

**Master of Science  
Hydrology & Water Resources  
Program Guide**

**Effective Fall 2019**

# Master of Science Hydrology

**31 units**

27 + 4 Thesis

30 + 1 Non-Thesis

## THESIS

- 12 Core
- 12 Elective (9 Primary)
- 3 Field (2+1)
- 4 Thesis

## NON-THESIS

- 12 Core
- 15 Elective (12 Primary)
- 3 Field (2+1)
- 1 Report

## GRAD PATH FORMS IN STUDENT UACCESS

- Yr1 Responsible Conduct of Research
- Yr1 Master's Plan of Study
- Yr2 Master's Committee Appointment
- Yr2 Master's Completion of Requirements
- Optional: Transfer Credit, Graduate Petition

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### WELCOME

Welcome to the Department of Hydrology and Atmospheric Sciences! Throughout your academic residency, these staff and faculty members will provide student services that support your academic life. Learn more about what staff do at the HAS website [Contact page](#).

Graduate students typically have **assigned office space** (see Corley), **computer lab room access** (see Santander and Phelan), and key/card **access to the building** (see Santander). Students supported through **graduate assistant or hourly wage positions** are hired through the business office (see Alvarez and Varin). Students receiving departmental- or college-sponsored **financial aid** should work with the program coordinator (see Romero).

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## INTRODUCTION

The [Master of Science degree](#) in Hydrology and Water Resources requires a combination of 1) approved coursework, 2) professional development experience, and 3) independent research.

**Enrollment:** Once matriculated, you must maintain **continuous enrollment** during all major semesters (fall and spring) until all degree requirements are satisfied.

If you complete degree requirements (take final exam and/or submit the final thesis manuscript to the Graduate College) *during the summer or winter session*, you do *not* need to enroll for credit.

All degree requirements must be completed within 6 years to ensure currency of knowledge. The **6-year clock** for time-to-degree begins with the earliest coursework, including transfer credit from another institution.

**Coursework:** The Master of Science degree in Hydrology requires 31 semester units.

- TRANSFER - A maximum of 6 graduate units, if deemed appropriate to the major, may be transferred from another university (see the Director of Graduate Studies-Hydrology for advice)
- CUM GPA - A minimum cumulative GPA of 3.0 or B average for all coursework is required to remain in Good Standing
- GRADES - A course with a grade of D or lower may not be included in any graduate degree program. A grade of C is acceptable *only* if you maintain a *cumulative GPA* of 3.0 or higher.
- NO GRO - The department does *not* permit use of the GRO Grade Replacement Opportunity.
- AVERAGE TIME-TO-DEGREE – Depending on undergraduate preparation, most MS students in the research-based Thesis option (thesis manuscript) complete requirements within 2 to 2.5 years of matriculation, while most students in the course-based Non-Thesis option (technical report) complete within 1.5 to 2 years.
- GOOD STANDING STATUS – To maintain Good Academic Standing, you must complete degree requirements in a reasonable timeframe as described in the Time-To-Degree Completion section (p. 12). Degree requirements include **completion of required undergraduate prerequisite courses by the end of year 1**, completion of fundamental and advanced graduate coursework, satisfactory progress on thesis research or technical report project, satisfactory completion of professional development requirements, and timely submission of administrative forms (see Grad Path section, page 10).

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**Professional Development Experience:** You must develop above-average (approaching professional level) oral presentation skills by observing student research- and invited speaker-presentation techniques through enrollment in **HWRS 595A *Current Topics in Hydrology and Atmospheric Sciences*** (1-unit maximum per semester), the Weekly Colloquium, and later demonstrate these skills at an approved conference. An oral or poster presentation of your Thesis or Report work at the **department's annual student research conference, El Día del Agua y la Atmósfera**, satisfies this requirement. (Units not included in Plan of Study.) If you cannot attend an approved conference, you may satisfy the requirement by taking an advanced HWRS special topic course that requires oral presentation (see the Director of Graduate Studies-Hydrology for advice).

**Computer Programming:** All graduate students are expected to have or to acquire capability for basic coding/computer programming (e.g. Python, MATLAB, Fortran, C++). Semester courses or short courses offered by various departments (e.g. Systems and Industrial Engineering, Civil Engineering, Electrical and Computer Engineering, and Computer Science) and the University Information Technology center are available. No graduate credit is granted for this work.

**Independent Research:** A research-based Master's Thesis (Thesis option) **OR** special topic-based technical paper or Master's Report (Non-Thesis option) is required. This work will become the focus of the final oral examination (aka Thesis defense or Report defense).

### MASTER'S PLAN OF STUDY (MPOS)

Graduate degrees in Hydrology require significant coursework taught by Primary Faculty members in Hydrology; however, **one** course from a short list of Non-Primary Courses may be substituted in the Master's Core category (see approved list) and **one** course in the Advanced Elective category. See the Director of Graduate Studies-Hydrology for both cases.

The **coursework** and **independent research** are documented on the **Master's Plan of Study Form** typically submitted to the Graduate College by the end of the second semester of year 1:

- 12 units Master's Core Courses
- 12 units Advanced Electives (Thesis option) **Or** 15 units (Non-Thesis option)
- 3 units total, Field Methods (2) and Field Synthesis (1)
- 4 units (exactly) HWRS 910 Master's Thesis (Thesis option) **Or** 1 unit (exactly) HWRS 909 Master's Report (Non-Thesis option)

The **professional development requirements** are *not* listed on the Plan of Study Form.

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### *Fundamental Master's Core Courses = 12 Units*

The fundamental core courses are not sequential and may be started in either the fall or spring semesters. Undergraduate prerequisite and co-requisite courses must be completed prior to, or concurrent with, the graduate-level course that requires them, and all must be completed by the end of Year 1. All core courses are 3-unit lecture format, unless noted otherwise.

Required 6 units (2 courses)

- HWRS 518 Fundamentals of Subsurface Hydrology (Fall)
- HWRS 519 Fundamentals of Surface Hydrology (Spring)

Choose 6 units (2 courses)

- HWRS 517A Fundamentals of Water Quality (Fall)
- HWRS 528 Fundamentals: Systems Approach to Hydrologic Modeling (Spring)
- Optional course substitution – You may substitute one of the following Non-Primary Faculty courses for 517A or 528 in the Core Course category
  - AREC/HWRS 575 Economics of Water & Environmental Markets/Policies (Fall)
  - AREC/HWRS 576 Natural Resource Law and Economics (Spring)
  - LAW/HWRS 641 Water Law (Spring)

### *Field Methods/Field Synthesis = 3 Units*

The HWRS field methods/synthesis two-course sequence is required for all students and should be completed in the same calendar year:

- HWRS 513A (2) Field Methods (Spring)
- HWRS 513B (1) Field Synthesis (Summer Pre-Session)

A field camp experience in Geology does not routinely satisfy this requirement; however, prior employment or experience may warrant a waiver. The waiver process is used primarily by individuals who were formerly (or are currently) employed by agencies (e.g. USGS, AZGS, USDA ARS), private consulting firms, or national laboratories. To request a waiver,

- Submit a letter requesting a waiver to the Director of Graduate Studies-Hydrology
- Include a resume with details of prior employment or experience that support your request, such as a description of job duties, relevant skills or certifications required, tools or equipment used, and contact information for a former supervisor of field work
- **No academic credit** (units, grade, etc.) can be awarded when this requirement is waived, so you must **replace units with an HWRS Primary Faculty course** (see the DGS-H)

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*Advanced Electives = 12 Units (Thesis) OR 15 Units (Non-Thesis)*

Primary Faculty elective courses are taught by HAS Hydrology faculty members, including:

Victor Baker	Tom Meixner
Ali Behrangi (for 555)	Guo-Yue Niu
Laura Condon	Peter Troch
P.A. Ty Ferré	T.C. Jim Yeh
Bo Guo	Larry Winter
Hoshin Gupta	Marek Zreda
Jennifer McIntosh	

A Primary course is one in which the Primary Faculty teaching load is 50% or more. Courses with multiple instructors where less than 50% is taught by a Primary Faculty member are not included in this category.

Advanced Electives in Hydrology

- ▶ THESIS OPTION REQUIRES 9 UNITS MINIMUM<sup>1</sup> FROM THIS CATEGORY
- ▶ NON-THESIS OPTION REQUIRES 12 UNITS MINIMUM<sup>1</sup> FROM THIS CATEGORY

All Primary Faculty courses use the prefix HWRS (where HWRS is the Home Department) and are 3-unit/lecture-format courses unless noted\*.

- **503** Subsurface Fluid Dynamics (Fall)
- **504** Numerical Methods in Subsurface Hydrology (**4**) (Spring)
- **505** Vadose Zone Hydrology (Fall)
- **516** Hydrologic Transport Processes (Fall)
- **521** Water Resources Systems Planning and Management (Fall)
- **524** Hydroclimatology (Spring)
- **531** Hydrogeology (Fall) \*3 units LEC & 1 unit LAB
- **532** Environmental Hydrogeology Laboratory (3) \*3 units LAB
- **535** Advanced Subsurface Hydrology (Spring)
- **543A** Risk Assessment for Environmental Systems (Fall)
- **549** Statistical Hydrology (Fall)
- **553** Glacial and Quaternary Geology (Baker) \**Exception to cross-listed rule; course is taught by Primary Faculty member in Hydrology; GEOS is home*
- **555** Introduction to Atmospheric and Hydrology Remote Sensing (Behrangi) \**Exception to cross-listed rule; ATMO is home*
- **570** Computer Simulation Water Quality Processes (Spring)

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<sup>1</sup> See APPENDIX A for a list of Pre-Approved Non-Primary Faculty Courses. Only **one** pre-approved course from the Non-Primary list may be included in the Advanced Elective category.

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- **573** Hydrology for Water Resources Management (Fall)
- **580** Isotope Tracers in Hydrogeology (Spring)
- **582** Applied Groundwater Modeling (Spring)
- **596G** Water-Rock-Microbial Interactions (Spring)
- **603A** Well Hydraulics & Pumping Test Analysis (as needed)
- **630** Advanced Catchment Hydrology (Fall)
- **642** Analysis of Hydrologic Systems (Spring)
- **645** Stochastic Methods Subsurface Hydrology (Spring)
- **655** Stochastic Methods Surface Hydrology (Fall)
- **696H** Advanced Topics in Geochemistry of Crustal Fluids (taught as needed)
- **696T** Cosmogenic Isotopes and Other Environmental Tracers (taught as needed)

See **Appendix A** (p. 14) for a list of Pre-Approved Non-Primary Faculty Courses. Only **one** pre-approved course from the Non-Primary list may be included in the Advanced Elective category.

**Independent Study enrollment** (e.g. HWRS 599, 699) is not included here and **may not be used to replace a 3-unit lecture course**. Exception: These units may be used when a course is canceled due to low enrollment (typically less than 5 students) and independent study units are used as a means to continue the course with a smaller number of students. Be aware, however, that independent study units will not receive quality-point grades (e.g. A, B) and will not affect the cumulative GPA. For use in the Plan of Study, see the Director of Graduate Studies-Hydrology for approval.

### *Master's Thesis 910 = 4 Units Total (Thesis Option)*

Enroll for your faculty advisor's section of **HWRS 910 Thesis**. Enrollment is available only through the program coordinator's office. You may enroll for all 4 units during the same semester or split enrollment over several semesters. These units are graded S or P (no points).

**List exactly (only) 4 units** of **HWRS 910 Thesis** on your Master's Plan of Study. *You may need to delete extra thesis units if you enroll for more than 4 units during residency.*

The Thesis should provide the **framework** for your poster or oral presentation at a conference and will be the **focus** of your final oral examination (aka Thesis Defense).

### *Master's Report 909 = 1 Unit Total (Non-Thesis Option)*

Enroll for your faculty advisor's section of **HWRS 909 Report**. Enrollment is available only through the program coordinator's office. You may enroll for your Master's Report unit during the last or next-to-last semester in residence. These units are graded S or P (no points).

**List exactly (only) 1 unit** of **HWRS 909 Report** on your Master's Plan of Study.

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The Report should provide a **framework** for your poster or oral presentation at a conference and will be the **focus** of your final oral examination (aka Report Defense).

### PROFESSIONAL DEVELOPMENT

**Part 1:** You must enroll in **HWRS 595A** Current Topics in Hydrology and Atmospheric Sciences (1-unit maximum per semester), the Weekly Invited Speaker Colloquium, for *at least one semester* during academic residency. **Do not include these units on your Master's Plan of Study.** When completing this form, classes you have completed may **automatically fill** the list, so **you may have to delete these units from your plan.**

**Part 2:** To develop competence in oral or poster presentation, you must present a poster or paper at an approved conference **or** take an approved HWRS special topic seminar course. Discuss this with the Director of Graduate Studies-Hydrology. To satisfy these requirements, submit a memo (email) to the Director of Graduate Studies-Hydrology with the **name, date, and location of the conference** you attended and the **title and format (oral or poster) of your presentation.** Also include a **PDF of the conference program or a URL** that links to an electronic copy of the program **with your presentation (and possibly abstract) listed.**

### GRAD PATH

[GradPath](#) is the Graduate College's nearly paperless system that makes tracking and monitoring student progress much easier. Students can fill out and submit forms online through [UAccess Student](#). The forms are routed electronically to everyone who needs to review or approve them. Forms are *sequential* and each one must be approved before proceeding to the next level. These forms are required for your program:

- Responsible Conduct of Research Statement
- Transfer Credit Form
  - Optional, may not apply to you
- Master's Plan of Study Form
  - Discuss what to include/exclude with the Director of Graduate Studies-Hydrology (DGS) *before* you fill out this form
- Master's Committee Appointment Form
  - Discuss membership with the program coordinator *before* you fill out this form
- Master's Completion Confirmation Form
  - The program coordinator submits this form on your behalf after your Master's Thesis or Master's Report has been approved by your faculty advisor

Refer to the [GradPath](#) website for FAQs related to preparing these forms.

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### FINAL ORAL EXAMINATION

**Timing:** You and your faculty advisor will determine when you are ready to defend the work you have completed for the Master's Thesis or Master's Report. When you have completed the penultimate or final draft of your manuscript, allow your faculty advisor and other committee members **at least 3 weeks** to read your draft before you consider potential dates for the final exam.

**Identify Committee:** Identify 3 tenured or tenure-track HWRS faculty members (including your faculty advisor) to serve on the final exam committee. Two of the 3 committee members must be Primary HAS (Hydrology) faculty members. If you would like to include a special member, for example, a non-tenured/tenure-track scientist at the UA or a scientist external to the UA, talk with the program coordinator to request Special Member approval. (**Ask your special member to submit a resume or CV** to the program coordinator for that approval process.) When a committee is fully formed, ask all members to choose several dates/times when they are available; choose the best date/time available for everyone.

When your committee is confirmed with the department and any special members have been approved, submit the **Master's Committee Appointment Form** in GradPath.

**Schedule the Exam:** Contact a HAS staff member responsible for making room reservations (Romero, Santander, Warren) and **request a room reservation** for your exam. The room should be reserved for a minimum of 2 hours; the minimum time required for an exam is 1 hour. If you require set up time for your laptop and projector, set up time for refreshments, or simply want to practice your presentation, add an additional 30 to 45 minutes (before the exam starts) to the reservation.

**Preparation:** We encourage you to practice your presentation and learn to navigate the impromptu Q&A process which will surely happen during your final oral exam. Every time you present your work at a meeting or conference, you will become more and more comfortable with extemporaneous speaking. Practice at every opportunity until you can talk with confidence about the work you have done. You can reserve a conference room in the department to practice presenting to students and faculty members. The more you practice, the better prepared you will be on the day of your exam.

**Exam Forms:** The department uses internal worksheets to record the date and the results of your exam. **Ask the program coordinator** to send a **Master's Final Oral Examination Worksheet** and a final **Change of Grade Form** (for either 910 Thesis or 909 Report) to your faculty advisor. Your advisor will complete the worksheets at the time of your exam and return them to the program coordinator's office.

**Closed Exam Policy:** Master's examinations are closed to the public, although you may make an initial presentation of your work to a public audience if you wish. After the presentation and a

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short public Q&A, the audience must leave so that the faculty committee members may examine your work more closely. Committee members may question you about your academic coursework and your specific project.

**Post-Exam:** After passing the exam, you may be required to revise your manuscript (Thesis or Report) and re-submit to your faculty advisor for final approval. If you write a Thesis, you will be required to submit the manuscript to the Graduate College for archival by ProQuest/UMI. The Graduate College will provide you with instructions about this process. If you write a Report, you will *not* be required to archive your work. *If you do not pass the exam*, you will be required to retake the examination within 6 months. Discuss your performance with your faculty advisor to learn how to better prepare for a future exam.

**Doctoral Qualifying Exam Waiver for MS Students:** If you plan to continue in a HAS doctoral program in Hydrology, Atmospheric Sciences, or Hydrometeorology, the Qualifying Exam will be waived if you have 1) successfully completed a HAS Master's degree at the University of Arizona, 2) received at least 2 As and 2 Bs in the fundamental core courses, and 3) received a unanimous endorsement from the MS final oral exam committee and the faculty advisor requests waiver of the exam.

## GRADUATION

**Commencement:** There are multiple ways to celebrate your graduation with friends and family. Depending on the time of year you complete requirements, you may join the campus-wide [Commencement Ceremony](#) in May and/or the [College of Science Graduation Convocation](#) (ceremonies held in May and December). Students graduating in August or December may attend the May commencement ceremony. You must **RSVP** to attend any ceremony or convocation. Find more information and RSVP links on the HAS website under the **Events** tab.

**Exit Interview and Housekeeping:** When you are ready to graduate, please return your **keys** and any borrowed manuscripts, books, or equipment to the department (**see Santander regarding return of keys**). It's also important to clean up and tidy your office space and desk for the next student.

Please arrange an appointment with the Director of Graduate Studies-Hydrology (see Whitaker) for a final **exit interview** to discuss your experiences in the graduate program. You may be able to complete this online.

## ACADEMIC PROGRESS: TIME-TO-DEGREE COMPLETION

Students in Good Academic Standing and making good progress meet these benchmarks:

### Year 1

Before/Beginning of Year 1

- Meet with Director of Graduate Studies-Hydrology (DGS) to discuss undergraduate course deficiencies (if any) and potential courses for first year
- Make a plan to complete specific courses for the first two semesters
- Submit the **Responsible Conduct of Research Form** in GradPath
- Discuss potential transfer coursework with the Director of Graduate Studies and submit the **Transfer Course Form** (optional—most students do not have transfer work)

End of Year 1 (end of second semester in residence)

- Complete undergraduate course deficiencies by end of Year 1
- Meet with the DGS to discuss progress and make a plan to complete remaining courses/requirements
- Submit the **Master's Plan of Study Form** in GradPath

### Year 2

Before/Beginning of Year 2

- Meet with faculty advisor to discuss the topic selected for the Master's Thesis or Master's Report
- Make a plan that includes a timeframe for completion: 1) define topic and scope of work by \*date\*, 2) write abstract and outline by \*date\*, 3) do the work—field, lab, computer programming, etc.—with specific start and end dates in mind, by \*dates\*, and 4) start writing about the work by \*date\*
- Satisfy part 2 of the professional development requirement by making an oral or poster presentation at El Día del Agua y la Atmósfera or an approved conference
- Notify the Director of Graduate Studies-Hydrology with details about your presentation

Beginning of **Final Semester**

- Meet with faculty advisor to discuss timing of the final exam
- Define committee membership and reserve a room for the exam
- Submit the **Master's Committee Appointment Form**

End of **Final Semester**

- Complete your work and writing
- Submit your abstract to the program coordinator and ask her to announce the date/time/location of your public presentation (*public presentation optional*)

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- Ask the program coordinator to prepare an Exam Worksheet and Change of Grade form for your faculty advisor to complete at the exam
- Ask the program coordinator to submit the **Master's Completion Confirmation Form** when you've satisfied all degree requirements
- Arrange an appointment (or correspond via email) with the Director of Graduate Studies-Hydrology for an **Exit Interview** (you may be able to complete this online)
- Return your **KEYS** before leaving campus! (see Santander for details)

### GRADUATION PETITIONS

Most students never need to submit a [Graduate Petition](#) to the Graduate College; however, you may need to submit a petition for a variety of reasons, such as:

- Petition for a Leave of Absence (e.g. medical leave, non-medical leave, study abroad leave) which temporarily suspends the continuous enrollment requirement
  - The 6-year time-to-degree clock *does not stop*
- Petition for extension of time to complete a course
- Petition for a retroactive enrollment change
- Petition for extension of time to complete the degree program

## APPENDIX A: PRE-APPROVED **NON-PRIMARY** FACULTY COURSE LIST

### ONE COURSE (3 UNITS) MAXIMUM FROM THIS CATEGORY

You may include only **one** course from this category as an Advanced Elective on the Master's Plan of Study form; no petition or other approval is required.

Courses in this category are taught at the graduate-level only\* and are not taught as a co-convened course (as a combined undergraduate-graduate course).

- ATMO/HWRS 529 Objective Analysis in Atmospheric and Related Sciences (3)
- ATMO/HWRS 558 Mesoscale Meteorological Modeling (3)
- ATMO/HWRS 595C General Circulation Observations-Modeling (1-3)
- AREC/HWRS 577 Advanced Topics Economic Environmental Regulation (3)
- ENVS/HWRS 566 Soil and Groundwater Remediation (3)
- ENVS/HWRS/LAW 596B Arizona Water Policy (3) If enrolled as LAW, permission and registration through College of Law
- ENVS/WSM 696M Using MATLAB for Environmental Data Processing (3)
- LAW 606 Constitutional Law I (3) Permission to enroll and register through College of Law
- PA/HWRS 581 Environmental Policy (3)
- WSM/HWRS 696Q Practical and Applied Meteorology (1-3)

### EXCLUSIONS - NOT ALL HWRS COURSES ARE PRE-APPROVED

Some HWRS courses listed in the Catalog and Schedule of Classes are **not automatically approved** for the Master's Plan of Study. Often, these courses have been cross-listed with HWRS to satisfy other departments' curricular requirements and not necessarily for our students. HWRS Primary Faculty members *do not teach these courses*. These courses are generally **co-convened** at both the undergraduate and graduate levels and may be less rigorous than graduate-only courses.

- ATMO/HWRS 436A-536A Fundamentals of Atmospheric Sciences (3)
- CE/HWRS 423-523 Hydrology (3)
- CE/HWRS 427-527 Computer Applications in Hydraulics (3)
- ENVS/HWRS 464-564 Environmental Organic Chemistry (3)
- GEOG 483-583 Geographic Applications of Remote Sensing (3)
- GEOS 439A-539A Introduction to Dendrochronology (4)
- GEOS 450-550 Geomorphology (4)
- GEOS/HWRS 478-578 Global Change (3)
- REM/HWRS 490-590 Remote Sensing for Study of Planet Earth (3)

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- RNR 417-517 Geographic Information Systems for Natural and Social Sciences (3)
- RNR/HWRS 473-573 Spatial Analysis and Modeling (3)
- WSM/HWRS 452-552 Dryland Ecohydrology and Vegetation Dynamics (3)
- WSM/HWRS 460A-560A Watershed Hydrology (3)

These courses are *not* automatically approved for inclusion in a Master's Plan of Study, regardless of whether they have been approved for another student.

Consult with the Director of Graduate Studies-Hydrology if you wish to include one on the Master's Plan of Study form. If you do, please prepare:

- A letter of petition explaining the relevance of the course to your research or project
- Include a copy of the proposed Plan of Study listing all coursework you have completed and/or will complete (be specific about which HWRS Primary Faculty courses you have completed or will complete)
- Allow 3-4 weeks for review, especially during a priority registration period, the first and last weeks of classes, and when fall or spring classes are not in session

When a course is approved from this **co-convened** Exclusion course list, it **replaces the option** to use a 3-unit course from the Pre-Approved Non-Primary Faculty course list.