

**CWR 5125, U01 (REF.: 85244) – GROUNDWATER HYDROLOGY****Prerequisites: Permission of the Instructor****Department of Civil and Environmental Engineering****Florida International University**

Fall 2024

**Instructor:** Professor Fuentes, Ph.D., P.E., B.C.E.E.

Office: EC-3671; Physical Mailbox: EC-3680

Phone No.: (305) 348-2837, E-mail: [fuentes@fiu.edu](mailto:fuentes@fiu.edu)Home Page: <http://myweb.fiu.edu/fuentes/> - Course Website: <http://web.eng.fiu.edu/fuentes/>

Office Hours: W: 1:00 - 4:00 &amp; R: 2:30 - 3:30 PM (all students, first-come, first-served)

*For an appointment, please email Professor Fuentes at [fuentes@fiu.edu](mailto:fuentes@fiu.edu).***Lecture location and time:** EC-1114

Tuesday: 5:00-7:40 PM

**A. Course Description & Objective**

Quantity and quality of water resources is vital to sustain the survival, health, and welfare of the planet and humankind. Their protection requires understanding theory and methods that are needed to use it, sustainably, while securing its quantity and protecting its quality. The *overall learning objective* of the course is to provide civil engineers and environmental engineers with working knowledge of the principles, processes and methodologies to characterize and solve groundwater flow problems, including an introduction to the concepts that are needed to estimate contaminant transport in groundwater environs. Contents will then focus on the following themes: groundwater occurrence, fundamental laws and principles, well hydraulics, vadose zone characteristics, and an introduction to contaminant fate and transport under advective-dispersive flow conditions. Some relevant questions are, for instance: What models are used to predict pumping effects in a well field? How much drawdown can well pumping cause in a confined aquifer? What is a wellhead protection area and related travel times? How analytical modeling solutions may be used to estimate the movement of an industrial spill in a saturated aquifer?

**B. Textbook & Reading Assignments**Required textbook:*Chabernau, R. J., "Groundwater Hydraulic and Pollutant Transport," Prentice-Hall, Inc., Upper Saddle River, NJ, 2000 (reissued 2006).*Recommended Technical Reports:Heath, R. C., *Basic Ground-Water Hydrology*, Water-Supply Paper 2220, U.S. Department of the Interior, U.S. Geological Survey, 1983: <https://pubs.er.usgs.gov/publication/wsp2220>USEPA, *Transport and Fate of Contaminants in the Subsurface*, Seminar Publication,

EPA/625/4-89/019, Cincinnati, OH, 1969:

<https://nepis.epa.gov/Exe/ZyPDF.cgi/300048II.PDF?Dockkey=300048II.PDF>**Version 08/26/2024 - Draft**

Although the required textbook and recommended reference will support your learning well during the course program, students should supplement textbook content with their own research notes, posted handouts, and additional references. Students are also responsible for the timely study of all assigned material, in advance to lectures thus enhancing their effective retention and learning. Careful study of theory, methods, and equations, and practice solving problems are critical to maximize the learning opportunity.

### C. Use & Management of Class Time

Class time is used to highlight and discuss theory and examples. Lectures will follow the following list of topics:

| <b><u>Theme/Topic (Study Assignment)</u></b>                    | <b>Estimated No. of Lectures</b><br>(1 lecture = 1.25 hours)<br>(2 lectures every Tuesday) |
|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| <b>Part I – Introduction</b>                                    |                                                                                            |
| 1. Introduction                                                 | 1                                                                                          |
| 2. Groundwater Hydrology (1.1 to 1.5)                           | 1                                                                                          |
| <b>Part II – Fundamentals</b>                                   |                                                                                            |
| 3. Basic Fluid Mechanics: 2.1                                   | 1                                                                                          |
| 4. Darcy's Law: 2.2                                             | 2                                                                                          |
| 5. Continuity Principle: 2.3 (2.3.4 excl.)                      | 1                                                                                          |
| 6. Management Models: 2.5                                       | 1                                                                                          |
| <b>Part III – Well Hydraulics</b>                               |                                                                                            |
| 7. Wells and Placement: 3.1                                     | 1                                                                                          |
| 8. Steady Flow: 3.2                                             | 1.5                                                                                        |
| 9. Transient Flow: 3.3                                          | 1.5                                                                                        |
| 10. Pumping Tests: 3.4                                          | 2                                                                                          |
| 11. Well Functions: 3.5                                         | 1                                                                                          |
| 12. Slug and Well Tests: 3.6-3.7                                | 1                                                                                          |
| 13. Special Applications: 3.8, 3.10                             | 1                                                                                          |
| 14. Wellhead Protection Areas (with WhAEM2000, 2007)            | 2                                                                                          |
| <b>Part IV – Vadose Zone Characteristics</b>                    |                                                                                            |
| 15. Characteristics and Laws: 4.1-4.3                           | 1                                                                                          |
| 16. Measurements: 4.4                                           | 1                                                                                          |
| <b>Part V – Contaminant Fate &amp; Transport</b>                |                                                                                            |
| 17. Sources and Processes: 5.1 – 5.6                            | 1                                                                                          |
| 18. Transport by Advection and Diffusion: 6.1, 7.1 – 7.3        | 1                                                                                          |
| 19. Advective-Dispersive Transport: 8.1 – 8.9 (8.6 excl.), 8.11 | 2                                                                                          |

**Version 08/26/2024 - Draft**

## D. Grading Policies

|               |                                                                                                                          |
|---------------|--------------------------------------------------------------------------------------------------------------------------|
| Homework      | 10 (TBA)                                                                                                                 |
| Exam 1        | 25 (October 8; 2 <sup>nd</sup> lecture time)                                                                             |
| Exam 2        | 30 (November 12; 2 <sup>nd</sup> lecture time)                                                                           |
| Project/Paper | 30 (Proposal due on October 15; written report due on Friday, December 6; and oral defense held on Tuesday, December 10) |
| Lecture       | 5 (TBD)                                                                                                                  |
| Total Maximum | 100                                                                                                                      |

Homework: a) will be collected a number of times during the term, at the discretion of the instructor; b) will be collected, at least, one class after completion of relevant lectures; c) must comply with requested format in engineering paper or equivalent (if approved); d) if late, will not be accepted, receiving “zero” points; and e) its completion or graded return does not condition, in any way, the content of exams.

All exams are open book (i.e., with access to the required textbook, only). Questions and problems in exams will be based on all assigned and covered material up to the last lecture before the scheduled day of the exam. Exams will be held on October 8 (No. 1), November 12 (No. 2). The project/paper presentation and defense will be on December 10, 2024, during the official “final exam time” for the course.

The written project report or paper is due on Friday December 6 at 4:30 PM (but best earlier) and may be dropped at the instructor’s mailbox or slide it under the door of his office at EC-3671. The project or paper oral defense will be held on December 10, 2024, from 5:00 to 7:00. The instructor may announce other criteria in advance to any deadlines for either homework, exams, lecture or report.

Artificial Intelligence (AI) tools include tools, such as ChatGtP, Elicit, etc.; the tools include text and artwork/graphics/video/audio. Students may use AI tools to help generate ideas and brainstorm. However, it is noted that the material generated by these programs may be inaccurate, incomplete, or otherwise problematic. Students should be aware that the use of AI may also stifle your own independent thinking and creativity. *Students may not submit any work generated by an AI program as their own. But if a student includes material generated by an AI program, the student should cite it like any other reference material (needless to say all students must give due consideration to the quality of any cited reference).*

Final grade is a function of the total number of points accumulated by the student at the end of the course, as follows:

|           |         |          |        |
|-----------|---------|----------|--------|
| 93.3 ≤ A  | ≤ 100.0 | 70.0 ≤ C | < 76.7 |
| 90.0 ≤ A- | < 93.3  | 60.0 ≤ D | < 70.0 |

**Version 08/26/2024 - Draft**

|           |        |   |        |
|-----------|--------|---|--------|
| 86.7 ≤ B+ | < 90.0 | F | < 60.0 |
| 83.3 ≤ B  | < 86.7 |   |        |
| 80.0 ≤ B- | < 83.3 |   |        |
| 76.7 ≤ C+ | < 80.0 |   |        |

***ADVICE: BEGIN YOUR STUDY AND DELIVERABLES PROMPTLY. DO NOT PROCRASTINATE. ANY QUESTIONS ON GRADES THAT YOU MAY HAVE WILL ONLY BE CONSIDERED WITHIN THE FIVE (5) WORKING DAYS AFTER THEIR OFFICIAL ANNOUNCEMENT. ALL GRADES OF HOMEWORK, EXAMS, AND PROJECT/PAPER WILL BE POSTED ON CANVAS. THE FINAL COURSE GRADE WILL ONLY BE POSTED ON PANTHERSOFT, AS REQUIRED, BY THE OFFICIAL SUBMITTAL DEADLINE.***

### **E. Other Performance Policies**

Class attendance is required and documented by signing the class roll; late arrival or early departures are considered absences. A student with three unjustified absences will be dropped from the course with a DR on November 4. Students will automatically lose 0.45 points per unjustified absence after November 4. No make-ups or incomplete grades will be considered, unless properly justified and documented emergencies. Please be in time for all lectures and keep any unauthorized e-devices off during all lectures and exams.

Class attendance is required, and it is monitored and recorded each Tuesday on the *FIU Check In 2.0* platform for the first lecture and in a hard-copy roster for the second one. Students must install and use *FIU Check In 2.0* to check in the lecture on each scheduled day. The procedure uses Bluetooth beacons in the classroom paired with the *FIU Check In 2.0* app where students can check in starting 10 minutes before the scheduled class start time. Please refer to [CheckIn2.0\\_Student.pdf \(fiu.edu\)](#) for details and, if needed, contact information for technical assistance. Late arrival or early departures are considered absences, and the student must report it, via email by the end of the lecture day, with a justification for consideration by Professor Fuentes. A student with three unacceptable, unjustified absences may be dropped from the course with a DR on November 4, 2024. Students will automatically lose 0.45 points per unjustified absence after November 4, including those prior to that date. *Students with a perfect record of attendance, as recorded in FIU Check In 2.0 and the roster (including up to three acceptable, justified absences) will receive 5 points added to the final calculated grade.*

Photographing and (audio- or video-) recording by any student are not allowed during lectures and especially during exam times and oral presentation.

Students may use one selected e-device only to access study materials (e.g., e-textbook or posted files in the course website or both) during lectures, but that type of use is limited to the required textbook during exam times.

Students should always carry their *FIU One Card* for official identification purposes and be

**Version 08/26/2024 - Draft**

ready to present it if requested by the Instructor or Teaching Assistant during any scheduled activity, but most especially during prep-quizzes and exams.

#### **F. Days to Remember (refer to the Official FIU Fall 2024 Academic Calendar for details)**

[2024-2025-academic-calendar---approved-fs-1\\_25\\_2022.pdf \(fiu.edu\)](#)

|                 |                                                     |
|-----------------|-----------------------------------------------------|
| August 26:      | Classes begin                                       |
| September 2:    | Labor Day (University Closed)                       |
| October 8:      | Exam No. 1                                          |
| October 15:     | Project Proposal Due                                |
| November 4:     | Deadline to drop a course with a DR grade.          |
| November 11:    | Veterans Day (University Closed)                    |
| November 12:    | Exam No. 2                                          |
| November 28-30: | Thanksgiving Day and Break                          |
| December 6:     | Written Report Due                                  |
| December 7:     | Classes end                                         |
| December 10:    | Project/Paper Oral Defense (5:00 - 7:00 PM)         |
| December 18:    | Deadline (by 11:59 PM) for faculty to submit grades |

The instructor will comply and enforce all applicable FIU's Policies and Regulations. It is the students' responsibility to know all applicable policies and requirements. All students should refer, for details, to the *FIU Student Conduct and Honor Code* at

[docs=322. \(fiu.edu\)](#)

All students are deemed by the university to understand that if they are found responsible for academic misconduct, they will be subject to the Academic Misconduct procedures and sanctions, as outlined in the FIU Student Handbook. Misconduct includes, among other, *cheating, plagiarism, misrepresentation misuse of computer services, bribery, conspiracy and collusion, falsification of records and academic dishonesty*. For details visit

[Student Conduct and Academic Integrity | Division of Academic & Student Affairs | Florida International University \(fiu.edu\)](#)

Students should be aware of both [Panthers Care](#) and [CAPS](#) services for students, which support their well-being.

#### **G. Some Recommended References**

*A good number of relevant references are available at the Steve and Dorothea Green Library. Some items may be checked out checked out from the instructor:*

*Aquifer Hydraulics, V. Batu, John Wiley & Sons, 1998.*

**Version 08/26/2024 - Draft**

*Applied Groundwater Hydrology and Well Hydraulics*, M. Kasenow, 3<sup>rd</sup> Edition, Water Resources Publications, LLC, 2010  
*Applied Hydrogeology*, C. W. Fetter, Prentice-Hall, 2001.  
*Groundwater*, R. A. Freeze and J. A. Cherry, Prentice-Hall, 1979  
*\*Ground Water Contamination Transport and Remediation*, P. B. Bedient, H. S. Rifai, and C. J. Newell, Prentice-Hall PTR, 1999 (*\*Recommended if available*)  
*Groundwater Hydrology*, H. Bouwer, McGraw-Hill, 1978  
*Groundwater Hydrology & Hydraulics*, D. B. McWhorter & D. K. Sunada, Water Resources Publications, 1977  
*Hydraulics of Groundwater*, J. Bear, McGraw-Hill, 1979  
*Subsurface Hydrology*, G. F. Pinder and M. A. Celia, Wiley Interscience, 2006.

*Important websites for computer models for groundwater flow and transport applications:*

<https://water.usgs.gov/software/lists/groundwater>

<https://www.epa.gov/land-research/ground-water-modeling-research>

<https://www.epa.gov/ceam/groundwater-models-assess-exposures>

*Important federal agency and other websites (among others):*

[www.epa.gov](http://www.epa.gov), [www.usgs.gov](http://www.usgs.gov), [www.ngwa.org](http://www.ngwa.org)

[IGWMC – Integrated Groundwater Modeling Center \(princeton.edu\)](http://www.igwmc.org)