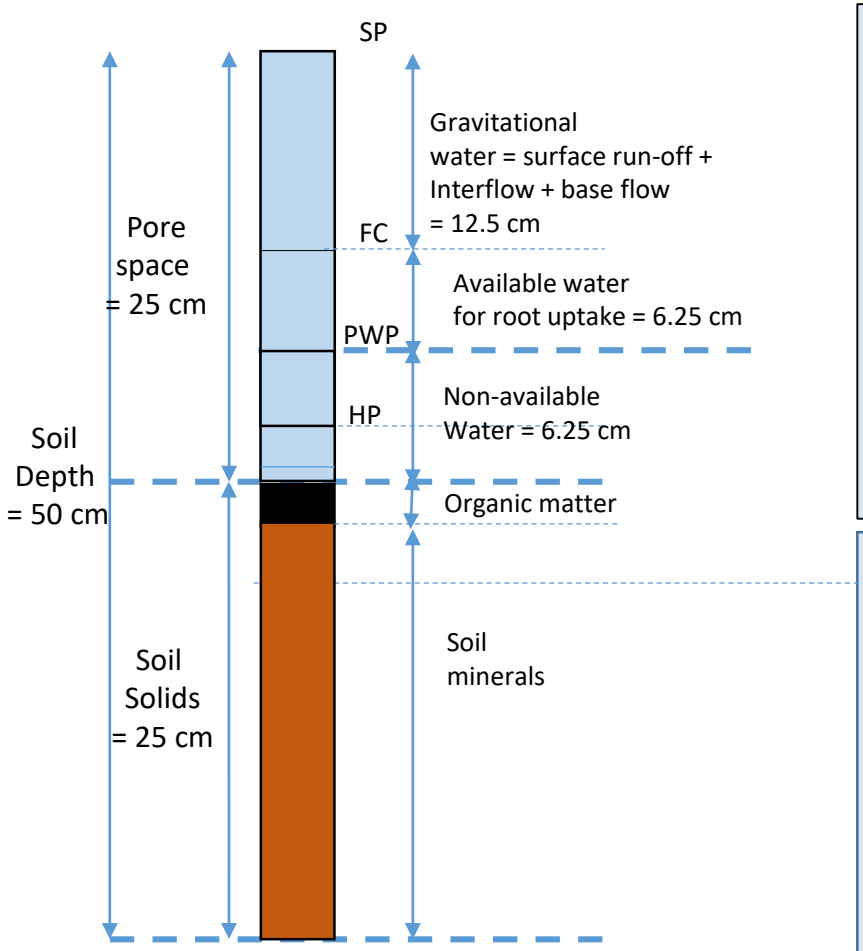
For3457, Lecture 3: Determining amounts of water retained by watersheds within soils, from dryness to saturation, with storm application



Amount of water available to flow from a 10 ha watershed
when soils are initially saturated until reaching field capacity (FC) 24 hours later:
V = Depth of gravitational water x watershed area
= 0.125 m x 10 x10^4 m^2 = 12,500 m^3.
Flow rate = V/ Day = 12,500 m^3 / (24 x 60 x 60 sec)
= 0.145 m^3/sec. Minimum required culvert radius (Manning's formula): 20 cm.

Converting from soil moisture content by weight (MCw: g of water over g of soil) to volumetric soil moisture content (MCv: cm^3 of water over cm^3 of soil):
MCv = Db MCw. In percent: MCv% = MCv x 100.

Converting MCv into cm of water per depth of soil: depth of soil in cm x MCv.

Manning Equation

ppt = Precipitation, in mm/day
BA =Watershed area, in ha
q=Stream discharge (flow rate), in m^3/sec
S=Downward (longitudinal) slope of channel, culvert, in m/m.
n= Manning roughness, varies with roughness of pipe, culvert, or channel. The higher n, the rougher the material.
R= Radius of pipe, culvert, in m
P=Wetted portion of the culvert circumference, in m when fully wet
A=Cross-section area of pipe, culvert, or channel, in m^2
V=Average velocity in the pipe, culvert, or channel, in m/sec

$$V = \frac{ppt\ (mm/day)}{1000}\ BA\ (ha)\ \frac{10^4}{24 * 60 * 60}$$

$$R = \left(\frac{2^{2/3}}{\pi}\frac{n\ q}{S^{0.5}}\right)^{8/3}$$

culvert at full capacity

$$P = 2\ \pi\ R$$

$$A = \pi\ R^2$$

$$q = V / A$$

Watershed area = 1,000 ha, Precipitation 100 mm within 24 hrs,
Total precipitation amount = 10^6 m^3,
Flow rate= 11.6 m^3/sec, assuming all precipitation = run-off,
Culvert slope = 0.015, Manning roughness = 0.022,
Result: Minimum culvert radius (fully wetted) R = 1.02 m

Storm event Oct 2015, New Brunswick
Kouchibouguac: 168 mm, Miramichi: 154 mm
Bouctouche: 144 mm, Fredericton: 141 mm
St. Stephen: 133 mm, Saint John: 111 mm
Moncton: 91 mm, Bathurst: 89 mm