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Curriculum Proposal Cover Sheet - University-Wide Undergraduate Curriculum Committee

Contact Person(s) **Karen Rose Cercone**	Email Address **kcercone@iup.edu**
Proposing Department/Unit **Geoscience**	Phone 724-357-**7650**

Check all appropriate lines and complete all information. Use a separate cover sheet for each course proposal and/or program proposal.

1. Course Proposals (check all that apply)

_____ New Course _____ Course Prefix Change _____ Course Deletion

__X__ Course Revision _____ Course Number and/or Title Change __X__ Catalog Description Change

Current course prefix, number and full title: **GEOS 312 Hydrogeology**

Proposed course prefix, number and full title, if changing:

2. Liberal Studies Course Designations, as appropriate

_____ This course is also proposed as a Liberal Studies Course (please mark the appropriate categories below)

_____ Learning Skills _____ Knowledge Area _____ Global and Multicultural Awareness _____ Writing Intensive (include W cover sheet)

_____ Liberal Studies Elective (please mark the designation(s) that applies – must meet at least one)

_____ Global Citizenship _____ Information Literacy _____ Oral Communication

_____ Quantitative Reasoning _____ Scientific Literacy _____ Technological Literacy

3. Other Designations, as appropriate

_____ Honors College Course _____ Other: (e.g. Women's Studies, Pan African)

4. Program Proposals

_____ Catalog Description Change _____ Program Revision _____ Program Title Change _____ New Track

_____ New Degree Program _____ New Minor Program _____ Liberal Studies Requirement Changes _____ Other

Current program name:

Proposed program name, if changing:

5. Approvals	Signature	Date
Department Curriculum Committee Chair(s)	Kenneth S. Coles	3/31/2014
Department Chairperson(s)	[signature]	4/24/14
College Curriculum Committee Chair	Anne Kondo	10/17/14
College Dean	Deanne Snavely	10/20/14
Director of Liberal Studies (as needed)		
Director of Honors College (as needed)		
Provost (as needed)		
Additional signature (with title) as appropriate		
UWUCC Co-Chairs	Gail S Sechrist	10/28/14

Received
OCT 23 2014
Liberal Studies

Part II. Description of Curricular Change

1. SYLLABUS OF RECORD

I. Catalog Description

GEOS 312 Hydrogeology (3c-3l-4cr)
Prerequisite: Grade of C or better in GEOS 201 and 202; MATH 121 or 125 or instructor permission

An overview of groundwater geology, including flow equations, aquifer parameter testing, groundwater sampling techniques, and remediation of groundwater pollution. Labs emphasize graphical and analytical solutions as well as computer modeling of groundwater flow systems.

II. Course Objectives

1. Students will master the fundamental principles that govern the flow of water in porous media such as rocks and soils, and will understand how groundwater flow is controlled by geology, topography, and fluid characteristics.

2. Students will be able to model and predict groundwater flow in porous media using mathematical analysis, graphical techniques and computer-based 2D and 3D models.

3. Students will learn how to extract groundwater through well pumping and be able to measure and predict the impact of pumping on groundwater systems.

4. Students will discover how vulnerable groundwater systems are to pollution and identify appropriate remediation methods for various types of groundwater contaminants.

III. Course Outline

Lecture Schedule

A. Fundamentals of Groundwater Flow (6 hours)
The hydrologic cycle, aquifer properties, Darcy's Law, fluid potential and the derivation of Darcy's Law from basic flow equations

B. Graphical Flow Models (6 hours)
Construction and analysis of graphical flow net solutions to groundwater flow. Modeling of anisotropy and heterogeneity in aquifers. Regional flow systems and time scales of flow

C. Exam 1 (1 hour)

D. Analytic Flow Models (7 hours)
Transient and radial flow equations. Predicting well flow and groundwater drawdown from aquifer parameters, for confined and unconfined aquifers and for multiple wells.

E. Aquifer Testing (7 hours)
Applying analytical flow equations to observed drawdown curves to estimate aquifer parameters. Single well (slug and bail tests) and multiple well tests.

F. Exam 2 (1 hour)

G. Numerical Flow Models (4 hours)

Application of computer-based finite element and finite difference methods to groundwater flow and groundwater contamination. Advective, diffusive and dispersive models of flow.

H. Groundwater Monitoring and Sampling (4 hours)

Typical groundwater contaminants (metals, low-density organics, high-density organics). Installation of monitoring wells and sampling techniques to prevent cross-contamination.

I. Groundwater Pollution and Remediation (6 hours)

Contaminant plumes and multiphase flow systems. Groundwater remediation methods. State and federal regulations governing groundwater remediation investigations and actions.

J. Final exam (2 hours during final exam period)

Lab Schedule

Week 1	Introduction to EXCEL as a hydrologic modeling tool
Week 2	Hydraulic Conductivity and Darcy's Law Problems
Week 3	Flow-net Analysis of Groundwater Flow Direction and Discharge
Week 4	Woburn Superfund Site Cross-section and Potentiometric Map/Profile
Week 5	Modeling Regional Flow Lines in the Potomac Aquifer
Week 6	Refraction of Groundwater Flow at Interfaces in the Black Mesa Basin
Week 7	Regional Flow Patterns in Sedimentary Basins for Hazardous Waste Isolation
Week 8	Theis Equation Drawdown Curves at the River Bend Station Nuclear Plant
Week 9	Stream-Aquifer Interactions at the Woburn Superfund Site and Aberjona River
Week 10	Aquifer Testing: Hazen Grain Size and Hvoslev Slug Tests Estimates
Week 11	Aquifer Testing: Bouwer-Rice, Theis curve & Cooper-Jacob straight-line models
Week 12	Contaminant Transport Modeling of South Wooster TCE Plume
Week 13	Contaminant Modeling and Capture Curve Analysis of Woburn TCE Plume
Week 14	Viewing and discussion of *A Civil Action* (movie about Woburn Superfund Site)

(all labs are 3 hours long but may require additional time for report preparation)

IV. Evaluation Methods

The final class grade will be determined from the following assessments:

Participation	10%
Exam 1	20 %
Exam 2	20 %
Final Exam	25 %
Lab Exercises	25 %
Total	100 %

Possible points earned are distributed between lecture and lab in proportion to the credit hour allocation for the course (3 credits for the lecture, 1 credit for the lab).

V. Example Grading Scale

The final grade will be assigned based on the semester average using the scale: 90-100%=A; 80-89%=B; 70-79%=C; 60-69%=D and below 60%=F.

VI. Attendance Policy

The attendance policy will conform to IUP's undergraduate course attendance policy.

VII. Required Textbook(s), Supplemental Books and Readings.

Fitts, Charles, 2012, Groundwater Science (2nd Ed.): Academic Press, 692 pp.
Bair, Scott & Terry Lahm, 2006, Practical Problems in Groundwater Hydrology: Problem-Based Learning Using Excel Worksheets: Prentice Hall, 168 pp.

VIII. Special Resource Requirements.
None.

IX. Bibliography
In addition to the required textbook and supplemental readings from current literature, the following will be used to develop the course curriculum:

Bear, Jacob, 2012, Hydraulics of Groundwater: Dover Publications, 592 pp.
Bear, Jacob, 2010, Modeling Groundwater Flow and Contaminant Transport (Theory and Applications of Transport in Porous Media): Springer, 834 pp.
Charbeneau, Randall J., 2013, Groundwater Hydraulics and Pollutant Transport: Waveland Press, 593 pp.
Fetter, Charles W., 2008, Contaminant Hydrogeology (2nd Ed.): Waveland Press, 500 pp.
Hiscock, Kevin, 2005 Hydrogeology: Principles and Practice: Wiley-Blackwell, 406 pp.
Howden, Nicholas (Ed.), 2012, History of Hydrogeology: CRC Press, 424 pp.
Karamous, M., Ahmadi, A. and Akhbari, M., 2012, Groundwater Hydrology: Engineering, Planning, and Management: CRC Press, 676 pp.
Lee, Kennan, Charles Fetter and John McCray, 2002, Hydrogeology Laboratory Manual (2nd Ed.): Prentice Hall, 160 pp.
Mays, Larry, 2012, Ground and Surface Water Hydrology: Wiley, 640 pp.
Strassberg Gil, Norman L. Jones and David R. Maidmont, 2011, Arc Hydro Groundwater: GIS for Hydrogeology: ESRI Press, 250 pp.
Sterret, Robert J. (Ed.), 2007, Groundwater and Wells: Smyth Company, 812 pp.
Taniguchi, Makoto and Holman, Ian (Eds.), 2010, Groundwater Response to Changing Climate: CDC Press, 246 pp.
Todd, David Keith and Larry Mays, 2004, Groundwater Hydrology (3rd Ed.): Wiley, 656 pp.
Weight, Willis, 2008, Hydrogeology Field Manual (2nd Ed.): McGraw-Hill, 751 pp.

2. SUMMARY OF PROPOSED REVISIONS

Hydrogeology is currently taught in a 3c-0l-3cr format. All course material is presented in lecture format, while all problem solving and computer modeling is done through homework assignments. This proposed revision would add a laboratory section to enable better student learning outcomes for department SLO goals III and IV (spatial data analysis and map interpretation; computer spreadsheet analysis, statistics or mathematical modeling). The new format for the class would then be 3c-3l-4cr with conceptual material covered in lectures and problem-solving/computer modeling moved to formal laboratory sessions. This change makes the class format similar to most other upper-level majors classes in the Geoscience Department.

3. JUSTIFICATION / RATIONALE FOR THE REVISION

In the 1990's and 2000's, the Hydrogeology class taught at IUP concentrated on concepts of flow and simple arithmetical and graphic problem sets that could generally be done by students on their own time using a calculator and graph paper. This made the format of 3 lecture hours and zero lab hours an appropriate one for this class at the time.

In 2006, an outstanding lab manual was published by Dr. Scott Bair of Ohio State University (IUP actually served as a test bed for development of this resource). Using only EXCEL software (because the commercial modeling software for groundwater flow has now become incredibly expensive), Dr. Bair was able to create realistic groundwater scenarios using real data from projects that he consulted on, such as the Woburn Superfund site in Massachusetts that was the setting for the non-fiction book and movie, A Civil Action. His Excel-based lab manual allows students to get a much deeper and more intensive exposure to groundwater flow systems and learn how critical it is to know aquifer parameters in order to get reliable results.

The Hydrogeology class has now been run three times (2008, 2010 and 2012) using Dr. Bair's lab manual but without an actual laboratory section scheduled for the class. Despite trying several learning strategies (informal computer room work sessions; online consulting and discussion forums on Moodle; in-class introductions to problem sets), the same problem was encountered each time: students required up to an hour of one-on-one guidance and mentoring by the instructor in order to master and use the complex EXCEL functions built into the labs. This was not as much of a problem when course enrollments were in the range of 6-10 students, but the 2012 section of Hydrogeology had 22 students enrolled, and overall Geoscience enrollments have continued to go up since then. It is simply not possible for any instructor to provide sufficient mentoring and guidance each week during office hours, or even outside of them, when students all had different class schedules. The negative impact was particularly noted on student learning outcomes for calculation-intensive labs such as those that involved the Theis equation (where students had to estimate an integral function using approximations). Some students were able to solve these EXCEL problems on their own, but many students did not master the modeling techniques at a proficient level even when given instructor guidance outside of class.

Fortunately, there is a simple and traditional solution to give students the guidance and mentoring they need in order to obtain the desired learning outcomes for the course: place their EXCEL computer problem sets in the context of a formal laboratory section with the instructor monitoring and guiding their work at adjacent computer stations at the same time. The Geoscience Department has a full computer lab that can be used for this purpose, and the new science building is anticipated to have even more dedicated resources (such as display screens and computer-centered work tables) for problem-based learning.

Note on time to degree:
The addition of this extra credit hour will not impact any student's time to graduation or required total credits for their major. Under our proposed new curriculum (included elsewhere in this revision package), all upper level Geoscience courses will be incorporated as options rather than as required courses for our degree tracks. Each optional category requires two of the four courses to be taken, and in these categories, most of the courses already carry four credits. Because of this, we have adjusted the overall program requirements so that the total major credits have actually decreased from 59 to 58 and free electives have therefore increased from 15 to 16.

These changes were made to reduce curriculum 'bottle-necks,' shorten time to degree, and allow more flexibility for transfer students and students switching between our degree tracks.

Note on faculty work-load requirements

The Geoscience Department is aware that that the changes requested here will require additional faculty work-load to cover the added class time. Financially, this change will be covered by the additional credit load payments by students for the class as well as by our on-going commitment to teach very large lecture sections of Liberal Studies classes such as GEOS 101, GEOS 103 and GEOS 105 in order to cover the curricular costs of our smaller majors' courses. Operationally, the department will absorb this increase in work-load hours mainly by decreasing the number of workload-intensive non-major lab sections (GEOS 102, GEOS 104 and GEOS 106) that we teach each term, a change which synchronizes well with the recent change in Liberal Studies science requirements from 8 to 7 with its concomitant decrease in demand for laboratory science sections. Under our proposed new curriculum, we will also be able to schedule upper-level majors classes more judiciously so as not to spread our student load over too many options in each semester. Currently required courses such as GEOS 324 Geology of Oil & Gas or GEOS 352 Stratigraphy must be taught once every two years to allow students to graduate on time. With the optional menu of courses that is built into our new program, we can offer those courses at longer intervals if needed to accommodate the increased workload of other courses. Although not optimal, we believe these changes are worth making in order to achieve our student learning outcome goals.

PREVIOUS SYLLABUS OF RECORD

I. Catalog Description

GEOS 312 Hydrogeology 3c-0l-3cr

Prerequisite: Grade of C or better in GEOS 201 and GEOS 202; MATH 121 or MATH 125 or instructor permission

An overview of groundwater geology, including flow equations, graphical solutions to flow problems, and computer modeling of flow systems, as well as the geotechnical and social implications of groundwater utilization. Field trips may occur on weekends.

II. Course Objectives

At the end of this course, students will be able to:

1. summarize the fundamental principles that govern the flow of water in porous media such as rocks and soils, and will understand how groundwater flow is controlled by geology, topography and fluid characteristics.

2. model and predict groundwater flow in porous media using mathematical, graphical and computer-based techniques.

3. evaluate how to extract groundwater through well pumping, and measure the impact of pumping on groundwater systems.

4. evaluate how vulnerable groundwater systems are to pollution, and identify appropriate remediation methods for various groundwater contaminants.

III. Course Outline

1. Introduction (3 academic hours)
    - The Hydrologic Cycle
    - Recharge, Discharge & Surface Water Flow
    - Groundwater Zones
2. Fundamentals of Flow (4 academic hours)
    - Aquifer Properties
    - Darcy's Law
    - Fluid Potential and Hydraulic Head
3. Graphic Depictions of Groundwater Flow (6 academic hours)
    - Flow Nets in Unconfined Aquifers
    - Flow Nets in Confined Aquifers
    - Heterogeneous Flow Nets
    - Anisotropic Flow Nets
    - Flow Tube Analysis
    - FLOWNET-D computer modeling

Exam #1 (1 academic hour)

4. Flow to Pumping Wells (4 academic hours)
    - Radial Flow Equations
    - Analytical Flow Models & Image Wells
    - Predicting Well Flow in Confined Aquifers

Predicting Well Flow in Unconfined Aquifers

5. Aquifer Tests (6 academic hours)
    - Single Well Tests
    - Multiple Well Tests
    - Pump Test Analysis
    - Pump Tests in the Field
    - AQTESOLV computer modeling
6. Computer Modeling of Groundwater Flow (3 academic hours)
    - Steady State & Transient Flow
    - Numerical Models
    - MODFLOW computer modeling
    - Regional Flow Systems

Exam #2 (1 academic hour)

7. Groundwater Remediation (6 academic hours)
    - Aqueous Pollutants
    - Non-aqueous Pollutants
    - Monitoring Wells
    - Remediation methods
    - Wellhead Protection
    - QUICKFLOW computer modeling
8. Groundwater Law and Protection (4 academic hours)
    - The Pennsylvania Land Recycling Act (Act 4)
    - The safe landfill program
    - The Superfund program
    - Preliminary Site Assessments
9. Applied Topics in Groundwater (3 academic hours)
    - Well Drilling & Field Methods
    - Salt-water intrusion
    - Hydrothermal fields

Exam #3 (1 academic hour)

Cumulative Final or Term Paper during Exam Week

IV. Evaluation Methods

Each component of the course will contribute to final grade as follows:

Exam 1	15%
Exam 2	15%
Exam 3	15%
Problem Sets	15%
Computer Models	15%
Final Exam or Paper	25%
Total	100%

V. Example Grading Scale

The final grade for this course will be determined using the following schedule:
A=90-100%; B=80-89%, C=70-79%, D=60-69%, F=<60%

VI. Attendance Policy

The attendance policy will conform to IUP's undergraduate course attendance policy.

VII. Required textbooks, supplemental books and readings

Fetter, C.W. *Applied Hydrogeology 4th Edition (with CD-ROM).* New York: Prentice Hall, 1999.

Bair, S. W. *Practical Problems in Groundwater Hydrology (with CD-ROM).* New York: Prentice Hall. 2006.

VIII. Special resource requirements

There are no special resource requirements for this course.

IX. Bibliography

In addition to the required textbook and supplemental readings from current literature, the following will be used to develop the course curriculum:

Anderson, Mary P. (2005) Heat as a Ground Water Tracer: Ground Water v. 43, n.6 p. 951

Boulding, Russell (2004) Practical handbook of soil, vadose zone, and ground-water contamination: assessment, prevention, and remediation (2^{nd} Edition): Boca Raton : Lewis Publishers, 948 pp.

Bredehoeft, J.D. (2002) The water budget myth revisited: why hydrogeologists model: Ground Water. 2002 Jul-Aug;40(4):340-5.

Deming, David. (2002) Introduction to Hydrogeology. Boston: McGraw-Hill, pp. 468.

Fitts, Charles R (2006) Exact solution for two-dimensional flow to a well in an anisotropic domain: Ground Water, v. 44 i. 1, p. 99

Hiscock, K.M. (2005) Hydrogeology, Principles and Practice: Malden MA: Blackwell, pp. 389.

Reilly, Thomas E., (2004) A Brief History of Contributions to Ground Water Hydrology by the U.S. Geological Survey: Groundwater: v. 42, i. 4 p.625.

Rubin, Yoram (2003) Applied Stochastic Hydrogeology: Oxford, New York: Oxford University Press, 391 pp.

Soliman, MM; LaMoreaux, PE; Memon, BA; Assad, FA; LaMoreaux, JW (1998) Environmental Hydrogeology. Boca Raton FL: CRC PRESS, 400 pp.

Theis, T.L., O'Carroll, D.M., Vogel, D. C., Lane, A.B., & Collins, K. (2003) Systems Analysis of Pump-and-Treat Groundwater Remediation: Pract. Periodical of Hazardous, Toxic, and Radioactive Waste Managementt, v. 7, i. 3, p. 177-181.

Voss, Clifford I. (2005) The future of hydrogeology: Hydrogeology Journal, v. 13, n. 1, p. 1-6.

Zheng, Li, Guo, Jian-Qing and Lei, Yuping (2005) An Improved Straight-Line Fitting Method for Analyzing Pumping Test Recovery Data: Ground Water, v. 43 p. 939.

<u>Part III. Letters of Support or Acknowledgment</u>

No other departments or programs are affected by these revisions.