**Geomorphologic controls on Tacoma area hydrology**

**Students need the following prerequisite knowledge:**

1) basic grounding in the glacial geomorphology of the Puget Lowland and ability to describe the origins of drumlins, outwash channels, glacial till, glacial outwash;

2) fundamentals of Google Earth, including basic navigation, loading KMZ files, turning KMZ layers on/off, changing the transparency of layers;

3) fundamentals of hydrology including controls on watershed boundaries, effect of slope on surface and groundwater flow, effects of permeability on infiltration;

The hydrology background can be achieved by performing the exercise at a point in the course post-dating studies of streams and groundwater. The Google Earth training can be assigned separately. Basic tutorials and instructions are available on the Google earth website, but this exercise may be best implemented in a class already using GE for other purposes. The glacial history of the Puget Lowland needs to be presented as a separate body by the instructor prior to using this exercise. If this exercise is used in an online class, the glacial history could be presented as a set of recorded lectures, or for that matter the recorded lectures could be made available to a regular face to face class.

**Goals:**

By drawing on their understanding of the recent geologic history of the Tacoma area, reading a case study, and working with different layers in Google Earth students will be able to:

1) describe the dominant role of glacial action in generating the local geomorphology and identify a few of the most common geomorphic features;

2) explain the influence of the geologic substrate on surface and groundwater flow;

3) distinguish between flooding caused by rising groundwater versus slow infiltration of surface water downward;

4) explain how topography effects surface and groundwater flow;

5) explain how the age of a stream effects its interaction with the landscape over which it flows;

6) cite examples of the effects of surface and groundwater flow on local development patterns, and how the urban landscape gets used by residents;

7) conceive of a field research plan to test ideas about how geologic features and materials control groundwater and surface water flooding.

**Preparation:**

Review the recent glacial history of the Puget Sound area. In particular, be sure to understand how drumlins and outwash channels form and the sedimentary characteristics of glacial till and glacial outwash. Review how to load KMZ files into Google Earth and how to turn layers on and off and control their transparency.

**The completed assignment will include:**

1) answers to the questions below;

2) two annotated screen captures;

3) four KMZ Place mark files.

**INSTRUCTIONS:**

**PART 1: Shallow Ground Water Flooding**

**1)** Read the USGS publication below and answer the following questions.

Ground-Water Flooding in Glacial Terrain of Southern Puget Sound, Washington, USGS Fact Sheet 111-00, September 2000.

1. Describe the process that formed the glacial outwash channels in Pierce County, such as the South Tacoma Channel.
2. Describe the type of sediment found in the vicinity of the channels.
3. As the water table rises after successive years of above-average precipitation, what aspect of the landscape causes water to collect in the outwash channels specifically, which are generally dry (except for some of the deeper ones like American Lake), as opposed to flooding the whole region more uniformly?

**2)** Load the following KMZ files into Google Earth:

Hillshade Tacoma

Pierce County geology

**3)** View the Hillshade Tacoma layer but turn the Pierce County geology off for the time being. The South Tacoma outwash channel is clear on the hillshade layer as the winding canyon-like feature cutting through Tacoma. Describe the areas directly to the east and west of the South Tacoma outwash channel by addressing the questions below.

What is the prominent pattern of the land surface in these adjacent areas?

How does it differ from the land surface in the outwash channel and further south?

What glacial geomorphic feature do the areas east and west of the outwash channel appear to show?

**4)** Turn on the Pierce County geology layer and make sure that it is above the Hillshade layer in the legend. If it’s not, then drag it above the Hillshade layer. Increase the transparency of the Hillshade layer until the geology shows through. Note how the distribution of the features you described in question three corresponds to the surface geology. The outwash channel is symbolized by Qgo, which means **Q**uaternary **g**lacial **o**utwash (i.e. gravel and sand from glacial outwash processes). The areas east and west of the South Tacoma outwash channel are symbolized with Qgt, which means **Q**uaternary **g**lacial **t**ill. Contrast the texture of these two types of deposits with respect to the following questions.

Which contain a significant amount of fine sediment?

Which may be more compacted, having been over-run and compacted by ice?

Based on grain size and degree of compaction which should have greater permeability and which should have reduced permeability?

**5)** When Pierce County receives greater than average precipitation for two years or more, shallow groundwater flooding can become an issue. In which areas is a rising water table likely to be linked to flooding, in Qgo or Qgt?

In which areas, Qgo or Qgt, is slow infiltration likely to cause flooding?

**6)** Turn off the geology layer and study the Hillshade layer. If shallow groundwater flooding occurs in both of the geologic units, where within each, in general, is it most likely to occur, with respect to elevation?

**PART 2: Surface flow patterns**

**1)** Study the Hillshade layer and consider how surface flow is directed by topography. Predict patterns of surface flow in the outwash channel area and the areas to either side, based on the downhill direction that flowing water always takes. Do this by printing a screen capture of the Tacoma area with the Hillshade layer fully opaque. Draw directly on the paper about ten to twelve examples where you would expect stream flow to occur.

**2)** Load the following KMZ files:

Pierce streams

Pierce County water bodies (this shows lakes and Puget Sound)

Turn on both of these layers. Increase the transparency of the Hillshade layer back and forth to see the relationship between topography and stream and lake distribution.

How does the actual distribution compare to your predictions?

How are they similar? How are they different?

**3)** Describe the concept of a watershed.

**4)** Print another screen capture of the Tacoma area. Draw directly on the paper where you think some of the watershed boundaries could lie within the Tacoma Hillshade layer area.

**5)** Load the Pierce County watershed boundaries KMZ file and turn it on. Keep the Pierce streams and Hillshade layer on as well but turn the others off. By changing the transparency for the Hillshade layer, study the relationship between watershed boundaries and topography. Discuss at least one geomorphic feature that exerts some control on watershed boundaries.

**PART 3: The Yakima River**

**1)** Load the WA rivers and the Yakima KMZ files. Double click on the Yakima Place mark file and GE will navigate to this site. The Yakima River starts on the east side of the Cascades and flows past Ellensburg and then onto Yakima and then finally meets the Columbia River. The WA rivers layer you can toggle on and off just for reference.

**2)** View the Yakima River near Ellensburg. Create four GE Place mark files that identify one example each of a meander, cutbank, point bar, and oxbow lake. Label the files correctly corresponding to the feature they point to.

**3)** Follow the course of the river past Ellensburg where it penetrates a series of low east-west trending mountains called the Yakima fold belt. The river comes out the other side of the folds near the city of Yakima. The Yakima folds began rising about 12 million years ago. What does this imply about the age of the Yakima River? Discuss your rationale. Do a little research to find the appropriate term for this type of river. Your textbook will have this term, or you may find it from another source.

**4)** Contrast the Yakima River and the streams in Tacoma with respect to the landscapes that they flow through by addressing the following questions.

How old is the Yakima River compared to the landscape that it flows over?

How old are the Tacoma streams compared to the landscape that they flow over?

How does the relationship between age of stream and the landscape effect the route of the stream flow?

**PART 4: Geomorphology in everyday life**

**1)** Write a short observation about how development in Tacoma was/is impacted by one of the glacial geomorphic features you studied in this exercise. Viewing the Hillshade layer in GE may help you think about the local landscape and to identify features. Turning on the Roads layer in the layer Pane might help you associate the local geomorphology with the Tacoma roads network and any familiar landmarks.

**2)** Write a short narrative that describes your direct experience with one of the glacial geomorphic features discussed in this exercise. It can be about a feature that you live on or near, or that you are near frequently, for school or work or recreation.

**3)** Reflect on **Parts 1 and 2**, and where geographically you predicted flooding to occur due to either a rising water table or slow infiltration**.** Write a short plan for how to collect data to test your ideas of the distribution of flooding problems in the study area. For example, rising groundwater level can flood basements. Slow infiltration can result in standing water. How could you collect data about these two phenomena to ground truth your hypotheses?