Name:_____ Date:_____

National Exams May 2012

98-Civ-A3, Municipal Engineering

3 hours duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.

2. This is an open book exam.

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

4. Candidates should answer any 4 out of 5 questions. **DO NOT ANSWER FIVE QUESTIONS.**

5. 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).

6. 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 number in a textbook).

7. **Candidates must hand in this examination paper, on which they may perform some of their calculations, as well as their answer booklets.**

Marks

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

2 a) Water conservation measures in the home, such as low-flow shower heads, low-flush toilets, etc., are becoming widespread. In your opinion, how would these devices affect the peaking factors for domestic wastewater production?

2 b) Canadian Drinking Water Guidelines require that lead (Pb) concentrations be lower than 0.01 mg/L AT THE TAP, and that faucets should be thoroughly flushed before water is taken for consumption or analysis.

i. Why is lead a concern?
ii. Why do the regulations specify "at the tap"?
iii. Why must faucets be thoroughly flushed?
iv. What steps could the drinking water treatment plant take if lead levels at the tap exceed the standard?

3 c) List 3 benefits and 3 disadvantages or problems associated with using groundwater as a drinking water source.

3 d) A factory desires to pump water at a constant flow from a reservoir several km away and 10 m lower in elevation. Two identical pumps are available at a good price, each one capable of delivering exactly half the desired flow at the head which has been specified when each pump is operating by itself. Should the factory owner purchase the two pumps? Explain your answer with a diagram.

2 e) We know that when water is supplied through dead-end (i.e. non-looped) pipes, there would be no water supply if a break in the pipe occurs upstream from the service point. What other problem may occur with such a branched supply pipe arrangement?

4 f) In the "old days", rectangular aqueducts made of brick and lined with plaster were used in some cities instead of pipes. Assuming that when new, these aqueducts had the same Hazen-Williams "C" value as unlined concrete pipes, what would be the diameter of an equivalent circular pipe flowing full and at the same slope, if the aqueduct (flowing full) had a cross-section 1.0 m wide and 0.75 m deep?

2 g) i. What are two consequences of having a velocity in a sanitary sewer which is not self-cleansing and results in sedimentation?

1 ii. Why are the self-cleansing velocities for sanitary and storm sewers different?

Marks		
2	h)	"Trenchless technology" is an alternative to digging up and replacing older sewer pipes which are leaking or may be expected to leak shortly. The technique involves inserting a new pipe into the older one. Will this process tend to increase or reduce the flow-carrying capacity of the pipe? Explain your reasoning.
4	i)	Calculations have shown that the load on a 350 mm nominal diameter buried reinforced concrete pipe will not exceed 60 kN/m. With a factor of safety of at least 1.5 for the bearing capacity, give two potential combinations of bedding class and pipe type (ASTM specification) that would be suitable.

Total 25

Marks (25 total)

Question 2. Storage.

A residential neighbourhood, population 20,000, is supplied with water from an elevated reservoir. This reservoir must have the capacity to balance the supply and demand ("service storage") as well as the fire demand. Your objective is to determine the total storage volume required.

a) The daily water consumption is as follows:

Period	% of daily demand
Midnight to 3 am	5
3 am to 6 am	7
6 am to 9 am	13
9 am to noon	20
Noon to 3 pm	20
3 pm to 6 pm	15
6 pm to 9 pm	10
9 pm to midnight	10

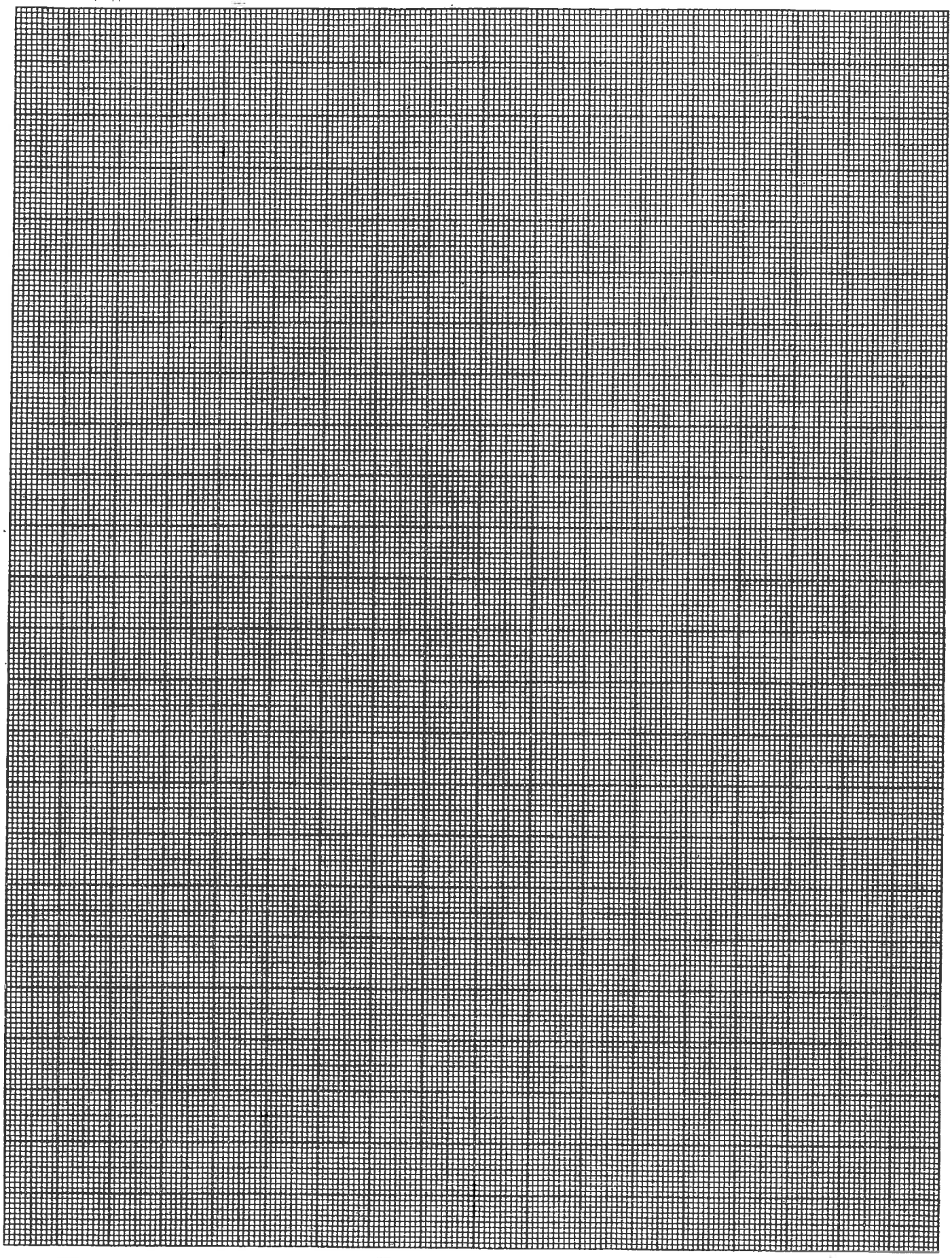
10 The average daily water consumption is 400 L/cap-d, and the maximum daily consumption is 125% of the daily average. Determine the storage volume (in m^3), based on the maximum daily consumption, necessary to balance supply and demand, assuming that water is pumped to the reservoir at a constant rate over 24 hours. You may use the graph paper on Page 6.

b) The critical fire is determined to be a warehouse containing easily combustible material. It is 10 m high (equivalent to a 2-storey building); the full height of the interior of the building will be used for storage. The surface area of the warehouse is equivalent to the area of a rectangle 60 m x 30 m, but there is a loading area in one corner, measuring 10 m x 4 m which cuts into the rectangle. The building is made entirely of bricks, and it is protected by a complete automatic sprinkler protection system. The front of the building (the longest side) and one side are on the corner of the street, 3 m away from it; residential buildings, each approximately 30 m x 20 m, of the same height as the warehouse, are located opposite the other two sides, 8 m away from the warehouse; the 20 m sides of the residences face the warehouse.

Marks			
3		i)	Sketch a plan of the warehouse, street, and neighbouring houses, giving key dimensions. It does not have to be to scale.
8		ii)	Calculate the required fire flow (L/min). Be sure to give your source(s) of information, and state clearly any assumptions.
4	c)		Determine the volume of the reservoir to accommodate both service storage and the fire demand.

Total 25

Graph paper for Question 2.



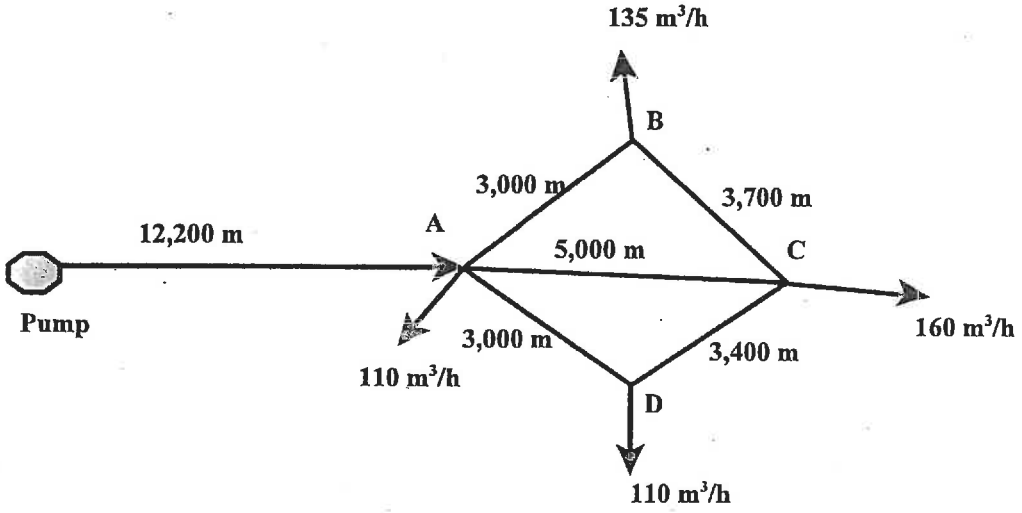
Marks

Question 3. Water distribution and pressure analysis.

The main water supply pipes for a system serving four towns A, B, C, and D, is shown in the diagram below, together with consumption at each town and pipe lengths. A pump at the water source supplies this water through a single long pipe. All pipes have the same Hazen-Williams coefficient (C) value of 130.
Pipe diameters: pump - A: 400 mm A-B: 250 mm
B-C: 150 mm C-D: 150 mm
D-A: 250 mm A-C: 300 mm

25 Determine the pressure head (in m) required at the pump, if the pressure required at node C is 250 KPa (or 25.5 m), and this node is at an elevation 45 m higher than the pump.

Note: The Hardy-Cross is one method which you can use to solve this problem, but any other appropriate method will also be satisfactory. If you use an iterative method, perform only 2 iterations.



Marks (25 total)

4. Sanitary sewers.

3 a) The design of sanitary sewers is constrained by minimum and maximum velocities, as well as by minimum pipe sizes. Explain why it is necessary to set such limits.

2 b) Where in sanitary sewer systems is one likely to encounter velocities lower than the minimum? What measures can be taken to overcome this problem?

20 c) You are required to determine the diameter and slope of two reinforced concrete sewer pipes at the beginning of a larger system. The location of the pipes, manholes (MH), and areas being serviced, are given in the table below. You must also use the following information and constraints:

- Minimum pipe diameter = 200 mm
- Other available commercial sizes: 225, 300, 375, 450 mm
- Manning's "n" = 0.013
- Population per hectare (ha) = 100
- Per capita sewage contribution, average flow = 400 L/d
- Infiltration and inflow = 5.7 m^3/ha-d (constant)
- Minimum allowable velocity = 0.6 m/s when full
- Pipe must flow half full or less at average flow (10% exceedance in depth of flow is O.K.)

To assist in your calculations, tables are given below with key data as well as empty columns, but you may create your own calculation tables if you wish. You must prepare a plan-view sketch as well as a section view before starting your calculations (4 out of 20 marks for the sketches).

MH	Area serving this MH (ha)	Street elevation (m)	Pipe # and MHs linked	Length (m)	Sewage flow (m^3/s)	Infiltration flow (m^3/s)	Total flow (m^3/s)
A	30	35.3	1 A-B	122			
B	13	34.1	2 B-C	122			
C		33.1					

MH	Pipe #	Slope (m/m)					
A	1						
B	2						

Marks (25 total)

5. Drainage of stormwater from roads.

A stormwater drainage system is shown in the figure below. It must handle flow from the residential area as well as the street.

Overland flow occurs over the residential area, which has a runoff coefficient, C, of 0.5 and a slope of 1%. The overland flow distance can be taken as perpendicular to the road.

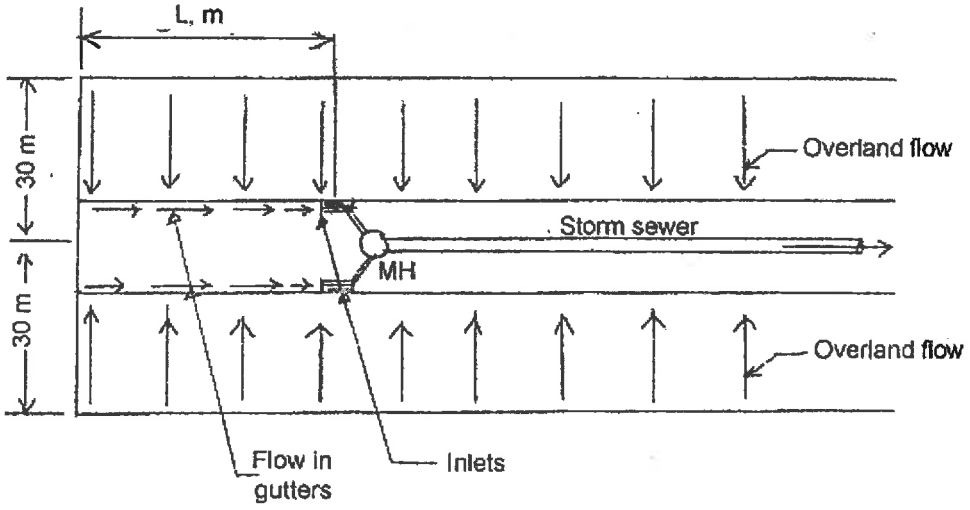
The street and gutter have a slope of 2% and a Manning's coefficient, n, of 0.016; the street is 16 m wide, has a transverse slope, S_x of 2%, and the maximum allowable spread, T, is 2.5 m (the spread is the width of stormwater on the street). Assume C = 0.95, and that the velocity of flow in the street is 0.9 m/s.

The design rainfall intensity is given by:

$$i = \frac{810}{t + 11}$$

where i = intensity (mm/h) and t = rainfall duration (min).

A design chart on the following page from the Ontario Ministry of Transportation gives the inlet capacity of the OPSD 400.03 type inlet. Determine whether these inlets will be suitable for the drainage system shown below (one inlet on each side of the street) if the inlets are spaced at 60 m intervals.



Design Chart 4.16: Inlet Capacity OPSD 400.03 (C & G OPSD 600.03)