Pond Routing

MSMA · https://mes100.com/docs/pond-routing/

Reference:

- *MSMA 2nd Edition; Chapter 2; 2.5 Hydrological Routing*
- *MSMA 2nd Edition; Chapter 7 - Detention Pond*

How to perform routing through a reservoir or storage facility using Equation 2.17

Equation 2.17

$$(I_1 + I_2 / 2) + [(S_1 / \Delta t) + (O_1 / 2)] - O_1 = [(S_2 / \Delta t) + (O_2 / 2)]$$

Step 1: Determine Inflow Hydrograph based on Stage-Discharge and Stage-Storage Graph

Develop:

i. Inflow hydrograph

- Rational Method refer Chapter 2; 2.3.2 Rational Hydrograph Method)
- Time Area Method refer Chapter 2; 2.3.3 Time Area Hydrograph Method)

ii. Stage-discharge curve

- Refer Chapter 7; 7.5.2 Stage Storage Curves Development

iii. Stage-storage curve

- Refer Chapter 7; 7.5.3 Stage Discharge Curves

For the proposed facility (pond)

Step 2: Determine Routing Time Period (t)

Select a routing time period (t); and provide a minimum of five (5) points on the rising limb of the inflow hydrograph

Step 3: Develop ‘storage indicator numbers’ table

Develop ‘storage indicator numbers’ table from ‘stage-discharge curve’ & ‘stage-storage curve’

Typical storage indicator numbers table contains the following column headings;

1 Stage (m)	2 Discharge (O_2) (m^3/s)	3 Storage (S_2) (m^3)	4 $O_2/2$ (m^3/s)	5 $S_2/\Delta t$ (m^3/s)	6 $S_2/\Delta t + O_2/2$ (Storage Indicator Number)

Notes;

- Discharge (O) and stage (S) - obtained from stage-discharge & stage-storage curves
- Subscript 2 is arbitrarily assigned in the table
- Time interval t must be the same interval used in the tabulated inflow hydrograph

Step 4: Plot Storage Indicator Number Graph

Storage indicator number curves are plotted by:

the outflow (column 2) vertically against the storage indicator numbers in column 6.

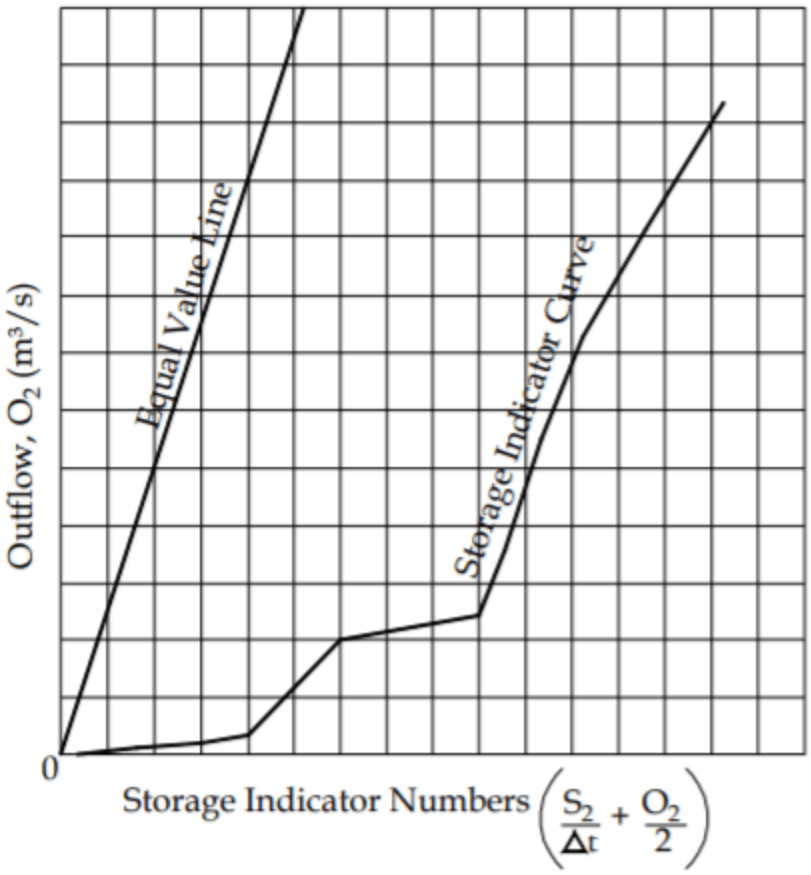


Figure 2.12: Storage Indicator Curve

Step 5:Plot Supplementary Curve of Storage Graph

Supplementary curve of storage: Column 3 vs Column 6 (S2 /t + O2 /2)

*refer figure 2.12 above.

Purpose: useful for identifying storage for any given value of S2 /t + O2 /2.

Step 6: Develop Routing Table

Now routing can be performed by developing a routing table for the solution of Equation 2.17 as follows:

1 Time (hr)	2 Inflow (m^3/s)	3 $(I_1+I_2)/2$ (m^3/s)	4 $(S_1/\Delta t+O_1/2)$ (m^3/s)	5 O_1 (m^3/s)	6 $S_2/\Delta t + O_2/2)$ (m^3/s)	7 O_2 (m^3/s)

Column 1 & 2

Time (min)	I (m^3/s)	$(I_1 + I_2)/2$ (m^3/s)	$S_1/\Delta t + O_1/2$ (m^3/s)	O_1 (m^3/s)	$S_2/\Delta t + O_2/2$ (m^3/s)	O_2 (m^3/s
0	0.00	0.00	0		0	0
1	0.15	0.07	0.00	0.00	0.07	0.00
2	0.30	0.22	0.07	0.00	0.30	0.00
3	0.45	0.37	0.30	0.00	0.67	0.00
4	0.60	0.52	0.67	0.00	1.20	0.00
5	0.75	0.67	1.20	0.00	1.87	0.00
6	0.90	0.82	1.87	0.00	2.69	0.06
7	1.05	0.97	2.69	0.06	3.61	0.06
8	1.20	1.12	3.61	0.06	4.67	0.06
9	1.35	1.27	4.67	0.06	5.88	0.12
10	1.50	1.42	5.88	0.12	7.18	0.12

from inflow hydrograph;
Refer MSMA 2; Chapter 7; Figure 7.6 & Figure 7.7

Note:

To calculate Inflow (Column 2); user can used equation 2.3; **Q = CiA / 360**

Column 3

Time (min)	I (m^3/s)	$(I_1 + I_2)/2$ (m^3/s)	$S_1/\Delta t + O_1/2$ (m^3/s)	O_1 (m^3/s)	$S_2/\Delta t + O_2/2$ (m^3/s)	O_2 (m^3/s
0	0.00	0.00	0		0	0
1	0.15	0.07	0.00	0.00	0.07	0.00
2	0.30	0.22	0.07	0.00	0.30	0.00
3	0.45	0.37	0.30	0.00	0.67	0.00
4	0.60	0.52	0.67	0.00	1.20	0.00
5	0.75	0.67	1.20	0.00	1.87	0.00
6	0.90	0.82	1.87	0.00	2.69	0.06
7	1.05	0.97	2.69	0.06	3.61	0.06
8	1.20	1.12	3.61	0.06	4.67	0.06
9	1.35	1.27	4.67	0.06	5.88	0.12
10	1.50	1.42	5.88	0.12	7.18	0.12

the average infow over the time interval

Column 4,5,6 & 7 (at time 0min)

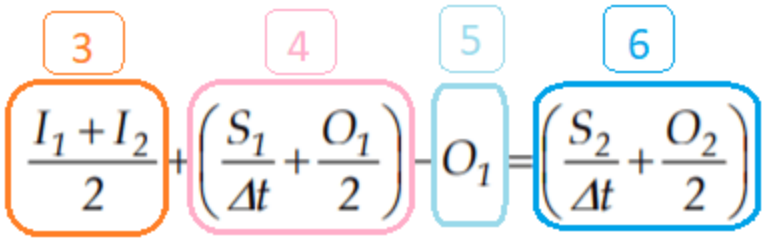
Time (min)	I (m^3/s)	$(I_1 + I_2)/2$ (m^3/s)	$S_1/\Delta t + O_1/2$ (m^3/s)	O_1 (m^3/s)	$S_2/\Delta t + O_2/2$ (m^3/s)	O_2 (m^3/s
0	0.00	0.00	0		0	0
1	0.15	0.07	0.00	0.00	0.07	0.00
2	0.30	0.22	0.07	0.00	0.30	0.00
3	0.45	0.37	0.30	0.00	0.67	0.00
4	0.60	0.52	0.67	0.00	1.20	0.00
5	0.75	0.67	1.20	0.00	1.87	0.00
6	0.90	0.82	1.87	0.00	2.69	0.06
7	1.05	0.97	2.69	0.06	3.61	0.06
8	1.20	1.12	3.61	0.06	4.67	0.06
9	1.35	1.27	4.67	0.06	5.88	0.12
10	1.50	1.42	5.88	0.12	7.18	0.12

Generally assumed to be zero (0m3/s) since there is no storage or discharge at the beginning of the hydrograph when there is no inflow into the basin

Column 6

Referring to Equation 2.17;

- From equation 2.17; the left side of equation is determined algebraically as columns (3) + (4) - (5). And this value equals the right side of the equation and is placed in column (6)



Note:

- Discharge (O) and storage (S) are obtained from the stage-discharge and stage-storage curves respectively
- Time interval (t) must be the same as the time interval used in the tabulated inflow hydrograph

Column 7

Enter the storage indicator curve with S2 / t + O2 / 2 (column 6) to obtain O2 (column 7)

Used Stage-Discharge Relation and Storage Indicator Numbers table to calculate O2

Table 7.A5: Stage-Discharge Relation and Storage Indicator Numbers
(5yr ARI 1st Trial)

H (m)	O (m^3/s)	S (m^3)	$(S/\Delta t)+O/2$ (m^3/s)
0.00	0.00	0	0.00
0.50	1.20	3171	53.44
1.00	3.76	6599	111.85
1.50	5.32	10258	173.62
2.00	6.51	14159	239.23
2.50	7.52	18311	308.93
3.00	8.40	22722	349.57

C_o=1.7 (Weir Flow) and 0.6 (Orifice Flow), A= 2.0m^2, (Dimension=2.0m x 1.0m)

For example;

take t = 9min ; S2 / t + O2 / 2 = 5.88 m3/s

So interpolate;

Table 7.A5: Stage-Discharge Relation and Storage Indicator Numbers
(5yr ARI 1st Trial)

H (m)	Q (m^3/s)	S (m^3)	$(S/\Delta t)+Q/2$ (m^3/s)
0.00	0.00	0	0.00
0.50	1.20	3171	53.44
1.00	3.76	6599	111.85
1.50	5.32	10258	173.62
2.00	6.51	14159	239.23
2.50	7.52	18311	308.93
3.00	8.40	22722	349.57

C_o=1.7 (Weir Flow) and 0.6 (Orifice Flow), A= 2.0m^2, (Dimension=2.0m x 1.0m)

Hence the O2 at t= 9min is 0.12 m3/s

(refer image below for reference)

Time (min)	I (m^3/s)	$(I_1 + I_2)/2$ (m^3/s)	$S_1/\Delta t + O_1/2$ (m^3/s)	O_1 (m^3/s)	$S_2/\Delta t + O_2/2$ (m^3/s)	O_2 (m^3/s
0	0.00	0.00	0		0	0
1	0.15	0.07	0.00	0.00	0.07	0.00
2	0.30	0.22	0.07	0.00	0.30	0.00
3	0.45	0.37	0.30	0.00	0.67	0.00
4	0.60	0.52	0.67	0.00	1.20	0.00
5	0.75	0.67	1.20	0.00	1.87	0.00
6	0.90	0.82	1.87	0.00	2.69	0.06
7	1.05	0.97	2.69	0.06	3.61	0.06
8	1.20	1.12	3.61	0.06	4.67	0.06
9	1.35	1.27	4.67	0.06	5.88	0.12
10	1.50	1.42	5.88	0.12	7.18	0.12

Next is how to proceed the pond routing?

Column 6 (S2 / t + O2 / 2) and Column 7 (O2) are transported to the next line and become the Column 4 (S1 / t + O1 / 2) and Column 5 (O1) respectively;

Time (min)	I (m^3/s)	$(I_1 + I_2)/2$ (m^3/s)	$S_1/\Delta t + O_1/2$ (m^3/s)	O_1 (m^3/s)	$S_2/\Delta t + O_2/2$ (m^3/s)	O_2 (m^3/s
0	0.00	0.00	0		0	0
1	0.15	0.07	0.00	0.00	0.07	0.00
2	0.30	0.22	0.07	0.00	0.30	0.00
3	0.45	0.37	0.30	0.00		
4	0.60	0.52	0.67	0.00	1.20	0.00
5	0.75	0.67	1.20	0.00	1.87	0.00
6	0.90	0.82	1.87	0.00	2.69	0.06
7	1.05	0.97	2.69	0.06	3.61	0.06
8	1.20	1.12	3.61	0.06	4.67	0.06
9	1.35	1.27	4.67	0.06	5.88	0.12
10	1.50	1.42	5.88	0.12	7.18	0.12

Column (3) + Column (4) - Column (5)

Time (min)	I (m^3/s)	$(I_1 + I_2)/2$ (m^3/s)	$S_1/\Delta t + O_1/2$ (m^3/s)	O_1 (m^3/s)	$S_2/\Delta t + O_2/2$ (m^3/s)	O_2 (m^3/s
0	0.00	0.00	0		0	0
1	0.15	0.07	0.00	0.00	0.07	0.00
2	0.30	0.22	0.07	0.00	0.30	0.00
3	0.45	0.37	0.30	0.00	0.67	0.00
4	0.60	0.52	0.67	0.00	1.20	0.00
5	0.75	0.67	1.20	0.00	1.87	0.00
6	0.90	0.82	1.87	0.00	2.69	0.06
7	1.05	0.97	2.69	0.06	3.61	0.06
8	1.20	1.12	3.61	0.06	4.67	0.06
9	1.35	1.27	4.67	0.06	5.88	0.12
10	1.50	1.42	5.88	0.12	7.18	0.12

Notes:

1. Peak storage depth and discharge (O2 in Column (7) will occur when Column (6) reaches maximum.
2. The storage indicator numbers table developed in **Step 3** is entered with the maximum value of S2 / t + O2 / 2 to obtain the maximum amount of storage required. The table also can be used to determine the corresponding elevation of the depth of stored water.

3. Designer needs to make sure that the peak flow in Column (7) does not exceed the allowable discharge as prescribed by the stormwater management criteria.

Step 7 : Plot Outflow Hydrograph

Plot outflow hydrograph; O2 Column (7) vs time Column (1)

Related



Ngu Soon Hui

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You can also contact me at soonhui@mes100.com