The answers to all questions must be given on these question sheets, using the reverse side if you need to. No additional papers handed in by the candidate will be accepted or considered in the grading.

Name:______________________________________ Date:______________________

National Exams May 2014

98-Civ-A3, Municipal Engineering

3 hours duration

Notes:

1. **Answers to all questions must be given on this question sheet, using the facing (blank) side if necessary. No additional papers handed in by the candidate will be accepted or considered in the grading.**

2. Each question carries a maximum of 25 marks, for a total of 100. Try to arrange your time in accordance with the value of the question (hence slightly less than 2 minutes per mark).

3. Candidates should answer any 4 out of 5 questions.
DO NOT ANSWER FIVE QUESTIONS. ONLY THE FIRST FOUR QUESTIONS ANSWERED WILL BE GRADED.

4. If doubt exists as to the interpretation of any question, the candidate is urged to include with their answer a clear statement of any assumptions made.

5. This is an open book exam.

6. Candidates may use one of two calculators, the Casio or Sharp approved models.

7. Please take care to give your answers clearly and logically. State any assumptions which you need to make, as well as any sources of information used which are not in the examination paper (for example, a table or page number in a textbook).

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Marks

Question 1. Short questions. Take note of the number of marks assigned for each question, and answer accordingly. (25 marks total)

2 a) i. Canada is blessed with abundant fresh water resources; nevertheless municipalities are taking measures to minimize leakage of water from their distribution systems. Give 4 reasons why such leakage is undesirable.

3 ii. If leakage through the holes in a pipe system can be modelled by water flowing through a single orifice, and the city estimates that it is losing 400 m^3/h, how much water could be saved if the water pressure in the distribution system is reduced from 400 KPa to 350 KPa?

b) Using any official fire code available to you, determine the fire flow, in m^3/min, needed to protect a 2-storey plus basement wood-frame home, given the following information:

Each storey and basement has a floor area of 300 m^2.
The basement is ⅓ below ground level.
The house has a large garden at the back, the front is 7 m from the street, and the houses along the street are separated from each other by 6 m.

Marks		
1	Source or name of the code	
3	Calculations	

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Marks

Question 1, contd.

2 c) i. A 300 mm diameter smooth concrete sanitary sewer (Manning's "n" coefficient 0.013) was designed to flow ⅔ full (in terms of depth). The intended slope was 0.002. Calculate the flow in the pipe. Assume variable "n".

2 ii. In fact, the pipe was actually laid at a slope of 0.0015 because during construction some hard rock was encountered. For the same flow as in the original design, what is the new depth of flow?

d) When preparing to design a water distribution system, both minimum and maximum velocities are often specified by the local design code, for example, 0.6 m/s and 3.0 m/s, respectively.

1 i. Why is the minimum velocity specified?

1 ii. Under what circumstances is it impossible or unrealistic to always achieve these minimum velocities?

1 iii. What can the city do in the cases mentioned above to minimize any problems caused by minimum velocities? When would this be necessary?

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Marks

Question 1, contd.

4 e) The rainfall intensity-duration-frequency relationship for a certain watershed may be obtained from the following equations:

frequency (years)	equation
2	$i = 1{,}780/(t + 13)$
5	$i = 2{,}460/(t + 16)$
10	$i = 2{,}820/(t + 20)$
25	$i = 4{,}320/(t + 27)$

where i is the rainfall intensity in mm/h, and t is the duration of the storm in minutes. If the time of concentration for the watershed is 20 minutes, the area is 80 acres (32.4 ha), and the watershed itself can be described as mainly single-family dwellings, which type of storm would yield the higher flow to the storm sewer:

- 5 year, 15 minutes
- 25 year, 30 minutes

f) Underground pipes are subject to loads from the soil cover, and may also be required to resist static and dynamic loads from point sources.

3 i. Explain briefly, with a sketch if necessary, how the loads from the soil cover are transmitted to the pipe, and compare these to the loads from point sources.

2 ii.. How do flexible and rigid pipes differ in their responses to these loads? Support your explanation by pointing to differences in the load formulae for rigid and flexible pipes.

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Marks

Question 2. Aquifers. (25 marks total)

a) Groundwater is used as a raw drinking water source in many parts of the country, for both small and medium-sized communities. List two benefits of using this water source, as well as two problems.

Marks		
1	Benefits	
1	Problems	

2 b) Key parameters describing the properties of an aquifer when pumping is being considered are the hydraulic conductivity, K [length/time], specific permeability, k [length^2], transmissivity T [length^2/time], and coefficient of storage, S_c [dimensionless]. Does groundwater temperature affect any of these values? If so, which ones, and how?

Marks

Question 2, contd.

c) A pumping test has been conducted on a test well in a confined aquifer from which 4.0 m^3/min of water are withdrawn at a constant rate. The drawdown in an observation well that is located 120 m away is recorded over time and is plotted in the figure below. A table of W(u) vs u is provided on the next page.

Showing your calculations on the opposite page(s),

i. Determine:

3 - The transmissivity (T) [m^2/min] and

3 - The storage coefficient (S_c) [dimensionless] for the aquifer.

8 ii. Estimate the pumping rate (in m^3/min) that would produce a drawdown of 1.5 m at a distance of 50 m from the test well after 2 days of pumping.

7 iii. If K is the hydraulic conductivity of the aquifer (m/d), and b is the thickness of the aquifer (m), show that the flowrate Q (in m^3/min) which must be pumped from the well, in order to create a situation in which the steady-state drawdown at a radial distance of 50 m from the pumped well is 0.75 m greater than the steady-state drawdown at a radial distance of 100 m, can be given by the expression:

$$Q = 6.8\ Kb$$

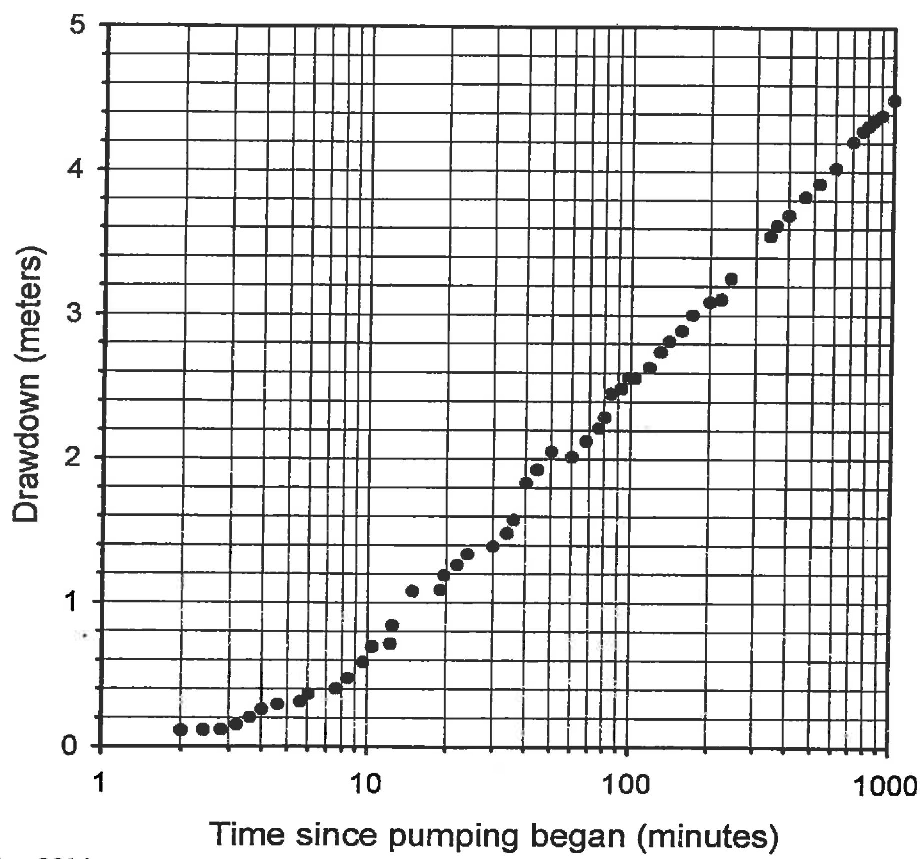

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TABLE 3.5 Values of $W(u)$ for Various Values of u

u	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
$\times 1$	0.219	0.049	0.013	0.0038	0.0011	0.00036	0.000038	0.000012	0.000012
$\times 10^{-1}$	1.82	1.22	0.91	0.70	0.56	0.45	0.37	0.31	0.26
$\times 10^{-2}$	4.04	3.35	2.96	2.68	2.47	2.30	2.15	2.03	1.92
$\times 10^{-3}$	6.33	5.64	5.23	4.95	4.73	4.54	4.39	4.26	4.14
$\times 10^{-4}$	8.63	7.94	7.53	7.25	7.02	6.84	6.69	6.55	6.44
$\times 10^{-5}$	10.94	10.24	9.84	9.55	9.33	9.14	8.99	8.86	8.74
$\times 10^{-6}$	13.24	12.55	12.14	11.85	11.63	11.45	11.29	11.16	11.04
$\times 10^{-7}$	15.54	14.85	14.44	14.15	13.93	13.75	13.60	13.46	13.34
$\times 10^{-8}$	17.84	17.15	16.74	16.46	16.23	16.05	15.90	15.76	15.65
$\times 10^{-9}$	20.15	19.45	19.05	18.76	18.54	18.35	18.20	18.07	17.95
$\times 10^{-10}$	22.45	21.76	21.35	21.06	20.84	20.66	20.50	20.37	20.25
$\times 10^{-11}$	24.75	24.06	23.65	23.36	23.14	22.96	22.81	22.67	22.55
$\times 10^{-12}$	27.05	26.36	25.96	25.67	25.44	25.26	25.11	24.97	24.86
$\times 10^{-13}$	29.36	28.66	28.26	27.97	27.75	27.56	27.41	27.28	27.16
$\times 10^{-14}$	31.66	30.97	30.56	30.27	30.05	29.87	29.71	29.58	29.46
$\times 10^{-15}$	33.96	33.27	32.86	32.58	32.35	32.17	32.02	31.88	31.76

Source: Viessman et al, 2009

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Marks

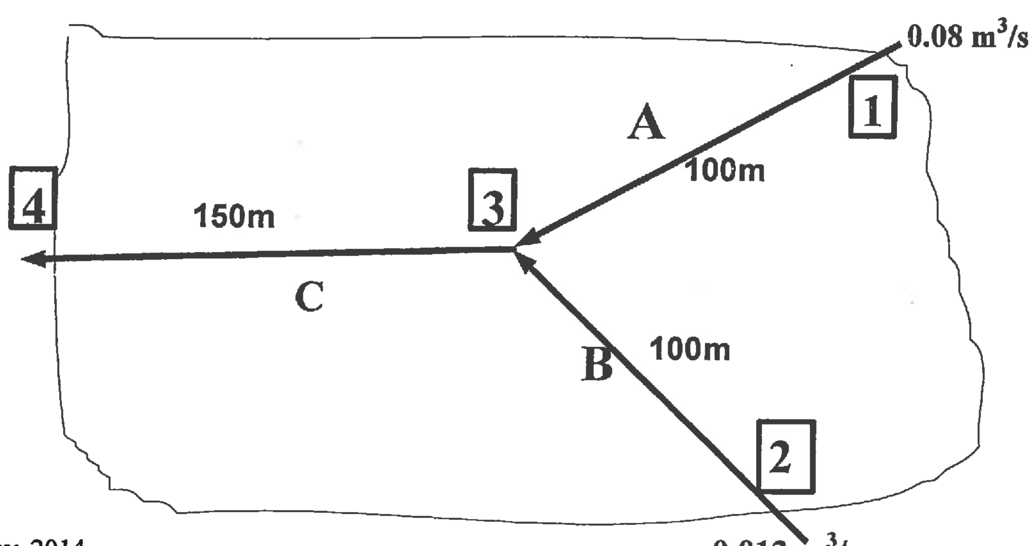
Question 3. Sanitary sewer design.

a) In addition to domestic sewage, sanitary sewers may carry some industrial wastewaters and gases. List two potentially problematic gases which may be found in a sewer, briefly explain how each one is formed, and what problems could arise in each case.

Marks		Gas 1	Gas 2
1	Chemical formula or name		
2	How formed		
2	Problems arising		

20 b) Two subdivisions feed their sanitary sewage into sewer pipes A and B via manholes (MH) 1 and 2, respectively, as shown below. These two sanitary sewers then meet in MH 3 from which a single sewer C carries the total flow. A sketch of the system is shown below. Use the following information, as well as that in the sketch and in the table on the next page, to design the three sewer pipes and complete the missing information in the table.

Sewers are concrete pipe, constant Manning's "n" = 0.013
Commercial pipe sizes (mm): 150; 200; 225; 300; 375; 450
Minimum velocity in the sewers = 0.6 m/s
The sewers should be designed to flow half full
Infiltration is 0.0008 m^3/s per km of pipe, and all infiltration for any particular pipe may be assumed to enter the pipe at its upstream MH
Minimum depth of cover = 2 m above the (inside) crown of the pipe



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Question 3b, contd.

Design Summary			
Characteristic	**Pipe A**	**Pipe B**	**Pipe C**
Length (m)	100	100	150
Design flow, including infiltration (m^3/s)			
Velocity at design flow (m/s)			
Depth to diameter ratio at design flow			
Slope of sewer (m/m)			
Inside diameter of sewer (mm)			
Capacity full (m^3/s)			
Ground elevation at upper manhole (m)	200.00	199.80	199.40
Ground elevation at lower manhole (m)	199.40	199.40	198.00
Invert elevation at upper manhole (m)			
Invert elevation at lower manhole (m)			
Depth of cover at upper manhole (m)			
Depth of cover at lower manhole (m)			

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Working page for Question 3b.

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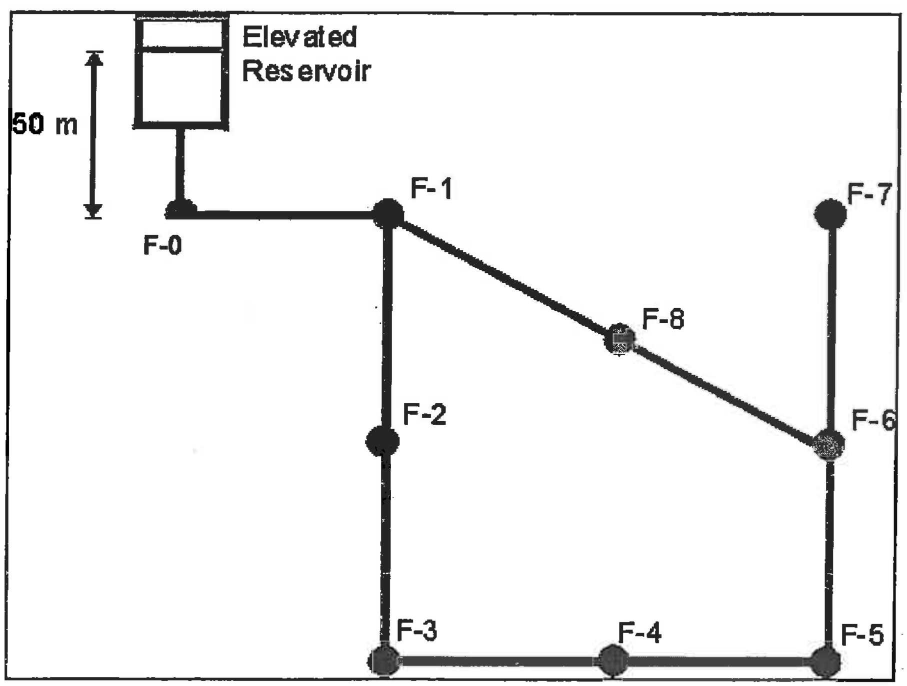
Marks

Question 4. Pipe networks and headlosses.

a) Water distribution systems are generally arranged in a loop configuration, but in some cases branches are used. Problems are associated with branched (or "dead-end") systems, but solutions do exist. Complete the table below by answering the three questions.

Marks		
1	When are branches necessary?	
2	Problems caused by branches?	
2	Solutions?	

20 b) A network of pipes is to be used to deliver fire flow to various fire hydrants (F-1 to F-8) in an industrial facility. All pipes have Hazen-Williams coefficients of 110 and internal diameters of 150 mm. All distances between fire hydrants (i.e. located at nodes indicated by black circles) are equal with a pipe length of 100 m. If the fire hydrant at F-7 is opened to the atmosphere (and all other fire hydrants remain closed), determine the flow rate (in L/min) that will be delivered when the height of water in the reservoir is 50 m above the level of the fire hydrant exit. Assume that all minor head losses (e.g. entrance, elbows, valves) and the head loss in the pipe leading from the elevated reservoir to the first node are insignificant. Use any suitable method.



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Working page for Question 4b.

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Marks

Question 5. Essay (25 marks)

High-rise condominium development in some major Canadian cities has resulted in a rapid increase in population density in downtown areas which had previously seen only commercial activities and very few- if any- residences. This essay should describe the changes experienced, the problems caused, and the solutions proposed, in the three municipal systems fields given by the section headings below. To obtain maximum marks for this essay, you will need to give quantitative illustrations of the problems identified and solutions proposed.

9 a) Water distribution

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Marks

Question 5. Essay (contd.)

8 b) Sanitary sewers

8 c) Storm sewers