Stormwater Guidelines and Case Studies

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Goals and Challenges for Manual

- State Stormwater Policy
- More Widespread Use of BMPs
- Address All Elements of Stormwater:
  - Volume
  - Peak Rate (Municipal Ordinance)
  - Channel Protection
  - Quality
  - Recharge

Guideline 1

1. Hold the runoff volume constant for up to the 2 year storm.

2. Peak Rates held to predevelopment levels for the 2 – 100 year storm.

3. Quality - Reduction of 85% of particulate associated pollutants (as represented by TSS) and 50% of solutes (as represented by NO3-N)

Guideline 2 – Special Areas

1. **Baseflow**
   - **Infiltrate Runoff from the first 1 ” of Rainfall**
2. **Quality**
   - **Reduction of 85% of particulate associated pollutants (as represented by TSS) and 50% of solutes (as represented by NO3-N)**
3. **Channel Protection**
   - **Release the post construction 1 year (24 hr) storm over at least 24 hours.**
4. **Flood Protection**
   - **Peak Rates held to predevelopment levels for the 2 – 100 year storm**

Challenges

More Widespread Use of BMPS, but

- How to Calculate?
- How to Show Compliance?
- Municipal Review and Approval
  - Peak Rate Attenuation

There is no benefit to the developer if the Design Engineer cannot get "credit" for BMPs.

What Have Other States/Cities Done? *Portland, OR*

"Simplified Method"

- Worksheets
- Specific Details for BMPs
- Alternative Methods Allowed

Form SIM: Simplified Approach for Stormwater Management

The city has produced this form to assist with a quick and simple approach to manage stormwater quality, flow rate, and volume on projects. Facilities sized with this form are presumed to comply with stormwater quality and flow control requirements.

New or Redeveloped Impervious Site Area _____ **Box 1**

INSTRUCTIONS

1. Enter square footage of new or redeveloped impervious site area in Box 1 at the top of this form.

2. Select impervious area reduction techniques from rows 1-3 to reduce the site's resulting stormwater management requirement. Tree credit can be calculated using the tree credit worksheet on the next page.

3. Select desired stormwater management facilities from rows 4-12. In Column 1, enter the square footage of impervious area that each facility will manage.

4. Multiply each impervious area from Column 1 by the corresponding sizing factor in Column 2, and enter the result in Column 3. This is the facility surface area needed to manage runoff from the impervious area.

5. Total Column 1 (Rows 1-12) and enter the resulting "Impervious Area Managed" in Box 2.

6. Subtract Box 2 from Box 1 and enter the result in Box 3. If this number is less than 500 square feet, stormwater quality and quantity requirements have been met. Submit this form with the application for permit.

7. If Box 3 is greater than 500 square feet, add square footage or facilities to Column 1 and recalculate, or use additional facilities from Chapter 3.0 of the Stormwater Management Manual to manage stormwater from these remaining surfaces.

	Column 1	Column 2	Column 3
Impervious Area Reduction Technique	**Impervious Area Managed = Facility Surface Area**		
1) Eco-Roof / Roof Garden	_____ sf		
2) Contained Planter Box	_____ sf		
3) Tree Credit (See Next Page)	_____ sf		

Note: Porous Pavement areas do not need to be included in Box 1

Stormwater Management Facility	**Impervious Area Managed**		**Sizing Factor**		**Facility Surface Area**	**Unit**
4) Infiltration Planter Box	_____ sf	x	0.06	=		sf
5) Flow-Through Planter Box	_____ sf	x	0.06	=		sf
6) Vegetated Swale	_____ sf	x	0.09	=		sf
7) Grassy Swale	_____ sf	x	0.1	=		sf
8) Vegetated Filter Strip	_____ sf	x	0.2	=		sf
9) Vegetated Infil. Basin	_____ sf	x	0.09	=		sf
10) Sand Filter	_____ sf	x	0.06	=		sf
11) East Side Soakage Trench	_____ sf	x	0.06	=		sf
12) West Side Soakage Trench	_____ sf	x	0.08	=		sf

Total Impervious Area Managed _____ **Box 2**

Box 1 - Box 2 _____ **Box 3**

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2) Contained Planter Box	_____	sf	
3) Tree Credit (See Next Page)	_____	sf	

Note: Porous Pavement areas do not need to be included in Box 1

- BMPs that receive direct "credit"
- Deciduous Trees = 100 SF
  - 6 Trees = 600 SF Impervious Area that is "managed"

3. Select desired stormwater management facilities from rows 4-12. In Column 1, enter the square footage of impervious area that each facility will manage.

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11) East Side Soakage Trench	_____ sf	x	0.06	=		sf
12) West Side Soakage Trench	_____ sf	x	0.08	=		sf

Total Impervious Area Managed		Box 2
Box 1 - Box 2		Box 3

- Planter Box
  - 1000 SF Impervious x 0.06 = 60 SF

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Total Impervious Area Managed		Box 2
Box 1 - Box 2		Box 3

- Vegetated Filter Strip
  - 2,600 SF Impervious x 0.2 = 520 SF

Portland, OR

"Simplified Method"

- Add up Areas Managed by Different BMPs
- Tells User "How Much" of a BMP is needed
- If Less Than 500 Square Feet "Unmanaged", You're Done!
- Alternative Methods Allowed

What Have Other States/Cities Done?
Georgia Manual

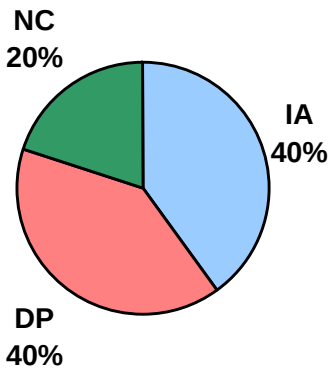
- Water Quality Worksheets
- Credit for
  - Structural
  - Non-structural
- Submitted for Regulatory Review

http://www.northgeorgiawater.com/

Drainage Area 01

Land Use Distribution (acres)

Enter Total Area :	**10.00**
Enter Impervious Area (IA) :	4.00
Enter Disturbed Pervious Area (DP) :	4.00
Enter Natural Conservation Area (NC) :	2.00
Total Area for check :	***10.00***
Percent Imperviousness (%) :	**40%**

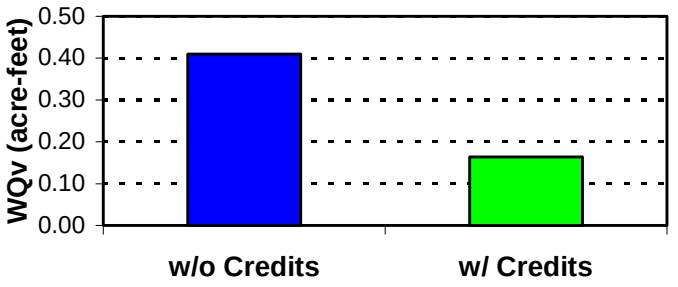


Non-Structural Controls (Site Design Credits)

Natural Conservation Area (acres):	2.00
Enter Area (acres) Treated by (if applicable):	
Undisturbed Stream Buffers :	2.00
Vegetated Channels :	2.00
Overland Flow Filtration / Recharge :	
Total Area receiving Credits (acres):	**6.00**

Water Quality Volume (WQ_V)

WQ_V (ac-ft) w/o Credits =	**0.410**
WQ_V w/ Non-Struc. Credits =	**0.164**

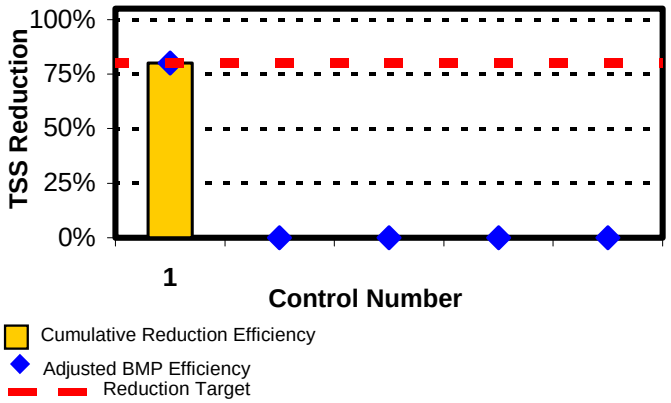


Structural Controls

Select Structural Control(s)		Control ID
Control 1	Bioretention Area	BRA-01-1
Control 2	NONE	NONE
Control 3	NONE	NONE
Control 4	NONE	NONE
Control 5	NONE	NONE

TSS Reduction Chart

TSS Reduction from Structural Controls: **80%**



Additional Downstream Treatment

If the runoff leaving this drainage area is treated by one or more additional structural controls downstream, please specify the appropriate drainage area(s) below:

☐ DA 2 ☐ DA 3 ☐ DA 4 ☐ DA 5 ☐ DA 6 ☐ DA 7 ☐ DA 8 ☐ DA 9 ☐ DA 10

Total TSS Reduction Using Non-Structural Controls (Site Design Credits), Structural Controls, and Additional Downstream Treatment (if applicable): **84%**

CH2MHILL

Local Government Specific Information (fill in only if required by Development Review Department)

Watershed Basin:	District/LL/Parcel:	Comm. District:

Georgia Stormwater Management Manual
Stormwater Quality Site Development Review Tool

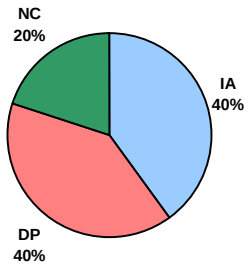
General Information

Name of Developer:	*John Q. Developer*	Date Submitted:	
Development Name:	*Happy Acres*	Permit Number:	
Site Location / Address:		Developer Contact:	
		Phone Number:	
Development Type:	*Office/Professional*	Name of Engineer(s):	
Area of Development (acres):	**10.00**	Maintenance Responsibility:	

Summary of Site and Structural Control Information

Number of Drainage Areas:	
Sum of Drainage Areas (ac) :	**10.00**
Total (IA) Impervious Area (ac) :	4.00
Total (DP) Disturbed Pervious Area (ac) :	4.00
Total (NC) Natural Conservation Area (ac) :	2.00
Percent Imperviousness (%) :	40%

Land Use Distribution Pie

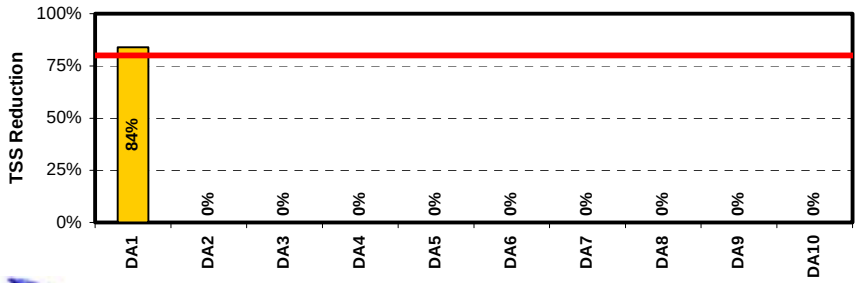


Total # of Structural Controls Used: 1

General Application Structural Stormwater Controls		Limited Application Structural Stormwater Controls	
Stormwater Pond	0	Filter Strip	0
Stormwater Wetland	0	Grass Channel	0
Bioretention Area	1	Organic Filter	0
Sand Filter	0	Underground Sand Filter	0
Infiltration Trench	0	Submerged Gravel Wetland	0
Enhanced Swales	0	Gravity (Oil-Grit) Separator	0
Detention Structural Stormwater Controls		Porous Concrete**	0
Dry Detention / Dry ED Basin	0	Modular Porous Paver System**	0
Multi-Purpose Detention Area	0	Alum Treatment System	0
Underground Detention	0	Proprietary Structural Control***	0

TSS Reduction

Total TSS Reduction (%) : 84%



Official Use Only

Tracking #:	
Reviewed By:	
Date Approved:	
Conditions of Approval:	

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Other States

- New Jersey
  - Worksheet to Calculate Required Recharge
  - Pervious and Impervious Calculated Separately
- Delaware
  - DURMM
  - Quality and Infiltration
  - One BMP

Proposal for Pennsylvania:

- A Simplified Method
- Worksheet for Designers
- Demonstrate Compliance for:
  - Volume
  - Rate
  - Water Quality
  - Stream Protection
- Municipal Approval and NPDES Permit
- Alternative Methodologies Accepted

Critical Challenges:

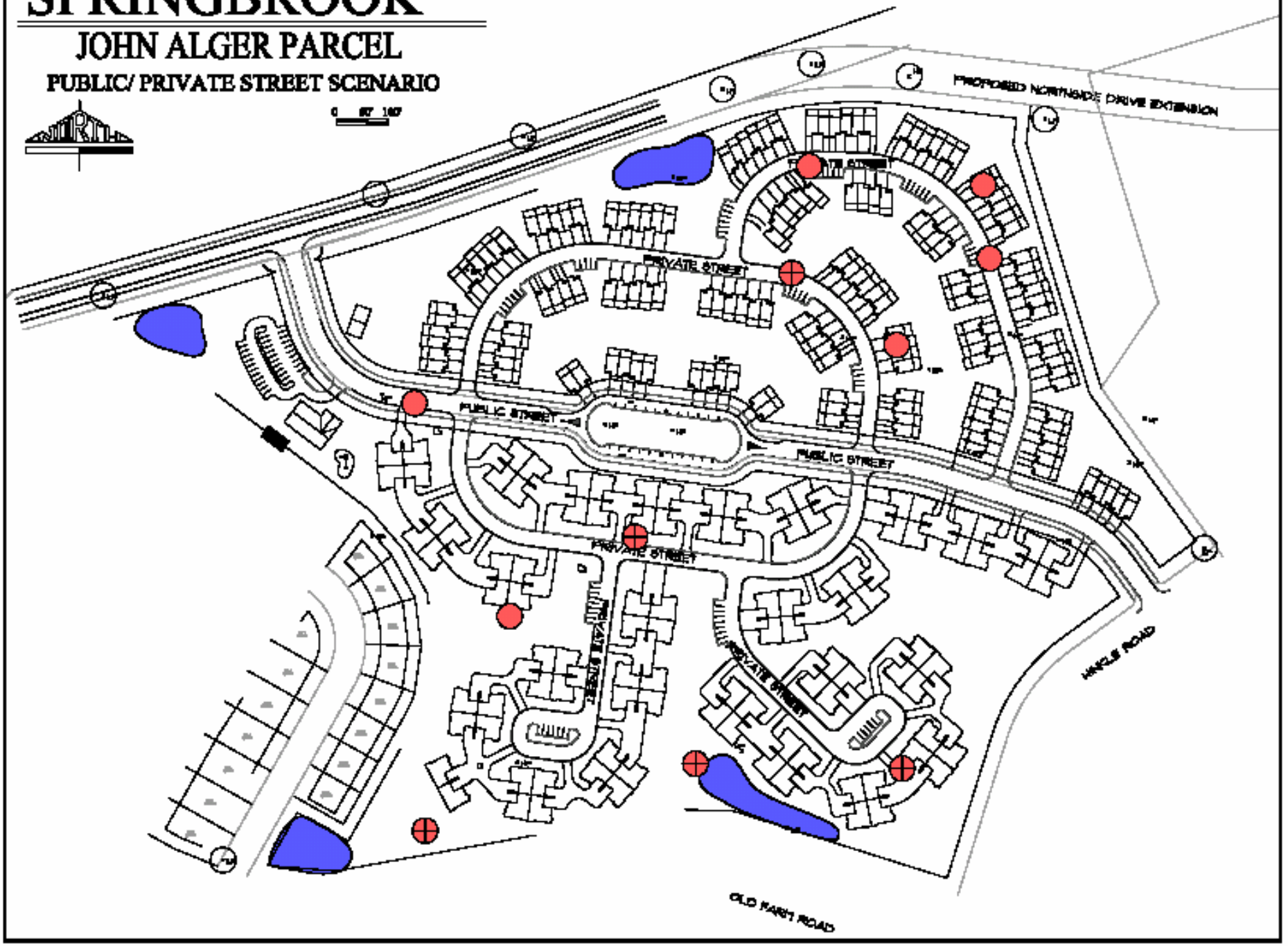
- Linking Volume, Rate, and Quality
- Decentralized – Linking Many BMPs
- Providing a Tool for LID Design Calculations
- Providing a Tool to Calculate Volume

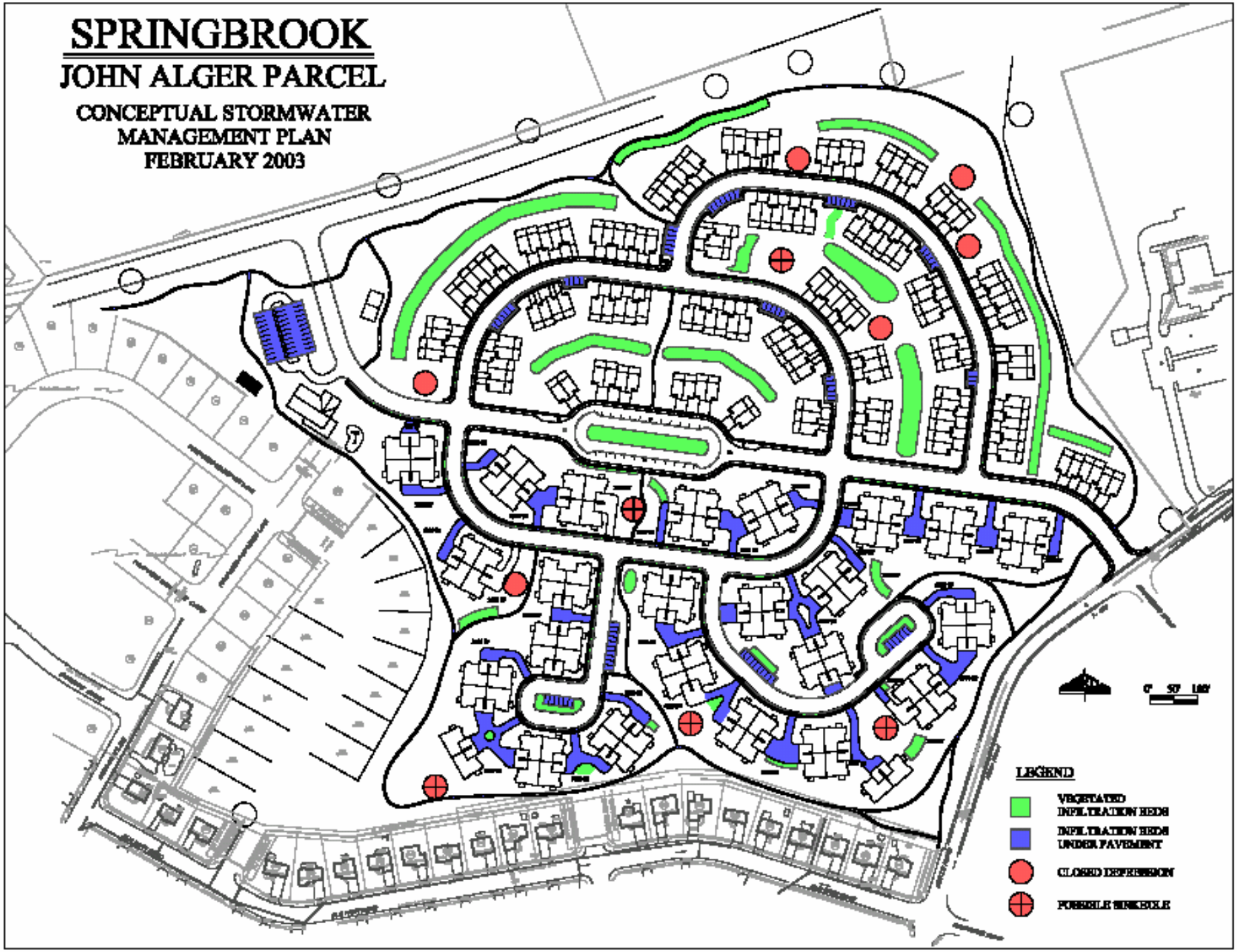
How Does the Designer Provide Stormwater Calculations?

SPRINGBROOK

JOHN ALGER PARCEL

PUBLIC/ PRIVATE STREET SCENARIO



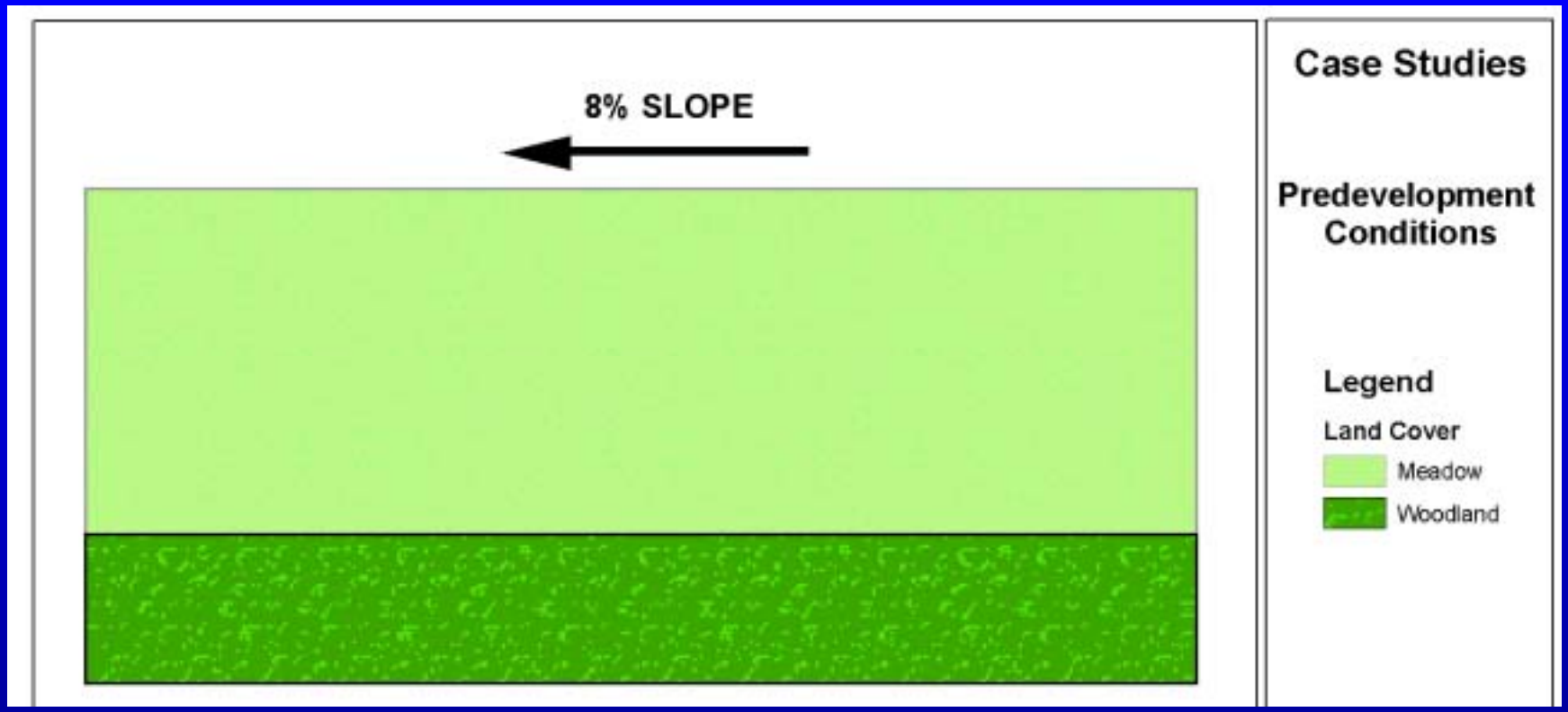

SPRINGBROOK
JOHN ALGER PARCEL
CONCEPTUAL STORMWATER
MANAGEMENT PLAN
FEBRUARY 2003
LEGEND
VEGETATED
INFILTRATION BEDS
INFILTRATION BEDS
UNDER PAVEMENT
CLOSED DEPRESSION
POSSIBLE SINKHOLE

Two Case Studies

- Residential
  - Ten Lots
  - Conveyance to Detention Basin
  - 20% Impervious
- Commercial “Big Box”
  - 52,000 Square Feet Building, 248 Parking Spaces
  - Detention Basin
  - 60% Impervious

Compare Conventional and BMP Design

Site Assumptions



- Ten Acres Undeveloped
- 70% Meadow, 30% Woods
- C Soils
- 8% Slope

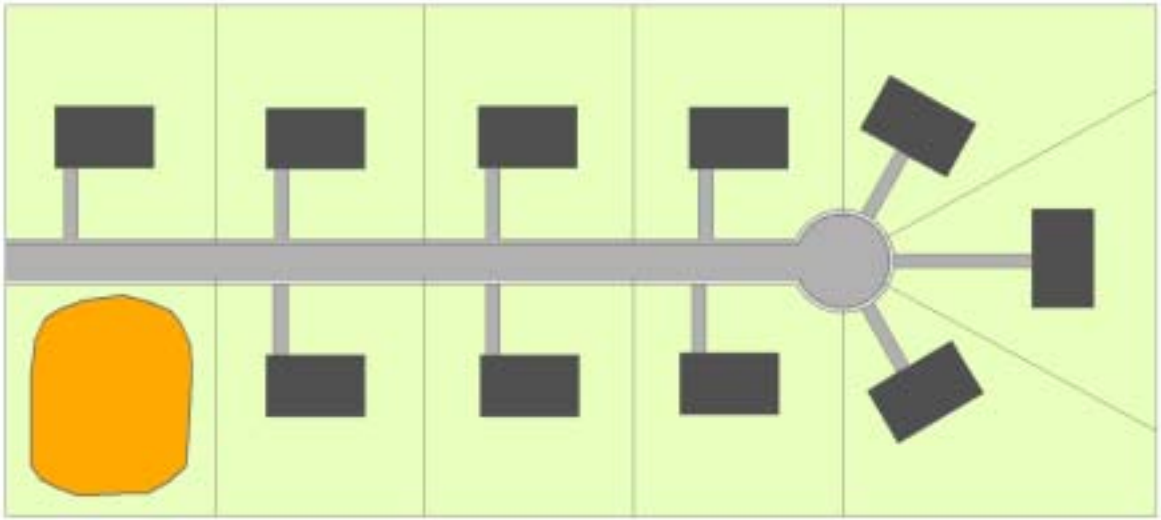
Methodology

- USDA NRCS Cover Complex
- Mitigate Peak Rates 2-Year to 100-Year Events
  - 1-Year 2.4 in 2-Year 2.8 in
  - 10-Year 4.3 in 100-Year 5.8 (Blair County)
- Impervious and Pervious Areas Considered Separately
  - Curve Number
  - Time of Concentration Tc
- Infiltration: National Engineering Handbook Chapter 12
  - Site Average affected by Head

Provide Calculations for Municipal Approval

Residential Case Study

Option #1 Detention Basin



Legend

Land Cover

- Building
- Road/Driveway
- Walkway/Curb
- Detention Basin
- Lawn

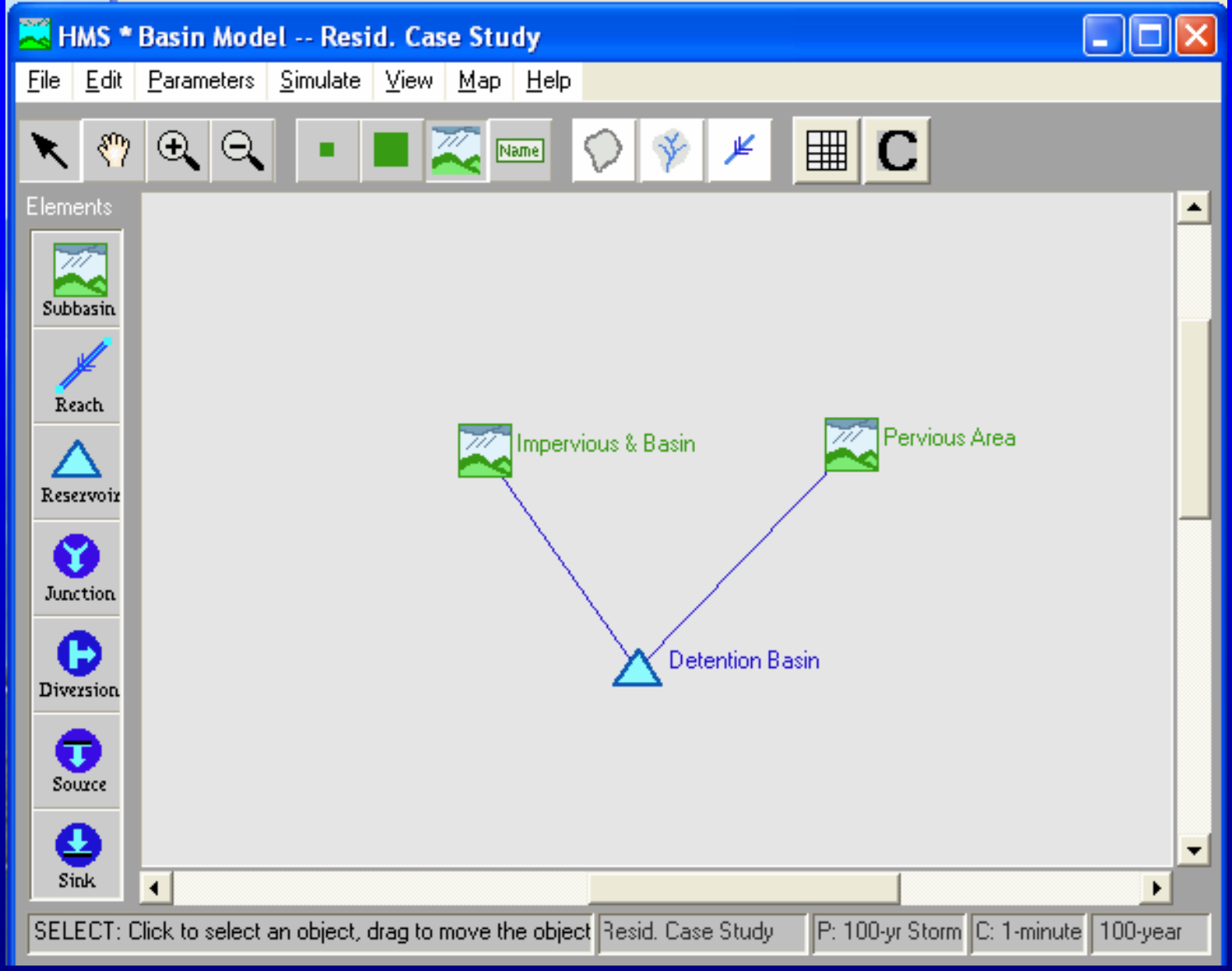
100 Feet

Land Cover Summary

Land Cover	Area (SF)	Area (Acres)
Impervious		
Building	45050	1
Road/Driveway	34902	1
Walkways/Curb	7168	0.2
Total	87120	2
Pervious/Semi-pervious		
Detention Basin	15000	0.3
Lawn	333480	8
Total	348480	8
Total Percent Impervious		**20%**

Detention Basin Storage: 40,000 cubic-feet

20% Impervious

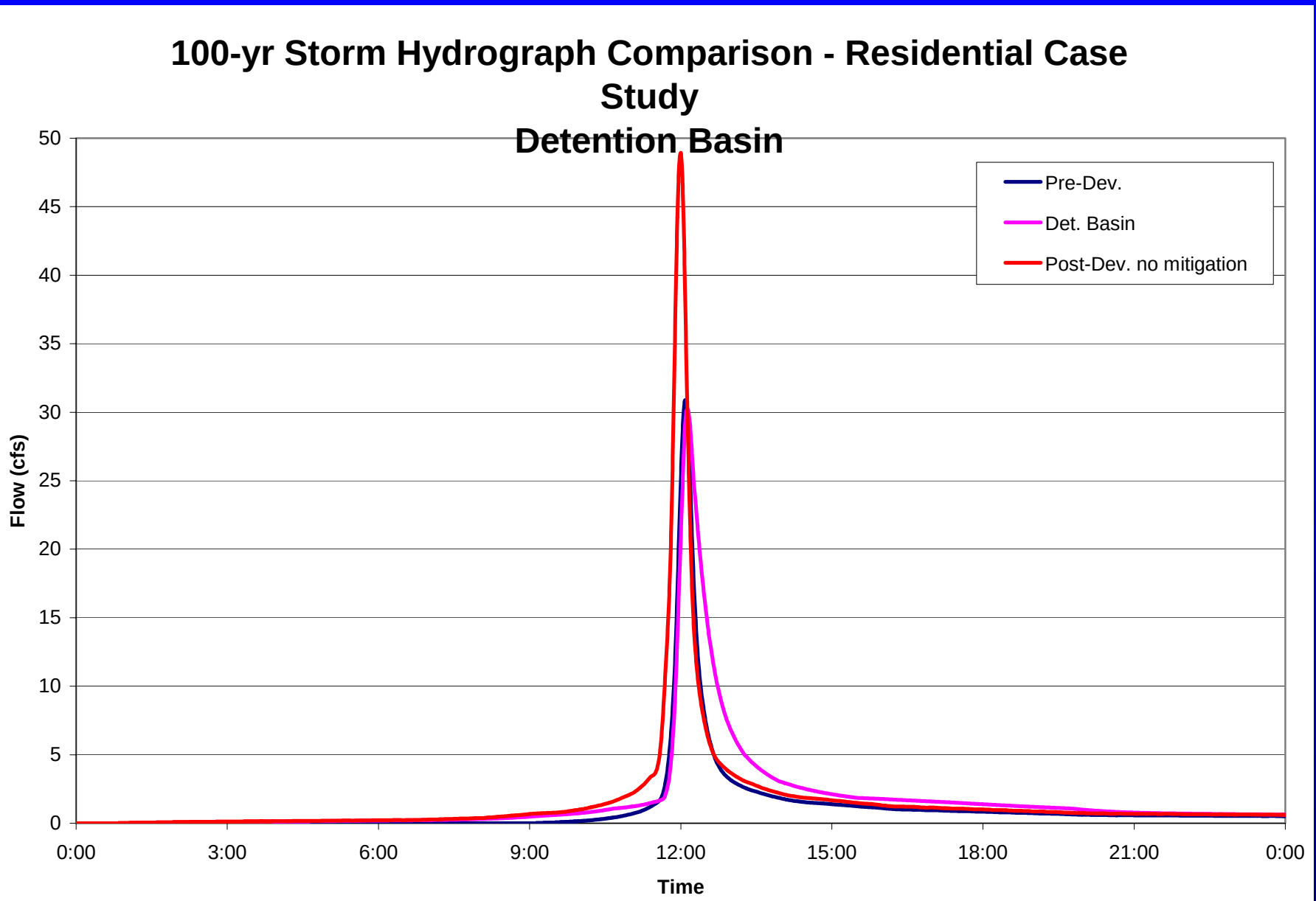


Residential Routing Through Detention Basin

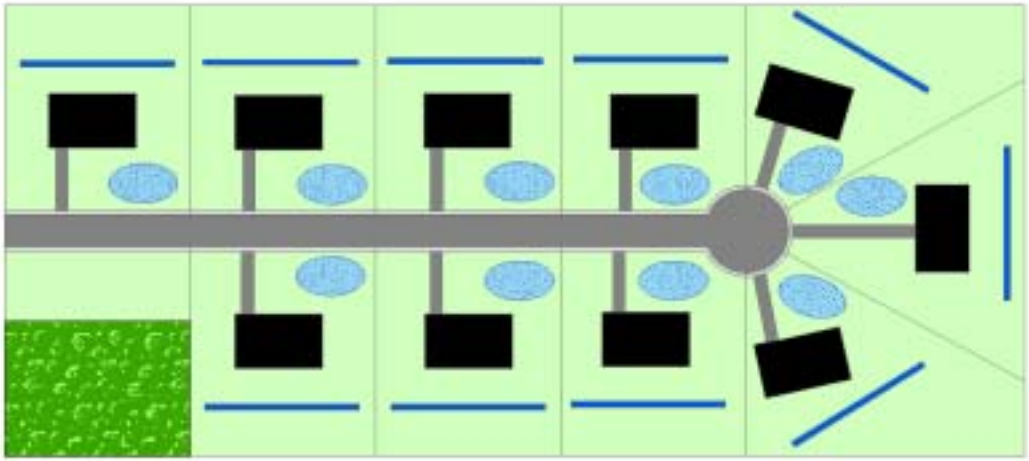
Residential Detention Basin

							For Rectangular Weir				Infiltration	Low-flow Orifice	
BB Elevation	Elev. (ft)	Area (ft^2)	Volume in Pipes (ft^3)	Volume[a] (ft^3)	Total Storage Volume (ft^3)	Total Storage Volume (ac-ft)	Head (ft)	Discharge Coefficient, Cd	Weir Length (ft)	Capacity (cfs)	Q=A*Infiltration Rate[b] (cfs)	Q=CdA(2gh)$^{1/2}$ (cfs)	**Q, total[c] (cfs)**
0.00	0.00	18325	0	0	0	0	---	---	---	0	0	0	**0.00**
0.25	0.25	18881	0.00	4651	4651	0.107	---	---	---	0	0.00	0.49	**0.49**
0.50	0.50	19438	0.00	9441	9441	0.217	---	---	---	0	0.00	0.69	**0.69**
0.75	0.75	19994	0.00	14370	14370	0.330	0.00	0.62	2.25	0.00	0.00	0.85	**0.85**
1.00	1.00	20550	0.00	19438	19438	0.446	0.25	0.62	2.25	0.94	0.00	0.98	**1.91**
1.25	1.25	21106	0.00	24645	24645	0.566	0.50	0.62	2.25	2.65	0.00	1.09	**3.74**
1.50	1.50	21663	0.00	29991	29991	0.688	0.75	0.62	2.25	4.87	0.00	1.20	**6.06**
1.75	1.75	22219	0.00	35476	35476	0.814	1.00	0.62	2.25	7.49	0.00	1.29	**8.78**
2.00	2.00	22775	0.00	41100	41100	0.944	1.25	0.62	2.25	10.47	0.00	1.38	**11.85**
2.25	2.25	23331	0.00	46863	46863	1.076	1.50	0.62	2.25	13.76	0.00	1.47	**15.23**
2.50	2.50	23888	0.00	52766	52766	1.211	1.75	0.62	2.25	17.35	0.00	1.54	**18.89**
2.75	2.75	24444	0.00	58807	58807	1.350	2.00	0.62	2.25	21.19	0.00	1.62	**22.81**
3.00	3.00	25000	0.00	64988	64988	1.492	2.25	0.62	2.25	25.29	0.00	1.69	**26.98**

- Stage – Storage – Discharge Table
- 40,000 cubic-feet
- Multi-Stage Outlet
- Only Managed Large Storm Peak


100-yr Storm Hydrograph Comparison - Residential Case Study
Detention Basin
Pre-Dev.
Det. Basin
Post-Dev. no mitigation
Flow (cfs)
50
45
40
35
30
25
20
15
10
5
0
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
Time

BMP Design



Residential Case Study

Option #2 Volume Control

Legend

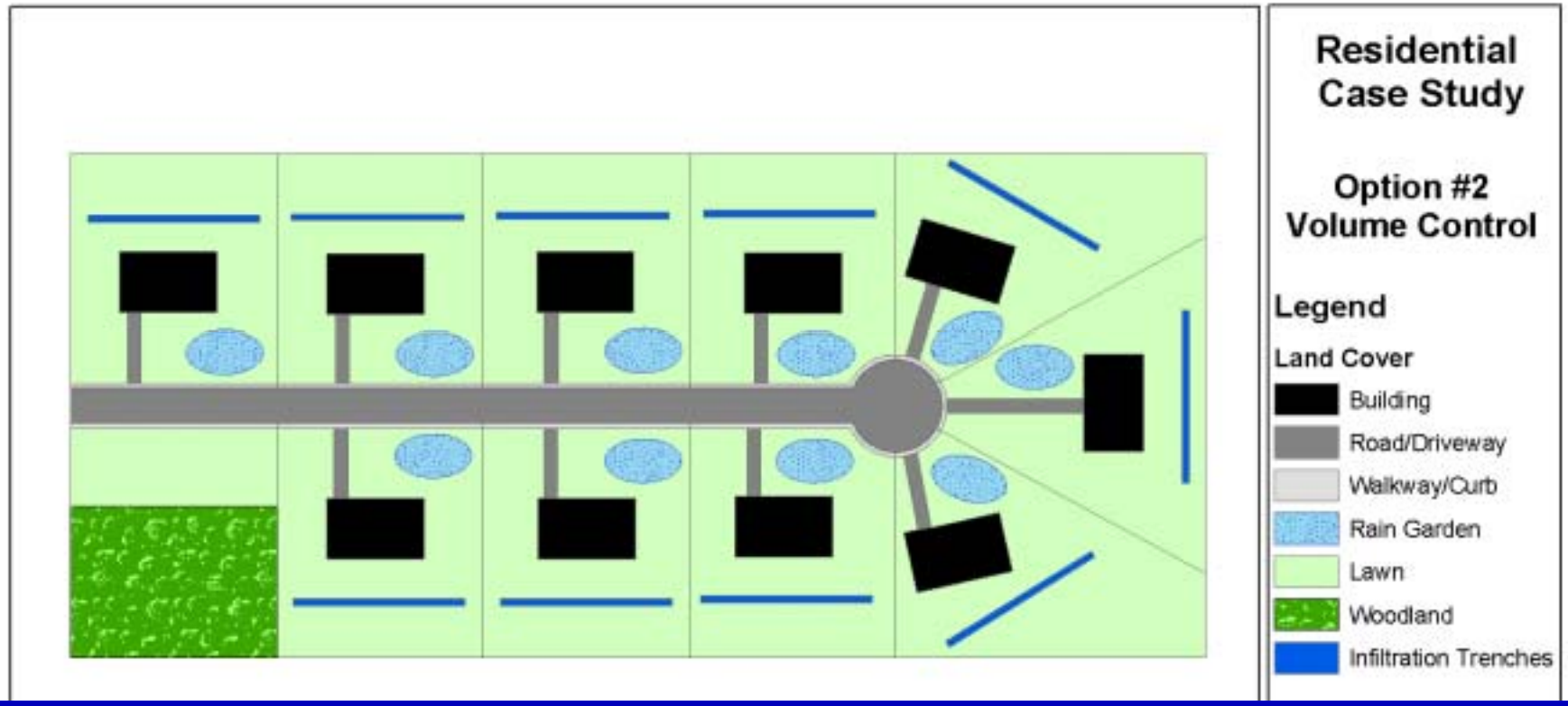
Land Cover

- Building
- Road/Driveway
- Walkway/Curb
- Rain Garden
- Lawn
- Woodland
- Infiltration Trenches

100 Feet

Land Cover Summary

Land Cover	Area (SF)	Area (Acres)
Impervious		
Building	45050	1
Road/Driveway	34902	1
Walkways/Curb	7168	0.2
Total	87120	2
Pervious/Semi-pervious		
Woodland	23760	0.5
Lawn	304720	7
Total	328480	8
Stormwater Management		
Rain Garden	20000	0.5
Total Percent Impervious		**20%**



- **20% Impervious**
- **2,000 SF Rain Garden on each Lot**
- **Infiltration Trench/Vegetated Swale for Conveyance**

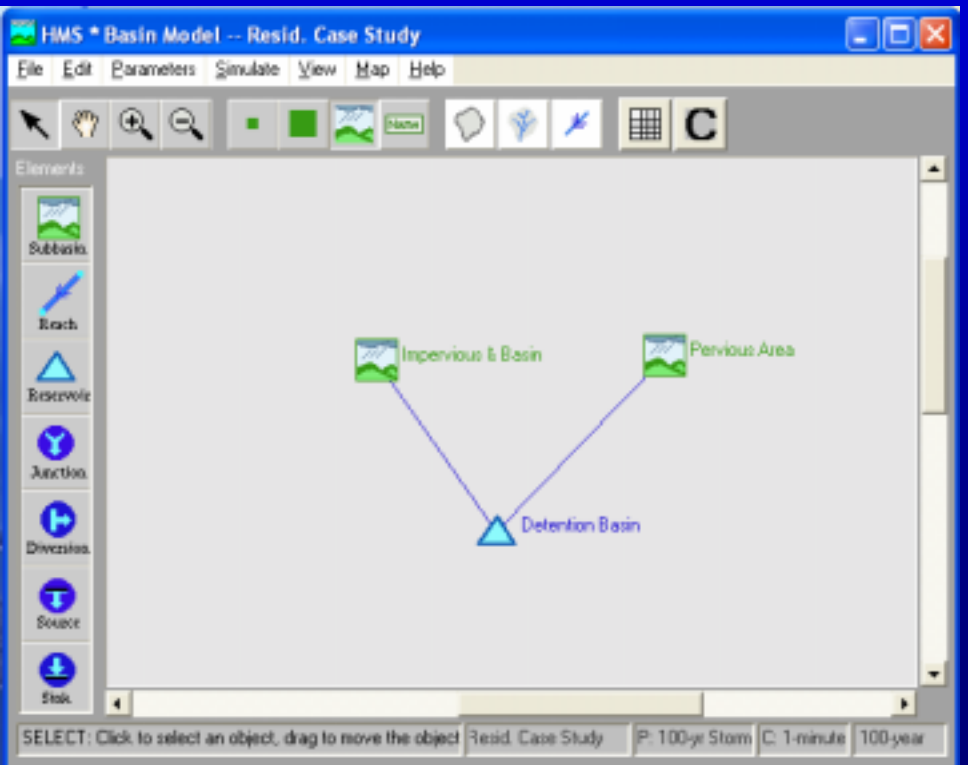
Storage in BMPs = 2-year Volume Increase 27,600 CF

	Land Cover	Area (SF)	Curve Number	Initial Abstraction (I_a), in.	2-year Storm 2.8 inches	
					Inches	CF
Proposed	Lawn	304,720	79	0.53	1.04	26,521
	R. Gardens	20,000	98	0.04	2.57	4,282
	Impervious	87,120	98	0.04	2.57	18,652
	Meadow	0	---	---	---	---
	Woods	23,760	70	0.86	0.61	1,200
	TOTAL	435,600	83.2	0.43	1.40	50,655
Existing	Lawn	0	---	---	---	---
	Det. Basin	0	---	---	---	---
	Impervious	0	---	---	---	---
	Meadow	304,920	71	0.82	0.65	16,469
	Woods	130,680	70	0.86	0.61	6,600
	TOTAL	435,600	70.7	0.83	0.64	23,069
Net Difference						**27,586**

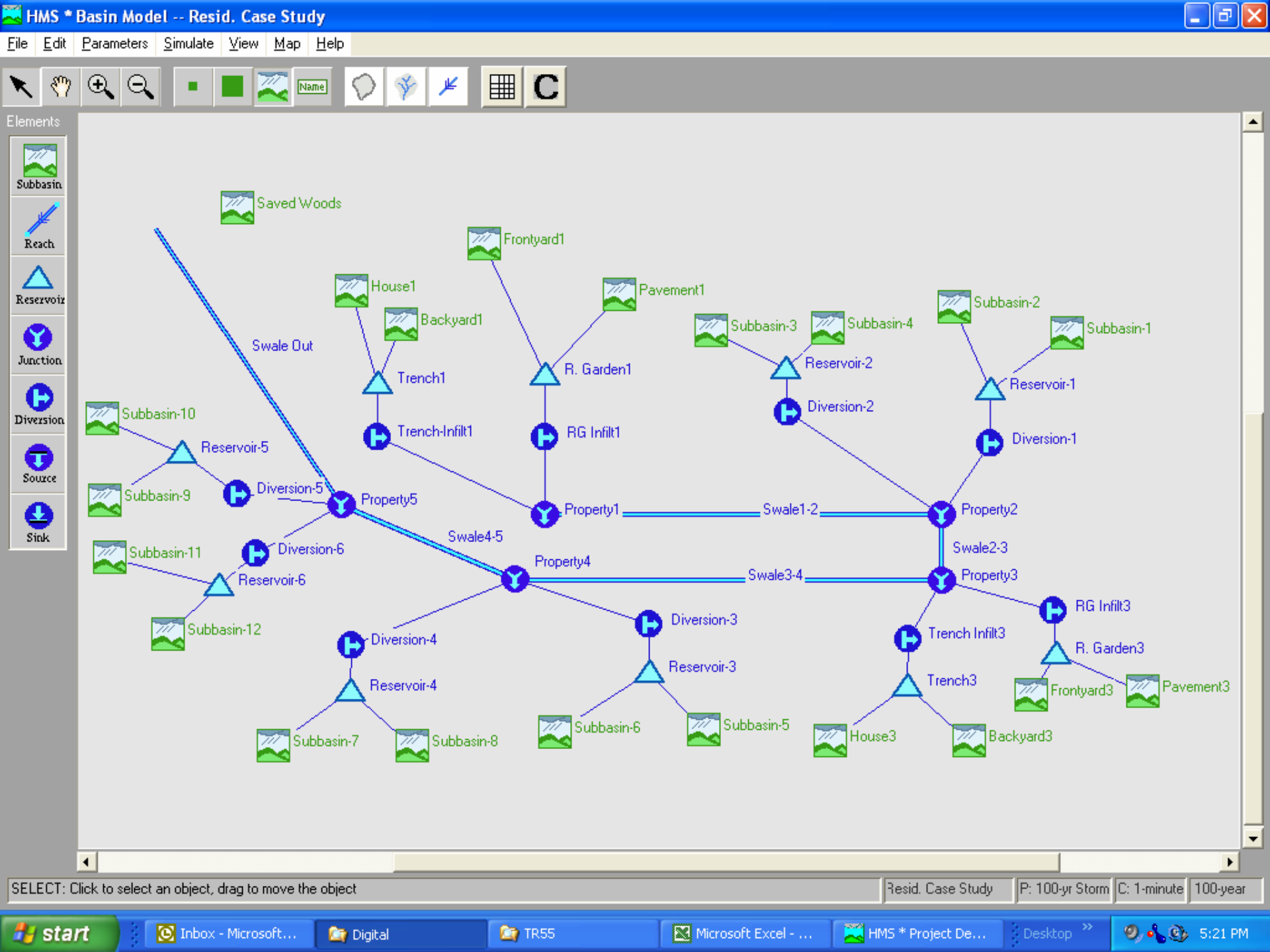
2-Year Volume Increase = 27,600 CF

Designer's Question:

Rain Gardens sound good, but how do I calculate Peak Rate Control and gain Municipal Approval??



Residential Routing Through Detention Basin


HMS * Basin Model -- Resid. Case Study
File
Edit
Parameters
Simulate
View
Map
Help
Name
C
Elements
Subbasin
Reach
Reservoir
Junction
Diversion
Source
Sink
Saved Woods
Frontyard1
House1
Pavement1
Backyard1
Subbasin-3
Subbasin-4
Subbasin-2
Subbasin-1
Swale Out
Trench1
R. Garden1
Reservoir-2
Reservoir-1
Diversion-2
Subbasin-10
Trench-Infilt1
RG Infilt1
Diversion-1
Reservoir-5
Subbasin-9
Diversion-5
Property5
Property1
Swale1-2
Property2
Subbasin-11
Diversion-6
Swale4-5
Swale2-3
Reservoir-6
Property4
Swale3-4
Property3
RG Infilt3
Subbasin-12
Diversion-4
Diversion-3
Trench Infilt3
R. Garden3
Reservoir-4
Reservoir-3
Trench3
Frontyard3
Pavement3
Subbasin-7
Subbasin-8
Subbasin-6
Subbasin-5
House3
Backyard3
SELECT: Click to select an object, drag to move the object
Resid. Case Study
P: 100-yr Storm
C: 1-minute
100-year
start
Inbox - Microsoft...
Digital
TR55
Microsoft Excel - ...
HMS * Project De...
Desktop
5:21 PM

INFILTRATION TRENCH TABLE			
Stage (ft)	**Storage (CF)**	**Infilt. (cfs)**	**Total Discharge (cfs)**
0.00	0	0.000	**0.00**
0.01	5	0.008	**0.008**
0.25	120	0.019	**0.019**
0.50	240	0.031	**0.134**
0.75	360	0.042	**0.145**
1.00	480	0.053	**0.209**
1.25	600	0.065	**0.529**
1.50	720	0.076	**0.983**
1.75	840	0.088	**1.538**

RAIN GARDEN TABLE			
Stage (ft)	**Storage (CF)**	**Infilt. (cfs)**	**Total Discharge (cfs)**
0.00	0	0.000	**0.00**
0.01	30	0.071	**0.081**
0.10	302	0.081	**0.314**
0.25	761	0.098	**0.652**
0.50	1545	0.129	**1.962**
0.65	2027	0.148	**2.409**

- Stage-Storage-Discharge Table for Every BMP?!
- Route every BMP to Calculate Peak Rate from Site?!
- What was my budget for this job?

Forget It!

We did the calculations

- Compare Runoff Volume
- Compare Peak Rates

Can BMP Method Mitigate Peak Rate for Municipal Approval?

Peak Rate Mitigation – Detention

Storm Event	Pre-Dev. Peak (cfs)	Post-Dev. Peak (cfs)	Post-Dev. Peak w/ Basin (cfs)	Change (%)
1	3.9	12.9	3.8	-2.6%
2	6.3	16.7	6	-4.8%
10	17.6	32.3	16.6	-5.6%
100	30.9	48.9	30.2	-2.1%

BMP Design

Storm Event	Pre-Dev. Peak (cfs)	Post-Dev. Peak (cfs)	Post-Dev. Peak w/ Volume Control (cfs)	Change (%)
1	3.9	12.9	3.9	0.0%
2	6.3	16.7	5.8	-7.9%
10	17.6	32.3	17.5	-0.7%
100	30.9	48.9	30.3	-1.9%

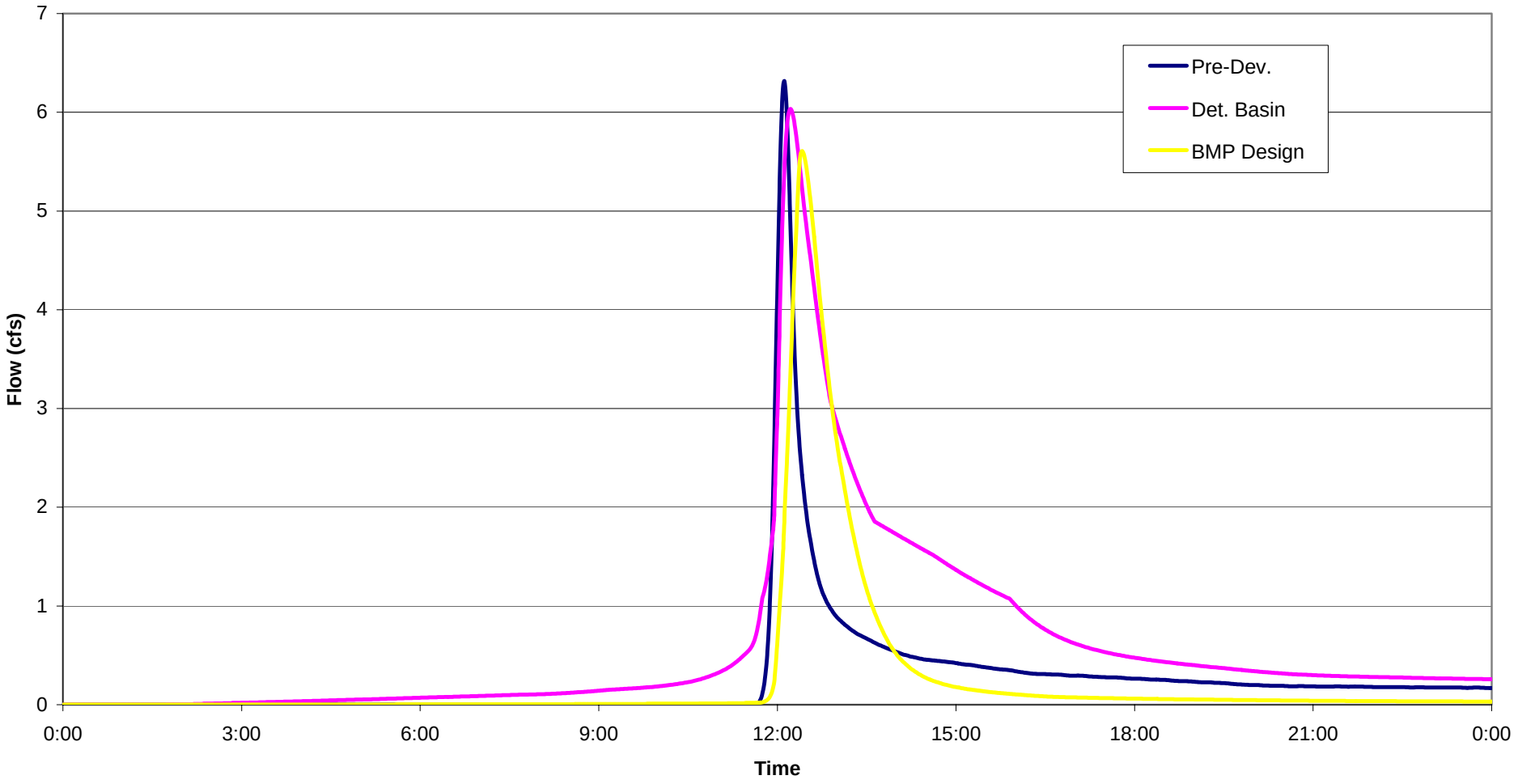
Increase in Volume – Detention

Storm Event	Pre-Dev. Runoff (in.)	Post-Dev. Runoff (in.)	Change (%)
1	0.43	1.09	153%
2	0.64	1.39	117%
10	1.57	2.62	67%
100	2.7	3.96	47%

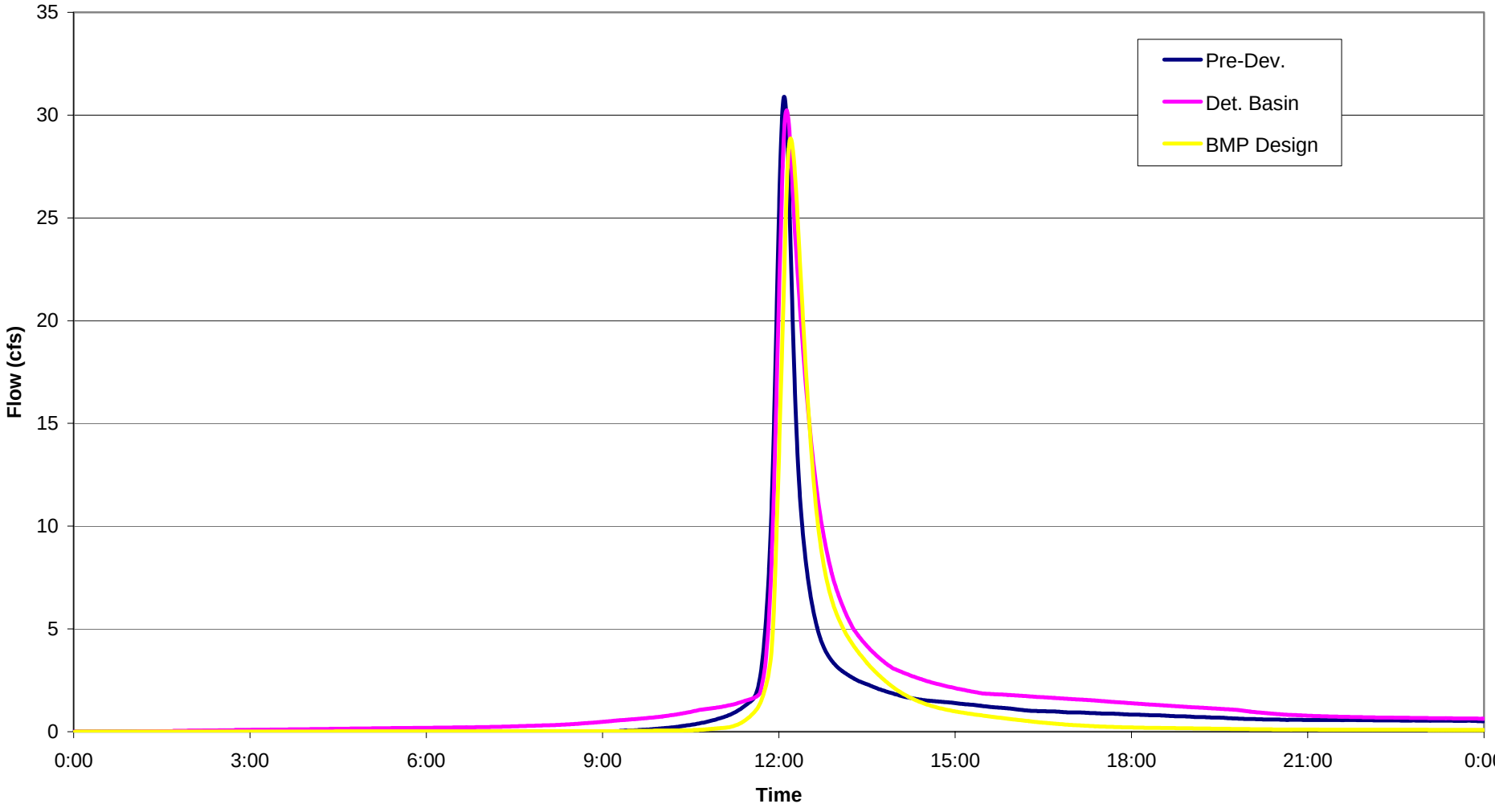
BMPs

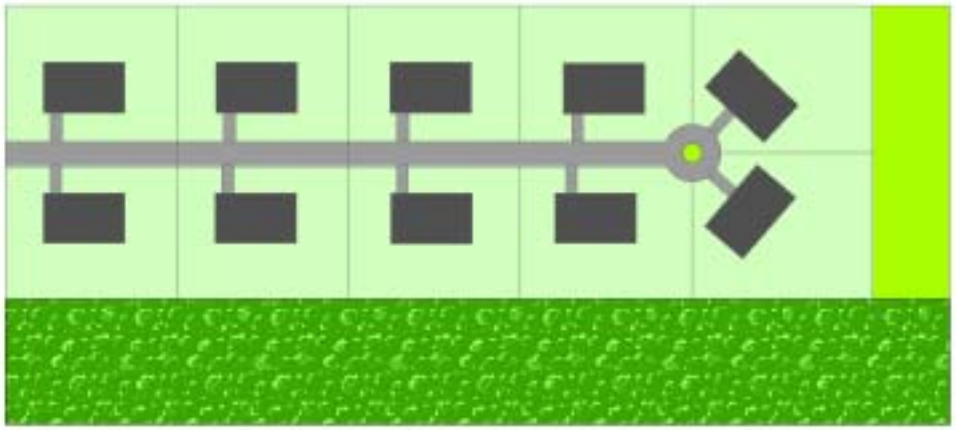
Storm Event	Pre-Dev. Runoff (in.)	Post-Dev. Runoff (in.)	Change (%)
1	0.43	0.41	-5%
2	0.64	0.6	-6%
10	1.57	1.47	-6%
100	2.7	2.49	-8%

Residential Development
2-Year



Residential Development
100-Year





Land Cover Summary

Land Cover	Area (SF)	Area (Acres)
Impervious		
Building	45050	1.0
Road/Driveway	22683	0.5
Walkways/Curb	1936	0.04
Total	69669	1.6
Pervious/Semi-pervious		
Improved Lawn	210011	4.8
Meadow	25240	0.6
Woodland	130680	3.0
Total	365931	8.4
Total Percent Impervious		**16%**

Residential Case Study

Option #3 Low Impact Development

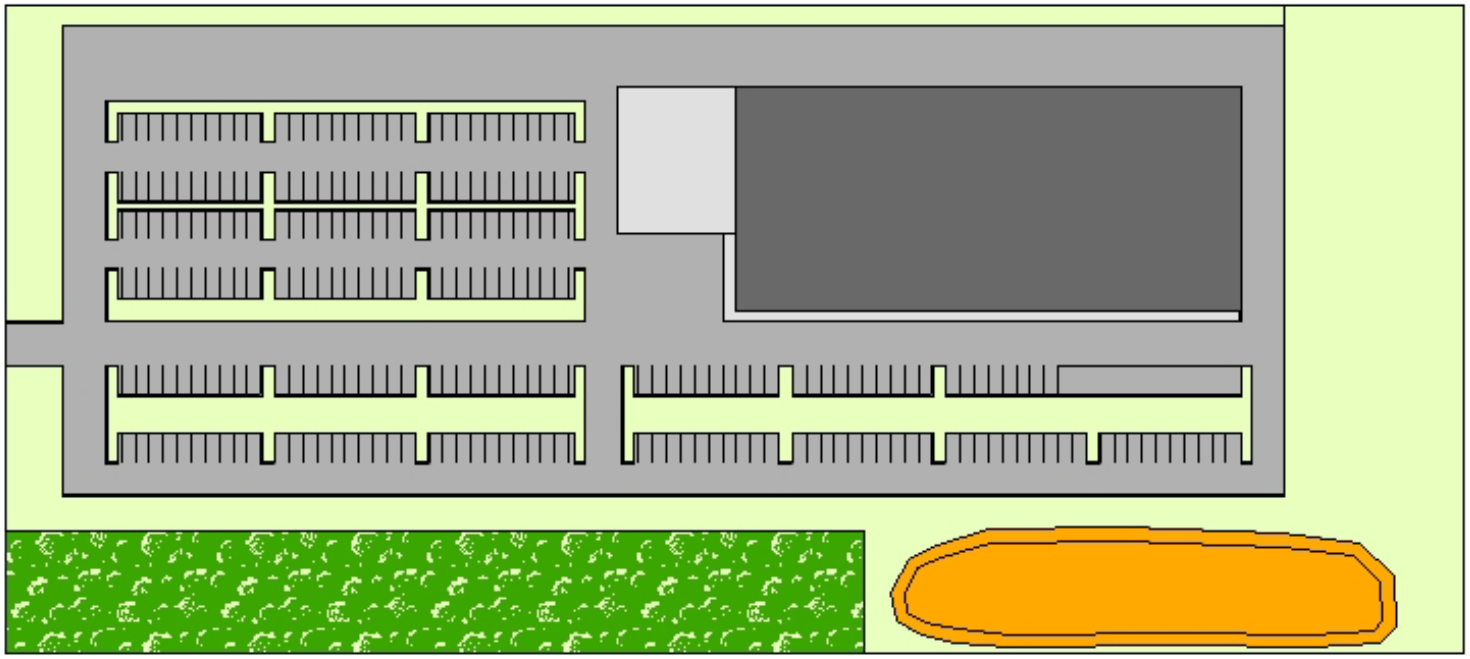
Legend

Land Cover

- Building
- Road/Driveway
- Walkway
- Improved Lawn
- Meadow
- Woodland

100 Feet

Second Case Study: Commercial Conventional



Commercial Case Study

Option #1 Detention Basin

Legend

Land Cover

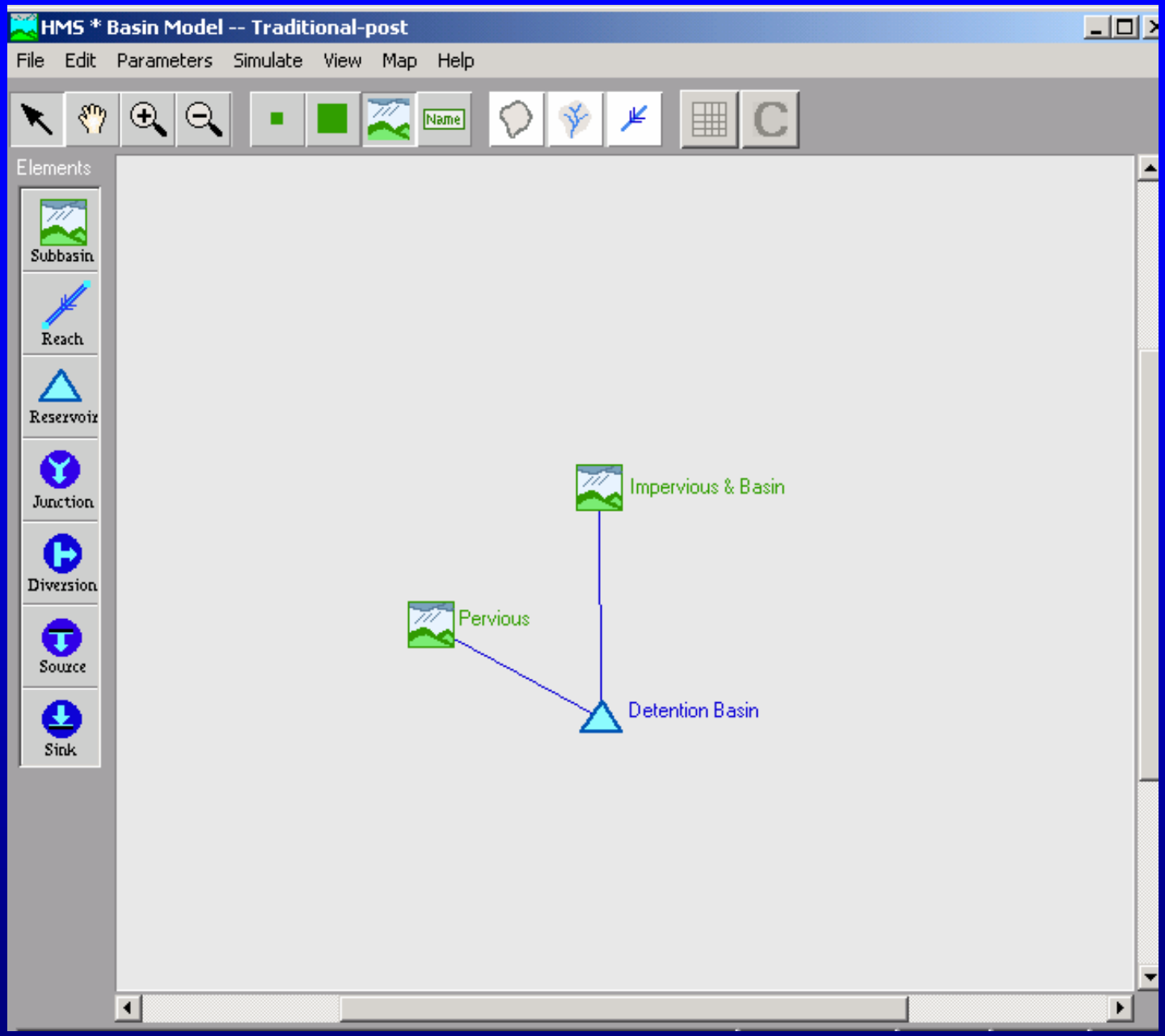
- Building
- Parking
- Walkways
- Detention Basin
- Lawn/Landscaping
- Woodland

- 52,000 Square Feet Building, 248 Parking Spaces
- 1.46 acre-feet Detention Basin
- 60% Impervious

Commercial Conventional

Land Cover Summary

Land Cover	Area (SF)	Area (Acres)
Impervious		
Building	52,271	1
Parking/Walkways	179,300	4
Stormwater Management		
Detention Basin	27,345	1
Total	258,916	6
Pervious/Semi-pervious		
Woodland	48,061	1
Landscaping	32,700	1
Lawn	93,182	2
Total	125,882	4
Total Percent Impervious		**60%**



Routing Through Detention Basin

Commercial Detention Basin

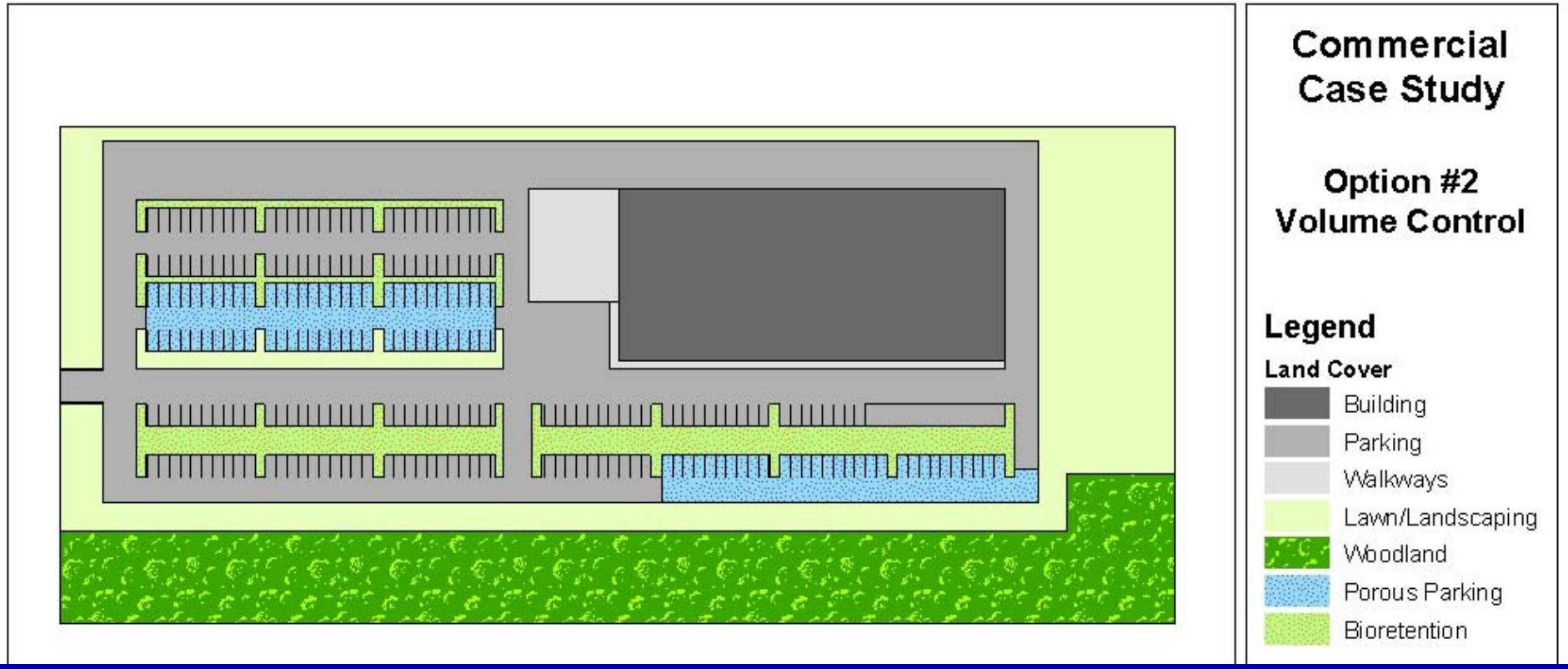
							For Rectangular Weir				Infiltration	Low-flow Orifice	
BB Elevation	Elev. (ft)	Area (ft^2)	Volume in Pipes (ft^3)	Volume[a] (ft^3)	Total Storage Volume (ft^3)	Total Storage Volume (ac-ft)	Head (ft)	Discharge Coefficient, Cd	Weir Length (ft)	Capacity (cfs)	Q=A*Infiltration Rate[b] (cfs)	$Q=CdA(2gh)^{1/2}$ (cfs)	**Q, total[c] (cfs)**
0.00	0.00	18325	0	0	0	0	---	---	---	0	0	0	**0.00**
0.25	0.25	18881	0.00	4651	4651	0.107	---	---	---	0	0.00	0.49	**0.49**
0.50	0.50	19438	0.00	9441	9441	0.217	---	---	---	0	0.00	0.69	**0.69**
0.75	0.75	19994	0.00	14370	14370	0.330	0.00	0.62	2.25	0.00	0.00	0.85	**0.85**
1.00	1.00	20550	0.00	19438	19438	0.446	0.25	0.62	2.25	0.94	0.00	0.98	**1.91**
1.25	1.25	21106	0.00	24645	24645	0.566	0.50	0.62	2.25	2.65	0.00	1.09	**3.74**
1.50	1.50	21663	0.00	29991	29991	0.688	0.75	0.62	2.25	4.87	0.00	1.20	**6.06**
1.75	1.75	22219	0.00	35476	35476	0.814	1.00	0.62	2.25	7.49	0.00	1.29	**8.78**
2.00	2.00	22775	0.00	41100	41100	0.944	1.25	0.62	2.25	10.47	0.00	1.38	**11.85**
2.25	2.25	23331	0.00	46863	46863	1.076	1.50	0.62	2.25	13.76	0.00	1.47	**15.23**
2.50	2.50	23888	0.00	52766	52766	1.211	1.75	0.62	2.25	17.35	0.00	1.54	**18.89**
2.75	2.75	24444	0.00	58807	58807	1.350	2.00	0.62	2.25	21.19	0.00	1.62	**22.81**
3.00	3.00	25000	0.00	64988	64988	1.492	2.25	0.62	2.25	25.29	0.00	1.69	**26.98**

- Tc Before = 20 Minutes
- Tc After = 15 Minutes Pervious
- Tc After = 6 Minutes Impervious

Alternative Design Commercial

- Bioretention Areas
- Storage/Infiltration Beneath Parking Area
  - National Engineering Handbook, Chap 12
  - Conservative Estimate
- Swales to Lengthen Tc
- Storage Equal to 2-Year Increase in Volume: 1.05 acre-feet

Commercial BMP



Commercial BMP

Land Cover Summary

Land Cover	Area (SF)	Area (Acres)
Impervious		
Building	52,271	1
Parking/Walkways	179,300	4
Stormwater Management		
Bioretention	35,183	1
Total	266,754	6
Pervious/Semi-pervious		
Woodland	85,987	2
Lawn	82,859	2
Total	168,846	4
Total Percent Impervious		**60%**

Proposed Condition **BMP Design**

Land Cover	Area (SF)	Curve Number	Initial Abstraction (I_a), in.	2-year Storm 2.8 inches Inches	CF
Lawn/Landscaping	82,859	79	0.53	1.04	7,212
Building	52,271	98	0.04	2.57	11,191
Impervious	179,300	98	0.04	2.57	38,387
Bioretention	35183	98	0.04	2.57	7,533
Meadow	0		---	---	---
Woods	85987	70	0.86	0.61	4,343
TOTAL	**435,600**	**88.9**	**0.25**	**1.89**	**68,665**

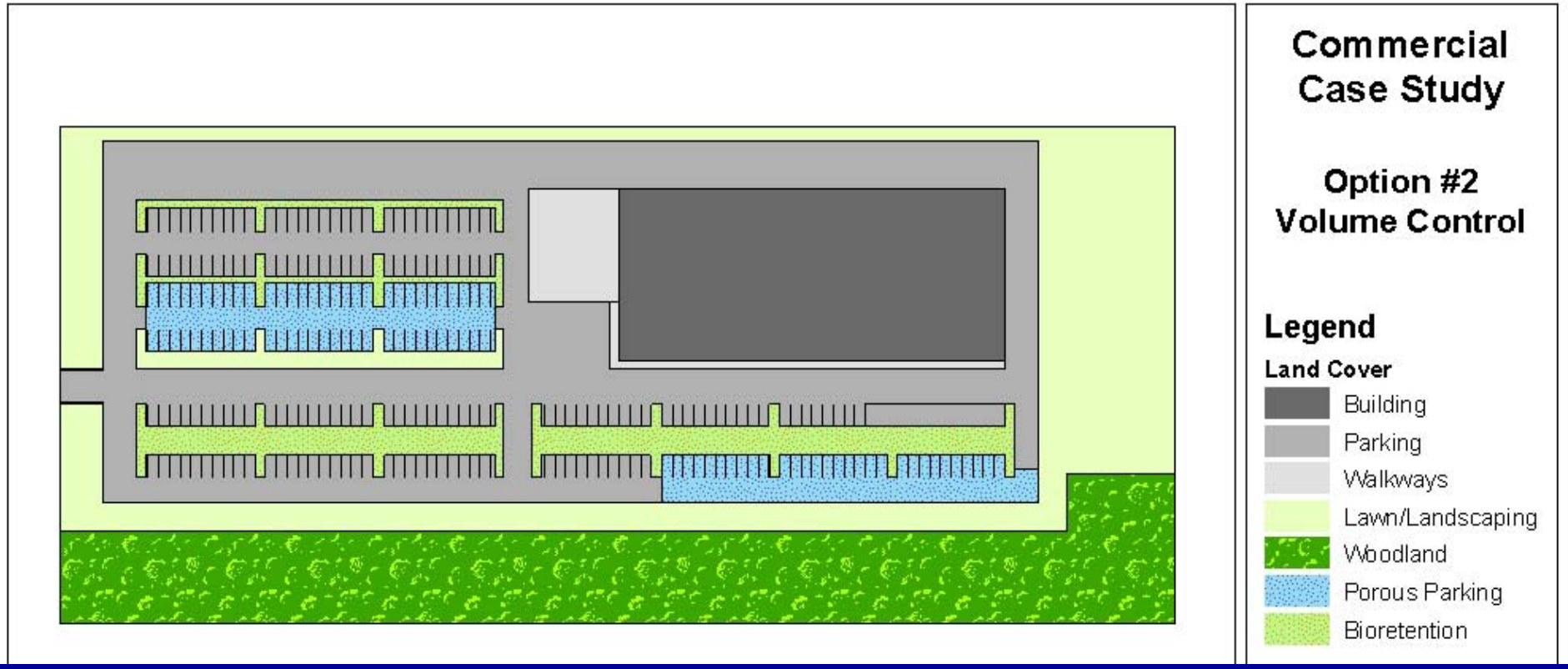
Existing Condition

Land Cover	Area (SF)	Curve Number	Initial Abstraction (I_a), in.	2-year Storm 2.8 inches Inches	CF
Lawn	0	---	---	---	---
Impervious	0	---	---	---	---
Meadow	304,920	71	0.82	0.65	16,469
Woods	130,680	70	0.86	0.61	6,600
TOTAL	**435,600**	**70.7**	**0.83**	**0.64**	**23,069**
Net Difference					**45,596** **cf**

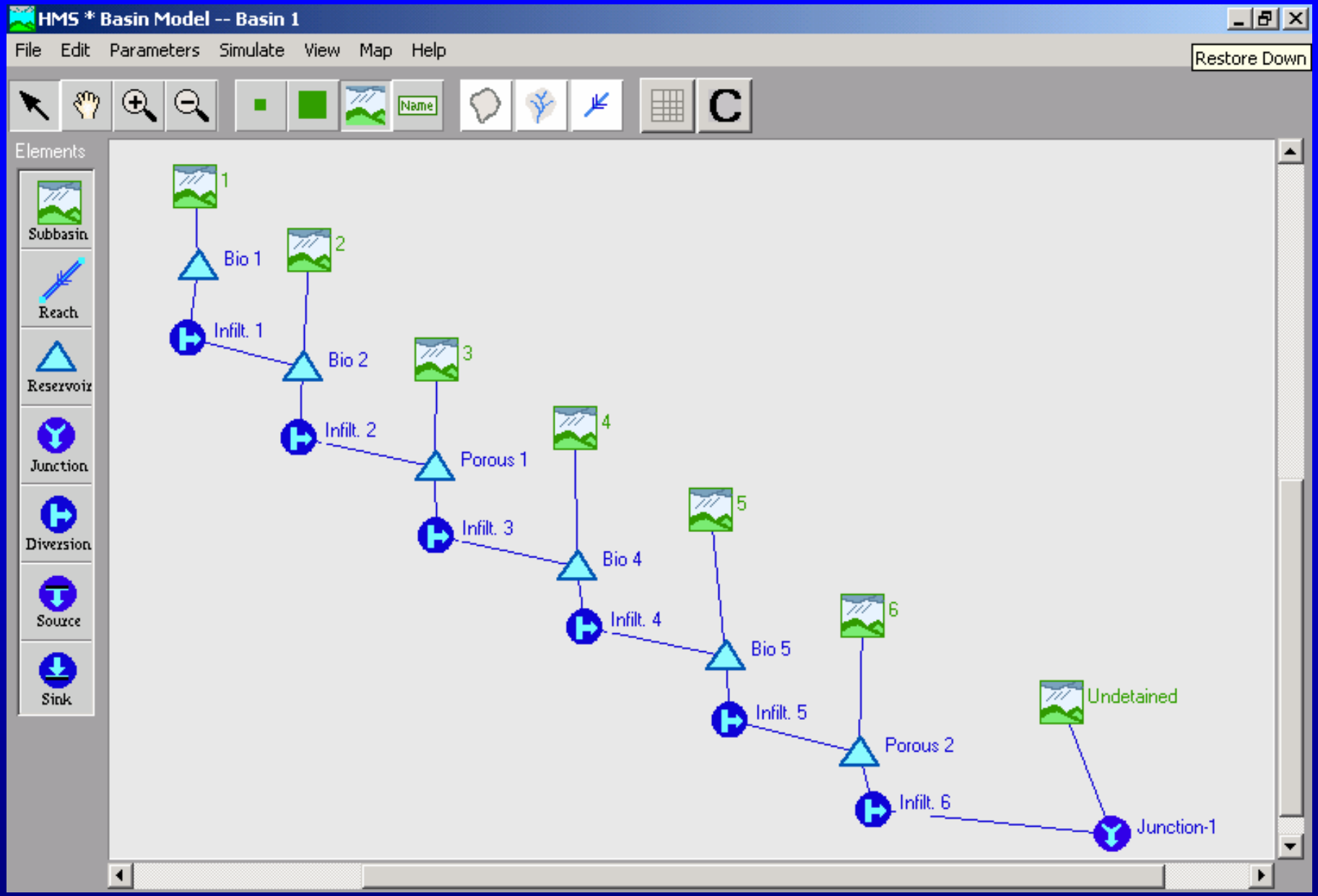
BMP Design

2-Year Volume Increase = 45,596 CF = 1.05 AF

Commercial BMP



- How to Model / Calculate?



Routing Through BMPs

Routing BMP Design

							Nyloplast Inlet				Infiltration	Low-flow Orifice	Outlet Orifice	
BB Elevation	Elev. (ft)	Area (ft^2)	Volume in Pipes (ft^3)	Surface Storage (ft^3)	Total Storage Volume (ft^3)	Total Storage Volume (ac-ft)	Head (ft)	Discharge Coefficient, Cd	Weir Length (ft)	Capacity from graph (cfs)	Q=A*Infiltration Rate[b] (cfs)	$Q=CdA(2gh)^{1/2}$ (cfs)	$Q=CdA(2gh)^{1/2}$ (cfs)	**Q, total (cfs)**
300.00	0.00	1262	0	0	0	0	---	---	---	0	0.00	0	0	0
300.25	0.25	1534	0	350	350	0.01	---	---	---	0	0.03	0.00	0.00	0.03
300.50	**0.50**	1806	**0**	**767**	**767**	**0.02**	**0**	**---**	**---**	**0**	**0.03**	**0.00**	**0.00**	0.03
300.75	0.75	2078	0	1253	1253	0.03	**0**	**---**	**---**	**0**	0.04	0.00	0.00	0.04
301.00	1.00	2350	0	1806	1806	0.04	**0**	**---**	**---**	**0**	0.05	0.00	0.00	0.05
301.25	1.25	2622	0	2428	2428	0.06	0.25	---	---	0.85	0.06	0.00	0.00	0.91
301.50	1.50	2894	0	3117	3117	0.07	0.50	---	---	1.9	0.07	0.00	0.00	1.97

- Bioretention
- Storage/Infiltration Beneath Parking
- Vegetated Drainage Swales
- Undisturbed Woods instead of Basin

Peak Rate Mitigation – Detention

Storm Event	Pre-Dev. Peak (cfs)	Post-Dev. Peak (cfs)	Post-Dev. Peak w/ Basin (cfs)	Change (%)
1	3.89	21.69	3.81	-2.1%
2	6.32	26.38	5.94	-6.0%
10	17.63	44.34	15.57	-11.7%
100	30.88	62.57	26.13	-15.4%

BMP Design

Storm Event	Pre-Dev. Peak (cfs)	Post-Dev. Peak (cfs)	Post-Dev. Peak w/ Basin (cfs)	Change (%)
1	3.89	21.69	3.81	-2.1%
2	6.32	26.38	5.94	-6.0%
10	17.63	44.34	15.57	-11.7%
100	30.88	62.57	26.13	-15.4%

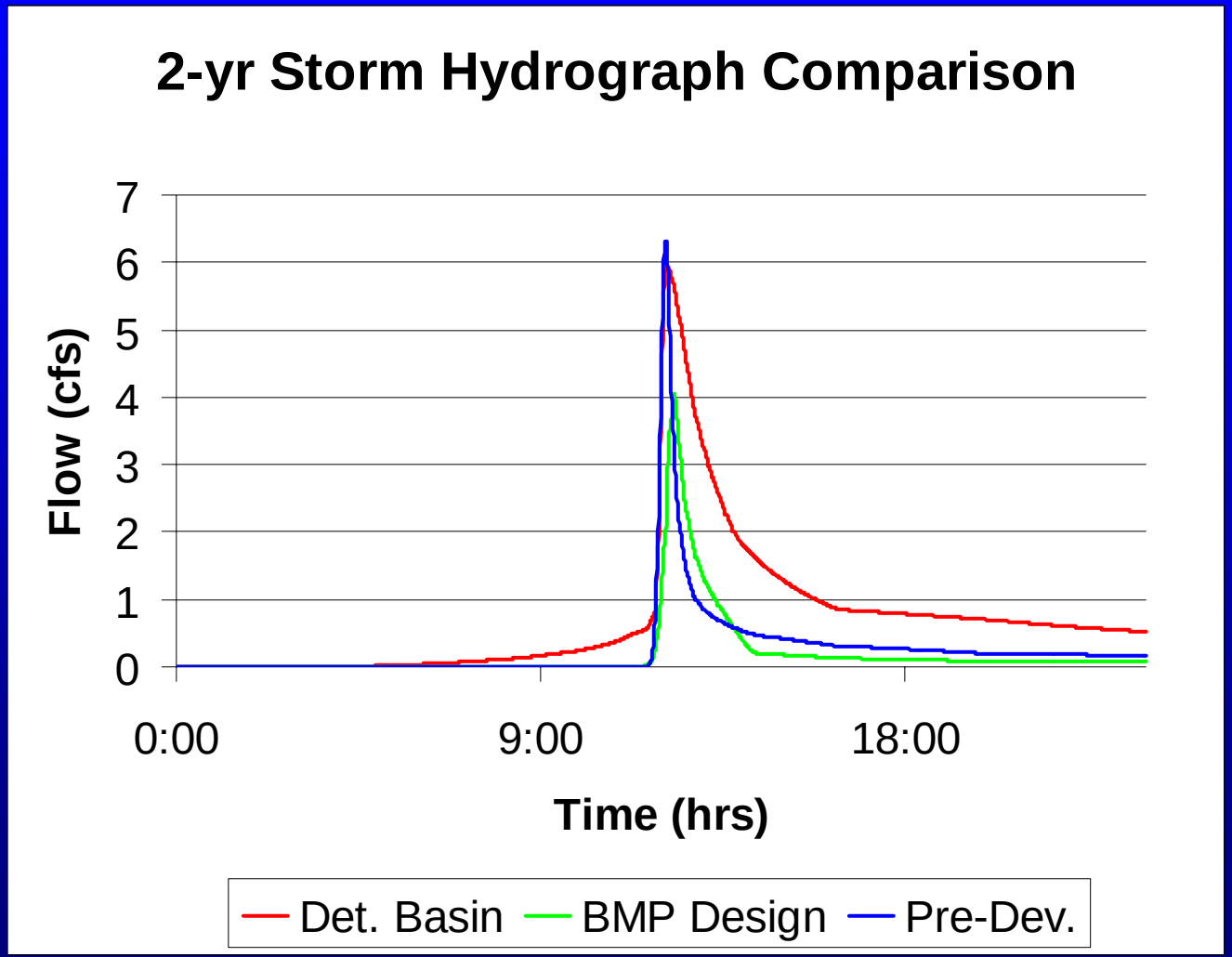
Increase in Volume – Detention

Storm Event	Pre-Dev. Runoff (in.)	Post-Dev. Runoff (in.)	Change (%)
1	0.43	1.38	221%
2	0.64	1.70	166%
10	1.57	2.94	87%
100	2.70	4.27	58%

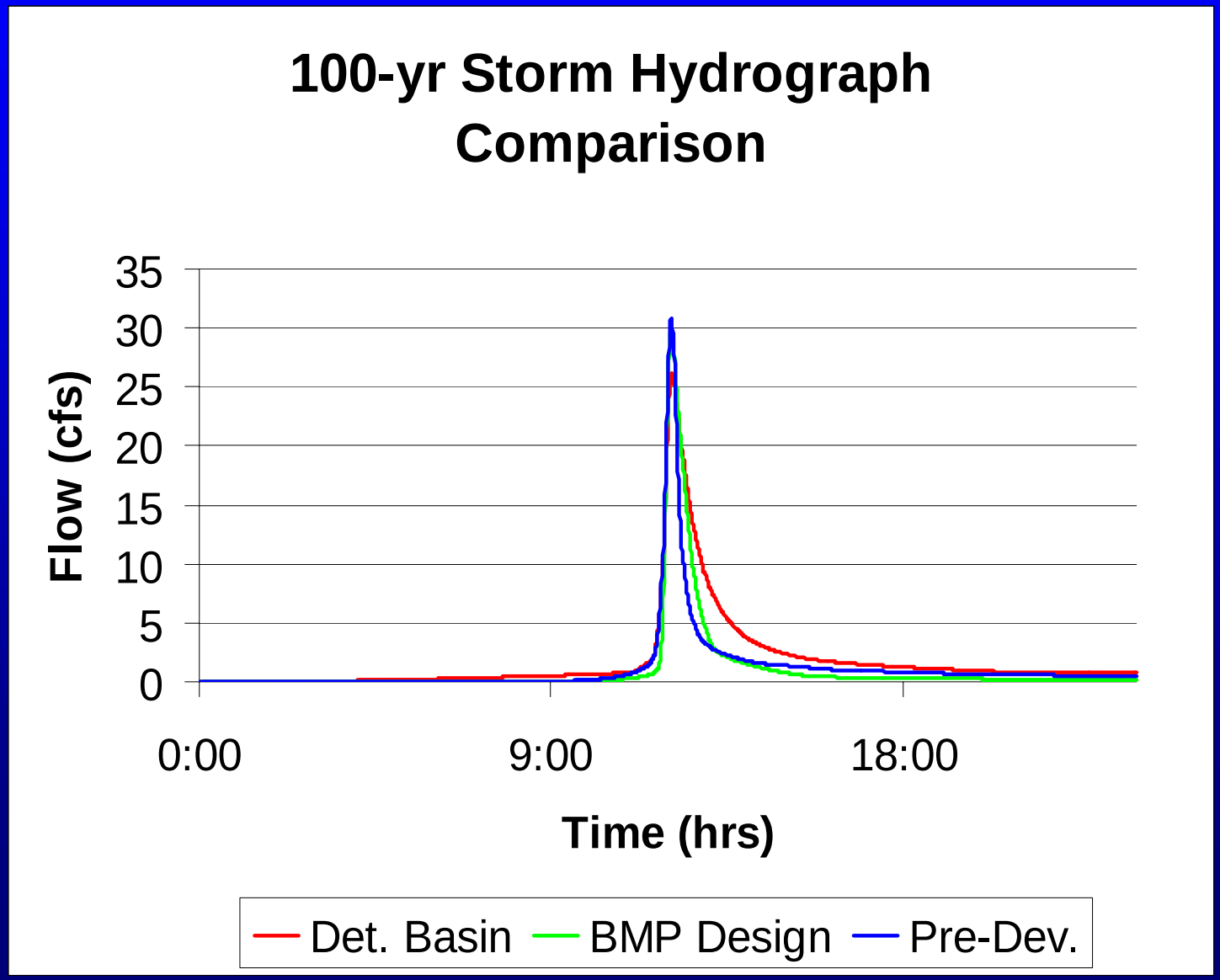
BMPs

Storm Event	Pre-Dev. Runoff (in.)	Post-Dev. Runoff (in.)	Change (%)
1	0.43	0.26	-40%
2	0.64	0.46	-28%
10	1.57	1.40	-11%
100	2.70	2.45	-9%

Commercial Development 2-Year



Commercial Development 100-Year



Proposal for BMP Manual: Simplified Method and Worksheets

- Calculate Volume Increase from Land Use Change
- Calculate Contribution of BMPs
- Detailed Routing May Be Waived
- Design Standards Must Be Met
- Alternative Analysis Accepted

Volume Calculation

WORKSHEET 1 . CHANGE IN RUNOFF VOLUME FOR 2-YR STORM EVENT

PROJECT: Big Box Store
DA: 1
2-Year Rainfall: 2.8

Existing Conditions:

Cover Type	Soil Type	Area (ac)	CN	S	Ia	Runoff (in)	Runoff (CF)
Woodland	C	3.00	71	4.08	0.82	0.65	7,058
Meadow	C	7.00	70	4.29	0.86	0.61	15,399
TOTAL:		**10**					**22,457**

Developed Conditions:

Cover Type	Soil Type	Area (sf)	CN	S	Ia	Runoff (in)	Runoff (CF)
Lawn	C	2.14	79	2.66	0.53	1.04	8,110
Impervious	C	5.38	98	0.20	0.04	2.57	50,174
Landscaping	C	0.75	79	2.66	0.53	1.04	2,843
Detention Basin	C	0.63	98	0.20	0.04	2.57	5,875
Meadow	C	0.00	71	4.08	0.82	0.65	0
Woods	C	1.10	70	4.29	0.86	0.61	2,420
TOTAL:		**10**					**69,423**

2-Year Volume Increase (cf):	**46,965**
AF	**1.1**

PROJECT: Big Box

SUB-BASIN: 1

Required Control Volume 46,965 cf

Proposed Measures

Measure Type	Area (sf)	Storage Volume Provided per SF* (cf/sf)	Net Storage Volume (cf)
Structural			
Storage/Infiltration Bed	22,700	1	22,700
Bioretention	19,092	1.25	23,865
Vegetated Swale	1,000	0.5	500
Tree Trench			
Green Roof			
Wet Pond			
Non-Structural			
Riparian Buffer			
Woodland Protection			
TOTAL STORAGE :			47065
REQ'D STORAGE (WS 1):			46965
DIFFERENCE			100

Proposal for BMP Manual:

- If 2-Year Volume Increase Can Be Managed by BMPs:
  - Water Quality Requirement Met
  - Channel Protection Requirement Met
  - Peak Rate Requirement Met
- If not
  - Water Quality
  - Peak Rate (Routing)
  - Channel Protection

Water Quality Calculation

WORKSHEET 3 . WATER QUALITY - 85% TSS CONTROL

PROJECT:	Big Box Store
DA:	1
2-Year Rainfall:	2.8

Existing Conditions:

Cover Type	TSS EMC mg/L	Runoff (CF)	TSS Load (lbs)
Woodland	40	7,058	3.63
Meadow	70	15,399	13.84
TOTAL:		**22,457**	17.5

Developed Conditions:

Cover Type	TSS EMC mg/L	Runoff (CF)	TSS Load (lbs)
Lawn	100	8,110	10.41
Impervious	100	50,174	64.42
Landscaping	100	2,843	3.65
Detention Basin	100	5,875	7.54
Meadow	70	0	0.00
Woods	40	2,420	1.24
TOTAL:		**69,423**	87.3

TSS Load Increase (lb):	**70**

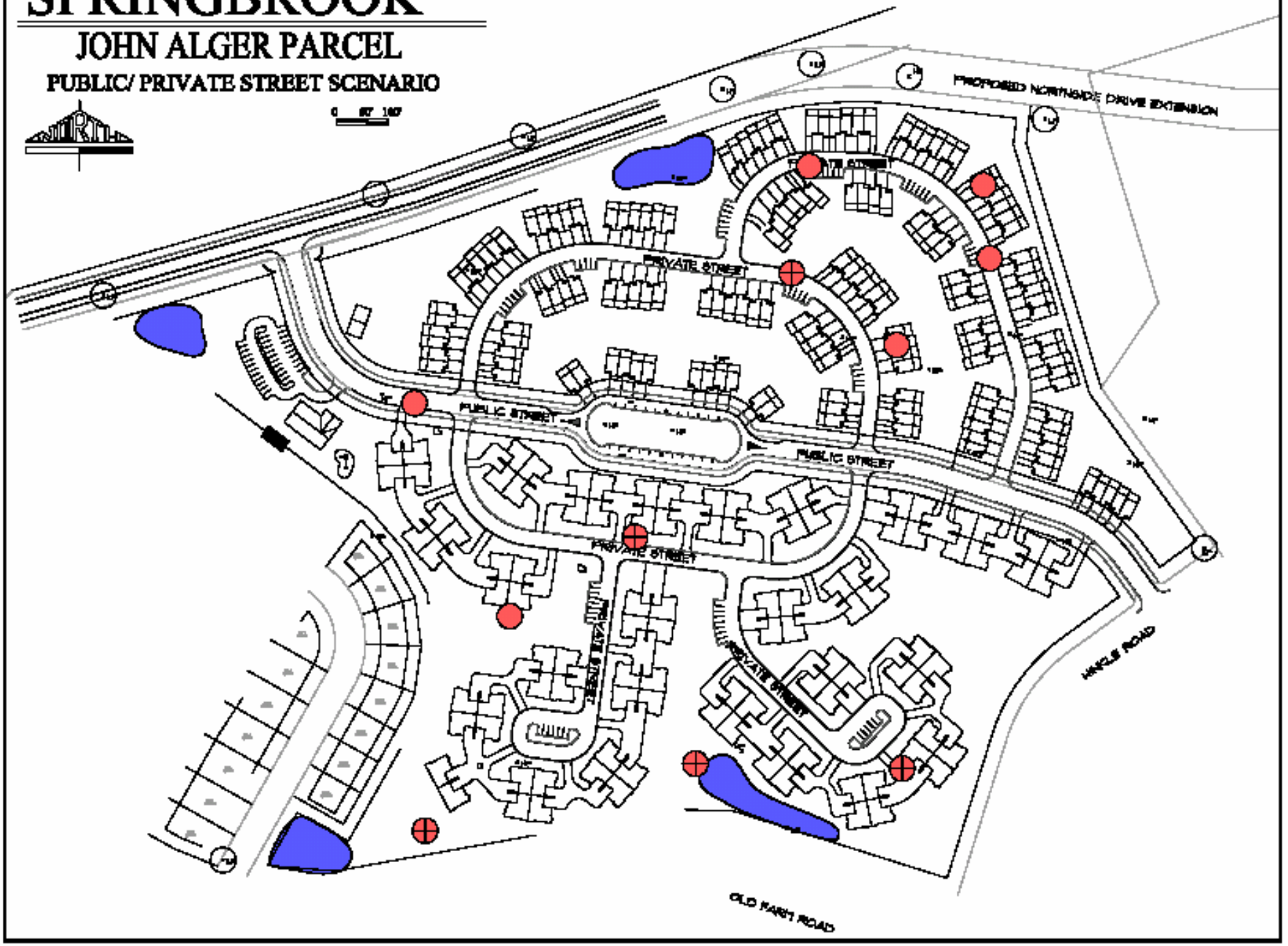
Why Do We Need This?

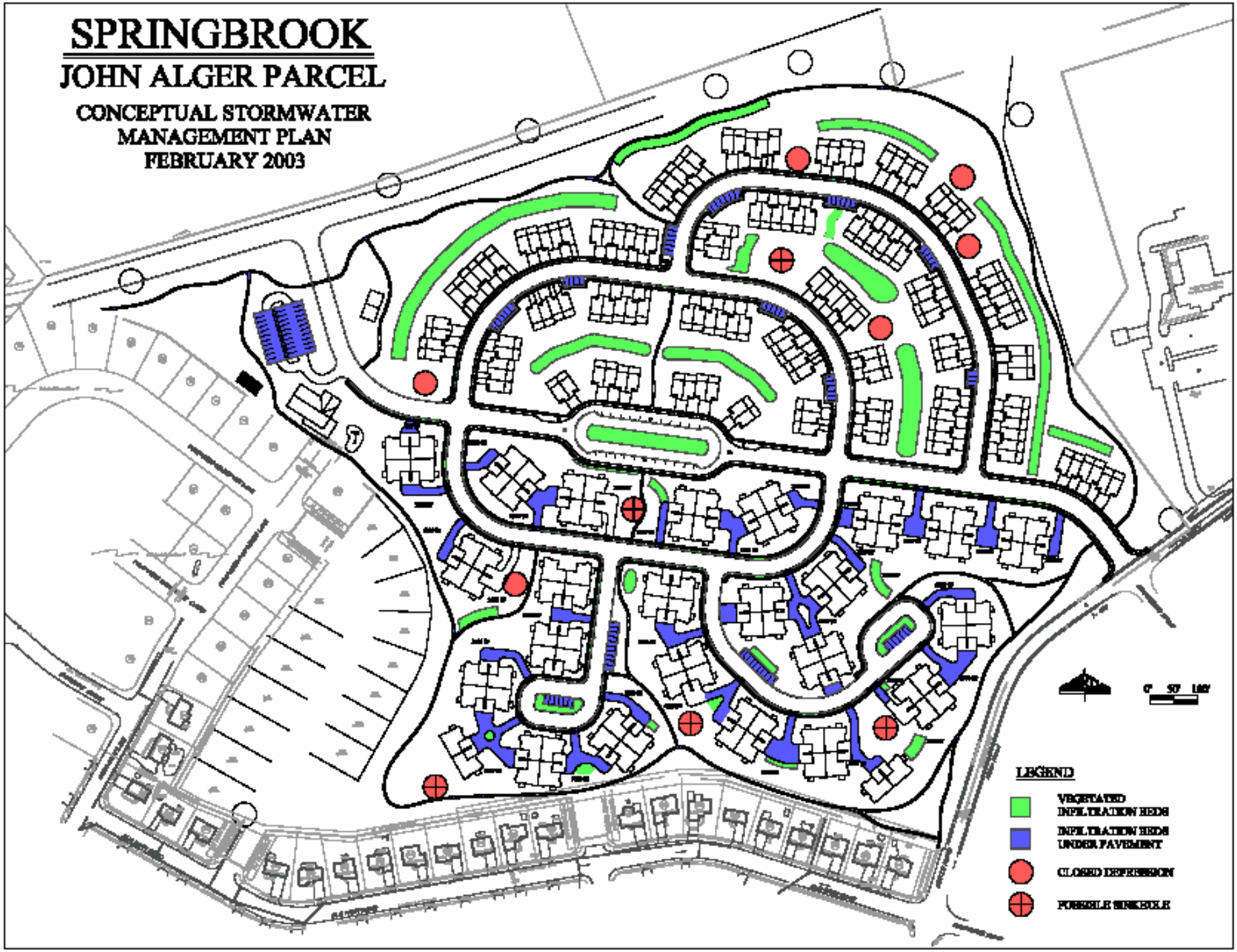
- Linking Volume, Rate, and Quality
- Decentralized – Linking Many BMPs
- Providing a Tool for LID Design Calculations

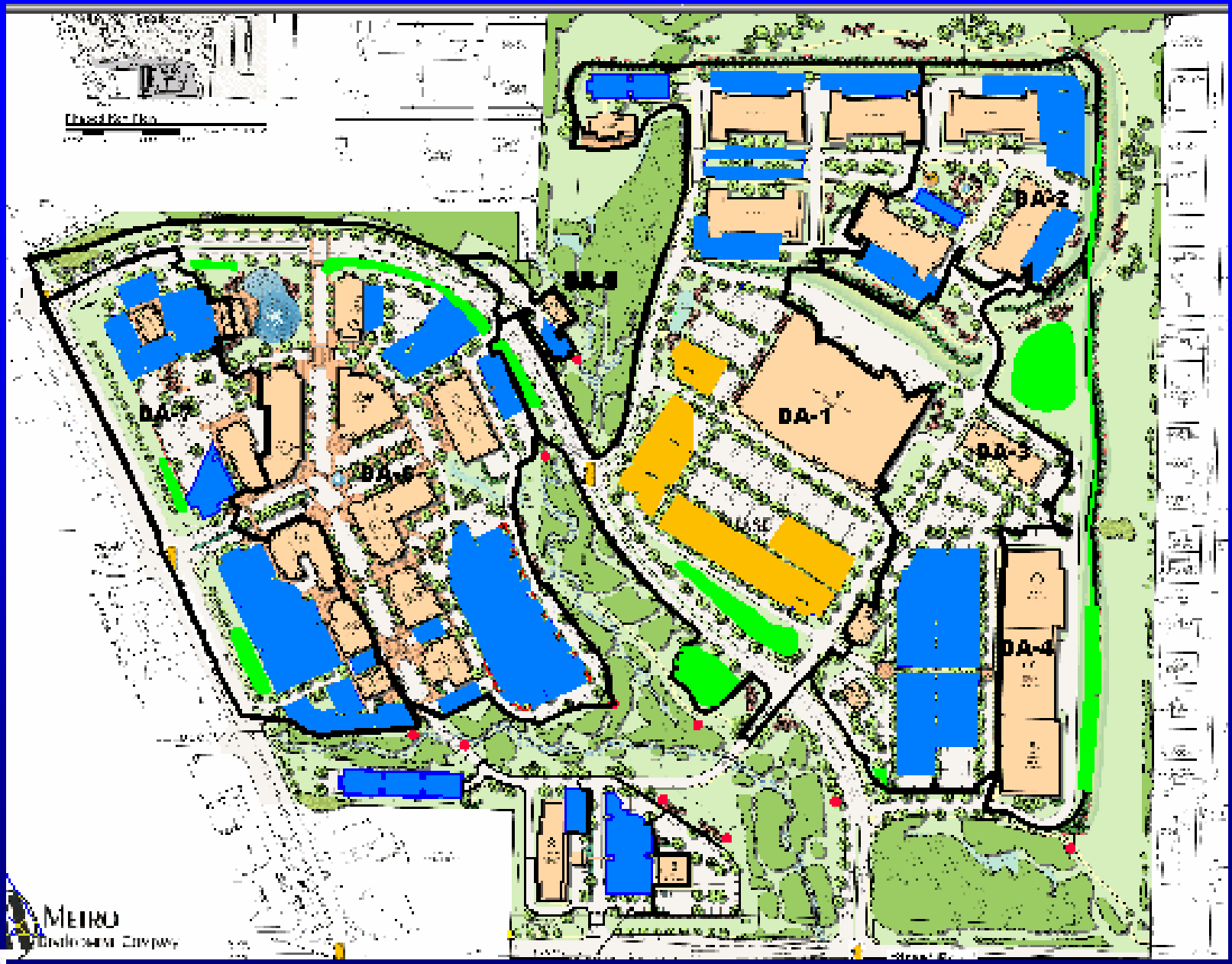
SPRINGBROOK

JOHN ALGER PARCEL

PUBLIC/ PRIVATE STREET SCENARIO




SPRINGBROOK
JOHN ALGER PARCEL
CONCEPTUAL STORMWATER
MANAGEMENT PLAN
FEBRUARY 2003
LEGEND
VEGETATED
INFILTRATION BEDS
INFILTRATION BEDS
UNDER PAVEMENT
CLOSED DEPRESSION
POSSIBLE SINKHOLE


DA-1
DA-2
DA-3
DA-4
DA-5
DA-6
Metro

Guideline 1

1. Hold the runoff volume constant for up to the 2 year storm.

2. Peak Rates held to predevelopment levels for the 2 – 100 year storm.

3. Quality - Reduction of 85% of particulate associated pollutants (as represented by TSS) and 50% of solutes (as represented by NO3-N)

Guideline 2 – Special Areas

1. **Baseflow**
   - **Infiltrate Runoff from the first 1 ” of Rainfall**
2. **Quality**
   - **Reduction of 85% of particulate associated pollutants (as represented by TSS) and 50% of solutes (as represented by NO3-N)**
3. **Channel Protection**
   - **Release the post construction 1 year (24 hr) storm over at least 24 hours.**
4. **Flood Protection**
   - **Peak Rates held to predevelopment levels for the 2 – 100 year storm**