ISOLINE MAPS and RAINFALL

Geography 101 Lab **Name**____

Purpose: Introduce students to one of the most common and useful types of maps used in studying the natural environment. When completed, the student should understand the basic meaning of isolines maps, how to construct them, and how to derive information from them. We will also explore the spatial and seasonal pattern of rainfall in Hawaii.

Many surfaces in nature are represented with isolines. They provide a way to represent a 3-Dimensional surface on a 2-Dimensional map. An isoline is simply a generic term for any line on a map that connects points of equal value. Some examples of isolines are:

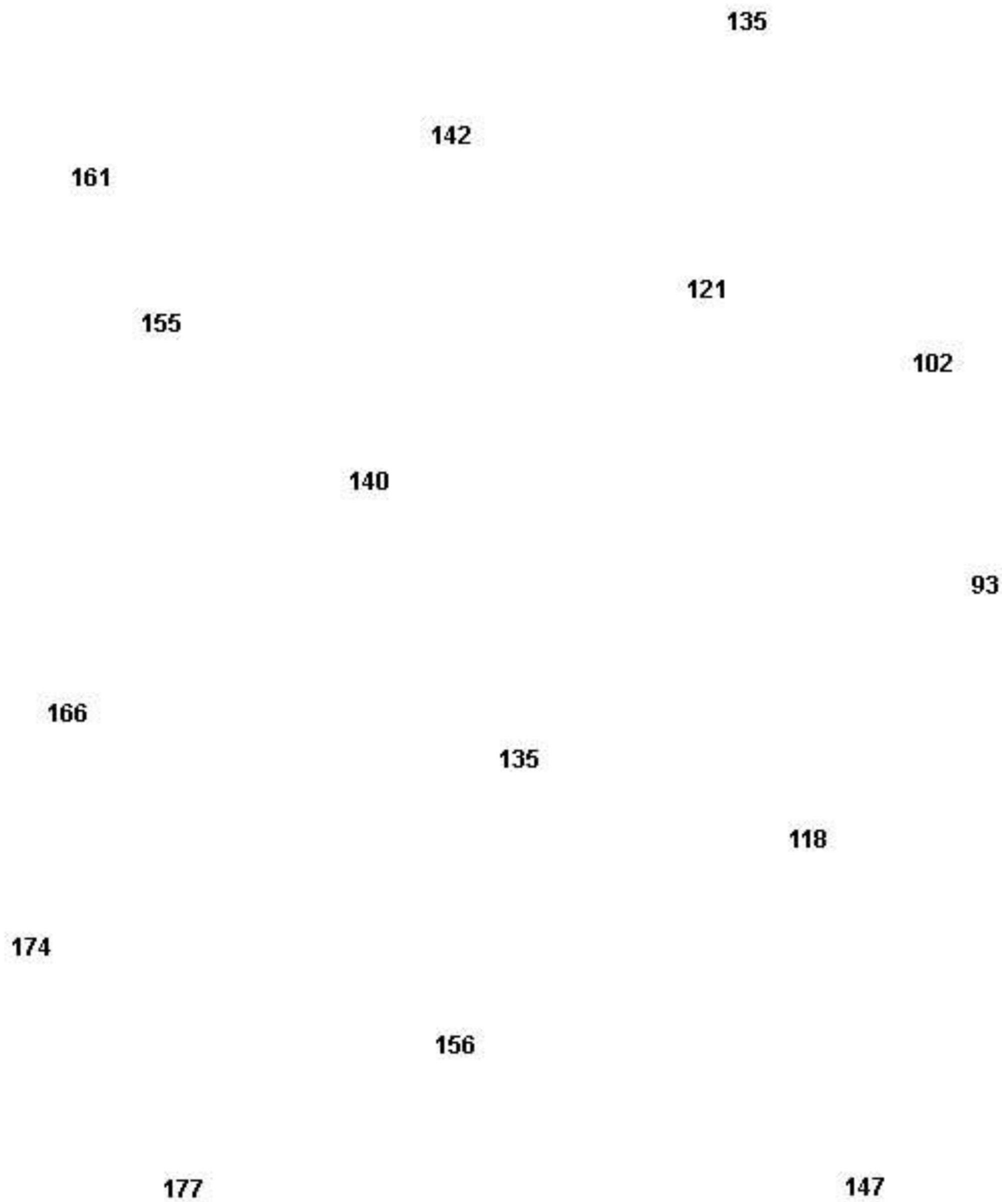
Name	**Connects Equal Values of**
Contour	Elevation
Isohyet	Rainfall
Isobar	Air Pressure
Isotach	Wind Speed
Isohaline	Salinity
Isoseismal	Earthquake Intensity
Isoflor	Number of Plant Species

Part 1: Basic Rules and Practice

Some basic rules regarding isoline maps are:

- **a.** isolines connect points of equal value
- **b.** isolines do not cross or touch (with the exception of vertical gradients, like cliffs)
- **c.** isolines pass between higher and lower values
- **d.** the **interval** is the numerical difference between adjacent isolines and is the same over the entire map (unless otherwise specified)
- **e.** isolines show **gradients**, defined as or the amount change over distance. Isolines close together show a high gradient, isolines far apart represent a low gradient.
- **f.** in nature, gradients usually indicate a flow from the higher values toward the lower values (for example, air moving from high pressure to low pressure and heat moving from areas of high temperature to areas of low temperature)

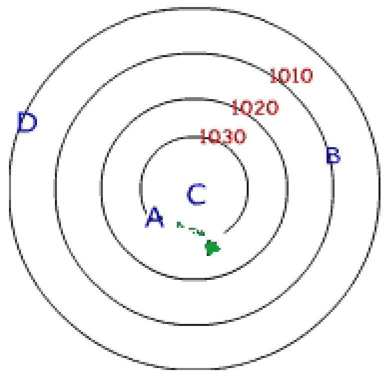
Draw isolines every 10



Does the pattern look like a hill or a valley to you?

Part 2: Interpreting Isoline Maps

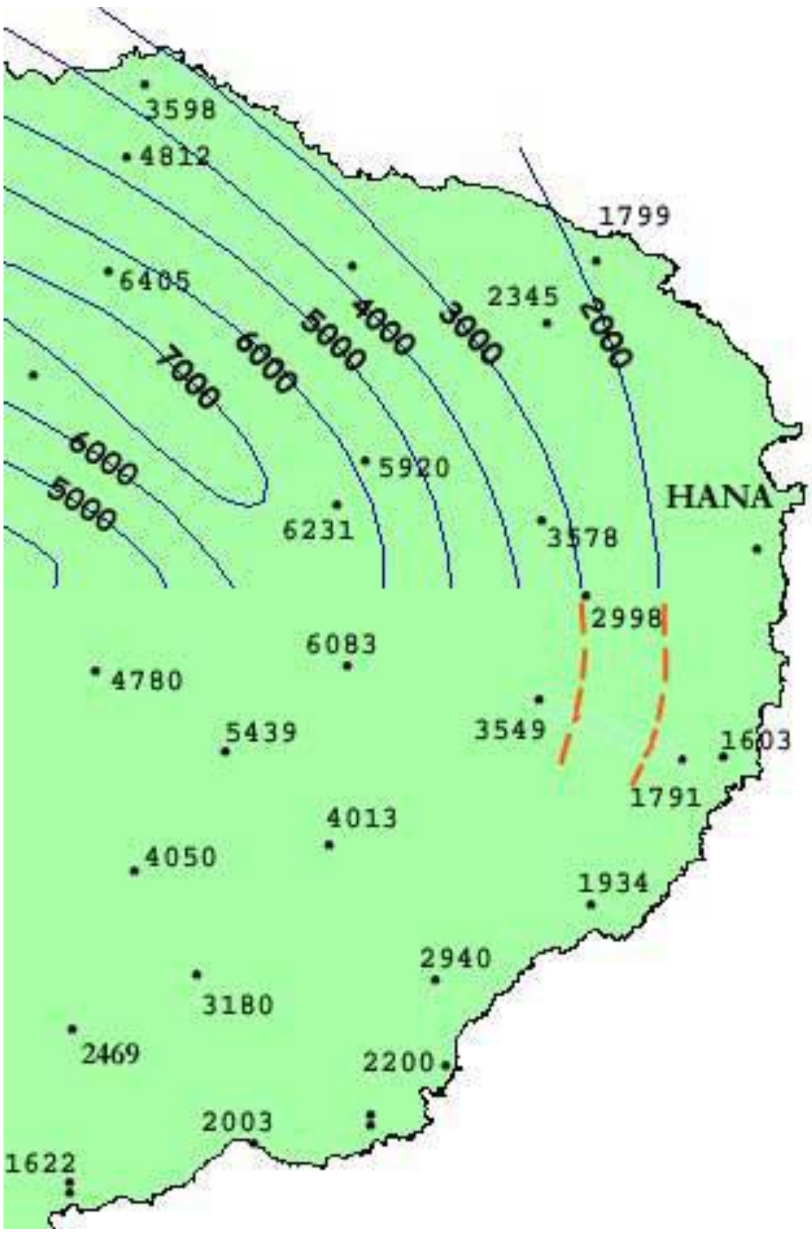
The map below is an isoline map showing isobars (in millibars) for the area Hawaiian Islands area. Isobar maps are useful in weather forecasts. After reading the information above, answer the following questions:



1. Isobars show equal values of what (Hint: see table at beginning of this lab)?
2. Do any isobars touch or overlap?
3. What is the pressure interval between isobars?
4. What is the pressure at point A?
5. What is the difference in pressure between B and A?
6. Where is the highest pressure located?
7. What direction will air want to flow, from B to C or from C to B (Hint: read Basic Rules above)?
8. Estimate the pressure at point D.
9. Estimate the pressure at point C.
10. Name three other environmental variables not mentioned in this lab exercise or listed above that could be mapped using isolines.

11. **Drawing isohyets:** Complete the isohyet map of East Maui below by finishing the 2000, 3000, 4000, 5000, and 6000 isohyets. As mentioned in class, begin by choosing pairs of points and determining where the isohyets lines would pass between them, as shown by the orange lines as an example. Then connect the equal value locations.

Remember, each isoline must pass between observations with higher and lower values, never between two lower values or between two higher values. It is OK if the isohyet is located over the ocean. It is also OK if isohyets form complete loops, as in the isobar exercise above.



Next consider the isohyet map below and answer the following questions (Hint: refer to the Basic Rules above for help with 14, 15, and 16):

12. What is the approximate rainfall value at A?

13. What is the approximate rainfall value at C?

14. What is the approximate rainfall value at D?

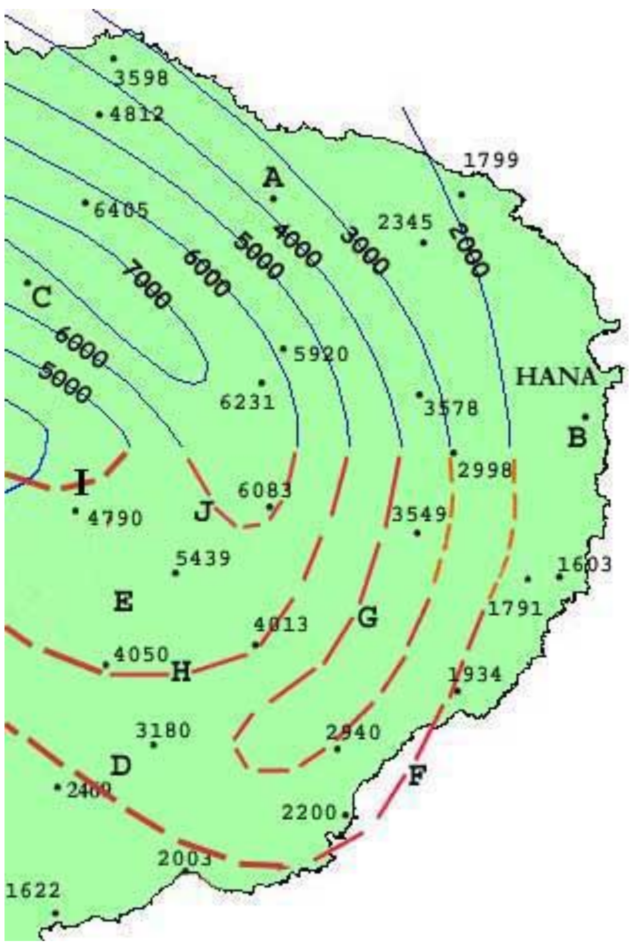
15. What is wrong with line G?

16. What is wrong with line F?

17. What is wrong with line I?

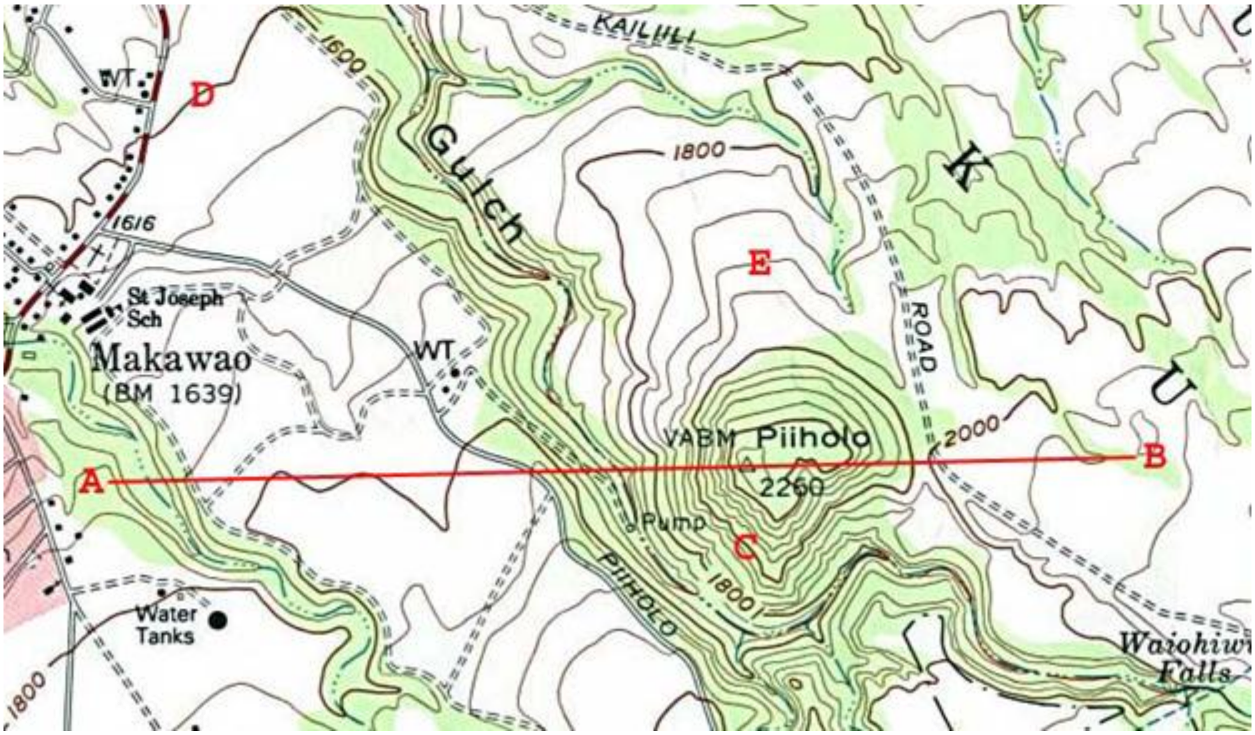
18. What is wrong with line H?

19. Does rainfall tend to increase or decrease as you move inland (westward) from Hana?



Part 3: Contour Maps and Profiles

Below is a topographic map of the area above Makawao, Maui showing isolines of elevation called contour lines. Only the darker contour lines are labeled, in even multiples of 200.



QUESTIONS:

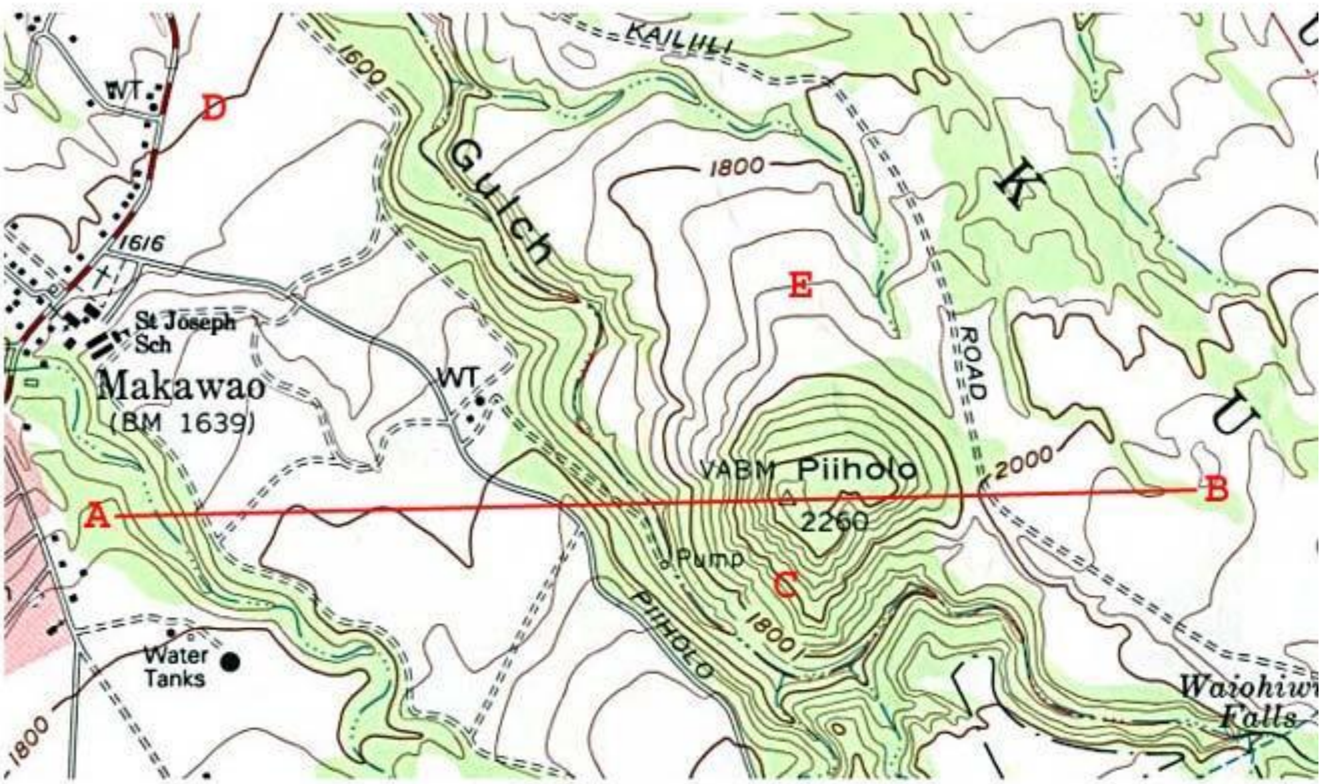
20. The height interval between contour lines is 40 feet. Show how to calculate this value using information given on the map. NOTE: 2260 is NOT a contour label, it is a summit elevation.

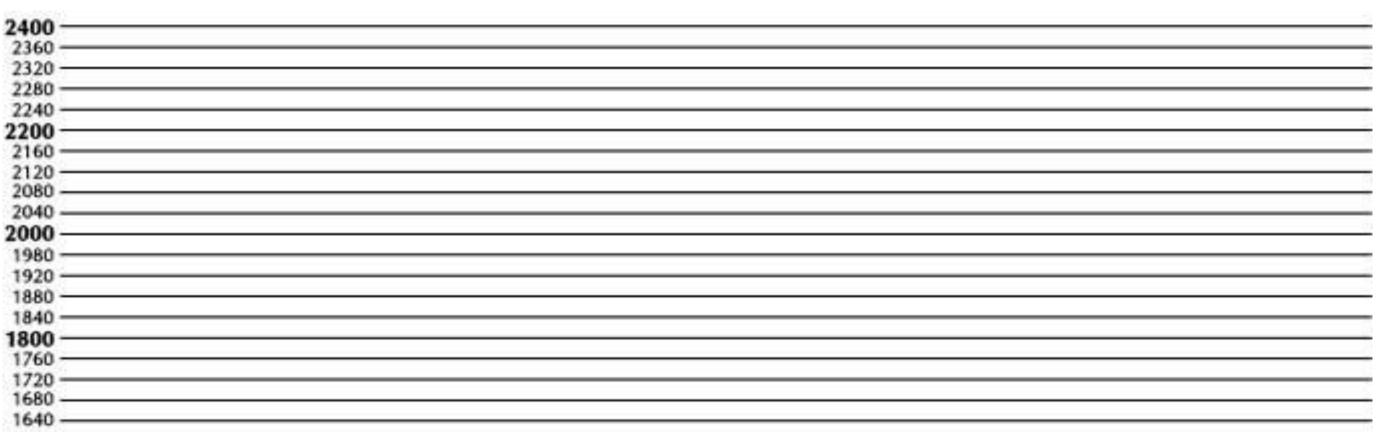
21. What (in feet) and where is the highest elevation point on the map?
22. What is the approximate elevation at point E?
23. What is the approximate elevation at point D?
24. What is the approximate elevation at point C?
25. From point C, which direction is downhill (NE, SE, NW, or SW)?
26. Which point lies on the highest elevation gradient, C, D, or E?
27. In your own words, what is physically meant by "high elevation gradient?"

28. Which point lies on the lowest elevation gradient, C, D, or E?
29. In your own words, what is physically meant by "low elevation gradient?"

30. Topographic maps show many features besides just elevation contour lines. Look at the map of Makawao and name four other features that it shows the location of (in other words, what else is on the map besides contour lines?).

31. On the profile diagram below, **draw an elevation profile** along the straight line that connects points A and B. Plot a point on the graph at the bottom for every intersection of line A-B and a contour line, then connect the points with a line to show the profile.

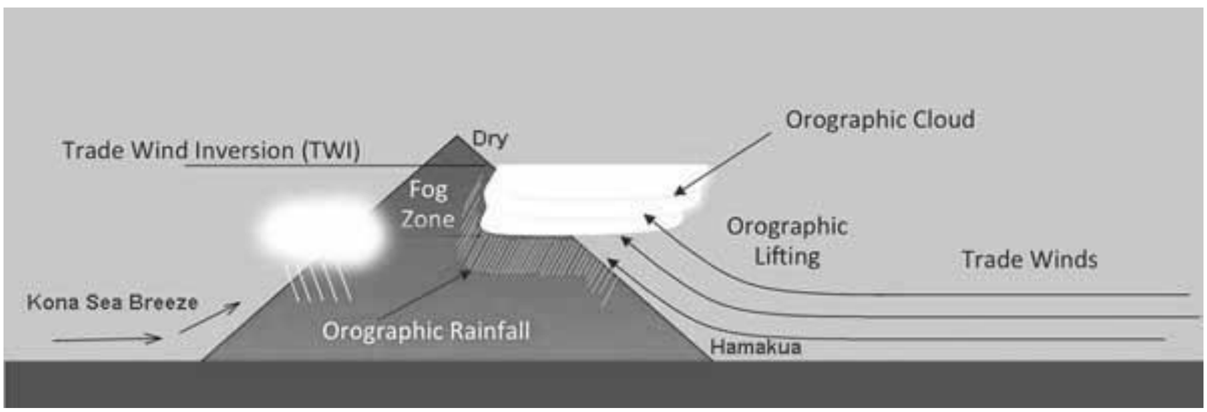




Part 4: Hawaii Rainfall

Without mountains, the Hawaiian Islands would be sparsely vegetated and dry. But because air is forced to rise as wind blows onto the windward slopes of mountains, the Islands extract about 3 times as much rain from the air as falls on the open ocean. Hawaiian mountains collectively milk an additional 20 billion cubic meters of water from the sky each year.

The science is pretty straightforward, as shown in the diagram. Wind pressure against a mountain barrier forces air to rise on the mountain's **windward** side. As it rises, it cools to the dew point, clouds form, and rain may fall. In the lee of the mountain (**leeward** side), the air, with its moisture removed, heats quickly as it flows downward producing hot, dry offshore winds and a low rain area called a **rainshadow**. The driest place in Hawai'i at sea level, Puako on the Big Island, lies in the rainshadow of the Kohala Mountains and Mauna Kea.

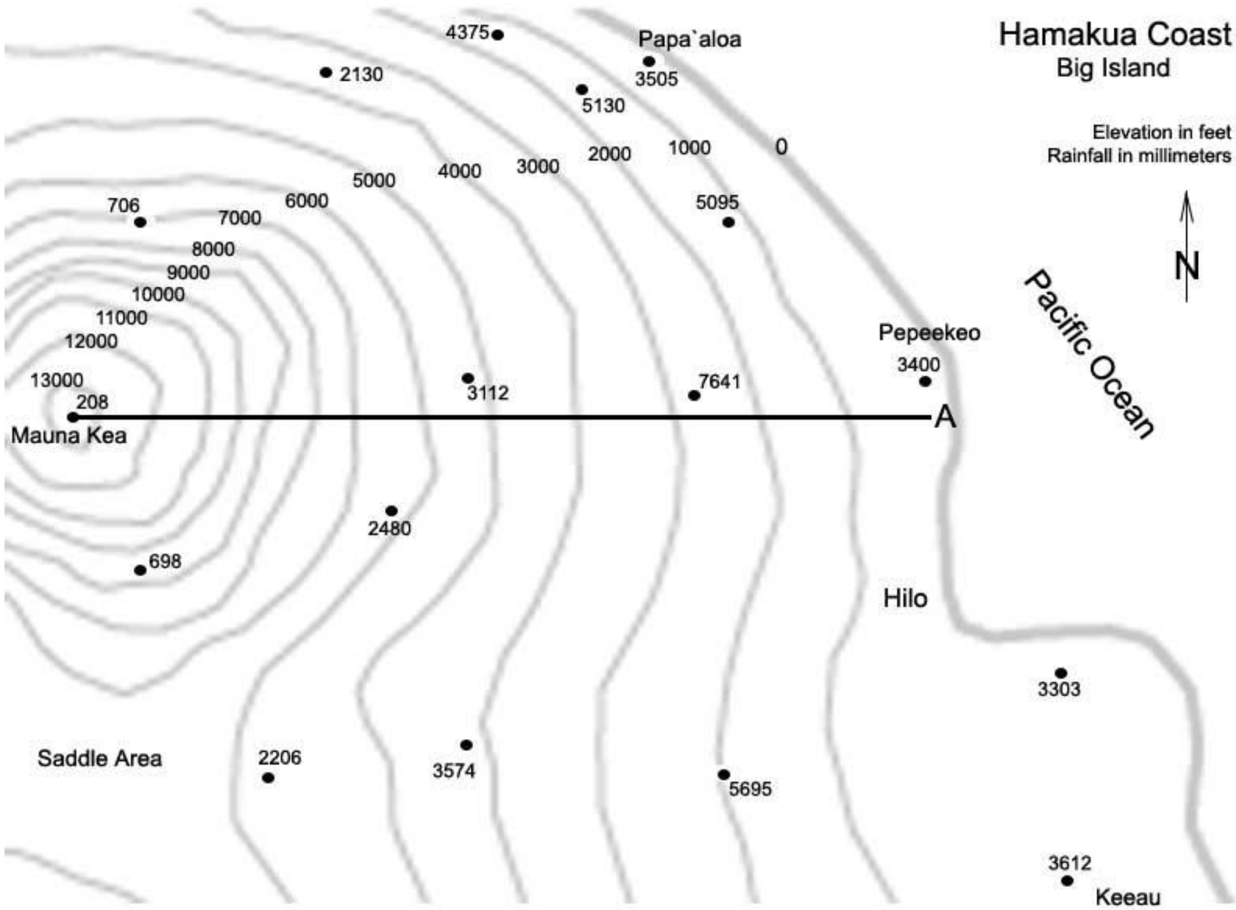


The amount rainfall generated by orographic lifting depends largely on the depth of the cloud formed. This, in turn, depends on the shape and height of the mountain. Why, for example, does Kaua'i have the highest rainfall in the Islands, even though it does not have the tallest mountain? The answer lies with the trade wind inversion, commonly located at about 2000 to 2500 meters (6000 to 8000 feet). Mountains such as Wai'ale'ale and West Maui rise to just below the inversion and thus the air can flow **over** the top, adding depth to the cloud and causes rainfall maxima near the mountain summits. For larger mountains, like Mauna Kea and Haleakala that rise well above the inversion, air must flow **around** them and thus clouds do not grow as deep, producing rainfall maxima far below the mountain summits. Large mountains may also generate rainfall through afternoon sea breeze clouds on sunny leeward slopes. This is quite common in the leeward Kona districts of the Big Island and accounts for most of the rainfall in this area.

Rainfall Spatial Pattern: We will examine the effect of orographic uplift and the trade wind inversion for the case of the windward Hamakua Coast on the Big Island. The map shows elevation contours for this part of the island. You will draw isolyets over the top of the contours. The result will be an isoline map (isohyets) overlying another isoline map (contours).

32. Draw in isohyets for every 1000 mm of rainfall on the Hamakua Coast map, interpolating from the rainfall station values (e.g., 2480, 3612, 7641 and so on)

33. In the graph below the map, draw a rainfall profile from the top of Mauna Kea to point A, as you did in the contour map exercise in #30 above.



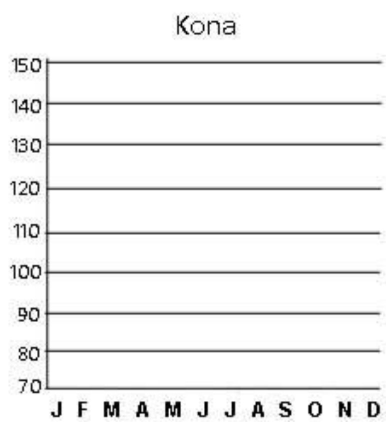
34. At what elevation is the maximum rainfall?

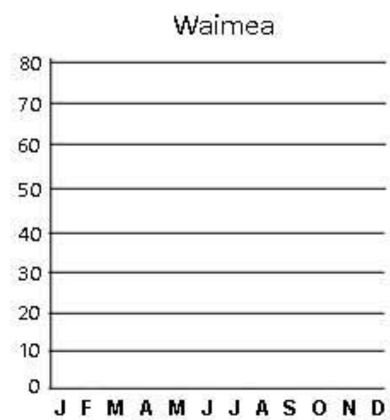
35. At what elevation is the minimum rainfall?

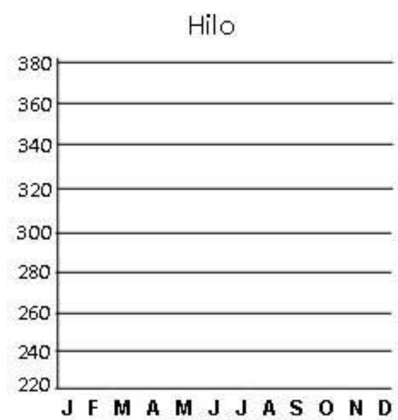
Rainfall Seasonal Pattern: Rainfall varies with location, but it also varies with season. Table 1 gives the average monthly rainfall for 3 Big Island stations that illustrate different seasonal rainfall patterns due to different causes of rainfall: a windward site (Hilo), a leeward site (Kona), and a site representing the open ocean pattern (Waimea). Plot the rainfall amounts as points on the graphs below, then connect the points with lines to better show the seasonal pattern.

Table 1: Average monthly rainfall averages for three stations on the Big Island

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Kona	79	87	111	101	104	129	125	98	124	93	71	70	1191
Waimea	79	60	65	46	28	25	26	22	20	27	48	58	504
Hilo	245	247	356	316	222	199	279	256	259	257	377	270	3303







36. Waimea represents the open ocean rainfall pattern in the Hawaiian Islands area and most locations in the Islands, including Honolulu. When is the season of maximum rainfall, winter or summer?

37. Kona lies in the leeward rainshadow of the Big Island's mountains, but experiences more rainfall than the open ocean because of its unique circumstances. The daily onshore sea breeze causes air to rise up the leeward slopes and produces afternoon rainfall almost daily. When is the season of maximum rainfall for the Kona slopes, winter or summer?

Why do you think it rains more in this season in Kona (just guess!)?

38. Hilo is characteristic of many high rainfall windward sites. Is there an obvious seasonal pattern? ________________ When are the wettest and driest seasons?

Does Hilo match the open ocean pattern, the Kona seasonal pattern, or is it different from both?