ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2017 SESSION

Open-book examination
Calculators : only authorized models
Duration : 3 hours

14 - EN-A2 - URBAN AND NATURAL HABITATS HYDROLOGY

QUESTION #1 (20 Points)
Water of kinematic viscosity of $1{,}003*10^{-6}$ m^2/s) is flowing at a flow rate of 1 m^3/s through a rough concrete-steel pipe (ε=3 mm) which connects two tanks (see Figure 1). Determine the nominal diameter of this pipe of length 1000 m if the difference in elevation between the two tanks is 10 m.

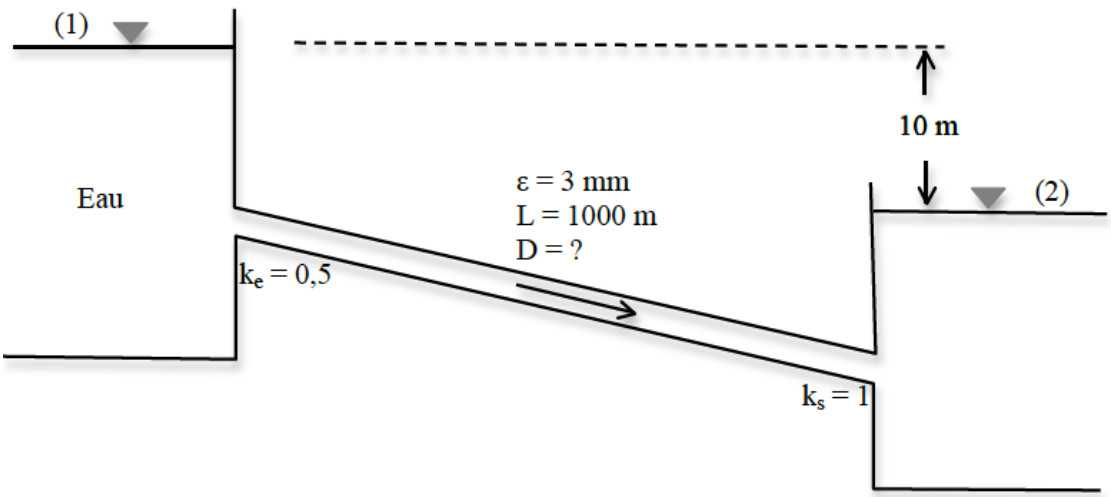

Figure 1: Set-up of the hydraulic system of QUESTION #1

QUESTION #2 (20 Points)
An undeveloped watershed in Quebec will be fully serviced by a sanitary sewer network built with all pipes 300 mm in diameter. Only one-family houses will be constructed and their front is 2 m away from the street. The service pipe links each house with the city water pipe in the middle of the street. Which is 20 m wide. The dimensions of lots are 25 m x 25 m (including streets and street intersections). Watershed characteristics are shown in Table 1:

Table1: Watershed characteristics of Question #2

Population	Watershed		
Present	0	Area	250 ha
10 years from now	8 000	Population Density	50-inhab./ha
30 years from now	10 000	Infiltration	To be determined
Ultimate	12 500	Inflow	To be determined
Pipe diameter (mm)	300	Pipes inlets (mm)	150

Determine the max and min sanitary flow (in m^3/d) required for the intercepting pipeline.

QUESTION #3 (35 Points)

A hydraulic system consisting of a 3 "Scot 57 series - 4x3" pumps identical in parallel (characteristics of the pumps given in Figure 2 where the wheel diameter is in inches) is to supply a 10,750-inhabitant residential municipality in Quebec with drinking water (ρ=1 000 kg/m^3) located next to a tank B where water level is 30 m higher than the tank A water level. Each residence has a meter. The inlet of each pump must be 6 m higher than the tank A. Vertically, each suction flow pipe has a length of 6 m and its diameter is 100 mm with f=0.018 and k=0.5. The single force main has a length of 500 m and a diameter of 300 mm with f=0.020). A non-return valve (k=1.12) and an elbow (k=0,416) are installed in each suction flow pipe and k=1 at the discharge outlet. P_{atm}/γ=10.33 m (water pressure); P_v/γ=0.24 m (water pressure).

3.1 What choice of pump (wheel diameter) will you make and what is its point of operation (Q in l/s) and H_p (m)? Justify your answer. (**25 Points**)

3.2 Is there a risk of cavitation? If not, justify. If so, how high should the pumps be placed to avoid cavitation? (**10 Points**)

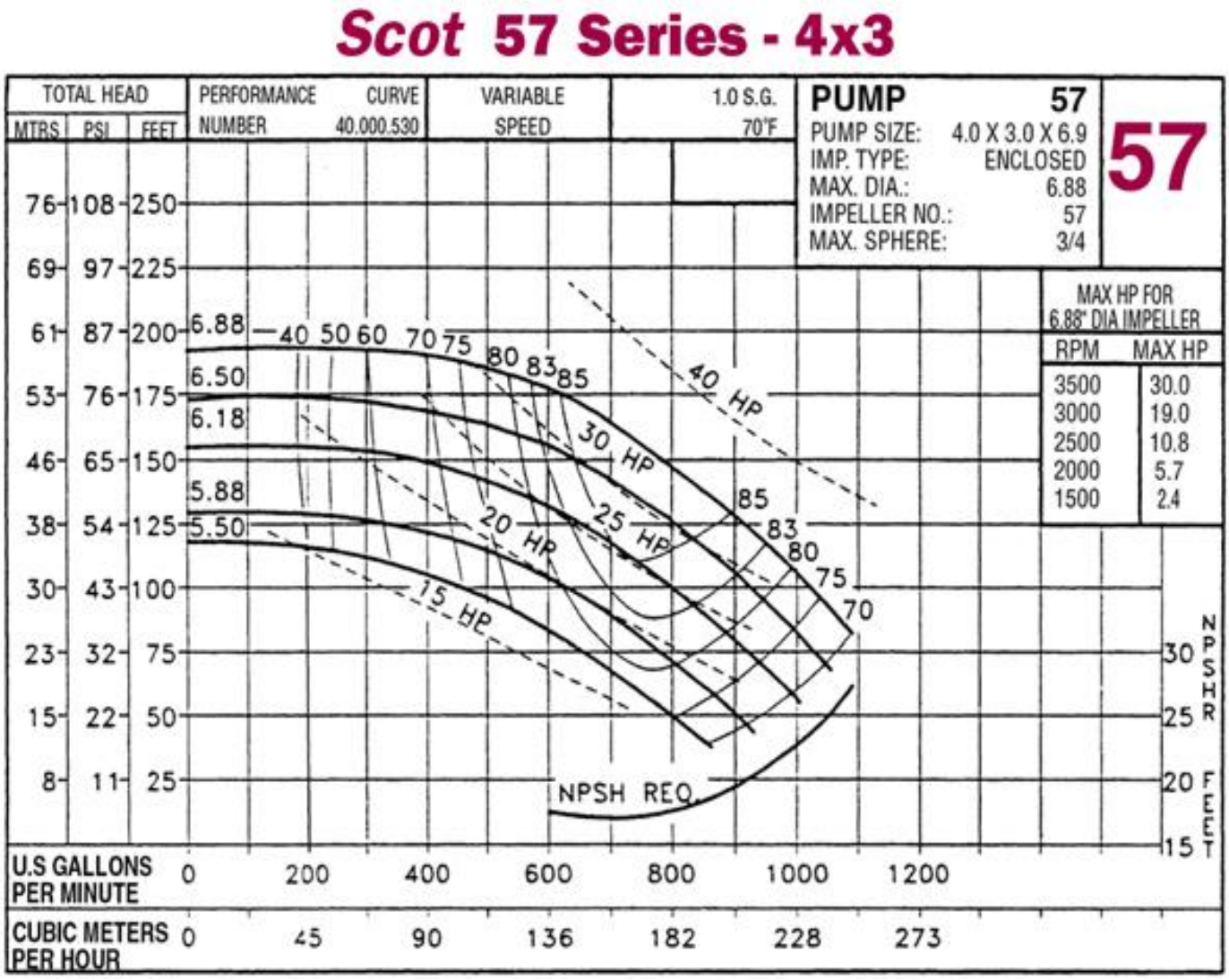

Figure 2: Pumps Characteristic Curves of Question#3

QUESTION #4 (25 Points)

The maximum monthly flows observed at a river station are listed in the following table. In a preliminary design study where the design storm is to be determined, you are asked to:

4.1 Calculate the flowrate values corresponding respectively to a return period of 50-year and 100-year, by using the Normal Distribution. (**10 Points**)

4.2 Based on the Extreme Values Distribution (Gumbel), determine the recurrence of a flowrate of 2600 m³/s. What is the hydrological risk that it will be exceeded at least once in the next 20 years? (**10 Points**)

4.3 Give your opinion after comparing the results obtained from 4.1 and 4.2 (**5 Points**)

	Flowrate in m³/s											
Year	**Jan.**	**Feb.**	**March**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
1980	99	81	62.8	250	1750	1720	600	530	439	579	374	147
1981	102	225	148	166	2200	2390	686	300	227	603	407	390
1982	115	71.5	60.2	70	1320	2050	645	328	283	228	379	160
1983	113	122	160	1380	2060	810	428	440	500	490	347	227
1984	116	81	72.5	335	1760	1730	448	324	348	311	183	122
1985	76.5	61.5	56.9	129	877	1100	714	526	251	369	212	111
1986	85	108	53.5	597	855	447	493	269	441	328	224	97
1987	59	45	49.5	608	524	501	411	463	370	703	568	390
1988	103	76	91	185	1650	1160	561	180	224	702	452	142
1989	76.9	54.5	45.9	109	1240	992	368	540	663	362	556	183
1990	82.3	52.9	49.8	111	778	627	290	251	268	310	233	137
1991	73.4	56.8	53.7	92	1103	1008	449.6	304.1	149.4	342.4	290.2	120
1992	70.4	61.3	54.8	103	872.1	617.1	455.3	466.4	386.4	392.8	341.7	105
1993	57.6	41.4	36.8	120	1165	909.8	404.6	322	410	510.5	345.4	207
1994	82.5	55.5	65.1	110	1542	1162	788	418.2	517.1	515.4	356.8	150
1995	83	59.9	53	282	1363	915.8	239.6	166.8	241	800.1	749.6	181
1996	76.3	127	141	406	1213	1115	890.1	595.5	167.8	238.9	791.3	365
1997	108	74.2	61.6	93.1	1339	1271	558.6	279.4	353.6	357.2	341.6	161
1998	81.7	67.1	277	268.7	1675	779.8	514.9	345.8	413.5	704.4	411.2	176
1999	97	74.8	134	314.2	2329	898.3	255	411.3	501.3	498.7	516	252.8
2000	109	69.7	73.6	213	1481	1488	845.7	363.9	330.6	211.1	294.2	146
2001	105	83	72.2	105	1422	545.4	796.4	294.7	214.5	404.1	348.6	163
2002	92	69.2	98.3	109	1157	1453	944.6	474.7	431.8	423.6	325.8	177.3
2003	101.4	72.85	61.23	262	1938	1139	373.1	297.9	141.6	887.5	840.6	323.7
2004	112.5	73.73	62.88	139.8	1488	1343	469.6	242.8	215.3	405.8	193.9	183.5
2005	141	87.65	117.5	216.5	1656	821.6	219.6	226.1	676.4	306.3	852.9	458.4

$$\sigma = s = \sqrt{\frac{1}{n}\sum_{i-1}^{n}\left(x_i - \bar{x}\right)^2}$$

$$K_t = -\frac{\sqrt{6}}{\pi}\left\{0.577 + ln\left[ln\left(\frac{T}{T-1}\right)\right]\right\}$$