Lab 9: Streams and floods

Geomorphology is the study of the way in which the environment is continually reshaping the Puget Sound (and the world’s) landscape. Running water is a major shaper of the land. Water on land is divided into two components: groundwater, which is underground (and we will study at a later date) and surface water, which includes rivers and lakes.

Running surface water in rivers and streams can be a depositional or erosional force (sometimes both simultaneously). The grain size terms you will use in this lab are: clay, silt, sand, gravel (which is both pebble and cobble) and boulder.

The slope of a streambed is important in determining the stream’s speed (velocity). Slope gradients can be expressed in two ways: degrees off of horizontal and percent grades. The former is used typically in research science, and the latter is used primarily by civil and environmental engineers. They are calculated in different ways:

\[
\text{gradient (degrees)} = \tan \left( \frac{\text{elevation gain}}{\text{lateral distance}} \right)
\]

\[
\text{gradient (percent)} = \frac{\text{elevation gain}}{\text{lateral distance}} \times 100\%
\]

Note that, for any given slope, you will get two different gradients depending on which equation you use, but that the two values ought to represent the same thing! Also, note that while both slope gradients will be zero for a level surface, the maximum slope is 90° in one case and an infinite percent slope in the other. Think about what a 100% slope’s degree equivalent would be.

Information about King County rivers can be found at [http://www-old.golder.com/ekcrwa/Aquifer/Hydrogeology.asp](http://www-old.golder.com/ekcrwa/Aquifer/Hydrogeology.asp)

The Mount Rainier National Park quadrangle (1955)

Find the White River, as it emerges from Emmons Glacier, high on the north-east flank of Mt. Rainier, and heads off toward the northeast corner of the map.

1. a. Obviously, is the White River, as shown on the map, closer to its headwaters or to its delta?

b. Would the White River be considered more of a braided river or a meandering river?

Remember the correlation between parts a and b.
2. a. Notice that there are multiple channels (blue lines) within the riverbed area. Notice also that there is a brown dotted pattern in this area. Does this area experience a high rate of erosion or a low rate of erosion?

b. From your experience of streams high up in the mountains, would the material at the bottom of this riverbed be coarse (boulder, cobble and sand) or fine (silt and clay)?

3. To calculate the stream gradient (in percent) of the White River, cut off a piece of string that represents 10,000 feet (use the scale at the bottom of the map). Lay it carefully along the path of the White River, starting at any point where the river crosses one of the brown contour lines.

a. Count how many contour lines the string crosses, then use the contour interval given on the map to calculate the elevation change from the front of the string to the back of the string.

b. Use the gradient (percent) formula given at the beginning of this handout to calculate the gradient in percent of the White River here.

4. a. Is the Mississippi River in this quadrangle closer to its headwaters or to its delta? How can you tell? Hint: is the river meandering or braided here?

b. How often, roughly, do the channels of the Mississippi seem to change? Hint: look for pairs of red dotted “Meander lines” and along the river itself for “Cutoffs”, both of which are dated. Is this more or less often than you would expect the White River channels to change?

c. From your experience of rivers of this type, would the material at the bottom of this riverbed be coarse (boulder, cobble and sand) or fine (silt and clay)?
d. Without doing any heavy calculations, what is the approximate percent stream gradient of the Mississippi River here? Hint: note how many contour lines it seems to cross.

5. a. Even in this part of the river, the processes of erosion and deposition continue. What feature in the Vicksburg area of the map shows that erosion by the river is an active force here (think back to your US history: the capture of Vicksburg by Union forces in 1863 — was this an easy battle or a difficult one? What made the battle harder for Union forces?)?

b. If the side of the river where Vicksburg lies is erosional, name the corresponding area (on the map) that is depositional in nature.

c. What two different structures have humans done to try and channelize the Mississippi River here? Have they been successful (before you answer look at a black dotted line structure on the former Kents Island in the southwestern corner of the map)?

d. What are features such as Thompson Lake and Goose Lake in the northern part of the map? They’re called oxbow lakes, but what are they really?

6. Summary — Connect two lines through each column of terms

<table>
<thead>
<tr>
<th>High stream gradient</th>
<th>Mostly depositional</th>
<th>Coarse riverbed grains</th>
<th>Slow stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low stream gradient</td>
<td>Mostly erosional</td>
<td>Fine riverbed grains</td>
<td>Fast stream</td>
</tr>
</tbody>
</table>

As the local example of running surface water, you will study Piper's Creek in Carkeek Park. Examine the two topographic maps of the Pipers Creek watershed in the Carkeek Park area (courtesy of John Figge). The contours are given in feet above mean sea level (amsl). The scale bar is also given in feet.

7. a. What is the contour interval of the topographic map? In other words, each of the unmarked contour lines represents a change of how many feet from the previous contour line?
b. **Calculate** the gradient (in percent) of the slope of the stream at point 1. You will have to decide what lateral distance and what elevation gain to use (if it’s not obvious, ask me).

c. **Calculate** the gradient (in percent) of the slope of the stream at point 2. Again, you will have to decide what lateral distance and what elevation gain to use.

*Take Northgate Way west and follow it (it becomes N 105th St. at one point) around its bend as it becomes Holman St. NW. Turn right at 3rd Ave. NW and then turn left at NW 103th St. Turn right at 6th Ave. NW and park in the Eddie McAbee lot. Walk down the trail to the point where you see running water on both sides of the trail, which is point 1 on the map.*

**Stop 1 — Upper Piper's Creek**

8. a. At the entrance to the park is a large boulder. What is the rock name? Is North Seattle known for outcrops of this rock? Then what is its origin? Hint: look for the parallel **striations** on its surface.

b. Piper’s Creek emerges from a drainpipe to the south and is the stream to your left as you face down the trail. How have humans affected the flow of this creek?

c. What **grain size** seems to describe the bulk of the deposited material?

d. The unnamed stream to your right seems a bit more energetic; this stream has been left in a comparatively natural state. What grain size seems to describe the bulk of the deposited material here?
9. Determine, roughly, the values for the first three rows on the table. The depth will be reasonably tough; try to get the deepest value on the rough channel bottom. You will calculate the last two rows later.

<table>
<thead>
<tr>
<th>Upper Piper’s Creek</th>
<th>Normal fall flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>River velocity (m/s)</td>
<td></td>
</tr>
<tr>
<td>River depth (m)</td>
<td></td>
</tr>
<tr>
<td>River width (m)</td>
<td></td>
</tr>
<tr>
<td>River cross-sectional area (m²)</td>
<td></td>
</tr>
<tr>
<td>River discharge (m³/s)</td>
<td></td>
</tr>
</tbody>
</table>

To measure the "normal" river velocity: set up a measuring tape parallel to the creek. Throw a twig into the creek upstream from the tape measure, sufficiently far away so that by the time the twig gets to the tape measure, the twig is moving at a uniform rate. Time how long it takes the twig to flow past the length of the measuring tape, then divide the length of the tape by the time. See next page to calculate flood stage velocity.

To measure the river depth: use a meter stick to find the deepest point in the creek; avoid pothole-type areas. For flood stage, place the meter stick where you measured the present summer depth and place the laser level on the top of the levee. Shine the laser at the meter stick, keeping the spirit level bubble level and note the height on the stick.

To measure the river width: use the tape measure to find an average river width. For flood stage, place the laser level on the top of the levee and shine the laser at the opposite bank, keeping the spirit level bubble level. Have someone else mark the point where the laser light and measure the distance between the laser and the mark.

Return to the parking lot and head back to NW 100th St. Turn left at 3rd Ave. NW and then left (past Viewlands Elementary School) at NW 110th St. Follow this road as it becomes Carkeek Park Drive and winds its way down to the park; turn left into the park entrance. Follow the loop road to the meadow area and park in the lot there. Walk across the grassy area to the wooden bridge (point 2 on the map). This is a salmon-spawning stream, so cross carefully, causing as little sediment disturbance as possible.
Stop 2 — The bridge over lower Piper’s Creek

10. Find a suitable vantage point that matches the creek’s channel shown here in map view. I drew this looking upstream from the wooden bridge. Label cut banks, levees and point bars, and show relative speeds and depths in the creek (use short/long arrows for speed and shading for depths). Finally, within the channel, show the distribution of grain sizes (for instance, shade in patches of different grain size material).

11. a. What is the correlation between depth and speed, if any?

b. Where does deposition take place in this part of the stream?

c. What is the grain size of the sediment deposited?

d. Where does erosion take place in this part of the stream?
e. What is the **grain size** of the sediment **eroded**? Hint: it’s the grain size you **don’t** see.

f. On the whole, is this part of the stream erosional or depositional (consider the total mass deposited versus the total mass eroded)?

12. Fill in the table for the normal fall flow values (don’t worry about the flood stage values just yet):

<table>
<thead>
<tr>
<th><strong>Lower Piper’s Creek</strong></th>
<th><strong>Normal fall flow</strong></th>
<th><strong>Flood stage</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>River velocity (m/s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River depth (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River width (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River cross-sectional area (m²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River discharge (m³/s)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To calculate the **river cross-sectional area**: approximate the creek’s cross-sectional shape as a "v" (see diagram). Then the cross-sectional area shape is a triangle, so the area = 0.5 (width) (depth).

To calculate the **river discharge**: multiply the river velocity by the river cross-sectional area. Now, what to do with these calculations:

13. a. What **grain size** of sediment is **deposited** during normal discharge periods on Piper’s Creek?

b. What grain size is **eroded**?

c. Is this **consistent** with what you saw in the first stop?

To calculate the **river velocity during flood stage**: Roughly speaking, the velocity of a river is proportional to the square root of its depth. In other words, if a river *quadruples* in depth during flood stage, the water will be moving *twice as*
fast as normal. Using this rule of thumb, estimate the creek velocity during flood stage, and fill in the table. (For the mathematically inclined: velocity = (constant) ÷(depth))

*Walk downstream and cross the railroad tracks on the footbridge*

**Stop 3 — The mouth of Piper’s Creek**

14. a. From the footbridge, what *part of the river* does the headland area (the beach below) represent?

b. What *grain size* of sediment would you expect?

c. What kind of *sedimentary structure* would you expect (if you could dig downward through the "beach" sediment)?

15. a. Descend to the beach area. Does the creek drain to the Sound in the widest part of the beach? **NO**. Why not?

b. Then what will ultimately happen to the wide part of the beach?

c. What do the sinuous depressed areas on the beach represent?

16. a. The graph on the next page is called **Hjulstrom's Curve**, after its creator, and is the basic graph for *sediment grain size/transport* relationships. Using the graph, fill in the appropriate grain size words in the table below, using the values of the stream velocity you calculated in the previous tables. Note that any given cell in the table can contain more than one grain size word (see example)!
<table>
<thead>
<tr>
<th>Stream regime</th>
<th>Upper Pipers Creek normal fall</th>
<th>Lower Pipers Creek normal fall</th>
<th>Lower Pipers Creek flood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosional</td>
<td>Fine sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>Silt, clay, sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depositional</td>
<td>Gravel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. a. How do the observations you made at the site compare with the theoretical model? If the observations do not match the model, suggest a reason why Hjulstrom’s Curve may not be appropriate for Piper’s Creek.

b. How do these grain sizes change when the creek floods?

**Floods**

Floods occur when the stream flow exceeds the banks of the stream. Fortunately, there are many good Internet resources concerning local rivers such as [http://dnr.metrokc.gov/topics/flooding/FLDtopic.htm](http://dnr.metrokc.gov/topics/flooding/FLDtopic.htm) for King County. For this part of the lab, go to the website: [http://wa.water.usgs.gov/data/realtime/rt latest_map.html](http://wa.water.usgs.gov/data/realtime/rt latest_map.html), then click on the Snoqualmie drainage, then finally click on yellow triangle to the northwest of North Bend along the Snoqualmie River (this should be the river gaging station near Snoqualmie). Scroll down to the “Available Parameters” menu; next to it is
a “Days” window. Below should be the “Discharge, cubic feet per second” graph. Type in an appropriate number of days such that the graph contains information from November 1 to present.

Open another window and go to the same King County map, but this time click on the next yellow triangle downstream (north) on the Snoqualmie River (this should be the station near Carnation). Again, scroll down to the “Discharge, cubic feet per second” graph and place the graphs side by side.

18. Examine the stream discharge versus date graph for both sites, especially around November 2 and 3. Which site was closer to the heavier rainfall? How does the shape of the graph tell you the proximity to a storm?

19. When (what date and time – you will have to estimate the time from the graph) was the peak discharge of the river at Snoqualmie? At Carnation? Why is there a difference in times?

20. Calculate the speed of the flood crest. For this you will probably need a topographic or road map of the area, and a piece of string (the river isn’t a straight line). Please show your calculation setup clearly. Recall that speed = distance/time.