

Information in Browse Course Catalog is subject to change. Information is term specific. Please refer to the appropriate term when searching for course content. Key to Course Descriptions may be found at: http://rcs.registrar.arizona.edu/course_descriptions_key.

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 201: Water Science and the Environment (3 units)

Description: Water plays a crucial role in the physical, chemical, and biological processes that regulate the Earth system. The relations of physical hydrology are derived from the fundamental laws of physics and chemistry. The water cycle forms the framework for the study of hydrological science. Honors section available.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$2

Course Components: Lecture Required

Repeatable: Course can be repeated for a maximum of 6 units.

Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: Fundamental arithmetic manipulation and/or basic algebra. Two courses from Tier One, Natural Sciences (Catalog numbers 170A, 170B, 170C).

Field trip: Field trips

General Education: Tier 2 Natural Sciences

HWRS 202: The Water Cycle (3 units)

Description: The purpose of this course is to help students gain a quantitative understanding of the relationship between the hydrosphere and atmosphere and their impact on hydrologic systems, with emphasis on environmental effects. Field trips to the National Weather Service and Tucson Water Purification Plant. Honors section available.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$11

Course Components: Discussion May Be Offered
 Lecture Required

Recommendations and additional information: Not open to science and engineering majors.

Field trip: National Weather Service and Tucson Water Purification Plant

General Education: Tier 2 Natural Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 203: Arizona Water Issues (3 units)

Description: Study of the use and misuse of water throughout Arizona and the fundamental tools used to study water supply, quality, and conservation. Introduction to basic hydrologic principles to help students deal with issues they will encounter later as public citizens in their own communities.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Discussion May Be Offered
 Lecture Required

Repeatable: Course can be repeated a maximum of 2 times.

Equivalent to: HWRS 213

Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: Two courses from Tier One, Natural Sciences (Catalog numbers 170A, 170B, 170C). Credit for HWRS 213 or HWRS 203 but not both.

General Education: Tier 2 Natural Sciences

HWRS 204: Environmental Water Quality Issues (3 units)

Description: This introductory course on water quality issues in the environment will address relevant topics like, How safe is your drinking water? What are natural versus human-made sources of contamination in the environment? What might the environmental consequences be of major disasters (e.g. BP oil spill)? Students will gain an understanding of what water is made of (i.e. what's dissolved in water), what controls water quality, standards and regulations, basic water quality measurements, and major water quality problems in the environment, focusing on current events.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring

Recommendations and additional information: High school level chemistry and algebra.

General Education: Tier 2 Natural Sciences

Honors Course: Honors Contract

Honors Course: Honors Contract

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 213: Arizona Water Problems (1 unit)

Description: This variable unit course is targeted to adults in the community wanting to learn more about Arizona's pressing water problems. Units may be taken separately or altogether. They are: a) Laws and Institutions controlling our water supply; b) problems related to Over-allocation and Flooding; and personal issues like Water quality and Conservation. This course is only offered on-line.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Repeatable: Course can be repeated a maximum of 3 times.

Equivalent to: HWRS 203

Course typically offered: Online Campus: Fall, Spring

Recommendations and additional information: Credit for HWRS 213 or HWRS 203 but not both.

HWRS 299: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

HWRS 299H: Honors Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 340: Environmental Chemistry (3 units)

Description: An introduction to the chemistry of air, water and terrestrial environments. Application of general chemistry to understanding processes that affect the quality of Earth's near-surface air/water/land environments.

Grading basis: Student Option ABCDE/PF

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: GEOS 340, HWRS 340

Also offered as: ENVS 340, GEOS 340

Course typically offered:

Main Campus: Fall

Recommendations and additional information: CHEM 103A, CHEM 103B.

Home department: Environmental Science

Honors Course: Honors Contract

Honors Course: Honors Contract

HWRS 349A: Principles of Hydrology (2 units)

Description: Introduction to the hydrologic cycle and review of main processes, such as precipitation, evaporation and transpiration, runoff, infiltration and ground water. Some concepts and tools for water resources management are discussed. Laboratory techniques complement lecture topics.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall

Online Campus: Fall

Recommendations and additional information: MATH 122B or MATH 125

HWRS 349B: Principles of Hydrology Lab (1 unit)

Description: Introduction to the hydrologic cycle and review of main processes, such as precipitation, evaporation and transpiration, runoff, infiltration and ground water. Some concepts and tools for water resources management are discussed. Laboratory techniques complement lecture topics.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$30

Course Components: Laboratory Required

Course typically offered:

Main Campus: Fall

Online Campus: Fall

Recommendations and additional information: MATH 122B or MATH 125. Have previously taken HWRS 249A or concurrent enrollment in HWRS 249A. Department permission required.

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-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 350: Principles of Hydrology (3 units)

Description: Introduction to the hydrologic cycle and review of main processes, such as precipitation, evaporation and transpiration, runoff, infiltration and ground water. Some concepts and tools for water resources management are discussed. Laboratory techniques complement lecture topics.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$30

Course Components:	Laboratory	Required
	Lecture	Required

Course typically offered:

Main Campus: Fall

Online Campus: Fall

Field trip: Field trip

Enrollment requirement: MATH 124 or MATH 125 or MATH 122B.

HWRS 392A: Directed Research in Hydrology and Water Resources (1 - 6 units)

Description: Individual or small group research under the guidance of faculty.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 12 units.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

HWRS 393: Internship (1 - 3 units)

Description: Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or governmental establishment.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring

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-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 394: Practicum (1 - 3 units)

Description: The practical application, on an individual basis, of previously studied theory and the collection of data for future theoretical interpretation.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring

HWRS 399: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

HWRS 399H: Honors Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

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-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 404: Numerical Methods for Environmental Transport Problems (3 units)

Description: This course is for senior undergraduate and graduate students. The goal of this course is to introduce commonly used numerical methods for ordinary and partial differential equations encountered in transport problems in environmental systems. The course covers finite difference and finite element methods with emphasis on basic discretization schemes and how to select the appropriate numerical schemes for a given differential equation. We will also discuss accuracy, stability, and convergence properties of the introduced numerical methods. Students will use MATLAB or other programming languages to implement numerical schemes to solve example problems. Experience with MATLAB is not required.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: HWRS 504

Course typically offered:

Main Campus: Fall (odd years only)

Recommendations and additional information: MATH 254 or with permission of the instructor

Field trip: None

HWRS 405: Vadose Zone Hydrology (3 units)

Description: This course builds on knowledge of water flow and solute transport through water-saturated porous media and extends this understanding to unsaturated (air/water) conditions. All lecture notes are provided electronically before the lectures. Lectures are problem based and discussion oriented. The goal is to have students build on previous knowledge while adding the nonlinear components of the flow and transport that characterize unsaturated conditions. All students will be expected to participate in class discussions and may be called to the front to help present a topic. Grades will be based on participation, homework, and exams.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: HWRS 505

Course typically offered:

Main Campus: Fall

Recommendations and additional information: The prerequisite for the course is HWRS 518 or HWRS 431 or equivalent. Equivalent background must be approved by the instructor.

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-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 411: Geology and Geophysics of the Solar System (3 units)

Description: Geologic processes and landforms on satellites and the terrestrial planets, their modification under various planetary environments, and methods of analysis. Required course for the undergraduate minor in Planetary Sciences.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Also offered as: GEOS 411, PTYS 411

Course typically offered:

Main Campus: Spring (even years only)

Home department: Planetary Sciences

HWRS 413A: Field Hydrology Methods (2 units)

Description: You have learned the theory of hydrologic measurement in this course you will apply this theory to individual measurements and to aggregating measurement into a greater explanation and understanding of hydrologic phenomena. Each week in the spring we will focus on an individual type of hydrologic measurement or characterization. You will then synthesize these individual measurements into a report that explain some underlying hydrologic phenomena.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$160

Course Components:	Laboratory	Required
	Lecture	May Be Offered

Co-convened with: HWRS 513A

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 431 or HWRS 423 or consent of instructor.

Field trip: Daily field trips and overnight camping in field required.

Student Engagement Activity: Professional Development

Student Engagement Competency: Interdisciplinarity

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 413B: Field Hydrology Synthesis (1 unit)

Description: You have learned the theory of hydrologic measurement in this course you will apply this theory to individual measurements and to aggregating measurement into a greater explanation and understanding of hydrologic phenomena. In this one-credit course you will complete a hydrologic characterization of a field site.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Laboratory Required

Co-convened with: HWRS 513B

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 413A

Field trip: The class will meet at Dead Horse Ranch State Park and then at the University of Arizona Campus. Topics, dates, and locations are subject to change. A change in any subsequent meeting will be announced at the preceding class meeting.

HWRS 415: Introduction to Water Resources Policy (3 units)

Description: Water resources policy including the identification of regional problems of water use, the elements of water planning, water rights, and a consideration of institutional structures and processes.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: GEOG 415

Co-convened with: HWRS 515

Course typically offered:

Main Campus: Spring

Writing Emphasis: Writing Emphasis Course

HWRS 417A: Fundamentals of Water Quality (3 units)

Description: Introduction to chemical processes affecting the behavior of major and minor chemical species in the aquatic environment. Physical, equilibrium, inorganic/organic, and analytical principles as applied to natural waters.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: HWRS 517A

Course typically offered:

Main Campus: Fall

Recommendations and additional information: CHEM 151 and 152, PHYS 143, MATH 129. Concurrent registration, MATH 254.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 421: Water Resources Systems Planning and Management (3 units)

Description: Quantitative analytical methods in water resources planning and management; introduction to systems analysis, benefit/cost, multi-objective planning and risk assessment.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: HWRS 521

Course typically offered:

Main Campus: Fall

Recommendations and additional information: MATH 125 and HWRS 250.

HWRS 422: Critical Zone Science & Management (3 units)

Description: This course targets undergraduate science majors and graduates interested in learning more about integrated and interdisciplinary team science while learning about the cross-cutting research and observational strategies employed across NSF's Critical Zone Observatory network. At least half of the course will focus on guided data analysis based on CZO data sets.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Also offered as: ENVS 422, GEOS 422

Co-convened with: HWRS 522

Recommendations and additional information: Class participants must have completed at least one university/college-level lab-based science course and mathematics through pre-calculus

Home department: Soil, Water, & Environmental Sciences

HWRS 423: Hydrology (3 units)

Description: Discussion and analysis of major topics of the hydrologic cycle and their interrelationship, such as rainfall, infiltration, evaporation, and runoff. Statistical and probabilistic methods in water supply and flood hydrology.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: HWRS 423, HYDR 423

Also offered as: ATMO 423, CE 423

Co-convened with: HWRS 523

Course typically offered:

Main Campus: Spring

Home department: Civil and Architectural Engineering and Mechanics

Enrollment requirement: Adv Standing: Engineering. CE 218.

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-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 427: Computer Applications in Hydraulics (3 units)

Description: Computer modeling of surface water hydrology, flood plain hydraulics and water distribution systems. Theoretical basis. Application and design studies.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: ABE 427, HWRS 427

Also offered as: BE 427, CE 427

Co-convened with: HWRS 527

Course typically offered:

Main Campus: Fall

Home department: Civil and Architectural Engineering and Mechanics

Enrollment requirement: Adv Standing: Engineering. CE 323 or consent of instructor.

HWRS 428: Fundamentals: Systems Approach to Hydrologic Modeling (3 units)

Description: This course is designed primarily for senior undergraduate (428 level) and graduate students (528 level), but anyone with an interest in how conceptual and computational models are used to support understanding, learning, prediction and decision making will find it beneficial. The overall goal is to familiarize students with the language, methods and tools of systems analysis and computer-based modeling, and their application to the science, risk assessment, management, and planning aspects of hydrology & water resources. Specifically, students will gain an understanding of, and experience with, the process of constructing conceptual and computer-based models of dynamical (time-varying) physical systems of the natural and/or engineered environment, and of the purposes to which such models can be applied. Even if a student has no ultimate interest in becoming an accomplished computer programming and/or skilled in construction of environmental systems models, the understanding gained in this course will better prepare the student to assess and use the information generated by such models, and to use such information in a decision-making context.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: HWRS 528

Course typically offered:

Main Campus: Fall

Recommendations and additional information: MATH 129 or 254, SIE 305, ECE 175 or equivalent.

Field trip: None

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 431: Hydrogeology (4 units)

Description: Hydrologic and geologic factors controlling the occurrence and dynamics of groundwater on regional and local scales.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$20

Course Components: Laboratory May Be Offered
Lecture Required

Equivalent to: GEOS 431, GEOS 431R, GEOS 435, HWR 431R, HYDR 431, HYDR 435

Co-convened with: HWRS 531

Course typically offered:

Main Campus: Fall

Recommendations and additional information: GEOS 251, MATH 129.

HWRS 432: Environmental Hydrogeology Lab (3 units)

Description: Introduction to field, lab, and office methods used in hydrogeology. Hands-on use of modern field and laboratory equipment to measure and monitor hydrogeological parameters and variables. Analysis, visualization, and interpretation of the data performed in chemistry and computer laboratories.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Laboratory Required
Lecture May Be Offered

Repeatable: Course can be repeated a maximum of 2 times.

Co-convened with: HWRS 532

Course typically offered:

Main Campus: Spring

HWRS 443A: Risk Assessment for Environmental Systems (3 units)

Description: A multidisciplinary course based on evaluating risk as the loss expected from environmental catastrophes or from the failure of systems designed for environmental protection. Examples will be drawn from hydrology, atmospheric science, and geology. The emphasis is on adapting the tools of probabilistic risk assessment to environmental analyses. Graduate-level requirements include a written review of a seminal paper and its presentation in class.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: HWRS 543A

Course typically offered:

Main Campus: Fall

Recommendations and additional information: SIE 305 or MATH 361 or MATH 363 or equivalent calculus-based probability/statistics course.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 449: Statistical Hydrology (3 units)

Description: Application of statistics and probability to uncertainty in the description, measurement, and analysis of hydrologic variables and processes, including extreme events, error models, simulation, sampling.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: CE 449, HWR 445

Also offered as: CE 449

Co-convened with: HWRS 549

Course typically offered:

Main Campus: Fall

Recommendations and additional information: SIE 305 or MATH 461 or equivalent calculus-based probability/statistics course.

HWRS 452: Dryland Ecohydrology and Vegetation Dynamics (4 units)

Description: Overview of ecological and hydrological interrelationships, including ecologically meaningful water budgets, and associated vegetation dynamics for water-limited, dryland ecosystems.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Also offered as: ECOL 452, RNR 452, WSM 452

Co-convened with: HWRS 552

Course typically offered:

Main Campus: Fall

Recommendations and additional information: RNR 316, ECOL 302, or consent of instructor.

Home department: Watershed Management

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 460A: Watershed Hydrology (4 units)

Description: Watershed hydrology looks at how water movement, storage and transformation on the Earth's surface is influenced by landscape characteristics, including human modifications of those characteristics, and weather. As such, watershed hydrology will focus on surface water. However, this course offers a brief introduction to groundwater as it pertains to watershed hydrology.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$65

Course Components:	Laboratory	Required
	Lecture	Required

Also offered as: WSM 460A

Co-convened with: HWRS 560A

Course typically offered:

Main Campus: Fall

Recommendations and additional information: Calculus and PHYS 102 or equivalent.

Home department: Watershed Management

HWRS 461: Environmental and Resource Geography (3 units)

Description: Examines physical resources (e.g. distribution, quantities, and availability) and the human factors which may contribute to their completion and deterioration as well as protection and maintenance.

Grading basis: Regular Grades

Career: Undergraduate

Course Components:	Lecture	Required
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Equivalent to: HWRS 461, LAS 461, PLAN 461, PLG 461, PLN 461, PLNG 461, WRA 461

Also offered as: EVS 461, GEOG 461, LAS 461, PLG 461

Course typically offered:

Main Campus: Spring

Home department: School of Geography and Development

Writing Emphasis: Writing Emphasis Course

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 476: Environmental Law and Economics (3 units)

Description: A complex set of laws has developed to control the environmental risks posed by potentially polluting activities. In this course, a survey and an economic evaluation are presented of major environmental legislation designed to protect air, land and water resource quality.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: AEC 476, ECON 476, HWRS 476, RNR 476, WRA 476, WSM 476

Also offered as: AREC 476, RNR 476

Course typically offered:

Main Campus: Spring

Home department: Agricultural & Resource Economics

Enrollment requirement: Major or minor: ABEM, EWRE. Junior or Senior status. (AREC 304 or ECON 300 or ECON 301 or ECON 361) and (MATH 113 or MATH 116 or MATH 122B or MATH 124 or MATH 125).

HWRS 479: Economic Analysis of Water, Food & Environmental Policies (3 units)

Description: This course focuses on economic methods for designing and evaluating water, food and environmental policies. Topics include optimizing water as an input in producing food, energy, recreation, and other ecosystem services; water & environmental issues in food production; pricing and conservation incentives; managing shortage risks; and economic tools for addressing conflicts over water, food and the environment. Interactive seminar style course. Calculus proficiency is required.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: GEOG 479, HWRS 479, RNR 479, SWES 479

Also offered as: AREC 479, ENVS 479, RNR 479

Course typically offered:

Main Campus: Spring

Recommendations and additional information: One semester of college calculus. One of the following courses: MATH 113, MATH 116, MATH 122B, MATH 125

Home department: Agricultural & Resource Economics

Enrollment requirement: Major in College of Engineering or major/minor in ABEM, ENVS, EWRE, HWRS, NTRS, or WSM. Junior or Senior status. MATH 113, MATH 116, MATH 122B, or MATH 125 (or AP credit for Calculus AB or BC).

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 480: Isotope Tracers in Hydrogeology (3 units)

Description: Fundamental principles of stable, radiogenic, and cosmogenic isotope chemistry of natural waters; geochemical processes affecting isotopic compositions of surface waters, soil waters, and groundwaters; and case studies of isotope hydrogeology. Mandatory field trip: Sampling surface- and ground-waters in Tucson Basin, field methods in isotope hydrogeology.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: GEOS 480

Co-convened with: HWRS 580

Course typically offered:

Main Campus: Spring

Recommendations and additional information: CHEM 103B, GEOS 251.

Field trip: Sampling surface- and ground-waters in Tucson Basin, field methods in isotope hydrogeology.

HWRS 481: Environmental Policy (3 units)

Description: Role of government in management of energy, natural resources and environment; process and policy alternatives; special attention to the Southwest.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: HWRS 481, POL 481, RNR 481, WRA 481

Also offered as: PA 481, POL 481, RNR 481

Co-convened with: HWRS 581

Course typically offered:

Main Campus: Fall

Recommendations and additional information: POL 201.

Home department: School of Government and Public Policy

HWRS 482: Applied Groundwater Modeling (3 units)

Description: Introduction to ground-water flow and transport modeling, with emphasis on model construction and simulation.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: HWRS 582

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 250, MATH 122 A&B and MATH 129-
Student must complete HWRS 250 or equivalent course.-Student must complete two semesters of basic calculus.-Vector calculus is preferred but not required.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 490: Remote Sensing for the Study of Planet Earth (3 units)

Description: Remote Sensing for the Study of Planet Earth introduces basic and applied remote sensing science as a means to explore the diversity of our planetary environments (biosphere, atmosphere, lithosphere and hydrosphere) within the radiometric, spectral, spatial, angular and temporal domains of remote sensing systems. This survey course strikes a balance between theory, applications and hands-on labs and assignments. We explore how you can download, process, analyze and interpret multi-sensor data and integrate online remotely sensed data sources/products into your research of interest.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$50

Course Components: Lecture Required

Equivalent to: ARL 490, ATMO 490, GEN 490, GEOG 490, GEOS 490, HWRS 490, MNE 490, OPTI 490, RNR 490, SW 490, SWES 490

Also offered as: ATMO 490, ENVS 490, GEOG 490, GEOS 490, OPTI 490, REM 490, RNR 490

Co-convened with: HWRS 590

Course typically offered:

Main Campus: Fall

Home department: Committee on Remote Sensing and Spatial Analysis

Enrollment requirement: GEOG/GEN/GEOS/ENVS/WSM/GIST 330.

HWRS 491: Preceptor for HWRS 350/349A & B, "Principles of Hydrology" (1 - 3 units)

Description: A Preceptor is an important member of the HWRS 350/349A&B teaching team. Having completed the class already, you know firsthand the challenges students face, especially regarding the weekly quantitative homework problem sets. You have also mastered these Homework problem sets and are in an excellent position to help students learn how to set up, solve, and analyze these quantitative problems. While students enrolled in HWRS 250 (350) can ask for your assistance with any aspect of the course, your primary responsibilities pertain to helping students navigate quantitative problems assigned as homework.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 3 times.

Course typically offered:

Main Campus: Fall

Recommendations and additional information: Must have completed HWRS 350 with a grade of "C" or higher.

Field trip: HWRS 350 require a lecture, lab and field trip experiences. Preceptor(s) will be required to attend the lectures. Lab/field trip attendance is optional.

Student Engagement Activity: Leadership

Student Engagement Competency: Professionalism

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 492A: Directed Research in Hydrology and Water Resources (1 - 6 units)

Description: Individual or small group research under the guidance of faculty.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 12 units.

Course typically offered:

Main Campus: Fall, Spring, Summer

HWRS 493: Internship (1 - 3 units)

Description: Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or governmental establishment.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

HWRS 495A: Current Topics in Hydrology and Atmospheric Science (1 unit)

Description: Exchange of scholarly information and/or primary research through the Department's regularly scheduled Distinguished Lecture Series. Student responsibilities include critical reviews of presentations by local and visiting faculty. This course gives students a broad survey of the latest research within the subdisciplines of Hydrology and Atmospheric Science.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Colloquium Required

Co-convened with:

Course typically offered:

Main Campus: Fall, Spring

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 496M: Dynamic Simulation Modeling using GoldSim (2 units)

Description: This course will spend equal time introducing the fundamental use and behavior of basic GoldSim operators as well as introducing the basic concepts of system dynamic modeling with applications drawn primarily from water resource planning and management. GoldSim is a relatively new but widely used dynamic simulation software. System dynamics assumes that the structure of a system, the network of cause and effect connecting disparate elements, governs system behavior. This framework focuses on interrelationships rather than elements, patterns of change rather than static snapshots, and processes rather than data. Within this framework, concepts of stocks and flows, feedback, time delay, and alternative growth modes (linear, exponential, goal seeking) will be demonstrated and reinforced through application to physical processes such as groundwater flows, river routing and population dynamics. Students will explore implementation of these techniques within the context of public-mediated decision making and policy analysis.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Seminar Required

Co-convened with: HWRS 596M

HWRS 498: Senior Capstone (1 - 3 units)

Description: Student must have engaged in a hydrology or water resources internship, water science research, or water policy research. The key requirement is that the project is water-related, and the student has engaged in data analysis during the project. This is a two-semester course, beginning in fall semester (3 units) and concluding in spring semester (1 unit). During fall semester students prepare a professional poster presentation of their undergraduate hydrology or water resources research project, to be presented in the subsequent spring semester at El Dia del Agua, the Department of Hydrology & Water Resources' Annual Student Research Exposition on UA campus. In the weeks following El Dia, guest speakers from various sectors of the hydrology and water resources industry speak to the class and answer questions about career paths, graduate school etc.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 4 units.

Course typically offered:

Main Campus: Fall, Spring

Student Engagement Activity: Professional Development

Student Engagement Competency: Innovation and Creativity

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 498H: Honors Thesis (3 units)

Description: Student must have engaged in a hydrology or water resources internship, water science research, or water policy research. The key requirement is that the project is water-related, and the student has engaged in data analysis during the project. This is a two-semester course, beginning in fall semester (3 units) and concluding in spring semester (1 unit). During fall semester students prepare a professional poster presentation of their undergraduate hydrology or water resources research project, to be presented in the subsequent spring semester at El Dia del Agua, the Department of Hydrology & Water Resources' Annual Student Research Exposition on UA campus. In the weeks following El Dia, guest speakers from various sectors of the hydrology and water resources industry speak to the class and answer questions about career paths, graduate school etc.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 6 units.

Course typically offered:

Main Campus: Fall, Spring

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

Student Engagement Activity: Professional Development

Student Engagement Competency: Innovation and Creativity

Writing Emphasis: Writing Emphasis Course

HWRS 499: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 499H: Honors Independent Study (3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

HWRS 500: Ecosystemology for Urban Planning (3 units)

Description: Introduction to conceptual tools used in complex ecosystems, particularly cities and urban areas; integration of human residents with larger natural systems (human ecology); environmental impact assessment (EIA) and statement (EIS). Water resource planning and impact on regional ecosystems; technical, legal, ethical dimensions of water transfer.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: PLAN 500, PLG 500, PLN 500, PLNG 500

Also offered as: PLG 500

HWRS 503: Subsurface Fluid Dynamics (3 units)

Description: Dynamics of immiscible fluids in porous and fractured media; anisotropy and scale; advective solute transport; consolidation and land subsidence; multiaquifer systems; free surface flow and salt water/fresh water interfaces.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: CE 503

Also offered as: CE 503

Course typically offered:

Main Campus: Fall (even years only)

Recommendations and additional information: MATH 250B or MATH 254 or MATH 355; CE 218.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 504: Numerical Methods for Environmental Transport Problems (3 units)

Description: This course is for senior undergraduate and graduate students. The goal of this course is to introduce commonly used numerical methods for ordinary and partial differential equations encountered in transport problems in environmental systems. The course covers finite difference and finite element methods with emphasis on basic discretization schemes and how to select the appropriate numerical schemes for a given differential equation. We will also discuss accuracy, stability, and convergence properties of the introduced numerical methods. Students will use MATLAB or other programming languages to implement numerical schemes to solve example problems. Experience with MATLAB is not required.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: CE 504, HYDR 504

Also offered as: CE 504

Co-convened with:

Course typically offered:

Main Campus: Spring (odd years only)

HWRS 505: Vadose Zone Hydrology (3 units)

Description: Fundamentals of flow and transport in the vadose zone, including multiphase flow. Methods for characterization of hydraulic properties. Vadose zone processes relative to ground water contamination.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Co-convened with: HWRS 405

Course typically offered:

Main Campus: Fall

Recommendations and additional information: HWRS 503 or HWRS 518.

HWRS 506: Modeling of Mass and Energy Flow in Soils (3 units)

Description: Water flow in soils; closely related problems of solute, pollutant, and heat transfer; emphasis on current concepts and research.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: ABE 605, ABT 605, AEN 605, HWRS 605, HYDR 605, SW 605

Also offered as: BE 506, ENVS 506

Course typically offered:

Main Campus: Fall

Recommendations and additional information: MATH 254.

Home department: Soil, Water, & Environmental Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 510: Mesoscale Meteorology (3 units)

Description: This course teaches the structure and dynamics of convective and mesoscale phenomena, including mesoscale convective systems, severe thunderstorms, tornadoes, low-level jets, mountain waves and tropical cyclones. For most of these phenomena, the course discusses their general behaviors and characteristics, the dynamics of their formation and development, and the types of weather and hazards they produce, and in some cases their prediction. Specific topics are given below.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Also offered as: ATMO 510

Recommendations and additional information: ATMO 541B.

Home department: Hydrology and Atmospheric Sciences

Interdisciplinary Interest Area: GEOS - Geosciences

HWRS 513A: Field Hydrology Methods (2 units)

Description: You have learned the theory of hydrologic measurement in this course you will apply this theory to individual measurements and to aggregating measurement into a greater explanation and understanding of hydrologic phenomena. Each week in the spring we will focus on an individual type of hydrologic measurement or characterization. You will then synthesize these individual measurements into a report that explain some underlying hydrologic phenomena.

Grading basis: Regular Grades

Career: Graduate

Flat Fee: \$160

Course Components:	Laboratory	Required
	Lecture	May Be Offered

Co-convened with: HWRS 413A

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 431 or HWRS 518, HWRS 423 or HWRS 519 or consent of instructor.

Field trip: Daily field trips and overnight camping in field required.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 513B: Field Hydrology Synthesis (1 unit)

Description: You have learned the theory of hydrologic measurement in this course you will apply this theory to individual measurements and to aggregating measurement into a greater explanation and understanding of hydrologic phenomena. In this one credit course you will complete a hydrologic characterization of a field site.

Grading basis: Regular Grades

Career: Graduate

Course Components: Laboratory Required

Co-convened with: HWRS 413B

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 513A

Field trip: The class will meet at Dead Horse Ranch State Park and then at the University of Arizona Campus. Topics, dates, and locations are subject to change. A change in any subsequent meeting will be announced at the preceding class meeting.

HWRS 515: Introduction to Water Resources Policy (3 units)

Description: Water resources policy including the identification of regional problems of water use, the elements of water planning, water rights, and a consideration of institutional structures and processes. Graduate-level requirements include an in-depth term paper.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: GEOG 515

Also offered as: GEOG 515

Co-convened with: HWRS 415

Course typically offered:

Main Campus: Spring (odd years only)

HWRS 516: Hydrologic Transport Processes (3 units)

Description: Development and application of equations describing mass and energy transport in the subsurface environment.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall

Recommendations and additional information: HWRS 503 or HWRS 535; SIE 270.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 517A: Fundamentals of Water Quality (3 units)

Description: Introduction to chemical processes affecting the behavior of major and minor chemical species in the aquatic environment. Physical, equilibrium, inorganic/organic, and analytical principles as applied to natural waters. Graduate-requirements include writing a review paper and oral presentation, differential problem sets for homework and exams.

Grading basis: Student Option ABCDE/PF

Career: Graduate

Course Components: Lecture Required

Co-convened with: HWRS 417A

Course typically offered:

Main Campus: Fall

HWRS 518: Fundamentals of Subsurface Hydrology (3 units)

Description: Survey of physical, mathematical, geologic, and engineering concepts fundamental to subsurface hydrologic processes.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall

Recommendations and additional information: Prerequisite or concurrent registration, C E 218; MATH 254, GEOS 251.

HWRS 519: Fundamentals of Surface Water Hydrology (3 units)

Description: Survey of main topics in surface water hydrology: hydrometeorology, evaporation, rainfall-runoff, statistical and probabilistic methods, unit hydrograph method, and flood routing.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring

Recommendations and additional information: Prerequisite or concurrent registration, C E 218, SIE 305.

HWRS 520: Fundamentals: Water Resources Policy: Management, Planning, & Rights (3 units)

Description: An introduction to basic concepts and issues of water resources management and administration, emphasizing water law and rights, water resources planning, institutional and organizational arrangements, and policy processes such as adjudication and rule-making.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 521: Water Resources Systems Planning and Management (3 units)

Description: Quantitative analytical methods in water resources planning and management; introduction to systems analysis, benefit/cost, multi-objective planning and risk assessment. Graduate-level requirements include a term project.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Co-convened with: HWRS 421

Course typically offered:

Main Campus: Fall

Recommendations and additional information: MATH 125.

HWRS 522: Critical Zone Science & Management (3 units)

Description: This course targets undergraduate science majors and graduates interested in learning more about integrated and interdisciplinary team science while learning about the cross-cutting research and observational strategies employed across NSF's Critical Zone Observatory network. At least half of the course will focus on guided data analysis based on CZO data sets. Graduate-level requirements include working with more complex data sets and a 10-page research paper. In general, most seasonal-annual or multi-site data sets will qualify. Please discuss with your instructor prior to turning in a research paper proposal.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: ENVS 522, GEOS 522

Co-convened with:

Recommendations and additional information: Class participants must have completed at least one university/college-level lab-based science course and mathematics through pre-calculus

Home department: Soil, Water, & Environmental Sciences

HWRS 523: Hydrology (3 units)

Description: Discussion and analysis of major topics of the hydrologic cycle and their interrelationship, such as rainfall, infiltration, evaporation, and runoff. Statistical and probabilistic methods in water supply and flood hydrology. Graduate-level requirements include a project paper.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: ARL 523, ARL 523, HWRS 523, HYDR 523

Also offered as: ARL 523, ATMO 523, CE 523

Co-convened with: CE 423

Course typically offered:

Main Campus: Spring

Home department: Civil and Architectural Engineering and Mechanics

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 524: Hydroclimatology (3 units)

Description: Precipitation formation processes, the surface and atmospheric branch of the hydrologic cycle, land surface-atmosphere interaction, surface energy balance, evapotranspiration, heat and moisture fluxes into the soil and atmospheric boundary layer.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: ATMO 524

Also offered as: ATMO 524

Course typically offered:

Main Campus: Spring

HWRS 527: Computer Applications in Hydraulics (3 units)

Description: Computer modeling of surface water hydrology, flood plain hydraulics and water distribution systems. Theoretical basis. Application and design studies. Graduate-level requirements include a research paper or project.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Equivalent to: ABE 527, HWRS 527

Also offered as: BE 527, CE 527

Co-convened with: HWRS 427

Course typically offered:

Main Campus: Spring

Home department: Civil and Architectural Engineering and Mechanics

HWRS 528: Fundamentals: Systems Approach to Hydrologic Modeling (3 units)

Description: Introduction to the language, methods, and tools of systems analysis and computer-based modeling, and their application to the science, risk assessment, management, and planning aspects of hydrology and water resources.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Co-convened with:

Course typically offered:

Main Campus: Fall

Recommendations and additional information: MATH 129, SIE 305, or ECE 175 or equivalent computer programming course approved by instructor. Concurrent registration, MATH 254.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 529: Objective Analysis in the Atmospheric and Related Sciences (3 units)

Description: This graduate course provides an overview of statistical methods used to interpret datasets in the atmospheric and related sciences. The objective is to provide a working knowledge of the statistical tools most commonly used. Topics include application of basic statistics (composite analysis; significance testing; curve fitting; regression analysis; correlation; and non-normal distributions), non-parametric statistical significance testing (e.g. Monte-Carlo methods and field significance), matrix methods (principal component analysis; SVD analysis; CCA), and time series analysis (harmonic analysis; power spectra; data filtering; cross-spectrum analysis; singular spectrum analysis; and wavelet analysis).

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: GEOG 529, GEOS 529, HWRS 529

Also offered as: ATMO 529, GEOG 529, GEOS 529

Course typically offered:

Main Campus: Fall (odd years only)

Recommendations and additional information: Undergraduate level statistics course and linear algebra required. Computer programming skills (C, Fortran, Matlab) and knowledge of graphical display packages needed or consent of instructor.

Home department: Hydrology and Atmospheric Sciences

HWRS 531: Hydrogeology (4 units)

Description: Hydrologic and geologic factors controlling the occurrence and dynamics of groundwater on regional and local scales. Graduate-level requirements include a research paper on a topic related to hydrogeology but not covered in lectures.

Grading basis: Regular Grades

Career: Graduate

Flat Fee: \$20

Course Components: Laboratory May Be Offered
 Lecture Required

Equivalent to: GEOS 531

Also offered as: GEOS 531

Co-convened with: HWRS 431

Course typically offered:

Main Campus: Fall

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 532: Environmental Hydrogeology Lab (3 units)

Description: Introduction to field, lab, and office methods used in hydrogeology. Hands-on use of modern field and laboratory equipment to measure and monitor hydrogeological parameters and variables. Analysis, visualization, and interpretation of the data performed in chemistry and computer laboratories. Graduate-level requirements include lab reports, demonstrated understanding of techniques learned and communicate results clearly/concisely; creative application of techniques to other problems.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Laboratory	Required
	Lecture	May Be Offered

Repeatable: Course can be repeated a maximum of 2 times.

Co-convened with: HWRS 432

Course typically offered:

Main Campus: Spring

HWRS 535: Advanced Subsurface Hydrology (3 units)

Description: Advanced aquifer and well hydraulics; heterogeneity, unsaturated flow; natural and artificial recharge; ground-water and surface-water interaction; mass and heat transport.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Equivalent to: GEOS 535

Also offered as: GEOS 535

Course typically offered:

Main Campus: Spring

Recommendations and additional information: MATH 250B or MATH 254 or MATH 355.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 536A: Fundamentals of the Atmospheric Sciences (3 units)

Description: Broadly covers fundamental topics in the atmospheric sciences. Topics include composition of the atmosphere, atmospheric thermodynamics, atmospheric chemistry, cloud physics, radiative transfer, atmospheric dynamics, and climate. Graduate-level requirements include additional questions on homework and exams plus a term paper on a specialized research topic.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: GEOG 536A, GEOS 536A, HWRS 536A, PHYS 536A, SWES 536A

Also offered as: ATMO 536A, ENVS 536A, GEOG 536A

Co-convened with:

Course typically offered:

Main Campus: Spring

Home department: Hydrology and Atmospheric Sciences

Interdisciplinary Interest Area: GEOS - Geosciences

Interdisciplinary Interest Area: PHYS - Physics

HWRS 543A: Risk Assessment for Environmental Systems (3 units)

Description: A multidisciplinary course based on evaluating risk as the loss expected from environmental catastrophes or from the failure of systems designed for environmental protection. Examples will be drawn from hydrology, atmospheric science, and geology. The emphasis is on adapting the tools of probabilistic risk assessment to environmental analyses. Graduate-level requirements include a written review of a seminal paper and its presentation in class.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Co-convened with: HWRS 443A

Course typically offered:

Main Campus: Fall

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 545: Introduction to Data Assimilation (3 units)

Description: Data assimilation (DA) involves combining information from observations and models of a particular physical system in order to best define and understand the evolving state of the system. It is currently applied across a wide range of Earth sciences, including weather forecasting, oceanography, atmospheric chemistry, hydrology, and climate studies. This course provides an introduction to the theory and applications of DA in atmospheric and related sciences. Topics include common DA methods like optimal interpolation, Kalman filtering and variational schemes within the context of estimation theory. The course is designed as a hands-on approach to key DA concepts that are currently used today.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: ATMO 545

Course typically offered:

Main Campus: Fall (odd years only)

Recommendations and additional information: Linear algebra, elementary statistics. Basic programming skills (C, Fortran, Matlab) is needed or consent of instructor.

Home department: Hydrology and Atmospheric Sciences

Interdisciplinary Interest Area: GEOS - Geosciences

HWRS 549: Statistical Hydrology (3 units)

Description: Application of statistics and probability to uncertainty in the description, measurement, and analysis of hydrologic variables and processes, including extreme events, error models, simulation, sampling. Graduate-level requirements include an in-depth simulation project.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Equivalent to: CE 549

Also offered as: CE 549

Course typically offered:

Main Campus: Fall

-SA represents a Student Abroad & Student Exchange offering

-**CC** represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 552: Dryland Ecohydrology and Vegetation Dynamics (4 units)

Description: Overview of ecological and hydrological interrelationships, including ecologically meaningful water budgets, and associated vegetation dynamics for water-limited, dryland ecosystems. Graduate-level requirements include different grading criteria and exam components plus completing a group research project in coordination with the instructor.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Also offered as: ECOL 552, RNR 552, WSM 552

Co-convened with: HWRS 452

Course typically offered:

Main Campus: Fall

Recommendations and additional information: RNR 316, ECOL 302, or consent of instructor.

Home department: Watershed Management

HWRS 555: Introduction to Atmospheric and Hydrology Remote Sensing (3 units)

Description: The purpose of this course is to introduce the basic remote sensing techniques and their applications to the atmosphere, hydrology and other fields. This includes understanding the basic concepts of radiation transfer, passive and active remote sensing, satellite and ground-based remote sensing and their retrieval techniques. Finally, inversion techniques in remote sensing will be briefly introduced and the uncertainties/errors of the retrieved cloud and precipitation properties will be estimated. Graduate students will do some homework, but primarily work on processing and analyzing the aircraft, ground-based and satellite remote sensing data collected from instructors research projects. Graduate students will get hands-on experience by doing these projects using IDL, MATLAB, FORTRAN, or other programs. For some projects, I may provide key codes as a reference.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Also offered as: ARL 555, ATMO 555, ENVS 555, GEOS 555, OPTI 555, REM 555

Course typically offered:

Main Campus: Spring

Home department: Hydrology and Atmospheric Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 558: Mesoscale Meteorological Modeling (3 units)

Description: This course provides an overview of mesoscale meteorological modeling, emphasizing limited area models. It is a modified version of a course originally developed by Professor Roger Pielke, Sr., and currently taught at the University of Colorado. The objective is to provide students a framework for understanding limited area models commonly used in the atmospheric science community, either as numerical weather prediction models or regional climate models. Topics include conservation equations of the atmosphere; methods of solution; boundary and initial conditions; coordinate systems; parameterization schemes; and model application and evaluation. Particular emphasis will be placed on the Weather Research and Forecasting (WRF) model, as this is used in the UA Department of Atmospheric Sciences.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Equivalent to: GEOS 558, HWRS 558

Also offered as: ATMO 558

Course typically offered:

Main Campus: Spring (even years only)

Recommendations and additional information: ATMO 541A, ATMO 541B or consent of instructor.

Home department: Hydrology and Atmospheric Sciences

Interdisciplinary Interest Area: GEOS - Geosciences

HWRS 560A: Watershed Hydrology (4 units)

Description: Watershed hydrology looks at how water movement, storage and transformation on the Earth's surface is influenced by landscape characteristics, including human modifications of those characteristics, and weather. As such, watershed hydrology will focus on surface water. However, this course offers a brief introduction to groundwater as it pertains to watershed hydrology. Graduate-level requirement includes required completion of a graduate environmental inquiry through volunteer work. Graduate students will be required to blog about these experiences.

Grading basis: Regular Grades

Career: Graduate

Flat Fee: \$65

Course Components:	Laboratory	Required
	Lecture	Required

Also offered as: WSM 560A

Co-convened with: HWRS 460A

Course typically offered:

Main Campus: Fall

Recommendations and additional information: Calculus and PHYS 102 or equivalent.

Home department: Watershed Management

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

Description: This course examines the characterization and remediation of contaminated hazardous waste sites. The course is focused on the scientific and engineering principles supporting site characterization and remediation activities. Standard and innovative technologies are covered. Multiple individual and team projects based on real-world examples are used to provide hands-on practical experience

Career: Graduate

Equivalent to: HWRS 566, SW 566

Also offered as: ENVS 566

Course typically offered:

Main Campus: Spring (even years only)

Recommendations and additional information: HWRS 531 or equivalent; SWES 564 or equivalent.

Home department: Soil, Water, & Environmental Sciences

Description: Introduction to the fundamentals of solving complex water chemistry problems using computer codes as tools. Equilibrium, mass transfer, 1-D transport models and catchment water quality models with multi-element chemistry, thermodynamic concepts, and use of equations in models; placing natural chemical processes into an interpretable framework, evaluation of error and uncertainty. Generally offered spring semester, alternating even-numbered years.

Career: Graduate

Course typically offered:

Main Campus: Spring (odd years only)

Recommendations and additional information: Prerequisite or concurrent registration, HWRS 506 or HWRS 517 or consent of instructor.

Description: Study of processes affecting global chemical fluxes. Particular attention to current global concerns, i.e., ozone hole, carbon cycle, climate warming, atmospheric oxidation, hydrologic cycle.

Career: Graduate

Equivalent to: GEOS 572, HWRS 572

Also offered as: GC 572, GEOS 572

Home department: Committee on Global Change

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 573: Hydrology for Water Resources Management (3 units)

Description: This course will develop the students understanding of the hydrologic cycle, its constituent parts on the hydrologic cycle. It will then expose students to various ways in which human management influences the hydrologic cycle and ways in which the hydrologic cycle controls water resources management.

Grading basis: Student Option ABCDE/PF

Career: Graduate

Course Components:	Lecture	Required
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Course typically offered:

Main Campus: Fall

HWRS 574B: Weather Analysis and Forecasting II (3 units)

Description: This course is for senior undergraduate and graduate students. The overall goal of this course is to apply the fundamental theoretical principles of synoptic-dynamic and mesoscale meteorology to the real atmosphere through a discussion of ensemble weather forecasting, an application of quasi-geostrophic principles and potential vorticity thinking to weather and forecasting, an overview of the dynamics of convective storms, and a real-time severe weather and quantitative precipitation forecasting exercise.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: ATMO 574B, PHYS 574B

Co-convener with: ATMO 474B

Course typically offered:

Main Campus: Spring (odd years only)

Online Campus: Spring (odd years only)

Home department: Hydrology and Atmospheric Sciences

Enrollment requirement: ATMO 474A/574A, or ATMO 441A/541A and ATMO 441B/541B, or permission of instructor.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

Description: Economic incentives, tradable permits and markets for ecosystem services are pivotal in contemporary water and environmental policy. This class covers theory and application of economic concepts needed to evaluate water and environmental laws and policies; including ecosystem service provision, tradable use permits, benefit cost analysis, externalities, public goods and valuation methodologies. Case studies include federal, state, tribal and international water and environmental policies.

Main Campus: Fall

Home department: Agricultural & Resource Economics

Main Campus: Spring

Home department: Agricultural & Resource Economics

Home department: Agricultural & Resource Economics

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 578: Global Change (3 units)

Description: Analysis of the Earth system through an examination of its component parts (particularly climate and biogeochemistry) and their interactions with human activities, emphasizing information needed to understand modern and future environmental changes. Graduate-level requirements include an in-depth written exercise and additional activities as described in the syllabus.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: ECOL 578, GC 578, GEOG 578, HWRS 578, HYDR 578, RNR 578, SW 578

Also offered as: ECOL 578, GC 578, GEOG 578, GEOS 578, RNR 578

Course typically offered:

Main Campus: Fall

Home department: Geosciences

Interdisciplinary Interest Area: ECOL - Ecology & Evolution Bio

HWRS 579: Boundary Layer Meteorology & Surface Processes (3 units)

Description: Designed for students in the atmospheric sciences, hydrology and related fields. It provides a framework for understanding the basic physical processes that govern mass and heat transfer in the atmospheric boundary layer and the vegetated land surface. In addition to the theoretical part of the course, there is a strong focus on modeling and students will be required to program numerical codes to represent these physical processes.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Repeatable: Course can be repeated a maximum of 2 times.

Also offered as: ATMO 579, ENVS 579, PTYS 579, WSM 579

Course typically offered:

Main Campus: Spring (even years only)

Recommendations and additional information: MATH 223, PHYS 141, PHYS 253.

Home department: Hydrology and Atmospheric Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 580: Isotope Tracers in Hydrogeology (3 units)

Description: Fundamental principles of stable, radiogenic, and cosmogenic isotope chemistry of natural waters; geochemical processes affecting isotopic compositions of surface waters, soil waters, and groundwaters; and case studies of isotope hydrogeology. Mandatory field trip: Sampling surface- and ground-waters in Tucson Basin, field methods in isotope hydrogeology. Graduate-level requirements include a facsimile research grant proposal (i.e., as if writing proposal to a government grant agency), including abstract, of not less than 10 pages; the grade will be based on both the written paper as well as oral presentation of the research proposal to the class.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: GEOS 580

Also offered as: GEOS 580

Co-convened with: HWRS 480

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 517 or HWRS 550.

Field trip: Sampling surface- and ground-waters in Tucson Basin, field methods in isotope hydrogeology.

HWRS 581: Environmental Policy (3 units)

Description: Role of government in management of energy, natural resources and environment; process and policy alternatives; special attention to the Southwest. Graduate-level requirements include additional readings and a substantial research paper of at least 25 pages in length.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: HWRS 581, POL 581, RNR 581, WRA 581

Also offered as: PA 581, POL 581, RNR 581

Co-convened with:

Course typically offered:

Main Campus: Fall

Home department: School of Government and Public Policy

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 582: Applied Groundwater Modeling (3 units)

Description: Introduction to ground-water flow and transport modeling, with emphasis on model construction and simulation. Graduate-level requirements include an in-depth research paper and/or project.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Co-convened with: HWRS 482

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 250, MATH 122 A&B and MATH 129-Student must complete HWRS 250 or equivalent course.-Student must complete two semesters of basic calculus.-Vector calculus is preferred but not required.

HWRS 590: Remote Sensing for the Study of Planet Earth (3 units)

Description: Remote Sensing for the Study of Planet Earth introduces basic and applied remote sensing science as a means to explore the diversity of our planetary environments (biosphere, atmosphere, lithosphere and hydrosphere) within the radiometric, spectral, spatial, angular and temporal domains of remote sensing systems. This survey course strikes a balance between theory, applications and hands-on labs and assignments. We explore how you can download, process, analyze and interpret multi-sensor data and integrate online remotely sensed data sources/products into your research of interest.

Grading basis: Regular Grades

Career: Graduate

Flat Fee: \$50

Course Components: Lecture Required

Equivalent to: ARL 590, ARL 590, ATMO 590, GEN 590, GEOG 590, GEOS 590, HWRS 590, MNE 590, OPTI 590, RNR 590, SW 590, SWES 590

Also offered as: ARL 590, ATMO 590, ENVS 590, GEOG 590, GEOS 590, MNE 590, OPTI 590, REM 590, RNR 590

Co-convened with: HWRS 490

Course typically offered:

Main Campus: Fall

Home department: GIDP on Remote Sensing and Spatial Analysis

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 595A: Current Topics in Hydrology and Atmospheric Science (1 unit)

Description: Exchange of scholarly information and/or primary research through the Department's regularly scheduled Distinguished Lecture Series. Student responsibilities include critical reviews of presentations by local and visiting faculty. This course gives students a broad survey of the latest research within the sub-disciplines of Hydrology and Atmospheric Science.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Colloquium Required

Repeatable: Course can be repeated a maximum of 4 times.

Co-convened with:

Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: consult department before enrolling.

HWRS 595B: Global Climate Change (3 units)

Description: The exchange of scholarly information and/or secondary research, usually in a small group setting. Instruction often includes lectures by several different persons. Research projects may or may not be required of course registrants.

Grading basis: Regular Grades

Career: Graduate

Course Components: Colloquium Required

Repeatable: Course can be repeated for a maximum of 6 units.

Equivalent to: GEOS 595B, HWRS 595B, HYDR 595B

Also offered as: ATMO 595B

Home department: Hydrology and Atmospheric Sciences

Interdisciplinary Interest Area: GEOS - Geosciences

HWRS 595C: General Circulation Observations and Modeling (1 - 3 units)

Description: The exchange of scholarly information and/or secondary research, usually in a small group setting. Instruction often includes lectures by several different persons. Research projects may or may not be required of course registrants.

Grading basis: Regular Grades

Career: Graduate

Course Components: Colloquium Required

Equivalent to: GEOS 595C, HWRS 595C

Also offered as: ATMO 595C

Course typically offered:

Main Campus: Spring (odd years only)

Home department: Hydrology and Atmospheric Sciences

Interdisciplinary Interest Area: GEOS - Geosciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 596B: Water Policy in Arizona and Semi-arid Regions (3 units)

Description: This course focuses on current water policy in Arizona, the Colorado River Basin, and other semi-arid regions from a multi-disciplinary perspective. Through readings, research, lectures, discussions, and presentations, the student is exposed to major, current water resource issues and policies to address them. The professor and guest lecturers draw upon their experiences to demonstrate the development, analysis and implementation of real-world water policy.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Equivalent to: GEOG 596B, HWRS 596B, LAW 596B

Also offered as: ENVS 596B, GEOG 596B, LAW 596B, PLG 596B

Course typically offered:

Main Campus: Spring

Recommendations and additional information: Consent of instructor is required.

Home department: Soil, Water, & Environmental Sciences

HWRS 596G: Water-Rock-Microbial Interactions (3 units)

Description: Advanced topics in aqueous geochemistry and geomicrobiology will be discussed from current literature. Students will gain an understanding of how waters evolve through, and are influenced by, the hydrologic cycle via reactions with minerals, organic matter, and biologic processes. Strong emphasis on field and laboratory analyses, coupled with geochemical modeling. Course will greatly expand on topics from HWRS 517 and be tailored to students' research interests.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Equivalent to: AREC 696G, GEOS 696G, SIE 696G

Also offered as: GEOS 596G

Course typically offered:

Main Campus: Fall (odd years only)

Recommendations and additional information: Consent of instructor.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 596M: Dynamic Simulation Modeling using GoldSim (2 units)

Description: This course will spend equal time introducing the fundamental use and behavior of basic GoldSim operators as well as introducing the basic concepts of system dynamic modeling with applications drawn primarily from water resource planning and management. GoldSim is a relatively new but widely used dynamic simulation software. System dynamics assumes that the structure of a system, the network of cause and effect connecting disparate elements, governs system behavior. This framework focuses on interrelationships rather than elements, patterns of change rather than static snapshots, and processes rather than data. Within this framework, concepts of stocks and flows, feedback, time delay, and alternative growth modes (linear, exponential, goal seeking) will be demonstrated and reinforced through application to physical processes such as groundwater flows, river routing and population dynamics. Students will explore implementation of these techniques within the context of public-mediated decision making and policy analysis.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Co-convened with: HWRS 496M

HWRS 597C: Hydrologic Literacy in the Secondary Classroom (1 - 2 units)

Description: The goal of the workshop is to increase the hydrologic literacy of practicing teachers and to demonstrate how to combine teaching techniques and activities in order to teach student-relevant, cognitively rigorous content using inquiry. A problem-based learning approach is used.

Grading basis: Regular Grades

Career: Graduate

Course Components: Workshop Required

Repeatable: Course can be repeated for a maximum of 2 units.

Recommendations and additional information: Open to current certified teachers K-12; all others should contact the department.

HWRS 599: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 602: Snow Hydrology (2 units)

Description: [Taught even-numbered years] The significance of snow in hydrologic budgets of watersheds and river basins, and potentials for snowpack management.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: WSM 602

Course typically offered:

Main Campus: Spring (even years only)

HWRS 603A: Well Hydraulic and Pumping Test Analysis (3 units)

Description: Theory and methodology of aquifer hydraulic testing by means of wells. Generally offered spring semester, alternating odd-numbered years.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Recommendations and additional information: HWRS 503 or HWRS 518 or HWRS 535.

HWRS 630: Advanced Catchment Hydrology (3 units)

Description: Concepts and methodology required to upscale near-surface hydrologic processes to catchment scales with development of watershed models to quantify hydrologic response in different climates. Special attention given to how landscape geomorphologic structure affects hydrologic behavior.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: CE 630

Also offered as: CE 630

Course typically offered:

Main Campus: Fall (even years only)

Recommendations and additional information: HWRS 518, HWRS 519, or consent of instructor. Computer programming skills (e.g. MATLAB, C++).

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 641: Water Law (3 units)

Description: The course in Water Law traditionally emphasizes state law rules that govern rights to use surface water and groundwater throughout the country. Although we will give ample attention to the prior appropriation doctrine, riparian water rights, and various systems for regulating groundwater use, this course will also emphasize how federal law may impact water rights. Increasingly, environmentalists and others claim that there are public rights to water that may take precedence over rights under the prior appropriation system.

Grading basis: Alternative Grading: ABCDE/SP

Career: Graduate

Course Components: Lecture Required

Also offered as: ENVS 641, GEOG 641, LAW 641, MNE 641

Course typically offered:

Main Campus: Spring

Home department: Law

HWRS 642: Analysis of Hydrologic Systems (3 units)

Description: Presentation and evaluation of a variety of mathematical modeling techniques; presentation of theoretical basis of linear/nonlinear systems, advantages and limitations of various approaches, e.g., linear vs. nonlinear, lumped vs. distributed, used in hydrologic modeling; interrelation between function development and model calibration requirements.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring (odd years only)

Recommendations and additional information: MATH 254.

HWRS 645: Stochastic Methods in Subsurface Hydrology (3 units)

Description: [Taught alternate years 2001 - 2002] Application of the theory of stochastic processes and random fields to natural variability in subsurface hydrology.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Repeatable: Course can be repeated a maximum of 2 times.

Course typically offered:

Main Campus: Spring

Recommendations and additional information: HWRS 545.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 655: Stochastic Methods in Surface Hydrology (3 units)

Description: Topics and applications will vary with instructor. Advanced application of statistics and probability to hydrology, time series analysis and synthesis, and artificial neural network methods, as applied in the modeling of hydro-climatic sequences or Bayesian and other analyses in the decision making process of water resources. A combination of theory and application to the fields of hydrology, environmental and water resources engineering, climatic modeling, and other related natural resource modeling.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: CE 655

Also offered as: CE 655

Course typically offered:

Main Campus: Fall (even years only)

Recommendations and additional information: Consult with course instructor.

HWRS 696B: Advanced Topics in Hydrology-Biogeochemistry Interactions (1 - 3 units)

Description: Investigation of current research related to the interactions between hydrologic and biogeochemical processes. Potential topics include the use of hydrologic flowpaths to scale biogeochemical reactions; liquid water availability as a physical constraint on biological processes; water availability as a biological constraint; hydrologic flowpaths as a deliverer of limiting reactants to surface and subsurface environments. Topics will vary depending on semester of offering and instructor.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Repeatable: Course can be repeated for a maximum of 3 units.

Recommendations and additional information: HWRS 580.

HWRS 696C: Advanced Topics in Subsurface Hydrology and Modeling (1 - 3 units)

Description: The development and exchange of scholarly information, usually in a small group setting. The scope of work shall consist of research by course registrants, with the exchange of the results of such research through discussion, reports, and/or papers.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Course typically offered:

Main Campus: Fall (even years only)

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 696F: Advanced Topics in Surface Hydrology and Modeling (1 - 3 units)

Description: The development and exchange of scholarly information, usually in a small group setting. The scope of work shall consist of research by course registrants, with the exchange of the results of such research through discussion, reports, and/or papers.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Repeatable: Course can be repeated for a maximum of 6 units.

Course typically offered:

Main Campus: Spring (even years only)

HWRS 696H: Advanced Topics in Geochemistry of Crustal Fluids (3 units)

Description: Advanced topics related to the physical and chemical processes that control the geochemistry of crustal fluids, including ore-forming fluids, basinal brines, formation waters in fractured bedrock, and hydrothermal waters. Course will greatly expand on topics covered in HWRS 517A, Fundamentals of Water Quality, and HWRS 580, Isotope Tracers in Hydrogeology, and will be tailored to students' research interests. Assignments include background reading and class discussion of research articles, problem sets working with geochemical datasets, and a State-of-Knowledge review paper.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Recommendations and additional information: HWRS 517A, HWRS 580 or consent of instruction.

HWRS 696I: Advanced Topics in Pore-Scale Processes (3 units)

Description: The seminar provides the student with a theoretical and computational basis for studying the pore-scale nature of porous media flows. Students will read and discuss a seminal paper each week. Grades will depend on a presentation and participation.

Grading basis: Student Option ABCDE/PF

Career: Graduate

Course Components: Seminar Required

Course typically offered:

Main Campus: Spring (odd years only)

HWRS 696L: Topics in Semi-Arid Hydrology (1 - 2 units)

Description: In conjunction with researchers in the NSF Center for Sustainability of Semi-Arid Hydrology and Riparian Areas (SAHRA), students and faculty will explore science and policy issues related to the estimation, delivery, and use of water resources.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Repeatable: Course can be repeated for a maximum of 4 units.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 696Q: Practical and Applied Hydrometeorology (1 - 3 units)

Description: This course is driven by the initiative and interest of the course members, on the basis of group decisions. Student-led discussion will be followed by a practical activity related to site development and site documentation. Field activity at the Biosphere 2 Research Facility (transportation provided) is built into the schedule as appropriate. The research goal is to document and investigate controls of vegetation on water, carbon and energy cycling as measured using eddy covariance and other micrometeorological techniques.

Grading basis: Regular Grades

Career: Graduate

Flat Fee: \$50

Course Components: Seminar Required

Equivalent to: HWRS 696Q, RNR 696Q

Also offered as: RNR 696Q, WSM 696Q

Field trip: Field activity at the Biosphere 2 Research Facility.

Home department: Watershed Management

HWRS 696T: Cosmogenic Isotopes and Other Environmental Tracers (3 units)

Description: [Taught alternate even years 2000 - 2001] Theory of isotopic and other tracers, and their applications to quantifying rates of hydrological and geological processes. Tracer production in the atmosphere, hydrosphere, and lithosphere. Their transport, deposition, and accumulation in different environments. Applications in earth, ocean, and atmospheric sciences.

Grading basis: Regular Grades

Career: Graduate

Course Components: Seminar Required

Course typically offered:

Main Campus: Spring

HWRS 699: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

HWRS 900: Research (1 - 4 units)

Description: Individual research, not related to thesis or dissertation preparation, by graduate students.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

HWRS 909: Master's Report (1 - 6 units)

Description: Individual study or special project or formal report thereof submitted in lieu of thesis for certain master's degrees.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 6 units.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

HWRS 910: Thesis (1 - 12 units)

Description: Research for the master's thesis (whether library research, laboratory or field observation or research, artistic creation, or thesis writing). Maximum total credit permitted varies with the major department.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 12 units.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

HWRS 920: Dissertation (1 - 12 units)

Description: Research for the doctoral dissertation (whether library research, laboratory or field observation or research, artistic creation, or dissertation writing).

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Winter, Spring, Summer

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.