Urban Stormwater Quality

Back of the envelope question from the last section. We selected a small pond on campus, known as "the Puddle" for our problem.

How much would the water in the Puddle rise in a 10 year storm (4.6 inches, 11.7 cm).

Well, how big is the watershed of the puddle?

Hey, we don't even have to know how big it is, just the ratio of the watershed area to the area of the puddle itself.

Lets guess… About 3 times? 4 times? (including the area of the puddle itself)

If all that water flows into the puddle, you would expect the level in the puddle to go up by 3 or 4 times the rainfall amount, or about 13-18 inches, not accounting for rapid drainage from the pond, or for the fraction of the rainfall that would not be turned immediately into runoff.

More accurate guess, based on PERCENT IMPERVIOUSNESS

Percent impervious surfaces	Runoff	Evapo transpiration	Shallow Infiltration	Deep Infiltration
0	10	40	25	25
10 to 20%	20	38	21	21
35 to 50%	30	35	20	15
75 to 90%	55	30	10	5

About 20-30% of precipitation turns up as runoff. So, lets take 20-30% of the amount we estimated first, which give us answer of between 2.5 to 6 inches.

We could model the actual rise (accounting for water leaving the puddle), but only if we had more information on the geometry of the outlet structure

We mentioned in the last section that urbanization affects water quality. Why is that? It is largely because the water that falls on an urban landscape has opportunities to come in contact with materials that negatively affect water quality and hence are known as pollutants. These pollutants include sediment, which comes from development sites, lawns and gardens, and road sand; nutrients, which include fertilizer, septic tank leachate and material from leaking sewer lines; bacteria, which can come from septic tank leachate, leaking sewer lines, and animal waste; compounds that generate a demand for oxygen, which include rotting organic matter, oil, grease and other organic matter, fecal material, and organic chemicals; trace metals, which come from wear and tear on buildings and equipment (e.g. break linings), atmospheric deposition (e.g. lead from automobile exhausts and other compounds in incinerators and smoke stacks – the mercury we were worrying about that is entering loons in Maine is an example of a trace metal that is dispersed through smoke stacks); toxic chemicals; chlorides (road salt); thermal impacts from heater water on road surfaces.

So, as you can see, there are lots of potential nasties that can get into the water in an urban landscape (and as you can also tell, not all of these pollutants are limited to urban landscapes). It turns out however that the impervious nature of developed landscapes leads to the retention of many of these nasties on the surface. The first part of a rain storm, known as the "first flush", tends to liberate the bulk of these materials and permit them to enter the storm water system.

So how do we manage these pollutants? Best management practices involve road sweeping, the detection and elimination of sewer pipe leaks, and the construction of treatment facilities.

What sort of treatment facilities can be constructed? The retention/detention basis we discussed earlier can be used to remove sediment through physical settling and can be modified to remove bacteria through exposure to UV light. Sand filters or sand/peat filters can be used to remove bacteria. Many cities have build combined sewer overflows that are designed to catch at least the initial run off from a storm and direct that water to the waste water treatment plant. Some developments have included human made wetlands on their sites. Shallow wetlands provide benefits. They work like detention basins and harbor plants and microorganisms that can detoxify certain pollutants.

How much pollutant are we talking about? It might be interesting for you to look for data from your community about the composition of urban run off. There is a national urban runoff program. In general, we assume that only the first 10% of the storm contribute significantly to the problem of urban stormwater pollution. Recall that not all the rainfall from a storm is converted to run off either. From this information, you should be able to estimate the pollution burden in your area in a typical storm.

See this page on the EPA's web site for more information

http://www.epa.gov/owow/nps/urban.html

While you are thinking about the material in this section, take a walk around an urban neighborhood. Do you see examples of retention/detention basins? Visiting the local wastewater treatment plant is always an excellent event. Find out how your locale manages urban storm water. Are any treatment strategies in place to remove pollutants from the "first flush"?

For more information on the effects of salt used in urban areas to combat winter storms, see the following recent articles in PNAS:

"From icy roads to salty streams", Robert B. Jackson and Esteban G. Jobbágy, PNAS 102, 2005, 14487-14488 www.pnas.org/cgi/doi/10.1073.pnas0507389102

and Kaushal et al (2005) PNAS, 102, 13517-13520

Interestingly, these papers report on a logarithmic relationship between the concentration of chloride in streams and the percent of the watershed that is covered with impervious surfaces.