

Many of Earth's surface environments are governed by the interaction of water with earth materials. This course introduces students to the nature of these interactions, utilizing qualitative, quantitative, physical, and chemical perspectives. Alongside exploration of surface and groundwater fundamentals, we will discuss current water-related issues, from transport and contamination to supplies and treatment. Laboratory exercises include field mapping and sampling, laboratory analysis, and GIS mapping and modeling. (Alternate Year Course, Prerequisite: GEOS 316)

Course Goals

-  to provide students with an understanding of water and flow through and across the Earth
-  to enable students to interpret the geologic forms and records of water in terms of integrated hydrologic systems
-  to emphasize the importance of water in global peace and sustainability, and of hydrologic science in geologic problem-solving

Course meets for

lecture	laboratory
M W F 10:00-10:50 in Dennis 324	M 13-15:50 in Dennis 305/333
Professor: Cynthia Fadem Email: fademcy@earlham.edu Phone: 765.983.1231	Office: Dennis 329 Office Hours: W R 11:00-12:00 <i>& by appointment/drop-in</i>

Required text:

Brutsaert, W. (2005). Hydrology: An Introduction. Cambridge University Press, Cambridge, UK. (ISBN: 0521824796)

Optional text:

Leopold L.B. (2006). A View of the River. Harvard University Press, Cambridge, Massachusetts. (ISBN: 0674018451)

Assessment

Assessment	Grades
40% Laboratory assignments (10)	90-92 – A- ≥93 – A
24% Term paper	80-82 – B- 83-85 – B 86-89 – B+
10% Seminar leadership	70-72 – C- 73-75 – C 76-79 – C+
16% Written Examination (2)	60-62 – D- 63-65 – D 66-69 – D+
10% Class participation (10)	≤59 – F

Policies

Open door: Students should feel free to write/talk to the instructor at any time regarding course material or life in general. Additionally assignments are returned as quickly as possible, usually within one week of the due date. All graded items are entered into the moodle grade-sheet so that students have constant access to their recorded grades and current course grade. PDF files of all class lectures are available on moodle at least one hour prior to the lecture meeting.

Academic integrity: Students are expected to abide by Earlham's policy on academic integrity (<http://www.earlham.edu/curriculumguide/academics/integrity.html>).

Accommodation: For information on disabilities legislation compliance or to discuss academic accommodation, contact the Academic Enrichment Center (<http://www.earlham.edu/~sas/support/>, 765.983.1341). Students with college-accommodated disabilities (including those not facilitated by the AEC) are encouraged to meet with the instructor as soon as possible so appropriate arrangements may be made.

Attendance: Students are expected to attend all class meetings. Should a student miss a lecture, it is the student's responsibility to obtain notes from a fellow student. Students are never excused from assignments or exams; however, there are cases in which a make-up or alternative assignment/exam would be provided:

- In the case of regularly-scheduled laboratories, absence will be accepted for illness with a doctor's note *only*.
- In the case of a weekend laboratory (field trip), absence will be accepted for illness with a doctor's note or religious obligations. *If the student will be missing a weekend laboratory for a religious obligation, s/he must notify the instructor at least one week prior to the scheduled laboratory.*

Due dates: Students may always turn in assignments early. Late assignments will incur a *10% per day penalty*. All assignments are issued with due dates, which are also listed in the syllabus schedule and on the class moodle site.

Curves: Written exams will be curved by a quantity sufficient to make the mean 75% if necessary.

Term Paper: Your term paper represents 24% of your course grade and consists of four parts: proposal, outline, rough draft, and final paper. Of your course grade these parts represent 2%, 4%, 8%, and 10%, respectively.

Readings

Adam, J.C., Hamlet, A.F., and Lettenmaier, D.P. (2009). Implications of global climate change for snowmelt hydrology in the twenty-first century. *Hydrological Processes* 23:962–972.

Andrews-Hanna, J.C.; Phillips, R.J., and Zuber, M.T. (2007). Meridiani Planum and the global hydrology of Mars. *Nature* 446:163-166.

Arthington, A.H., Bunn, S.E., Poff, N.L., Naiman, R.J. (2006). The challenge of providing environmental flow rules to sustain river ecosystems. *Ecological Applications* 16:1311–1318.

Barnett, T.P. Pierce, D.W., Hidalgo, H.G., Bonfils, C., Santer, B.D., Das, T., Bala, G., Wood, A.W., Nozawa, T., Mirin, A.A., Cayan, D.R., and Dettinger, M.D. (2008). Human-induced changes in the hydrology of the Western United States. *Science* 319:1080-1083.

- Christensen, N. S., and Lettenmaier, D.P. (2007). A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River Basin. *Hydrology and Earth System Sciences* 11:1417–1434.
- Elsner, M.M., Cuo, L., Voisin, N., Deems, J.S., Hamlet, A.F., Vano, J.A., Mickelson, K.E.B., Lee, S.-Y., and Lettenmaier, D.P. (2010). Implications of 21st century climate change for the hydrology of Washington State. *Climatic Change* 102:225–260.
- Goldscheider, N., Meiman, J., Pronk, M., Smart, C. (2008). Tracer tests in karst hydrogeology and speleology. *International Journal of Speleology* 37:27-40.
- Gregory, K.B., Vidic, R.D., Dzombak, D.A., (2011). Water management challenges associated with the production of shale gas by hydraulic fracturing. *Elements* 7:181–186.
- Humphreys, W.F. (2008). Hydrogeology and groundwater ecology: Does each inform the other? *Hydrogeology Journal* 17: 5–21.
- Huxman, T.E., Snyder, K.A., Tissue, D., Leffler, A.J., Ogle, K., Pockman, W.T., Sandquist, D.R., Potts, D.L., Schwinning, S. (2004). Precipitation pulses and carbon fluxes in semiarid and arid ecosystems. *Oecologia* 141:254–268.
- Jurgens, B.C., Burow, K.R., Dalgish, B.A., and Shelton, J.L. (2008). Hydrogeology, water chemistry, and factors affecting the transport of contaminants in the zone of contribution of a public-supply well in Modesto, Eastern San Joaquin Valley, California. Scientific Investigations Report 2008–5156, U.S. Geological Survey, Reston, Virginia.
- Oelkers, E.H., Hering, J.G., Zhu, C. (2011). Water: Is there a global crisis? *Elements* 7: 157–162.
- MacDonald, A.; Davies, J.; Callow, R.C. (2008). African hydrogeology and rural water supply. In: Adelana, Segun; MacDonald, Alan, (eds.) *Applied groundwater studies in Africa*. IAH selected papers on hydrogeology No. 13. Leiden, the Netherlands, CRC Press: 127-148.
- McDonnell, J.J., Sivapalan, M., Vaché, K., Dunn, S., Grant, G., Haggerty, R., Hinz, C., Hooper, R., Kirchner, J., Roderick, M.L., Selker, J., and Weiler, M. (2007). Moving beyond heterogeneity and process complexity: A new vision for watershed hydrology. *Water Resources Research* 43:1-6.
- Oberdorfer, J.A., Charette, M., Allen, M., Martin, J.B., and Cable, J.E. (2007). Hydrogeology and geochemistry of near-shore submarine groundwater discharge at Flamengo Bay, Ubatuba, Brazil. *Estuarine, Coastal and Shelf Science* 76:457-465.
- Poff, N.L., Olden, J.D., Merritt, D.M., and Pepin, D.M. (2007). Homogenization of regional river dynamics by dams and global biodiversity implications. *Proceedings of the National Academy of Sciences* 104: 5732–5737.
- Saffer, D.M., Tobin, H.J. (2011). Hydrogeology and mechanics of subduction zone forearcs: Fluid flow and pore pressure. *Annual Review of Earth and Planetary Sciences* 39:157–86.
- Valjarevic, A.Đ. and Valjarevic, D.J. (2011). Natural laws of precipitation, great cycle, infiltration overland and groundwater runoff with a new formulas. *Hydrology and Earth System Sciences Discussions* 8:59–88.
- Vereecken, H., Huisman, J.A., Bogena, H., Vanderborght, J., Vrugt, J.A., and Hopmans, J.W. (2008). On the value of soil moisture measurements in vadose zone hydrology: A review. *Water Resources Research* 44:1-21.
- Vidal, L., Ménot, G., Joly, C., Bruneton, H., Rostek, F., Çağatay, M.N., Major, C., and Bard, E. (2010). Hydrology in the Sea of Marmara during the last 23 ka: Implications for timing of Black Sea connections and sapropel deposition. *Paleoceanography* 25:1-16.
- Zhu, C., and Schwartz, F.W. (2011). Hydrogeochemical processes and controls on water quality and water management. *Elements* 7: 169–174.

Schedule

Date			Topic	Type	Reading	Assignment	Due Date	
A U G	24	W	Past & Present Waters	Lecture	Brutsaert Ch. 1 & 14			
	26	F		Lecture				
	29	M		Lecture	Valjarevic & Valjarevic, 2011			
	31	W		Laboratory		Lab Safety Certification		
				Discussion	Andrews-Hanna et al., 2007; Oelkers et al., 2011	Seminar 1		
S E P T	2	F	Super-surface	Lecture	Brutsaert Ch. 2			
	5	M		Lecture	Brutsaert Ch. 3			
	7	W		Laboratory		Lab 1	12 Sept	
	9	F		Lecture	Brutsaert Ch. 4	paper proposal due		
	12	M		Lecture				
	12	M		Laboratory		Lab 2	19 Sept	
	14	W		Discussion	Huxman et al., 2004; Vereecken et al., 2008	Seminar 2		
	16	F	Surface	Lecture	Brutsaert Ch. 5; Leopold Ch. 1			
	19	M		Lecture	Leopold Ch. 2			
	19	M		Laboratory		Lab 3	26 Sept	
	21	W		Lecture	Brutsaert Ch. 6; Leopold Ch. 3			
	23	F		no class - DIG - paper outline due				
	26	M		Lecture	Leopold Ch. 4			
26	M	Laboratory			Lab 4	3 Oct		
28	W	Discussion	Arthington et al., 2006; Poff et al., 2007	Seminar 3				
30	F	Lecture	Brutsaert Ch. 7; Leopold Ch. 5					
O C T	3	M	Sub-surface	Lecture	Leopold Ch. 6			
	3	M		Laboratory		Lab 5	17 Oct	
	5	W		Review				
	7	F		Exam 1				
	10	M		no class - GSA				
	12	W		no class - GSA				
	14	F		Lecture	Brutsaert Ch. 8			
	17	M		Lecture				
	17	M		Laboratory		Lab 6	24 Oct	
	19	W		Discussion	Adam et al., 2010; McDonnell et al., 2007	Seminar 4		
	21	F		no class - Early Semester Break				
	24	M		Lecture	Brutsaert Ch. 9			
	24	M		Laboratory		Lab 7	31 Oct	
26	W	Lecture	Jurgens et al., 2008					
28	F	Lecture	Brutsaert Ch. 10	paper rough draft due				
31	M	Lecture						
31	M	Laboratory	Saffer & Tobin, 2011	Lab 7	7 Nov			

Date		Topic	Type	Reading	Assignment	Due Date	
N O V	2	W		Discussion	Goldscheider et al., 2008; Humphreys, 2008	Seminar 5	
	4	F	Model Surface	Lecture	Brutsaert Ch. 11; Leopold Ch. 7		
	7	M		Lecture	Brutsaert Ch. 12; Leopold Ch. 8		
	9	W		Laboratory		Lab 8	14 Nov
	11	F		Discussion	Gregory et al., 2011; Perry et al., 2009	Seminar 6	
	14	M		Lecture	Brutsaert Ch. 13; Leopold Ch. 9		
	14	M		Lecture	Leopold Ch. 10		
	14	M		Laboratory		Lab 9	28 Nov
	16	W	Review				
	18	F	Exam 2				
	21	M	no class - Fall Break				
	23	W					
	25	F					
28	M		Lecture	Leopold Ch. 11			
28	M		Laboratory	Elsner et al., 2010	Lab 10	5 Dec	
30	W		Discussion	Oberdorfer et al., 2007; Vidal et al., 2010	Seminar 7		
D E C	2	F	Future Waters	Discussion	Barnett et al., 2008; Christensen & Lettenmaier, 2007	Seminar 8	
	5	M		Lecture	Leopold Ch. 12 & 13		
	5	M		Laboratory		Final Lab	
	7	W		Discussion	MacDonald et al., 2008; Zhu & Schwartz, 2011	Seminar 9	
	9	F		Lecture	Leopold Ch. 14		
15	R	Final Paper Due					