well as flexibility, to meet the needs and interests of students and their faculty advisors. With a Master's degree option, and two Ph.D. concentrations, focusing on science or policy, students with a strong interest in water can complete a graduate degree well tailored to their career goals.

## **C. TRANSFERABILITY**

Previous graduate level courses (a maximum of 9 credit hours) can be considered toward completion of Ph.D. course requirements, subject to approval by the Program Committee.

## **D. ACCESS TO GRADUATE AND PROFESSIONAL PROGRAMS**

The graduate program in Water Science & Policy will prepare students for rewarding careers in the public, private and academic sectors. MS students will have excellent prospects in the public and private sectors, and will be well positioned to continue graduate studies at the doctoral level. Ph.D. students will be prepared to carry out interdisciplinary research, including through careers in academia.

## **E. DEMAND AND EMPLOYMENT FACTORS**

The graduate program in Water Science & Policy will be attractive to students because it prepares them for challenging careers in an expanding field. The US Bureau of Labor Statistics (BLS) 2010-2011 *Occupational Outlook Handbook* predicts employment growth of 18 percent for geoscientists and hydrologists between 2008 and 2018, faster than the average for all occupations. BLS further predicts increasing demand in the public and private sector for technical assistance and environmental management and planning expertise. Critical needs include monitoring the quality of the environment, including soil and water contamination and sea level rise. Research is needed to develop informatics, models and other predictive tools that can synthesize high-volume and heterogeneous data sources, and that draw upon multiple disciplines to make nuanced, data-driven policies. US demographic trends will also drive demand, as populations increase in environmentally sensitive coastal ecosystems, for example. ([http://www.bls.gov/oco/ocos312.htm#projections\\_data](http://www.bls.gov/oco/ocos312.htm#projections_data))

## **F. REGIONAL, STATE AND NATIONAL FACTORS**

### **F.1. COMPARABLE COURSES OF STUDY IN THE REGION OR STATE**

While there are a few graduate programs in Hydrologic and Water Sciences across the United States (see list in appendix) there is no such program in the Mid-Atlantic region. This is especially surprising considering that large-scale anthropogenic land use changes (e.g., increasing population and conversion of agricultural and forest lands to urbanizing landscapes) in this region are having tremendous impacts on our region's waters. The poor water quality of the Chesapeake Bay and its impact on the Bay food web is an excellent example. Furthermore, the Bay also provides a classic case study of how water quality management may impact social, economic and policy decisions and vice-versa. Thus, a graduate program in Water Science and Policy is urgently needed and is well positioned to address the increasing challenges associated with water resources in our region.

We believe that the UD graduate program in Water Science & Policy will emerge as a highly competitive educational opportunity based on: (i) a strong interdisciplinary curriculum, (ii) proximity to both a large number of environmental consulting firms and US government agencies, (iii) rich opportunities for thesis research projects and immersive internships.

### **F.2. EXTERNAL REQUIREMENTS**

We note that there are no formal guidelines for an interdisciplinary program in Water Science & Policy, nor are there accreditation standards. The proposed curriculum was designed based on a careful review of hydrology and policy curricula offered by other institutions. We have closely examined offered programs at selected, prominent research universities, and have recognized needs from both the student and employer perspectives. The proposed curriculum compiles the information gathered from these resources into one carefully tailored program.

## **G. OTHER STRENGTHS**

### **G.1. SPECIAL FEATURES**

A special feature of the proposed program is the close collaboration among participating faculty who conceived of and developed this interdisciplinary graduate program. Going forward, this collaboration will continue in the form of the governing body, the Program Committee.

The University of Delaware offers superb laboratory, informatics, library, environmental sensing and shared core instrumentation facilities. Delaware is ideally located near government agencies and NGOs in Washington, DC and New York.

The program faculty also solicited input from their own graduate students on the direction and framework for this program. Thus, many of the ideas developed and proposed in this program come from the students themselves!

In addition to academia, this program will also encourage faculty and student interactions with other water professionals in research institutions, local, state and federal governments (e.g., Delaware Geological Survey, US Geological Survey, US Fish and Wildlife Service, etc.) as well as private industry. Such exchanges would not only broaden and enrich the educational experience of students and faculty but also help develop partnerships that will be beneficial to the future professional development of the students.

Many of the program faculty have strong and fruitful international projects and collaborations. Partnerships also include institutions associated with the United Nations. Students will be encouraged to use these opportunities to conduct research and/or internships at these international institutions and locations.

Program faculty will also facilitate and encourage student interactions with regional environmental organizations and agencies such as the Chesapeake Bay Program (CBP). This exchange will occur via seminars, workshops, and study tours.

## **G.2. COLLABORATIVE ARRANGEMENTS**

No collaborative arrangement is required.

# **III. ENROLLMENT, ADMISSIONS AND FINANCIAL AID**

## **A. ENROLLMENT**

There is no need to limit enrollment due to resources. Enrollment is estimated at 10 new students per academic year in the steady state. Based on the entrance requirements and specified prerequisites, students may enroll in the program with a regular status or provisional status:

- **Regular status** is offered to students who meet all of the established entrance requirements, who have a record of high scholarship in their fields of specialization, and who have the ability, interest, and maturity necessary for successful study at the graduate level in a degree program.
- **Provisional status** is offered to students who are seeking admission to a degree program but with deficiencies in their backgrounds, as determined by the faculty Program Committee. The deficiencies are ordinarily remedied by satisfactory performance in a course in the specific area of the deficiency. Satisfactory performance in the areas of deficiency stipulated in the letter of provisional admission will result in a change of status from provisional to regular status.

## **B. ADMISSION REQUIREMENTS**

Admission to graduate programs is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

To be admitted to the graduate program applicants should meet the following requirements:

1. A completed University of Delaware Graduate Studies application. In the application, prospective students should indicate clearly whether they are applying for the MS or the Ph.D. program (select the Water Science or the Water Policy concentration). Students may apply to the program prior to arranging for a faculty advisor; however, all students in the program will need the agreement of a program faculty member to serve as advisor for admission to the program.
2. A personal statement is required in the Graduate Studies application, and should discuss the following questions:
  - a. What are your specific research and educational goals?
  - b. What are your long-term professional career objectives?
  - c. How do you see this program assisting you with achieving your objectives?

- d. What is the name of the faculty member (affiliated with the program) who has agreed to be advisor?
3. Graduate Record Examination Scores are required (a minimum of 1050 on the VERBAL and QUANTITATIVE is desirable). Subject GRE scores are not required.
4. Official, up-to-date transcripts of all undergraduate and graduate programs. A minimum of 3.0/4.0 is required in the major.
5. Three letters of recommendation from individuals knowledgeable of the applicant's academic preparation and potential ability as a graduate student.
6. International students must take the Test of English as a Foreign Language (TOEFL) (Minimum Score: 550 paper test, 213 computer test or 79 on Internet-based tests.) TOEFL scores more than two years old cannot be considered official.

A graduate student applicant must, at the time of admission, have a faculty advisor who has agreed to direct and advise a program of study.

Applicants for the Ph.D. program will typically have an M.S. degree in a related field. Direct admission to the Ph.D. program immediately after a B.S. degree will only be considered for exceptionally qualified candidates, as determined by the Program Committee. These candidates will, however, have to complete all the course requirements associated with the Water Science and Policy M.S. program prior to starting the Ph.D. curriculum. Prior graduate coursework will be considered toward Ph.D. course requirements, with the approval of the Program Committee.

### **Change of Classification and Transfer Students**

Students that are currently matriculated in other degree programs should complete a “Change of Classification” Form to seek approval to be admitted into the Water Science and Policy Program. The Program Committee will evaluate the change in classification and transfer requests on a case-by case basis to determine if the applicant will need to complete a full application form submitted to the Office of Graduate and Professional Education. All transfer students will still have to meet the requirements listed above.

### **Application Deadlines**

Admission decisions are made on a rolling basis as and when applications are complete. The application deadlines are:

- Fall Semester: July 1<sup>st</sup> (regular application); March 1<sup>st</sup> (financial aid)
- Spring Semester: December 1<sup>st</sup> (regular application); October 1<sup>st</sup> (financial aid)

## **C. FINANCIAL ASSISTANCE**

Financial assistance for students in the program is available on a competitive basis. Preference for graduate student stipends will be given to students in the PhD Program, followed by students in the MS program. Students receiving full stipends will be expected to work 20 hours per week on faculty projects and students are expected to maintain full-time status.

## **IV. Curriculum Specifics**

### **M.S. Requirements**

The development of a program of study will be the joint responsibility of the student in consultation with the major advisor. The student will select a three-person thesis committee that includes the student's major advisor and one other member from the Water Science and Policy program. The two program members should be from different concentrations (i.e., one each from the Water Science and Water Policy groups). The names of the thesis committee members should be submitted to the Program Committee for approval.

M.S. students must complete 24 credit hours of course work and 6 credit hours of thesis (a total of 30 credits). Students must maintain a minimum of 3.0 cumulative GPA in order to receive the degree. Courses with a grade below a C will not be counted toward the degree. All full-time MS students are required to complete the degree requirements in six semesters or fewer. Students are expected to write and successfully defend the thesis to receive the degree.

Advancement to degree candidacy is contingent upon successful completion and presentation of the thesis proposal. The thesis proposal should be presented to the Thesis Committee for approval within the first two semesters in the program. The completed thesis will be presented to the Thesis Committee in typewritten form at least two weeks before the scheduled oral defense. The oral defense of the student thesis will be publicly announced and all program members will be notified at least one week prior to the defense date.

The maximum time for the completion of the MS program is 5 years from the time of entry.

### **Ph.D. Requirements**

The development of a program of study will be the joint responsibility of the student in consultation with the graduate advisor. The student will select a five-person Dissertation Committee that includes the student's major advisor and at least one other faculty member from the Water Science and Policy program. The two program members should be from different disciplines (i.e., one each from the Water Science and Water Policy groups). The Dissertation Committee needs to be established within the first year of study in the program. The names of the Committee members should be submitted to the Program Committee for approval.

Ph.D. students must complete 18 credit hours of course work, plus 9 credit hours of research, and 9 credit hours of thesis (a total of 36 credits). Specific course requirements for the Water Science and the Water Policy concentrations are described below in Section IV, Curriculum Requirements. Students must maintain a minimum of 3.0 cumulative GPA in order to receive the degree. Course with a grade below a C will not be counted towards the degree. The program of study must be submitted before the end of the first year to the graduate advisor for approval.

The qualifying examination should be taken before the end of the fourth semester and will include written and oral portions. The student's graduate advisor will chair and administer the exam and the content of the exam (written and oral) will be decided jointly by the student's Dissertation Committee. The exam will be graded by the Dissertation Committee and each member of the committee will provide a single grade (including written and oral sections) - PASS or FAIL. A failure in the exam will result in dismissal from the PhD program.

Upon successful completion of the qualifying exam, the student is certified as a candidate for the doctoral degree. The graduate advisor will notify the Program Committee on the result of the qualifying exam.

Upon the recommendation of the Dissertation Committee the student may be admitted to candidacy for the Ph.D. degree. The stipulations for admission to doctoral candidacy are that the student has (1) had a program of study approved, (2) completed one academic year of full-time graduate study in residence at the University, (3) passed the program's qualifying examination, (4) demonstrated the ability to do research, and (5) had a research project accepted by the Dissertation Committee.

The student must submit a research proposal prior to initiating dissertation research. A pre-proposal should be prepared within the first year and should be shared with the Dissertation Committee (preferably at the time of formation of the committee). A formal, more detailed, proposal should be developed and submitted to the Dissertation Committee for approval. After approval by the Dissertation Committee, the Program Committee will be notified and a copy of the proposal will be placed in the program records.

The final examination of the PhD degree will involve approval of the written dissertation and an oral defense of the candidate's dissertation. The written dissertation will be submitted to the Dissertation Committee and the Water Science & Policy Program office at least three weeks in advance of the oral defense date. The oral defense date will be publicly announced at least two weeks prior to the scheduled date. The oral presentation will be open to the public and all members of the Water Science and Policy program. The Dissertation Committee will approve the candidate's dissertation. The student and graduate advisor will be responsible for making all corrections to the dissertation document and for meeting all Graduate School deadlines for submission. A copy (electronic and printed hard copy) of the final completed dissertation should be provided to the program office for records.

The maximum time for the completion of the PhD program is 10 years from the time of entry.



**Table 2. PhD Program Requirements: Water Science & Policy**

PhD in Water Science & Policy (36 Credits)		
Course Areas	Water Science Concentration	Water Policy Concentration
Water Science	9 Credits	3 Credits
Water Policy	3 Credits	9 Credits
Research Methods	3 Credits	3 Credits
Statistics, Analysis & Techniques	3 Credits	3 Credits
Directed Rsch/Special Prob./Internship/Independent Study	9 Credits	9 Credits
Dissertation	9 Credits	9 Credits
<div><div>Science Courses</div><div><div>Water Science Concentr. Students (9) [Select at least 3 credits from each category.]</div><div>Water Policy Concentr. Students (3) [Select one course from physical or chemical/biological science.)</div></div></div>	<b>a) Physical Sciences</b>	
	BREG 623 Advanced Storm water Management	
	CIEG 698 Groundwater Flow and Contaminant Transport	
	GEOG 632 Environmental Hydrology	
	GEOG 656 Hydroclimatology	
	GEOG 651 Microclimatology (4)	
	GEOL 628 Hydrogeology	
	GEOL 611 Fluvial Geomorphology	
	PLSC 603 Soil Physics	
	<b>b) Chemical/Biological Sciences</b>	
	BREG 621 Nonpoint source pollution	
	BREG 667 Watershed Hydrochemistry	
	CHEM/MAST 683 Environmental Chemistry	
	CIEG 632 Chemical Aspects of Environmental Engineering	
	CIEG 636 Biological aspects of Environmental Engineering	
	CIEG 668 Principles of Water Quality Criteria	
	GEOG 631 Watershed Ecology	
	GEOG 667 Watershed Hydro-Ecology	
	PLSC 608/CHEM 608 Environmental Soil Chemistry	
	<b>c) Policy</b>	
	ENEP 626 Climate Change: Science, Policy and Political Economy	
	ENEP 666 Topics in Sustainable Development	
	ENEP 810 Political Economy of the Environment	
	ENEP 868 Sustainable Water Policy Research	
	ENEP 870 Sustainable Water Policy Readings	
	GEOG 617 Seminar in Climate Change	
	GEOG 649 Environment & Society	
	MAST 672/ECON 670 Applied Policy Analysis	
	MAST/ECON 867 Valuing the Environment	
MAST 670 US Ocean and Coastal Policy		
MAST/ECON 676 Environmental Economics		
MAST/UAPP 663 Decision Tools for Policy Analysis		
POSC 818 Environmental Politics and Policy		
UAPP 611 Regional Watershed Management		
UAPP/ENEP 617 Contemp. Issues in Environmental and Energy Policy (1)		
UAPP 628 Issues in Land Use and Environmental Planning		
UAPP 667 Field Seminar in Water Policy		
<b>Research Methods Courses (3)</b>	<b>d) Research Methods</b>	
	PLSC 667 Research Methods and Topics in Water Science & Policy (2)	
	PLSC 667 Interdisciplinary Seminar (1)	
<div><div>Statistics, Analysis &amp; Techniques (3) [Select three credits from the category Statistics, Analysis &amp; Techniques]</div></div>	<b>e) Statistics, Analysis &amp; Techniques:</b>	
	CHEG 604 Probability and Statistics for Engineering Problem Solving	
	FREC/STAT 608 Statistical Research Methods	
	FREC 615 Advanced Prices and Statistics	
	FREC/STAT 674 Applied Database Management	
	FREC 807 Mathematical Programming with Economic Applications	
	GEOG 671 Advanced Geographic Information Systems	
	MAST 681 Remote Sensing of Environment	
	MEEG 690 Intermediate Engineering Mathematics	
	STAT 657 Statistics for Earth Sciences	
	STAT 675 Logistic Regression	
	UAPP 816 Advanced Social Statistics	
	UAPP 691 Quantitative Analysis in Public & NP Sectors	
	UAPP 652 Geographic Information Systems in Public Policy (1)	
Directed Research/Special Problem/Internship/Independent Study (9)		
Dissertation (9)		

**Table 3. Master of Science Program Requirements: Water Science & Policy**

<b>MS in Water Science &amp; Policy (30 Credits)</b>	
Credit Hours Total	
Water Science, Policy, Statistics & Analysis	24 Credits
Thesis	6 Credits
<p><b>Select 24 credits, with at least 3 credits from each category.</b></p>	<b>a) Physical Sciences</b>
	BREG 623 Advanced Storm water Management
	CIEG 698 Groundwater Flow and Contaminant Transport
	GEOG 632 Environmental Hydrology
	GEOG 656 Hydroclimatology
	GEOG 651 Microclimatology (4)
	GEOL 628 Hydrogeology
	GEOL 611 Fluvial Geomorphology
	PLSC 603 Soil Physics
	<b>b) Chemical/Biological Sciences</b>
	BREG 621 Nonpoint source pollution
	BREG 667 Watershed Hydrochemistry
	CHEM/MAST 683 Environmental Chemistry
	CIEG 632 Chemical Aspects of Environmental Engineering
	CIEG 636 Biological aspects of Environmental Engineering
	CIEG 668 Principles of Water Quality Criteria
	GEOG 631 Watershed Ecology
	GEOG 667 Watershed Hydro-Ecology
	PLSC 608/CHEM 608 Environmental Soil Chemistry
	<b>c) Policy</b>
	ENEP 626 Climate Change: Science, Policy and Political Economy
	ENEP 666 Topics in Sustainable Development
	ENEP 810 Political Economy of the Environment
	ENEP 868 Sustainable Water Policy Research
	ENEP 870 Sustainable Water Policy Readings
	GEOG 617 Seminar in Climate Change
	GEOG 649 Environment & Society
	MAST 672/ECON 670 Applied Policy Analysis
	MAST/ECON 867 Valuing the Environment
	MAST 670 US Ocean and Coastal Policy
	MAST/ECON 676 Environmental Economics
	MAST/UAPP 663 Decision Tools for Policy Analysis
	POSC 818 Environmental Politics and Policy
	UAPP 611 Regional Watershed Management
	UAPP/ENEP 617 Contemp. Issues in Environmental and Energy Policy (1)
	UAPP 628 Issues in Land Use and Environmental Planning
	UAPP 667 Field Seminar in Water Policy
	<b>d) Research Methods</b>
	PLSC 667 Research Methods and Topics in Water Science & Policy (2)
	PLSC 667 Interdisciplinary Seminar (1)
	<b>e) Statistics, Analysis &amp; Techniques:</b>
	CHEG 604 Probability and Statistics for Engineering Problem Solving
	FREC/STAT 608 Statistical Research Methods
	FREC 615 Advanced Prices and Statistics
	FREC/STAT 674 Applied Database Management
	FREC 807 Mathematical Programming with Economic Applications
	GEOG 671 Advanced Geographic Information Systems
	MAST 681 Remote Sensing of Environment
	MEEG 690 Intermediate Engineering Mathematics
	STAT 657 Statistics for Earth Sciences
<b>Directed Research Option (3)</b> With advisor approval, MS students may opt to carry out directed research, in lieu of one course, within categories a, b, or c above.	
<b>Thesis (6)</b>	

## V. RESOURCES AVAILABLE

### A. LEARNING RESOURCES

There are no special Learning Resources required to support this program. No new library or technology resources will be required for the graduate program in Water Science & Policy as it builds on resources and courses in the participating departments. The library's current holdings and subscriptions are sufficient as instructional materials.

### B. FACULTY/ADMINISTRATIVE RESOURCES

Faculty resources will be available to the graduate program in Water Science & Policy for course offerings from the participating departments (see letters of approval). Affiliated faculty members may serve as course directors, course instructors, and/or research mentors. The research mentors (thesis and dissertation advisors or committee members) will also serve as the Faculty Advisors who will be the primary contact for students and who will develop courses of study with the students. The faculty listed in the table below are affiliated with the graduate program.

Table 4: Affiliated Faculty, Water Science & Policy

Name	College	Department	Expertise
Balascio, Carmine	Agriculture & Natural Resources	Bioresources Engineering	Hydrologic modeling; surface water quality; storm water management
Bowman, Jacob	Agriculture & Natural Resources	Entomology & Wildlife Ecology	Wildlife restoration, techniques, biometry; conservation biology; habitat modeling & management
Cha, Daniel	Engineering	Civil & Environmental Engineering	Population dynamics of biological wastewater treatment processes; biotransformation of environmental contaminants in natural and engineered systems
Claessens, Luc	Earth, Ocean & Environment	Geography	Hydrology and ecosystem processes; biogeochemistry; water resources engineering
DeLiberty, Tracy	Earth, Ocean & Environment	Geography	Geographical information systems, climatology, remote sensing
Dentel, Steven	Engineering	Civil & Environmental Engineering	Application of colloid and interface science to water and wastewater treatment processes
DiToro, Dominic	Engineering	Civil & Environmental Engineering	Water quality modeling; water quality and sediment quality criteria models for organic chemicals, metals, mixtures; organic chemical and metal sorption models; statistical models
Duke, Joshua	Agriculture & Natural Resources	Food and Resource Economics	Land use, natural resource and environmental economics; law and economics; property rights
Geiger, Cathleen	Earth, Ocean & Environment	Geography	Impact of geophysical scale ice-water phase change on transportation and national security
Hough-Goldstein, Judy	Agriculture & Natural Resources	Entomology and Wildlife Ecology	Biological control; Plant/insect interactions; invasive plants; Insect pest management

Huang, Chin-Pao	Engineering	Civil & Environmental Engineering	Industrial wastewater management; aquatic chemistry; soil and groundwater remediation; environmental nanomaterials and processes
Imhoff, Paul	Engineering	Civil & Environmental Engineering	Transport of fluids and contaminants in multiphase systems; mass transfer processes in soil, groundwater, surface water, and in landfills; and mathematical modeling.
Inamdar, Shreeram (Program Director)	Agriculture & Natural Resources	Bioresources Engineering	Hydrology and Biogeochemistry of watersheds; sustainable watershed management
Jaisi, Deb	Agriculture & Natural Resources	Plant & Soil Sciences	Environmental biogeochemistry of both pristine and contaminated environments
Jin, Yan	Agriculture & Natural Resources	Plant & Soil Sciences	Contaminant fate and transport; water quality technology
Kauffman, Gerald	Arts & Sciences	School of Public Policy & Administration	Water supply, water quality, policy, droughts and floods. Watershed planning/mgt.
Leathers, Daniel	Earth, Ocean & Environment	Geography	Meteorology, Hydrology, Water Resources, Climate Change and Variation
Legates, David	Earth, Ocean & Environment	Geography	Hydroclimatology, precipitation and climate change, computational methods
Levia, Delphis	Earth, Ocean & Environment	Geography	Ecohydrology, forest biogeochemistry, snow science, field methods and instrumentation.
Maresca, Julia	Engineering	Civil & Environmental Engineering	Microbial responses to environmental inputs using high-throughput sequencing, bacterial genetics, and physiology
Messer, Kent	Agriculture & Natural Resources	Food & Resource Economics	Environmental conservation; provision of public goods; behavioral response to risk
Michael, Holly	Earth, Ocean & Environment	Geology	Groundwater-surface water interaction in dynamic coastal systems; water in developing countries; geostatistical modeling
Pizzuto, James	Earth, Ocean & Environment	Geology	Fluvial geomorphology
Schreuder, Yda	Earth, Ocean & Environment	Geography	Global resources, development and the environment; Sustainable development; Global climate change policies; International migration
Sparks, Donald	Agriculture & Natural Resources	Plant and Soil Sciences	How contaminants, (e.g., metals) bind to soils and move into water; remediation strategies for contaminated soils.
Wang, Young-Doo	Engineering	Center for Energy & Environmental Policy	Energy and environmental policy; economic analysis of alternative energy options; econometric applications.

Williams, Christopher	Agriculture & Natural Resources	Entomology and Wildlife Ecology	Wildlife population ecology; wildlife habitat interaction; upland game bird ecology; waterfowl ecology
Wommack, Eric	Agriculture & Natural Resources	Plant & Soil Sciences	Viral processes within natural ecosystems; viral metagenomics

The total enrollment each year in the program is projected at 20 students in the steady state. The demand from Water Science & Policy students can be absorbed by most existing classes.

Administrative resources will be available from the College of Agriculture & Natural Resources in the form of administrative assistance to support the Program Director in day-to-day administration of the program, and to support the Program Committee in their oversight role for the program. The Delaware Environmental Institute will assist with developing marketing and recruitment materials, including print and web-based materials.

## C. EXTERNAL FUNDING

Faculty affiliated with the Graduate Program in Water Science & Policy are active in research, and will support graduate students from externally funded research. The Program Committee will actively pursue larger-scale training grants (such as IGERT) to support the Program.

## VI. RESOURCES REQUIRED

### A. LEARNING RESOURCES

No new learning resources are required.

### B. PERSONNEL RESOURCES

No additional personnel resources will be requested beyond the faculty and administrative resources described in Section V.

### C. BUDGETARY NEEDS

#### C.1. PROJECTED EXPENSES

The projected expenses for the graduate program in Water Science & Policy include personnel costs for program administration, course instruction, mentoring and student scholarships, as well as costs for advertisement, materials and supplies and for hosting program activities.

	% Effort/Costs	Initial Funding
Personnel Expenses		
Program Administration		
Faculty Director	10%	CANR
Administrative Assistant	5%	CANR
Communications/Website Maintenance	5%	CANR
Fellowships		
2 Research assistantships for CANR students (for a 3 year period each)	\$120,000	CANR
Operational Expenses		
Web Design	\$1,700	DENIN (in-kind)
Brochures and Advertisement	\$1,500	DENIN
Operational Expenses Total	\$3,700	

The initial funding for the administration personnel costs is available from the initial host college – the College of Agriculture & Natural Resources (CANR) for the Faculty Director, and an Administrative Assistant. The Delaware Environmental Institute (DENIN) Communications Manager will develop web and print materials to support program recruitment and marketing. Materials will be shared across all colleges involved.

The Water Science and Policy Program Committee further recommends that financial assistance be sought from

Deans of the participating Colleges to provide tuition scholarships to outstanding students in the initial period of the program to increase the prestige and success of the program.

CANR has also committed to two graduate assistantships and tuition for 3 years each (total of 12 semesters of funding). These assistantships will be limited to graduate students whose primary advisors have a primary appointment in CANR. The assistantships will be decided by the Program Director in consultation with the Program Committee. The Program Committee hopes that other colleges will also follow the lead of CANR and contribute fellowships and assistantships to support the program.

## **C.2. BUDGET PLAN**

A budget plan should be in place and agreed upon among the Deans of the participating Colleges to cover the costs of launching the program initially, to incentivize faculty members to participate and contribute to this educational program, and to share the profit generated by the success of the program.

The proposed graduate program in Water Science & Policy is fully endorsed by the Deans of the following participating Colleges. Their letters of support are attached in Appendix II.

College of Agriculture & Natural Resources  
College of Arts & Sciences  
College of Earth, Ocean & Environment  
College of Engineering

## **VII. IMPLEMENTATION AND EVALUATION**

### **A. IMPLEMENTATION PLAN**

The graduate program in Water Science & Policy is planned for an official start in the fall semester of 2011. The Water Science & Policy Program Committee will establish policies of their operation and for the program, and coordinate with other participating departments about course offerings.

### **B. ASSESSMENT PLAN**

#### **B.1. PROGRAM OBJECTIVE**

The graduate program in Water Science & Policy aims to train the next generation of researchers and policy makers who will play a key role in multi- and interdisciplinary research and decision-making teams.

#### **B.2. CURRICULAR MAP AND LEARNING OUTCOMES**

The program has five major curriculum components:

1. Water Science, with a Physical, Chemical, and Biological Focus
2. Water Policy, with an Economics, Public Policy, Social and Management Focus
3. Research Methods
4. Statistics, Analysis and Techniques
5. Thesis or Dissertation

Students will demonstrate the following competencies at a level commensurate with graduate work. The program offers different emphases, with corresponding learning outcomes.

Ph.D. Students in Water Science & Policy, Water Sciences Concentration

1. Core competency in the fundamentals of water sciences and water policy
2. Advanced knowledge of water science and related disciplines
3. Ability to carry out independent, original research
4. Ability to use experimental, statistical and computational methods
5. Ability to recognize and appreciate the inherent connections and inter-dependence between science, economic, social and policy approaches to solving water problems
6. Ability to contribute effectively as individual and as team members in academia, industry and government
7. Competence in written and oral scientific communication

Ph.D. Students in Water Science & Policy, Water Policy Concentration

1. Core competency in the fundamentals of water sciences and water policy
2. Advanced knowledge of water policy and related disciplines
3. Ability to carry out independent, original research
4. Ability to use experimental, statistical and computational methods
5. Ability to recognize and appreciate the inherent connections and inter-dependence between science, economic, social and policy approaches to solving water problems
6. Ability to contribute effectively as individual and as team members in academia, industry and government
7. Competence in written and oral scientific communication

M.S. Students in Water Science & Policy

1. Core competency in the fundamentals of water sciences and water policy
2. Advanced knowledge of water science & policy and related disciplines
3. Ability to carry out directed research
4. Ability to use experimental, statistical and computational methods
5. Ability to recognize and appreciate the inherent connections and inter-dependence between science, economic, social and policy approaches to solving water problems
6. Ability to contribute effectively as individual and as team members in academia, industry and government
7. Competence in written and oral scientific communication



**Table of Curricular Components and Learning Outcomes**

Curriculum	Core competency in the fundamentals of water sciences and water policy	Advanced knowledge of water science/policy and related disciplines	Directed research experiences	Independent research experiences	Ability to use experimental, statistical and computational methods	Ability to recognize and appreciate the inherent connections and inter-dependence between science, economic, social and policy approaches to solving water problems	Ability to contribute effectively as individual professionals and as team members in academia, industry and government	Ability to apply training in a public or private sector internship assignment	Competence in written and oral scientific communication
Water Science Core	X	X							
Water Policy Core	X	X							
Research Methods		X	X	X		X			
Statistics, Analysis & Techniques				X	X				
Thesis/Dissertation		X	X	X	X	X	X	X	X

### B.3. ASSESSMENT PLAN

Goals	Activities	Measures	Outputs/Outcomes
Goal 1: To train graduate students in the areas of water science and policy	Recruit high quality graduate students through faculty networks of colleagues and leading researchers in the field, supported by effective online resources.	Numbers, credentials, & demographic data on student applicants	Retention and completion of degrees
	Course work covering multidisciplinary and multi-institutional training in water science policy that will enable them to solve complex environmental problems	<p>Faculty advisors evaluate student progress in coursework; students progress on schedule.</p> <p>Survey of students in program during and post-graduation on learning experiences; Students report applying knowledge from courses to work</p>	<p>Students find positions in Water Science and Policy related fields</p> <p>Students possess scientific and policy knowledge to sustain long term success in academic, industry and government careers</p>

		settings.	
	Present research findings at specialized national and international conferences, and to local business, government & citizens	Number and diversity of conferences and meetings attended and data presented	Students can communicate effectively with diverse audiences
	Exposure to distinguished scientists and leaders through lectureships and colloquia	Number of student-organized colloquia; active dialogue with symposia speakers	Students can communicate effectively with diverse audiences
Goal 2: To provide experiential training in research to prepare students for careers in water science and policy.	Conduct cutting-edge research through mentored (thesis/dissertation) projects	Research helps students secure initial employment; Students and graduates report applying knowledge from research to work settings. Students publish in journals.	Students possess scientific and policy knowledge to sustain long term success in academic, industry and government careers
	Participate in internships in public and private sectors.	Experiential training prepares students for the workplace and helps them secure their first post-graduation position	Students secure careers through expanded networks and internships provided by the program

Program improvement will be an ongoing process. The results of the assessment measures will be shared with the Program Committee, and the curriculum will be modified as necessary to achieve the goal of producing graduates who apply the knowledge, skills and abilities gained from the graduate program in Water Science & Policy to their careers.

## **VIII. APPENDIX I**

### **LETTERS OF APPROVAL FROM CONTRIBUTING DEPARTMENTS/UNITS**

#### **College of Agriculture & Natural Resources**

Dr. William Ritter, Department of Bioresources Engineering  
Dr. Blake C. Meyers, Department of Plant & Soil Sciences  
Dr. Thomas Ilvento, Department of Food & Resource Economics

#### **College of Arts & Sciences:**

Dr. Maria Aristigueta, Director, School of Public Policy & Administration  
Dr. Gretchen Bauer, Chair, Department of Political Science & International Relations  
Dr. Martha Corrozi Narvaez, Policy Scientist, Delaware Water Resources Agency  
Dr. Klaus Theopold, Chair, Department of Chemistry & Biochemistry

#### **College of Earth, Ocean & Environment**

Dr. Tracey DeLiberty, Department of Geography  
Dr. Susan McGeary, Department of Geological Sciences  
Dr. Charles Epifanio, Director, School of Marine Science and Policy

#### **College of Engineering**

Dr. John Byrne, Center for Energy and Environmental Policy  
Dr. Norman Wagner, Department of Chemical Engineering  
Dr. Harry W. Shenton, Chair, Department of Civil & Environmental Engineering  
Dr. Annette Karlsson, Chair, Department of Mechanical Engineering



February 14, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree:

The Department of Bioresources Engineering fully supports your efforts in the development of two new Master and Ph.D. programs in Water Science and Policy (WS&P). We welcome students from the new programs to take core Water Science and Water Policy courses as well as electives within the Department. Specifically, students will be allowed to enroll in:

BREG 423/623 Advanced Storm water Management  
BREG 421/621 Nonpoint source pollution  
BREG 667 Watershed Hydrochemistry  
BREG 667: Research Topics and Methods in Water Science and Policy (experimental new course)  
BREG 667: Seminar in Water Science and Policy (experimental new course)

We are very excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,

A handwritten signature in cursive script that reads "William F. Ritter".

William F Ritter  
Professor and Chair

8 March 2011

MEMO TO: Graduate Water Science & Policy Program

MEMO FROM: Tracy DeLiberty  
Interim Chair

A handwritten signature in blue ink that reads 'Tracy DeLiberty'.

The Department of Geography supports the new proposed program in Water Science and Policy. Given the pressuring environmental problems affecting the world's water resources, this graduate program is critical to meeting challenges in water sustainability, while also timely given the federal voice for the need to train students and professionals in both the science and policy aspects of water.

Several geography faculty including Del Levia, Luc Claessens, and Dan Leathers are excited to play an integral part of the graduate program. Additional geography faculty would like to be included as affiliated members (Tracy DeLiberty, Cathy Geiger, David Legates, Yda Schreuder). The geography courses listed as part of the graduate program are regularly taught by the geography faculty and are open to students across campus.

Thank you for including Geography as an integral planner in the proposed graduate program. We look forward to teaching in the program and guiding and mentoring the graduate students.



**CENTER FOR ENERGY AND  
ENVIRONMENTAL POLICY**



College of Education & Public Policy  
University of Delaware  
278 Graham Hall  
Newark, DE 19716-7381  
Internet: jbyrne@udel.edu  
Website: ceep.udel.edu  
Ph: 302/831-8405  
Fax: 302/831-3098

**John Byrne**  
Director and  
Distinguished Professor of  
Energy & Climate Policy

**Young-Doo Wang**  
Associate Director

**The Honorable  
Russell W. Peterson**  
Distinguished  
Policy Fellow

**Faculty and Staff**  
Judy Allarey  
Ralph Begleiter  
Allen M. Barnett  
Terri D. Brower  
Jingguang Chen  
Steven Hegedus  
Kristen Hughes  
Lado Kurdgelashvili  
William Latham  
Cecilia Martinez  
William F. Ritter  
Yda Schreuder  
Ismat Shah  
Richard T. Sylves  
Robert Warren

**Adjunct Faculty**  
Cesar Cuello  
Paul T. Durbin  
Steven M. Hoffman  
Jong-dall Kim  
Jung Ku Kim  
Hoesung Lee  
Ralph Nigro  
Subodh Wagle  
William Wallace

**Degree programs:**

**Energy and Environmental  
Policy Program (ENEP)**

Ph.D. in Energy & Environmental Policy  
Master of Energy &  
Environmental Policy (MEEP)  
B.S. in Energy & Environmental Policy

**Urban Affairs and Public  
Policy Program (UAPP)**

Ph.D. specialization in Technology,  
Environment & Society  
M.A. concentration in Energy,  
Environment & Equity

*The Center for Energy & Environmental  
Policy administers the ENEP degrees.*

March 4, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19716

Dear Shree:

The Center for Energy and Environmental Policy is pleased to support you and your colleagues' efforts to develop a new Master's and Ph.D. program in Water Science and Policy (WS&P). If adopted, we will welcome students from the new program to take core and elective courses from our ENEP program. Specifically, we will reserve seats for WS&P students in:

ENEP 626: Climate Change: Science, Policy and Political Economy  
ENEP 666: Topics in Sustainable Development  
ENEP 810: Political Economy of the Environment  
ENEP 868: Sustainable Water Policy Research  
ENEP 870: Sustainable Water Policy Readings

We are very excited to be a part of this initiative and look forward to seeing WS&P students in the classroom. We wish you all success.

Sincerely,

John Byrne  
Director and Distinguished Professor  
of Energy and Climate Policy

Young-Doo Wang  
Professor and  
ENEP Program Director



February 18, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree,

The Department of Civil and Environmental Engineering fully supports your efforts in the development of two new Master and Ph.D. programs in Water Science and Policy (WS&P). We welcome students from the new programs to take core Water Science and Water Policy courses as well as electives within the Department. Specifically, students will be allowed to enroll in:

CIEG 498/698 Groundwater Flow and Contaminant Transport  
CIEG 632 Chemical Aspects of Environmental Engineering  
CIEG 636: Biological aspects of environmental engineering  
CIEG 668 Principles of Water Quality Criteria

We are very excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,

A handwritten signature in blue ink, appearing to read "Harry Shenton", with a stylized flourish at the end.

Harry "Tripp" Shenton, Ph.D.  
Professor and Chair



DEPARTMENT OF CHEMISTRY  
AND BIOCHEMISTRY  
OFFICE OF THE CHAIRMAN

102 Brown Laboratory  
University of Delaware  
Newark, Delaware 19716-2522  
Ph: 302/831-1247  
Fax: 302/831-6335

February 7, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Dr. Inamdar,

The University's Department of Chemistry and Biochemistry acknowledges your efforts in the development of two new Master and Ph.D. programs in Water Science and Policy (WS&P). If these programs are instituted, we shall welcome students from them to take electives within this Department. Specifically, students will be allowed to enroll in:

CHEM/MAST 683 Environmental Chemistry  
CHEM 608/PLSC608 Environmental Soil Chemistry

We are pleased to facilitate your initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

With best regards,

A handwritten signature in black ink that reads "Klaus H. Theopold".

Klaus H. Theopold  
Professor and Chair





College of Earth, Ocean,  
& Environment  
SCHOOL OF MARINE SCIENCE & POLICY

Charles E. Epifanio  
Harrington Professor and School Director  
Hugh R. Sharp Campus  
700 Pilottown Road  
Lewes, DE 19958  
Phone: 302-645-4263  
Fax: 302-645-4213  
Email: [epi@udel.edu](mailto:epi@udel.edu)  
<http://www.ceoe.udel.edu/cepfanio>

February 4, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree,

The School of Marine Science and Policy fully supports your efforts in the development of two new M.S. and Ph.D. programs in Water Science and Policy (WS&P). We welcome students from the new programs to take core Water Science and Water Policy courses as well as electives within the Department. Specifically, students will be allowed to enroll in:

MAST 672/ECON 670 Applied Policy Analysis  
MAST 670 US Ocean and Coastal Policy  
MAST/ECON 676 Environmental Economics  
MAST/UAPP 663 Decision Tools for Policy Analysis  
MAST 681 Remote Sensing of Environment  
MAST/ECON 867 Valuing the Environment

We are very excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,

A handwritten signature in blue ink that reads 'C. E. Epifanio'.

Charles E. Epifanio  
Harrington Professor and School Director



**DEPARTMENT OF FOOD  
AND RESOURCE ECONOMICS**

Thomas W. Ilvento  
213 Townsend Hall  
University of Delaware  
Newark, DE 19716-2130  
*Ph: 302-831-6773*  
*Fax: 302-831-6243*  
*Ilvento@udel.edu*

March 14, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree,

The Department of Food and Resource Economics fully supports your efforts in the development of two new Master and Ph.D. programs in Water Science and Policy (WS&P). We welcome students from the new programs to take core Water Science and Water Policy courses as well as electives within the Department. Specifically, students will be allowed to enroll in:

FREC/STAT 608 Statistical Research Methods  
FREC 615 Advanced Prices and Statistics  
FREC/STAT 674 Applied Database Management

We are very excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,

A handwritten signature in blue ink that reads "Thomas W. Ilvento".

Thomas W. Ilvento, Professor and Chair



COLLEGE OF EARTH, OCEAN, AND ENVIRONMENT

DEPARTMENT OF  
GEOLOGICAL SCIENCES

103 Penny Hall  
University of Delaware  
Newark, DE 19716-2544 U.S.A.  
Ph: 302/831-2569  
Fax: 302/831-4158  
URL: [www.geosci.udel.edu](http://www.geosci.udel.edu)

February 4, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree,

The Department of Geological Sciences fully supports your efforts in the development of two new Master and Ph.D. programs in Water Science and Policy (WS&P). We welcome graduate students from the new programs to take core Water Science and Water Policy courses as well as electives within the Department. Specifically, students will be encouraged to enroll in:

GEOL 428/628 Hydrogeology  
GEOL411/611 Fluvial Geomorphology

Geological Sciences is excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,

A handwritten signature in dark ink that reads "Sean McBeary".

Professor and Chair



**College of Agriculture &  
Natural Resources**

DEPARTMENT OF PLANT & SOIL SCIENCES

Dr. Blake C. Meyers  
Edward F. and Elizabeth  
Goodman Rosenberg Professor  
Chair of Department  
153 Townsend Hall  
Newark, DE 19716-2170  
Phone: (302) 831-3418  
Email: meyers@dbi.udel.edu

February 4, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree,

The Department of Plant & Soil Sciences fully supports your efforts in the development of two new Master's and Ph.D. degree programs in the area of Water Science and Policy (WS&P). We welcome students from the new programs to take core Water Science and Water Policy courses as well as electives within our department. Specifically, students will be allowed to enroll in the following two courses:

PLSC 603 Soil Physics  
PLSC 608/CHEM 608 Environmental Soil Chemistry

We are very excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,

A handwritten signature in black ink, appearing to read 'Blake C. Meyers'.

Blake C. Meyers, Ph.D.  
Professor & Chair

February 21, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree,

The Department of Chemical Engineering fully supports your efforts in the development of two new Master and Ph.D. programs in Water Science and Policy (WS&P). We welcome students from the new programs to take core Water Science and Water Policy courses as well as electives within the Department. Specifically, students will be allowed to enroll in:

CHEG 604 Probability and Statistics for Engineering Problem Solving

We are very excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,



Alvin B. and Julia O. Stiles Professor and Chair,  
Department of Chemical Engineering



Department of  
Mechanical Engineering

126 Spencer Laboratory  
Newark, DE 19716-3140  
Phone: 302-831-2421  
Fax: 302-831-3619  
Email: [info@me.udel.edu](mailto:info@me.udel.edu)

February 14, 2011

Professor Shreeram Inamdar  
Department of Bioresources Engineering  
University of Delaware  
Newark, DE 19711

Dear Shree,

The Department of Mechanical Engineering fully supports your efforts in the development of two new Master and Ph.D. programs in Water Science and Policy (WS&P). We welcome students from the new programs to take core Water Science and Water Policy courses as well as electives within the Department. Specifically, students will be allowed to enroll in:

MEEG 690 Intermediate Engineering Mathematics

We are very excited to be a part of this initiative and we look forward to seeing WS&P students in the classroom. We wish you great success.

Sincerely,

A handwritten signature in cursive script, appearing to read 'Anette M. Karlsson'.

Anette M. Karlsson, Ph.D.  
Chair and Professor of Mechanical Engineering



INSTITUTE FOR  
PUBLIC ADMINISTRATION

180 Graham Hall  
University of Delaware  
Newark, DE 19716-7380  
Ph: 302/831-8971  
Fax: 302/831-3488  
Email: [ipa@udel.edu](mailto:ipa@udel.edu)  
<http://www.ipa.udel.edu>

Shreeram Inamdar, Ph.D.  
Associate Professor  
Bioresources Engineering  
260 Townsend Hall  
University of Delaware  
Newark, DE 19716

February 16, 2011

Dear Dr. Inambar:

I am writing in support of a new, university-wide, interdisciplinary, graduate program on "Water Science and Policy". It is my understanding that this program will provide an opportunity to address water-related challenges and problems across the nation in an integrated approach, providing a comprehensive education for students.

I have been working as a Policy Scientist with the University of Delaware's Water Resources Agency since 2004. Through my work at the Water Resources Agency I have learned first-hand the need for collaboration and to work with multiple disciplines to complete a project.

Interdisciplinary and collaborative research and work has become increasingly common and necessary in the water resources field. Examples of such collaboration and multi-disciplinary work are prominent on the local, regional, and national levels. For example, the Water Resources Agency is working to restore fish passage to the National Wild and Scenic White Clay Creek watershed and we have been collaborating with geologists, biologists, historians, and policy scientists across campus to complete this project. On a national level I serve on the Board of Directors for the American Water Resources Association. This national professional association will be hosting a conference on Integrated Water Resources Management in June 2011. This conference will focus on an integrated approach to water resource issues and will showcase projects and research that addresses broader social, economic, and environmental goals.

Delaware is an ideal setting for this type of program due to its varied geography, diversity of water resource issues from the north to the south, and the small nature of the state that enables students to easily explore water resources throughout the state. The ability to access Delaware's policy makers at the national, state, and local levels is also a great asset for this type of program. The practical experiences that can be realized while enrolled in this program are limitless.

In closing, I highly support the new "Water Science and Policy" program and believe there is great value and necessity for such a water-focused program here in Delaware.

Sincerely,

A handwritten signature in black ink, appearing to read "Martha Corrozi Narvaez".

Martha Corrozi Narvaez  
Water Resources Agency  
Institute for Public Administration  
University of Delaware



DEPARTMENT OF  
POLITICAL SCIENCE AND  
INTERNATIONAL RELATIONS

University of Delaware  
Newark, Delaware 19716-2574  
Ph: 302/831-2355  
Fax: 302/831-4452

February 18, 2011

Dr. Shreeram P. Inamdar  
Associate Professor  
Department of Bioresources Engineering  
University of Delaware

Dear Dr. Inamdar,

Subject: Support for the Graduate Program in Water Science & Policy

This letter is in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering.

The proposed program represents a critical area of research in the 21<sup>st</sup> century. It builds on strengths at the University of Delaware and will be an effective program to attract excellent students who have an interest in both the scientific aspects of water, as well as the tools needed to develop sound policy.

We welcome students to take courses in the Department, and specifically:

POSC 818 Environmental Politics and Policy.

Please keep me updated on the progress of this exciting proposal to the Faculty Senate.

Sincerely,

Gretchen Bauer  
Professor and Chair  
Department of Political Science and IR



## **IX. APPENDIX II**

### **LETTERS OF SUPPORT FROM DEANS OF PARTICIPATING COLLEGES**

1. Dr. Robin W. Morgan, Dean, College of Agriculture & Natural Resources
2. Dr. George H. Watson, Dean, College of Arts & Sciences
3. Dr. Nancy M. Targett, Dean, College of Earth, Ocean & Environment
4. Dr. Michael J. Chajes, Dean, College of Engineering

Office of the Dean  
113 Townsend Hall  
Newark, Delaware 19716-2103  
Phone: 302-831-2501  
Fax: 302-831-6758  
Email: [morgan@udel.edu](mailto:morgan@udel.edu)

February 4, 2011

Dr. Shreeram P. Inamdar  
Associate Professor  
Department of Bioresources Engineering  
University of Delaware

Subject: Support for the Graduate Program in Water Science & Policy

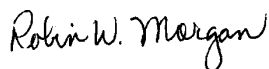
Dear Shree,

I am writing in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources, Arts & Sciences, Earth, Ocean & Environment, and Engineering.

The proposed program represents a critical area of research in the 21<sup>st</sup> century. It builds on strengths at the University of Delaware and promises to attract excellent students who have an interest in both the scientific aspects of water, as well as the tools needed to develop sound policy. This program will allow us to effectively leverage other investments that we are making.

The program will be an excellent interdisciplinary option for both students and faculty. Please keep me updated on the progress of this proposal to the University of Delaware Faculty Senate.

Sincerely,



Robin W. Morgan, Dean



College of Earth, Ocean,  
& Environment  
OFFICE OF THE DEAN

111 Robinson Hall  
Newark, DE 19716-3501 U.S.A.  
Phone: 302-831-2841  
Fax: 302-831-4389  
Email: [ntargett@udel.edu](mailto:ntargett@udel.edu)

February 4, 2011

Dr. Shreeram P. Inamdar  
Associate Professor  
Department of Bioresources Engineering  
University of Delaware

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shree,

I'm writing in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering.

The proposed program represents a critical area of research in the 21<sup>st</sup> century. It builds on strengths at the University of Delaware, and promises to attract excellent students who have an interest in both the scientific aspects of water, as well as the tools needed to develop sound policy.

The program will be an excellent interdisciplinary option for both students and faculty. Please keep me updated on the progress of this proposal to the University of Delaware Faculty Senate.

Sincerely,

A handwritten signature in black ink that reads 'Nancy M. Targett'.

Nancy Targett  
Dean, College of Earth, Ocean, and Environment

9 February 2011

Dr. Shreeram P. Inamdar  
Department of Bioresources Engineering  
University of Delaware

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shree,

I am writing in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering.

The proposed program represents an excellent area of interdisciplinary research for the University and our students. It builds on strengths at UD and should attract excellent students who have an interest in both the scientific aspects of water, as well as the tools needed to develop sound policy. The global internship, field-based study, and career opportunities for these graduates are promising.

Sincerely,



George H. Watson  
Dean



College of Engineering  
OFFICE OF THE DEAN

University of Delaware  
102 du Pont Hall  
Newark, DE 19716-3101  
Phone: 302-831-2401  
Fax: 302-831-8179

February 8, 2011

Dr. Shreeram P. Inamdar  
Associate Professor  
Department of Bioresources Engineering  
University of Delaware

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shree,

I'm writing in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering.

The proposed program represents a critical area of research in the 21<sup>st</sup> century. It builds on strengths at the University of Delaware, and promises to attract excellent students who have an interest in both the scientific aspects of water, as well as the tools needed to develop sound policy.

The program will be an excellent interdisciplinary option for both students and faculty. Please keep me updated on the progress of this proposal to the University of Delaware Faculty Senate.

Sincerely,

A handwritten signature in black ink, appearing to read 'Michael Chajes'.

Michael J. Chajes  
Professor and Dean

## **X. APPENDIX III**

### **Letters of Support from External Partners and Scientific Collaborators**

Dr. Arthur Gold, Professor of Watershed Hydrology, College of the Environment and Life Sciences, University of Rhode Island, Kingston, RI

Dr. Peter Groffman, Senior Scientist, Cary Institute of Ecosystem Studies, Millbrook, NY

Dr. George Hornberger, Distinguished University Professor, Craig E. Philip Professor of Engineering, Professor of Earth and Environmental Sciences and Director, Vanderbilt Institute for Energy and Environment, Vanderbilt University, Nashville, TN

Dr. Richard Lowrance, Research Ecologist, United States Department of Agriculture - ARS

Dr. Jeffrey J. McDonnell, Director, Institute for Water and Watersheds, Oregon State University, Corvallis, OR

Dr. Myron Mitchell, Distinguished Professor and Director of the Council on Hydrologic Systems Science, College of Environmental Science and Forestry, State University of New York, Syracuse, NY

Dr. Saied Mostaghimi, H. E. and Elizabeth F. Alphin Professor, Associate Dean for Research and Director of VA Agricultural Exp. Station, Virginia Tech, Blacksburg, VA

Dr. Bernard Sweeney, Director, Stroud Water Research Center, Avondale, PA

February 28, 2011

Dr. Shreeram P. Inamdar  
Associate Professor and Director, Water Science & Policy Program  
University of Delaware  
260 Townsend Hall  
Newark, DE 19716

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shreeram,

I'm writing in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering.

The proposed program represents a critical area of need in the 21<sup>st</sup> century. This program will provide an excellent opportunity to address water-related challenges and problems across the nation and especially in the Chesapeake Bay and the Delmarva region.

I am particularly impressed with the interdisciplinary nature of the program. We have just finished an NSF funded IGERT Ph.D. program on Coastal Management that brought together faculty from the natural sciences, economics, communications and ethics. Our students have been highly competitive for jobs in the private and public sector. The integration of science, economic, policy, and regulatory aspects of water and watersheds is extremely timely and responds to the needs of our students, decision makers, green industry and the public.

This program will also provide a wonderful opportunity for students and faculty to interact and exchange ideas with water experts from multiple disciplines across local, state, and federal government, industry, environmental organizations and the local community.

I strongly support this program and look forward to interacting with the program faculty and the students in the near future.

Sincerely,

*Arthur J. Gold*

Arthur J. Gold, Ph.D.  
Professor of Watershed Hydrology

*George M. Hornberger  
Distinguished University Professor  
Craig E. Philip Professor of Engineering  
Professor of Earth and Environmental Sciences  
Vanderbilt University  
Nashville, TN*

February 23, 2011

Dr. Shreeram P. Inamdar  
Associate Professor and Director, Water Science & Policy Program  
University of Delaware  
260 Townsend Hall  
Newark, DE 19716

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shreeram,

Thanks for sending me your proposal for a Graduate Program in Water Science & Policy that involves four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering. In my opinion, your group has identified an excellent template for adapting the standard university structure to deal with water resources issues in a modern setting.

Meeting the water needs of humans and ecosystems is perhaps one of the greatest challenges of the 21st Century. Over the last decade, it has become increasingly clear that if we are to face the water and environmental challenges of the future we must view Earth as a single, although highly complex, system that includes the atmosphere, the hydrosphere, the geosphere and the biosphere. And increasingly, the impacts of the “biosphere”, which includes humans, cannot be treated without explicit recognition of behavioral and institutional aspects of society that affect and are affected by the natural and engineered systems; the natural sciences, engineering, and economics and policy can no longer be treated as separate and distinct. Understanding coupled processes and feedbacks in the face of anthropogenic and natural changes and with sufficient accuracy to address the Nation’s and the globe’s critical problems will require synthesis across disciplines and scales. The interdisciplinary nature of your proposed program with integration of science, economic, policy, and regulatory aspects is exactly on target.

I also note that your proposed program aims to provide the opportunity for students and faculty to interact and exchange ideas with water experts from multiple



disciplines across local, state, and federal government, industry, environmental organizations and the local community. This will place you in a good position to develop the collaborations that will be needed for research programs that will be developed in response to recommendations from several recent National Academies reports that point out the need for engaging people outside the walls of the ivory tower<sup>1</sup>. In this vein as well, you have identified a critical emerging role for universities to play in coming decades.

As you can tell, I like your proposal very much and hope that you are successful in navigating it through the approval process at the University of Delaware. I look forward to keeping in touch and learning about how your work proceeds in the future.

Sincerely,

A handwritten signature in black ink, appearing to read "George". The signature is fluid and cursive, with a large initial "G" and a trailing flourish.

Director, Vanderbilt Institute for Energy and Environment

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<sup>1</sup> For example, a recent panel on which I served recommended the following as part of the rationale for having federal programs devote resources to integrative research. “Developing the science to support choices about climate change also requires engagement of decision makers and other stakeholders.” [NRC 2010. *Advancing the Science of Climate Change*. National Academies Press.]

February 20, 2011

Dr. Shreeram P. Inamdar  
Associate Professor and Director, Water Science & Policy Program  
University of Delaware  
260 Townsend Hall  
Newark, DE 19716

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shreeram,

I am glad to write in support of your proposal to establish a Graduate Program in Water Science & Policy at the University of Delaware. I have been involved in multidisciplinary research related to water science for over 30 years and feel strongly that there is a critical need for graduate training that includes multiple scientific disciplines as well as a strong policy and outreach component. Such programs are essential for addressing critical environmental issues related to land use, climate change, water supply, and water quality and ecosystem integrity. These issues are especially critical in the Chesapeake Bay and the Delmarva region.

I am particularly impressed that your proposal includes faculty from four Colleges at the University: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering. It is essential to provide students and faculty the opportunity to interact and exchange ideas with water experts from multiple disciplines. I am also impressed with your ideas to collaborate with local, state, and federal government, industry, environmental organizations and the local community.

Your proposed approach is very consistent with two programs that I have been involved with, an IGERT program on "Water in the Urban Environment" at the University of Maryland Baltimore County (<http://www.umbc.edu/cuere/igert/>) and the Baltimore Ecosystem Study (BES) Long-Term Ecological Research (LTER) project that seeks to understand a major urban region as an ecological system. The BES project focuses on a five county metropolitan region in which watersheds are used as the stage on which to understand the reciprocal interactions of the social, biophysical, and built environments. Like your proposed program, these projects are based on the idea that there is a critical need for graduate training that includes multiple scientific disciplines as well as a strong policy and outreach component. By establishing such a program at Delaware, you will be setting up a strong platform for attracting other funding and for developing state-of-the-art research in environmental science and policy.

I strongly support this program and look forward to interacting with the program faculty and the students in the near future.

Sincerely,



Peter M. Groffman  
Senior Scientist





March 1, 2011

Dr. Shreeram P. Inamdar  
Associate Professor and Director, Water Science & Policy Program  
University of Delaware  
260 Townsend Hall  
Newark, DE 19716

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shreeram,

I am excited to hear about the development of the Graduate Program in Water Science & Policy at the University of Delaware. I'm writing in support of the proposal for this graduate program.

The proposed program will fill a critical need for training graduate students to meet 21<sup>st</sup> century challenges. This program will provide an excellent opportunity to address water-related challenges and problems across the nation and globally. Given the critical water resources issues in the Chesapeake Bay, Delaware Bay, and Delmarva regions one could argue that the program is long overdue. The interdisciplinary nature of the program with integration of science, economic, policy, and regulatory aspects is especially novel and should be very attractive to prospective graduate students. I think having faculty representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering involved in the development of the Graduate Program is an excellent harbinger of the future success of the program.

Having come out of an interdisciplinary program at the University of Georgia Institute of Ecology in the 1980s, it is clear to me that solving societal problems related to water and sustainability require both good science and good science based policy. It appears that this program will also provide a unique opportunity for students and faculty to interact and exchange ideas with water experts from multiple disciplines across local, state, and federal government, industry, environmental organizations and the local community.

I strongly support this program and look forward to interacting with the program faculty and the students in the near future.

Sincerely,

A handwritten signature in black ink that reads "Richard Lowrance". The signature is written in a cursive, flowing style.

Richard Lowrance  
Research Ecologist  
USDA-ARS



State University of New York  
College of Environmental Science and Forestry

Department of Environmental and Forest Biology

February 23, 2011

Dr. Shreeram P. Inamdar  
Associate Professor and Director, Water Science & Policy Program  
University of Delaware  
260 Townsend Hall  
Newark, DE 19716

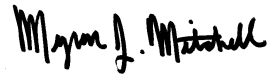
Dear Shreeram:

This letter provides my strong support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering. The proposed program addresses important areas of scientific, engineering and policy needs in the 21<sup>st</sup> century. Water resources are critical within urban, suburban and rural regions and impact a broad range of societal needs ranging local to international levels. The program at the University of Delaware will provide exceptional opportunities for addressing a broad range of water-related issues with particular focus on the Chesapeake Bay and the Delmarva region with their unique challenges on water resources.

This program will build upon previous efforts at the University of Delaware and will provide new opportunities for students and faculty to interact and exchange ideas with water experts from multiple disciplines. Participants will include stake holders from all levels of government (i.e., local, state, and federal) as well as from industry, environmental organizations and the local community.

I strongly support this program and look forward to interacting with the program faculty and the students at the University of Delaware.

Sincerely yours

A handwritten signature in black ink, reading "Myron J. Mitchell". The signature is written in a cursive style with a large initial "M".

Myron J. Mitchell

Distinguished Professor and Director of  
the Council on Hydrologic Systems  
Science



Jeffrey J. McDonnell  
*OSU Distinguished Professor and Richardson Chair in Watershed Science*

**DEPARTMENT OF FOREST ENGINEERING, RESOURCES AND MANAGEMENT**  
015 Peavy Hall, Corvallis, OR 97331-5706  
T +1-541-737-8720 | F +1-541-737-4316 | <http://www.cof.orst.edu/cof/fe/watershd>

Mar 2, 2011

Dr. Shreeram P. Inamdar  
Associate Professor and Director, Water Science & Policy Program  
University of Delaware  
260 Townsend Hall  
Newark, DE 19716

Subject: Support for the Graduate Program in Water Science & Policy

Dear Shreeram,

I'm writing in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by your faculty working group from your Colleges Agriculture & Natural Resources, Arts & Sciences, Earth, Ocean, and Environment and Engineering.

As a Director of a similar program at OSU, I can see that your proposed program clearly represents a critical area of need for the 21<sup>st</sup> century. This program will provide an excellent opportunity to address water-related challenges and problems across the nation and especially in the Chesapeake Bay and the Delmarva region. The interdisciplinary nature of the program with integration of science, economic, policy, and regulatory aspects is especially novel.

This program will also provide a wonderful opportunity for students and faculty to interact and exchange ideas with water experts from multiple disciplines across local, state, and federal government, industry, environmental organizations and the local community.

I strongly support this program and look forward to interacting with the program faculty and the students in the near future.

Sincerely,

A handwritten signature in black ink that reads "JJ McDonnell".

Jeffrey J. McDonnell  
*Director, Institute for Water and Watersheds*



VirginiaTech

College of Agriculture  
and Life Sciences

Office of Research and  
Virginia Agricultural Experiment Station  
104 Hutcheson (0402)  
Blacksburg, Virginia 24061  
540/231-6336 Fax: 540/231-4163  
E-mail: calresearch@vt.edu  
[www.cals.vt.edu](http://www.cals.vt.edu)

February 18, 2011

Dr. Shreeram P. Inamdar  
Associate Professor and Director, Water Science & Policy Program  
University of Delaware  
260 Townsend Hall  
Newark, DE 19716

RE: Support for the Graduate Program in Water Science & Policy

Dear Dr. Inamdar,

I am writing in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering.

The proposed program represents a critical area of need in the 21<sup>st</sup> century. This program will provide an excellent opportunity to address water-related challenges and problems across the nation and especially in the Chesapeake Bay and the Delmarva region. The interdisciplinary nature of the program with integration of science, economic, policy, and regulatory aspects is especially novel.

This program will not only has the potential to bring together interdisciplinary groups of faculty from the University of Delaware to address the important water issues faced by society, it also would a wonderful opportunity for students and faculty to interact and exchange ideas with water experts from multiple disciplines across local, state, and federal government, industry, environmental organizations and the local community.

I strongly support this program and look forward to interacting with the program faculty and the students in the near future.

Sincerely,

Saied Mostaghimi  
H. E. and Elizabeth F. Alphin Professor  
Associate Dean for Research and Director of VA Agricultural Exp. Station

*Invent the Future*



February 11, 2011

Dr. Shreeram P. Inamdar  
Associate Professor  
Department of Bioresources Engineering  
University of Delaware

Subject: Support for the Graduate Program in Water Science & Policy

Dear Dr. Inamdar,

This letter is in support of the proposal for a Graduate Program in Water Science & Policy that has been developed by a faculty working group representing four Colleges at the University of Delaware: Agriculture & Natural Resources; Arts & Sciences; Earth, Ocean, and Environment; and Engineering.

The proposed program represents a critical area of research in the 21<sup>st</sup> century, and is at the heart of the mission of the Stroud Water Research Center. It builds on strengths at the University of Delaware and will be an effective program to attract excellent students who have an interest in both the scientific aspects of water, as well as the tools needed to develop sound policy.

A graduate program in Water Science & Policy will also be an excellent platform for the growing number of collaborative research projects underway between our two institutions.

The program will be an excellent interdisciplinary option for both students and faculty. Please keep me updated on the progress of this proposal to the University of Delaware Faculty Senate.

Sincerely,

A handwritten signature in black ink, which appears to read "Bernard W. Sweeney".

Bernard W. Sweeney  
President and Director



## **XI. Appendix IV – Course Descriptions**

### **Physical**

#### **BREG623: Advanced Storm Water Management (3)**

- Design of gutters, storm drain inlets, and storm drains. Design of distributed and low impact development storm-water management systems. Erosion and sediment control for site development, flood plain hydraulics and analysis.

#### **CIEG698: Groundwater Flow and Contaminant Transport (3)**

- Development and application of models for fluid flow and contaminant transport in porous media. Derivation of governing equations, analytical and numerical solutions, and application to the movement of groundwater and transport of contaminants at an actual field site.

#### **GEOG632: Environmental Hydrology (3)**

- Introduction to hydrologic science. Topics include precipitation, snowmelt, evapotranspiration, infiltration, groundwater, runoff, streamflow, water resources management, and hydrologic applications of remote sensing and geographic information systems. Case studies illustrate hydrological response to changes in land use and climate. Group studies include field measurements and computer simulations.

#### **GEOG651: Microclimatology (4)**

- Introduction to instrumentation and techniques involved in microclimatic monitoring and sampling. Field observation carried out in varying environmental situations.

#### **GEOG656: Hydroclimatology (3)**

- Study of the hydrologic cycle as it relates to water in the atmosphere and in and on the earth's surface. Hydrologic processes including precipitation, soil moisture, evapotranspiration, runoff and streamflow will be examined.

#### **GEOL611: Fluvial Geomorphology (3)**

- Hydrologic and sediment transport processes in rivers and watersheds. Morphology and evolution of rivers and watersheds. Depositional processes and evolution of floodplains. Structure and interpretation of fluvial deposits in the geologic record.

#### **GEOL628: Hydrogeology (3)**

- Principles of groundwater flow and water chemistry in varied geologic media. Evaluation of groundwater resources and assessment of environmental problems associated with groundwater use.

**PLSC603: Soil Physics (3)**

- Examines the importance of soil physics in relation to other disciplines of soil and environmental sciences. Topics include status of water in soil, fundamental principles of water flow, differences between saturated and unsaturated water flow, water balance in the field, infiltration, evapotranspiration, heat, gas and solute (contaminant) transport in soil.

**Chemical/Biological**

**BREG421/621: Nonpoint Source Pollution (3)**

- Understanding sources, transport pathways, and transformations of important pollutants and toxic chemicals generated by anthropogenic activities. Topics include transport, transformation, and fate of these pollutants in watersheds. Impacts of these pollutants on soil, forest, and aquatic ecosystems using specific case studies.

**BREG 667: Watershed Hydrochemistry (3)**

- The role of hydrology in the exports of solutes and chemicals from watersheds. Linkages and feedbacks between hydrologic and biogeochemical processes. Mechanistic conceptual models for solute transport will be emphasized. Innovative methods to characterize and quantify solutes in watersheds will be discussed.

**CHEM/MAST683: Environmental Chemistry (3)**

- Reactions in gas, liquid and solid phases of the Earth's atmosphere, hydrosphere, and geosphere, and energy fluxes and chemical exchanges across these interfaces discussed in the context of basic chemical principles. Applications to current issues such as climate change and air/water pollution discussed.

**CIEG632: Chemical Aspects of Environmental Engineering (3)**

- The principles and applications of aqueous chemistry to environmental systems. Includes a review of general chemistry, with emphasis on the structure of matter and stoichiometry; chemical thermodynamics; chemical kinetics; equilibrium reactions in homogeneous and heterogeneous solutions; applied electrochemistry and Redox reaction; and interfacial phenomena.

**CIEG636: Biological Aspects of Environmental Engineering (3)**

- Presents fundamental molecular biological concepts that pertain to cellular function in the environment and in engineered environmental treatment systems. Briefly reviews elementary organic chemical classifications.

**CIEG668: Principles of Water Quality Criteria (3)**

- Toxicological and chemical background and technical basis necessary for understanding the models of water and sediment quality criteria for individual and mixtures of organic chemicals and metals that focus on bioavailability: narcosis

models of toxicity, complexation models applied to both the water column and sediments.

**GEOG631: Watershed Ecology (3)**

- Examines key biogeochemical processes and functional ecology of wooded ecosystems. Emphasis on examination of peer-reviewed scientific literature. Topics include inter- and intrasystem transport of nutrients and effects of abiotic stressors and animals on catchment scale nutrient budgets.

**GEOG667: Watershed Hydro-Ecology (3)**

- Examines linkages between hydrology and ecosystem processes in primarily human impacted watersheds. Addresses both terrestrial and aquatic ecosystems. Particular emphasis on effect of land use and climate change, and adaptive management practices.

**PLSC/CHEM608: Environmental Soil Chemistry (3)**

- Principles of soil chemical reactions and their application to environment including: inorganic and organic soil components, soil solution-solid phase equilibria, sorption phenomena, ion exchange reactions, kinetics of soil chemical processes, redox chemistry, soil acidity and salinity.

**Policy**

**ENEP626: Climate Change: Science, Policies & Political Economy (3)**

- Examines existing policy responses to climate change, alongside opportunities for a redirected political economy to achieve energy and environmental conditions with meaningful CO<sub>2</sub> reductions. Specific attention given to possibilities and limits of scientific knowledge and technology in galvanizing social change.

**ENEP 666: Topics in Sustainable Development**

**ENEP 810: Political Economy of the Environment (3)**

- Reviews major theories developed over the last half century to explain nature-society relations. Policy case studies on environmental justice, trade and environment, global climate change, and sustainable development used to evaluate current range of political-economic explanations of nature-society relations. International, national and local responses to these problems are analyzed.

**ENEP 868: Sustainable Water Policy Research (1-6)**

**ENEP 870: Sustainable Water Policy Readings (3)**

**GEOG617: Seminar in Climate Change (3)**

- Examines facts and fallacies regarding global warming and climate science and assesses the current state of scientific understanding of and ability to forecast climate change.

GEOG649: Environment & Society (3)

- Considers the relationships between environmental and social processes from theoretical, philosophical, and methodological perspectives of geography. Explores the ethical and contextual implications implied in framing environmental questions and posing solutions. Examines approaches to the geographical analysis of environmental problems.

MAST/UAPP 663: Decision Tools for Policy Analysis (3)

- Develops quantitative decision-making skills for science and technology policy decisions. Covers decision-making under uncertainty, axioms of decision analysis, decision trees, influence diagrams, sensitivity analysis, confidence intervals, value of information, probabilistic risk assessment, and multi-attribute decision theory.

MAST672/ECON670: Applied Policy Analysis (3)

- Empirical analysis of environmental and natural resource policy issues. Topics include valuation of natural resources, decision making under uncertainty, dynamic control and intertemporal issues in resource use and institutional aspects of policy analysis.

MAST670: US Ocean and Coastal Policy (3)

- Provides an overview and assessment of the evolution of U.S. ocean and coastal policies, including such policy areas as coastal management, fisheries management, marine mammal protection, offshore oil development, and marine pollution control.

MAST/ECON 676: Environmental Economics (3)

- Study of the choice of policies to protect the environment, including land, air and water resources. Theory of market failure and externalities, use of economic incentives in policy design, valuation of environmental resources and examination of inefficiencies in existing U.S. environmental policies.

MAST/ECON 867: Valuing the Environment (3)

- The economic theory and empirical methods used for valuing environmental goods. Topics include welfare theory, contingent valuation, choice experiments and conjoint analysis, travel cost models, hedonic price analysis, defensive expenditure methods, and benefits transfer. The foundation for each method is developed along with contemporary readings on actual applications. Students must complete a 'valuation project' using empirical data.

POSC818: Environmental Politics and Policy (3)

- U.S. and international environmental politics, policies, laws, and agreements regarding air, water, and natural resource protection. Examines environmental governance regimes, politics and science, theories of environmental policy, public

and private interaction, and epistemic communities in global warming, ozone layer protection, and environmental public health.

**UAPP611: Regional Watershed Management (3)**

- Reviews the practical applications of watershed planning as a tool to manage land, water and ecosystem resources. Explores public policies and practices of watershed planning by examining case studies. Uses a multidisciplinary approach involving the fields of geography, environmental science, geology, public policy, land planning, geographic information systems (GIS) and engineering.

**UAPP/ENEP 617: Contemporary Issues in Environmental and Energy Policy (1)**

- Links students with leading energy and environmental policy scholars on a bi-weekly basis to debate key issues such as global warming, ozone layer deterioration, environmental justice, sustainable development and ecological democracy. International, national and community dimensions of these and other policy issues are explored through seminar discussion.

**UAPP628: Issues in Land Use and Environmental Planning (3)**

- Examines theory and contemporary practice in land use and environmental planning with emphasis on creating an integrative framework that balances development demands for urban, suburban, and agricultural land against the needs to conserve and enhance environmental and cultural resources.

**UAPP667: Field Seminar in Water Policy (3)**

- Using case studies from the Delaware River and Chesapeake Bay basins, students will examine the social, economic, legal, and policy aspects of water resources planning and management. This field seminar will include visits and field reconnaissance to watershed governance organizations in the Mid- Atlantic such as the Delaware River Basin Commission, Delaware Estuary Program, and Chesapeake Bay Program. Service-based learning is envisioned, in which students will be encouraged to collaborate with career watershed managers in the field while integrating the fundamentals of water policy through instruction in the classroom.

**Research Methods**

**PLSC667: Research Methods and Topics in Water Science & Policy (2)**

- Selected topics and field and laboratory methods to investigate the physical, chemical and biological aspects of water and the socioeconomic, policy, and regulatory issues associated with water.

**PLSC667: Interdisciplinary Seminar in Water Science & Policy (1)**

- Interdisciplinary seminar series highlighting important scientific and policy issues related to water.

## **Statistics, Analysis & Techniques**

### **CHEG604: Probability and Statistics for Engineering Problem Solving (3)**

- Fundamental approach to modeling, characterization and analysis of random phenomena with the objective of providing students with the basic principles, methods and tools for solving engineering problems involving randomly varying phenomena. Application areas explored include experimental design, manufacturing, system reliability, and cellular biology.

### **FREC/STAT608: Statistical Research Methods (3)**

- Experimental design and plot plans, collection, analysis and presentation of data in agricultural and biological research.

### **FREC615: Advanced Prices and Statistics (3)**

- Statistical tools used in agricultural economics research and operations research. Introduction to econometric specifications, estimation and interpretation.

### **FREC/STAT674: Applied Data Base Management (3)**

- Provides an in-depth understanding of using computers to manage data using programs such as SAS and Microsoft/Access.

### **FREC 807/ORES801**

- Explores the development and application of optimization models and methods such as linear programming, integer programming, non-linear programming, and goal programming. Applications to both firm and sector-level economic issues with a particular emphasis on agricultural, environmental, resource economic applications.

### **GEOG671: Advanced Geographic Information Systems (4)**

- Commercial geographical information systems (GIS) are introduced and used to analyze a wide variety of spatial databases. Georeferenced data are acquired, restructured and manipulated in a GIS environment. GIS methods are applied to local-scale geographical, environmental and land planning problems.

### **MAST681: Remote Sensing of the Environment (3)**

- Detection and mapping of land and ocean resources with optical, infrared and microwave sensors. Digital analysis of satellite images using multispectral and spatial analysis techniques and correlation with ground/ship data. Application to oceanography, coastal processes, geology, land use, geography, agriculture, climate and pollution studies. Includes hands-on image analysis in GIS laboratory.

### **MEEG690: Intermediate Engineering Mathematics (3)**

- Linear algebra: generalized vector space, eigenvalue problem, diagonalization, quadratic forms. Field theory: divergence theorem, Stokes' theorem, irrotational fields. Sturm-Liouville theory, Bessel functions, Legendre polynomials. Partial

differential equations: diffusion and Laplace equations by separation of variables and Sturm-Liouville theory, wave equation. Engineering applications.

STAT657: Statistics for Earth Sciences (3)

- Spatial distributions; directional data; statistical graphics, regression and time series analysis; model validation; sampling; principal components; cluster analysis; discriminant analysis; and statistical software routines. PREREQ: MATH201

STAT675: Logistic Regression (3)

- Practical and computational introduction to logistic regression and related topics. Applications include financial, marketing and biomedical research. The use of SAS and other statistical packages will be emphasized.

UAPP652: Geographic Information Systems in Public Policy (1)

- Hands-on introduction to Geographic Information Systems (GIS) and their uses in public policy areas. Content varies. Exercises focus on using geographic data in fields such as environmental analysis, land use planning, and socio-economic analysis.

UAPP691: Quantitative Analysis in Public & NP Sectors (3)

- Study of basic research design and data analysis techniques stressing applications in the public and nonprofit sectors. Includes research design, data acquisition, measurement, descriptive statistics, data collection, probability, exploratory data analysis, hypothesis testing, simple and multiple regression, correlation, and graphical procedures.

UAPP816: Advanced Social Statistics (3)

- Provides advanced training in applied social research. Topics include analysis of variance, regression analysis, analysis of covariance, multi-dimensional cross-classifications and future analysis. Lectures supplemented by laboratory work involving computer statistical packages and simulations.

## **XII. APPENDIX V — Selected Graduate Programs in Water Science & Policy at Other Institutions**

Texas A&M – Water Degree Program

<http://waterprogram.tamu.edu/>

University of Minnesota – Water Resources Science

<http://wrs.umn.edu/>

Oregon State University – Water Resources Graduate Program

<http://oregonstate.edu/gradwater/degreeprograms/wrs.php>

University of Colorado – Hydrologic Sciences Program

<http://hydrosciences.colorado.edu/about/index.php>

University of California at Davis – Hydrologic Sciences

<http://hydscigrad.ucdavis.edu/program/reqs.html>

University of Nevada - Reno & Las Vegas- Hydrologic Sciences

<http://www.hydro.unr.edu/home/>

<http://sciences.unlv.edu/wrm/>