Environmental Engineering and Earth Sciences

The laboratories and facilities of the Department of Environmental Engineering and Earth Sciences (EEES) at Clemson University are located at three locations: (1) approximately nine miles off campus at the L. G. Rich Environmental Laboratory (342 Computer Court, Anderson, SC 29625); at the Clemson Environmental Technology Laboratory (CETL), located adjacent to Rich Lab; and (3) in Brackett Hall and the Biosystems Research Complex (BRC) on the main University campus.

Department Offices

The Department has offices in two locations. The departmental office for the undergraduate programs (BS degrees in Environmental Engineering, Biosystems Engineering, and Geology; minors in Environmental Science and Policy; Sustainability; Nuclear Engineering and Radiological Sciences; and Geology) is in 445 Brackett Hall. The main office for the department is in the L.G. Rich Environmental Laboratory at the Advanced Materials Center, which was formerly called the Clemson Research Park. This is about nine miles from Brackett Hall. Clemson University considers Rich Laboratory and CETL as part of the main campus.

For the first 2010-2011 and 2011-2012 academic years, the BS Environmental Engineering program was centered in McAdams Hall along with the Biosystems Engineering degree programs. Starting in the Fall Semester 2012, both degree programs transitioned into renovated office, classrooms, and laboratories in Brackett Hall, where Geology has been situated for decades. This move was due to a major commitment of the College to the Department for its Environmental Engineering and Biosystems Engineering degree programs. The expenditures on the Brackett undergraduate labs and classroom set-ups for 2012-2013 were $281,253.

Brackett Hall is now the principal teaching and advising location for the BS degrees in Environmental Engineering, Biosystems Engineering, and Geology. Brackett Hall was built in 1951. The addition, which houses the administrative offices for the department's three undergraduate programs was built in 1966. The entire building was renovated in 1992. Some of our laboratories and classrooms in Brackett Hall were renovated in 2012. There are offices for the Environmental Engineering, Biosystems Engineering, and Geology teaching faculty. Janet Lee, who is the student services coordinator for BS Environmental Engineering, BS Biosystems Engineering, and BS Geology degrees has an office in Brackett. She maintains the advising files

for the students. For some of the EEES faculty, there are shared offices in Brackett while teaching on campus. The lead administrative staff member for EEES (Briana Peele) is also located in Brackett Hall. In addition to administrative duties, Briana Peale oversees the readiness of the undergraduate laboratories. There are two student lounge/study rooms, Brackett 330 and 333, for undergraduate students in Environmental Engineering, Biosystems Engineering, and Geology in Brackett Hall.

Rich Laboratory

The L.G. Rich Environmental Research Laboratory is the administrative and principal facility for research within EEES. The Department is the sole occupant of the L.G. Rich Environmental Laboratory, which is a 42,000 square foot laboratory and office building completed in the spring of 1991. The building contains offices, classrooms, teaching and research laboratories, an auditorium seminar room, a conference room, computer laboratory, and a machine shop. Classrooms, which are largely used for graduate courses, are equipped with a computer, and a computer projector.

Most of the EEES faculty and most of the departmental administrative and research support staff have individual offices at Rich Laboratory or in the adjacent Clemson Engineering Technologies Laboratory (CETL). The laboratory manager, L. David Lipscomb, has an office in 130 Rich Laboratory, which is adjacent to the research laboratories. He also has responsibility for safety programs of the department. About two thirds of the EEES graduate students have carrels in a number of shared offices adjacent to the laboratories in Rich Lab and CETL.

The department also has offices and laboratories in the adjacent Clemson Environmental Technology Laboratory (CETL), which was built in about 1992 by a commercial enterprise and donated to the University around 1996. EEES has machine shops in both Rich Laboratory and CETL. They are equipped with hand tools, machine tools, such as drill presses, saws, milling machines, and sanders, and a welding shop for routine maintenance and construction of relatively simple experimental apparat. Rodney Morgan, Lab Specialist III, is the shop supervisor in Rich Lab. Rodney Merck, Lab Specialist III, is the shop supervisor in CETL.

Offices in Rich Laboratory and CETL

Office space is available for administrative, faculty and clerical offices. 1000 square feet are dedicated to nine administrative offices and a clerical area, and 3200 square feet to 19 offices for faculty and postdoctoral researchers. The typical faculty/staff office size is 150 square feet. The graduate student offices equipped with student carrels (72 total) occupy a total of 2565 square feet.

In CETL, office space is available for faculty and there are carrels for graduate students. It should be noted that CETL is also used by faculty and staff in other departments and programs. EEES does not "own" the space in CETL, but EEES faculty and students are the main users of the facility.

Classrooms

Two classrooms are available in Rich Lab. One is in the process of being converted to a Virtual Technology Classroom. EEES also manages several classrooms in Brackett Hall. All EEES undergraduate courses are taught on the main campus. Some of the graduate courses are also taught on the main campus; others are taught at Rich Lab. These are equipped with computer projection facilities. There is a computer laboratory with 24 student work stations for the department in the newly renovated 434A Brackett Hall. Other classes are taught in campus classrooms having projection facilities. The classrooms available to the program are adequate; improvements have been made using Lab Infrastructure funding made available through the College.

Classrooms and Associated Equipment

Most of the graduate courses offered in EEES at the 8000 level are taught at the Rich Laboratory where there are two classrooms (1065 square feet) and an auditorium (1270 square feet) that are used for student instruction. The lectures for the laboratory courses (e.g., EES 6110 and EES 8130) are taught in the Rich Laboratory while laboratory exercises are taught in Rich Lab or CETL. The auditorium and classrooms in the Rich Laboratory are equipped with computer projection systems. All of the graduate courses offered for the graduate degrees in Hydrogeology and Biosystems Engineering are taught on the main campus (mainly in Brackett Hall).

Typically the associated equipment for these lecture classrooms is a computer projector, computer, whiteboard/chalk board, and sufficient number of desks so that there is one for each student.

The main teaching laboratory for the BS in Environmental Engineering and BS in Biosystems Engineering is in 424 Brackett Hall. In the case of a few laboratories that utilize specialized equipment, the laboratory class can be switched to the L.G. Rich Environmental Laboratory. Several EEES labs for teaching and conducting research are also available in Brackett Hall and in the Biosystems Research Complex on campus. Brackett Hall houses the Biosystems Engineering, Geology and Hydrogeology programs and portions of the associated research. Labs pertaining to water and soil analysis, fermentation and other bioprocessing areas are also available in Brackett Hall. Also in Brackett Hall, the Thin Section Lab contains several rock saws, a trim saw, a thin-section cutoff saw, and a thin-section grinder. These instruments allow the complete preparation of standard thin sections for petrographic study, or polished sections for microprobe analysis. The lab also contains two sieve shakers and associated sieve pans for grain-size distribution analyses.

Laboratory Facilities

Rich Lab contains 21 laboratories (~30,000 sq ft). Of these, 4 laboratories are dedicated to the Nuclear Environmental Engineering and Science (NEES) focus area. In addition, approximately 4,500 sq ft of laboratory space in the CETL building is dedicated to radiochemistry research. Both laboratory facilities are operated under South Carolina Department of Health and Environmental Control radioactive materials licenses. The licenses are for liquid and solid sources from ^{3}H to ^{244}Cm. Both laboratories are equipped with appropriate laboratory facilities and radioanalytical equipment. Below and in more detail is a list of all available EEES laboratory and portable equipment for both routine and specialized applications.

The organic separations laboratory contains specialized glassware, large chemical fume hoods, supercritical fluid extraction equipment, and other apparatus for the preparation of environmental samples for analysis. Several well-equipped laboratories are established for the study of the decomposition of industrial pollutants through the use of biological and

physicochemical methods. The biological treatment labs include bench-scale continuous flow bioreactors of various sizes, as well as batch respirometric equipment for analyzing biodegradation kinetics.

A biotechnology lab includes equipment for applying molecular techniques to the characterization of microbial community structure. The physicochemical treatment lab contains equipment for studying adsorption and chemical oxidation, as well as other unit operations. A well-equipped analytical instrumentation laboratory is available for student and faculty member use. The laboratory contains several Hewlett Packard gas chromatographs (GCs) with mass spectrometer, flame ionization, nitrogen-phosphorus and electron capture detectors.

There are also a Perkin Elmer atomic absorption spectrometer with Zeeman graphite furnace, Dionex HPLCs, UV Visible spectrophotometers, organic carbon analyzers, and ion chromatographs. An industrial size autoclave is available, as well as a gas cylinder storage area. A loading dock for receiving supplies and environmental samples is conveniently located adjacent to the various storage rooms.

The EEES machine shops are capable of manufacturing specialized research equipment. Other more precise needs can be met at the College of Engineering, Computing and Applied Sciences machine research facility located in Freeman Hall on main campus.

The Rich Laboratory contains a computer laboratory for student use. Six desktop computers are maintained by the Clemson Computing and Information Technology (CCIT). A two story, high bay is available for research requiring unusually tall equipment.

Students have 24/7 access to the Rich Lab and the EEES facilities in the CETL building. This includes student offices, the computer lab, and research labs. Graduate students are instructed NOT to work in the lab alone. If they are conducting an experiment, they are to use the buddy system, in which case the student working tells another student that "if you don't see me in several minutes, come looking for me."

Analytical Chemistry Equipment

EEES laboratories are equipped with a number of research analyzers for different types of environmental research. The following is a list of analytical equipment available in the EEES laboratories. These instruments are accessible to the EEES faculty, students and researchers on a need basis. The great majority of the analyzers are computer controlled and equipped with autosamplers.

Gas Chromatography Systems

- HP 5890 Series II Gas Chromatograph with FID and NPD detectors
- Two HP 5890 Gas Chromatographs with FID and ECD detectors
- Two Agilent 6850 Gas Chromatographs with μ μ-ECD detectors
- Agilent 6890 Gas Chromatograph with FID and μ μ-ECD detectors
- Agilent 6890 Plus Gas Chromatograph with μ μ-ECD detectors
- Agilent 7890 B GC system with 7000 C triple quadruple mass spectrometer
- Shimadzu GC-2010 with FID
- Shimadzu GC-2010 with FID and TCD detector
- Shimadzu GC-2014 with DTCD detector

Liquid Chromatography Systems

- Dionex Ultimate 3000 HPLC with Fluorescence, UV-Vis and RI detectors, fraction detectors, autosampler (3 systems)
- Dionex Model CD25A/GP50-2 Ion Chromatograph with EC and UV detectors
- Dionex ICS2100 ion chromatography system, autosampler
- Agilent 1100 HPLC with UV-Vis detector

- Agilent (HPLC) 1290 Infinity II with 6470 triple quadrupole mass spectrometer

UV-VIS Spectrometers

- Varian Cary Model 300 UV-Vis Spectrometer
- Varian Cary Model 50 UV-Vis Spectrometer
- Thermo Nanodrop 2000 Spectrophotometer
- Beckman DTX880 Multimode detector/plate reader

Labeled Compound/Radiochemistry Analysis

- Eight High-Purity Germaniun Gamma-Ray Spectrometers (one portable and one low energy)
- One low-energy high-resolution X-ray spectrometer (HPGe, Be window)
- Three NaI(Tl) spectrometers (5″ x 5″,3″ x 3″, and 2″ x 2″)
- Four alpha/beta discriminating Liquid Scintillation Counters
- Three Flow Cell Radiation Detectors (one digital, one pulse shape discriminating)
- 38 Alpha Spectrometers
- 18 Gas Flow Proportional Counters
- Miscellaneous gas-filled and scintillation detectors
- Neutron dosimetry instruments
- Portable health physics instrumentation
- Geophex GEM2 EM induction sensor

Organic Carbon and Nitrogen Analyzers

- Shimadzu Model TOC-V Total Organic Carbon/Total Nitrogen Analyzer
- Shimadzu Model TOC-L Total Organic Carbon/Total Nitrogen Analyzer
- Thermo Model EA1112 Combustion CHNS-O Analyzer

Other Analyzers

- Applied Biosystems StepOne RT PCR system
- Anton Parr SurPASS electrokinetic analyzer
- Analytik Jena MultiX2500 adsorbable organic carbon (AOX) analyzer with APU2 adsorption module
- BioRad Gel DocXR
- Brookhaven Instruments 90Plus particle analyzer with ZetaPALS and ZetaPlus; autotitrator
- Dionex ASE200 accelerated solvent extraction system
- Harshaw Model 3500 Thermo Luminescence Dosimetry System
- Jenapol U petrographic microscope
- Kruss contact angle measurement system (for drop shape analysis)
- Microbics M500 Toxicity Analyzer
- Micromeritics ASAP2010 and ASAP 2020 physisorption (surface area and pore size distribution determinations) analyzers with chemisorption capabilities
- Metrohm 836 Titrando computer controlled titration system
- Misc. Aquifer Testing Equipment

- Model MP401 Electronic Field Gas Permeamiter
- Perkin Elmer Model C653 Florescent Spectrometer
- Thales ProMark III differential GPS receivers
- Thermo ICP-Mass Spectrometer X Series II
- Thermo Nicolet FTIR spectrometer
- Virtis Bench top 6K Freeze Dryer
- Zeiss Model AXIOSKOP 2 Research Fluorescence Microscope
- Wyatt Asymmetric-Flow Field-Flow-Fractionation (AF4) System

Field Equipment

Geophysical Instruments

- Ground Penetrating Radar: Pulse Ekko 100 and 1000 (50,100, 225, 450, 900MHz surface and 100MHz borehole antennas)
- Electrical Resistivity: IRIS Syscal R1+ Switch 48 imaging system
- EM Induction: Geophex GEM-2
- EM Induction: Geonics EM-34
- Gamma: GR-110 Exploranium portable gamma ray
- GPS: Thales ProMark III differential GPS (rover + base station)
- Leica TPS1200+ robotic total station
- Geonics EM38-MK2 EM induction sensor

Drilling Rig

- CME 45 drill rig
- Augers (4″ solid stem; 8″ hollow stem)
- Geoprobe Hydraulic hammer
- Geoprobe sampling equipment with 3-4″ auger

Well Pumping Test Equipment

- 5 Parascientific precision transducers
- Druck portable transducer
- 5 In situ Troll water level data recorders
- 15 kw Kubota generator, Honda generator
- 25, 7.5, 5, 3, and 1/3 Hp submersible pumps
- 2 Campbell Scientific CR10X data acquisition systems
- 2 Grunfos variable rate sampling pumps

Vadose Zone Equipment

- Portable mini-permeameter
- 2 Guelph permeameters
- 7502B time domain reflectometry soil moisture device
- Small-Drill-Hole Mini-Permeameter

Water Chemistry

Water quality portable field meters (pH, DO, conductivity, turbidity, temperature, ORP)

Stream Gauging

- Swoffer current meter
- Ohio current meters
- Pygmy meter

Borehole Geophysics

Logging instruments with caliper tool and capabilities for measuring Single point resistance Gamma ray Temperature.

Hydraulic Fracturing Equipment

A specially designed system for creating and monitoring shallow hydraulic fractures is available. This system consists of a slurry mixer and pump with related equipment for controlling the fracturing process and monitoring associated ground deformation.

Aquifer Characterization Equipment

The lab contains a suite of flexible wall permeameters for measuring saturated permeability. In addition, the lab contains a Hassler cell for making permeability measurements under confining pressure and a Boyle's Law helium porosimeter. A capillary pressure vessel is also available.

Equipment Used in the Undergraduate Environmental Laboratories

Item	EES 2021	EES 3050
Columbus Instruments Respirometer	x	x
Spec 20 Spectrophotometer	x	x
COD digestion block	x	x
TSS and VSS equipment		x
UV lamp (*E. coli* fluorescence)		**x**
ASM1 Modeling Software		**x**
Microscope with camera		**x**
Centrifuge (bench top)		**x**
Dionex Ion Chromatograph (nitrate analysis)	**x**	**x**
Low-pressure membrane testing equipment		**x**
High-pressure membrane testing equipment		**x**
Jar tester (Phipps & Bird)	**x**	**x**
CSTR tank	**x**	**x**
Plug flow tubing		**x**
Clear well model tank		**x**
Sand filter column (2-story lab, Rich Laboratory)		**x**
AQ4500 Turbidity meter		**x**
Turbidity meter		**x**
Floor centrifuge (hanging 50-mL conical tubes)		**x**
HP 6890 GC-FID with computer interface	**x**	
96-well plate reader spectrophotometer	**x**	
Hach kit spec-based nitrate assay	**x**	
Hach DR 890 Portable Colorimeter		**x**
Thermo Genesys 10S UV-vis spectrophotometer		**x**
Thermo Genesys 20 visible-light spectrophotometer		**x**
Canberra iSolo alpha and beta particle counter		**x**