UNIVERSITY OF WASHINGTON

OFFICE OF THE PRESIDENT

June 3, 2010

Interim Dean Dennis Hartmann
College of the Environment
Box 355679

Dear Dennis:

Based on the recommendation of its Subcommittee on Admissions and Programs, the Faculty Council on Academic Standards has recommended approval of the revised program requirements for the all of the options within the Bachelor of Science degree in Earth and Space Sciences. A copy of the changes is attached.

I am writing to inform you that the Department of Earth and Space Sciences is authorized to specify these requirements beginning autumn quarter 2010.

The new requirements should be incorporated in printed statements and in individual department websites as soon as possible. The *General Catalog* website will be updated accordingly by the Registrar's Office.

Sincerely yours,

Mark A. Emmert
President

Enclosure

cc: Dr. J. Micheal Brown (with enclosure)
Mr. Robert Corbett (with enclosure)
Dr. Deborah H. Wiegand (with enclosure)
Mr. Todd Mildon, J.D. (with enclosure ESS-20100506)

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UNIVERSITY OF WASHINGTON

CREATING AND CHANGING UNDERGRADUATE ACADEMIC PROGRAMS

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After college/school/campus review, send a signed original and 8 copies to the Curriculum Office/FCAS, Box 355850.

For information about when and how to use this form: http://depts.washington.edu/uwcr/1503instructions.pdf

College/Campus Environment / Seattle	**Department/Unit** Earth and Space Sciences	**Date** 5/6/2010

New Programs

- ☐ Leading to a Bachelor of _____ in _____ degree.
- ☐ Leading to a Bachelor of _____ degree with a major in _____.
- ☐ Leading to a _____ Option within the existing major in _____.
- ☐ Leading to a minor in _____

Changes to Existing Programs

- ☐ New Admission Requirements for the Major in _____ within the Bachelor of _____.
- ☐ Revised Admission Requirements for the Major in _____ within the Bachelor of _____.
- ☐ Revised Program Requirements for the Major in _____ within the Bachelor of _____.
- ☒ Revised Requirements for the Option in all options for Bachelor of Science within the major in Earth and Space Sciences.
- ☐ Revised Requirements for the Minor in _____.

Other Changes

- ☐ Change name of program from _____ to _____.
- ☐ New or Revised Continuation Policy for _____.
- ☐ Eliminate program in _____.

Proposed Effective Date: **Quarter:** ☒ Autumn ☐ Winter ☐ Spring ☐ Summer **Year: 20** 10

Contact Person: J. Michael Brown	Phone: 6-6058	Email: brown@ess.washington.edu	Box: 351310

EXPLANATION OF AND RATIONALE FOR PROPOSED CHANGE

For new program, please include any relevant supporting documentation such as student learning outcomes, projected enrollments, letters of support and departmental handouts. (*Use additional pages if necessary*).

See attached document.

OTHER DEPARTMENTS AFFECTED

List all departments/units/ or co-accredited programs affected by your new program or changes to your existing program and acquire the signature of the chair/director of each department/unit listed. Attach additional page(s) if necessary. *See online instructions.

Department/Unit:	Chair/Program Director:	Date:
N/A		
Department/Unit:	Chair/Program Director	Date:
N/A		

CATALOG COPY

Catalog Copy as currently written. Include only sections/paragraphs that would be changed if your request is approved. Please cross out or otherwise highlight any deletions.

See attached document.

PROPOSED CATALOG COPY

Reflecting requested changes (Include exact wording as you wish it to be shown in the printed catalog. Please underline or otherwise highlight any additions. If needed, attach a separate, expanded version of the changes that might appear in department publications). **Please note:** all copy will be edited to reflect uniform style in the General Catalog.

See attached document.

APPROVALS

Chair/Program Director: R.W. Lee	Date: 5/6/2010
College/School/Campus Curriculum Committee: Stephen D. West	Date: 7 May 2010
Dean/Vice Chancellor: James R. Stark	Date: 5/14/10
Faculty Council on Academic Standards/ General Faculty Organization/Faculty Assembly Chair: John Schaubleiser	Date: 5/28/2010

POST TRI-CAMPUS APPROVAL (when needed)

Faculty Council on Academic Standards/ General Faculty Organization/Faculty Assembly Chair:	Date:

UW CREATING AND CHANGING UNDERGRADUATE ACADEMIC PROGRAMS

College/Campus: Environment / Seattle
Department/Unit: Earth and Space Sciences
Date: 5/6/2010

CATALOG COPY

~~90 credits as follows:~~

2. ESS Options (minimum 55 credits):

   a. Standard Option
      i. Supporting science (13-15 credits): MATH 126 ~~or equivalent~~; PHYS 115/PHYS 118 or PHYS 122; and one of PHYS 116/PHYS 119 or PHYS 123, CHEM 152, MATH 307, MATH 308, STAT 311.
      ii. ESS required (22 credits): Two of ESS 311, ESS 312, ESS 313, ESS 314; ESS 400.
      iii. ESS electives (18-20 credits): ESS 400-level courses or any ESS 311-series course not taken as a required course, above. (May not include independent study or seminar courses numbered ESS 489 through ESS 499.)

   b. Biology Option
      i. Supporting science (21 credits): CHEM 152, CHEM 162 ~~or equivalent~~; BIOL 180, BIOL 200. ~~(or two from BIOL 201, BIOL 202, BIOL 203).~~
      ii. ESS required (22 credits): Two of ESS 311, ESS 312, ESS 313, ESS 314; ESS 400.
      iii. ESS electives (12 credits): ESS 400-level courses or any ESS 311-series course not taken as a required course, above. (May not include independent study or seminar courses numbered ESS 489 through ESS 499.)

   c. Environmental Earth Sciences Option
      i. Supporting science (10 credits): STAT 311 or Q SCI 381; CHEM 152 or CHEM 220.
      ii. ESS required (35 to 37 credits): ESS 201; one of ESS 311, ESS 312, ESS 313, ESS 314, ESS 326; two from ESS 315, ESS 421, ESS 426, ESS 427, ESS 455, ESS 456, ESS 459; ESS 400.
      iii. Electives (10 credits): Additional courses chosen from any ESS 311-series course not taken as a required course above, from ESS 400-level courses (may not include independent study or seminar courses numbered ESS 489 through ESS 499), or from an approved list of courses outside ESS.

   d. Physics Option
      i. Supporting science (32-35 credits): MATH 126, MATH 308, MATH 324 or MATH 136, MATH 324; PHYS 122, PHYS 123, PHYS 227, PHYS 228, PHYS 321, PHYS 322.
      ii. ESS required (5 credits): One of ESS 311, ESS 312, ESS 313, ESS 314.
      iii. ESS electives (15-18 credits): ESS 400-level courses or any ESS 311-series course not taken as a required course, above. (May not include independent study or seminar courses numbered ESS 489 through ESS 499.)

UW CREATING AND CHANGING UNDERGRADUATE ACADEMIC PROGRAMS

College/Campus: Environment / Seattle
Department/Unit: Earth and Space Sciences
Date: 5/6/2010

PROPOSED CATALOG COPY

~~90 credits as follows:~~

2. ESS Options (minimum 66 credits):

   a. Standard Option
      i. Supporting science (18 to 20 credits): MATH 126 [redacted]; PHYS 115/PHYS 118 or PHYS 122; and two of PHYS 116/PHYS 119 or PHYS 123, CHEM 152, MATH 307, MATH 308, STAT 311.
      ii. ESS required (31 credits): Three of ESS 311, ESS 312, ESS 313, ESS 314; ESS 400; ESS 418.
      iii. ESS electives (18-20 credits): ESS 400-level courses or any ESS 311-series course not taken as a required course, above. (May not include independent study or seminar courses numbered ESS 489 through ESS 499.)

   b. Biology Option
      i. Supporting science (26 credits): CHEM 152, CHEM 162 [redacted]; BIOL 180, BIOL 200 [redacted]; and one of BIOL 220, PHYS 115/PHYS 118 or PHYS 122, MATH 126, STAT 311.
      ii. ESS required (31 credits): Three of ESS 311, ESS 312, ESS 313, ESS 314; ESS 400; ESS 418.
      iii. ESS electives (12 credits): ESS 400-level courses or any ESS 311-series course not taken as a required course, above. (May not include independent study or seminar courses numbered ESS 489 through ESS 499.)

   c. Environmental Earth Sciences Option
      i. Supporting science (15 credits): STAT 311 or Q SCI 381; CHEM 152 or CHEM 220; and one of CHEM 162, PHYS 115/117 or PHYS 122, MATH 126.
      ii. ESS required (44 to 46 credits): ESS 201; two of ESS 311, ESS 312, ESS 313, ESS 314; ESS 326; two from ESS 315, ESS 421, ESS 426, ESS 427, ESS 454, ESS 455, ESS 456, ESS 457, ESS 459; ESS 400; ESS 418.
      iii. Electives (10 credits): Additional courses chosen from any ESS 311-series course not taken as a required course above, from ESS 400-level courses (may not include independent study or seminar courses numbered ESS 489 through ESS 499), or from an approved list of courses outside ESS.

   d. Physics Option
      i. Supporting science (32 to 35 credits): MATH 126, MATH 308, MATH 324 or MATH 136, MATH 324; PHYS 122, PHYS 123, PHYS 227, PHYS 228, PHYS 321, PHYS 322.
      ii. ESS required (14 credits): Two of ESS 311, ESS 312, ESS 313, ESS 314; ESS 418.
      iii. ESS electives (15-18 credits): ESS 400-level courses or any ESS 311-series course not taken as a required course, above. (May not include independent study or seminar courses numbered ESS 489 through ESS 499.)

Augmentation of the Earth and Space Sciences BS Degree Requirements

Motivation: The department wishes to better align "learning outcomes" (attached) with degree requirements, and better prepare students pursuing a Washington state "professional geologist" license.

Background: The College of Arts and Sciences framework shapes the current set of major requirements for the Bachelor of Science in Earth and Space Sciences. Of 180 credits needed for graduation 90 are specified within the major. In contrast, earth science degree requirements well in excess of 50% of the credits needed to graduate are common at other institutions. For example, Central Washington University requires 105 credits for the geology major and 115 credits in their environmental geology option. At the University of Washington, degree requirements of 105 to 130 credits are found in some interdisciplinary programs (e.g. Biochemistry) and programs with national accreditation requirements (e.g. engineering degrees).

Given the breadth of the Earth sciences, it is not surprising that past efforts to design undergraduate curriculum within the 90-credit constraint struggled to find acceptable compromises. In particular, "standard" supporting science preparation (with a year each of calculus, chemistry and physics) consumes half of the total A&S mandated limit leaving too few credits for "in-the-major" course work. Furthermore, the current in-major course requirements allow some students to graduate without taking courses that are mandatory for application for state licensing.

The move to the new College of the Environment provides a unique opportunity to take action to address our concerns about degree requirements. College/University general education requirements (75 credits) are significantly reduced relative to the College of Arts and Sciences (110 credits). In principal this change could allow us to greatly expand major credit requirements. However, a balance is sought that enhances student preparation without unduly impacting student degree planning.

The new requirements fall in three categories;

1. Enhanced supporting science (5 credits)
2. Enhanced ESS core breadth (5 credits)
3. Enhanced communicating in the discipline (6 credits)

The revised credit total increases from 90 to 106. In the following specific components of the recommendations are discussed.

Enhanced Supporting Science (Math, Chemistry, Physics) Requirements

Action: Increase requirements by 5 credits to be selected from an approved list. (Exempt physics options from this since the supporting requirements in this option are already large.)

Current situation: We require 33-35 credits in the Standard option, 30 in Biology, 30 in Environmental, and 52-55 in Physics

A standard model for freshman undergraduate science education includes about 45 credits distributed as a year each of calculus, chemistry (with or without lab) and physics (with or without lab). More quantitative upper division courses in ESS need additional math preparation including linear matrix algebra, advanced calculus and ordinary/partial differential equations. In addition a better grounding in statistics is widely recognized as important. More specialized physics and chemistry beyond freshman level is essential in several of the ESS options.

ESS supporting science requirements are variable in the different options but (with the exception of the physics option) fall short of a full year (45 credits) preparation. The spectrum of courses that could improve student preparation includes those quarters of freshman calculus, physics and chemistry not currently required in an option. In addition, more advanced courses including math and statistics could benefit our students.

There appears to be no one optimal set of courses for all options. The extra 5 credits are to be taken from the approved list.

Expected Outcome: ESS "Learning outcome" 1 focuses on the core supporting sciences. Members of the faculty believe that this augmented requirement will improve student preparation and proficiency.

ESS Core Course Requirement

Action: Increase by one (5 credits more) the number of required 3XX courses - 311 (geomechanics), 312 (geochemistry), 313 (geobiology), or 314 (geophysics) .

3XX courses are designed to provide quantitative and rigorous development of breadth within the department. The current requirement is to take either one or two of these courses (depending on the option). The result of this change will be that most students will take a full year sequence.

Expected Outcome: ESS "Learning outcome" 2 focuses on earth science breadth proficiency. The faculty believes that this augmented requirement will improve

student preparation and proficiency. In addition, "learning outcomes" 3 and 5 will be enhanced. Furthermore, under the prior degree requirements, students taking the minimum number of 3XX courses were not well prepared to take the professional geology-licensing test.

Communicating in the Discipline

Action:

(1) Add one course (4 credits) in communication skill: ESS 418 "Geoscience Communication" (new course package attached).

(2) Defer adding a second course (2 credits) emphasizing oral and on-line communication: ESS 488 "Geoscience Portfolio" . This course is noted here but cannot be launched under the current budgetary crisis.

Beyond the general education English requirement the current degree provides no comprehensive education in writing or oral communication. Some ESS courses contain significant oral or written projects. However, within the constraints of an already crowded core schedule, such existing course projects are frequently not embedded in a strong pedagogical framework of extensive feedback and opportunities for revision that are necessary for developing skills. The augmented requirement provides a course that concentrates on writing.

A second seminar-based course will emphasize on-line and oral communication skills. In the face of current budgetary constraints, introduction of the second course must be deferred. The department lacks adequate resources to launch it at this time.

Expected Outcome: This attention to communication skills is essential in efforts to achieve better results for "learning outcome" 6.

Bachelors of Science
Earth and Space Sciences
Learning Outcomes

Overarching Outcomes:

1. Demonstrate competence in scientific inquiry, writing, and oral presentation
2. Demonstrate competence in relevant field methods, laboratory methods, and computer applications
3. Demonstrate the ability to use multidisciplinary quantitative approaches to critically evaluate earth science questions that impact society and planet Earth
4. Be employable in earth science related fields or be able to further education in graduate programs

To achieve these Outcomes, Proficiency is Expected in:

1. **Core Sciences** including Mathematics, Chemistry and Physics
2. Earth Science **Breadth** including solid earth geology, geophysics, geobiology, surface processes, space physics, and planetary studies
3. Core discipline **Depth** through completion of requirements in one of four options: geology, geobiology, geophysics, or environmental
4. **Experiential** components including fieldwork and/or laboratory experiences
5. **Quantitative Analysis** of natural systems including interpretation and prediction of their behavior
6. **Communication skills** (oral/written) including the ability to read, understand, and use scientific literature.

To be reviewed and revised on a 5 year schedule:

Learning Outcome	Direct and Indirect Measures	Current Situation	Action Taken/Planned
Core Science Proficiency	Grades, when taken, student /alumni feedback	Current requirements are judged to be marginally adequate, students too frequently postpone courses so that they do not contribute appropriately to other learning	Increase requirements, use advising efforts to encourage more effective scheduling. Enforce appropriate prerequisites.
Breadth	Grades, faculty assessment student/alumni feedback	Current requirements are not sufficiently broad and lack adequate focus	Increase requirement of 3XX courses by one
Experiential	Grades, faculty assessment, student alumni feedback, survey of research experiences	Some students are involved in original, supervised research experience. However, lab/research experience is not universal Geology fieldcamp is excellent training in traditional geologic skills but does not address the needs of the broader student community.	1. Explore additional comprehensive summer field experiences 2. Require a research project of all students possibly as a "capstone"
Quantitative	Grades, course distributions, faculty assessment and student/alumni feedback	Required curriculum has clear quantitative components.	TBD? Identify "societal impact" components in courses.
Communication	Alumni/employer surveys, grade distribution, presentations at conferences	We have continued concern about student writing and oral communication. Training is not universally distributed	1. develop on-line portfolios to emphasize department commitment to communications skills. 2. increase

			requirements in area
Employment/education	Survey of alumni Exit survey.	We have participated and organized career days. Numbers needed here. Where are current students going? What should we do to enhance?	Attempt survey of graduates 5 and 10 years post degree

Environmental Geochemistry (ESS 457)

This course focuses on the geochemistry of natural waters emphasizing natural systems including ones that may be polluted. Topics include soil/ground water composition; weathering and the carbon cycle; equilibrium computer modeling; colloids and clay minerals; organic geochemistry of water and soil; biogeochemistry; and topics on groundwater quality.

There are weekly homework assignments and a midterm. The final consists of a project where the students collect and analyzes water samples from any natural water source they wish. They will analyze the sample and be exposed to laboratory and instrumental methods. For the project, you should discuss and model the solution composition. You will give a brief presentation in class and hand in a final written project.

We meet for lecture twice per week for 80 minutes and in the quiz/discussion section for 2 hours once per week. The quiz section is useful for discussing the problems sets, more in depth explanations, and working together on the homework.

Text: Langmuir, D. 1997. *Aqueous Environmental Geochemistry*. Englewood Cliffs, NJ, Prentice Hall. Additional, supplemental reading material will be assigned or passed out in class.

Prerequisite: ESS 312 or Chemistry 150/152 equivalent

Evaluation: Students will demonstrate proficiency by completing problem sets, a midterm exam, and a final project applying concepts in this course to water samples.

Learning Objectives:

After taking this course students will be proficient in water chemistry with the ability to quantitatively describe the controls on the chemical quality of surface- and subsurface-waters. And write a research report in the form of a scientific paper and present research findings in a conference-style oral presentation.

Students will be able to:

Week 1:

- understand the composition of natural waters and explain the importance of complexation on the speciation of natural waters

Week 2:

- quantitatively apply thermodynamics to natural waters for quantitatively describing the composition
- quantitatively determine if and to what extent reactions will occur in natural waters
- use activity coefficients to determine effective concentrations of aqueous species

Week 3:

- determine the kinetic order of reactions
- relate the rate of reactions to equilibrium constants
- describe the kinetics of important reactions controlling the speciation in natural waters
- describe the species that buffer pH in natural systems

Week 4:

- quantitatively determine the influence of carbon dioxide on aqueous chemistry

- quantitatively determine the degree of ionization of acids
- describe how carbon dioxide and carbonate minerals buffer pH of natural systems

Week 5:

- understand how computer models determine the speciation of natural waters
- use PHREEQC to quantitatively determine the speciation of natural waters
- describe how soils forms
- understand how weathering affects the composition of natural waters

Week 6:

- explain how water samples are analyzed

Week 7:

- explain how natural organic matter impacts water composition, weathering, and toxicity of metal ions
- understand what colloids are and how they affect water composition
- identify important colloids in natural waters
- describe how colloids react with aqueous species
- qualitatively describe the reactivity of clay and oxide surfaces

Week 8:

- quantitatively describe the surface reactivity of the mineral and bacterial surfaces
- quantitatively describe how surface reactivity affects water composition
- explain how computer programs derive quantitative parameters describing surface reactivity

Week 9:

- quantitatively describe how redox chemistry affects water composition
- qualitatively describe how bacterial metabolism affects water composition

Week 10:

- explain how microbes catalyze mineralization and affect water composition
- qualitatively describe how complexation, adsorption, ionic strength, and solubility affect uranium speciation in natural waters

ESS 454 Hydrogeology

COURSE BASICS

Instructor: Michael Brown (ATG 220, brown@ess.washington.edu)
Text: Fetter *Applied Hydrogeology*: Course will follow book and take homework and test material from it
Lectures: MWF 1:30-2:20
Evaluation:
Homework (35%): exercises due Wednesdays at class
Quizzes (35%): 15 minutes each Friday covering previous week
Final Exam (30%) comprehensive (Monday June 7 2:30 pm)

SCHEDULE

Week	Reading from Fetter	Topics
1	Chapters 1&2	Elements of the Hydrologic Cycle
2	Chapter 3	Properties of Aquifers
3	Chapter 4	Principles of groundwater flow
4	Chapter 5	Groundwater flow to wells
5	Chapter 7	Regional groundwater flow
6	Chapter 8	Geology of groundwater occurrences
7	Chapter 13	Groundwater modelling
8	Chapter 9	Groundwater chemistry
9	Chapter 10	Groundwater quality and contamination
10	Chapter 11	Groundwater Development and management, Professional licensing

LEARNING OBJECTIVES

The expected outcome in this course is the development of an understanding of the following topics and concepts:

1. Groundwater Budget (week one)
    a. Hydrologic Equation: (Conservation of Mass)
    b. Fluxin = Fluxout + change in Storage
    c. Basic Components
        i. Precipitation
        ii. Infiltration
        iii. Evapotranspiration
        iv. Recharge
        v. Discharge
    d. Western US issues of sustainability
2. Aquifers, and Aquitards (week two)

a. Aquifers
    i. Confined
    ii. Unconfined
    iii. Leaky
b. Properties
    i. Transmissivity vs Hydraulic Conductivity
        1. Confined vs unconfined storage
        2. Units and general idea of ranges
    ii. Storage versus Storativity
    iii. Compressibility and storage in confined systems
    iv. Porosity and specific yield in unconfined systems
    v. Concept of leakage
c. Energy and Head (week three)
    i. Elevation Head
    ii. Pressure Head
        1. Conversion between pressure and head
    iii. Water density effect on Head (freshwater equivalent)
d. Water Table and potentiometric surfaces
e. Permeability and Hydraulic Conductivity
f. Darcy's Law
    i. Permeameters
    ii. Darcy velocity and pore velocity
    iii. Difference between permeability and hydraulic conductivity
        1. Equations
        2. Units
        3. Influence of viscosity, density, temperature

3. Hydraulic Characterization of Wells (week four)
    a. Steady Flow
        i. Theim equation (radius of influence)
    b. Transient flow
        i. Theis equation
        ii. Jacob Cooper approximation and the semi log slope
    c. Slug Tests
        i. Falling head tests (Hvorslev)
        ii. Cooper-Papadopolos
    d. Wellbore storage
    e. Linear flow and its significance
    f. Boundary effects: getting volume from compressibility
4. Flow Systems (week five)
    a. Draw simple flownets
    b. Flow system scales
    c. Local vs regional
    d. Vertical gradients and their relationships to recharge and discharge regions
    e. Groundwater gradients and velocities in regional systems
    f. Lag time to see effects

5. Groundwater Occurrence (week six)
    a. Sedimentary environments
        i. Layered Systems
        ii. Glacial Environments (especially local section)
            1. Till
            2. Outwash sands
            3. Clays and Shales
    b. Karstic Systems
    c. Non-Sedimentary
        i. Plutonic and metamorphic
        ii. Volcanic esp basalt
6. Numerical Modeling (week seven)
    a. General uses and abuses of models
    b. Appropriate use of MODFLOW
        i. Boundary conditions
        ii. Initial conditions

7. Ground Water Chemistry and Contaminants (week eight)
    a. General knowledge of groundwater types
    b. Stiff and Piper diagram
8. Transport (week nine)
    a. Advection
    b. Dispersion – Mechanical
        i. longitudinal and transverse
        ii. Diffusion
        iii. Matrix Diffusion
    c. Sorption
    d. How fast does water move?
9. Water Law (week ten)
    a. Riparian Rights
    b. Prior allocation
    c. Washington uses a mix
10. Licensing
    a. California started in early 70's
    b. Washington licenses geologist
        i. Specialty addition in engineering geology and hydrogeology
        ii. Basic course requirements plus 5 years project experience: