Environmental & Water Studies

The Environmental and Water Studies Program in the Department of Civil and Environmental Engineering covers a broad spectrum of technical specialties including hydraulics, hydrology, environmental fluid mechanics, environmental engineering and science, hazardous substance control, and environmental planning. Course offerings are scheduled to permit either intensive study in a single area or interrelated study between areas. Seminars provide a broad coverage of environmental and water problems.

The department welcomes applicants with backgrounds in all areas of engineering and science who are interested in applying their specialized abilities to the solution of environmental and water problems. Comprehensive introductory courses in each major area of study are given to provide a common basis of understanding among those with dissimilar backgrounds. Programs of study are highly flexible to allow for diversity and to encourage the development of either intensive or broadened abilities. The two major areas of specialization in the graduate program are:

(1) Environmental Engineering and Science
(2) Environmental Fluid Mechanics and Hydrology

Admissions to these two degree programs are handled separately. Prospective students should clearly indicate their preference on the application by specifying one or the other degree under "Field of Specialization."

Within the Environmental Engineering and Science Program the major focus is on water quality and hazardous substance control, but air and soil pollution, as well as broader aspects of environmental concern are also covered. Thus, the physico-chemical, biological, and engineering aspects of water quality and water pollution control, including groundwater remediation and hazardous chemical treatment, can be studied in depth. There is also opportunity for specialization in atmospheric chemistry, physics, and pollutant transport. Related programs afford a broad range of offerings in the earth sciences, fluid mechanics, energy systems, and environmental and water resources planning and impact assessment.

The Environmental Fluid Mechanics and Hydrology Program focuses on developing an understanding of the physical processes controlling the movement of mass, energy, and momentum in the water environment and the atmosphere. The program also considers environmental and institutional issues involved in planning water resources development projects. Environmental fluid mechanics courses address experimental methods; fluid transport and mixing processes; the fluid mechanics of stratified flows; natural flows in coastal waters, estuaries, lakes, and open channels; and turbulence and its modeling.

Hydrology courses consider flow and transport in porous media, stochastic methods in both surface and subsurface hydrology , and watershed hydrology and modeling. Atmosphere-related courses deal with climate, weather, storms and air pollution and the modeling of these. Planning courses emphasize environmental policy implementation and sustainable water resources development.

Degree Programs

M.S. Degree

1. Within Environmental and Water Studies, there are two programs of study at the M.S. level:

a. Environmental Engineering and Science (EES)
b. Environmental Fluid Mechanics and Hydrology (EFMH)

2. Students admitted to graduate standing with a bachelor's degree in civil engineering (or its equivalent) can satisfy the requirements for the degree of Master of Science in Civil and Environmental Engineering by completing a minimum of 45 units of study in residence beyond the bachelor degree, of which at least 24 units must comprise courses within the School of Engineering. An average grade point average (GPA) of 2.75 or higher must be maintained for all Stanford course work. No more than 6 units of coursework that is offered with a letter grade option can be taken for credit (CR)/no credit; however, there is no limit on units taken for satisfactory (S)/no credit (where a letter grade option is not offered). No courses numbered less than 100 can count towards the MS degree. The two degree M.S. programs differ in their requirements for the number of units that must be taken at the graduate level (courses numbered 200 or higher): EES requires at least 30 such units, whereas EFMH requires at least 36. The coursework must form a coherent program of study approved by the student's faculty advisor.

3. Candidates for the M.S. degree who do not have a bachelor's degree in engineering may, in addition to the above, be required to complete those undergraduate courses that are prerequisite to their graduate program. In such cases, more than three quarters of residency may be needed to complete the degree.

4. Students will find the attached Planning Guidelines useful for devising their own program. Each student's program may be tailored to his/her individual goals and objectives, subject to the requirements listed under item 2 above and the approval of their advisor.

Engineer Degree

The engineer degree is available for students interested in professional practice who desire advanced work beyond the M.S. A student with a master's degree in civil engineering may satisfy the requirements for the degree of Engineer in Civil and Environmental Engineering by completing, in residence, 45 or more units of work including an acceptable thesis (12 to 15 units) and maintaining a B (3.0 GPA) average or higher. Acceptance requires approval by a faculty member who is willing to serve as thesis advisor and has openings for additional students. Consult the Engineer Degree Student Handbook for detailed requirements and procedures.

Ph.D. Degree

The Ph.D. degree is primarily for students planning a career in teaching, research, or technical work of an advanced nature. Candidacy for the Ph.D. degree is formally obtained upon satisfactory completion of a General Qualifying Examination. Candidates for the Ph.D. degree must obtain departmental approval of their course programs and a B (3.0 GPA) average must be maintained for all graduate work. The Ph.D. requires a minimum of two years of study (including one year of course work) beyond the M.S. degree, followed by completion of an acceptable dissertation. Acceptance requires approval by a faculty member who is willing to serve as the dissertation adviser and has openings for additional students. Candidates for the Ph.D. are required to gain teaching experience by serving at least one quarter as a teaching assistant. Consult the PhD Student Handbook for detailed requirements and procedures.

Planning Guidelines

Guidelines for Designing a MS program

In the **Environmental and Water Studies Program** there are a group of relevant breadth courses within each program area, and a broad range of electives, permitting each student to design a program of particular interest. The degree programs are kept flexible to foster interaction among students and to encourage the development of individual programs suitable for a broad range of engineering and science backgrounds and career goals.

If you are planning to continue for the Engineer or Ph.D. degrees, your first-year program might well include additional courses in related topics supporting your research interest. Check the detailed course descriptions in the ***Stanford Bulletin*.**

Undergraduate Prerequisites

The Environmental and Water Studies Program is open to applicants with backgrounds in all areas of engineering and science. Certain basic subjects from the traditional areas of civil and environmental engineering are considered essential for students who will receive the master's degree in civil and environmental engineering. These requirements are usually fulfilled by an ABET accredited B.S. Degree in Civil Engineering or Environmental Engineering. The guiding principle is that students are expected to develop adequate preparation for all coursework taken during their M.S. programs. Up to six units of credit may be counted toward the master's degree for undergraduate prerequisites taken at Stanford, provided these courses are numbered at or above 100-level.

Essentials for Both Degree Programs

Mechanics of Fluids	CEE 101B	4	Spring	Monismith
Statistics & Probability	CEE 203 or	3-4	Aut	
(not required, but recommended)	Stats 110 or	4-5	Aut, Sum	
	Stats 116	3-5	Aut, Spr, Sum	
Calculus (1 year)	Math 41	5	Aut	
	Math 42	5	Aut, Win	
	Math 51 or	5	Aut, Win, Spr, Sum	
	CME100	5	Aut	

Additional Essentials for Environmental Engineering & Science

Chemical Principles	Chem 31A+B	5+5	Aut, Win, Sum
Structure & Reactivity (*Intro. Organic Chem.*)	Chem 33	4	Win, Spr, Sum
Aquatic Chem. & Biol. or	CEE 177	4	Aut
Gen., Biochem. & Molec. Biol.	Bio 41	5	Aut
Phys. Chem. (*recommended*)	Chem 135	3	Win

Addl. Essentials for Environmental Fluid Mechanics and Hydrology

Watersheds and Wetlands	CEE 166A	3	Aut	Freyberg
Engineering Economy	CEE 146A	3	Win	
Programming Methodology	CS 106A	3-5	Aut, Win, Spr, Sum	

M.S. – Environmental Fluid Mechanics & Hydrology

Guidelines for Designing a MS Program

Environmental Fluid Mechanics (typically 2 courses)

Hydrodynamics	CEE 262A	3-4	Aut	Fong
Transp. & Mix. in Surf. Water Flows	CEE 262B	3-4	Win	Fong
Intro. to Physical Oceanography	CEE 262D	4	Win	Fong
Lakes and Reservoirs	CEE 262E	2-3	Spr (14-15)	
Ocean Waves	CEE 262F	3	Spr	Monismith
Rivers, Streams, and Canals	CEE 264A	3-4	Aut	Koseff
Mechanics of Stratified Flows	CEE 363A	3	Aut (13-14)	Fong
Ocean Fluid Dynamics	CEE 363F	3	Spr (14-15)	

Hydrology/Meteorology (typically 2 courses)

Physical Hydrogeology	CEE 260A	4	Aut	Gorelick
Surface and Near-Surface Hydrologic Response	CEE 260B	3	Aut (14-15)	
Contaminant Hydrogeology	CEE 260C	4	Win	Gorelick
Weather and Storms	CEE 263C	3	Aut	Jacobson
Watersheds and Wetlands	CEE 266A	3	Aut	Freyberg
Floods & Droughts, Dams & Aqueducts	CEE 266B	3	Win	Freyberg
Adv. Topics in Hydrol./Water Res.	CEE 266C	3	Spr (14-15)	Freyberg
Water Resources/Hazards Field Trips	CEE 266D	2	Win	Freyberg
Groundwater Flow	CEE 268	3-4	Win (13-14)	Kitanidis
Heterogeneity and Scale in Groundwater	CEE 362H	3-4	Win (14-15)	Kitanidis
Field Tech. in Coastal Oceanography	CEE 363G	3	Spr	

Applied Mathematics (typically 3 courses)

Math & Comp. Methods in Engrg. *(strongly recommended for Ph.D.)*	CME 200 CME 204 CME 206	3 3 3	Aut Win Spr	Gerritsen Lele Iaccarino
Computations in CEE	CEE 201D	3	Aut	Kitanidis
Modeling Environmental Flows	CEE 262C	3	Spr	
Air Pollution Modeling	CEE 263A	3-4	Spr (13-14)	Jacobson
Numerical Weather Prediction	CEE 263B	3-4	Spr (14-15)	Jacobson
Sediment Transport Modeling	CEE 264	3	Spr (14-15)	Fringer
Numerical Modeling of Subsurf. Proc.	CEE 362	3-4	(14-15)	
Stochastic Inverse Modeling	CEE 362G	3-4	Spr	Kitanidis
Applied Math in Reservoir Eng.	Energy 281	3	Spr (14-15)	
Linear Alg. and Prtl. Diff. Eqn. for Engs.	CME 104	5	Spr	Khayms
Partial Differential Equations I	Math 131P	3	Aut,Win	

Advanced Electives numbered 200 or above in Statistics, or in the 210's or 220's in MS&E

M.S. – Environmental Fluid Mechanics & Hydrology (Cont.)

Guidelines for Designing a MS Program (Cont.)

Communication Skills *(normally 1 course)*

Teaching Public Speaking	ENGR 100	3	Aut,Win, Spr	
Public Speaking	ENGR 103	3	Aut,Win,Spr	
Technical Writing	ENGR 202W	3	Aut,Win, Spr	

Air/Water Quality *(normally 1 course)*

Air Pollution: from Urban Smog to Global Change	CEE 263D	3	Win	Jacobson
Movement & Fate of Organic Contaminants in Waters	CEE 270	3	Aut	Luthy
Physic. & Chem. Treatment Processes	CEE 271A	3	Win	Luthy
Environmental Biotechnology	CEE 271B	4	Win	Criddle
Aquatic Chemistry	CEE 273	3	Aut	Leckie
Environmental Microbiology I	CEE 274A	3	Aut	Spormann
Air Pollution Fundamentals	CEE 278A	3-4	Aut	Hildemann

Planning & Management *(normally 1 course)*

Environmental Planning Methods	CEE 171	3	Win	Ortolano
Sustainable Water Resources Development	CEE 265A	3	Spr	Ortolano
Water Resources Mgmt.	CEE 265C	3	Sum	Findikakis
Water and Sanitation in Developing Countries	CEE 265D	1-3	Spr	Davis

Technical Electives

(Take additional courses as necessary to complete the 45 unit M.S. course work requirement)

Additional courses may be selected from the above list of courses and/or from course offerings from other engineering and engineering-related disciplines that contribute to a coherent program of study. In particular, the Departments of Aeronautics and Astronautics, Chemical Engineering, Computer Science, Geological and Environmental Sciences, Mechanical Engineering, Energy Resources Engineering and Statistics all offer courses of interest. The Departments of Economics and Political Science and the Law School also offer courses related to resource planning issues.

M.S. – Environmental Engineering & Science

Guidelines for Designing a MS Program

MS Degree Requirements

Technical Core

18 units required

(Select courses from the Core Required list totaling at least 10 units; must include 1 unit of CEE 279. Select another 8 units from either Required or Electives. Courses marked with dates are given in alternate years. To count as Technical Core, courses must be taken for a grade, if possible; otherwise, will be counted under Other Technical Electives.)

Core Required (at least 10 units)

Envir. Engrg. Seminar (1 unit)	CEE 279	1	Aut, Win, Spr	Hildemann
Movement/Fate of Org. Contam. in Waters	CEE 270	3	Aut	Luthy
Envir. Organic Reaction Chemistry	CEE 270B	3	Spr	Mitch
Physical & Chemical Processes	CEE 271A	3	Win	Luthy
Environmental Biotechnology	CEE 271B	4	Win	Criddle
Transport Phenomena	CEE 271M	3	Win (13-14)	Boehm
Aquatic Chemistry	CEE 273	3	Aut	Leckie
Environmental Microbiology	CEE 274A	3	Aut	Spormann
Air Pollution Fundamentals	CEE 278A	3-4	Aut	Hildemann

Core Electives

Wastewater Treatment Process Modeling	CEE271D	2	Spr	
Coastal Contaminants	CEE 272	3-4	Aut	Boehm
Aquatic Chemistry Lab	CEE 273A	3	Win	
Membrane Technol. for Water/WW Trtmt.	CEE 273C	3	Sum (14-15)	Reinhard
Microbial Energy Systems	CEE 274B	3	Win	Spormann
Pathogens and Disinfection	CEE 274D	3	Spr (15-16)	Criddle
Environ. Health Microbiology	CEE 274P	3-4	Spr (13-14)	Boehm
Proc. Design for Env. Biotechnology	CEE 275B	3	Spr (14-15)	Criddle
The Practice of Environ. Consulting	CEE 275K	2	Win	
Intro. Human Exposure Analysis	CEE 276	3	Spr	
Atmospheric Aerosols	CEE 278B	3	Spr (14-15)	Hildemann
Indoor Air Quality	CEE 278C	2-3	Spr (13-14)	Hildemann
Urban Hydrology	CEE 279H	1	Aut (13-14)	

Breadth Electives

(Select courses totaling at least 15 units from the following six categories. In addition to the courses

Environmental Biology, Chemistry and Geology

Aquatic Chemistry & Biology	CEE 177	4	Aut	Criddle
Physical Hydrogeology	CEE 260A	4	Aut	
Surface/Near Surf. Hydr. Resp.	CEE 260B	3	Aut (14-15)	
Contaminant Hydrogeology	CEE 260C	4	Win	
Intro. to Physical Oceanography	CEE 262D	4	Win	
Physical Chemical Principles	CHEM 135*	3	Win	
Biology and Global Change	Bio 117	4	Win	
Biosphere/Atmos. Interactions	Bio 264	4	Win (14-15)	
Parasites and Pestilence	HumBio 153	4	Win	
Fundamentals of GIS	EarthSys 144	4	Aut	
Remote Sensing of Oceans	EarthSys 241	3-4	Win	
Remote Sensing of Land	EarthSys 242	4	Win	
Environmental Geochemistry	GES 170	4	Win	
Atmos, Ocean, Climate Dyn: Atmos.	EESS 246A	3	Win (13-14)	
Atmos, Ocean, Climate Dyn: Oceans	EESS 246B	3	Spr (14-15)	
Soil and Water Chemistry	EESS 256	2-4	Win (13-14)	
Envir. Microbial Genomics	EESS 259	2-3	Win (13-14)	

*Considered an undergraduate prerequisite; up to 6 units may count towards MS degree

M.S. – Environmental Engineering & Science (Cont.)

Breadth Electives
(continued)

Fluid Mechanics and Transport

Mechanics of Fluids	CEE 101B*	4	Spr	Monismith
Hydrodynamics	CEE 262A	3-4	Aut	
Transp../Mixing in Surf. Water Flows	CEE 262B	3-4	Win	
Modeling Environmental Flows	CEE 262C	3	Win	
Lakes and Reservoirs	CEE 262E	2-3	Spr (14-15)	
Ocean Waves	CEE 262F	3	Spr	Monismith
Air Pollution Modeling	CEE 263A	3-4	Spr (13-14)	Jacobson
Numerical Weather Prediction	CEE 263B	3-4	Spr (14-15)	Jacobson
Weather and Storms	CEE 263C	3	Aut	Jacobson
Sedment Transport Modeling	CEE 264	3	Spr (14-15)	Fringer
Rivers, Streams, and Canals	CEE 264A	3-4	Aut	Koseff
Watersheds and Wetlands	CEE 266A	3	Aut	Freyberg
Floods/Droughts, Dams/Aqueducts	CEE 266B	3	Win	Freyberg
Water Resources/Hazards Field Trips	CEE 266D	2	Win	Freyberg
Groundwater Flow	CEE 268	3-4	Win (13-14)	Kitanidis
Fluid Mechanics	ME 351A	3	Aut	

Planning, Analysis and Management

Environmental Planning Methods	CEE 171	3	Win	Ortolano
Air Quality Management	CEE 172	3	Win	Hildemann
Providing Safe Water for Devel. World	CEE 174A	3	Aut	Mitch
Wastewater Treatment: Disposal/Recovery	CEE 174 B	3	Win	Mitch
Decision Anal. for Civil & Envir. Engrs.	CEE 206	3	Spr	
Planning Tools/Methods in Power Sector	CEE 221A	3	Win	
Life Cycle Assess. for Complex Systems	CEE 226	3-4	Aut	Lepech
Negotiating Sustainable Develop.	CEE 242A	3	Win (14-15)	
Air Pollution: Smog to Global Change	CEE 263D	3	Win	Jacobson
Sustainable Water Resources Develop.	CEE 265A	3	Spr	Ortolano
Water Resources Management	CEE 265C	3	Sum	
Water and Sanit. in Dev. Countries	CEE 265D	2-3	Spr	Davis
Greenhouse Gas Mitigation	CEE 272S	2-3	Spr	
Calif. Coast: Science/ Policy/Law	CEE 275A	3-4	Spr (14-15)	Boehm
Environ. Governance	CEE 277C	3	Win (13-14)	
Engineering Risk Analysis	MS&E 250A	3	Win	
Decision Analysis I	MS&E 252	3-4	Aut	
Sust. Product Develop. & Mfg.	MS&E 264	3-4	Aut	
Science, Technol. & Contemp. Soc.	ENGR 130	4-5	Aut	
Human Society & Envir. Change	EarthSys 112	4	Aut	
Controlling Climate Change	EarthSys 247	3	Aut (14-15)	
Econ. of Health in Dev. Countries	Econ 127	5	Win (14-15)	
Hot Topics in Envir. Statutory Schemes	Law 432	2-3	Aut	

*Considered an undergraduate prerequisite; up to 6 units may count towards MS degree

M.S. – Environmental Engineering & Science (Cont.)

Breadth Electives
(continued)

Applied Mathematics and Computing

Computations in CEE	CEE 201D	3	Aut	Kitanidis
Probabilistic Models in Civil Env.	CEE 203	3-4	Aut	
Programming Methodology	CS 106A	3	Aut, Win, Spr, Sum	
Programming Abstractions	CS 106B	3	Aut, Win, Spr, Sum	
Statistical Methods in Eng. / Sci.	Stats 110*	4-5	Aut, Sum	
Mathematical and Computational Methods in Engineering.	CME 200 CME 204 CME 206	3 3 3	Aut Win Spr	
Partial Differential Equations I	Math 131P	3	Aut, Win	

Communication Skills

Public Speaking	ENGR 103	3	Aut,Win,Spr	
Tech. & Professional Writing	ENGR 202W	3	Aut,Win, Spr	
Oral Comm. for Graduate Students	CTL 219	2-3	Sum	
Art/Heart of Effective Speaking	OralComm 222	3	Win	

Energy Systems

Energy Efficient Bldgs.	CEE 176A	3-4	Win	Masters
Elec. Power:Renewables and Effic.	CEE 176B	3-4	Spr	Masters
Energy Storage Integration	CEE 176C	3-4	Aut	
Energy Resources	CEE 207A	3-5	Aut	Knapp/Woodward
Renewable Energy Infrastructure	CEE 217	3	Spr	
Modern Power Systems Engineering	CEE 272R	3	Spr	Rajagopal
Energy Sys. Field Trips	CEE 276F	2	Win (13-14)	
Energy Thermodynamics	ME 370A	3	Aut	
Combustion Fundamentals	ME 371	3	Win	
Fundam. of Energy Processes	EE 293B	3	Win	
Energy & the Environment	Energy 101	3	Win	
Renewable Energy Sources	Energy 102	3	Spr	
Transition to Sust. Energy Systems	Energy 104	3	Spr	
Carbon Capture & Sequestration	Energy 253	3-4	Aut	
Energy Infrastructure/Technol/Econ	Energy 271	3	Aut	
Solar Cells, Fuel Cells, &Batteries	MatSci 256	3-4	Aut	

Other Technical Electives
(Take additional courses as necessary to complete the 45 unit M.S. course work requirement)

Additional courses may be selected from the list of breadth electives and from course offerings from other engineering and engineering-related disciplines that contribute to a coherent program of study. In particular, see course offerings in the Departments of Biology, Biochemistry, Chemical Engineering, Chemistry, Computer Science, Energy Resources Engineering, Geological and Environmental Sciences, Earth Systems, Management Science and Engineering, Mechanical Engineering, and Medical Microbiology. A maximum of 9 units of independent study-type courses (e.g. CEE 299, CEE 299S) can count towards the MS degree. A maximum of three 1-unit seminar-type courses can count towards the MS degree, including CEE 279.

*Considered an undergraduate prerequisite; up to 6 units may count towards MS degree.