Rules: This is a closed book exam, but you can use brief notes. Leave an empty seat on either side of you. Turn phones off, don’t copy from others, and no google-glasses!!

Crossword Puzzle (1 pt ea word)

ACROSS

1 Used to guide non-point pollution abatement (abbreviation).

3 A radioactive byproduct of fertilizers that causes cancer when smoked.

6 The zone near a river where the vegetation and the river affect each other.

8 A type of erosion associated with overland flow.

11 A type of erosion in large, ephemeral channels resulting from concentrated flows.

13 The temperature at which an air mass reaches 100 percent humidity.
17 The maximum flow resulting from precipitation.
18 The region that drains to a particular point.
22 A measure of the ability of porous material to transmit fluid.
27 A type of confined aquifer with flowing wells.
28 Change in temperature with altitude (two words).
29 A shallow section of a stream with higher water velocities.
30 Loss of water to the atmosphere from soil, lakes, and plants.
31 An abandoned river meander.
32 Downward movement of water through the unsaturated zone.
33 A geologic formation that yields significant water when pumped.
35 Area next to rivers subject to flooding.

DOWN

2 Associated with oceanic air.
4 The fluid that drains from a landfill.
5 Region near equator that generates great rainfall (abbreviation).
7 A type of aquifer that is overlain by an aquitard.
9 A plot of streamflow as a function of time.
10 Having elevated nutrients.
12 Zone in the subsurface above the water table.
14 A type of heat associated with a change of phase (e.g., from solid to liquid).
15 A geologic formation that does not transmit water.
16 To cause or become thickened.
19 Region along waterways that require extra protection (abbreviation).
20 Streamflow directly resulting from precipitation.
21 The accumulation of precipitation on plants.
23 The movement of water into soil.
24 A geologic formation the does not prevent flow, but does not yield significant water when pumped.
25 A type of heat associated with a change in temperature.
26 Part of the hydrograph not associated with storm water.
34 A type of erosion in small, ephemeral channels resulting from concentrated flows.
Calculations

   - Two wells are located five kilometers apart ($\Delta x = 5$ km), one upstream of another.
   - The water level drops fifteen meters ($\Delta h = 15$ m) between the two wells.
   - The aquifer hydraulic conductivity is estimated to be one centimeter per day ($K = 0.01$ m/day).
   - The aquifer thickness is estimated to be twelve meters ($b = 12$ m).

   (a) What is the hydraulic gradient ($G = \Delta h/\Delta x$) between the two wells? __________ (3 pts)
   (b) What is the flux ($q = KG$) in the aquifer between the two wells? __________ (3 pts)
   (c) What is the total flow per unit width of aquifer ($Q = qb$), in units of L/day/km? __________ (4 pts)

2. Streamflow. Complete the following worksheet table and use the results to answer the following questions.

<table>
<thead>
<tr>
<th>Interval:</th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
<th>(e)</th>
<th>(f)</th>
<th>(g)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (ft):</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>11</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Width (ft):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth (ft):</td>
<td>0.9</td>
<td>5.9</td>
<td>3.1</td>
<td>2.1</td>
<td>1.5</td>
<td>0.8</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Area ($ft^2$):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity (ft/s):</td>
<td>0.9</td>
<td>2.1</td>
<td>4.1</td>
<td>6.9</td>
<td>2.3</td>
<td>1.3</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Flow (cfs):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   (a) What is the total stream area? (Hint: Sum areas) $A (ft^2) = $ __________ (3 pts)
   (b) What is the total streamflow? (Hint: Sum flows) $Q (cfs) = $ __________ (3 pts)
   (c) What is the average velocity? (Hint: $\bar{v} = Q/A$) $\bar{v} (ft/s) = $ __________ (4 pts)

3. Temperature and Precipitation. (2 pts ea)
   (a) Why is the lapse rate for dry air ($1^\circ$C/100 m) different than for wet air ($0.5^\circ$C/100 m)?

   (b) Find the temperature near the Dead Sea (elevation is -450 m) if it’s $40^\circ$C ($104^\circ$F) in Jerusalem (elevation is 750 m) using the lapse rate for dry air.

   (c) What rainfall mechanism(s) caused the record rainfall of over 20 inches in Atlanta in September 2009?

   (d) What is the annual probability for this 10,000-year Atlanta storm?
1. Runoff. Sketch two infiltration curves (one for a bare soil and one for a mulched soil) for a storm with a constant precipitation rate. Label the vertical axis. (3 pts)

Give three reasons why the two curves are different. (2 pts ea)
(a) __________________________________________
(b) __________________________________________
(c) __________________________________________

2. Water Quality. Identify the three components of water quality and provide two examples of each. (3 pts ea)
(a) __________________________________________
(b) __________________________________________
(c) __________________________________________

(a) Identify the following factors in the Universal Soil Loss Equation: (1 pt ea)
A ___________________________ C ________________
R ___________________________ P ________________
K ___________________________ T ________________
LS __________________________

(b) Find the annual soil loss (t/ac/yr) for \( R = 350 \), \( K = 0.15 \), \( LS = 2.1 \), \( C = 0.075 \), \( P = 1 \) and \( T = 5 \). (2 pts)

(c) Is this an acceptable soil loss (circle one)? Yes - No (1 pt)

4. Infiltration. The 1000-acre Artemis Forest was first converted to Demeter Gardens, and then to Hades Mall.
(a) What is the runoff volume (AF) from an 8" storm? (2 pts ea)
   i. Artemis Forest (CN = 60) _________
   ii. Demeter Gardens (CN = 75) _________
   iii. Hades Mall (CN = 90) _________

(b) Why is soil infiltration important, and how can we maximize it? (3 pts)