3.7.9

The energy equation yields, $h_1 - h_2 = h_f = 26$ m

The Hazen-Williams eq'n can be written as: $h_f = KQ^m$

a) **One 30-cm pipe**: $K = (10.67L)/(D^{4.87} \cdot C^{1.85})$; m = 1.85

$K = (10.67 \cdot 2000)/(0.30^{4.87} \cdot 140^{1.85}) = 804$

$h_f = 26 = KQ^m = (804)(Q)^{1.85}$; $\mathbf{Q_{30} = 0.156\ m^3/sec}$

b) **Two 20-cm pipes**: $K = (10.67L)/(D^{4.87} \cdot C^{1.85})$; m = 1.85

$K = (10.67 \cdot 2000)/(0.20^{4.87} \cdot 140^{1.85}) = 5790$

$h_f = 26 = KQ^m = (5790)(Q)^{1.85}$; $Q_{20} = 0.0538\ m^3/sec$

$\mathbf{Q_{20s}} = 2(Q) = \mathbf{0.108\ m^3/sec}$; Not as much flow!!

3.11.1

Contraction: $h_c = K_c[(V_2)^2/2g]$; V_2 is small pipe V

$V_2 = Q/A = (0.106\ m^3/s)/[\pi(0.075m)^2] = 6.00$ m/sec

$\mathbf{h_c} = (0.15)[(6.00\ m/s)^2/2 \cdot 9.81\ m/s^2] = \mathbf{0.275\ m}$

Expansion: $h_E = [(V_1 - V_2)^2/2g]$; V_2 is now large pipe

$V_2 = Q/A = (0.106\ m^3/s)/[\pi(0.10\ m)^2] = 3.37$ m/sec

$\mathbf{h_E} = [(6.00\ m/s - 3.37\ m/s)^2/2 \cdot 9.81\ m/s^2] = \mathbf{0.353\ m}$

Sudden expansion loss is much greater (by 28%).

3.11.3

The headloss is expressed as: $h_L = [K_v]\ (V)^2/2g$

$\Delta P/\gamma = (14.5\ lb/in^2)(144\ in^2/ft^2)/62.3\ lb/ft^3 = 33.5\ ft = h_L$

$V = Q/A = (1.4\ ft^3/s)/[\pi((1.5/12)\ ft)^2] = 28.5\ ft/sec$; thus

$33.5\ ft = [K_v]\ (28.5\ ft/s)^2/(2 \cdot 32.2\ ft/s^2)$

$\mathbf{K_v = 2.66}$

3.11.10

Applying the energy equation from the surface of the storage tank (1) to the outlet of the pipe (2) yields;

$\frac{V_1^2}{2g} + \frac{P_1}{\gamma} + h_1 = \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + h_2 + h_L$; where $P_1 = P_2 = 0$;

$h_L = [\sum K](V^2/2g)$; $h_f = 0$ (short pipe), $V_1 = h_2 = 0$. Thus

$h_1 = [1 + \sum K](V^2/2g)$; where $V_2 = V$ (pipe V);

$K_e = 0.5$; & $K_v = 10.0$. Rearranging the energy eq'n

$V = [2g(h_1)/(1+\sum K)]^{1/2} = [2 \cdot 32.2(h_1)/11.5]^{1/2} = 2.37h^{1/2}$

For tank flow, $Q = d(Vol)/dt = (\pi D^2/4)dh/dt$;

and pipe flow $Q = AV = (\pi d^2/4)\ [2.37h^{1/2}]$ where
d = pipe diameter; D = tank diameter. Equating yields:

$(\pi D^2/4)dh/dt = (\pi d^2/4)[2.37h^{1/2}]$

$dt = [(D^2/d^2)dh]\ /\ [2.37h^{1/2}]$; integrating yields

$t = (1/2.37)(D^2/d^2) \int_{h_1=5}^{h_2=10} h^{-1/2}dh$

$t = (1/2.37)[(16)^2/(0.667)^2] \cdot 2[(10)^{1/2} - (5)^{1/2}] = \mathbf{450\ sec}$