

PONDNET.WK1 - Flow and Phosphorus Routing in Pond Networks

Version 2.1 - March 1989

William W. Walker, Jr. Ph.D., Environmental Engineer
1127 Lowell Road, Concord, Massachusetts 01742
508-369-8061

PONDNET.WK1 is a Lotus-123 worksheet which permits routing of flow and phosphorus through networks of wet detention ponds.

Phosphorus removal is predicted using an empirical phosphorus retention function described in NALMS 1986 conference proceedings (Walker, W.W., "Phosphorus Removal by Urban Runoff Detention Basins", Lake and Reservoir Management, Volume III, North American Lake Management Society, pp. 314-326, 1987).

Each column in the spreadsheet represents a different pond (C,D,E, etc.)

To add or remove ponds, copy or delete entire columns (rows 5-52).

To display a graph of pond inflow and outflow concentrations, press ALT-G.

Other named graphs include "LOAD" and "REMOVAL".

Output area is contained in Rows 14-18 and 25-52. User would normally not modify these.

Cell C3 = title for labeling graphs

User input area is high-lighted (Rows 5-11):

Row	Label	Description
5	case label	(descriptive info.)
6	total watershed area	(draining directly into pond)
7	runoff coefficient	(approx. = impervious fraction)
8	pond surface area	(permanent pool)
9	pond mean depth	(" ")
10	upstream pond p load	(use to rout p from one pond to another)
11	upstream pond outflow	(use to rout flow from one pond to another)

If a pond does not receive outflow from another pond, set rows 10 and 11 to 0.

If a pond receives outflow from another pond(s) in the spreadsheet, assign rows 10 and 11 to appropriate column(s) in rows 14 and 15, respectively. For example, consider the following pond networks:

EXAMPLE 1: 2 Pairs

Column:	D	E	F	G
pond:	a ---> b	c <---	d	
Row 10	0	+D14	+G14	0
Row 11	0	+D15	+G15	0

EXAMPLE 2: 4 Ponds in Series

Column:	D	E	F	G
pond:	a ---> b	---> c	---> d	
Row 10	0	+D14	+E14	+F14
Row 11	0	+D15	+E15	+F15

EXAMPLE 3: 4 Ponds in Parallel

Column:	D	E	F	G
pond:	a	b	c	d
Row 10	0	0	0	0
Row 11	0	0	0	0

EXAMPLE 4: Branched Network

Column:	D	E	F	G
pond:	a ---> b	<---	c <---	d
Row 10	0	+D14+F14	+G14	0
Row 11	0	+D15+F15	+G15	0

Column C is set up to represent a pond designed according to NURP/VLAWMO criteria (volume = runoff from 2.5-inch storm). Note that this includes a 25% increase in volume to provide longevity (sediment storage allocation).

Pond network performance can be gauged by comparing predicted outflow concentrations for ponds discharging out of system with predicted outflow concentration for NURP/VLAWMO pond in Column C.

Networking of ponds can substantially reduce total volume requirements to achieve same outflow quality, because of the benefits of plug flow.

The watershed loading function is specified in Rows 21 to 24:

Row	Nominal Value		
21	Period Length	.5 year	(period of mass-balance calcs)
22	Period Precip.	20 inches	(total precip. over period)
23	Runoff Total P	650 ppb	(regional runoff characteristic)
24	Runoff Ortho P / Total P	.3	"
25	Relative Decay Rate	1.	(use to adjust P sedimentation)

Precipitation and runoff quality refer to average April-September conditions for urban watersheds in Twin Cities area.

These parameters should be adjusted to reflect regional factors and/or watershed land uses.

POND CONFIGURATION FOR TEST CASE: a b----->c----->d----->e

PONDNET 2.1 FLOW AND PHOSPHORUS ROUTING IN POND NETWORKS
W. Walker March 1989 Press ALT-G for Graphs

TITLE--> PONDNET TEST CASE

INPUT VARIABLES....	UNITS		NURP	Pond A	Pond B	Pond C	Pond D	Pond E	*
case labels									
watershed area	acres		100	8.3	8.3	0	0	0	*
runoff coefficient	-		0.2	0.9	0.9	0	0	0	*
pond surface area	acres		1	0.40	0.1625	0.1625	0.1625	0.1625	*
pond mean depth	feet		4.16	4	7	7	7	7	*
upstream pond p load	lbs/yr		0	0	0	16.6860	8.90629	5.70932	*
upstream pond outflow	ac-ft/yr		0	0	0	24.9	24.9	24.9	*

OUTPUT VARIABLES.....									
outflow p load	lbs/yr	43.6462	16.3015	16.6860	8.90629	5.70932	4.07815		
outflow volume	ac-ft/yr	66.6666	24.9	24.9	24.9	24.9	24.9		
outflow p conc	ppb	240.873	240.868	246.549	131.597	84.3598	60.2580		
pond removal	%	62.9445	62.9452	62.0713	46.6242	35.8956	28.5702		
total removal	%	62.9425	62.9432	62.0693	79.7541	87.0215	90.7295	**	

ASSUMED EXPORT FACTORS.....									
period length	yrs	0.5	0.5	0.5	0.5	0.5	0.5	*	
period precipitation	inches	20	20	20	20	20	20	*	
runoff total p	ppb	650	650	650	650	650	650	*	
runoff ortho p/total p	-	0.3	0.3	0.3	0.3	0.3	0.3	*	
relative decay rate	-	1	1	1	1	1	1	*	
unit runoff	in/yr	8	36	36	0	0	0		
unit export	lbs/ac-y	1.17786	5.30038	5.30038	0	0	0		

POND WATER BUDGETS.....								
runoff	ac-ft/yr	66.6666	24.9	24.9	0	0	0	
upstream pond	ac-ft/yr	0	0	0	24.9	24.9	24.9	
total inflow	ac-ft/yr	66.6666	24.9	24.9	24.9	24.9	24.9	
outflow	ac-ft/yr	66.6666	24.9	24.9	24.9	24.9	24.9	

POND PHOSPHORUS BUDGETS.....								
runoff	lbs/yr	117.786	43.9931	43.9931	0	0	0	
upstream pond	lbs/yr	0	0	0	16.6860	8.90629	5.70932	
total inflow	lbs/yr	117.786	43.9931	43.9931	16.6860	8.90629	5.70932	
net sedimentation	lbs/yr	74.1399	27.6915	27.3071	7.77973	3.19697	1.63116	
outflow	lbs/yr	43.6462	16.3015	16.6860	8.90629	5.70932	4.07815	

HYDRAULIC PARAMETERS.....								
pond volume	acre-ft	4.16666	1.6	1.1375	1.1375	1.1375	1.1375	
vlawmo pond volume	acre-ft	4.16666	1.55625	1.55625	0	0	0	
relative volume	inches	2.5	2.57028	1.82730	ERR	ERR	ERR	
residence time	years	0.0625	0.06425	0.04568	0.04568	0.04568	0.04568	
residence time	days	22.8125	23.4538	16.6741	16.6741	16.6741	16.6741	

overflow rate	ft/yr	66.6666	62.25	153.230	153.230	153.230	153.230
inflow phos conc	ppb	650.034	650.034	650.034	246.549	131.597	84.3598
outflow phos conc	ppb	240.873	240.868	246.549	131.597	84.3598	60.2580
p reaction rate	-	4.58408	4.58430	4.31474	1.63652	0.87350	0.55995
1-rp	-	0.37055	0.37054	0.37928	0.53375	0.64104	0.71429

Notes:

* user input rows (others are calculated or output values)

** This estimate of total removal % for entire system is correct only if runoff total p concentration is the same for each pond. Estimates of removal % for each pond are correct for any set of runoff total p concentrations.

Program Documentation Update

PONDNET Version 3.0
Flow and Phosphorus Routing in Complex Watersheds

prepared for
Maine Department of Environmental Protection
by
William W. Walker, Jr.
1127 Lowell Road
Concord, MA 01742

D R A F T

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ENHANCEMENTS:

Alternative Runoff Treatment Schemes:

- Detention Pond
- Infiltrating Wetland
- Other (User Specifies Removal Efficiency)

Detention Pond configuration (completely-mixed vs. plug flow) specified in Row 26. Parameter values in the range of 0 (mixed) to 1 (plug-flow).

Runoff curve number and phosphorus concentration specified by land use category and Hydrologic Soil Group (Rows 81-95). Curve number values entered here (C81..C95) are for AMC II. The program automatically adjusts these values to other Antecedent Moisture Conditions (as specified in C76) when computing runoff from the design storm. Maine DEP should develop a "standard" set of categories and coefficients for use in Maine watersheds. Normally, users of the program would not modify the standard values.

Rout Flow and Load to Downstream Segments by Specifying Outflow Segment Number in Row 6:

Segments are numbered from 1 to 20. This draft includes 10 "active" segments. Idle (unused) segments do no harm, except for increasing computation time.

In order to modify the number of active segments, cell protection will first have to be disabled (Lotus Command: /WGPD).

To increase the number of segments, copy cells from M3.M140 to the right (not beyond Column W= segment 20).

To decrease the number of active segments, use the RANGE ERASE (/RE) command on unused columns (between Rows 3 and 140). DO NOT DELETE COLUMNS.

Specify Outflow Segment Number = 0 (Row 6) to rout flow out of pond network (i.e., last pond in network).

Column C "OVERALL" summarizes performance of entire watershed network. Overall phosphorus removal efficiency is also shown in upper right corner (Cell G1).

Manual recalculation is required to update results. Hit "CALC" key (F9). For complex watersheds, (many linked ponds) it may be necessary to hit "CALC" more than once to reach a stable solution.

Note that watershed flow estimates generally do not reflect baseflow. For this reason, the model is designed primarily for small watersheds and detention ponds (vs. large watersheds and lakes).

Case-specific user inputs are boxed in single lines.
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Global inputs are boxed in double lines.
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Everything else on the spreadsheet is output and should not be modified by users.

	A	B	C	D	E	F	G	H
1	PONDSIZ VERSION 2.0		W. WALKER		PRESS 'ALT-G' FOR GRAPHS			
2	INPUT VARIABLE	UNITS	NOTES					
3	maximum depth	feet	10	<= 10 ft				
4	bench width bc	feet	10	>= 10 ft				
5	bench slope bc	ft/ft	10	>= 10 ft horiz / ft vertical				
6	side slope ab	ft/ft	3	>= 3 ft horiz / ft vertical				
7	pond shape factor		3	1=triangle,2=rectangle,3=ellipse				
8	length/width ratio	-	3	>= 3				
9	top length c	feet	590	adjust to achieve volume				
10								
11	OUTPUT VARIABLE	UNITS	VALUE					
12	target volume	acre-ft	11.83 = design storm runoff volume					
13	design volume	acre-ft	11.72 should be >= target volume					
14	design mean depth	feet	5.60 should be >= 4 feet					
15								
16	PREDICTED PERFORMANCE		Removal Effic. (%)		P Export (lbs/ac-y)			
17	Hydrologic Condition --->		Normal High-Flow		Normal High-Flow			
18	plug flow		71.1%	64.2%	0.41	0.75		
19	completely mixed		53.4%	48.2%	0.65	1.09		
20	estimated		62.2%	56.2%	0.53	0.92	21	
21								
22	WATERSHED CHARACTERISTICS		Runoff		Maximum		Design Storm.	
23	Soil	RCN	P Conc	Area	Retent.	Runoff	P Load	
24	Land Use	Group	AMC II	PPB	Acres	inches	ac-ft	lbs
25								
26	forest	A	36	100	100	7.47	0.27	0.07
27	forest	B	60	100		2.80	0.00	0.00
28	forest	C	73	100		1.55	0.00	0.00
29	forest	D	79	100		1.12	0.00	0.00
30	field	A	39	100		6.57	0.00	0.00
31	field	B	61	100		2.69	0.00	0.00
32	field	C	74	100		1.48	0.00	0.00
33	field	D	80	100		1.05	0.00	0.00
34	lawn	A	68	400		1.98	0.00	0.00
35	lawn	B	79	400		1.12	0.00	0.00
36	lawn	C	86	400	50	0.68	5.68	6.18
37	lawn	D	89	400		0.52	0.00	0.00
38	rooftops to lawns	D	90	400	20	0.47	2.55	2.78
39	other impervious	D	98	400	20	0.09	3.17	3.44
40	ponds and wetlands	D	98	30	1	0.09	0.16	0.01
41								
42	TOTALS			388	191		11.8	12.48
43								
44	DESIGN PARAMETERS	UNITS	COMMENTS					
45	relative decay rate		1= 1 adjust p sedimentation rate					
46	design storm	inches	2= 2 used to size pond					
47	antec moisture condition		3= 3 SCS (AMC = 1, 2, 3)					
48	period length	yrs	1= 1 length of mass-balance period					
49	period precip	inches	43= 43 total precipitation					
50	runoff ortho p/total p		0.3= .3 ortho p/total p ratio					
51	highflow/normal flow		1.5= 1.5 runoff ratio high/normal flow yr					

52 l/w at 50% plug flow || 3||= 3 length/width for removal calc
53 └────────┘
54 POND PERFORMANCE CALCULATIONS
55 watershed area acres 191
56 pond volume acre-ft 11.72
57 pond area acres 2.09
58 mean depth feet 5.60
59 runoff coefficient - 0.37
60 relative volume inches 1.98
61

62 WATER AND PHOSPHORUS BALANCES

63 Hydrologic Condition ---->NORMAL..... ..HIGH-FLOW..

64		Inflow	Outflow	Inflow	Outflow
65	flow	ac-ft/yr	254.3	254.3	381.4
66	unit runoff	in/yr	16.0	16.0	24.0
67	total p load	lbs/yr	268.3	101.3	402.5
68	unit p load	lbs/a-yr	1.40	0.53	2.11
69	total p conc	ppb	388.2	146.6	388.2
70					
71	residence time	years		0.046	0.031
72	residence time	days		16.8	11.2
73	overflow rate	ft/yr		121.5	182.3
74	p reaction rate			2.46	1.80
75	plug flow removal	%		71.1%	64.2%
76	mixed removal	%		53.4%	48.2%
77	estimated removal	%		62.2%	56.2%

78

79 CONTOUR DIMENSIONS

Geometry = ELLIPSE

80		TOP	BENCH	BOTTOM	
81	contour	C	B	A	TOTAL
82	elevation	feet	0.0	-1.0	-10.0
83	depth	feet	0.0	1.0	10.0
84	max length	feet	590.0	519.2	327.9
85	max width	feet	196.7	173.1	109.3
86	triangle area	feet^2	58017	44923	17924
87	rectangle area	feet^2	116033	89847	35848
88	ellipse area	feet^2	91132	70565	28155
89	used area	feet^2	91132	70565	28155
90	increm. volume	feet^3		80630	429879
91	imcrem. volume	yd^3		2986	15921
92	imcrem. volume	ac-ft		1.85	9.87
93	slope length	ft		10.0	27.0
94	centroid offset	ft	0.0	25.4	94.0

	A	B	C	D	E	F	G
1 PONDNET 3.0	W. Walker	Oct 1988	PONDNET TEST CASE				57.5%
2 SEGMENT NUMBER ----->			0	1	2	3	4
3 SEGMENT LABEL ----->		OVERALL	NONE	WETLAND	POND 1	POND 2	
4 CASE TITLE ----->			PONDNET TEST CASE				
5 SEGMENT LABEL ----->		OVERALL	NONE	WETLAND	POND 1	POND 2	etc -->
6 OUTFLOW SEGMENT NUMBER ----->			4	4	4	0	

7 LAND USE-SOIL GROUP	RCN	WATERSHED AREAS (acres)			
8 -----						
9 forest-A	36	289	100	90	99	0
10 forest-B	60	0				
11 forest-C	73	0				
12 forest-D	79	0				
13 field-A	39	0				
14 field-B	61	0				
15 field-C	74	0				
16 field-D	80	0				
17 lawn-A	68	0				
18 lawn-B	79	30	10	10	10	
19 lawn-C	86	0				
20 lawn-D	89	0				
21 rooftops to lawns-D	90	30	10	10	10	
22 other impervious-D	98	0				
23 detention pond/wetland	98	12	0	10	1	1
24 -----						
25 pond mean depth	feet	0	0	0.1	4	4
26 pond config (0=mixed,1=plug flow)			0	0	0	1
27 forced removal	%		0	0	0	0
28 infiltration	in/day		0	0.5	0	0
29						

30 OUTPUT VARIABLES.....						
31 total watershed area	acres	361	120	120	120	1
32 runoff coef	-	0.153	0.123	0.201	0.130	0.950
33 outflow p load	lbs/yr	68.6	52.7	44.5	24.2	68.6
34 outflow unit p load	lbs/ac-yr	0.19	0.44	0.37	0.20	68.56
35 outflow volume	ac-ft/yr	187.1	52.8	74.8	56.1	187.1
36 outflow unit volume	in/yr	6.2	5.3	7.5	5.6	2245.3
37 outflow p load	mg/m2-yr	21.3	49.2	41.6	22.6	7688.4
38 outflow p conc	ppb	134.8	367.2	218.7	158.6	134.8
39 phosphorus removal	%	57.5%	0.0%	19.5%	54.3%	43.6%
40						

41 WATER BALANCES.....						
42 runoff flow	ac-ft/yr	198.5	52.8	86.2	56.1	3.4
43 upstream segments	ac-ft/yr	0.0	0.0	0.0	0.0	183.7
44 total inflow	ac-ft/yr	198.5	52.8	86.2	56.1	187.1
45 infiltration	ac-ft/yr	11.4	0.0	11.4	0.0	0.0
46 outflow	ac-ft/yr	187.1	52.8	74.8	56.1	187.1
47						

48 PHOSPHORUS BALANCES.....						
49 runoff load	lbs/yr	161.1	52.7	55.3	52.9	0.3

50	upstream segments	lbs/yr	0.0	0.0	0.0	0.0	121.3
51	total inflow	lbs/yr	161.1	52.7	55.3	52.9	121.6
52	net sedimentation	lbs/yr	85.8	0.0	4.0	28.7	53.1
53	infiltration	lbs/yr	6.8	0.0	6.8	0.0	0.0
54	outflow load	lbs/yr	68.6	52.7	44.5	24.2	68.6
55							

```

56 HYDRAULIC PARAMETERS.....
57 pond volume      acre-ft      9.0    0.0    1.0    4.0    4.0
58 relative volume  inches      1.95   0.00   0.50   3.07  50.51
59 residence time    years              0.000  0.012  0.071  0.021
60 residence time    days              0.0    4.2    26.0    7.8
61 overflow rate     ft/yr              0.0    8.6    56.1   187.1
62 inflow phos conc  ppb             367.2  235.8  347.0  239.1
63 outflow phos conc ppb             367.2  218.7  158.6  134.8
64 p reaction rate   -              0.00   0.08   2.60   0.77
65 plug flow removal %              0.0%   7.8%   72.2%  43.6%
66 mixed removal     %              0.0%   7.2%   54.3%  33.9%
67 sedimentation 1-rp -            1.000  0.928  0.457  0.564
68 infiltration 1-rp -            1.000  0.868  1.000  1.000
69
70 GENERAL PARAMETERS.....

71 period length     yrs      || 1 ||
72 period precipitation inches || 43 ||
73 runoff ortho p/total p - || 0.3 ||
74 relative decay rate -      || 1 ||
75 design storm       inches || 2 || to calculate runoff coef & load
76 antec moisture cond || 3 || SCS (AMC = 1, 2, or 3)
77 infiltration time/total time || 0.075 || storm duration / total time
78
79                      SOIL          RCN RUNOFF P
80 LAND USE            GROUP        AMC II    PPB

81 ||forest            A            36    100 ||
82 ||forest            B            60    100 ||
83 ||forest            C            73    100 ||
84 ||forest            D            79    100 ||
85 ||field             A            39    100 ||
86 ||field             B            61    100 ||
87 ||field             C            74    100 ||
88 ||field             D            80    100 ||
89 ||lawn              A            68    400 ||
90 ||lawn              B            79    400 ||
91 ||lawn              C            86    400 ||
92 ||lawn              D            89    400 ||
93 ||rooftops to lawns D            90    400 ||
94 ||other impervious  D            98    400 ||
95 ||detention pond/wetlandD      98    30 ||
96 ||

```

100	Maximum					
101	LAND USE-SOIL GROUP	Ret. (in)	Design Storm Runoff (acre-ft)	
102	-----					
103	forest-A	7.47	0.78	0.27	0.24	0.27
104	forest-B	2.80	0.00	0.00	0.00	0.00
105	forest-C	1.55	0.00	0.00	0.00	0.00
106	forest-D	1.12	0.00	0.00	0.00	0.00
107	field-A	6.57	0.00	0.00	0.00	0.00
108	field-B	2.69	0.00	0.00	0.00	0.00
109	field-C	1.48	0.00	0.00	0.00	0.00
110	field-D	1.05	0.00	0.00	0.00	0.00
111	lawn-A	1.98	0.00	0.00	0.00	0.00
112	lawn-B	1.12	2.73	0.91	0.91	0.91
113	lawn-C	0.68	0.00	0.00	0.00	0.00
114	lawn-D	0.52	0.00	0.00	0.00	0.00
115	rooftops to lawns-D	0.47	3.83	1.28	1.28	1.28
116	other impervious-D	0.09	0.00	0.00	0.00	0.00
117	detention pond/wetland	0.09	1.90	0.00	1.58	0.16
118	-----					
119	design runoff	acre-ft	9.2	2.5	4.0	2.6
120	total runoff	ac-ft/yr	198.5	52.8	86.2	56.1
121						
122						
123	Runoff P					
124	LAND USE	(ppb)	Design Storm P Export (lbs)	
125	-----					
126	forest-A	100	0.21	0.07	0.07	0.07
127	forest-B	100	0.00	0.00	0.00	0.00
128	forest-C	100	0.00	0.00	0.00	0.00
129	forest-D	100	0.00	0.00	0.00	0.00
130	field-A	100	0.00	0.00	0.00	0.00
131	field-B	100	0.00	0.00	0.00	0.00
132	field-C	100	0.00	0.00	0.00	0.00
133	field-D	100	0.00	0.00	0.00	0.00
134	lawn-A	400	0.00	0.00	0.00	0.00
135	lawn-B	400	2.97	0.99	0.99	0.99
136	lawn-C	400	0.00	0.00	0.00	0.00
137	lawn-D	400	0.00	0.00	0.00	0.00
138	rooftops to lawns-D	400	4.16	1.39	1.39	1.39
139	other impervious-D	400	0.00	0.00	0.00	0.00
140	detention pond/wetland	30	0.15	0.00	0.13	0.01
141	-----					
142	design storm load	lbs/storm	7.5	2.4	2.6	2.5
143	total load	lbs/year	161	53	55	53