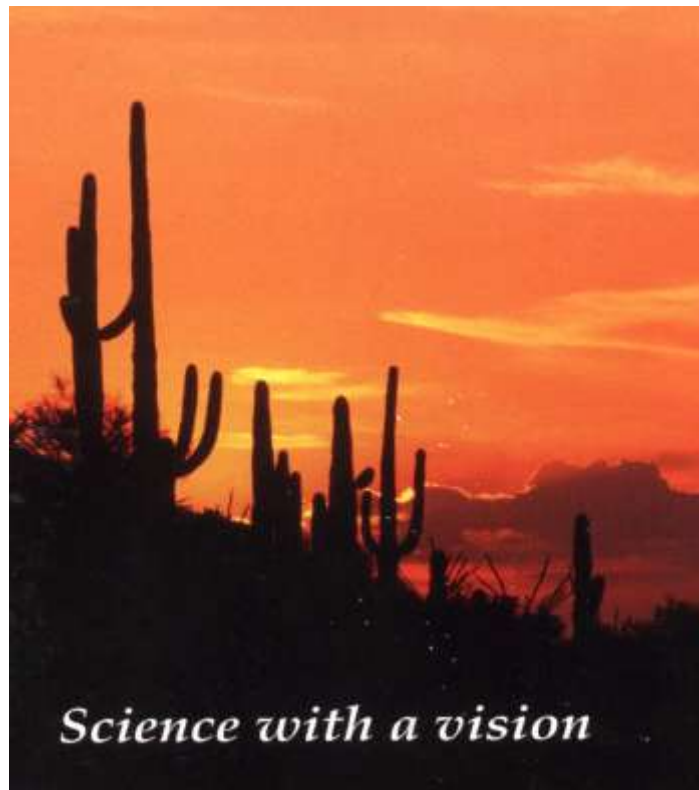


# GRADUATE STUDENT HANDBOOK



**Department of Soil, Water and Environmental Science  
The University of Arizona  
Tucson, Arizona**

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## **INTRODUCTION**

The Department of Soil, Water and Environmental Science (SWES) brings together a faculty of outstanding scientists, distinguished by their understanding of soil, water, and the environment, and their ability to carry out research and planning towards the solution of environmental and resource use problems. The department offers graduate work leading to the Master of Science and Doctor of Philosophy degrees in Soil, Water and Environmental Science, with focal areas in either Environmental Science or Soil and Water Science. Approximately 80 graduate students and 150 undergraduate students are enrolled in the department.

Graduate study in the Department of Soil, Water and Environmental Science is open to students with undergraduate preparation in biological, chemical, physical, earth, or engineering sciences. Students with other backgrounds can be accepted into the program, with course deficiencies noted.

The total enrollment at the University of Arizona is over 38,000; thus, the University is of a size that offers a wide range of academic and extra-curricular programs. Tucson is a metropolitan area of about 1,024,700 people situated in a desert valley ringed by mountains which rise to 3,000 meters.

The University of Arizona is an equal opportunity employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex or national origin.

### **MAJOR PROGRAM AREAS (Instruction, Research, and Extension)**

The Department research activities are focused around three areas:

- 1) environmental science, with emphasis on contaminant transport and fate, water quality, waste management/reuse, soil/groundwater remediation, and ecosystem restoration;
- 2) subsurface science, with emphasis on physical, chemical, and microbiological processes; and
- 3) soil, plant, atmosphere systems, with emphasis on remote sensing, climate science, soil-water-plant relations, soil genesis, morphology and pedology, and aquaculture.

**The specific program areas in the department include:**

<u>Aquaculture</u>	Freshwater and marine systems; aquaponics; integrated farming systems
<u>Contaminant hydrology:</u>	Transport and fate of contaminants (organic/inorganic chemicals, pathogenic organisms) in soil and groundwater; transport modeling
<u>Climate science</u>	Applied climatology; global change; physical and environmental geography; environmental monitoring.
<u>Ecosystem restoration:</u>	Phytoremediation; salt-tolerant plants; re-vegetation
<u>Environmental chemistry:</u>	Analytical methods; sorption of chemicals; phase partitioning
<u>Environmental Microbiology:</u>	Biodegradation of organic compounds; molecular/genetic techniques; microbial ecology of stressed environments
<u>Environmental pedology</u>	Pedogenesis; soil forming processes; response of soil systems to climate change
<u>Soil and groundwater remediation:</u>	Innovative site characterization methods; innovative technologies for remediation of groundwater, source zones, and vadose zones
<u>Remote sensing:</u>	Canopy modeling; terrestrial biophysics; global change
<u>Soil-water-atmosphere Relations:</u>	Evapotranspiration; irrigation; leaching; plant water stress; crop production research; spatial variability; water use efficiency
<u>Soil and water quality:</u>	Hazardous-waste chemistry; salinity; soil/groundwater contamination, water-borne pathogens
<u>Soil biology and biochemistry:</u>	Molecular approaches to microbial ecology; pathogen detection; rhizosphere biology; N <sub>2</sub> - fixation
<u>Soil fertility and plant nutrition:</u>	Plant responses to N and P; nitrogen movement; denitrification losses; N-tracer chemistry; nutrient availability; fertilizer use efficiency
<u>Soil morphology, genesis, classification and survey:</u>	Micromorphology; soil mineralogy; soil mapping; soil erosion; GIS; remote sensing in soil surveys
<u>Vadose zone hydrology:</u>	Infiltration and redistribution of water; characterizing permeability
<u>Waste disposal and management:</u>	Land treatment; land reclamation; waste-water reuse; waste management; air-pollution abatement

## SOIL, WATER AND ENVIRONMENTAL SCIENCE FACULTY

### FACULTY

### RESEARCH INTERESTS

Silvertooth, Jeffrey C.  
Professor and Department Head  
[silver@ag.arizona.edu](mailto:silver@ag.arizona.edu)

Soil fertility/plant nutrition, soil and water management, salinity and sodicity management

Artiola, Janick F.  
Associate Research Scientist  
Associate Professor  
[jartiola@ag.arizona.edu](mailto:jartiola@ag.arizona.edu)

Soil, water, and waste chemistry; analytical and environmental chemistry, land treatment of hazardous and non-hazardous wastes, waste management

Brown, Paul W.  
Extension Specialist  
Research Scientist  
[pbrown@ag.arizona.edu](mailto:pbrown@ag.arizona.edu)

Agricultural meteorology, biometeorology, evapotranspiration, crop water use, heat units, Ag weather information

Brusseau, Mark L. Professor  
[brusseau@ag.arizona.edu](mailto:brusseau@ag.arizona.edu)

Contaminant transport and fate, mass-transfer processes, modeling, soil/groundwater contamination and remediation

Chief, Karletta  
Assistant Professor  
Assistant Specialist  
[kchief@cals.arizona.edu](mailto:kchief@cals.arizona.edu)

Watershed hydrology, unsaturated flow in arid environments, and natural and human disturbance affect on soil hydrology through the use of physically based methods

Chorover, Jon, Professor  
[chorover@ag.arizona.edu](mailto:chorover@ag.arizona.edu)

Sorption and transformation reactions in soil and water

Crimmins, Michael  
Assistant Extension Specialist  
Assistant Professor  
[crimmins@u.arizona.edu](mailto:crimmins@u.arizona.edu)

Applied climatology, global change, physical and environmental geography, environmental monitoring

Curry, Joan, Associate Professor  
[curry@ag.arizona.edu](mailto:curry@ag.arizona.edu)

Soil physical chemistry, surface chemistry, molecular modeling

Fitzsimmons, Kevin  
Research Scientist  
Professor, Intl Programs  
[kevfitz@ag.arizona.edu](mailto:kevfitz@ag.arizona.edu)

Aquaculture, reuse of effluents for crop irrigation, international economic development

Gerba, Charles P. Professor  
[gerba@ag.arizona.edu](mailto:gerba@ag.arizona.edu)

Environmental microbiology: gene probes, water reuse, biocolloid transport in the subsurface, virology, parasitology, risk assessment

Glenn, Edward P. Professor  
[eglenn@ag.arizona.edu](mailto:eglenn@ag.arizona.edu)

New crops, utilization of saline water, plants for bioremediation, environmental management

<p>Maier, Raina M. Professor  <a href="mailto:rmaier@ag.arizona.edu">rmaier@ag.arizona.edu</a></p>	<p>Microbial ecology of stressed environments (caves, deserts, dust), bioremediation and reclamation of mining sites, biosurfactant discovery and characterization</p>
<p>Matthias, Allan D.  Associate Professor  <b>matthias@ag.arizona.edu</b></p>	<p>Micro meteorology, energy budget, trace gases</p>
<p>Megdal, Sharon  Director, Water Resources  Research Center, Extension  Specialist, Professor  <b>smegdal@ag.arizona.edu</b></p>	<p>Projects include study of artificial recharge and municipal water use in growing, arid regions</p>
<p>Pepper, Ian  Professor, Director ERL  <b>ipepper@ag.arizona.edu</b></p>	<p>Soils and human health; potable water quality including real-time sensors for microbial and chemical contaminants: fate of emerging microbial and biological contaminants; water and wastewater reuse</p>
<p>Rasmussen, Craig  Assistant Professor  <a href="mailto:crasmuss@ag.arizona.edu">crasmuss@ag.arizona.edu</a></p>	<p>Pedogenesis, soil forming processes, response of soil systems to climate change</p>
<p>Rich, Virginia  Assistant Professor  <b>vrich@email.arizona.edu</b></p>	<p>Microbial communities impact biogeochemistry and global change</p>
<p>Riley, James J. Assoc. Professor  <b>jjriley@ag.arizona.edu</b></p>	<p>International agriculture, arid-land management, halophytes</p>
<p>Rock, Channah  Assistant Specialist in Water  Quality, Assistant Professor  <b>channah@cals.arizona.edu</b></p>	<p>Molecular pathogen detection, water quality</p>
<p>Sanchez, Charles  Professor, Research Scientist  Res. Director, Yuma Ag. Center  <b>sanchez@ag.arizona.edu</b></p>	<p>Soil fertility, vegetable/fruit crops, environmental impact of fertilizer use</p>
<p>Schaap, Marcel  Assistant Professor  <b>schaap@cals.arizona.edu</b></p>	<p>Environmental physics, measurements and computer modeling of physical transport processes in the environment</p>

Tuller, Markus  
Associate Professor  
**mtuller@cals.arizona.edu**

Greenhouse gas emissions from natural and managed ecosystems; electromagnetic characterization and physical reclamation of mine tailings; X-Ray Computed Tomography; Modeling of evaporation and hydraulic behavior of soils and porous media

Walworth, James  
Extension Soils Specialist  
Professor  
**walworth@ag.arizona.edu**

Soil fertility, plant nutrition, bioremediation, waste management

## ADMISSION POLICIES

### **Application for Admission**

Applications must be done on-line at the Graduate College. An application processing fee of \$75.00 is required with the application. A check or money order should be made payable to: Graduate College, University of Arizona. Students applying online at <https://apply.grad.arizona.edu> and can submit electronic payments using a Visa, Mastercard, or American Express credit card. Domestic applications are due by June 1, for the Fall Semester, and October 1, for the Spring Semester; International applications are due December 1, for the Fall Semester of the following year, and June 1, for the Spring Semester of the following year.

### **Admission**

The acceptance in to the Soil, Water and Environmental Science Department (SWES) is granted to a student on the availability of a faculty supervisor and funding. We do not admit graduate students that require funding without commitment of a faculty member to sponsor and supervise the student. Qualified applicants should hold a bachelor's degree from the University of Arizona or from a college or university that grants degrees recognized by the University of Arizona.

- a) **Regular Graduate Status** B Students who meet all admission requirements may be admitted to Regular Graduate Status to undertake work leading to an advanced degree.
- b) **Admission with Deficiencies** B An additional number of undergraduate courses may be required when previous work has not approximated the general requirements to pursue an advanced degree in the Department of Soil, Water and Environmental Science.
- c) **Conditional Admission** B International students, who meet all other requirements EXCEPT the TOEFL, may be recommended for Conditional Admission provided they attend CESL. The actual semester of admission will be determined by submission of a TOEFL score of 213 (computer based) or 550 (paper based) to the Graduate Admissions Office, or successful completion of CESL (Center for English as a Second Language). The University of Arizona's code for the TOEFL test is 4832.

- e) **Graduate Non-degree Status B** Individuals holding a bachelor's degree, or its equivalent, may attend graduate-level courses without being admitted to a graduate degree program. Note that a maximum of 12 units of course work taken while in this status may be applied, with approval of the department, to the graduate degree. International applicants requiring a student visa are not eligible for graduate Non-Degree admission.

### **Evaluation for Admission**

The Graduate Program Director, a faculty member appointed by the Department Head, will review all applications. The academic record of each applicant will be reviewed by an ad hoc committee of at least three faculty appointed by the Director. A **Major Advisor** must be identified in order for a student to be accepted to the graduate program in SWES. Admission is competitive and normally no candidate with a grade point average below 3.00 over the last 60 units of course work will be considered. The GRE is recommended for all applicants. A TOEFL score of **80** (Internet based) or **550** (paper based), an iBT with a score of 80, an cBT with a score of 213, or an IELTS with a score of 7 is required of all international students. The Director will ultimately give a recommendation to the Department Head on the applicant's suitability for graduate work. Any course deficiencies will be noted. Admission is also subject to the availability of space and facilities.

### **\*PREREQUISITES and DEFICIENCIES**

The minimum undergraduate preparation for admission into the SWES graduate program includes the following courses (or equivalent):

<b><u>Course Descriptions</u></b>	<b><u>UA Course Numbers</u></b>
Fundamentals of Chemistry I - (Lec & Lab)	Chemistry 103a, 104a
Fundamentals of Chemistry II - (Lec & Lab)	Chemistry 103b, 104b
Introductory Physics (Lec & Lab)	Physics 102, 181
General Microbiology (Lec), <b>or</b> Intro. Biology	MIC 205 A <b>or</b> MIC 181R
Calculus I	Math 125
Statistics	Math 263
Physical Geology (Lec), <b>or</b> Soil Science (Lec)	Geoscience 251 <b>or</b> SWES 200

**\*Note:** Students majoring in **Soil and Water Science (SWS)**, must take both Geology and Soil Science. Students majoring in **Environmental Science (ES)** may choose either Geology or Soil Science. Please note that additional requirements may apply for specific program areas, and these courses may also be listed as deficiencies if applicable.

Students who lack some prerequisites, but who are otherwise qualified, may be admitted with the missing courses listed as deficiencies that must be completed early in their program. It is

advantageous to take immediate steps toward removing any deficiencies noted, within the first two semesters. Note that a higher-level course may be used to satisfy a prerequisite with prior approval of the Graduate Program Director. Normally, a grade of "C" or better must be obtained to satisfy deficiency requirements.

## **GENERAL DEPARTMENT POLICIES AND PROCEDURES**

### **Major Advisor - Advisory Research Committee**

The advisory committee is responsible for guiding each student's academic program, including all examinations. The major advisor is someone within the student's general study area. With the help of the major advisor, additional members from appropriate areas will be identified to complete the student's Advisory Committee.

The minimum number of members is three for a Masters committee and three for a Ph.D. committee, but more may be added as necessary. Generally, a majority of the committee must be faculty members in the Department of Soil, Water and Environmental Science, with expertise in the immediate field of research. The student may also have a co-director or committee member outside the department, provided that he or she has acceptable credentials.

### **Course Loads**

The usual minimum load for full-time graduate students is ten units of graduate credit. For graduate students on an assistantship, the required minimum is ten units, six of which must be graduate level.

### **Grades**

The Graduate College has specific regulations on grades necessary for continuing in a degree program and other forms of scholarship requirements. Please read the current Graduate Catalog carefully. The Department follows these regulations. Should the grade point average fall below a 3.00, the student will be placed on probation. If at the end of the following semester the cumulative average is still less than 3.00, the Graduate College will convert the student to non-degree seeking status, and the Department will request the termination of graduate studies. According to departmental policy, a student on academic probation cannot hold a scholarship, fellowship, assistantship, or an associateship during the period of probation.

### **Continuous Enrollment**

#### ***Master's and Educational Specialist Continuous Enrollment Policy***

A student admitted to a master's program must register each fall and spring semester for a minimum of 3 graduate units, from original matriculation until all course and thesis requirements are met. When these requirements are met, master's students not on financial assistance and/or not needing to maintain appropriate visa status, must register for a minimum of 1 unit of thesis or master's report credit each semester until the thesis or report is finalized. WHILE 1 UNIT SATISFIES CONTINUOUS ENROLLMENT, IT DOES NOT MEET REQUIREMENTS FOR FULL-TIME STATUS. Students receiving funding such as assistantships, fellowships, loans, grants, scholarships or traineeships may be required by their funding source to register for more than 1 unit to meet full-time status requirements, and should check with their program advisor regarding such requirements to ensure that they remain qualified for funding. If the degree program requirements are to be completed in the summer, the student must register for a minimum of 1 unit of graduate credit during that term. Master's and Educational Specialist candidates do not have to register for graduate units during summer sessions unless they plan to make use of University facilities or faculty time. If they do plan to use facilities or faculty time, they must enroll for a minimum of 1 unit of graduate credit.

[Summer-Only students](#) are required to enroll continuously for a minimum of 3 units during consecutive summers until the coursework and thesis requirements are met. After that, they may enroll for 1 unit.

### ***Doctoral Continuous Enrollment Policy***

- A student admitted to a doctoral program must register each Fall and Spring semester for a minimum of 3 graduate units from original matriculation until the completion of all course requirements, written and oral comprehensive exams, and 18 dissertation units. When these requirements are met, doctoral students not on financial assistance and/or needing to maintain appropriate visa status, must register for a minimum of 1 unit of dissertation credits each semester until final copies of the dissertation are submitted to the Graduate Degree Certification Office.
- Students receiving funding such as assistantships, fellowships, loans, grants, scholarships or traineeships may be required by their funding source to register for more than 1 unit to meet full-time status requirements, and should check with their program advisor regarding such requirements to ensure that they remain qualified for funding.
- If not graduating in the Summer term, Doctoral students do not have to register for graduate units during summer sessions *unless* they plan to make use of faculty time. If they plan to utilize faculty time, they must enroll for a minimum of 1 unit of graduate credit in the term(s) in which they are using facilities or faculty time.
- If degree requirements (including the Comprehensive Exams and the Final Oral Exam) are completed during the summer term, the student must be registered for a minimum of 1 unit of graduate credit in either Summer I or Summer II.
- If degree requirements are completed during an intersession (winter session or the Pre-Session), the student must have been registered for a minimum of 1 unit during the preceding semester.

Unless excused by an official **Leave of Absence** (which may not exceed one year throughout the student's degree program), all graduate students are subject to the Continuous Enrollment Policy and must pay in-state and out-of-state tuition and fees in order to remain in the program. If the student fails to obtain a Leave of Absence or maintain continuous enrollment, he or she will be required to apply for re-admission, to pay the Graduate College application fee, and pay all overdue tuition and fees, including cumulative late penalties. Tuition or registration waivers cannot be applied retroactively.

*Please note that "continuous enrollment" is not the same as "full time enrollment" for financial aid purposes. Please refer to [Full-Time Graduate Student Status](#).*

### **SWES PROGRAM REQUIREMENTS FOR A MASTER OF SCIENCE DEGREE**

#### **General Requirements**

The department program leading to the Master of Science degree requires a minimum of 30 units of graduate credit, including thesis units. There must be 15 units in the major field, and at least 15 units must be from courses in which letter grades of A and B have been earned. No more than half the units can be graded S or P (SWES 900, SWES 599). In cases in which a thesis is part of the degree program, a limited number of thesis units (910) may count toward the degree. Except as specified below, all units of coursework for the

master's degree must be in 500-level courses or above. All graduate students are encouraged to attend the weekly department seminars. The last semester of the student's study, the student must be enrolled in the department seminar SWES 696A.

### ***Coursework taken prior to acceptance into the program***

The total number of units of coursework taken as an undergraduate, in graduate non-degree status and transferred from other institutions can be no more than 12. Please refer to the form entitled '[Evaluation of Transfer Credit](#)'. This form is due at the Graduate College before the end of the first year in residence.

General limits on the 12 units taken prior to acceptance into the program:

- Not more than 6 units of University of Arizona undergraduate coursework at the 400 level can be accepted into a master's program, **only if they were not used toward the undergraduate degree**.
- No more than 12 units of coursework taken in graduate non-degree seeking status may be used toward a master's degree.
- Transfer work may not exceed 20% of the required number of units for the master's degree being sought. (Example: For a degree that requires 30 units, no more than 6 units of transfer work may be used.)
- Such transfer credit can be applied to an advanced degree only upon satisfactory completion of deficiencies as prescribed by the head of the major department in which the student seeks a degree.
- Transfer of credit toward an advanced degree will not be made unless the grade earned was A or B, and unless it was awarded graduate credit at the institution where the work was completed.
- Grades of transfer work will not be used in computing the student's grade-point average.
- Credit for correspondence courses or extension work from other institutions will not be accepted for graduate credit.
- Students who wish transfer credit must submit an '[Evaluation of Transfer Credit](#)' form before the end of their first year of study.

### **SWES Core Course Requirements**

The core course requirements for the M.S. degree with a major in **Environmental Science (ES)** are met by completing one course from each of the following three categories:

1. Environmental Biology and Microbiology:
  - SWES 525 Env Microbiology
  - SWES 574 Aquatic Plants & the Env
  - WSM 552 Dryland Ecohydrology and Vegetation Dynamics
2. Environmental and Soil Chemistry:
  - SWES 564 Env Chemistry
  - SWES 562 Env Soil & Water Chemistry
3. Environmental Physics and Water Science:
  - SWES 520 Env Physics
  - SWES 570 Soil Physics

Core course requirements for the M.S. degree with a major in **Soil and Water Science (SWS)** are met by completing any **four** of the five following courses:

- SWES 562 Environmental Soil and Water Chemistry
- SWES 525 Environmental Microbiology
- SWES 531 Soil Morphology
- SWES 570 Soil Physics
- SWES 602 Soil-Plant Relationships

Note that there are no exceptions from the courses listed above. It is the student's responsibility to ensure that they complete the required core courses.

### **Additional Course Work Requirements**

For each major area, additional courses to meet the minimum total credit requirement will be selected with the guidance and approval of the student's committee.

### **Plan of Study**

In conjunction with their major advisor, each student is responsible for developing a written Plan of Study. This Plan is to be filed with the Graduate College by the end of the second semester in residence. The Plan of Study should identify (1) courses the student intends to transfer from other institutions, (2) courses already completed at the University of Arizona that the student intends to apply toward the graduate degree, and (3) additional courses the student plans to complete to fulfill degree requirements. The Plan of Study must have the signature approval of the student's major professor and department head (or chair of the graduate committee) before it is submitted to the Graduate College. Students using transfer coursework to meet requirements should submit the Transfer Credit Form to the Graduate College, prior to submitting the Plan of Study. Please be sure to complete the form online, rather than by hand - it's available on the Graduate College web site with log-in through My Grad Coll (<https://grad.arizona.edu/gc/>).

### **Thesis**

Evidence of academic and research abilities are verified by presenting research results in a formal Master's thesis (SWES 910) or Master's report (SWES 909) to the Department. By the end of the second semester in residence, a research topic should be chosen by the student in consultation with their committee. From two to eight units of SWES 910 (Thesis) can be earned for the preparation of either document, which are counted as part of the **30 minimum units** required for the Master's degree.

### **Summary of M.S. degree requirements:**

- Core courses: 9 units (ES) or 12 units (SWS)
- Additional Major course work completed at UA: 3 units (ES)
- Elective course work: 9-15 units
- Seminar: 1 unit
- Thesis research: 2 - 8 units

**Total: 30 units**

### **Non-Thesis option for M.S. students**

**Note: Students must be registered during the semester the report is finalized (including Summer I or II)**

Students may meet requirements for the M.S. degree by submitting a report in lieu of a thesis. The report will comprise a professional report in the field of environmental or soil science authored by the student. The

report must be read and approved by the student's graduate committee, (2 tenure track and 1 special committee member), the major advisor, and the department head. The student may register for 1-2 credits of SWES 909 (Master's Report) in the semester in which they complete the report. Students must also present a seminar to the department. Additional requirements include a total of 30 units of course work, one semester of seminar, and any additional requirements specified by the committee. The Master's Report uses the form "Master's/Specialist Completion of Degree Requirements. This form must be signed by the major advisor and two other tenured faculty or one special committee member.

### **Master's Completion of Degree Requirements and Final Examination**

**Note: Students must be registered during the semester they defend (including Summer I or II)**

The Master's final exam in the Department of Soil, Water and Environmental Science involves a defense of the thesis, and submission of the Master's/Specialist Completion of Degree Requirements form to the SWES Department for the Department Head's signature and then to the Graduate College. Master's examination committees consist of at least three members. At least two members must be tenure-track faculty at the rank of Assistant Professor or higher, and at least two must hold faculty appointments in the Department of Soil, Water and Environmental Science. If the candidate fails the final exam, a second exam may be granted no sooner than four months from the date of the first exam.

**Time Limitation - All requirements for the master's degree must be completed within 6 years.**

**Time-to-degree begins with the earliest course to be applied toward the degree, including credits transferred from other institutions. Work more than 6 years old is not accepted toward degree requirements.**

## **SWES PROGRAM REQUIREMENTS FOR A PH.D. DEGREE**

### **Credit Requirements and Transfer Credit**

The equivalent of at least six semesters of full-time graduate study is required for the Ph.D. A minimum of 36 units of course work in the area of the major subject, 12 units in the minor subject, and 18 units of dissertation (SWES 920) **must be completed**. Graduate credit earned at other approved institutions, if accepted by the major department and the Graduate College and the grade was an A or B, may be counted toward the requirements of this degree, but will not be calculated in The University of Arizona G.P.A. All required units of credit must be at the **500-level** or above at The University of Arizona (or, in the case of transfer units, their equivalent at other institutions). Six units of 400-level credit taken at The University of Arizona may be used in the minor but will not receive graduate credit or be calculated in the graduate grade-point average. At least one half the units used on the Doctoral Plan of Study must be in courses in which regular grades (A, B, C) have been earned. A minimum of 12 units of regular grades taken at The University of Arizona are required to establish a University of Arizona G.P.A. Credit for correspondence courses or extension work obtained at other institutions will not be accepted for graduate credit.

Students who wish transfer credit must submit a ['Evaluation of Transfer Credit'](#) form before the end of their first year of study.

### **General**

The equivalent of at least six semesters of full-time study are required. At least two full-time semesters (i.e., at least 10 units each semester), and at least 30 credits of graduate work must be completed at the

University of Arizona. For students holding graduate assistantships, the residence requirement can be met by four semesters, during each of which they register for six or more units of graduate credit. Graduate credit for which grades of A or B were obtained during a prior program at the UA may be used to meet the credit requirements upon approval of the advisor and committee. In addition, graduate credit for which grades of A or B were obtained may be transferable from other institutions with the approval of the advisor and the Graduate College. Ph.D. students are required by the Graduate College to complete their degree within five years of passing the Comprehensive Examination, with permission of the program.

At least 36 units of course work, exclusive of dissertation units, must be in the major subject area. A minor course of study is also required; this constitutes at least nine units. A minimum of 18 units of dissertation research (SWES 920) must be completed during the conduct of the dissertation. Thus, a minimum of **63** total units is required for the Ph.D. At least one half of these units must be from courses in which letter grades have been earned. Students are allowed to use up to six units of 400-level course work in the minor area. The 400-level courses in the minor program are accepted toward fulfilling the requirements for total number of units in the student's program of study. However, 400-level courses do **NOT** receive graduate credit, and are not calculated in the cumulative GPA. Students using transfer coursework to meet requirements should submit the Transfer Credit Form to the Graduate College, prior to submitting the Plan of Study.

### **Minimum Course Requirements**

The minimum course requirements for the Ph.D. with majors in Environmental Science or Soil and Water Science are as follows:

- S Complete the core-course requirements listed for the Master's Degree program (see above)  
[9-12 credits]
- S Additional course work in Major [24-27 credits]
- S Total Major coursework = 36 credits minimum.

Of the 36 units of coursework, a minimum of 18 units are required in graded (A,B) lecture-based courses; the remaining units may comprise credits from non-dissertation research courses (e.g., independent study, laboratory rotation), special-topics discussion courses, seminars, and similar.

- S Two credits of Seminar  
Seminar requirement may be met by selecting one of the following options:
  - a. Two semesters of SWES seminars - SWES 696a
  - b. One semester of SWES 696a, plus one semester as a teaching assistant (TA) or proctor
  - c. One semester of SWES 696a plus one semester of seminar from another department
  - d. One semester of SWES 696a plus one semester of GRAD 697C AWorkshop for Teaching at the College Level@
- S Minor: The SWES department requires 12 units for the minor. Since requirements vary by department, students should check with their minor department. The Graduate College requires a minimum of 9 units for the minor for all programs.
- S 18 units of dissertation (SWES 920)
- S Total Credits required = 63-66

### **Minors**

SWES students have two options for completing their minor, as enumerated below:

**Intradepartment:** In recognition of the diversity of the SWES Department, students whose major department is SWES can also obtain their minor within the SWES Department if they so desire. In this case, the faculty acting as the major committee must be distinguished from those acting as the minor committee.

Twelve credits are required for the minor. The set of courses used to satisfy the minor should comprise a topic area that is clearly distinguishable from the major. For example, a student majoring in Environmental Microbiology could complete an intradepartmental minor in Environmental and Soil Chemistry. The specific courses used to complete the minor will be selected in consultation with the minor committee member(s), who have final approval. The SWES department requires 12 units for the minor.

**Interdepartment:** Students may also obtain a minor from another department. In this case, the requirements of that department must be followed. Per University of Arizona Graduate College, a written comprehensive exam must be taken also.

### **Foreign Language Requirement**

The Department of Soil, Water and Environmental Science recommends, but does not require proficiency in a foreign language.

### **Academic Advisor and Advisory Committees**

Upon admittance, each student's major advisor will be the advisor who has accepted the student into his/her program. There are two separate advisory committees with which the student will interact: the Comprehensive Examination Committee and the Dissertation Advisory Committee. The Comprehensive Examination Committee consists of at least four members (three for the major, one for the minor), and should be formed by the end of the first year in consultation with the advisor. The purpose of this committee is to conduct the Comprehensive Examination (see below). The Dissertation Advisory Committee should be formed by the time the Results of the Oral Comprehensive Examination form is submitted to the Graduate College; formation earlier in the student's program is encouraged. The purpose of the Dissertation Advisory Committee is to help supervise the student's research, and to conduct the Final Oral Defense examination (see below). This committee consists of three tenure-track members from the Major, and may include members from the Comprehensive Examination committee.

### **Plan of Study**

By the end of the first semester, students should develop a list of courses for their Ph.D. graduate program, in conjunction with, and final approval by, the student's major advisor and graduate committee. Suitable courses from other departments can be included in the major program. Requirements for the minor are determined by the appropriate department, but usually consist of a minimum of 12 to 15 units.

The student is then responsible for completing the official Plan of Study. After approval by the Major Department Head/Major Advisor and Minor Department Head/Minor Advisor, the Plan of Study form is to be filed with the Graduate College by the end of the third semester in residence. The Plan of Study should identify (1) courses the student intends to transfer from other institutions, (2) courses already completed at the University of Arizona which the student intends to apply toward a graduate degree, and (3) additional courses the student plans to complete to fulfill degree requirements. The Plan of Study must have the signature approval of the student's major professor and department head (or chair of the graduate committee) before it is submitted to the Graduate College.

### **Comprehensive Examination**

**Note: Students must be registered during the semester in which the Comprehensive Exam is taken (including Summer I or II)**

Before admission to candidacy for the doctoral degree, the student must pass a written and an oral Doctoral Comprehensive Examination. This examination is intended to test the student's comprehensive knowledge of the major and minor subjects of study, both in breadth across the general field of study and in depth within the area of specialization. The examination, therefore, should not take place until the student has completed all, or almost all, of their coursework. The Comprehensive Examination is considered a single

examination, although it consists of written and oral parts. While the Graduate College sets general policies and guidelines for exams, it is expected that each program will have different ways of assessing a student's knowledge of the field and their preparation to begin the dissertation. Each program determines the format and administration of the written portion. The minor department controls the minor portion of the written examination and may waive it at their discretion. A student will pass the written portion before sitting for the oral portion. Programs will have written policies regarding whether or not students may retake failed written exams as well as specific policies regarding second attempts. The time between the written and oral portion is determined by individual programs, but the oral portion should come early enough to allow the student to advance to candidacy in a timely fashion. Normally, the written and oral portions of the comprehensive examination should take place at least three months prior to the Final Oral Examination (defense of dissertation). The exact time and place of this examination must be scheduled with your department.

**The Comprehensive Examination Committee** must consist of a minimum of four members. The Major Advisor and two additional members must be tenured, or tenure track. The fourth member may be tenured or tenure-track, or a special approved member. Special members must be pre-approved by the Dean of the Graduate College. Any members beyond the fourth can also be tenured or tenure-track, or special approved members.

Upon successful completion of the written portion of the examination, the Oral Comprehensive Examination is conducted before the examining committee of the faculty. The oral portion of the examination must cover both the major and the minor. This is the occasion when faculty committee members have both the opportunity and obligation to require the student to display a broad knowledge of the chosen field of study and sufficient depth of understanding in areas of specialization. Discussion of proposed dissertation research may be included. The examining committee must attest that the student has demonstrated the professional level of knowledge expected of a junior academic colleague. The Graduate College allows no more than one re-take of the oral exam. Before the Oral Comprehensive Examination, the **Student** must go to the Graduate College website and print out the form “**Results of Oral Comprehensive Examination for Doctoral Candidacy**” with the ballots that he/she must take to the examination site.

Should a student fail the oral portion of the Comprehensive Examination, they will be permitted to re-take the oral Exam upon the recommendation of their committee. Receiving more than one “fail” vote constitutes failure of the exam. Prior to re-taking the Exam, they will be directed to complete a remedial program recommended by their committee. This remedial program may include additional course work to improve their depth or breadth of knowledge in the targeted area(s), completion of an independent study, or other activities as deemed appropriate by the committee. Upon successful completion of the remedial program, the student will be granted the opportunity to re-take the oral portion of the Comprehensive Exam. The second examination, if approved, may not take place sooner than **four months** from the date of the first examination. The Comprehensive Oral Examination can only be taken twice. Two negative votes are necessary and sufficient for failure. An abstaining vote counts as a negative vote

The Comprehensive Examination should be taken late enough in the student's program of study that essentially all course work, excepting dissertation credit, is completed. The phrase “essentially all” is intended to mean that the student should have completed as much course work as possible to enable a reasonable examination of breadth in field and depth in specialization to be conducted. It is highly recommended that the exam be taken by the end of the second year in residence.

When the student has an approved doctoral Plan of Study on file with the Graduate Degree Certification Office, has satisfied all course work, language, and residence requirements, and passed the written and oral portions of the Comprehensive Examination their bursar account will be billed the [fee for candidacy, dissertation processing, and archiving](#). This is a one-time fee and the student will not be billed again if they change their anticipated graduation date. Copyrighting is optional and carries an additional fee.

### **Committee Appointment (Formally Advancement to Candidacy)**

The Committee Appointment form must be filed with the Graduate College no later than **six months before** the student schedules the Final Oral Defense Examination. Information on this form will notify the Graduate College of the student's intended semester of graduation, title of dissertation, and diploma mailing address. An approved **Committee Appointment** form must be on file with the Graduate College before scheduling the Final Oral Defense Examination. Prior to, or at this time, the student should select the members of the dissertation advisory committee, who will also serve as the Final Oral Defense Examination Committee. This committee is composed of three tenure-track faculty members from the Major, although the student may have additional members if so desired. It is recommended that this committee be constituted as soon as possible.

### **Final Oral Defense Examination**

**Note: Students must be registered during the semester they defend (including Summer I or II)**

Upon the completion of the dissertation, the candidate is to submit to a Final Oral Defense Examination. A student must be in good academic standing to schedule the defense. The examination focuses on the dissertation itself but can include general questioning related to the field(s) of study within the scope of the dissertation.

The exact time and place of this examination must be scheduled with the Graduate Degree Certification Office at least 7 working days in advance, and announced publicly in [Lo Que Pasa](#) at least one week in advance. Final Oral Examinations should be scheduled during days when the university is in session and during normal business hours. Permission to hold examinations during University holiday closures or outside of normal university business hours may be granted by Graduate College.

The dissertation director presides over the examination. The initial seminar portion during which the student presents the dissertation and entertains questions is open to the public. The committee's deliberation is closed to the public.

There is no minimum time limit for the Final Oral Examination, but the entire proceedings may not exceed three hours. Members of the committee must be present for the entire examination.

A minimum of three members from the Major (including the Major Advisor) and one member from the Minor are required for the Final Oral Examination, all of whom must be University of Arizona tenured, tenure-track, or approved as equivalent. A successful defense requires receiving a "pass" vote from all three committee members. For committees comprising four or five members, more than one "fail" vote constitutes failure of the exam.

**Time Limitations** - AComp + 5" rule applies. Students entering the Ph.D. program must complete their degree within **five** years after taking the Oral Comprehensive Examination. Students may petition for an extension of time to complete their Ph.D. degree, if they are only slightly past the five-year rule.

## REGULAR COURSES

**SWES 501. Sustainable Management of Arid Lands and Salt-Affected Soils** (3) Principles and practices of soil, water and crop management under arid and semiarid conditions, the use of diagnostic procedures for evaluating soils and waters, reclamation, and economics of irrigation project development. Field trips. *Silvertooth*.

**SWES 508. Scientific Writing for Environmental, Agricultural and Life Sciences** (3) This course will aid students in developing the writing and organizational skills needed to produce effective technical reports, theses, dissertations and journal articles. Graduate-level requirements include work on theses, dissertations or journal articles. *Glenn*.

**SWES 515. Translating Environmental Science** (3) In this course students learn journalism techniques to translate environmental science topics into language a layperson could appreciate. *Lenart*

**SWES 518. Introduction to Human Health Risk Assessment** (3) The purpose of this course is to enhance students knowledge and skills related to environmental risk assessment, including hazard assessment, exposure assessment, toxicity assessment, and risk assessment, including hazard assessment, exposure assessment, toxicity assessment, and risk characterization. Graduate-level requirements include conducting a case study that will require them to collect secondary data in the field. *Reynolds*

**SWES 520. Environmental Physics** (3) Physical principals used in assessment, prevention or reduction of environmental problems. Main themes include energy sources; energy and mass transport; and pollution within soil, water and air. *P, MATH 125, PHYS 102. Schaap*

**SWES 525. Environmental Microbiology** (3) (Identical with MBIM 525) Current concepts in water quality, aerobiology and microbial biogeochemistry. *P, SW 325, CR, CHEM 241b. Maier.*

**SWES 526. Environmental Microbiology Laboratory** (2) (Identical with MBIM 526) Basic techniques for isolation and characterization of environmental soil and water microflora including methods for enumeration and measurement of physiological activity. *P, SWES 425. Pepper/Gerba.*

**SWES 530R. Environmental Monitoring and Remediation** (3). **SWES 530L** (1) Lab. Basic statistics, data quality, field surveying, near-surface air measurement, automated data acquisition, soil, vadose zone and groundwater sampling and monitoring, soil and water biological properties, including pathogen monitoring and remote sensing. *Artiola*

**SWES 531. Soil Morphology, Classification and Interpretations** (3) Theory and practice of describing characteristics of soils; principles of soil classification and the classification systems; making soil interpretations for selected land uses. Field trips. *P, SWES 200, 201. Rasmussen.*

**SWES 540. Biodegradation of Pollutants in Soil and Groundwater** (3) (Identical with MBIM 540) Description of modern pollution problems and potential biological remediation techniques focusing on the chemistry, biochemistry and molecular biology of biodegradation of hazardous and toxic compounds. *P, SWES 425. Maier.*

**SWES 541. Advanced Soil Genesis** (3) (Identical with GEOS 541) Physical and chemical processes and mineralogy of weathering and soil formation; quantitative pedology; the soil as part of the ecosystem. Field trips. *P, GEOS 251 and CHEM 103b. Rasmussen.*

**SWES 544. Applied Environmental Law.** (3) A guided journey through real world environmental law; U.S. legal system, major environmental laws--criminal and civil; common marketplace problems and solutions; high profile cases; essential professional skills. *Proctor.*

**SWES 546. Environmental Biotechnology.** (2) (Identical with MBIM 546) Molecular methods for detection of microorganisms in the environment. Fate and survival of introduced organisms in the environment. Molecular mechanisms of microbial inactivation in waste treatment systems and microbial risk assessment. *P, SWES 525.*

**SWES 553. Remote Sensing of the Environment.** (3) Remote sensing techniques and applications for improved natural resource utilization of soils, water, grasslands, and forest. Fundamental energy-matter interactions that influence the spectral characteristics of vegetation, soil, and water. Field trips. *P, SW 330 or PHYS 102b.*

**SWES 554. Water Harvesting.** (3) Focuses on water harvesting principles and techniques. *Riley*

**SWES 561. Soil and Water Conservation.** (3) Consideration of major world soil and water conservation problems and solutions; principles of soil erosion by wind and water and their effects on world food production and environmental problems related to land degradation by erosion. Offered during Summer. Field trips. *P, SWES 200.*

**SWES 562. Environmental Soil and Water Chemistry.** (3) An introduction to the principal chemical constituents and processes occurring in soils and sediments. *P, Chem 103b, Chem 104b, SWES 200. Chorover.*

**SWES 563. Advanced Soil and Water Chemistry.** (3) Fundamentals of aqueous surface and colloid chemistry through lecture and assigned readings. **Chorover.**

**SWES 564. Environmental Organic Chemistry.** (3) Physical and chemical processes influencing the behavior of contaminants in the subsurface environment. Includes equilibrium and kinetic theory of solubilization-dissolution, volatilization, sorption, hydrolysis, photolysis, surface catalysis, and radioactive decay. *P, CHEM 480a, PHYS 110. Curry.*

**SWES 565. Contaminant Transport in Porous Media.** (3) The transport of contaminants in the subsurface environment. Effects of dispersion, interphase mass transfer, transformation reactions, and porous-media heterogeneity on transport; covers aqueous (dissolved) and multiphase (immiscible liquid, gas) systems. *P, SWES 570 or HWR 518 or 531. Brusseau.*

**SWES 566. Soil and Groundwater Remediation.** (3) Methods for remediating contaminated soil and groundwater; factors influencing efficacy of remediation systems. **Brusseau.**

**SWES 568. Molecular Biogeochemistry.** (2) Reading and discussion of papers in the emerging field of environmental molecular biogeochemistry. Through reading and discussion, experiments and models designed to understand coupled biotic-abiotic (e.g., biomineralization, oxidation-reduction) processes in environmental systems will be explored. **Chorover**

**SWES 570. Soil Physics.** (3) Provides the theoretical and practical basis for understanding and quantifying physical and hydrological properties of soils. Hydro-physical processes taking place near the Earth's surface emphasizing mass and energy exchange, and transport processes in saturated and partially-saturated soils at multiple scales are discussed. The coupling with the atmosphere and the role of plants in the hydrological cycle will be studied. Modern measurement methods and analytical tools for hydrological data collection and interpretation will be reviewed. *P, SWES 200, PHYS 103, CR, MATH 12a. Tuller*

**SWES 571. Stream Ecology.** (3) Will examine the structure and function of stream ecosystems with emphasis on the interaction of physical and biotic elements of streams in arid regions. Examine the role of natural and anthropogenic stressors in shaping aquatic assemblages in streams. **Walker/Matter**

**SWES 572. Interfacial Chemistry of Biomolecules in Environmental Systems.** (3) Introduction to the chemical and adhesive properties of macromolecules at interfaces and inter-particle adhesion will be discussed. *P, Chem 103b. Curry.*

**SWES 573. Monitoring Biosphere Processes.** (2) Global-scale interactions of soils with their plant cover and climate. The spatial distributions and dynamics of soil-plant-water processes with emphasis on measurements from space. *P, SWES 200; 330 or 453.*

**SWES 574. Aquatic Plants and the Environment.** (4) The role of riparian areas, estuaries, and constructed wetlands in the environment. Emphasis on plants as wildlife habitat, for nutrient cycling and bioremediation. **Fitzsimmons / Glenn.**

**SWES 575. Freshwater and Marine Algae.** (4) Systematics, ecology, and evolution of planktonic and benthic species; field techniques and lab culture. Graduate-level requirements include a special topic report on an aspect of freshwater algae. **Fitzsimmons/Glenn.**

**SWES 596B. Arizona Water Policy.** (1-3 units) This seminar focuses on current Arizona water policy from a multi-disciplinary perspective. Through readings, research, discussion and presentations, the student is exposed to current water resource issues facing Arizona and other parts of the West and policies to address them. The faculty draw upon their and guest-lecturers' experiences to demonstrate the development, analysis and implementation of real-world water policy. *Consent of instructor. Megdal*

**SWES 602. Nutrient Dynamics in Soils.** (3) Principles of soil solution and colloid chemistry, soil-water relationships, soil microbiology, and plant physiology and metabolism will be discussed. These principles will be applied to processes of soil nutrient cycling, nutrient availability and plant growth. *P, SWES 200. Walworth*

**SWES 605. Soil-Water Dynamics.** (3) (Identical with HWR 605 and ABE 605) Water flow in soils; closely related problems of solute, pollutant, and heat transfer; emphasis on current concepts and research, and on mathematical descriptions. *P, MATH 254. Schaap, Tuller*

**SWES 625, Physical Characterization and Monitoring of the Critical Zone.** (3) Introduce students to the challenge and complexity of monitoring spatial and temporal highly variable parameters in the natural environment and provide students with theory and hands-on training with state-of-the-art technology for CZ characterization, the design and setup of complex monitoring systems, and the required skills for analyzing and interpreting resulting data streams. *P. Math 250 A&B, Recommended Phys205. Tuller/Ferre/Schaap*

**SWES 665. Advanced Contaminant Transport.** (3) The transport and fate of contaminants in subsurface systems. The course is based on critical, detailed analyses of case studies of actual contaminant transport problems. This provides a real-world basis, and allows an opportunity to develop skills necessary to evaluate real systems. *P, SWES 565 or equivalent. Brusseau.*

**SWES 696A. Seminar.** (1) Topics in Soil, Water and Environmental Science. 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/or papers *Matthias.*

**SWES 696B. Seminar.** (1) Molecular Biogeochemistry. P, CHEM 103B. *Chorover.*

## INDIVIDUAL STUDIES

**SWES 599** (1-4 units per semester), 599 (1-4 units per semester), 699 (1-6 units per semester) Independent Study. Qualified students working on an individual basis with professors who have agreed to supervise such work. *Grades available: S/P,C,D,E,I,W.* (Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699).

**SWES 900. Research.** (1 – 6 units per semester) Individual research, not related to thesis or dissertation preparation, by graduate students. *Grades available: S/P,C,D,E,K,W.*

**SWES 909, Master's Report** (1-9 units per semester) Research for master's program. Grades available: S/P,E,K,W.

**SWES 910. Thesis.** (1-8 units per semester) 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. *Grades available: S/P,E,K,W.*

**SWES 920. Dissertation.** (1 to 9) Research for the doctoral dissertation (whether library research, laboratory or field observation or research, artistic creation, or dissertation writing). *Grades available: S/P,E,K,W.*

## APPENDIX I. Guidelines for Theses and Dissertations

Theses and dissertations may be completed using one of two formats: (1) traditional or (2) journal publication. The guidelines for preparing a traditional thesis or dissertation may be found in the Graduate College Manual for Thesis and Dissertations <http://grad.admin.arizona.edu/degrecert/>. The SWES department guidelines for preparing a thesis or dissertation following the journal-publication format are given below.

### Alternative Thesis and Dissertation Format: Inclusion of Journal Manuscripts

It is the policy of the Department to allow a thesis or dissertation to contain one or more papers prepared for submission, submitted, or accepted for publication. The thesis or dissertation must adopt the format described in Appendix A of the Graduate College manual. In addition, to ensure that a student has made a significant contribution to papers in the thesis or dissertation, the following rules must be met in order to use the journal-publication format.

1. The student must be the primary author on at least one paper for a M.S. thesis, and at least two papers for a dissertation subject to the criteria outlined below.
2. If a paper that has already been published is used in the thesis or dissertation it must have been published in a referred journal.
3. Papers that have been submitted (but not yet accepted) to a refereed journal can be used as a part of the dissertation.
4. Papers that have been prepared for submission, but have not yet been submitted, are also acceptable so long as the paper has been prepared for eventual submission to a refereed journal.
5. All co-authors will be listed on the cover page of each paper. In cases where multiple authors appear on one or more papers, it must be clear what the responsibilities of the various authors were in completing that work, and that the student completed a significant portion of that work. The student will indicate responsibilities for his or her work in the thesis/dissertation body, and acceptance of this explanation by the committee constitutes their acceptance of the author=s explanation. A specific, separate section in the body of the thesis/dissertation will be included, wherein the contributions of the student and of all other co-authors will be clearly delineated.
6. In cases where members of the committee are co-authors, the remaining members can vote to exclude papers that do not, in their professional opinion, meet the requirement that the student has contributed a significant amount of the research to be listed as senior author.
7. A summary of the methods, results, and conclusions for each paper will be included in the body of the thesis/dissertation.
8. The student will be expected to defend all of the thesis/dissertation, even in cases where multiple co-authors are included.