THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering
Diploma in Technology - Level 4

CEX 4234- WATER SUPPLY AND SEWERAGE ENGINEERING

FINAL EXAMINATION - 2008/2009

C79

Time Allowed: Three Hours *Index No.* | | | | |

Date: 18th March, 2009 **Time: 0930 - 1230**

Answer any FIVE questions. All questions carry equal marks.

Q1.

(a) Since population is always a relevant factor in estimating future water use, it is necessary to predict, in some manner, what the population will be.

(i) List any three methods of estimating the future population of a city. What are there relative merits? [01 marks]

(ii) A community has experienced the growth in population and water use shown. Estimate the population, per capita water use, and total average daily water demand in the year 2028. [08 marks]

Year	1968	1978	1988	1998	2008
Population	8000	8990	11,300	14,600	18,400
Average daily flow, m^3	2270	2720	3630	4970	6600

(b) Due to less rainfall to Kalani river basin, the water level of the Kalani river has drastically reduced. NWS & DB has decided to provide intermittent water supply to the Colombo city.

(i) List advantageous and disadvantageous of intermittent water supply systems over continuous systems. [02 marks]

(ii) It is also recorded that the considerable amount is account for Non revenue water (NRW). What are the causes for NRW? [03 marks]

(c) A well with a radius of 0.4m penetrates a confined aquifer with k=20m/day and thickness=35m. The well is pumped so that its drawdown is maintained at 5m. Assuming that the drawdown is essentially zero at 600m from the pumped well what is its discharge? [06 marks]

Q2.

(a) Water, whether it is drawn from surface or ground water supplies, must be conveyed to community and distributed to the users.

(i) Explain the importance of chemical and bacteriological analysis of water used for domestic purposes. [02 marks]

(ii) What are the methods available for conveyance of water from the source to the water treatment plant? [02 marks]

(iii) Elevated storage tanks are important in a water supply system and they are located at selected points. Discuss the advantages of having elevated water tanks at specified locations. [03 marks]

(b) A sedimentation basin is to be designed so that it will remove 100% of all particles which have a settling velocity of 0.3mm/s. For a flow of $10m^3$/min, determine appropriate dimensions for a rectangular basin in which the length is 4 times the width. The detention time is 2 hrs. Also determine the total weir length required if the total overflow rate is $250m^3$/m/day. [07 marks]

(c) A circular sedimentation tank fitted with standard sludge removal equipment is to handle daily supply of 3600 m^3 of water to the town. The depth of the tank is 3m and the diameter of the tank is 20m estimate the detention period of the tank. Estimate over flow rate and weir loading of the above circular tank. For circular sedimentation tanks V is given by $V = D^2 (0.011D + 0.785H)$. [06 marks]

Q3.

(a) **(i)** What are the various methods which are commonly used for the removal of color, odour and taste from the water? Describe any method in detail. [03 marks]

(ii) Why desalination is necessary for brackish water? What are the common methods used in desalination? [03 marks]

(b) A rapid sand filter is to produce a maximum flow of 23,000 m^3/day. The nominal filtration rate is 120m/day and is not to exceed 180m/day with one filter being backwashed nor 240m/day with one filter being backwashed and one filter out of service. Determine the number of units required and the individual filter area. How much water is required to wash one filter if the backwash rate is 1m/min and the duration is 10min? [08 marks]

(c) A water net work consists of ABC distribution system proposed for a new city. It is need to have a 700 m equivalent pipe to replace the looped ABC system. Determine the theoretical diameter of a single 700m long equivalent pipe line from A to C shown in figure Q3 (b). (Hazen William Constant; C=100 for the pipe material) [06 marks]

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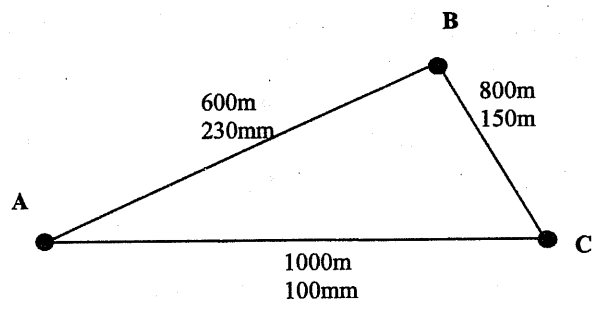

Figure Q3. Illustration for Problem Q3 (c)

Q4.

(a) Determine the runoff from 125mm/hr of rain for a $4x10^6$ m^2 watershed, which is to be developed in future. The proposed land use in 50% single story houses on $1000m^2$ lots with runoff coefficient of 0.98; 10% commercial places with runoff coefficient of 0.85, 25% streets with curbs and gutters, parking lots with runoff coefficient of 0.90, 15% open space, parks, with good grass cover with runoff coefficient of 0.56.
[Rational formula Q=0.278 CIA] [05 marks]

(b) (i) Explain the importance of 'self cleansing velocity' in the design of wastewater carrying pipes? [01 marks]

(ii) A residential community has an estimated ultimate population density of 15,000 /km^2 and an area of 120,000 m^2. The average wastewater flow is presently 300 liters per capita per day. Estimate the maximum sewage flow rate to be expected from this area. Also compute the size of the sewer main to carry the sewage flow. List the assumption you have made to solve this question. [04 marks]

(c) **(i)** What is meant by "assimilative capacity of streams"? What factors affecting assimilative capacity of a stream? [04 marks]

(ii) A food preparation factory had discharged their wastewater with BOD of 300mg/l to a river of mean velocity of 0.2 m/s. The DO upstream of the tributary is 9.0 mg/l. Assuming the deoxygenation rate K_1 =0.23d^{-1} and the reaction rate k_2=0.4 d^{-1}, find the time and critical DO of the river. Also find the distance downstream when DO is minimum. t_c and critical DO are given in the following equation with usual notations

$$t_c = \frac{1}{(K_2 - K_1)} \ln\left\{\frac{K_2}{K_1}\left[1 - \frac{DO_0(K_2 - K_1)}{K_1 L_0}\right]\right\} \; ; \; DO_c = \frac{K_1}{K_2} L_0 e^{-k_1 t}$$ [06 marks]

Q5.

(a) (i)A community discharges a wastewater flow of 1000m^3/day through as out fall to a small stream. The minimum flow in the stream is 5.74 m^3/min, the maximum stream temperature is 30°C. At this condition, the stream BOD_5 concentration is 6 mg/l and the pollutant at the outfall is 350 mg/l above the sewage outfall. Determine the effluent BOD_5 from the sewage treatment plant. [04 marks]

(ii) In the above question, if the reaction rate constant is 0.25/day. What would be the ultimate BOD_5 of waste? Also compute the five day BOD at the temperature 30°C. [03 marks]

[$k=k_{20}\theta^{(T-20)}$; $BOD_5 = Lo\,(1-e^{-kt})$; $\theta = 1.047$]

(b) (i) What are the requirements of sewer joints? List joints which can be used for cement concrete pipes. [02 marks]

(ii) Explain the necessity of providing manhole in sewer line. [01 marks]

(iii) Why explosions occur in the sewer lines and how they can be prevented? [03 marks]

(c) Oxidation ponds are shallow ponds of about 1m depth, used to stabilizing organic material for small communities. Design data for an oxidation pond in a city is as follows.

Population of the city	=2500 persons
Sewage flow	= 125 l/c/day
Five day BOD of sewage	= 350 mg/l
BOD loading	= 200 kg/day/hectare

(i)Estimate the surface area and the volume of the pond required and the detention period. [06 marks]

(ii) List two factors affect for the efficiency of oxidation pond? [01 marks]

Q6.

Wastewater treatment usually divided into four categories. Those are preliminary, primary, secondary and tertiary or advanced treatments. During preliminary treatment grits are removed by grit chambers and 30-60% of suspended solids are removed at the clarifiers in primary treatment.

(a) A grit chamber to remove sand particles (density = 2650 kg/m^3) with a mean diameter of 0.20 mm. Assume the sand is spherical and the temperature of the wastewater is 25°C. The wastewater flow is 15,000 m^3/d. A velocity of 0.3 m/s will be automatically maintained, and the depth must be 1.5 times the width at maximum flow.

$v_s = \dfrac{g(\rho_s - \rho)d^2}{18\mu}$ Viscosity of water =1.0 x10^2 cm^2/sec

(i) Calculate the settling velocity of sand particles. [02 marks]

(ii) What is the cross sectional area of the grit chamber? [02 marks]

(iii) Determine the detention time and the length required for a particle to fall the entire tank depth. [03 marks]

(iv) What are the dimensions of the grit chamber? [03 marks]

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(b) Calculate the maximum radius of the clarifier (settling tank) for which a single peripheral weir surface will provide adequate length. Assume surface overflow rate SOR=30 m/day and weir overflow rate WOR=370 m^2/day. [04 marks]

(c) Secondary treatment is usually biological treatment where microorganisms are employed for removal of organic matters.

(i) What are the treatment methods involving in secondary treatment? List them. [02 marks]

(ii)Estimate the solids production from a secondary treatment treating a flow of 1000m^3/day with BOD of 210mg/l and suspended solids of 260 mg/l. Assume that the primary clarifier removes 60% of the suspended solids and 30%of the BOD. [04 marks]

Q7.

(a) Sludge production in a "typical" plant treating domestic wastewater amounts to about 100g.day per capita of which 70 % is volatile. The sludge is commonly 95% water. Calculate the volatile solids loading and the volume per capita in a digester with a detention time of 20 days. [08 marks]

(b)(i) Proper handling of sludge is very important in wastewater treatment plant. What is the importance of sludge management? Explain briefly. [03 marks]

(ii) Sludge digestion can be done aerobically as well as anaerobically. What are the advantageous of anaerobic digestion process over aerobic system? [03 marks]

(c) (iii) Estimate the volume of a aerobic sludge digestion tank for a plant which produces 750Kg of primary solids and 450 kg of waste from secondary treatment per day. The mixed sludge has a solids content of 4 percent. Retention time for sludge digestion is 20 days. Assume the solids are 70% volatile estimate the total solids loading per day. [06 marks]

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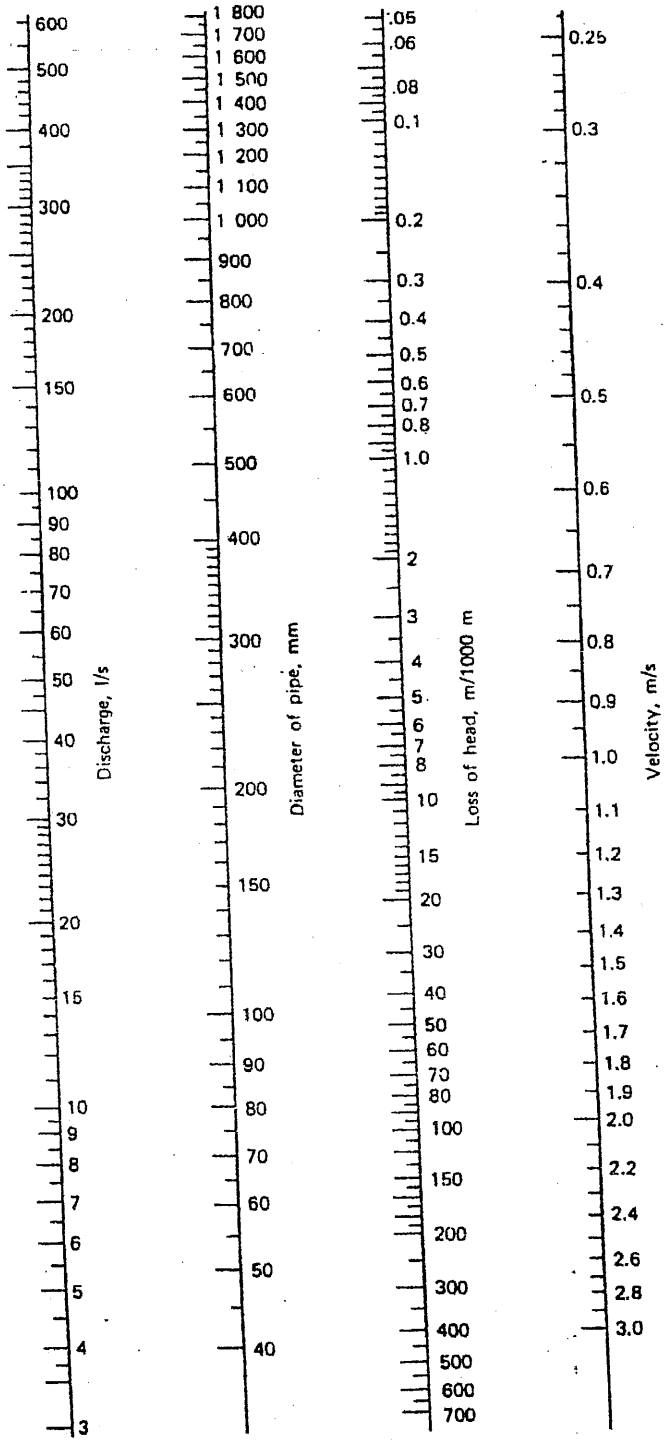

Nomograph for Hazen Williams Formula, based on $C = 100$.