Hydrological Processes and Effects of Land Use Spring 2009
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Homework #1 (due 14 February)

Goals and Principles

The objectives of this homework are to: (1) introduce you to some of the units and conversions commonly used by hydrologists; (2) acquaint you with some typical hydrologic problems; (3) begin providing you with a "feel" for hydrologic values; (4) introduce you to some on-line information sources; and (5) provide us with some guidance with respect to your interests and current knowledge.

In terms of presenting your work, most employers--particularly engineering consulting firms--will require you to show all calculations, to carry the units throughout the calculations, and to do neat work. The same standards will be applied in this course, and engineering paper may be useful.

Another key element is the issue of significant figures. The accompanying handout discusses this issue in some detail. You should follow these guidelines in all your work for this class, and hopefully throughout your careers!

In general, you should do your calculations in units with which you are familiar, and lead to numbers that are easily understood. It is difficult to evaluate the reasonableness of one's calculations when working in units such as cubic kilometers or cubic millmeters rather than cubic centimeters or cubic meters.

I encourage you to review your work. Three very useful tools for evaluating your quantitative results are dimensional analysis, unit analysis, and order of magnitude analysis. Dimensional analysis uses the basic units of length (L), mass (M), and time (T) to assess whether these balance and your answer has the appropriate dimensions (e.g., $L\ T^{-1}$ is velocity, L^3 is volume). Unit analysis is similar, but more specific in that you consider the specific units (e.g., centimeters, kilograms, seconds). Again the goal is to ensure that your units balance and you made all the necessary conversions. Since both dimensional and unit analyses do not consider the actual values, order of magnitude analysis should be used as both a qualitative and semi-quantitative check on whether the numbers seem "reasonable" (i.e., is the answer an appropriate order of magnitude?). I suspect that some of the answers to this homework may be surprising.

Part I: Basic Conversions

1. The residents on St. John in the U.S. Virgin Islands depend on rainwater for their domestic water supply. Each house therefore has a cistern, and all runoff from the roof is directed into these cisterns. (a) If you have a large house with a roof area of 130 square meters and 1.5 cm of rain falls overnight, how many liters have you captured (assume that interception and evaporation losses are negligible)? (b) If you have a household with four people and the average per capita water use is 100 liters per day, for how many days can you survive on this one storm? (c) To allow gravity flow, you decide to build your cistern on the second floor of your house. What weight of water would you have to design for if the cistern were to hold all of the 15 cm of rainfall that fell during hurricane Hortense in September 1996? Express this value in metric tons (one metric ton is exactly 1000. kg or one megagram [Mg]).

2. During the dry season much of the rain that falls is likely to be stored in the soil and used for evapotranspiration, while in the rainy season a relatively high proportion of the rainfall is likely to become runoff. If we assume that 85 mm of rainfall falls each day for five consecutive days during the rainy season on a 500 km^2 watershed, the water balance suggests that the amount of runoff per day is likely to be quite consistent. (a) If we assume that 50% of the daily rainfall becomes runoff, what is the average daily runoff in cubic meters per second? (b) Does this amount of runoff seem too high, too low, or just about right?

3. It is important to recognize that a rain gage technically captures a volume of water, and this is converted to a depth by knowing the cross-sectional area of the rain gage. In Vietnam the standard rain gages are handmade, but let's assume that the opening is exactly 16.000 cm in diameter. To estimate the volume of rainfall over a given area or catchment, you generally have to multiply a measured rainfall depth by the area of interest (you can use dimensional analysis to verify this). Most people don't appreciate the magnitude of the extrapolation that is involved in this simple step. (a) Calculate the ratio between the area of a small catchment that is 10.0 ha to the area of a rain gage. (b) The actual density of rain gages in Vietnam is probably only about one gage for every 1000 square kilometers. If we are trying to do a water balance and we want to estimate the volume of water that falls over the average area represented by one rain gage, we are effectively extrapolating from the area of the rain gage to 1.0×10^3 square kilometers. By what factor are we extrapolating (i.e., what is the ratio between the average area represented by each rain gage in Vietnam and the opening of a standard rain)?

4. The instantaneous record peak flow at a gaging station in the Red River basin was estimated to be 30,000 $m^3 s^{-1}$. The drainage area is 150,000 km^2. (a) If we assume that the average peak flow over an entire 24-hour period was 25,000 $m^3 s^{-1}$, how many millimeters of runoff does this represent when averaged over the entire drainage basin? (b) Convert your answer in part (a) to $m^3 s^{-1}$ per square kilometer, and compare that to the value you calculated in problem #2. Does this answer change what you said in part (b) of problem #2?

5. At high flows the velocity of the water in a big river might be around 2 m per second. If a flood occurs at Hoa Binh, how much hours will be available to warn the residents in Ha Noi, which is about 80 km downstream?

6. Except in relatively dry areas, annual precipitation usually follows a normal (bell-shaped) distribution. The mean annual precipitation in Xuan Mai is about 1800 mm, and the standard deviation is about 250 mm. If we assume that the annual precipitation in Xuan Mai has a normal distribution, (a) what is the probability of receiving 1300 mm of precipitation? (Hint: you may need to refer to the proper statistical table (z table) to answer this, and these are available in almost any statistics book.)

Part III. Understanding and integrating hydrologic processes

7. Choose any landuse hydrology problem that is of particular interest to you. In an essay of about 1-3 double-spaced pages briefly describe: (a) the problem; (b) the hydrologic processes being affected by humankind; (c) how these human-induced changes cause the problem; and (d) suggest some actions that could be taken to mitigate or solve the problem.

OPTIONAL: Part II. Information sources on-line.
There has been a remarkable explosion of information available through the World Wide Web. Although I personally do not spend much time surfing around, you should be aware of what is out there. One key source of hydrologic data in the U.S. is the U.S. Geological Survey, as they are responsible for measuring flows on streams and rivers throughout the U.S. Using their web site (http://www.waterdata.usgs.gov/nwis/rt): (a) identify any stream gaging station of interest, and give the name and USGS gaging station number; (b) state the current flow in cubic feet per second and stage at the time you do this part of the assignment; (c) give the highest instantaneous flow and stage on record (i.e., for all days, not just the day you are looking at; look under peakflows); (d) convert this record flow to cfm (cubic feet per second per square mile) based on the area above the gaging station (see "station information" to get the drainage area); and (e) convert the value in part(d) to cubic meters per square kilometer.

Now think how much easier it is to do hydrologic studies since all this information is so easily and readily available on line! How long do you think it will be until Vietnam has something similar?