

## VT Water-Related Graduate Courses

See [Virginia Tech Academic Catalog](#) for more information.

### BIOL 6064 Topics in Freshwater Ecology

Readings and discussion in a specific area of freshwater ecology, including species interactions, and community level functions. Topics will vary, and course may be taken for credit more than once.

### BSE 5124 AI and Cyberbiosecurity in Water and Agriculture

An introduction to emerging technologies (AI & Cyber) as they are applied to water systems and agriculture. AI topics will include machine learning, neural networks, knowledge-based reasoning, probabilistic inference, and reinforcement learning. Cyberbiosecurity topics will include detecting and mitigating cyber-physical threats, cyber hygiene, protecting big data, cybercrime, and cyber policies. AI and cyber application examples are presented, such as addressing water security challenges, protecting water supply systems, optimizing smart-farming and precision agriculture, using sensors for data collection, and understanding the effects of outlier events on biological systems. While applying AI to biological systems, serious challenges arise, such as the need for AI assurance, bias mitigation, AI explainability, data poisoning, and imbalance challenges. Spring semester.

### BSE 5214 Advanced Topics in Biological Systems Engineering

An in-depth exploration of advanced topics in biological systems engineering. Reading, discussion, summary and presentation of current research in the areas of biological systems engineering. Topics will vary by semester and may include Ecological Engineering for Urban Streams, Hydrometeorology and Water Management, Hydroclimate Extremes, Emerging Surface Water Contaminants of Human Health Concern, Biological Control Systems, Biosensors and Diagnostics, Advances in Engineering Biology, Biomaterials Engineering. May be repeated 3 times with different topics for a maximum of 12 credits. Fall and/or spring semester.

### BSE 5224G Advanced Field Methods in Hydrology

Site characterization: surveying, channel and floodplain mapping, land use, electronic data acquisition. Techniques for measuring surface and subsurface hydrological processes: water flow, hydrologic conductivity, precipitation, evaporation. Sampling techniques: surface water, groundwater, and soil pore water sampling. In-situ monitoring: automatic samplers, dataloggers, water quality sondes. Laboratory analyses: GLP practices, selection of analytical method, calibration, QA/QC. Fall semester.

### BSE 5324 Applied Fluvial Geomorphology

Introduction to landscape evolution. Influence of geology and climate on stream form and processes. Fundamental river mechanics and sediment transport. Stream surveying and classification. River system response to changes in hydrology and sediment supply. Interactions between ecosystems and fluvial systems. Human impacts on stream systems. Fall semester.

### BSE 5364 Stream Restoration

Stream restoration practices related to channel dynamics, sediment transport, impact of human activities, aquatic habitat improvements, and design and assessment. Inspecting, classifying, identifying and measuring river features of channel morphology to predict river reaction to human activities and watershed change. Spring semester, even years.

#### **BSE 5404 Agricultural Nonpoint Source Pollution**

Assessment and management of agricultural nonpoint source pollution (NPS). Precipitation, runoff, erosion, pollutant fate and transport, and best management practices. Application of Total Maximum Daily Loads and water quality standards. Pre: Background in physical, chemical, biological, and soil factors affecting the environment and in environmental regulations. Fall semester, even years.

#### **BSE/CEE 5244 Advanced GIS in Hydrologic Analysis**

Advanced GIS course focusing on raster analysis with particular application to the issues associated with hydrologic analysis. Application and evaluation of algorithms for terrain analysis, watershed characterization, and hydrologic analysis and modeling as implemented in GIS. Digital elevation data sources and error assessment. Approaches to GIS/model integration and application.

#### **CEE 5125 and 5126 Environmental Engineering Design**

5125: Design of wastewater treatment facilities for the reduction and elimination of organic and inorganic pollutants; 5126: Design of water treatment facilities for the production of potable waters from surface and groundwater systems. Fall semester.

#### **CEE 5244 Advanced GIS in Hydrologic Analysis**

Advanced GIS course focusing on raster analysis with particular application to the issues associated with hydrologic analysis. Application and evaluation of algorithms for terrain analysis, watershed characterization, and hydrologic analysis and modeling as implemented in GIS. Digital elevation data sources and error assessment. Approaches to GIS/model integration and application.

#### **CEE 5304 Environmental Fluid Mechanics**

The first part of the course will be devoted to basic concepts and equations of fluid motion. The remainder of the course will be concerned with the theory of incompressible viscous and inviscid fluids. Selected applications will be drawn from environmental and water resources topics. Spring semester.

#### **CEE 5314 River Mechanics and Sediment Transport**

Sediment properties; critical stress; bed-form regimes in alluvial streams; depth-discharge relations for rivers; bed load and suspended load movement; river stability; flow in bends; river training.

#### **CEE 5334 Analysis of Water Resources Systems**

Introduction to quantitative hydrology. Diverse computational aspects within watersheds. Methods and models used to examine components of hydrologic cycle. Risk analysis and

statistical probability in hydrology. Comprehensive models for watershed management and urban hydrology. Fall semester.

#### CEE 5344 Surface Water-Groundwater Interaction

Interaction (exchange) of surface water with groundwater at watershed, reach, sediment-patch scales including bidirectional hyporheic flows. Focus on streams and rivers, consideration of lakes. Steady and unsteady exchange hydraulics including laminar and turbulent flows. Exchange benefits and engineering goals including heat transfer, nutrient processing, and contaminant attenuation. Engineering applications including conjunctive use of surface water and groundwater resources and impact of groundwater pumping on rivers. Field methods.

#### CEE 5354/GEOS 5814 Numerical Modeling of Groundwater

Theory and practice of numerical techniques are developed and applied to fluid flow and transport in ground-water flow systems. Governing equations are formulated using FD and FE techniques with appropriate BCs and ICs. Additional topics include: model conceptualization and grid design in multidimensional systems; practical applications of numerical models including calibration, validation, and prediction; concepts and techniques of advective transport using particle tracking and dispersive transport. Introduction to MODFLOW, MODPATH, MT3D, and others.

#### CEE 5374 Dynamics Groundwater

The theory of dynamics of fluids in porous media; fluid and matrix properties; transport equations; boundary and initial value problems; flow of immiscible fluids; dispersion.

#### CEE 5384 Advanced Open Channel Flow

Advanced treatment of the mechanics of open channel flow, including uniform flow, gradually varied flow, channel transitions, and unsteady flow. Independent research project. Fall semester.

#### CEE 5390 Advanced Urban Water Sustainability

Climate change and the supply of freshwater. Coupled socio-hydrologic feedback loops (systems dynamics models) and implications for water systems resilience. Urban water transitions theory and the evolution of water systems through time. Water productivity. Stormwater capture and reuse, green stormwater infrastructure, and ecosystem services. Decentralized water and wastewater treatment systems. Emphasis is placed on the social (equity), environmental, and technological context in which urban water systems operate. Advanced statistical computing is used to quantitatively explore urban water systems challenges. Spring semester.

#### CEE 5714 Surface Water Quality Modeling

Use, analysis, and development of water quality models for lakes, rivers, and estuaries. Emphasis on model calibration, verification, and post-audit analysis. Lab portion will develop and apply a eutrophication model for an estuary using existing data.

#### CEE 5724 Environmental Monitoring and Sampling

Experimental design and sampling techniques for environmental analysis, including environmental monitoring techniques and statistical principles for planning monitoring locations and frequencies at environmental sites such as landfills, rivers, lakes, and the atmosphere. Development of monitoring strategy; examination of sampling techniques for various sample types.

#### CSES 5314 Water Quality for Professionals

Global water resource sustainability and management. Current water quality policies. Physical, chemical, biological, and anthropogenic factors affecting water quality, fate and transport of contaminants in water. Approaches of water quality risk assessment. Water treatment and management technologies.

#### CSES 5604 Environmental Science Concepts for Professionals

Physical, chemical, and biological principles and processes that are central to human-environment interactions. Emphasizes air and water resources and the role of energy in human and natural systems. Major U.S. environmental legislation and regulations. Summer session.

#### CSES 5854 Advanced Wetland Soils

Wetlands soils as components of natural landscapes: biogeochemistry, hydrology, geomorphology, hydric soil indicators, and wetland functions under various land uses. Soil and hydrologic factors important to wetland delineation and jurisdictional determination. Mitigation of wetland impacts with emphasis on restoration and creation. Outdoor lectures at local wetlands and a two-day long field trip to observe and identify wetland soils are mandatory. Fall semester, every other year.

#### CSES 5864 Advanced Wetland Soils and Mitigation

Wetland soils as components of natural landscapes and their interactions with hydrologic systems. Hydric soil identification and delineation, preparation of wetland water budgets, restoration of damaged wetlands, and creation of compensation wetlands. Utilization of advanced soil information systems and GIS/GPS in wetlands study. Constructed wetlands for nutrient removal and acid mine drainage treatment. Summer session, every other year.

#### FIW 5534 Advanced Wetland Ecology and Management

Introduction to the variety of wetland systems found in North American, with emphasis on eastern and mid-Atlantic wetland systems. Origin and processes of formation of wetlands, functions and values of wetlands, wetland delineation, wetland classification, regulatory processes affecting wetlands. Objective of management and techniques used to protect and/or manipulate wetland systems for wildlife and other human needs.

#### FREC 5354 Soil Science and Biogeochemistry

Foundations of soil science and biogeochemistry. Concepts in soil and landscape evolution; elemental cycling; soil-plant-microbe interactions; soil sampling and analysis; and relationships among physical, chemical, and biological properties and processes.

#### FREC 5374G Advanced Forested Wetlands

Classifications, jurisdictional delineation, and management options of forested wetlands.

Relationship of hydrology, soils, and vegetation to ecosystem processes, societal values, and management with regard to environmental and legal considerations and best management practices. Emphasis is on forested wetlands in the southern U.S. but national and international wetlands are included. Data analysis, interpretations, and report for field trips are required for graduate credit. Fall semester.

#### **FREC 5784G Advanced Wetland Hydrology and Biogeochemistry**

Water flows creating wetland hydrologic regime. Hydrologic controls on wetland processes. Linkages between hydrology and biogeochemical cycles. Carbon, nitrogen, phosphorus, and other element cycles within and across wetland boundaries. Field methods to assess hydrologic regime and biogeochemical cycles. Ecosystems services from hydrologic and biogeochemical processes. Applications of wetland hydrology and biogeochemistry in wetland restoration, delineation, and creation. Spring semester.

#### **FREC/CSES 5144 Watershed Hydrology**

Physical concepts of hydrological processes that affect age, origin, cycling, and flowpaths of water within watersheds. Analysis of current and historical research methods. Hydrological science as an interdisciplinary topic.

#### **FREC/WATR 5244 Advanced Hydroinformatics**

Analysis and examination of hydrologic data using basic statistics and computer programming. Calculation and interpretation of flow frequency and duration, hydrologic analysis of geospatial digital terrain data, and implementation and analysis of simple hydrologic models. Advanced methods of temporal and spatial hydrologic data visualization using computer programming. Spring semester.

#### **GEOG 5134 / GEOS 5844 Advanced Interdisciplinary Issues and Ethics in Water Resources**

Issues and ethics related to water resources, water as a hazard upon human (infrastructure, economy) and ecological (rivers, groundwater) systems, water- and vector-borne disease, climate change, dams, and eutrophication. Multidimensionality of water resources. Fall semester.

#### **GEOS 5804G Advanced Groundwater Hydrology**

Physical principles of groundwater flow, including application of analytical solutions to real-world problems. Well hydraulics. Geologic controls on groundwater flow. Fall and spring semesters.

#### **GEOS 5814/CEE 5354 Numerical Modeling of Groundwater**

Theory and practice of numerical techniques are developed and applied to fluid flow and transport in ground-water flow systems. Governing equations are formulated using FD and FE techniques with appropriate BCs and ICs. Additional topics include: model conceptualization and grid design in multidimensional systems; practical applications of numerical models including calibration, validation, and prediction; concepts and techniques of advective transport using particle tracking and dispersive transport. Introduction to MODFLOW, MODPATH, MT3D, and others.

#### **GEOS 5834 Chemical Hydrogeology**

Study of solute transport in geologic systems. Focus on processes of advection, dispersion, mineral dissolution and precipitation, chemical reactions and microbially-mediated reactions. Includes use of hydrogeochemical models to simulate chemical transport in geologic systems.

#### **LAR 5154 Environment and Resilience in Design**

Explores environment and resilience in design in response to climate change. Focus on the relationship between resilience design and the biophysical environment. Systems and process of environment and resilience. Topics of ecology and landscape ecology. Compare ecology and other environmental knowledge including Feng Shui. Resilience in relation to climate change. Analyze resilient design projects. Survey and analyze a selected study site.

#### **NR 5204 Water Conflict & Management**

Freshwater conflict issues and management for environmental sustainability professionals. Amount, quality, and distribution of freshwater in the US and globally. Major US and global water management agencies and programs. Impacts of local needs, cultures, and laws on water conflict. Case studies of water management and water conflicts in US and globally. Water conflict management. Water refugees. Pre: Graduate standing; restricted to online Virtual Campus students. Fall semester.

#### **NR 5214 Urban Water Systems**

Urban water systems and planning challenges for sustainability professionals. Case studies of contemporary urban water problems and solutions from North America and globally. Water, hydrology, green infrastructure, and rapid urbanization. Water and emergency management. Connection of urban water system to the regional landscape. Pre: Graduate standing; restricted to Virtual Campus students.

#### **NR 5264 Watershed Stewardship**

Watershed stewardship theory and practices for sustainability professionals. Identification, mapping, evaluation of peri-urban and rural watershed characteristics. Watershed threat assessment and restoration planning. Stewardship programming promoting water quality monitoring, public education, and advocacy. Pre: Graduate standing; restricted to Virtual Campus students. Fall semester.

#### **NR 5284 Coastal & Marine Management**

Science, management, planning, and policy for sustainability professionals working in coastal and marine environments. Social, economic, and environmental interactions that cause coastal and marine system problems. National and international policy. Coastal zone management strategies and marine spatial planning. Pre: Graduate standing; restricted to Virtual Campus students. Spring semester.

#### **UAP 5134G Advanced Land Use and Environment: Planning and Policy**

Environmental factors involved in land use planning and development, including topography, soils, geologic hazards, flooding, and storm water management, ecological features and visual quality. Techniques for conducting environmental land inventories and land use suitability analyses. Policies and programs to protect environmental quality in land use planning. Fall

semester.

**UAP 5214 Topics in Natural Resources and Natural Hazards Planning**

Concepts, theory, and practice of resilience-based, climate- change integrated natural resources management and hazards planning. Effects of land, water, soil, and ecosystem management on quality of life for present and future generations. Natural resources and natural hazards planning process and tools for local communities and policies at state and federal levels.

**UAP 5414 Natural Resources Planning Topics**

The natural resource planning process as implemented by federal public lands and water resources agencies in the U.S. Public participation, environmental impact assessment, and resource evaluation methods used in planning and decision-making. Applications to resources planning in developing countries.

**WATR 5004 Seminar in Water Science and Society**

Interdisciplinary seminar on contemporary issues in water science and society. Critical evaluation, comparison, and discussion of effective science communication, current research issues, findings, and interdisciplinary approaches in water science, policy, and management.

**WATR 5464G Advanced Water Resource Policy and Economics**

Economic theory and methods to explain water use decisions. Efficiency, equity, and ethical considerations in U.S. water policy. Analysis of water markets, climate change, and environmental flows from diverse stakeholder perspectives.

**WATR 5614G Advanced Watershed Assessment, Management, and Policy**

Multidisciplinary perspectives of assessment, management, and policy issues for protecting and improving watersheds ecosystems. Topics include: monitoring and modeling approaches for assessment, risk-based watershed assessment, geographic information systems for watershed analysis, decision support systems and computerized decision tools for watershed management, policy alternatives for watershed protection, urban watersheds, and current issues in watershed management. Spring semester.

**WATR 6004 Water Quality in Aquatic Ecosystems**

Classification and biophysical characteristics of aquatic ecosystems and processes. Fundamentals of water quality and aquatic biogeochemistry. Drivers and consequences of water quality, including implications for policy and management. Case studies of research in water quality assessment.