WinSLAMM v 10.3
Porous Pavement

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University of Alabama

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We will cover . . .

- Porous Pavement Options in WinSLAMM
- Porous Pavement Performance Algorithm
- Entering Porous Pavement Data into the Program
- Modeling Notes
- Example Input and Output

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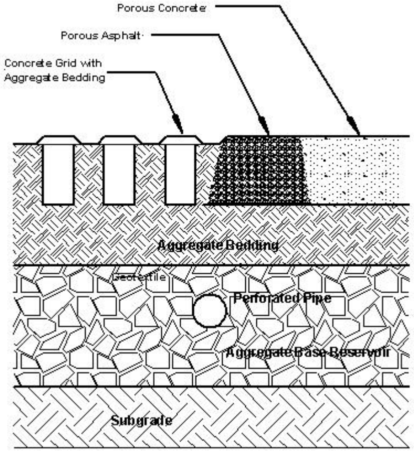
Porous Pavement Cross Section



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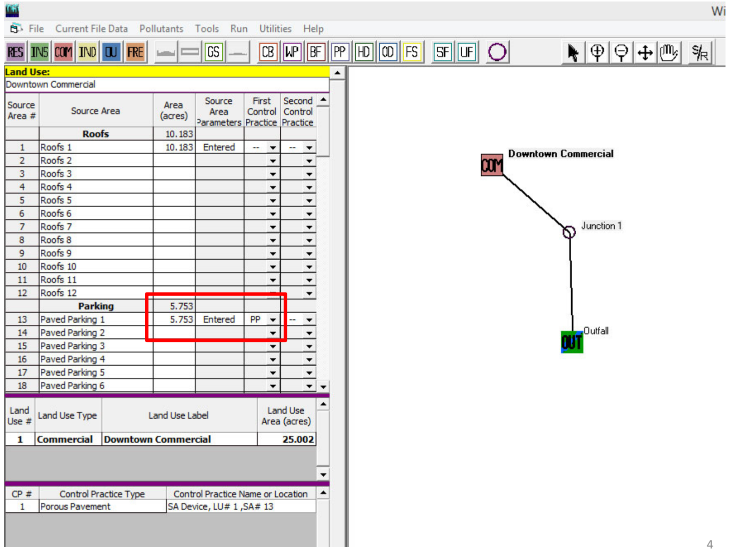

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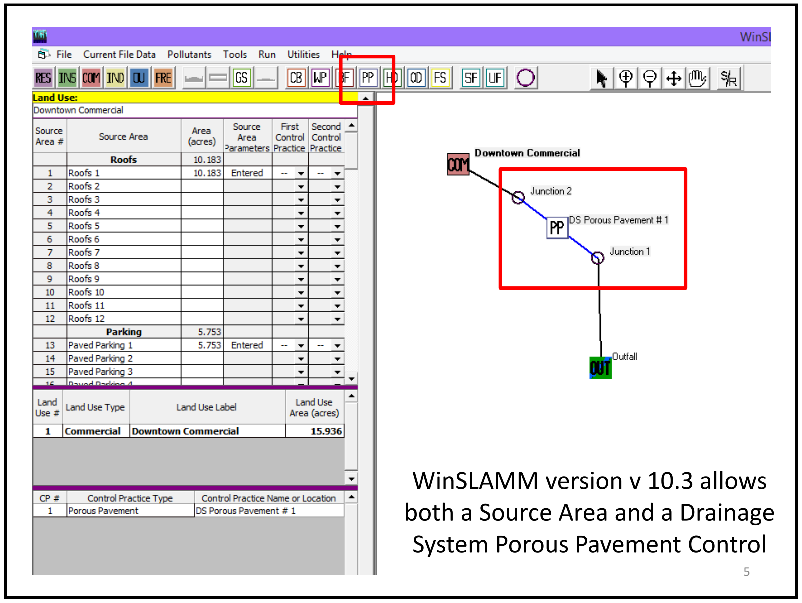
Downtown Commercial
Junction 2
DS Porous Pavement # 1
Junction 1
Outfall
WinSLAMM version v 10.3 allows both a Source Area and a Drainage System Porous Pavement Control
5

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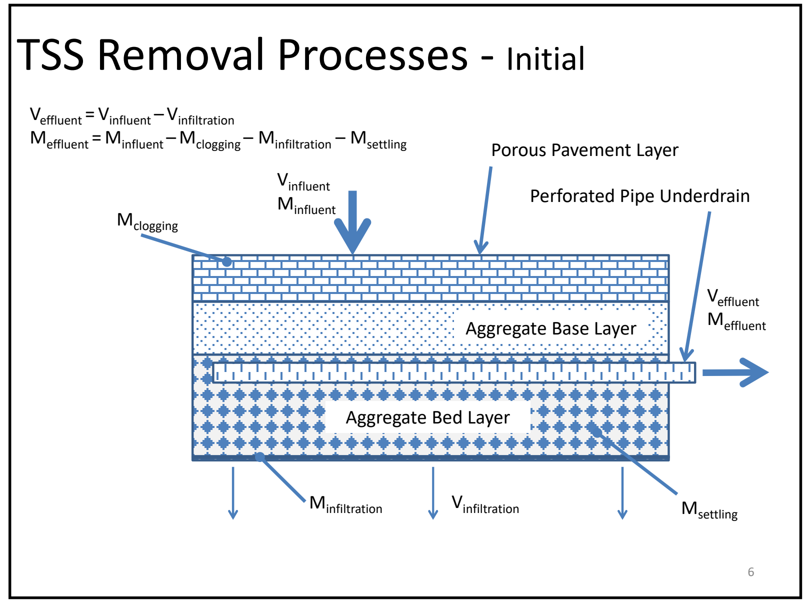
TSS Removal Processes - Initial
V effluent = V influent − V infiltration
M effluent = M influent − M clogging − M infiltration − M settling
Porous Pavement Layer
Perforated Pipe Underdrain
V influent
M influent
M clogging
Aggregate Base Layer
V effluent
M effluent
Aggregate Bed Layer
M infiltration
V infiltration
M settling
6

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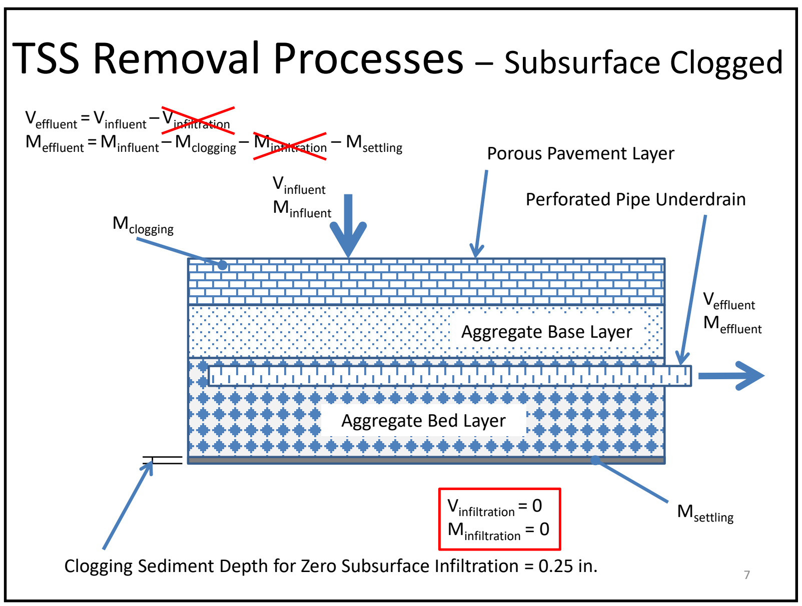
TSS Removal Processes – Subsurface Clogged
V effluent = V influent − V infiltration
M effluent = M influent − M clogging − M infiltration − M settling
Porous Pavement Layer
Perforated Pipe Underdrain
V influent
M influent
M clogging
Aggregate Base Layer
V effluent
M effluent
Aggregate Bed Layer
V infiltration = 0
M infiltration = 0
M settling
Clogging Sediment Depth for Zero Subsurface Infiltration = 0.25 in.
7

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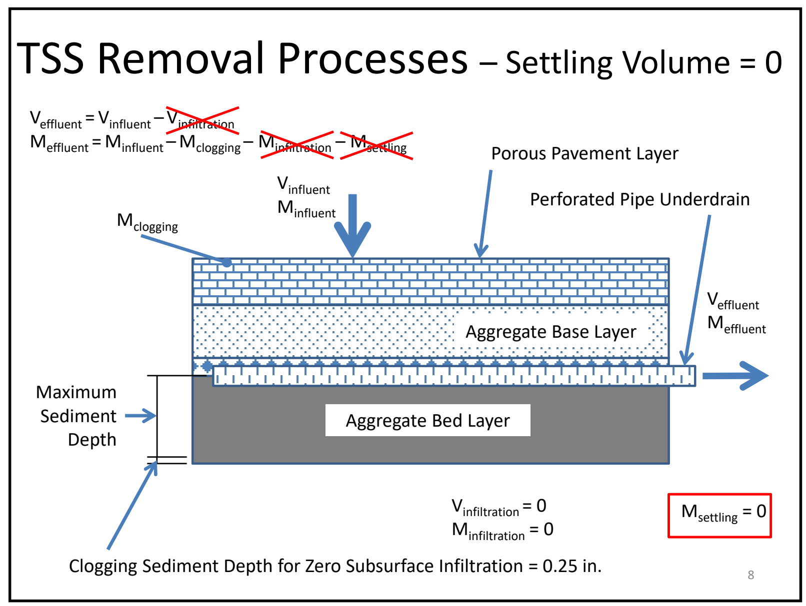
TSS Removal Processes – Settling Volume = 0
V effluent = V influent − V infiltration
M effluent = M influent − M clogging − M infiltration − M settling
Porous Pavement Layer
Perforated Pipe Underdrain
V influent
M influent
M clogging
Aggregate Base Layer
V effluent
M effluent
Maximum Sediment Depth
Aggregate Bed Layer
V infiltration = 0
M infiltration = 0
M settling = 0
Clogging Sediment Depth for Zero Subsurface Infiltration = 0.25 in.
8

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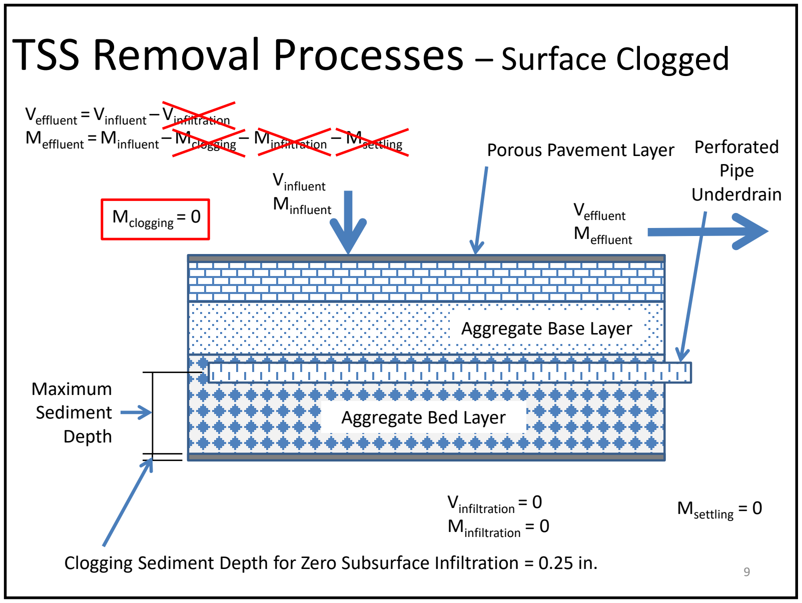

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Entering Porous Pavement Data into the Program

- Pavement Geometry and Properties
- Outlet/Discharge Options
- Surface Pavement Layer and Cleaning Data
- Native Soil Infiltration Data

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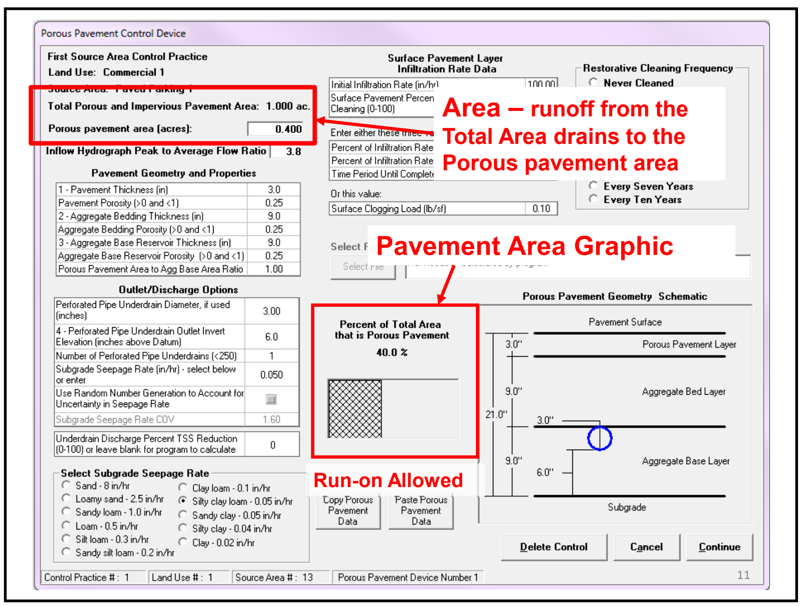

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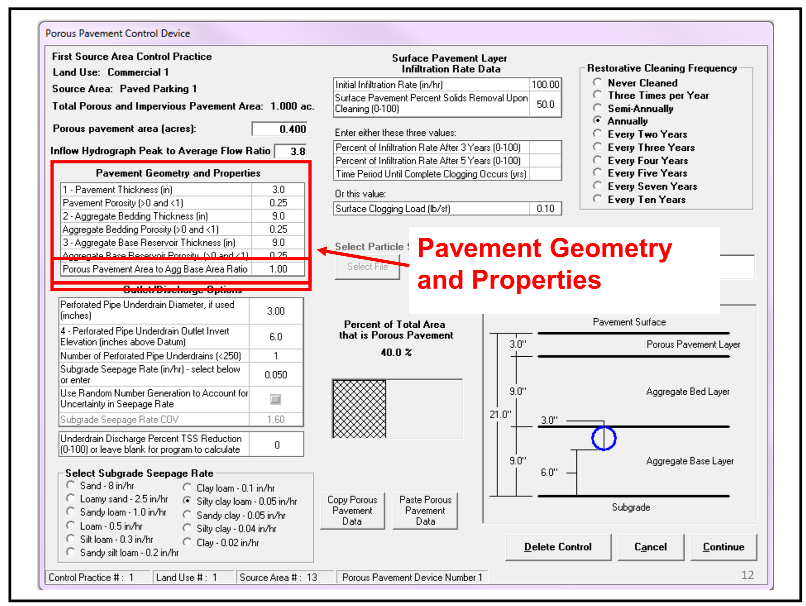

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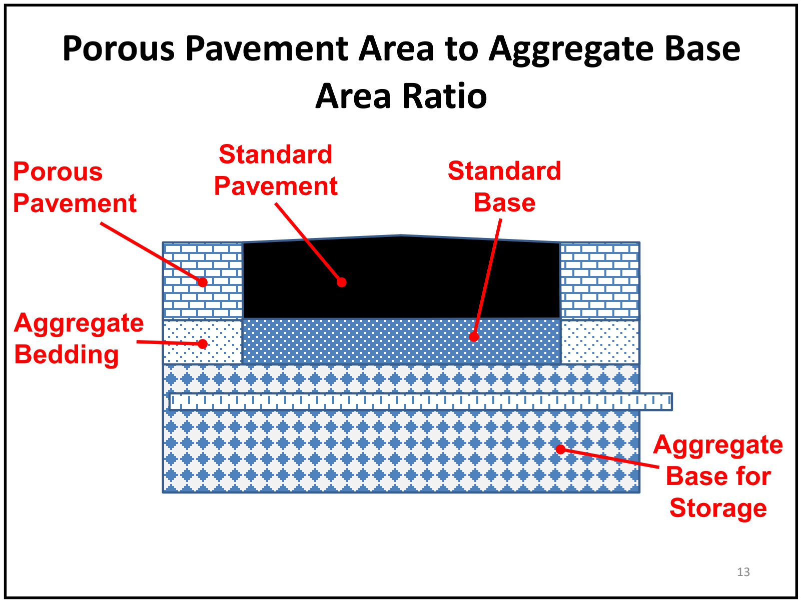
Porous Pavement Area to Aggregate Base Area Ratio
Porous Pavement
Standard Pavement
Standard Base
Aggregate Bedding
Aggregate Base for Storage
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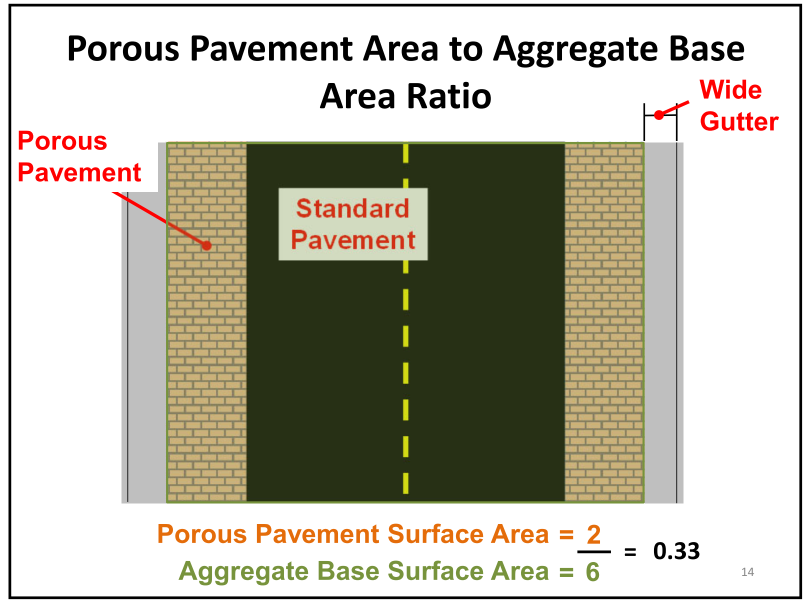
Porous Pavement Area to Aggregate Base Area Ratio
Wide Gutter
Porous Pavement
Standard Pavement
Porous Pavement Surface Area = 2
Aggregate Base Surface Area = 6
= 0.33
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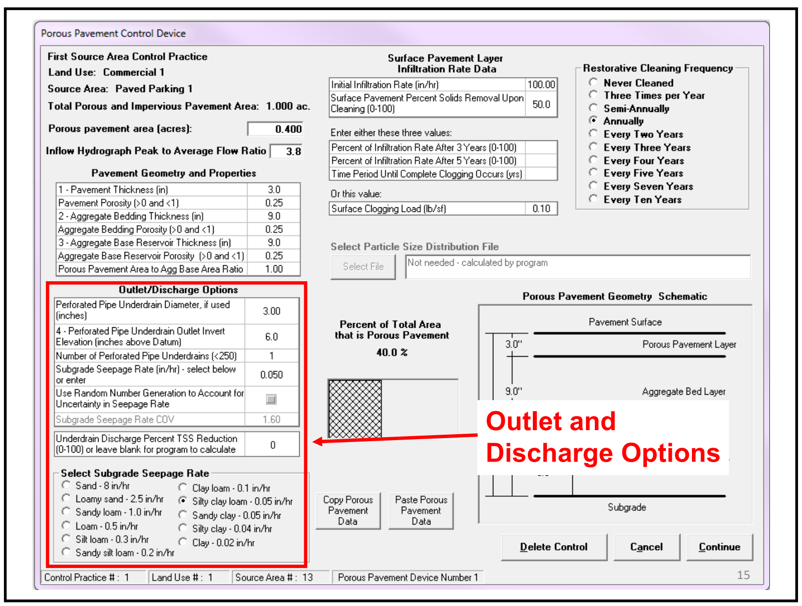
Porous Pavement Control Device
First Source Area Control Practice
Land Use: Commercial 1
Source Area: Paved Parking 1
Total Porous and Impervious Pavement Area: 1.000 ac.
Porous pavement area (acres): 0.400
Inflow Hydrograph Peak to Average Flow Ratio 3.8
Pavement Geometry and Properties
Surface Pavement Layer Infiltration Rate Data
Restorative Cleaning Frequency
Never Cleaned
Three Times per Year
Semi-Annually
Annually
Every Two Years
Every Three Years
Every Four Years
Every Five Years
Every Seven Years
Every Ten Years
Select Particle Size Distribution File
Outlet/Discharge Options
Porous Pavement Geometry Schematic
Percent of Total Area that is Porous Pavement
40.0 %
Select Subgrade Seepage Rate
Outlet and Discharge Options
Delete Control
Cancel
Continue
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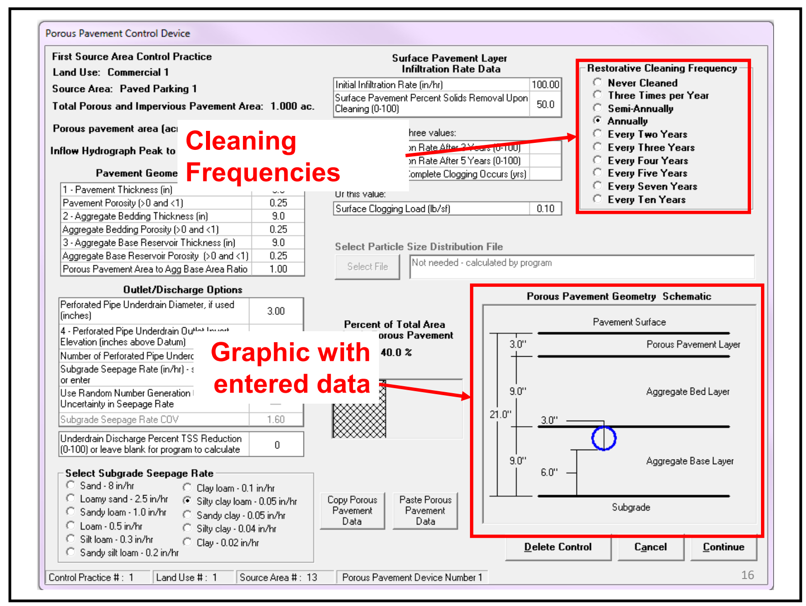
Porous Pavement Control Device
First Source Area Control Practice
Land Use: Commercial 1
Source Area: Paved Parking 1
Total Porous and Impervious Pavement Area: 1.000 ac.
Cleaning Frequencies
Restorative Cleaning Frequency
Never Cleaned
Three Times per Year
Semi-Annually
Annually
Every Two Years
Every Three Years
Every Four Years
Every Five Years
Every Seven Years
Every Ten Years
Graphic with entered data
Porous Pavement Geometry Schematic
Pavement Surface
Porous Pavement Layer
Aggregate Bed Layer
Aggregate Base Layer
Subgrade
Delete Control
Cancel
Continue
16

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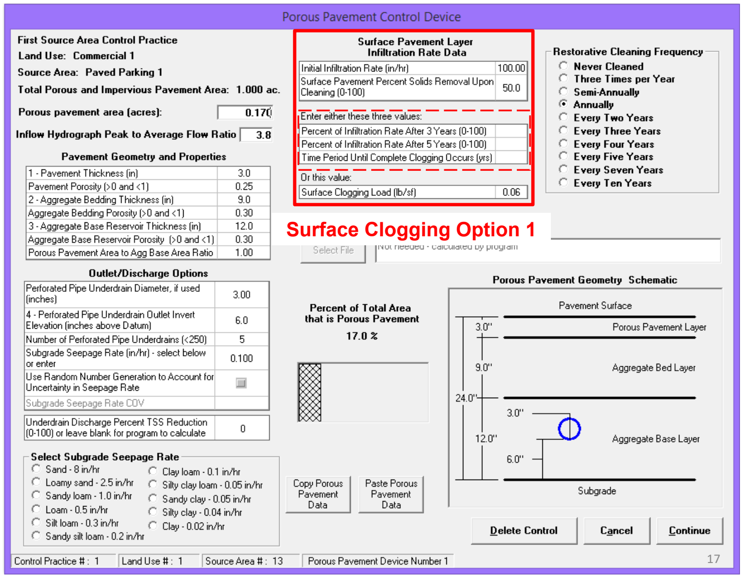

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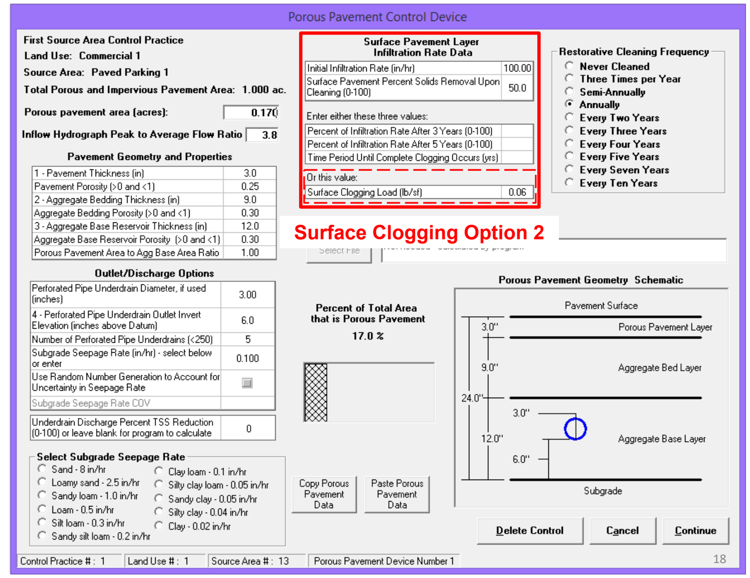

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Modeling Notes

- **Porous Pavement routing is performed using the Modified Puls Storage – Indication Method.**
- **Time increments are established by the user and vary by event.**
- **Yield reductions are due to**
  - **surface pavement filtering**
  - **subsurface settling**
  - **runoff volume reduction through infiltration**
- **The pavement surface can be any material – paver blocks, porous asphalt or porous concrete**
- **The porous pavement structure is assumed to be flat**

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Modeling Notes

- **In Northern Climates, groundwater contamination due to Chlorides may be a problem – check with your regulatory agency**
- **Porous pavement clogging and cleaning time frames may require a multi-year analysis to correctly evaluate performance**
- **Clogging due to run on increases as the porous pavement area to drainage area ratio decreases**

Data File: C:\Files\SLAMM\Training-Presentations\DNR PP Feb 2015 Webinar\PPTest.mdb
Rain File: WisReg - Madison WI 1981.RAN
Date: 01-25-15 Time: 12:38:41 PM
Site Description:

Col. #:	2	3	4	5	6	7	8	9	10	11	12	13	14	26	28	29	30	36	61
Control Practice No.	Control Practice Type	Control Practice Name or Location	Total Inflow Volume (cf)	Total Outflow Volume (cf)	Percent Volume Reduction	Total Influent Load (lbs)	Total Effluent Load (lbs)	Percent Load Reduction	Flow Weighted Influent Conc (mg/L)	Flow Weighted Effluent Conc (mg/L)	Percent Conc. Reduction	Influent Median Part. Size (microns)	Effluent Median Part. Size (microns)	% of Clogging Factor	Maximum Subsurface Ponding Time (hrs)	Volume Infiltrated (cf)	Underdrain Discharge Vol. (cf)	Final Surface Infiltration Rate (in/hr)	Runoff Producing Events/ Ttl. Rains
1	Porous Pavement	SA Device, LU# 1 ,SA# 13	75538	37980	49.72	613.0	94.06	84.66	130.0	39.67	69.483	7.80	2.33	0.12	68.50	37524.94	37979.71	87.93	21/86

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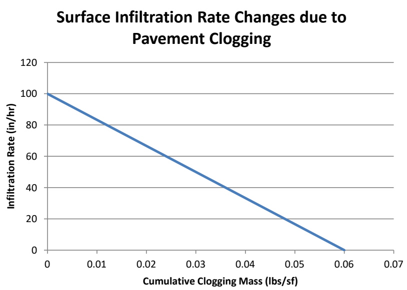
Surface Seepage Rate Changes due to Surface Clogging

Table 1 - Particulate Treatment in Porous Pavement Devices
Fractional Removal of Stormwater Particulates

Media	0.45 to 3µm	3 to 12µm	12 to 30µm	30 to 60µm	60 to 120µm	120 to 250µm	>250µm
Porous pavement surface (asphalt or concrete)	0.00	0.00	0.00	0.00	0.25	0.50	1.00



Infiltration rate decreases as sediment clogs the surface

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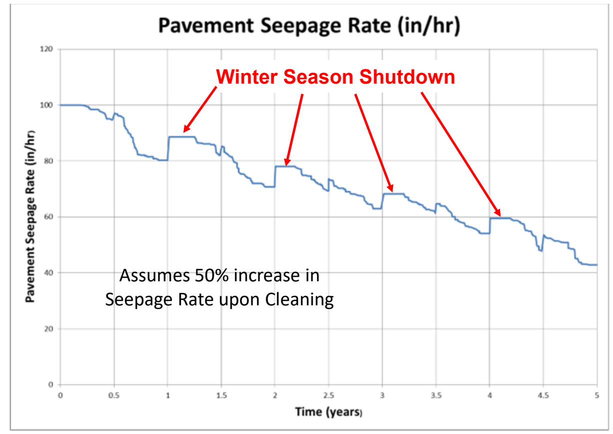
Surface Seepage Rate Changes to the Control Practice



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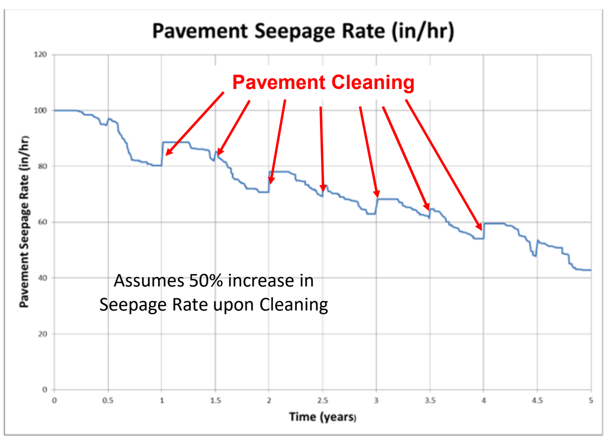
Surface Seepage Rate Changes to the Control Practice



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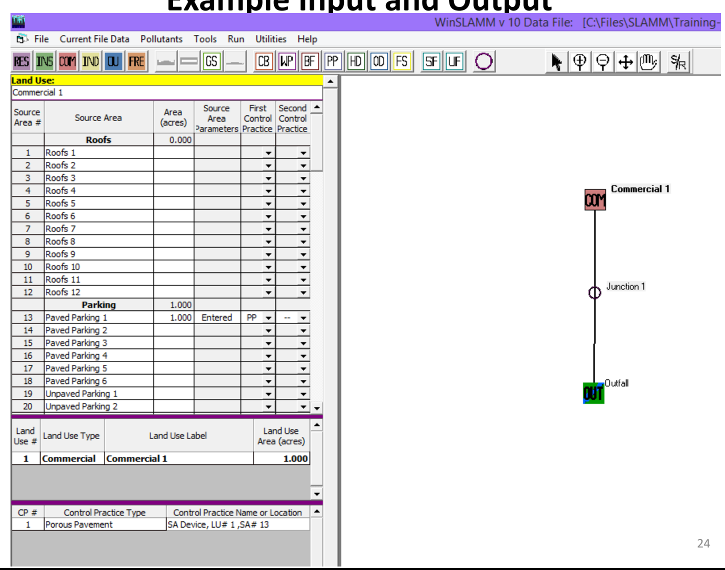
Example Input and Output



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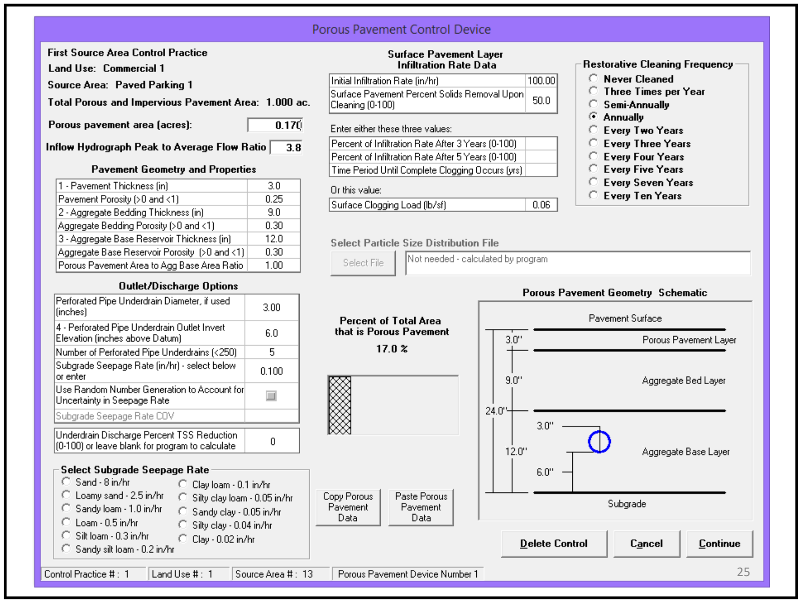
24


Porous Pavement Control Device
First Source Area Control Practice
Land Use: Commercial 1
Source Area: Paved Parking 1
Total Porous and Impervious Pavement Area: 1.000 ac.
Porous pavement area (acres): 0.170
Inflow Hydrograph Peak to Average Flow Ratio 3.8
Pavement Geometry and Properties
1 - Pavement Thickness (in) 3.0
Pavement Porosity (>0 and <1) 0.25
2 - Aggregate Bedding Thickness (in) 9.0
Aggregate Bedding Porosity (>0 and <1) 0.30
3 - Aggregate Base Reservoir Thickness (in) 12.0
Aggregate Base Reservoir Porosity (>0 and <1) 0.30
Porous Pavement Area to Agg Base Area Ratio 1.00
Outlet/Discharge Options
Perforated Pipe Underdrain Diameter, if used (inches) 3.00
4 - Perforated Pipe Underdrain Outlet Invert Elevation (inches above Datum) 6.0
Number of Perforated Pipe Underdrains (<250) 5
Subgrade Seepage Rate (in/hr) - select below or enter 0.100
Use Random Number Generation to Account for Uncertainty in Seepage Rate
Subgrade Seepage Rate COV
Underdrain Discharge Percent TSS Reduction (0-100) or leave blank for program to calculate 0
Select Subgrade Seepage Rate
Sand - 8 in/hr
Loamy sand - 2.5 in/hr
Sandy loam - 1.0 in/hr
Loam - 0.5 in/hr
Silt loam - 0.3 in/hr
Sandy silt loam - 0.2 in/hr
Clay loam - 0.1 in/hr
Silty clay loam - 0.05 in/hr
Sandy clay - 0.05 in/hr
Silty clay - 0.04 in/hr
Clay - 0.02 in/hr
Surface Pavement Layer Infiltration Rate Data
Initial Infiltration Rate (in/hr) 100.00
Surface Pavement Percent Solids Removal Upon Cleaning (0-100) 50.0
Enter either these three values:
Percent of Infiltration Rate After 3 Years (0-100)
Percent of Infiltration Rate After 5 Years (0-100)
Time Period Until Complete Clogging Occurs (yrs)
Or this value:
Surface Clogging Load (lb/sf) 0.06
Restorative Cleaning Frequency
Never Cleaned
Three Times per Year
Semi-Annually
Annually
Every Two Years
Every Three Years
Every Four Years
Every Five Years
Every Seven Years
Every Ten Years
Select Particle Size Distribution File
Select File
Not needed - calculated by program
Percent of Total Area that is Porous Pavement
17.0 %
Porous Pavement Geometry Schematic
Pavement Surface
Porous Pavement Layer
Aggregate Bed Layer
Aggregate Base Layer
Subgrade
Copy Porous Pavement Data
Paste Porous Pavement Data
Delete Control
Cancel
Continue
Control Practice #: 1
Land Use #: 1
Source Area #: 13
Porous Pavement Device Number 1
25

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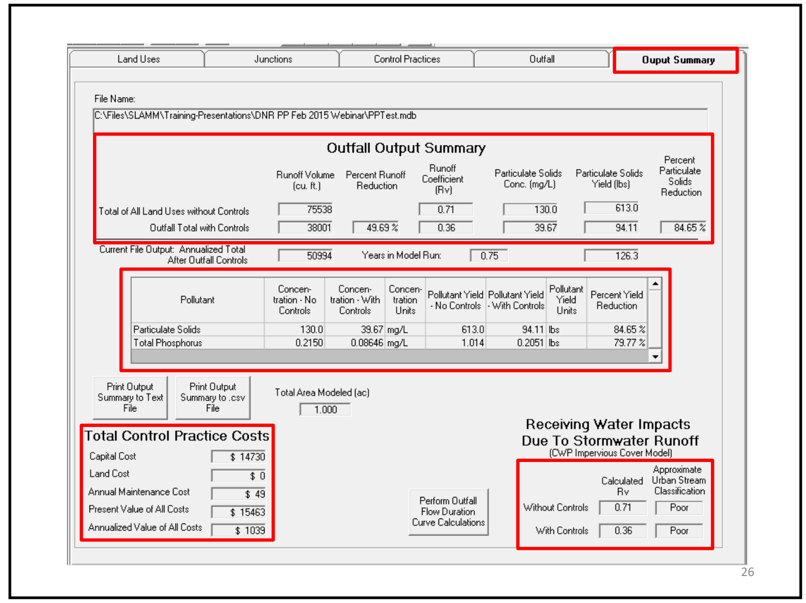
Land Uses
Junctions
Control Practices
Outfall
Ouput Summary
File Name:
C:\Files\SLAMM\Training-Presentations\DNR PP Feb 2015 Webinar\PPTest.mdb
Outfall Output Summary
Runoff Volume (cu. ft.)
Percent Runoff Reduction
Runoff Coefficient (Rv)
Particulate Solids Conc. (mg/L)
Particulate Solids Yield (lbs)
Percent Particulate Solids Reduction
Total of All Land Uses without Controls 75538 0.71 130.0 613.0
Outfall Total with Controls 38001 49.69 % 0.36 39.67 94.11 84.65 %
Current File Output: Annualized Total After Outfall Controls 50994
Years in Model Run: 0.75
126.3
Pollutant
Particulate Solids 130.0 39.67 mg/L 613.0 94.11 lbs 84.65 %
Total Phosphorus 0.2150 0.08646 mg/L 1.014 0.2051 lbs 79.77 %
Print Output Summary to Text File
Print Output Summary to .csv File
Total Area Modeled (ac) 1.000
Total Control Practice Costs
Capital Cost $ 14730
Land Cost $ 0
Annual Maintenance Cost $ 49
Present Value of All Costs $ 15463
Annualized Value of All Costs $ 1039
Perform Outfall Flow Duration Curve Calculations
Receiving Water Impacts Due To Stormwater Runoff
(CWP Impervious Cover Model)
Calculated Rv
Approximate Urban Stream Classification
Without Controls 0.71 Poor
With Controls 0.36 Poor
26

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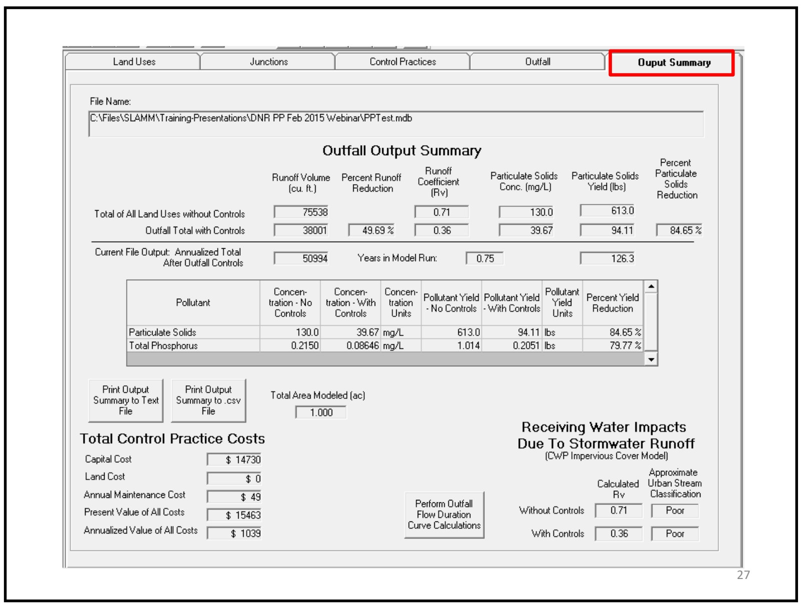
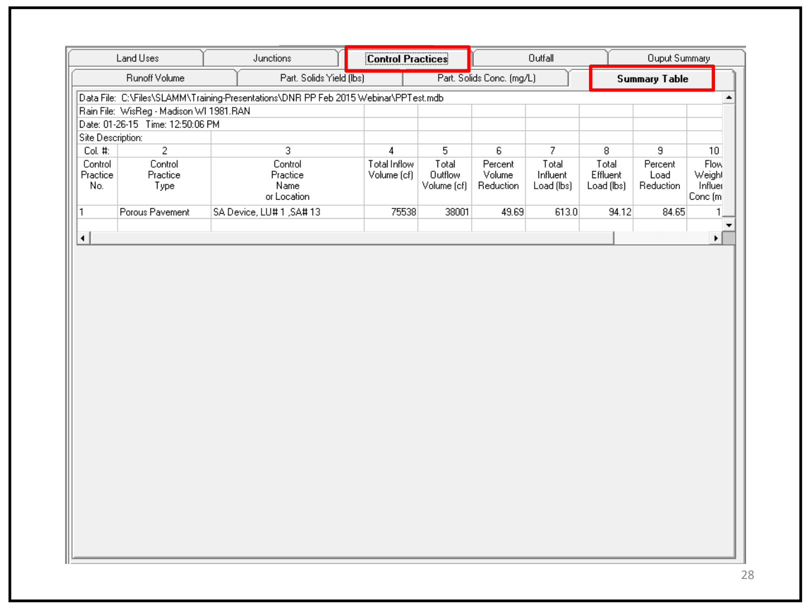

Land Uses
Junctions
Control Practices
Outfall
Ouput Summary
File Name:
C:\Files\SLAMM\Training-Presentations\DNR PP Feb 2015 Webinar\PPTest.mdb
Outfall Output Summary
Total of All Land Uses without Controls 75538 0.71 130.0 613.0
Outfall Total with Controls 38001 49.69 % 0.36 39.67 94.11 84.65 %
Current File Output: Annualized Total After Outfall Controls 50994
Years in Model Run: 0.75
126.3
Particulate Solids 130.0 39.67 mg/L 613.0 94.11 lbs 84.65 %
Total Phosphorus 0.2150 0.08646 mg/L 1.014 0.2051 lbs 79.77 %
Total Area Modeled (ac) 1.000
Total Control Practice Costs
Capital Cost $ 14730
Land Cost $ 0
Annual Maintenance Cost $ 49
Present Value of All Costs $ 15463
Annualized Value of All Costs $ 1039
Receiving Water Impacts Due To Stormwater Runoff
(CWP Impervious Cover Model)
Without Controls 0.71 Poor
With Controls 0.36 Poor
27

27


Land Uses
Junctions
Control Practices
Outfall
Ouput Summary
Runoff Volume
Part. Solids Yield (lbs)
Part. Solids Conc. (mg/L)
Summary Table
Data File: C:\Files\SLAMM\Training-Presentations\DNR PP Feb 2015 Webinar\PPTest.mdb
Rain File: WisReg - Madison WI 1981.RAN
Date: 01-26-15 Time: 12:50:06 PM
Site Description:
1 Porous Pavement SA Device, LU# 1 ,SA# 13 75538 38001 49.69 613.0 94.12 84.65
28

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Control Practice Summary Table

Data File: C:\Files\SLAMM\Training-Presentations\DNR PP Feb 2015 Webinar\PPTest.mdb
Rain File: WisReg - Madison WI 1981.RAN
Date: 01-25-15 Time: 12:38:41 PM
Site Description:

Col. #:	2	3	4	5	6	7	8	9
Control Practice No.	Control Practice Type	Control Practice Name or Location	Total Inflow Volume (cf)	Total Outflow Volume (cf)	Percent Volume Reduction	Total Influent Load (lbs)	Total Effluent Load (lbs)	Percent Load Reduction
1	Porous Pavement	SA Device, LU# 1 ,SA# 13	75538	37980	49.72	613.0	94.06	84.66

10	11	12	13	14	26	28	29	30	36	61
Flow Weighted Influent Conc (mg/L)	Flow Weighted Effluent Conc (mg/L)	Percent Conc. Reduction	Influent Median Part. Size (microns)	Effluent Median Part. Size (microns)	% of Clogging Factor	Maximum Subsurface Ponding Time (hrs)	Volume Infiltrated (cf)	Underdrain Discharge Vol. (cf)	Final Surface Infiltration Rate (in/hr)	Runoff Producing Events/ Ttl. Rains
130.0	39.67	69.483	7.80	2.33	0.12	68.50	37524.94	37979.71	87.93	21/86

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Control Practice Detail Tables

Runoff Volume

Data File: C:\Files\SLAMM\Training-Presentations\DNR PP Feb 2015 Webinar\PPTe
Rain File: WisReg - Madison WI 1981.RAN
Date: 01-25-15 Time: 12:38:40 PM
Site Description:

Control Practice Type ==> CP# 1 - Porous Pavement
Control Practice Name/Location ==> SA Device, LU# 1 ,SA# 13

Rain Number	Start Date	Rain Total (in)	Influent Runoff Vol.(cf)	Effluent Runoff Vol.(cf)	Runoff Vol. Percent Reduction
36	05/13/81	0.01	3.227	0	100.00
37	05/23/81	0.02	12.91	0	100.00
38	05/24/81	0.10	169.5	0	100.00
39	05/29/81	0.34	763.0	0	100.00
40	06/02/81	0.01	3.227	0	100.00
41	06/03/81	0.01	3.227	0	100.00
42	06/08/81	0.01	3.227	0	100.00
43	06/08/81	0.33	735.6	0	100.00
44	06/09/81	0.07	106.7	0	100.00
45	06/12/81	0.43	1013	0	100.00
46	06/15/81	2.59	8610	7311	15.09
47	06/20/81	0.34	763.0	0	100.00
48	06/21/81	0.32	708.6	0	100.00
49	06/23/81	0.51	1240	0	100.00
50	06/25/81	0.13	236.2	0	100.00
51	06/28/81	0.24	503.1	0	100.00
52	07/04/81	0.05	67.94	0	100.00
53	07/11/81	0.50	1211	56.08	95.37
54	07/12/81	0.14	258.9	21.94	91.53
55	07/12/81	0.86	2325	2075	10.74
56	07/13/81	1.32	3966	3778	4.72
57	07/14/81	0.12	214.2	0	100.00

Part. Solids Yield (lbs)

Data File: C:\Files\SLAMM\Training-Presentations\DNR PP Feb 2015 Webinar\PPT
Rain File: WisReg - Madison WI 1981.RAN
Date: 01-25-15 Time: 12:38:41 PM
Site Description:

Control Practice Type ==> CP# 1 - Porous Pavement
Control Practice Name/Location ==> SA Device, LU# 1 ,SA# 13

Rain Number	Start Date	Rain Total (in)	Influent Part. Sol. Yield(lbs)	Effluent Part. Sol. Yield(lbs)	Part.Yield Percent Reduction
36	05/13/81	0.01	0.02619	0	100.00
37	05/23/81	0.02	0.1048	0	100.00
38	05/24/81	0.10	1.376	0	100.00
39	05/29/81	0.34	6.192	0	100.00
40	06/02/81	0.01	0.02619	0	100.00
41	06/03/81	0.01	0.02619	0	100.00
42	06/08/81	0.01	0.02619	0	100.00
43	06/08/81	0.33	5.970	0	100.00
44	06/09/81	0.07	0.8662	0	100.00
45	06/12/81	0.43	8.224	0	100.00
46	06/15/81	2.59	69.88	22.59	67.67
47	06/20/81	0.34	6.192	0	100.00
48	06/21/81	0.32	5.751	0	100.00
49	06/23/81	0.51	10.06	0	100.00
50	06/25/81	0.13	1.917	0	100.00
51	06/28/81	0.24	4.083	0	100.00
52	07/04/81	0.05	0.5513	0	100.00
53	07/11/81	0.50	9.825	0.02718	99.72
54	07/12/81	0.14	2.101	0.004246	99.80
55	07/12/81	0.86	18.87	7.473	60.40
56	07/13/81	1.32	32.18	12.83	60.13
57	07/14/81	0.12	1.738	0	100.00

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Additional Output

Available through:
Tools/
Default Model Options

- ➢**Water Balance File**
- ➢**Mass Balance File**
- ➢**Stage Outflow File**
- ➢**Surface Seepage Rate File**
- ➢**Detailed Output File**
- ➢**Stochastic Seepage Rate Detail File**

PorPav Source Area Number	Rain Number	Rain Depth (in)	Time (Julian Date)	Maximum PorPav Stage (ft)	Minimum PorPav Stage (ft)	Total Source Area Runoff Before Porous Pavement (ac-ft)	Non-Porous Pavement Area Runoff Volume (ac-ft)	Event Inflow Volume onto Porous Pavement (ac-ft)	Event Bypass Volume Due to Surface Clogging (ac-ft)	Event Overflow Volume (ac-ft)	Event Infil Outflow (ac-ft)	Event Orifice Outflow (ac-ft)	Event Total Outflow (ac-ft)	Event Flow Balance (ac-ft)	Volume Reduction Fraction	Solids Reduction Fraction
46	1	0.46	0	0.01	0	0.01	0	0.01	0	0	0.01	0	0.01	0	1	0
46	2	0.58	5	0	0	0.012	0	0.012	0	0	0.012	0	0.012	0	1	0
46	3	0.25	9	0	0	0.005	0	0.005	0	0	0.005	0	0.005	0	1	0
46	4	0.03	11	0	0	0.001	0	0.001	0	0	0.001	0	0.001	0	1	0
46	5	0.39	11	0	0	0.008	0	0.008	0	0	0.008	0	0.008	0	1	0
46	7	0.05	18	0	0	0.001	0	0.001	0	0	0.001	0	0.001	0	1	0
46	8	0.03	22	0	0	0.001	0	0.001	0	0	0.001	0	0.001	0	1	0
46	9	2.33	23	0.01	0	0.049	0	0.049	0	0	0.049	0	0.049	0	1	0
46	12	0.51	34	0	0	0.011	0	0.011	0	0	0.011	0	0.011	0	1	0
46	15	0.67	47	0.01	0	0.014	0	0.014	0	0	0.014	0	0.014	0	1	0
46	16	0.61	50	0.01	0	0.013	0	0.013	0	0	0.013	0	0.013	0	1	0
46	18	0.85	63	0	0	0.018	0	0.018	0	0	0.018	0	0.018	0	1	0
46	20	1.02	66	0.01	0	0.021	0	0.021	0	0	0.021	0	0.021	0	1	0
46	22	1.48	70	0.01	0	0.031	0	0.031	0	0	0.031	0	0.031	0	1	0

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Modeling Wet Detention Ponds in WinSLAMM ver. 10.3

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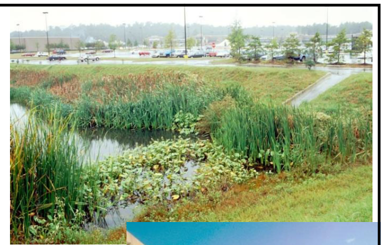
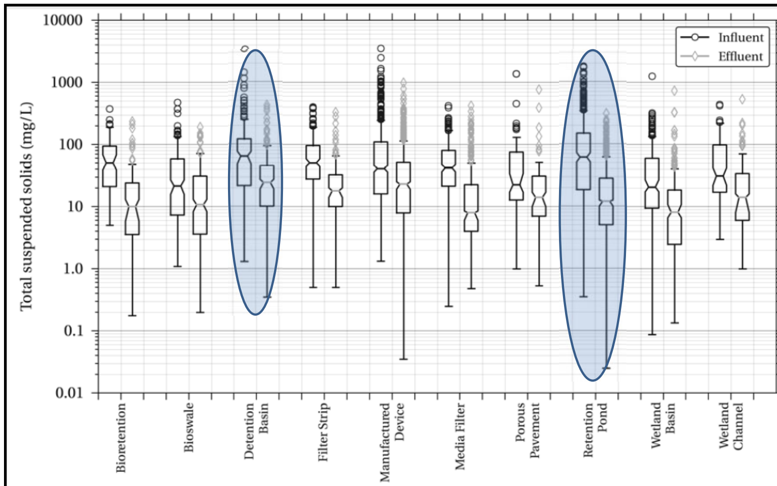
We will cover . .

- Pond Performance
- Entering Wet Detention Pond Data into the



33



TSS influent and effluent for different stormwater practices

International Stormwater BMP Database

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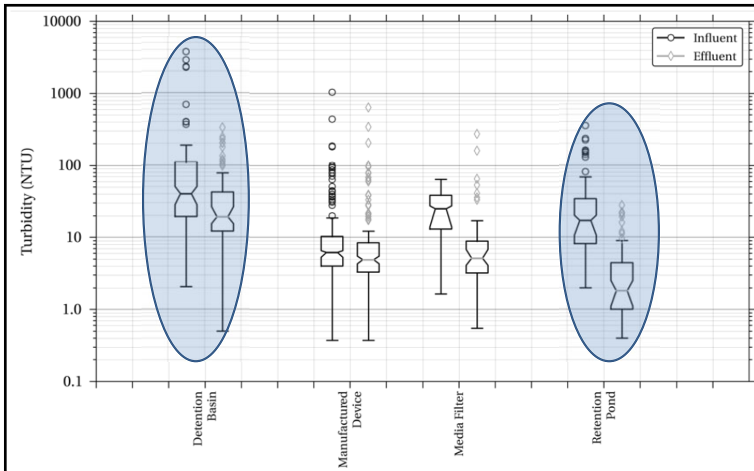

Turbidity influent and effluent for different stormwater practices

International Stormwater BMP Database

35

35

Why is there such a large difference in performance between a dry and a wet pond?

- Usually due to scour
  - Need at least 3 ft for wet ponds to protect previously captured silt
  - Grass filters look like dry ponds (and the grass filters can work well, but require lengthy sheetflows with level spreaders, low slopes, good grass stands, no pilot channels, etc.)
  - Terminology issues (in many areas, dry ponds are actually percolation ponds or infiltration ponds with no surface discharges). HIGs

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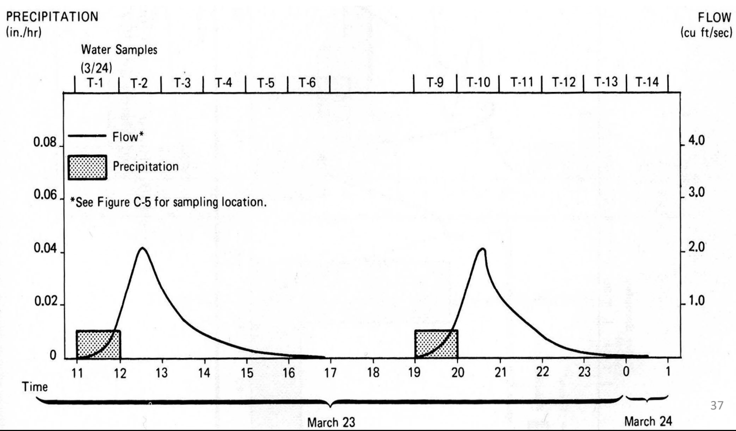
Urban Hydrology Simplifications for Small to Intermediate Storms

Examined about 550 monitored urban hydrographs that ranged from small and simple:



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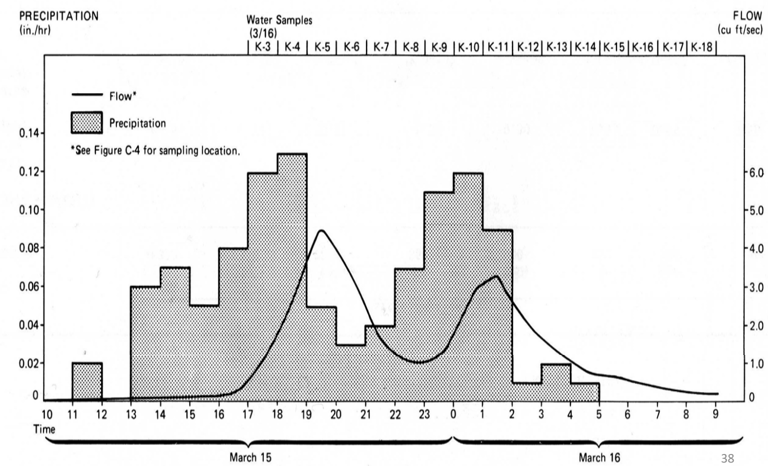
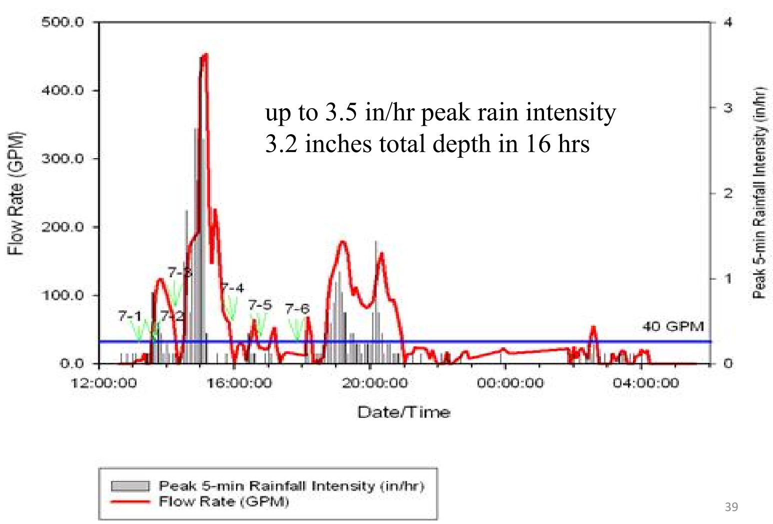


38



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Observed Urban Hydrographs

Evaluated about 550 different urban area hydrographs from 8 watersheds (1, 1a, 2, and 3 rain distributions and B soils to pavement)

Location	Land use	area (acres)	directly connected impervious	# of events monitored
Bellevue, WA				
Surrey Downs	Resid, med. den.	95	17 %	196
Lake Hills	Resid, med. den.	102	17	201
San Jose, CA				
Keyes	Resid, med. den.	92	30	6
Tropicana	Resid, med. den.	195	25	8
Toronto, Ontario				
Thistledowns	Resid, med. den.	96	21	35
Emery	Industrial	381	42	60
Tuscaloosa, AL				
City Hall	Institutional/com	0.9	100	31
BamaBelle	Commercial	0.9	68	17

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Observed Runoff Characteristics

	Monitored rains (inches, range)	Observed Rv (average)	Observed CN (range)	peak/avg flow ratio (average)
Bellevue, WA				
Surrey Downs	0.03 - 4.38	0.18	64 - 100	4.4
Lake Hills	0.02 - 3.69	0.21	73 - 100	5.4
San Jose, CA				
Keyes	0.01 - 1.06	0.10	88 - 100	3.2
Tropicana	0.01 - 1.08	0.59	95 - 100	3.8
Toronto, Ontario				
Thistledowns	0.03 - 1.01	0.17	84 - 99	4.0
Emery	0.03 - 1.0	0.23	87 - 99	3.1
Tuscaloosa, AL				
City Hall	0.02 - 3.2	0.60	95 - 99	4.2
BamaBelle	0.1 - 1.9	0.80	94 - 100	5.5

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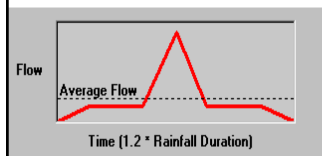
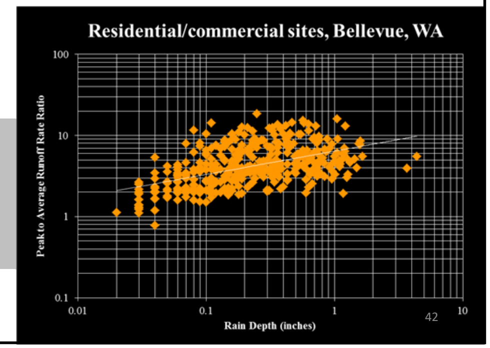
Complex Hydrograph Creation by WinSLAMM

- Flow rate calculated using Complex Triangular Hydrograph, based on statistical analysis of hundreds of monitored events throughout North America and for different land uses
  - Runoff Volume calculated from WinSLAMM
  - Runoff Duration = 1.2 times rainfall duration
  - Peak to average flow rate ratio user defined, but usually about 3.8





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Modeling Notes

- WinSLAMM assumes a 3.0 ft scour depth for complete settling; reduces treatment effectiveness for shallower depths.
- Pond routing is performed using the Modified Puls – Storage Indication Method.
- Time increments are established by the user; default = 6 minutes.

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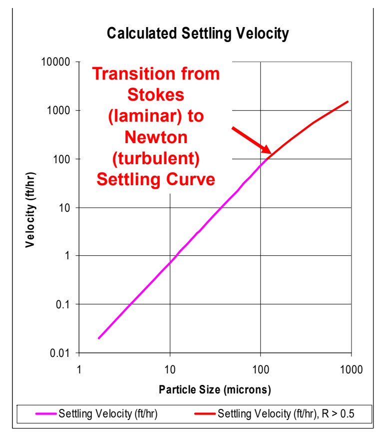
Particulate Settling

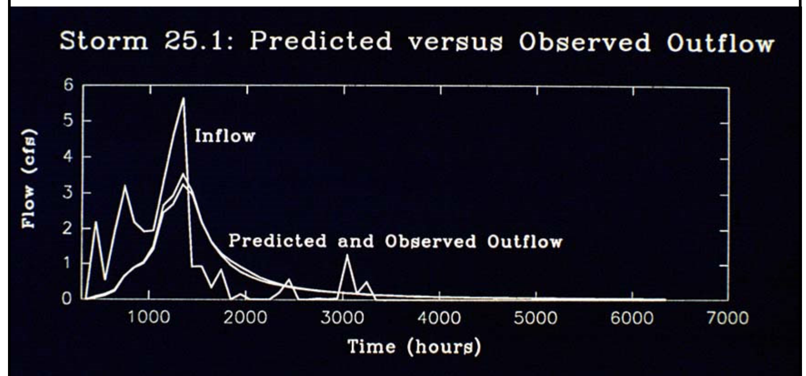
- Ideal settling is modeled
  - Using Stokes Law (laminar flow) for smaller particles
  - Settling velocity as a function of Reynolds number and particle size for larger particles under turbulent flow conditions
  - Water temperature (can vary monthly) and particle density also affect settling rates and can be changed in WinSLAMM



44

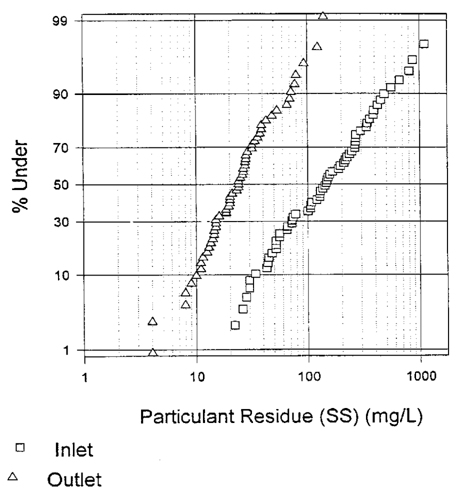
The Monroe St. detention pond in Madison has been monitored by the WI DNR and USGS for many years. The data have been used to verify the wet detention pond routines in WinSLAMM and Detpond (amongst other ponds). Retrofitted to result in 90% SS control, the long-term monitored results were 87%.

45



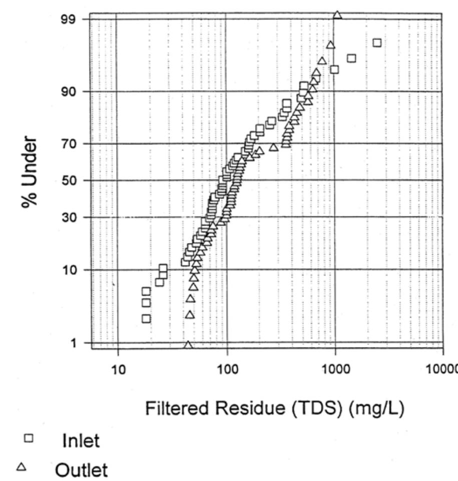
46

Suspended Solids Control at Monroe St. Detention Pond, Madison, WI (USGS and WI DNR data)



47

Dissolved Solids Control at Monroe St. Detention Pond, Madison, WI (USGS and WI DNR data)



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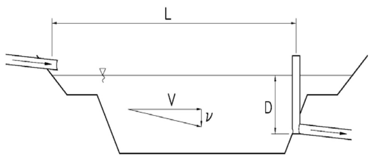
Particulate Settling



$$\frac{V}{v} = \frac{L}{D} \rightarrow v = \frac{Q_{out}}{A}$$

As shown on pages 23-25 of detention pond design.pdf and outlined on the following ppts

- **Ideal Settling: Particle path is vector sum of particle velocity through pond and settling (upflow) velocity**

- L = Pond Length
- D = Outlet Depth
- V = Water Velocity through Pond
- v = Settling Velocity
- Q_{out} = Outflow from Pond
- A = Pond Surface Area

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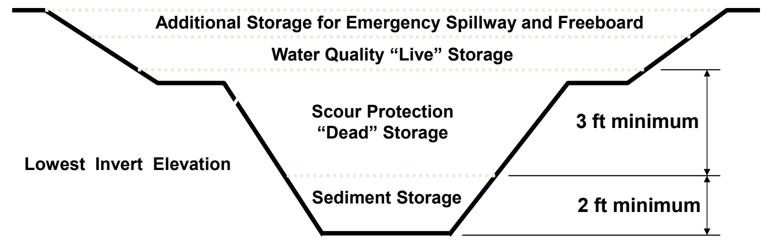
Conceptual Issues – Pond Geometry and Scour

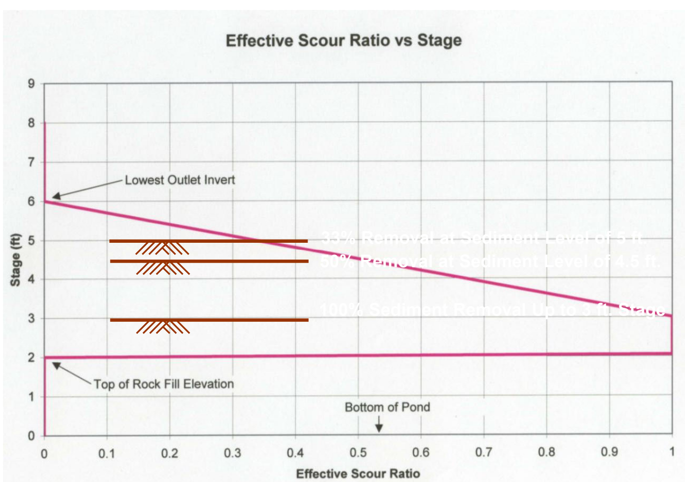


The "dead" storage is needed to prevent scour of previously deposited material and should be at least 3 ft. deep over the sediment. Sediment storage volume is also needed and can be estimated using the program, or should be at least 2 ft. deep.

50

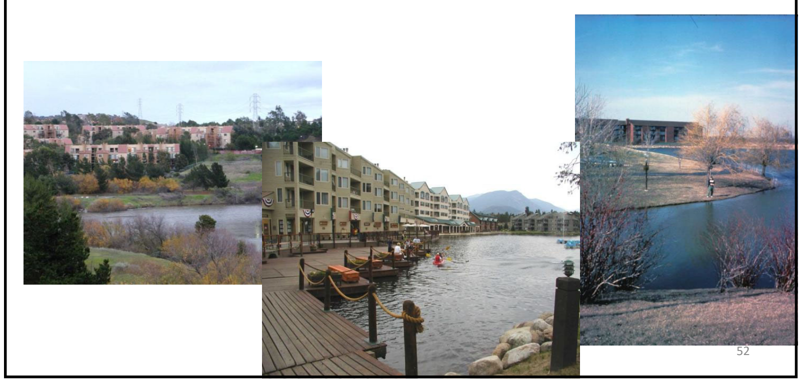
50

Scour in WinSLAMM



51

51



52

52

Wet Detention Pond Performance Calculation Data Requirements

- Surface area of pond
- Water quality volume (live storage above lowest pond water surface elevation, usually the pond volume between the water quality outlet and the emergency spillway)
- Depth of water over the sediment to prevent scour
- Stage-discharge relationship for all outlets
- Particle size distribution of inflowing
- Hydrograph of influent flows

53

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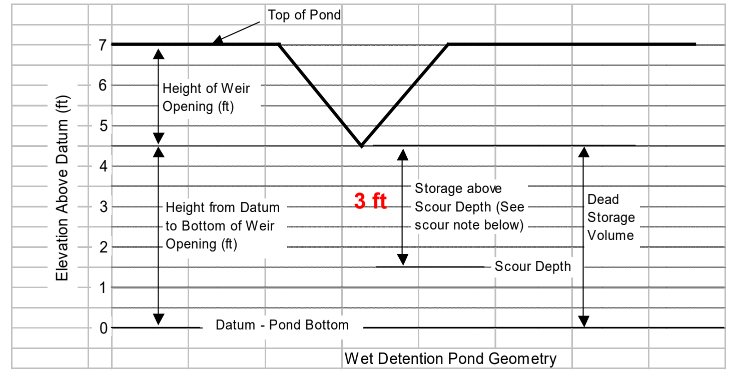
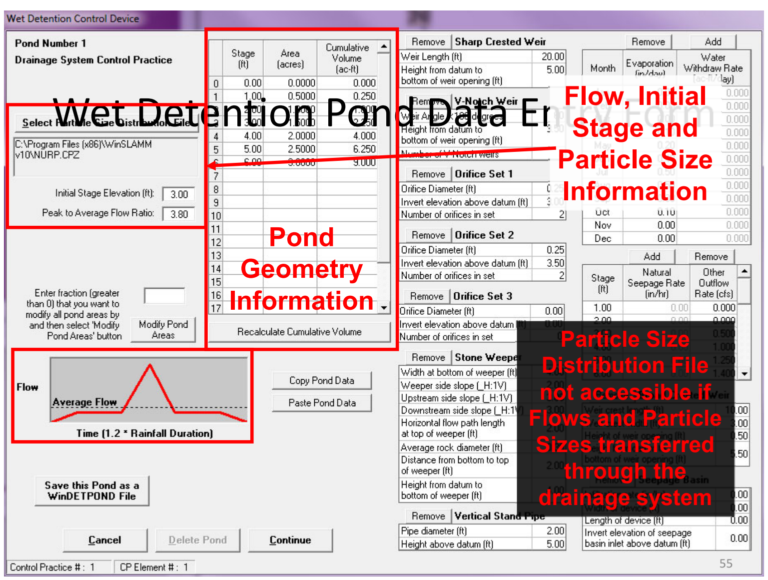
Pond Geometry



Pond Datum is always zero ft.

54

54



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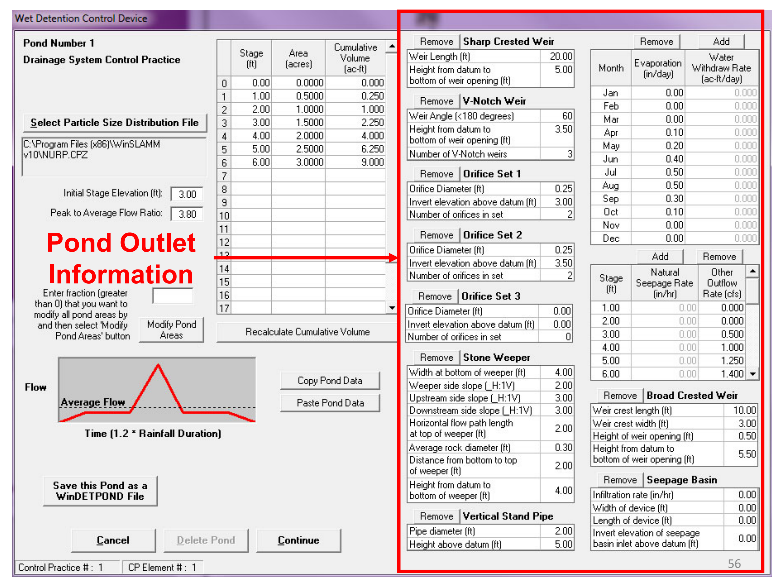
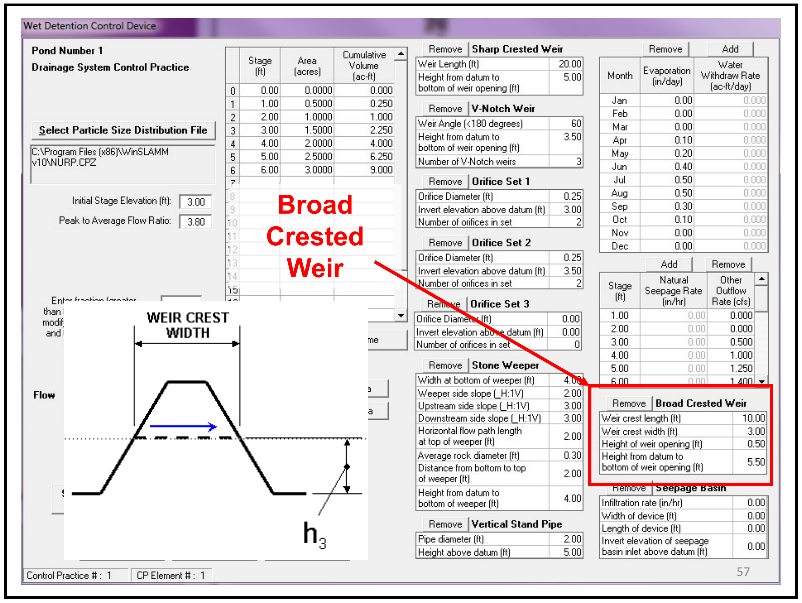
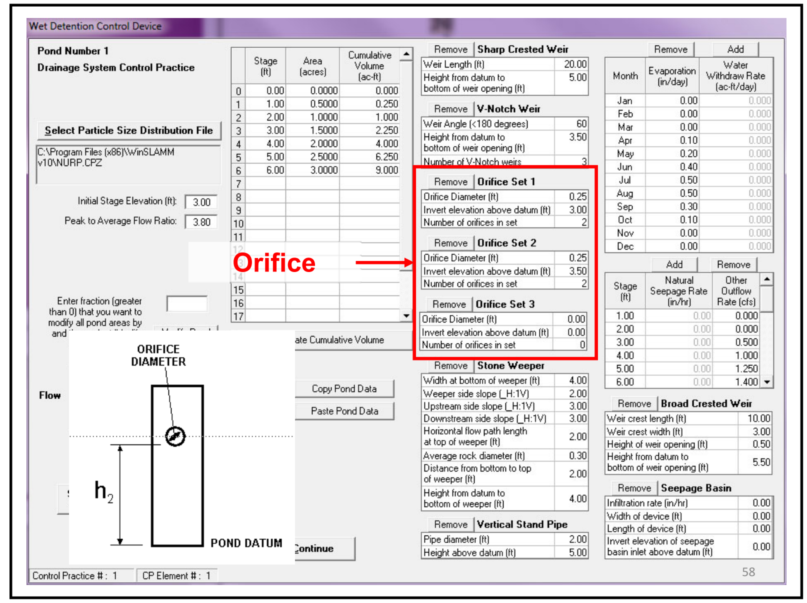


56

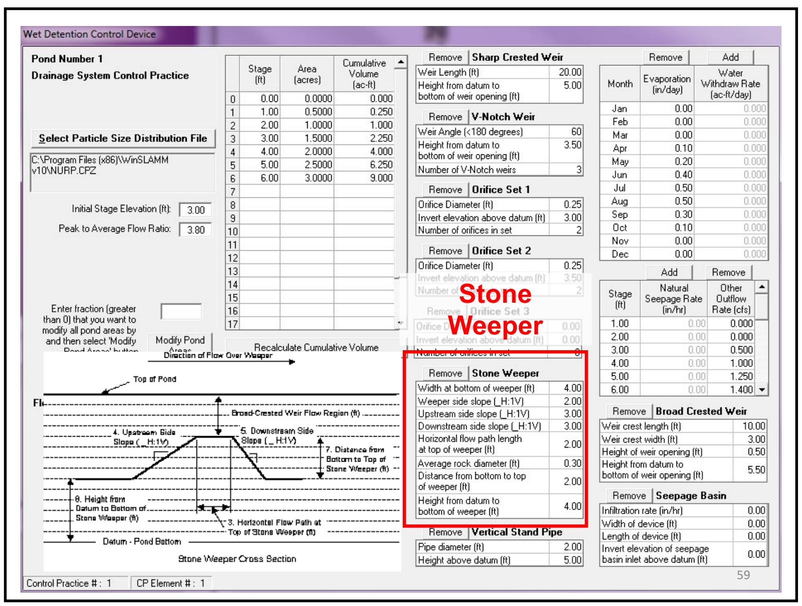
56


Wet Detention Control Device
Broad Crested Weir
WEIR CREST WIDTH
Flow
h_3

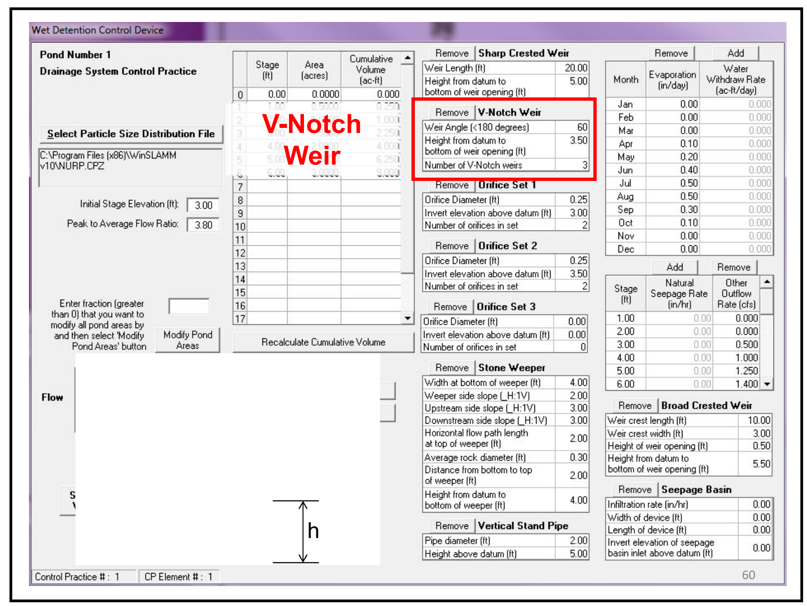
57


Wet Detention Control Device
Orifice
ORIFICE DIAMETER
Flow
h_2
POND DATUM

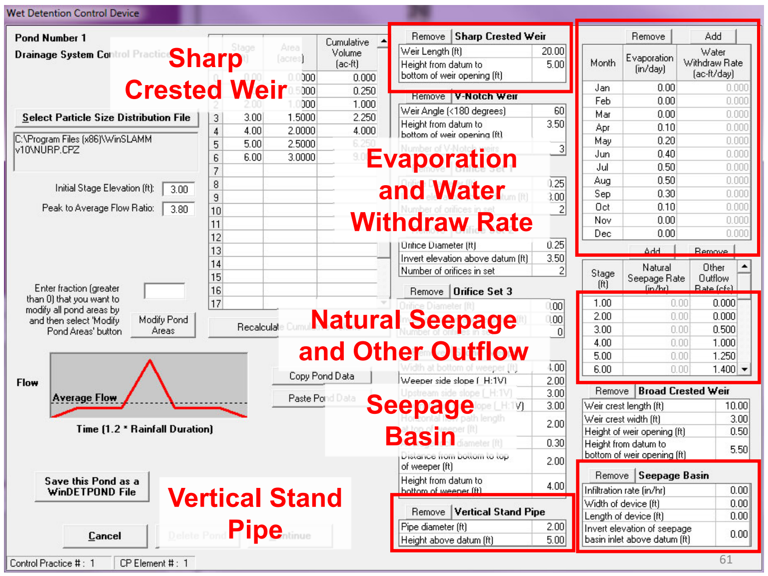
58


Wet Detention Control Device
Stone Weeper
Stone Weeper Cross Section

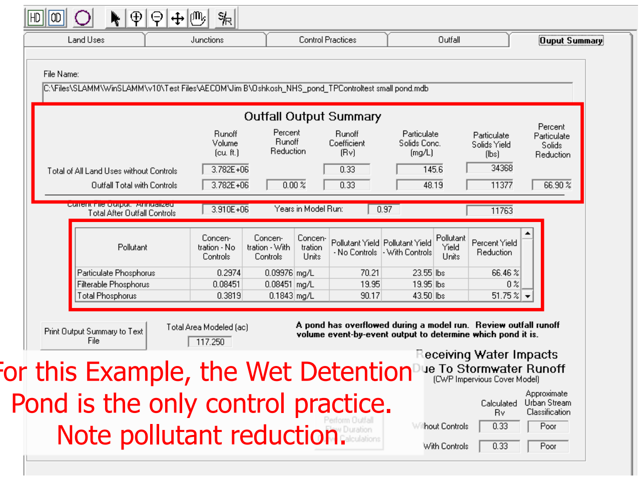
59


Wet Detention Control Device
V-Notch Weir
Flow
h

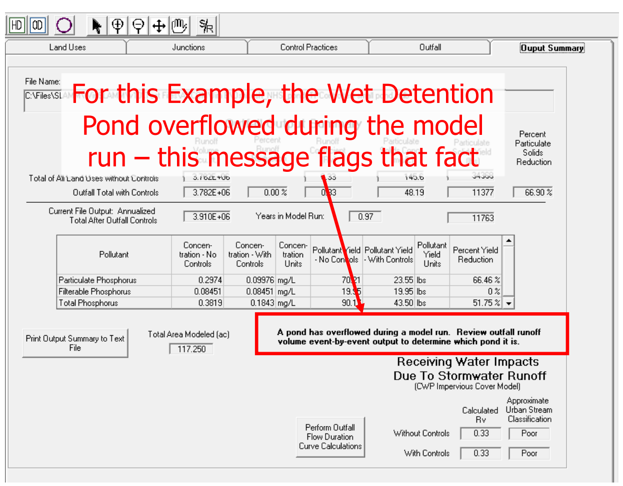
60



61



62



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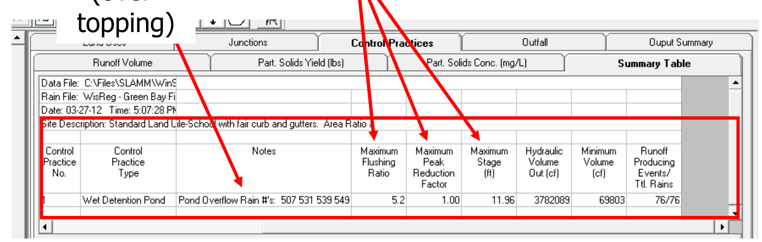
Outfall Runoff Volume

Pond Outlet Structure Failure (over-topping)

Maximum Flushing Ratio

Maximum Peak Reduction Factor

Maximum Stage



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Additional Output

- Stage Outflow
- Stone Weeper Flow
- Detailed Output by Time Step
- Pond Water Balance

Detention Pond Source Area Number	Pond Rain Number . .	Water Rain Depth (in) .	Balance Time (Julian Date) .	Performan Maximum Pond Stage (ft)	Summary, Minimum Pond Stage (ft)	by Event Inflow Volume (ac-ft)	Event Event Hydr Ouflow (ac-ft)	Event Infil Ouflow (ac-ft)	Event Evap Ouflow (ac-ft)	Event Wtr_Wdrl Outflow (ac-ft)	Event Total Ouflow (ac-ft)	Event Flow Balance (ac-ft)	Total Outflow (ac-ft) .	Cum Flow Balance (ac-ft)
162	1	0.46	0	3.67	3	0.63	0.6	0	0	0	0.6	0.03	0.6	0.03
162	2	0.58	5	3.57	3.06	0.843	0.834	0	0	0	0.834	0.009	1.434	0.039
162	3	0.25	9	3.38	3.08	0.277	0.249	0	0	0	0.249	0.029	1.683	0.068
162	4	0.03	11	3.14	3.12	0.009	0.013	0	0	0	0.013	-0.004	1.696	0.064
162	5	0.39	11	3.55	3.08	0.476	0.501	0	0	0	0.501	-0.025	2.198	0.039
162	6	0.01	14	3.08	3.03	0	0.026	0	0	0	0.026	-0.026	2.224	0.013
162	7	0.05	18	3.08	3.03	0.029	0.029	0	0	0	0.029	0	2.253	0.013
162	8	0.03	22	3.04	3.03	0.009	0.006	0	0	0	0.006	0.003	2.259	0.016
162	9	2.33	23	4.35	3.03	5.329	5.326	0	0	0	5.326	0.004	7.585	0.02
162	10	0.01	30	3.04	3.03	0	0.002	0	0	0	0.002	-0.002	7.587	0.017
162	11	0.01	30	3.03	3.01	0	0.012	0	0	0	0.012	-0.012	7.599	0.006
162	12	0.51	34	3.57	3.01	0.71	0.694	0	0	0	0.694	0.015	8.293	0.021
162	13	0.01	40	3.04	3.01	0	0.018	0	0	0	0.018	-0.018	8.312	0.003
162	14	0.01	46	3.01	3.01	0	0	0	0	0	0	0	8.312	0.003
162	15	0.67	47	3.94	3.01	1.026	0.991	0	0	0	0.991	0.035	9.303	0.038
162	16	0.61	50	3.86	3.08	0.896	0.8	0	0	0	0.8	0.096	10.103	0.134
162	17	0.01	51	3.25	3	0	0.133	0	0	0	0.133	-0.133	10.236	0.001
162	18	0.85	63	3.78	3	1.28	1.22	0	0	0	1.22	0.06	11.455	0.062
162	19	0.01	66	3.12	3.1	0	0.013	0	0	0	0.013	-0.013	11.468	0.049
162	20	1.02	66	3.94	3.1	1.56	1.402	0	0	0	1.402	0.158	12.87	0.207
162	21	0.01	67	3.38	3.08	0	0.166	0	0	0	0.166	-0.166	13.036	0.041
162	22	1.48	70	4.23	3.08	2.524	2.442	0	0	0	2.442	0.082	15.479	0.123
162	23	0.01	71	3.24	3.15	0	0.046	0	0	0	0.046	-0.046	15.524	0.078
162	24	0.01	72	3.15	3.1	0	0.028	0	0	0	0.028	-0.028	15.552	0.05
162	25	3.64	73	4.82	3.06	11.492	11.511	0	0	0	11.511	-0.019	27.063	0.031
162	26	0.04	78	3.1	3.06	0.022	0.008	0	0	0	0.008	0.014	27.071	0.045

65