UNIVERSITY OF BOLTON

WESTERN INTERNATIONAL COLLEGE FZE

BENG(HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2018/2019

WATER ENGINEERING AND THE ENVIRONMENT

MODULE NO: CIE6012

Date: Wednesday 29th May 2019 **Time: 10.00am - 1.00pm**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions on this paper.

Answer any FIVE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Supplementary Information is provided on pages 6-10.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

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Question 1

a) Estimate the peak flow during a 10 year flood event for the a river using a synthetic, 10mm – 1 hour, unit hydrograph analysis with the data listed below. The base flow in the river is 12 m^3 /sec.

T_B = 5 hours

T_P = 2 hours

Q_P = 24 m^3 /sec.

The hourly depths of rainfall, for the chosen 5 hour event, are shown in the table **Table Q1a** below.

Unit hydrograph **Table Q1b** is also provided on **page 8**

Table Q1a Rainfall data

Time(hour)	1	2	3	4	5
Rainfall (mm)	6.4	10.2	15	9.3	3.5

(14marks)

b) List the catchment characteristics which affect the rainfall/run-off relationship and critically comment upon their impact on the accuracy of catchment modelling.

(6 marks)

Total 20 marks

Question 2

a) A stilling basin, utilising a hydraulic jump to dissipate energy, is to be designed for the dam spillway. The maximum flood flow over the spillway is to be 40m^3/sec. The spillway is 7m wide and slopes at 45° and has a Manning 'n' value of 0.018. Determine a suitable weir height, above the stilling basin apron, to ensure the formation of a hydraulic jump.

(10 marks)

Question 2 continued to the next page

Question 2 continued

b) Water is pumped from an underground reservoir to a tank located on a hospital roof using two pumps which are mounted in series. The pumping main is a 250mm diameter pipe which is 600m in length with a friction factor λ of 0.07.

Each pump has the performance characteristics given below.

Q (litres/s)	0	10	20	30	40
H (m)	18	16	12	8	4
P (kW)	7.0	9.5	11.0	11.5	13
E (%)	0	54	66	60	50

If the static head is 10 m, using the graph paper provided,

i.) Using **Table Q2** , determine the maximum possible flow to the tank.

(10 marks)

Total 20 marks

Question 3

a) Sketch a flow chart identifying the sequence of water treatment processes and the chemicals used if it contains manganese and colour in excess of standards.

(12 marks)

b) Briefly explain the purpose and operation of the following treatment process units

i) Rapid Sand Filter (4 marks)

ii) Activated Sludge Process (4 marks)

Total 20 marks

Please turn the page

Question 4

a) Give a situation where both "Alternate Depth and Conjugate Depth" in open channel flow may occur. Explain with suitable diagrams

(8 marks)

b) A long rectangular channel 12.0m wide, Manning 'n' value of 0.023, has a bed slope of 1 in 800 and a uniform flow depth of 2.5m when the flow rate is 36m^3/s. The channel has a weir located at the downstream end which causes the depth of flow just upstream of the weir to rise to 3.0m.

i. Explain the classification system used for free surface profiles in open channel flow.

(6 marks)

ii. Identify the profile which exist upstream of the weir in the above scenario. Use suitable sketches.

(6 marks)

Total 20 marks

Question 5

a) A trapezoidal irrigation channel of base width 2.5m is to be constructed in very angular fine gravel, where d_{50} is 7.5mm. If the peak flow is to be 20m^3/sec, determine a suitable channel gradient using the maximum permissible velocity method. Choose the side slope of channel as 2H:1V. **Table Q5** is provided with properties of different bed materials.

(12 marks)

b) Discuss the types of sediment related problems facing the civil engineer

(8 marks)

Total 20marks

Please turn the page

Question 6

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a) A stilling pond CSO chamber of breadth 2.75m is designed for a combined sewerage system serves a population of 8000 and receives a peak storm flow of 2.5 m^3/s(Hydroworks). A 250 mm diameter orifice is used to control the flow passing to the downstream sewer which is 400 mm in diameter, has a k_s value of 1.5mm and is laid at a gradient of 1 in 125. The overflow weir crest height above the centre of the orifice is 2.0m. Using the information given below, check the adequacy of the control and determine the peak flow passing to the downstream sewer. HRS tables are provided.

G = 220 l/h/d

I = 40 l/h/d

E = 1,50,000 l/d

(12marks)

b) Outline the objectives that an effective Combined Sewer Overflow should satisfy. Describe the design features which you would incorporate so as to optimise the performance of the overflow structure.

(8 marks)

Total 20marks

END OF QUESTIONS

Please turn the page (for Supplementary Information)

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Supplementary Information

Formulae Sheet

$h_f = S_0 \times L$

$Q = A\,v$

$$v = \frac{1}{n}.R^{\frac{2}{3}}.S_0^{1/2}$$

$$E = y + \frac{v^2}{2g} = y + \frac{q^2}{2gy^2} = y + \frac{Q^2}{2gA^2}$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} \quad ; \quad q = \frac{Q}{B}; \quad v_c = \sqrt{gy_c} \quad ; \quad F_r = \frac{v}{\sqrt{gy}}$$

$$y_2 = \frac{y_1}{2}[\sqrt{1+8F_{r1}^{\;2}} - 1]$$

$Q = 1.7\ B\ H^{3/2}$

DWF=P.G+P.I+E

Formula A: Q= DWF+1360.P+2E

$$D = 0.815Q^{0.4}$$

$$Q_0 = C_d.A_0.\sqrt{2.g.H_0}$$

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Table Q2.

Flow (l/s)					
H for one pump alone (m)					
H for two pumps in series (m)					
h_f for two pumps in series(m)					
H_T for two Pumps in series(m)					
P (kW)					
E (%)					

To be handed in with answer booklet **Candidates ID No……………………………………….**

Table Q1b

Time Period	Rainfall (Relative to UH)	Unit hydrograph ordinates				Surface runoff +Base flow
		u_1=	u_2=	u_3=	u_4=	
1						
2						
3						
4						
5						
6						
7						
8						

To be handed in with answer booklet **Student ID No………………………………**

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19 continued

ks = 1·500mm
i = 0·004 to 0·1
ie hydraulic gradient = 1 in 250 to 1 in 10

Water (or sewage) at 15° C
full bore conditions.

velocities in m/s
discharges in m^3/s

Gradient	Pipe diameters in mm: 350	375	400	450	500	525	600	675	700	750	800	825
0.00400 1/ 250	0.967 0.093	1.012 0.112	1.055 0.133	1.139 0.181	1.219 0.239	1.257 0.272	1.370 0.387	1.477 0.528	1.511 0.582	1.579 0.698	1.645 0.827	1.678 0.897
0.00420 1/ 238	0.991 0.095	1.037 0.115	1.081 0.136	1.167 0.186	1.249 0.245	1.289 0.279	1.404 0.397	1.513 0.542	1.549 0.596	1.618 0.715	1.686 0.848	1.719 0.919
0.00440 1/ 227	1.015 0.098	1.061 0.117	1.107 0.139	1.194 0.190	1.278 0.251	1.319 0.286	1.437 0.406	1.549 0.554	1.586 0.610	1.657 0.732	1.726 0.868	1.760 0.941
0.00460 1/ 217	1.038 0.100	1.085 0.120	1.132 0.142	1.221 0.194	1.307 0.257	1.349 0.292	1.469 0.415	1.584 0.567	1.621 0.624	1.694 0.748	1.765 0.887	1.800 0.962
0.00480 1/ 208	1.060 0.102	1.109 0.122	1.156 0.145	1.248 0.198	1.335 0.262	1.378 0.298	1.501 0.424	1.618 0.579	1.656 0.637	1.731 0.765	1.803 0.906	1.838 0.983
0.00500 1/ 200	1.082 0.104	1.132 0.125	1.180 0.148	1.274 0.203	1.363 0.268	1.407 0.304	1.532 0.433	1.652 0.591	1.691 0.651	1.766 0.780	1.840 0.925	1.876 1.003
0.00550 1/ 182	1.135 0.109	1.187 0.131	1.238 0.156	1.336 0.212	1.430 0.281	1.476 0.319	1.607 0.454	1.733 0.620	1.773 0.682	1.853 0.819	1.930 0.970	1.968 1.052
0.00600 1/ 167	1.186 0.114	1.240 0.137	1.293 0.163	1.396 0.222	1.494 0.293	1.541 0.334	1.679 0.475	1.810 0.648	1.852 0.713	1.936 0.855	2.016 1.014	2.056 1.099
0.00650 1/ 154	1.235 0.119	1.291 0.143	1.346 0.169	1.453 0.231	1.555 0.305	1.605 0.347	1.748 0.494	1.884 0.674	1.928 0.742	2.015 0.890	2.099 1.055	2.140 1.144
0.00700 1/ 143	1.281 0.123	1.340 0.148	1.398 0.176	1.508 0.240	1.614 0.317	1.665 0.361	1.814 0.513	1.956 0.700	2.001 0.770	2.091 0.924	2.178 1.095	2.221 1.187
0.00750 1/ 133	1.327 0.128	1.387 0.153	1.447 0.182	1.561 0.248	1.671 0.328	1.724 0.373	1.878 0.531	2.024 0.724	2.072 0.797	2.165 0.956	2.255 1.134	2.299 1.229
0.00800 1/ 125	1.370 0.132	1.433 0.158	1.494 0.188	1.613 0.256	1.726 0.339	1.781 0.385	1.940 0.548	2.091 0.748	2.140 0.824	2.236 0.988	2.329 1.171	2.375 1.270
0.00850 1/ 118	1.413 0.136	1.477 0.163	1.541 0.194	1.662 0.264	1.779 0.349	1.836 0.397	2.000 0.565	2.156 0.771	2.206 0.849	2.305 1.018	2.401 1.207	2.448 1.309
0.00900 1/ 111	1.454 0.140	1.520 0.168	1.585 0.199	1.711 0.272	1.831 0.359	1.889 0.409	2.058 0.582	2.218 0.794	2.270 0.874	2.372 1.048	2.471 1.242	2.520 1.347
0.00950 1/ 105	1.494 0.144	1.562 0.173	1.629 0.205	1.758 0.280	1.881 0.369	1.941 0.420	2.114 0.598	2.279 0.816	2.333 0.898	2.437 1.077	2.539 1.276	2.589 1.384
0.01000 1/ 100	1.533 0.147	1.603 0.177	1.672 0.210	1.804 0.287	1.930 0.379	1.992 0.431	2.169 0.613	2.339 0.837	2.393 0.921	2.501 1.105	2.605 1.309	2.656 1.420
0.01100 1/ 91	1.608 0.155	1.682 0.186	1.753 0.220	1.892 0.301	2.025 0.398	2.089 0.452	2.276 0.643	2.453 0.878	2.510 0.966	2.623 1.159	2.732 1.373	2.786 1.489
0.01200 1/ 83	1.680 0.162	1.757 0.194	1.832 0.230	1.976 0.314	2.115 0.415	2.182 0.472	2.377 0.672	2.562 0.917	2.622 1.009	2.740 1.210	2.854 1.435	2.910 1.556
0.01300 1/ 77	1.748 0.168	1.829 0.202	1.907 0.240	2.057 0.327	2.202 0.432	2.272 0.492	2.474 0.700	2.667 0.954	2.730 1.050	2.852 1.260	2.971 1.493	3.029 1.619
0.01400 1/ 71	1.815 0.175	1.898 0.210	1.979 0.249	2.135 0.340	2.285 0.449	2.358 0.510	2.568 0.726	2.768 0.991	2.833 1.090	2.960 1.308	3.083 1.550	3.144 1.681
0.01500 1/ 67	1.879 0.181	1.965 0.217	2.049 0.257	2.210 0.352	2.365 0.464	2.441 0.528	2.658 0.752	2.866 1.025	2.933 1.129	3.064 1.354	3.192 1.604	3.254 1.740
0.01600 1/ 62	1.940 0.187	2.029 0.224	2.116 0.266	2.283 0.363	2.443 0.480	2.521 0.546	2.746 0.776	2.960 1.059	3.029 1.166	3.165 1.398	3.297 1.657	3.361 1.797
0.01700 1/ 59	2.000 0.192	2.092 0.231	2.181 0.274	2.354 0.374	2.519 0.495	2.599 0.563	2.830 0.800	3.051 1.092	3.122 1.202	3.262 1.441	3.398 1.708	3.465 1.852
0.01800 1/ 56	2.059 0.198	2.153 0.238	2.245 0.282	2.422 0.385	2.592 0.509	2.674 0.579	2.913 0.824	3.140 1.123	3.213 1.237	3.357 1.483	3.497 1.758	3.566 1.906
0.01900 1/ 53	2.115 0.203	2.212 0.244	2.306 0.290	2.488 0.396	2.663 0.523	2.748 0.595	2.993 0.846	3.226 1.154	3.301 1.270	3.449 1.524	3.593 1.806	3.664 1.958
Coefficient for part-full pipes:	120	130	140	150	200	200	200	250	250	250	300	300

ks = 1·500mm   i < 0·1

Table Q5.

Critical tractive force and mean velocity for different bed materials

Material	Size mm	Critical tractive force N/m^2	Approximate mean velocity m/sec	Manning's coefficient of roughness
Sandy loam (non-colloidal)		2·0	0·50	0·020
Silt loam (non-colloidal)		2·5	0·60	0·020
Alluvial silt (non-colloidal)		2·5	0·60	0·020
Ordinary firm loam		3·7	0·75	0·020
Volcanic ash		3·7	0·75	0·020
Stiff clay (very colloidal)		1·22	1·15	0·025
Alluvial silts (colloidal)		12·2	1·15	0·025
Shales and hard-pans		31·8	1·85	0·025
Fine sand (non-colloidal)	0·062–0·25	1·2	0·45	0·020
Medium sand (non-colloidal)	0·25–0·5	1·7	0·50	0·020
Coarse sand (non-colloidal)	0·5–2·0	2·5	0·60	0·020
Fine gravel	4–8	3·7	0·75	0·020
Coarse gravel	8–64	14·7	1·25	0·025
Cobbles and shingles	64–256	44·0	1·55	0·035
Graded loam and cobbles (non-colloidal)	0·004–64	19·6	1·15	0·30
Graded silts to cobbles (colloidal)	0–64	22·0	1·25	0·30

END OF PAPER