Name____________________

Catch it if you can – Quantifying Storm Water Runoff

Background:
As our population grows so too does our need for housing and infrastructure. However, this development comes with costs. Our open spaces are not only homes to established ecosystems, but they provide the ecological service of water storage among other services. When we "develop" these spaces we are increasing the percent of impervious surfaces and therefore changing how water drains from the area after a storm. This is called a positive feedback since the modification of the land is causing greater storm water runoff. This runoff can be detrimental to the stream ecosystems in the area of the development since the runoff could be carrying toxic pollutants and/or sediments. The toxic pollutants could kill off organisms living in the stream, and the sediments could create turbid conditions preventing the sunlight from penetrating the water which is required by photosynthetic organisms at the bottom of the stream ecosystem food chain.

Scenario:
In the town of Jonesville a 50 acre wooded lot was recently sold to housing developer. As a precaution, the Jonesville Zoning Board wants to know what will happen to the rain water striking this lot after the parcel of land is developed since the wooded lot appears to be containing most of the water with very little runoff. Their concern is for the water quality of a nearby river should runoff on this lot increase after it is developed. The developer is proposing to build homes on ¼ acre lots, whereas the Zoning Board feels that fewer homes will mean less runoff and would prefer the developer consider building on 1 acre lots.

What is the Jonesville Zoning Board concerned about?

How will building homes on this lot affect storm water runoff on this lot? Use the space below to craft a hypothesis that includes an explanation.

What do we know?

- Current land cover: wooded lot
- Size of the lot: 50 acres
- Proposed future land cover: homes on ¼ lots
- There is a stream nearby
- Soil type for a sample that is 30% clay, 45% silt, and 25% sand
- Average rainfall rate for this area is 1"/hour

What do we need to find out?
The quantity of runoff before and after development for a wooded lot if there were 1/4 acre homes and 1 acre homes

To calculate these values from the above scenario, we'll need to refer to our data tools for some answers.

1. What is the soil type? (*Hint: use the soil triangle*) _____________________

2. What is the Hydrologic Soil Group for this soil type? (*Hint: use the table provided*) ______________

3. Using your answer in question 2, what are the curve numbers for the following?

   Wooded lot: ______________
   Homes on ¼ acre lots: _______
   Homes on 1 acre lots: _______

What are a few assumptions when using the above curve numbers?

Now we're ready to calculate the runoff from this lot using the NRCS runoff equation. (The details below are adapted from *Urban Hydrology for Small Watersheds, Technical Report 55. 1986,* USDA, NRCS, Conservation Engineering Division)

We'll begin with the wooded lot.

Step 1:
Calculate the "S" value which is refers to the ability of the soil type to retain water as related to the land use type. Use the curve number (CN) from above in the formula.

$$S = \frac{1000}{CN} - 10$$

Our S value for the wooded lot is________________

Step 2:
Initial runoff equation:

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$

Where
Q = runoff (in)
P = rainfall (in) *(use 1 inch in this case study)*
S = potential maximum retention after runoff begins (in)
I_a = initial abstraction (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation: $I_a = 0.2 S$. By removing I_a as an independent parameter, this approximation allows use of a combination of S (from Step 1) and P to produce a unique runoff amount.

Substituting the I_a value into the equation gives us <u>our final equation</u> we will use in this case:

$$Q = \frac{(P - .2\,S)^2}{(P + .8\,S)}$$

Our Q value for our wooded lot is ______________

Our value above is in inches and we need to scale this up for our entire lot.

- To do this, first divide your Q value by 12 inches/ft
- Next multiple the above answer by 43,560 ft^2/acre
- Finally, multiple your previous answer by the number of acres in question. Your answer will be in cubic feet to represent the volume of runoff water for this precipitation event.

Final Runoff Volume: ___________________________

Showing your work, complete the above steps for

Homes on ¼ acre lots:

S = _____________________

Final Q = ________________

Homes on 1 acre lots:

S = _____________________

Final Q = ________________

Comparison table: Add your computed values to the table below

Land use type	**Runoff volume in $feet^3$ for 50 acres in a 1" storm**
Wooded lot	
Homes on ¼ acre lots	
Homes on 1 acre lots	

Step 3:

The Zoning Board decided to allow the developer to build homes on the site under the condition that the excess water running off the site be contained on the site and not be allowed to run into the nearby stream. Using the runoff numbers for the ¼ acre lot homes and the 1 acre lot homes determined how much excess runoff there would be if the lot were left wooded. Use the space below to analyze the runoff data for these 3 sites and argue for or against each of the three land use types.

Choose a housing model the developer should use and then develop a plan to contain the excess water within this new development.

Conclusion:
How did this problem model reality?

Earlier in the calculations it was mentioned that there were assumptions that went into the curve numbers. There were assumptions that were made in order to solve this problem and to keep it simple. Describe at least 3 additional assumptions that would make this problem more complicated, but closer to what is considered by hydrologists surveying a site being considered for development.

How would the runoff be different if this 50 acre lot were instead going to be used as an urban center? Why do you think this?