

ESM 226: Groundwater Management

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“Examines the principles and tools for groundwater management and stewardship of groundwater resources in the US and includes examples drawn from global groundwater management challenges.”

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Office Hours: By appointment

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Course Text and Relevant Readings: Readings posted online

Grading:

Item	Percent of course grade
Quiz	30
Participation	10
Term project oral presentation	20
Term project final report	40

Course Objectives:

1. Develop proficiencies in core qualitative and quantitative principles of groundwater storage, flow, recharge, discharge, quality, management and legal frameworks [Classes #1 through #9]
2. Develop ability to quantify and evaluate groundwater management challenges arising from groundwater overuse and pollution including those identified by California's Sustainable Groundwater Management Act (SGMA):

(2a) Develop abilities to quantify spatiotemporal trends in groundwater levels and identify key processes driving groundwater level fluctuations and trends over time [Classes #7, #11]

(2b) Learn to quantify groundwater storage and its relevance to stakeholders in a groundwater basin [Class #12]

(2c) Develop knowledge of common groundwater pollutants and techniques available to evaluate contaminant sources and processes governing their abundance [Class #8]

(2d) Understand factors impacting aquifer storage and evaluate techniques applied to identify land subsidence induced by groundwater pumping [Class #14]

- (2e) Understand theory and principles governing seawater intrusion and engineering and management interventions available to ameliorate seawater intrusion vulnerability [Class #13]
- (2f) Develop skills to evaluate where rivers gain and lose water, and understand how pumping from wells can impact streamflow [Class #15]
3. Review, synthesize and present groundwater quality and quantity research and couple results to potential management strategies [Oral Presentations during Classes #18 and #19; Term project final report]
 4. Review and discuss interconnections between environmental justice and groundwater [Many classes will begin with an active learning exercise devoted to environmental justice and groundwater, drawing from a series of readings to be posted to GauchoSpace ahead of class e.g., https://link.springer.com/chapter/10.1007/978-3-319-23576-9_10]

Course Overview and Connections to Course Objectives:

- Classes #1 through #9 introduce core principles of groundwater science, including introductions to groundwater storage, flow, replenishment, discharge, quality, management and legal frameworks [Direct link to course objective 1]
- Classes #11 through #15 couple lectures on the six key aspects of California's Sustainable Groundwater Management Act (the six "undesirable results") to problem sets highlighting one or more ways these aspects can be evaluated. Lectures will take place on Mondays; guidance and support for problem sets will usually take place on Wednesdays. Critically, each student will complete a problem set for a different groundwater basin (i.e., region) identified by the Sustainable Groundwater Management Act; results of each problem set will be synthesized into the student's final project. [Direct link to course objectives 2a, 2b, 2c, 2d, 2e and 2f]
- Term project presentations—where each student provides a synthesis of results from Problem sets 1-6 for their unique groundwater basin—take place during classes #18 and #19 [Direct link to course objective 3 – objective outcome evaluated via Oral presentation and Final report]

Tentative schedule (subject to changes)

https://docs.google.com/spreadsheets/d/1ycsxe3vXR3iJEPlsYvg_w8ldBv2kroNH7woFXvwwTxl/edit?usp=sharing

Week	Date	Meeting #	Topic	Concepts
1	Monday, January 8, 2024	1	Groundwater hydrology 1	Topics: relevance of groundwater to provision of drinking water, industry and irrigation, and streamflow generation; global (and US-wide) overview of groundwater withdrawals; overview of role of groundwater in global change processes; definitions of key terms (e.g., groundwater, wells, groundwater management, recharge, gaining/losing streams); porosity (primary and secondary)
1	Wednesday, January 10, 2024	2	Groundwater hydrology 1	Topics: relevance of groundwater to provision of drinking water, industry and irrigation, and streamflow generation; global (and US-wide) overview of groundwater withdrawals; overview of role of groundwater in global change processes; definitions of key terms (e.g., groundwater, wells, groundwater management, recharge, gaining/losing streams); porosity (primary and secondary)
2	Monday, January 15, 2024	MLK Jr. Day	no class	no class
2	Wednesday, January 17, 2024	3	Groundwater hydrology 2	Topics: permeability; hydraulic conductivity; definitions of aquifer, aquitard, aquiclude; heterogeneity and anisotropy; confined conditions; water tables; types of aquifer systems; sources of water to wells;
3	Monday, January 22, 2024	4	Groundwater hydrology 2	Topics: permeability; hydraulic conductivity; definitions of aquifer, aquitard, aquiclude; heterogeneity and anisotropy; confined conditions; water tables; types of aquifer systems; sources of water to wells;
3	Wednesday, January 24, 2024	6	Groundwater hydrology 3	Topics: storativity; specific yield; residence times; estimating groundwater flow rates; (ground)watersheds; hydraulic heads and gradients (horizontal and vertical); flow nets; discharge
4	Monday, January 29, 2024	7	Recharge, Discharge	Topics: quantifying 'groundwater' contributions to streamflow; diffuse recharge, focused recharge, water table fluctuation method, tracer hydrology methods; detecting groundwater discharges, managed aquifer recharge
4	Wednesday, January 31, 2024	8	Groundwater quality	Topics: Conservative versus non-conservative solutes, Solubility, Major and minor ions, Solute sources, Advection, Dispersion, Common groundwater contaminants (hydrocarbons, arsenic, salinity, nitrate, fluoride) and controls on their mobility, retardation, reaction, point and non-point sources, geogenic sources
5	Monday, February 5, 2024	9	Pumping and Management	Topics: Well hydraulics, Cone of depression, Radius of influence, Spatial scales, Legal principles, SGMA, GSPs, GSAs,
5	Wednesday, February 7, 2024	10	Quiz	Quiz
6	Monday, February 12, 2024	11	Groundwater levels	Topics: Groundwater depletion, techniques to evaluate groundwater levels (e.g., GRACE, piezometric records)
6	Wednesday, February 14, 2024	12	Groundwater storage	Topics: SGMA's "minimum threshold" value, managed aquifer recharge
7	Monday, February 19, 2024	Presidents' Day	no class	no class
7	Wednesday, February 21, 2024	13	Seawater intrusion	Topics: Prevalence, Theory, Treatment and engineering 'solutions'
8	Monday, February 26, 2024	14	Land subsidence	Topics: land subsidence; Problem set (5 of 6): "Significant and unreasonable land subsidence that substantially interferes with surface land uses" [SGMA "undesirable result" 5 of 6]
8	Wednesday, February 28, 2024	15	Streamflow depletion	Topics: Capture, groundwater dependent ecosystems, losing and gaining reaches
9	Monday, March 4, 2024	16	Guest lecture	tbd
9	Wednesday, March 6, 2024	17	Guest lecture	tbd
10	Monday, March 11, 2024	18	Final presentations	
10	Wednesday, March 13, 2024	19	Final presentations	