INTRODUCTION TO HYDROGEOLOGY, GEOL 3302-01, Fall 2017
MWF, 10:00-10:50a
Room: VIN 158

Professor: James W. Ward, Ph.D., P.G.
Office: VIN 124
Phone: 325.486.6767
Dept. office: 325.942.2242
E-mail: james.ward@angelo.edu

Office hours: Monday-Friday 11:00-Noon, T and R 10:00-11:00.
Or contact me to set up an alternate time to meet

Course Materials:

Supplementary Readings: Papers of interest will be found in a folder on your blackboard webpage

Course content and activities: This course encompasses the occurrence, movement and quality of fresh water in the water cycle, including environmental problems and possible solutions. Case studies will be explored in part through readings and field trips.

Grading:
There will be 8 in-class and/or out-of-class exercises (typically weekly), which will count for a total of 40% of the final grade (5% each). There will be one major field trip report and one research paper report each 10% of the final grade. Oral presentation to class of hydrogeology research 5% of final grade to be given during dead week.

Both the midterm and final will include questions from field trips, readings and guest lectures.
The exams may include conceptual, short-answer questions and calculations. The final will be cumulative but will focus on the second half of the course. Each exam will count 17.5% of the final grade.

Late penalties for homework and papers will be 10% per day if unexcused.

Overall grades will be as follows: 89.5 and above = A; 79.5–89.5 = B; 69.5–79.5 = C; 59.5–69.5 = D; below 59.5 = F; curving is possible but not guaranteed.

Student learning outcomes
1) To practice techniques used in the field of Hydrology/Hydrogeology. Many of these are applicable to other fields and to everyday life. Some problem-solving techniques that you will learn and practice:
   a. Calculation of water budgets
   b. Field applications of hydrology/hydrogeology
   c. Being skeptical: look for ways to test hypotheses
   d. Researching topics of hydrology/hydrogeology
   e. Quantifying water flow and discharge using mathematics
   f. Applying Darcy’s Law of flow
   g. Working together
   h. Carefully defending your thinking when answering questions.
2) To learn the practical and theoretical applications of general hydrology/hydrogeology.

3) Learn about the water resources of West Texas. These learning outcomes are all assessed by grades on Exams and Reports.

**Program Learning Goals to be assessed and/or required for the BS Geosciences Program**
- Demonstrate factual knowledge in Geology (Final Exam)
- Demonstrate geology skills in the field on actual outcrops (Field trip report)

**Attendance Policy**
Attendance is expected, it will be difficult to pass this class if you do not attend regularly and participate (e.g., view grading section).

**Course Webpage**
[http://blackboard.angelo.edu](http://blackboard.angelo.edu) contains class outlines, your official grades, readings, etc.

**Know the ASU Honor Code**
Angelo State University expects its students to maintain complete honesty and integrity in their academic pursuits. Students are responsible for understanding the Academic Honor Code, which is contained in print and web versions of the Student Handbook.

Persons with disabilities which may warrant academic accommodations must contact the Student Life Office, Room 112 University Center, in order to request such accommodations prior to any accommodations being implemented. You are encouraged to make this request early in the semester so that appropriate arrangements can be made.

A student who intends to observe a religious holy day should make that intention known in writing to the instructor prior to the absence. A student who is absent from classes for the observance of a religious holy day shall be allowed to take an examination or complete an assignment scheduled for that day within a reasonable time after the absence.

**Field Trips**
1) Sept. 15-16, Texas Hydro-Geo Days 2016, Cave Without a Name, Boerne, Texas

2) November?, Concho Valley Hydro Trip With Mr. Stephen Shaw of First View Resources.

3) Many others in Class to local areas, including the Lipan-Kickappo aquifer, Concho River, etc.

**Guest Lectures**
Mr. Stephen Shaw, P.G., Firstview Resources, LLC, Hydrogeologist
Mr. Jarrett Louder, San Angelo TCEQ
Mr. Raymond Straub, Jr., P.G., President of Straub Geosciences
Ms. Kathryn Ward, P.G., Mesa Geologicals, LLC
**Tentative class schedule** (subject to change):

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
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<tbody>
<tr>
<td>8/29, 8/31, 9/2</td>
<td>Introduction; origin of water on Earth, water cycle and properties of water</td>
</tr>
<tr>
<td>9/7, 9/9</td>
<td>9/5 Labor Day, Water cycle and properties of water (cont’d.); evaporation</td>
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<tr>
<td>9/12, 9/14, 9/16</td>
<td>Plant water use and precipitation</td>
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<tr>
<td>9/19, 9/21, 9/23</td>
<td>Infiltration and soil water/ Limnology</td>
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<tr>
<td>9/26, 9/28, 9/30</td>
<td>Watershed delineation and fluvial geomorphology</td>
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<tr>
<td>10/3, 10/5, 10/7</td>
<td>Streamflow and runoff, Flooding and drought</td>
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<tr>
<td>10/10, 10/12, 10/14</td>
<td>Review for Mid-Term, Midterm Exam</td>
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<tr>
<td>10/17, 10/19, 10/21</td>
<td>Hydraulic properties</td>
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<tr>
<td>10/24, 10/26, 10/28</td>
<td>National GSA in Seattle. Guest Lectures and out of Class Assignments.</td>
</tr>
<tr>
<td>10/31, 11/2, 11/5</td>
<td>Ground water and aquifer systems</td>
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<tr>
<td>11/7, 11/9, 11/11</td>
<td>Ground water and aquifer systems</td>
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<tr>
<td>11/14, 11/16, 11/18</td>
<td>Well dynamics</td>
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<tr>
<td>11/21, 11/23,</td>
<td>Chemical quality of natural water, Thanksgiving!!!!!!</td>
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<tr>
<td>11/28, 11/30, 12/2</td>
<td>Water pollution, Water usage, resources management</td>
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<tr>
<td>12/5, 12/7, 12/9</td>
<td>12/5 research papers due!, Presentations/Final Exam review</td>
</tr>
<tr>
<td>12/11</td>
<td><strong>Final exam 10:30a-12:30p</strong></td>
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</table>
Guidelines for Research Paper

The research paper for this class is to be written over the application applied hydrogeology. The Paper should be no shorter than 6 pages, not including a cover page, figures/tables, or reference pages. It should be 1.5 spacing and properly referenced according to the format found below. There should be at a minimum of 10 references with a maximum of 2 internet references (i.e., the references must come from journal articles and books). The paper should have an introductory paragraph followed by the main body and conclusion; no abstract is necessary. You can use the ASU library or Science Direct, etc. to obtain your sources. Sources are to be turned in with the research paper.

The paper is due at the beginning of class December 5.

The reference format for this paper comes from the journal *Restoration Ecology* and is described below.

**Literature Cited**

In the text, unpublished studies should be referred to as such or as a personal communication and should include an affiliation. Example: (R. Davis 1999, Harvard University, Boston, MA, personal communication). References in the text should be inserted in parentheses, in chronological order as follows: (Johnson & Van Cleve 1976; Cairns 1981; Plafkin et al. 1989). The reference list should be in alphabetical order according to first-named author. Papers with two authors should follow those of the first-named author, arranged in alphabetical order according to the name of the second author. Papers with more than two authors should follow in chronological order. All authors' names, dates, title of book or article, publisher and place of publication must be included. Do not use abbreviations. The following are examples:


GEOL 3302, Into Hydrology Research paper topics

1) Wetland restoration
2) Surface mining and stream health
3) Karst aquifers
4) Groundwater tracing techniques
5) Over exploitation of aquifers
6) Saltwater intrusion into freshwater aquifers
7) Effects of dams on rivers
8) Water rights in the US
9) Flood plain regulations (FEMA)
10) Desertification effects on groundwater systems
11) Naturally occurring groundwater contaminants
12) Unnatural groundwater contaminant
13) Remediation techniques for groundwater
14) Drilling techniques for water wells
15) Geophysical methods for groundwater detection
16) Isotopes and groundwater
17) Glaciers and climate change
18) Restoration of watersheds
19) Urbanization effects on watersheds
20) Modeling groundwater flow
21) Development of drinking water standards
22) Climatic change effects on the hydrologic cycle
VARIABLES DISCUSSED HYDROGEOLOGY

L, l length

\( t \) time

P precipitation (L, L/t, or L^3/t) or probability or fluid pressure (M/(t^2L))

E evaporation (L, L/t, or L^3/t)

T transpiration (L, L/t, or L^3/t) or recurrence interval or transmissivity (L^2/t)

ET evapotranspiration (L, L/t, or L^3/t)

PET potential evapotranspiration (L, L/t, or L^3/t)

\( R_o \) runoff (L, L/t, or L^3/t)

\( \Delta \) change in property

S storage or storativity (dimensionless)

\( R_N \) ground-water recharge (L, L/t, or L^3/t)

Q volumetric flow rate or discharge (L^3/t)

\( Q_i \) surface-water inflow to ground-water storage (L^3/t)

\( Q_o \) initial volumetric flow rate or natural discharge (L^3/t)

\( Q_p \) discharge by pumping (L^3/t)

\( f_o \) maximum (initial) infiltration rate (L/t)

\( f_c \) minimum (equilibrium) infiltration rate (L/t)

\( f_{p, f} \) infiltration rate (L/t)

k constant representing rate of decreased infiltration capacity (1/t) or permeability (L^2)

v velocity (L/t)

A area (L^2)

\( K_0 \) baseflow recession constant (1/t)

n total number of records in a series or porosity (dimensionless) or grain size (L)

m order of data in a series or mass or thickness (L)

V volume (L^3) or voltage

\( V_T \) total volume (L^3)

\( V_V \) volume of voids (L^3)

\( V_S \) volume of solids (L^3)

\( V_w \) volume of water (L^3)

\( V_a \) volume of air (L^3)

\( \theta_v \) volumetric water (or moisture) content (dimensionless)

\( M_w \) mass of water

\( M_s \) mass of solids or specific area of solids (1/L)

e void ratio (dimensionless)

\( \rho \) density (M/L^3)

\( \rho_s \) grain density (M/L^3) (2.65 g/cm^3 for quartz)

\( \rho_b \) bulk density (M/L^3)

\( n_e \) effective porosity (dimensionless)

K hydraulic conductivity (L/t)

h hydraulic head (L)

I current

R electrical resistance or pore-throat diameter (L)

q specific discharge or Darcy velocity (L/t)

\( \nabla h, i \) hydraulic gradient (dimensionless)

d( ) regular derivative

\( \psi \) pressure head (tension head, suction head, matric potential) (L)

\( \rho_w \) density of water (M/L^3) (1.00 g/cm^3 for fresh water)

z elevation (L) or elevation head (L) or vertical coordinate

g acceleration due to gravity (9.81 m/s^2)

\( \gamma \) unit weight (M/(t^2L^2)) (62.4 lb/ft^3 for fresh water)

\( \phi \) fluid potential (L^2/t^2) or fracture porosity (dimensionless)

\( \mu_w \) viscosity of water (M/(tL))
N  shape factor (dimensionless)
d  grain diameter (L)
d_{10}  effective grain size (cm) (10% of particles are finer)
d_{m}  grain size (L)
\mu  mean
x, y  lateral coordinates
\partial( )  partial derivative
Σ  summation notation
θ  angle or water content (dimensionless)
\eta  arithmetic mean
H  harmonic mean or aquitard thickness (L)
G  geometric mean
h_{S}  hydraulic head (elevation) of surface-water body (L)
h_{p}  hydraulic head of piezometer (L)
b  aquifer thickness or fracture aperture (L)
W  width (L)
S_{s}  specific storage (1/L)
\beta_{w}  compressibility of water (t^2L/M)
\beta_{p}  matrix compressibility (t^2L/M)
B  bulk modulus (M/(t^2L))
σ_{T}, σ_{T}  total stress (M/(t^2L))
σ_{e}  effective stress (M/(t^2L))
S_{Y}  specific yield (dimensionless)
S_{R}  specific retention (dimensionless)
s  fracture spacing (L) or water saturation (dimensionless)
\nabla^2( )  Laplacian operator
c  aquitard compressibility constant (dimensionless)
\beta_{p}'  aquitard compressibility (t^2L/M)
n_{f}  number of flow tubes
n_{d}  number of hydraulic-head drops
ΔH  total hydraulic-head drop (L)
s  water saturation (dimensionless) or drawdown (L)
h_{c}  height of capillary rise (dimensionless)
r  pore radius (L) or radial distance from pumping well to observation well (L)
ψ_{a}  air-entry pressure head (L)
K(θ), K(ψ)  unsaturated hydraulic conductivity (L/t)
K_{sat}  saturated hydraulic conductivity (L/t)
S  storativity (dimensionless)
T  transmissivity (L^2/t) or temperature
h_{0}  initial hydraulic head (L)
e  base of ln (= 2.718…)
W( )  well function (dimensionless)
u  argument of Theis well function (dimensionless)
t_{0}  extrapolated initial time for Cooper-Jacob straight-line solution
Δs'  residual drawdown (L)
h'  recovered head (L)
t'  time since pumping stopped
B  Hantush-Jacob leakage factor or Debye-Hückel constant (both dimensionless)
K'  vertical hydraulic conductivity of bounding aquitard (L/t)
m'  thickness of bounding aquitard (L)
\beta  or \Gamma  Neuman’s parameter (dimensionless)
u_{A}  argument of Neuman’s well function at early time (dimensionless)
u_{B}  argument of Neuman’s well function at late time (dimensionless)
A  cross-sectional area of well (L^2) or Debye-Hückel constant (dimensionless)
F  shape factor (L)
H  ratio of drawdown at time t to maximum drawdown at beginning of slug test
r_c  casing radius (L)
\( r_w \)  well radius (L)
\( L_e \)  screen length (L)
\( \Sigma \)  summation notation
\( z_0 \)  elevation of lowest point on surface of watershed (Tóth’s solution) (L)
B'  elevation of topographic divide above \( z_0 \) (L)
L  width of flow field
b  amplitude of sine wave (L)
\( \lambda \)  period of sine wave (dimensionless)
K  equilibrium constant (dimensionless) or degrees Kelvin
\( \Delta G_r^\circ \)  Gibbs free energy of reaction (ML^2/t^2)
R  ideal gas constant (8.134 J/(mol K))
[ ]  concentration (M/L^3)
( )  activity (M/L^3)
\( \gamma_i \)  activity coefficient (dimensionless)
\( z_i \)  ionic charge (dimensionless)
I  ionic strength of solution (M/L^3)
M  molality
\( \hat{\alpha}_i \)  radius of hydrated ion (cm)
IAP  ion activity product (dimensionless)
SI  saturation index (dimensionless)
pH  \(-\log_{10}\) of H^+ activity
Eh  measured e^- potential for an electrochemical cell (V)
SC  specific conductance (\( \mu \)S/cm)
k  reaction rate constant (1/t)
C_0  initial concentration (M/L^3)
M_s  mass of solids
KD  distribution coefficient (L^3/M)
\( K_{oc} \)  organic solute partition coefficient (L^3/M)
f_{oc}  fraction of organic carbon (M/M)
p_e  \(-\log_{10}\) of e^- activity