Watershed Analysis

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Groundwater is a major source for drinking and irrigation water. 50% of the people in the United States depend on groundwater for their drinking water, and 75% of U.S. cities derive all or part of their water from groundwater[1]. Locating groundwater reservoirs is one of the most important jobs of the hydrogeologist. There are many techniques available to help identify the groundwater potential of an area. A regional or watershed level approach is one method which is used to identify watersheds which are likely to contain significant groundwater reservoirs. This type of study can also be used to determine the maximum sustainable yield of water which can be removed from the groundwater reservoir on an annual basis. Analyses of this type are often performed using data which are generally available from the U.S Geological Survey (USGS), the National Climatic Data Center (NCDC), and other government agencies.

In this lab, you will conduct a preliminary analysis of a moderate-sized watershed (a few hundred square miles or less). For any single water year, you will determine the hydrologic budget of that watershed. This will include determining the total amount of water into the basin (precipitation), the stream discharge out of the basin, and the percent of water lost to other factors (evaporation, plant transpiration, human consumption, agricultural use, ...).

You may do this assignment individually or in teams of no more than **2** people; *I recommend doing this assignment as a team if possible*. Each individual or team will do analyses on a different watershed, and we will compare your results in our next lab meeting.

By the end of this project you should be able to:

- *Identify and describe physical characteristics of a watershed.*
- *Use data collected from the internet and elsewhere to quantify the major elements of the annual hydrologic cycle for a particular watershed.*
- *Graph and interpret precipitation and discharge data.*
- *Analyze your results and compare them with estimates predicted prior to your analysis.*
- *Demonstrate your understanding of the hydrologic cycle of your watershed through an oral presentation in which you teach your classmates about your watershed.*
- *Gain insight into regional variations of the hydrologic cycle by comparing and contrasting the watershed results from all student teams.*

[1] Environmental Protection Agency: http://www.epa.gov/seahome/inject/src/grndwtr.htm

ASSIGNMENT

Choose a watershed in the United States on which to do your analysis. It will be helpful to choose an area with which you or your teammate is familiar, such as near your hometown or your favorite vacation spot, or someplace you've always wanted to visit. You will use data retrieved from the web to determine the annual hydrologic cycle of the watershed and its groundwater potential.

Before finalizing your choice of watershed, ensure that you have access to the necessary data for the watershed. Instructions for locating data on-line are found below. **You _must_ have discharge and precipitation data for the area from the same time period**. Precipitation data should be from the nearest station even if it is not within your watershed.

Below are some links that I've found useful; you may find others. Please let me know if you find something that may be of interest to this or future classes!

Geologic information can be found at:
http://www.ldeo.columbia.edu/users/menke/envdata/quality/map/

http://wwwdggs.dnr.state.ak.us/akgeomap.html

Topography information can be found at:
http://www.ldeo.columbia.edu/~small/GDEM.html

Some aerial photographs and topographic maps can be found at:
http://terraserver.homeadvisor.msn.com

Regional precipitation and temperature histories can be found at:
http://www.cdc.noaa.gov/USclimate/states.fast.html

Average annual precipitation can be found at:
http://www.worldclimate.com/

ftp://ftp.ftw.nrcs.usda.gov/pub/ams/prism/maps/usp.pdf

http://www.cdc.noaa.gov/USclimate/states.fast.html

http://www.wrcc.dri.edu/precip.html

Daily precipitation data can be found at:
http://cdo.ncdc.noaa.gov/dly/DLY?
(see Precipitation handout for instructions for accessing data from this site)

Surface water data, including stream discharge, can be found at:
http://water.usgs.gov/
(see Stream Discharge handout for instructions for accessing data from this site)

To generate your hydrologic report, you will fill in the information on the last few pages of this handout. These worksheet pages are there to help you keep important information easily accessible. You will be using computer programs to access data from the internet (such as Netscape or Internet Explorer) and Excel to analyze your data. You may use additional graphing programs of your choice, but this is not necessary.

You will collect precipitation and discharge data for a single "water year". Since most precipitation occurs from late fall through early spring, it makes sense to use a water year which runs from **October 1 to September 30** of the following year.

Finding a year's worth of data for both precipitation and discharge within the same watershed may be a bit tricky. I suggest that you do some exploration to find what years have data available, and then continue with the project when you find sufficient overlap. You must have both precipitation and discharge for the area from the same water year.

Part I: Watershed Description

Do some on-line exploration to determine the general climate, geology and other potentially important factors of the region of your potential watershed choice. Bear in mind that the actual watershed you select may be different from your initial choice (due to data availability), but as long as you remain in the same general region your work here should translate to your final watershed.

Hint: Don't spend too much time here initially. Once you've verified that you have precipitation and discharge data for a particular watershed you may want to revisit this question and dive into specifics.

Part II: Predicted/Expected Results

The amount of water that leaves the watershed as stream discharge is related to both the amount of precipitation into the watershed as well as the amount of water lost (e.g. evaporation, human consumption …).

1. Estimate how much of the water that enters the watershed as precipitation actually leaves the watershed as discharge. Give your answer as a percentage of the precipitation, as well as your rationale for your estimated value.

Part III: Testing Your Hypothesis

Part III A: Precipitation Data

Precipitation data are available as text files from the NCDC for the location in which you are interested. Once you have obtained this information, you will load it into Excel and retrieve the relevant data. (NOTE: the data are reported in inches).

It's best to find a precipitation station at a higher elevation than that of the gauging station you use for discharge. This is because of the *orographic effect* – an increase in elevation usually results in an increase in precipitation for an area. Thus, since the discharge station will be at the *lowest* elevation in your watershed, you want a precipitation station at a higher elevation to represent better the overall precipitation into your watershed.

1. Determine the total precipitation (in inches) that occurred in your area during your study *(see the Precipitation Data handout for instructions)*.
2. Compare the annual precipitation you determined for your watershed with the average for your area.
    a. Are your results reasonable given the averages for this area?
    b. Is your water year a typical year?
    c. If not how is it different?

Part III B: Discharge Data

Stream discharge is the volume of water that leaves the watershed per unit time. Discharge is usually reported as ft^3/sec (cubic feet per second, or cfs). Here, we are interested in the amount of water that leaves the watershed as discharge during the water year in question. We can then compare the amount of water that enters the watershed via precipitation with the amount that flows out as stream discharge.

1. The first step in this process is to obtain the daily discharge values for your watershed *(see the Stream Discharge Data handout for instructions)*.
2. Calculate the total discharge from the watershed during your water year.
    a. *Think carefully about what the data mean*. You have daily discharge measurements in cfs and you want the total discharge for the year (cubic feet per year). This is the step where most people have trouble – again, think carefully about what the data mean (follow your units – do they make sense to you?).

Part IV: Where does the water go?

In order for us to compare results between the various watersheds you and your classmates study, we need to be able to take out the influence of the *size* of the watersheds. To do this, you will all determine the unit discharge for your watershed. Obviously a large watershed will yield a large discharge value while a much smaller watershed will have a small discharge value. In order to compare discharge between different watersheds (and to compare with precipitation values), a unit discharge is determined for each watershed. To do this, divide the total discharge by the area of the watershed – this normalizes the discharge data and eliminates any differences due to watershed size. PAY ATTENTION TO UNITS!

1. Determine unit discharge in inches/year (*note*: there are 5280 feet in a mile).

You are now ready to determine the hydrologic budget for your watershed. The hydrologic equation says the total amount of water that enters a watershed during a single year equals the amount that leaves the watershed during that same year. This assumes that there is no change in groundwater storage (a reasonable first-order assumption).

Water In (precipitation) = Water Out (Discharge + Other)

Other forms of outflow from the watershed include evaporation, plant transpiration, and human consumption.

2. Compare the unit discharge with the total annual precipitation.
   a. *Hint*: If your discharge exceeds your precipitation by a factor of 100 or more, chances are you've made a common error and you should revisit the step in which you determined the total annual discharge (in cfs). If you do end up with a lot more discharge than precipitation, talk yourself through the units again and make sure that you think about what each unit means and are not just blindly doing unit conversion.
   b. *Hint*: If your discharge equals or only slightly exceeds your precipitation, check the elevations of your precipitation and discharge stations, as well as the elevation range in your watershed. Is your precipitation station likely to be a good representative for your watershed? Why or why not?
3. Determine the amount of water in "Other" output from your watershed.
4. What percentage is this of the total water input into the system?
5. Given what you know about your watershed, what comprises the "Other" output? Is it dominated by evapotranspiration? by human consumption? by agriculture? by something else? State your reasoning and give evidence, where appropriate.
6. What percentage of the annual precipitation leaves the watershed as stream discharge? How does this compare with your initial estimate (prior to any calculations)?

Part V: Teach us about your watershed!

Next week during lab: You and your teammate will give a 5-8 minute oral presentation on your watershed study. You should use PowerPoint slides to help your audience follow the key elements of your talk. You can include personal pictures of the area, maps… This is an opportunity to **teach** your classmates about your watershed, and it provides us with an opportunity to compare watersheds in different regions of the U.S. For help using/making PowerPoint slides, see me, Karina or one of the TAs. If you want to ask Karina for help, please make an appointment with her (karina.bailon@pomona.edu; 621-8677).

NOTE: Please give Karina your PowerPoint file by 9:30 AM next Thursday in order to ensure that she can get the file onto the computer before lab (you can put it in the class folder "dropbox" or bring it on a CD or zip disk).

Name ____

Part I: Watershed Description

State	River	Geology (Bedrock, surficial deposits … groundwater potential?)	Elevation Range (feet)	Climate

Other comments:

Part II: Predicted/Expected Results

Estimate the percentage of precipitation that leaves the watershed as stream discharge:

Discuss your rationale for your estimated value:

Name ____

Part III: Testing Your Hypothesis

Part III A: Precipitation Data:

Station #	Location (include elevation)	Start Date	End Date	total precipitation (inches/year)	month(s) of peak precipitation

Why does precipitation peak when it does?

What is the average annual precipitation for your area (averaged over several years)?

Where did you get this information (e.g., list web site or library source)?

How does the total annual precipitation you calculated compare with the multi-year average for your area?

If there are differences, what might be the cause of these differences?

Name ____

Part III: Testing Your Hypothesis

Part III A: Discharge Data:

Station #	Latitude	Longitude	County	Basin Name	Drainage Area (square miles)	Elevation (feet)

Start Date	End Date	Total Discharge (cubic feet/year)	month(s) of peak discharge

Attach graphs of discharge and precipitation through time.

Discuss the relationships (if any) between the months of peak precipitation and peak discharge.

How might these relationships be related to the climate of the area?

Name ____

Part IV: Where does the water go?

Unit Discharge Determination:

Total Discharge (cfy)	Total Discharge (cubic inches per year)	Unit Discharge (inches/year)

Hydrologic Equation:

Precipitation In (inches/year)	Discharge Out (inches/year)	Other Out (inches/year)	% of input as discharge	% of input not discharge

What are the likely sources of water loss in your watershed in addition to water lost through stream discharge? State your reasoning and give evidence, where appropriate.

What percentage of the annual precipitation leaves the watershed as stream discharge?

Discuss how the percentage you calculated compares with your initial estimate, and why they may be different.

Name ____

Indicate possible areas in your watershed which may serve to store groundwater (e.g. possible aquifers), and indicate whether or not they are likely to be good suppliers of groundwater.

List and describe any other relevant information about your watershed, including why you chose this particular watershed. ☺