Mimicking Pre-Construction Runoff: A Requirement for New Development Projects in MSD

March 10, 2010

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Metropolitan St. Louis Sewer District

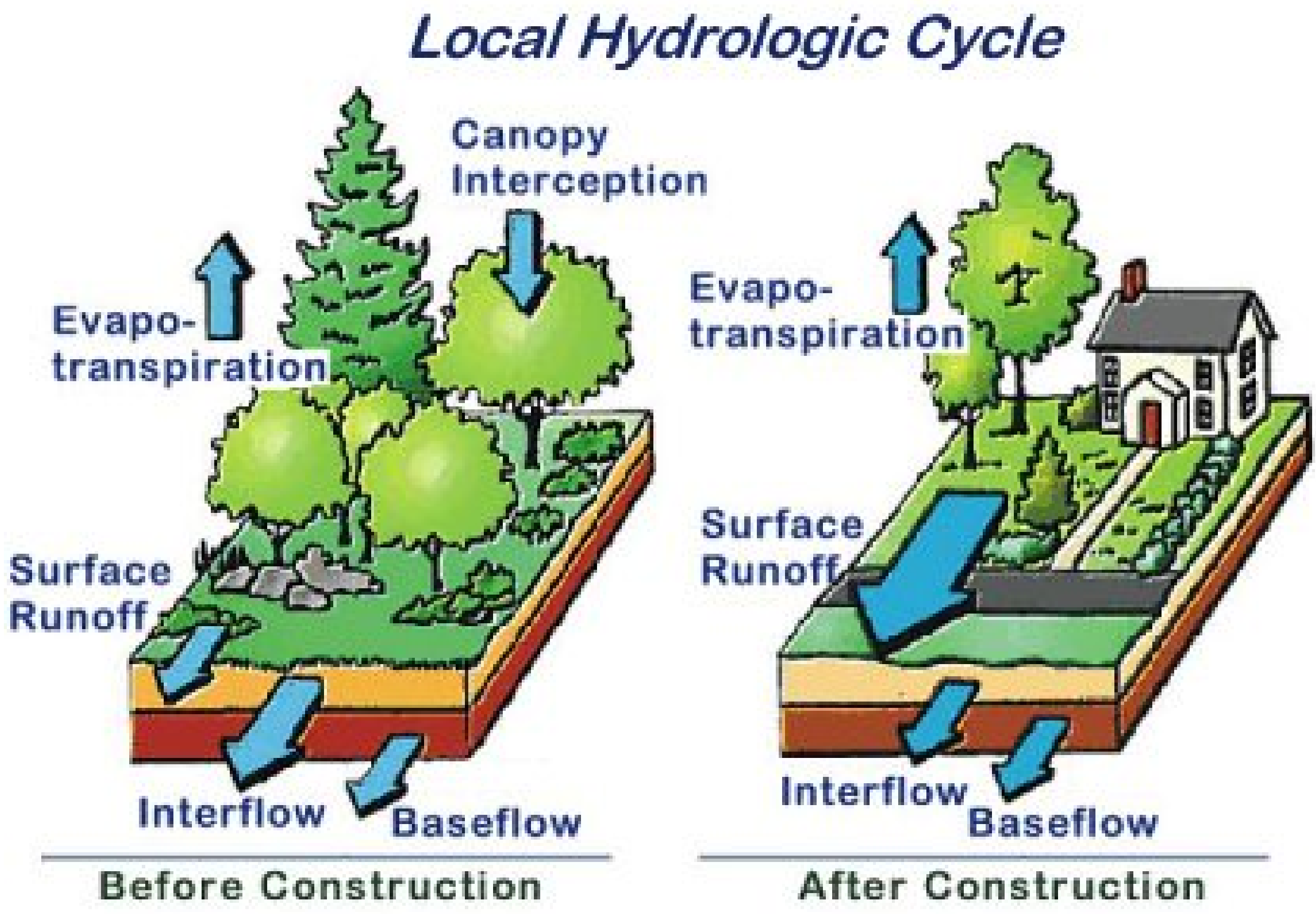
2003-2008 MS4 Permit

The permittee shall develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment project….The permittee's program shall ensure that controls are in place that would prevent or minimize water quality impacts;

2008-2013 MS4 Permit

The permittee's program shall ensure that controls are in place that have been designed and implemented to prevent or minimize water quality impacts by reasonably mimicking pre-construction runoff conditions on all affected new development projects and by effectively utilizing water quality strategies and technologies on all affected redevelopment projects, to the maximum extent practicable.

How Imperviousness Changes Runoff



http://www.mde.state.md.us/environment/wma/stormwatermanual/

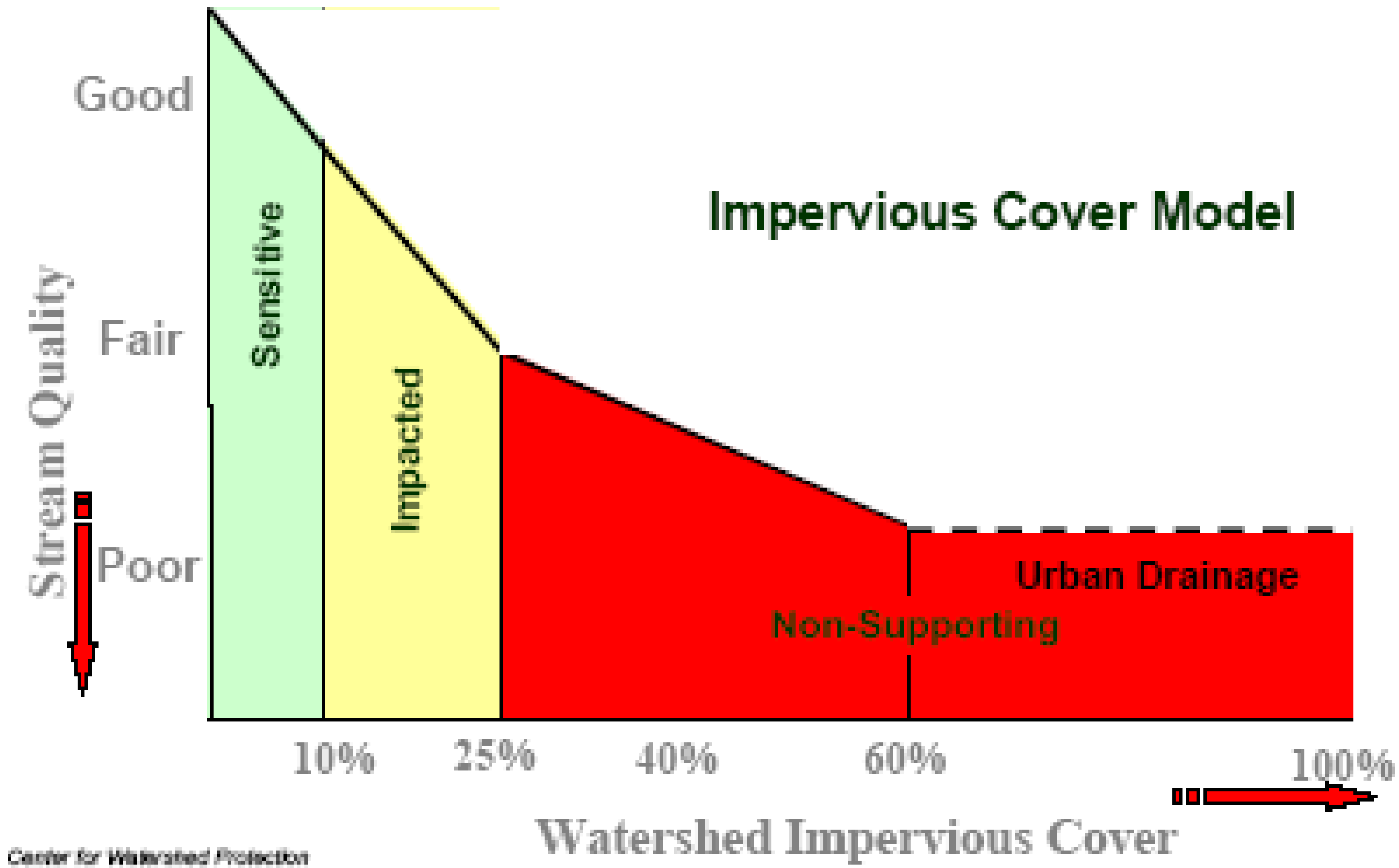
NRC Report
(AND EPA Proposed Rulemaking)

- Key Findings
  - Current approach is unlikely to accurately depict problem or control stormwater's contribution to waterbody impairment
  - Requirements leave too much discretion to dischargers, which results in inconsistency across the nation
  - Poor accountability and uncertain effectiveness
- Key Recommendations
  - A straightforward way to regulate stormwater contributions...would be to use flow or a surrogate, like impervious cover
  - Efforts to reduce stormwater flow will achieve reductions in pollutant loading...would linke flow to downstream erosion/sedimentation
  - Stormwater control measures that harvest, infiltrate, and evapotranspirate stormwater are critical to reducing the volume and pollutant loading of small storms

New Development Requirements: Big Picture

- Define new development
- Upfront planning for water quality
  - Regulated by County and Municipal Co-permittees
- Design/construct BMPs that address runoff volume
  - Regulated by MSD

What is new development?



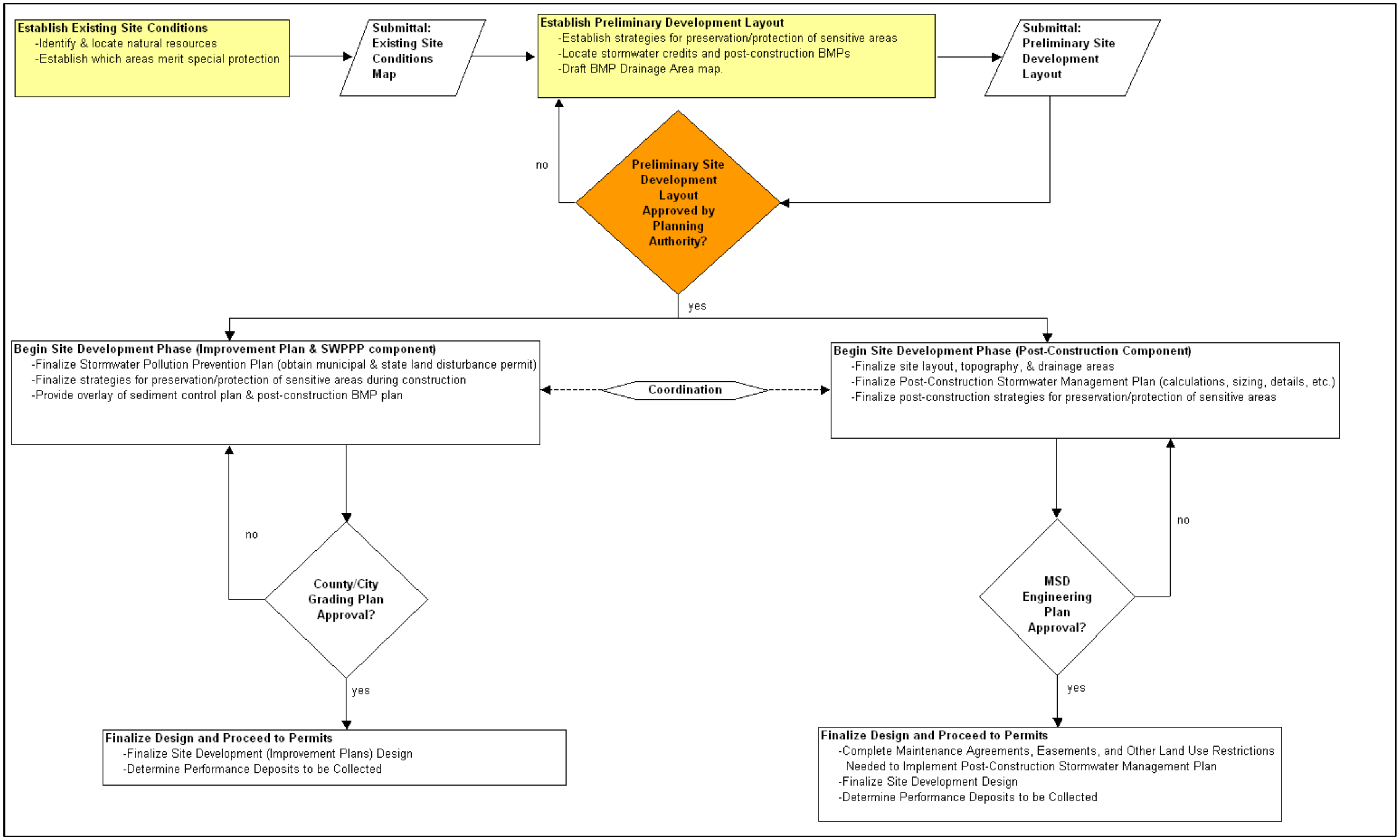
New Development = < <u>20% Existing</u> Imperviousness

Example New Development

Upfront Planning for Water Quality: MSD Site Design Guidance

- Existing Conditions Evaluation
  - Existing Natural Resources
  - Infiltration Testing
- Concept Plan Evaluation
  - Address impacts on sensitive areas
  - Reduce impervious footprint
  - Implement the BEST water quality strategies

Concept Plan: Integration of Reviews

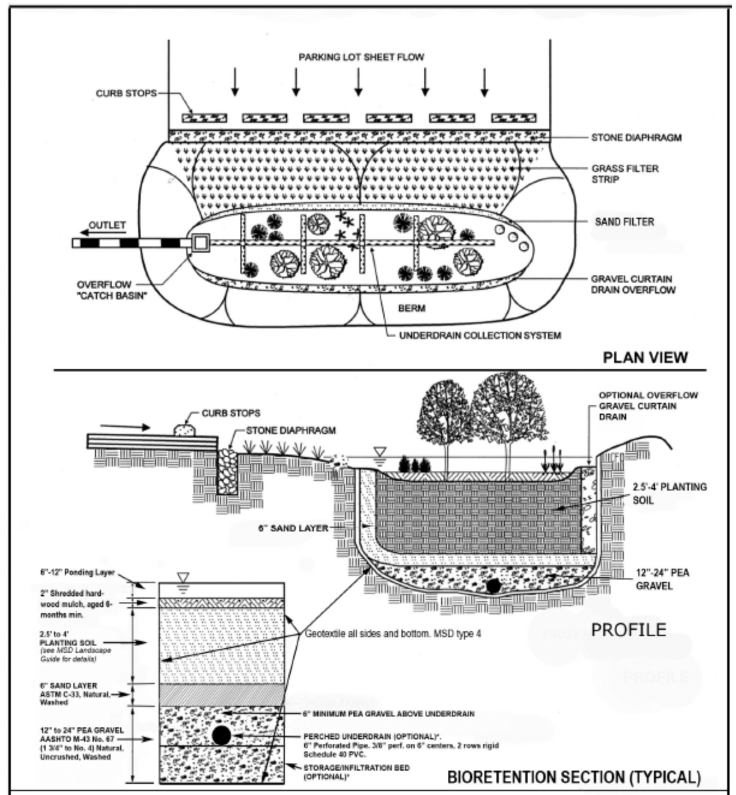


Legal Impediment Workgroup

- Direct code conflicts
  - Highest priority based on a specific goal in SWMP
  - Example – BMP design illegal under existing code
- Reducing required impervious footprint
  - Priority based on EPA Guidance, permit conditions
  - Example – Reduce parking requirements
- Eliminating legal uncertainty and unknowns
  - Approving authorities promote desirable BMPs
  - Example – standard drawings, models, case studies

Implementing the Best Stormwater Management Practices

- Treat Stormwater
  - Reduced contaminant load
- Detain Stormwater
  - Reduced peak rate
- Reduce Runoff Volume
  - Reduced load, peak rate, & volume



Bioretention combines open space with stormwater treatment.

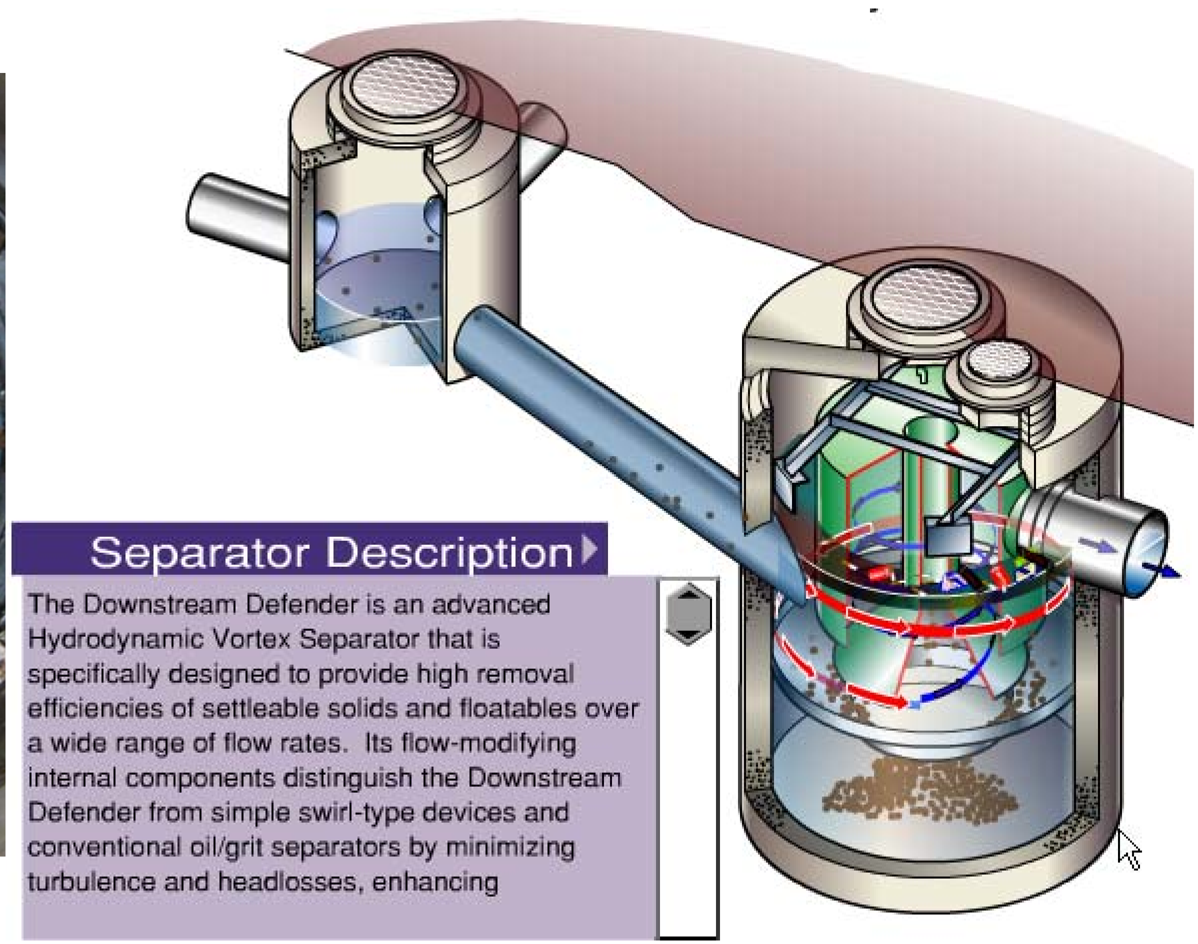
At the Source + Multiple Locations = Cumulative Effect

Runoff Reducing Practices

Stormwater Detention (Like This) Doesn't Reduce Runoff Volume

Stormwater Filtration Doesn't Reduce Runoff Volume

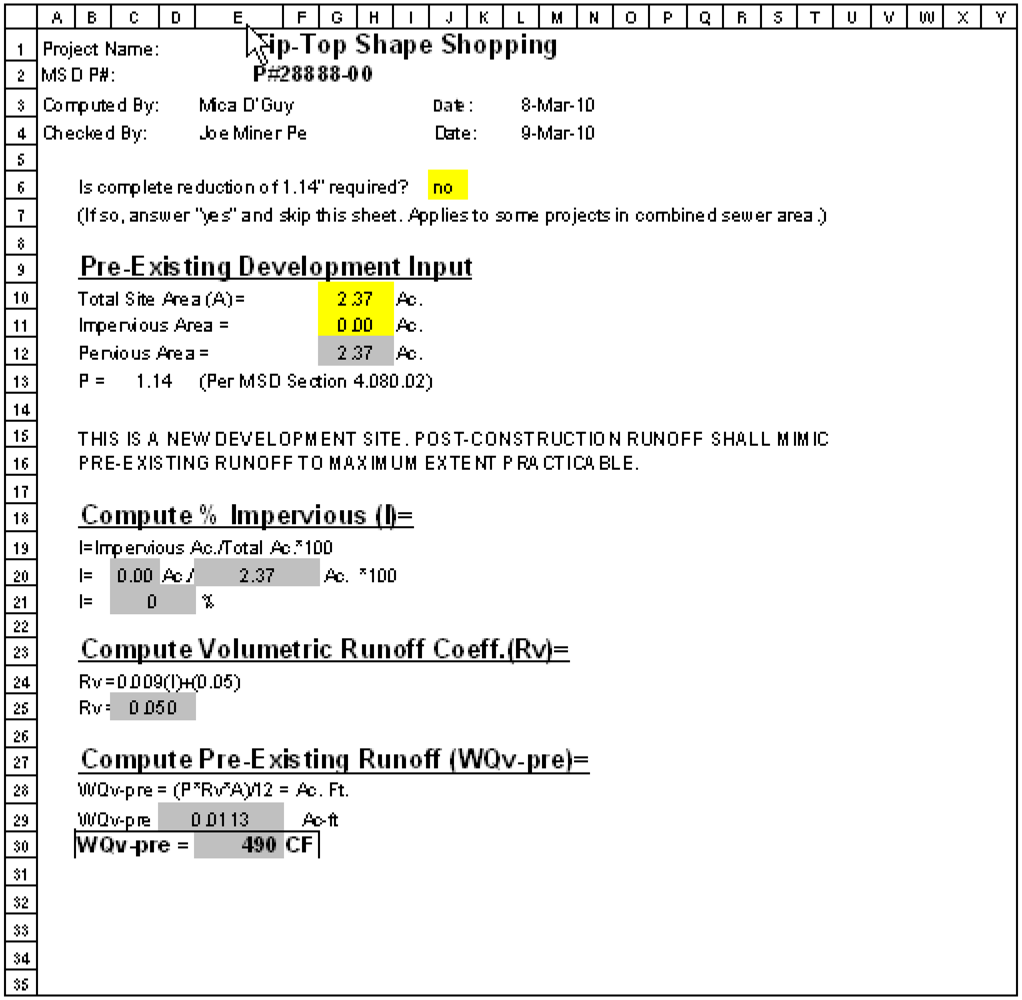
Flow-through BMPs Do Not Reduce Runoff Volume



BMP Design Approach for Runoff Reduction

- Establish the pre-existing runoff condition
  - P=1.14" (90th percentile storm)
- Calculate the post-construction WQv and size BMPs per the Maryland Manual
  - Include BMPs with a volume reduction component
  - Treatment train approach...multiple practices
- Use CWP tool to estimate effect of BMPs on volume reduction BMPs
- Enhance BMPs for additional volume reduction
  - Infiltration bed design (under bioretention)
  - Pervious pavement design (terraced/perched layer)

Spreadsheet Tool Sheet 1
Establish the Pre-Existing Runoff Condition



Project Name: Tip-Top Shape Shopping
MSD P#: P#28888-00
Computed By: Mica D'Guy Date: 8-Mar-10
Checked By: Joe Miner Pe Date: 9-Mar-10

Is complete reduction of 1.14" required? no
(If so, answer "yes" and skip this sheet. Applies to some projects in combined sewer area.)

Pre-Existing Development Input

Total Site Area (A) = 2.37 Ac.
Impervious Area = 0.00 Ac.
Pervious Area = 2.37 Ac.
P = 1.14 (Per MSD Section 4.080.02)

THIS IS A NEW DEVELOPMENT SITE. POST-CONSTRUCTION RUNOFF SHALL MIMIC PRE-EXISTING RUNOFF TO MAXIMUM EXTENT PRACTICABLE.

Compute % Impervious (I)=

I=Impervious Ac./Total Ac.*100
I= 0.00 Ac./ 2.37 Ac. *100
I= 0 %

Compute Volumetric Runoff Coeff.(Rv)=

Rv=0.009(I)+(0.05)
Rv= 0.050

Compute Pre-Existing Runoff (WQv-pre)=

WQv-pre = (P*Rv*A)/12 = Ac. Ft.
WQv-pre 0.0113 Ac-ft
WQv-pre = 490 CF

Spreadsheet Tool Sheet 2: Calculate post-construction WQv

1	Project Name:	Tip-Top Shape Shopping		Computed By: Mica D'Guy	Date:	8-Mar-10
2	MSD P#:	P#28888-00		Checked By: Joe Miner Pe	Date:	9-Mar-10
3						
4	**Post-Construction Dev. Input**			**Compute WQ Peak Discharge (Qp)**		
5						
6	Total Site Area (A) =	2.37	Ac.	Where: P = 1.14	(Per MSD Section 4.080.02)	
7	Impervious Area =	1.87	Ac.	Qa = P*Rv		
8	Pervious Area =	0.50	Ac.	Qa = 0.87		
9	P = 1.14 (Per MSD Section 4.080.02)					
10				**Compute CN Value**		
11	**Compute % Impervious (I)=**			CN = 1000/10+5P+10Qa^2*1.25Qa*P/0.5		
12	I=Impervious Ac./Total Ac.*100			CN = 97		
13	I= 1.87 Ac./ 2.37	Ac. *100		Tc (Time of Concentration) =	0.10	hr
14	I= 79	%				
15				Compute Initial Abstraction (Ia)	See (qu) from Figure D-11.1	
16	**Compute Volumetric Runoff**			Ia=(200/CN)-2	*qu* = 980	csm/in
17	**Coeff.(Rv)=**			Ia= 0.0548		
18	Rv =0.009(I)+(0.05)			Ia/P= 0.055 / 1.14		
19	Rv = 0.760			Ia/P= 0.048		
20						
21	**Compute Post-Construction**			**Compute Water Quality (WQf-post)=**		
22	**Runoff (WQv-post)=**					
23	WQv-post= (P*Rv*A)/12 = Ac. Ft.			Qp = quAQa		
24	WQv-post 0.1711	Ac-ft		**Qp = 3.14 cfs**		
25	**WQv-post = 7,455 CF**					
26				**Compute Water Quality Orifice Size**	C =	3.1
27				Ao = Qp/[C*(2gh)^0.5]=Qp/[4.81h^0.5]	hs =	2.34 ft
28				Ao = 0.4273 sf	pi =	3.14
29				**Do** = [(4*Ao)/pi)]^0.5 = 0.7378 ft	=	9 in

Spreadsheet Tool Sheet 3
CWP Tool

data input cells
calculation cells
constant values

1. Post-Development Project & Land Cover Information

Constants

Annual Rainfall (inches)	39
Target Rainfall Event (inches)	1.14

Land Cover Summary

Weighted Rv(forest)	0.05
Weighted Rv(turf)	0.25
Rv(impervious)	0.95

2. Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load

Credit	Unit	Description of Credit	Credit	Credit Area (acres) (cf for Credit 2.e)	Adjustment to Treatment Volume (cf)
1. Protected Open Space Receiving Runoff from Developed Areas					
1.a. A/B Soils	impervious acres draining to conserved open space	75% runoff volume reduction for treated area	0.75	0.00	0
	turf acres draining to conserved open space	75% runoff volume reduction for treated area	0.75	0.00	0
1.b. C/D Soils	impervious acres draining to conserved open space	50% runoff volume reduction for treated area	0.50	0.00	0
	turf acres draining to conserved open space	50% runoff reduction volume for treated area	0.50	0.00	0
2. Rooftop Disconnection					
2.a. Simple Disconnection to A/B Soils	acres of rooftop disconnected	50% runoff volume reduction for treated area	0.50	0.00	0
2.b. Simple Disconnection to C/D Soils	acres of rooftop disconnected	25% runoff volume reduction for treated area	0.25	0.00	0
2.c. To Amended Soils	acres of rooftop disconnected	75% runoff volume reduction for treated area	0.75	0.00	0
2.d. To Rain Garden or Dry Well	acres of rooftop disconnected	75% runoff volume reduction for treated area	0.75	0.00	0
2.e. To Rain Barrel, Rain Tank, or Cistern	cubic feet of water captured	75% of volume captured	0.75	0.00	0
3. Pervious Parking					
3.a. A/B Soils, Infiltration Design	acres of pervious parking	75% runoff volume reduction	0.75	0.00	0
	upgradient non-pervious parking draining to pervious	50% runoff volume reduction	0.50	0.00	0
3.b. C/D Soils, With Underdrain	acres of pervious parking	50% runoff volume reduction	0.50	0.00	0
	upgradient non-pervious parking draining to pervious	25% runoff volume reduction	0.25	0.00	0
4. Green Roof					
4.a. Green Roof #1	acres of green roof	45% runoff volume reduction	0.45	0.00	0
4.b. Green Roof #2	acres of green roof	65% runoff volume reduction	0.65	0.00	0

Spreadsheet Tool Sheet 3 CWP Tool

MSD P#: P#28888-00 Checked By: Joe Date: 3/5/10

data input cells
calculation cells
constant values

1. Post-Development Project & Land Cover Information

Constants

Annual Rainfall (inches)	39
Target Rainfall Event (inches)	1.14

Land Cover Summary

Weighted Rv(forest)	0.05
Weighted Rv(turf)	0.25
Rv(impervious)	0.95

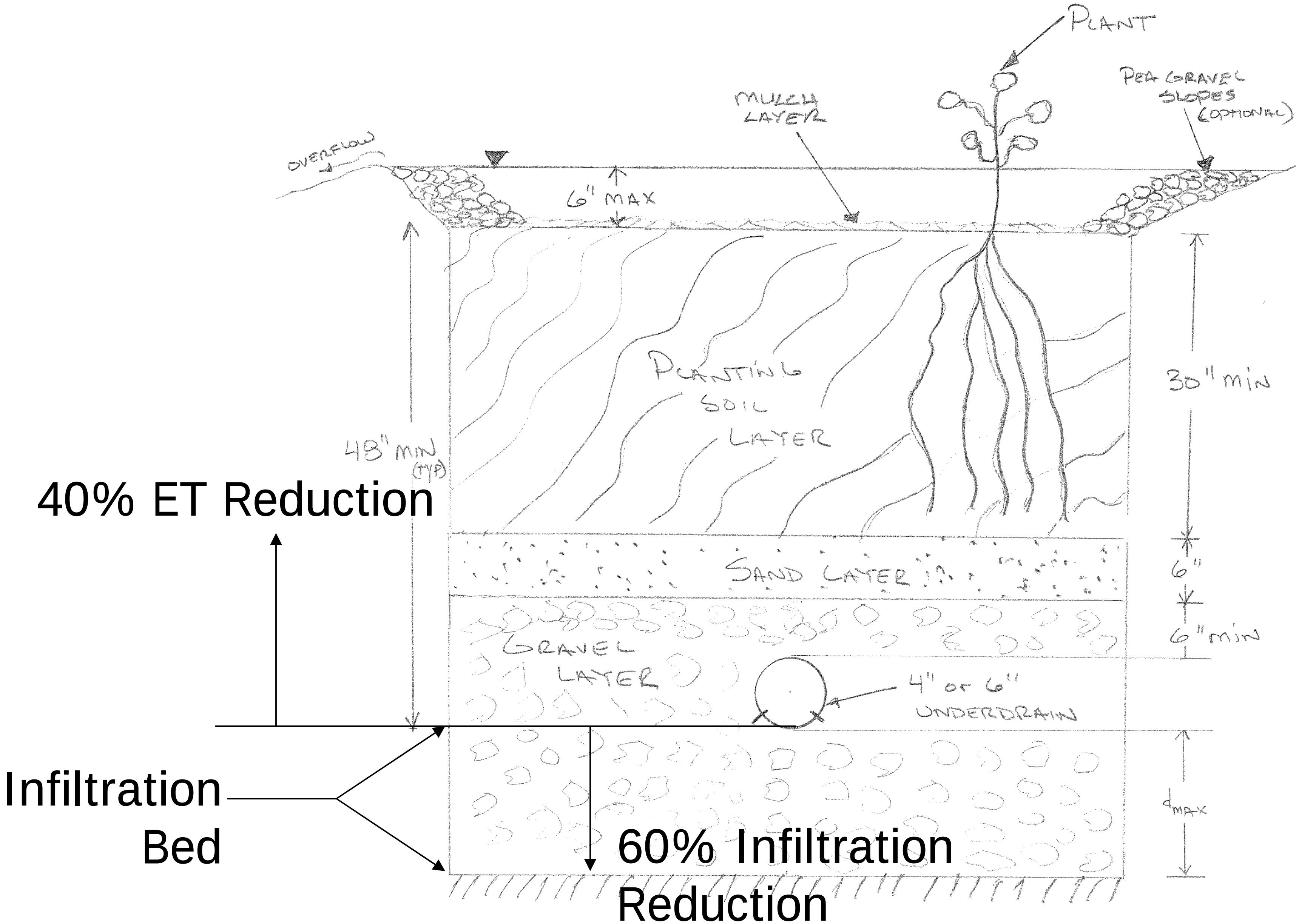
2. Apply Runoff Reduction Practices to Reduce Treatment Volume & Post-Development Load

Credit	Unit	Description of Credit	Credit	Credit Area (acres) (cf for Credit 2.a)	Adjustment to Treatment Volume (cf)
5. Grass Channels					
5.a. A/B Soils	impervious acres draining to grass channels	30% runoff volume reduction	0.30	0.00	0
	channels	30% runoff volume reduction	0.30	0.00	0
5.b. C/D Soils	impervious acres draining to grass channels	15% runoff volume reduction	0.15	0.00	0
	channels	15% runoff volume reduction	0.15	0.00	0
6. Bioretention (includes Native Planted Dry Swales)					
6.a. Bioretention #1 (C/D Soils)	impervious acres draining to bioretention	40% runoff volume reduction	0.40	1.87	2941
	bioretention	40% runoff volume reduction	0.40	0.50	207
6.b. Bioretention #2 (A/B Soils)	impervious acres draining to bioretention	70% runoff volume reduction	0.70	0.00	0
	bioretention	70% runoff volume reduction	0.70	0.00	0
8. Infiltration					
7.a. Infiltration #1 (C/D Soils, w/ underdrain)	impervious acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0
	infiltration	50% runoff volume reduction	0.50	0.00	0
7.b. Infiltration #2 (A/B Soils, w/out underdrain)	impervious acres draining to infiltration	75% runoff volume reduction	0.75	0.00	0
	infiltration	75% runoff volume reduction	0.75	0.00	0
9. Extended Detention					
8.a. ED #1	ED	5% runoff volume reduction	0.05	0.00	0
	turf acres draining to ED	5% runoff volume reduction	0.05	0.00	0
8.b. ED #2	ED	10% runoff volume reduction	0.10	0.00	0
	turf acres draining to ED	10% runoff volume reduction	0.10	0.00	0

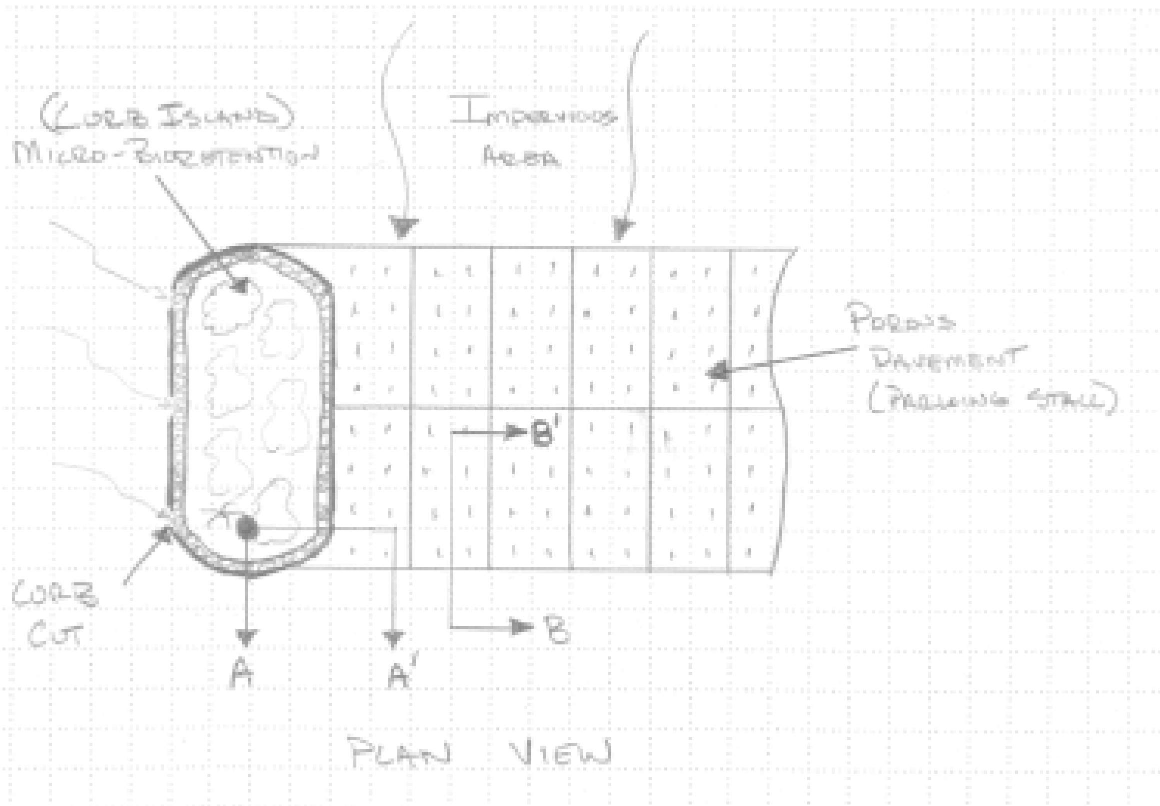
POST-CONSTRUCTION WQv (cf)	7,455
VOLUME REDUCTION BY PRACTICE W/OUT ENHANCEMENT (cf)	3,148
PRE-CONSTRUCTION WQv (cf)	490
REMAINING WQv REDUCTION NEEDED (cf)	3,817

Is this MEP?

Enhanced Bioretention

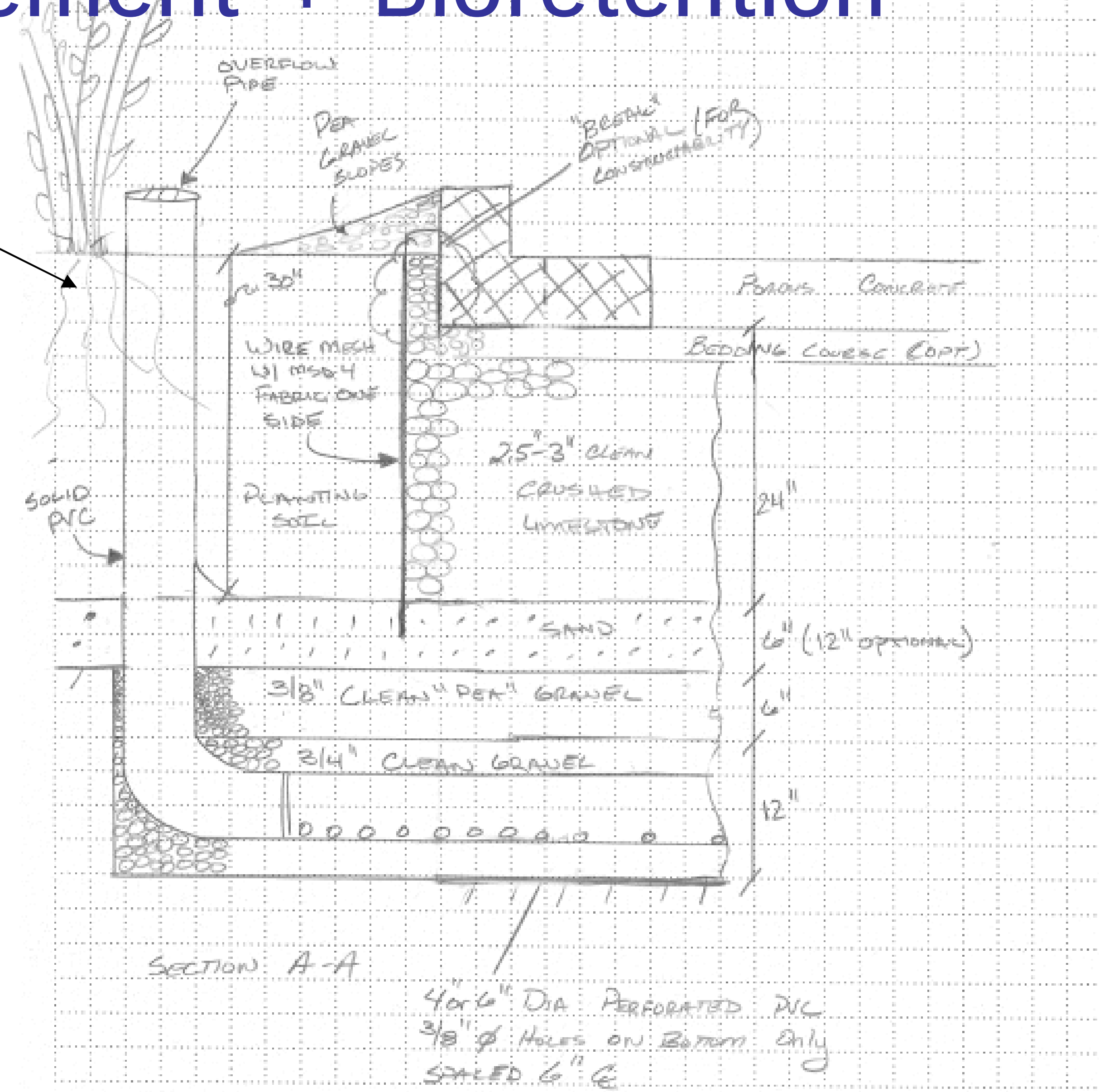


Enhancing Performance
Porous Pavement + Bioretention

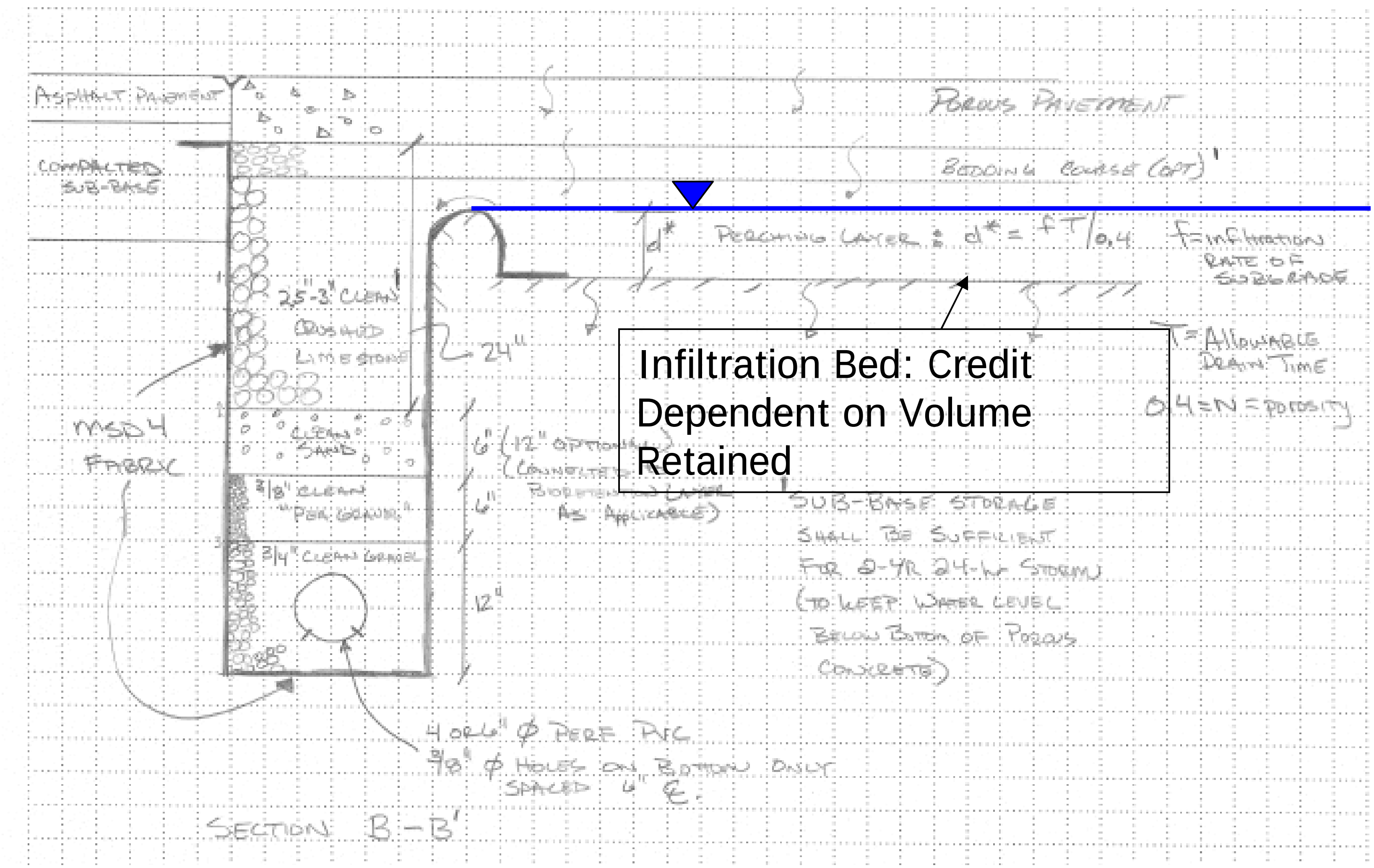


Enhancing Performance
Porous Pavement + Bioretention

40% ET Reduction (for sheetflow into bioretention)



Enhancing Performance
Porous Pavement + Bioretention



Spreadsheet Tool Sheet 4

Project Name:Tip-Top Shape Sh	Computed By: Mica D'Guy	Date: 3/8/10
MSD P#: P28888-00	Checked By: Joe Miner Pe	Date: 3/9/10

Infiltration Bed Sizing

WQv reduction needed =	3,817	CF	See runoff reduction method sheet.
Subgrade Infiltration Rate (f) =	0.2	in./hr. Measured from infiltration test.	
Allowable Drain Time (T) =	48	hrs	
Porosity (n)	0.4	Use 0.4 for gravel, 0.3 for planting soil.	
D_{max} (max perching bed depth)	2	feet	Dmax = f x T /n
D (perching bed depth used)	2	feet	

Filling Time (T_f)

Is the infiltration bed located underneath a bioretention or another filter? yes

If you answered "yes", provide: filter bed depth (df) 2.5 feet

filter bed hydraulic conductivity (k) 2 feet/day

Filling Time (Tf) = 30 hrs

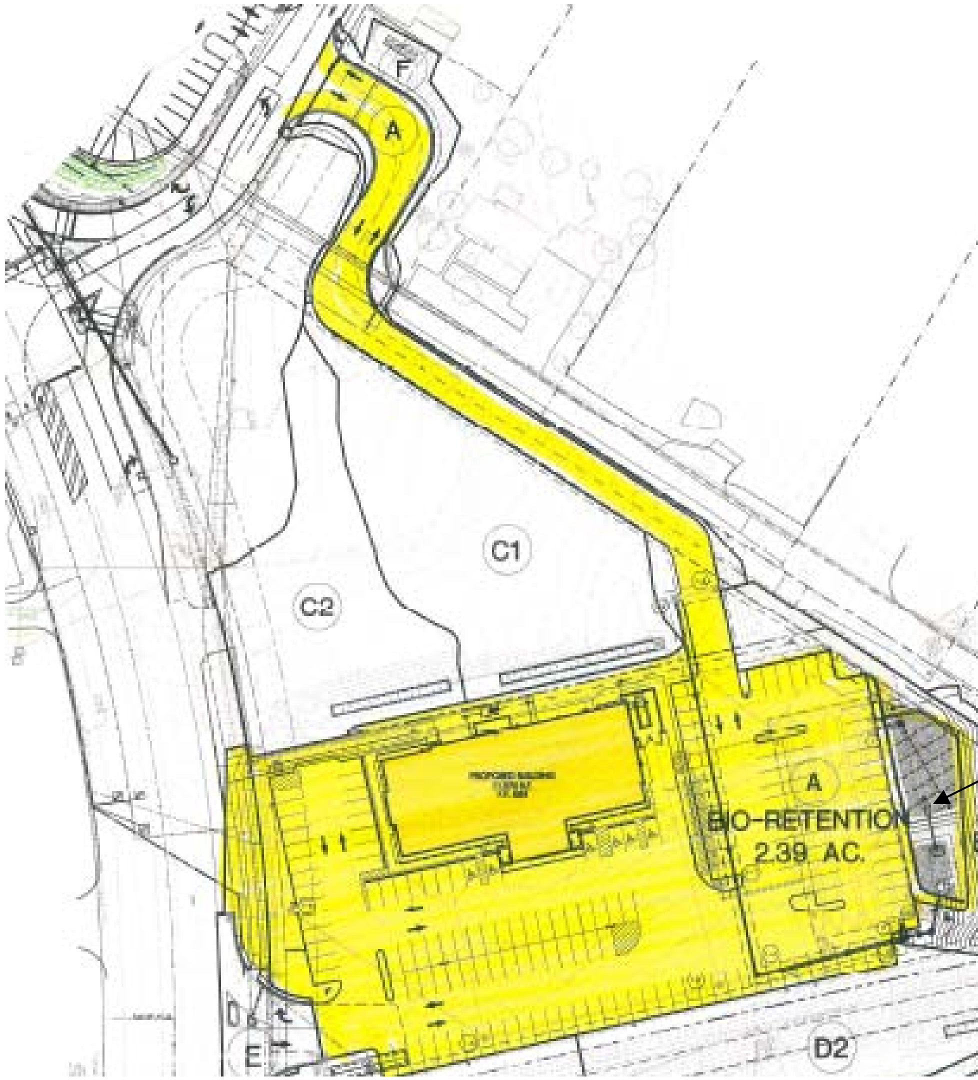
Tf = df/k x 24 hrs/day when under a filter

Tf= 2 hrs without a filter

Infiltration Bed Area (A_b)

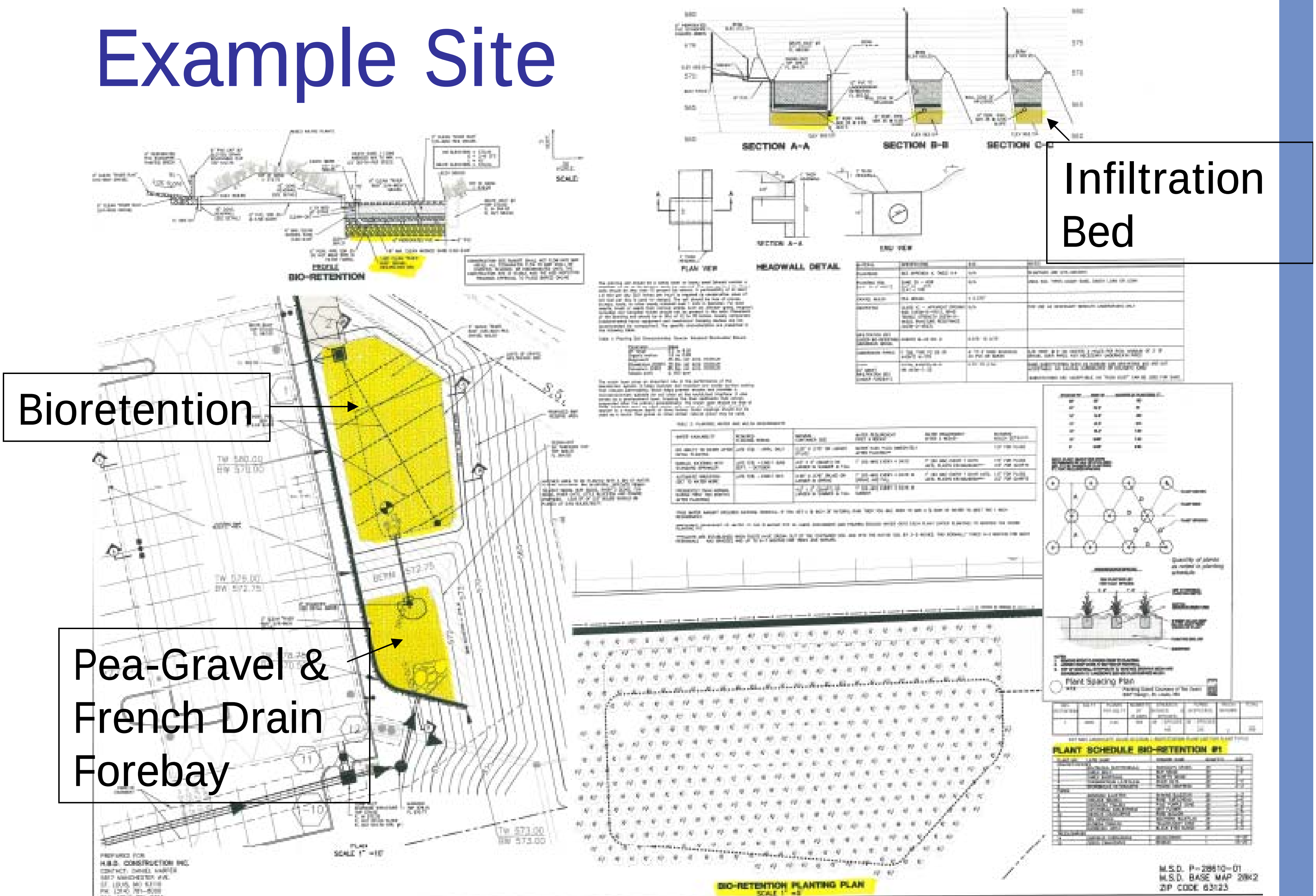
Min. Required Surface Area (Ab) = **2936** **SF** Ab = WQv (Recution) / (n x D + f x T)

Example Site

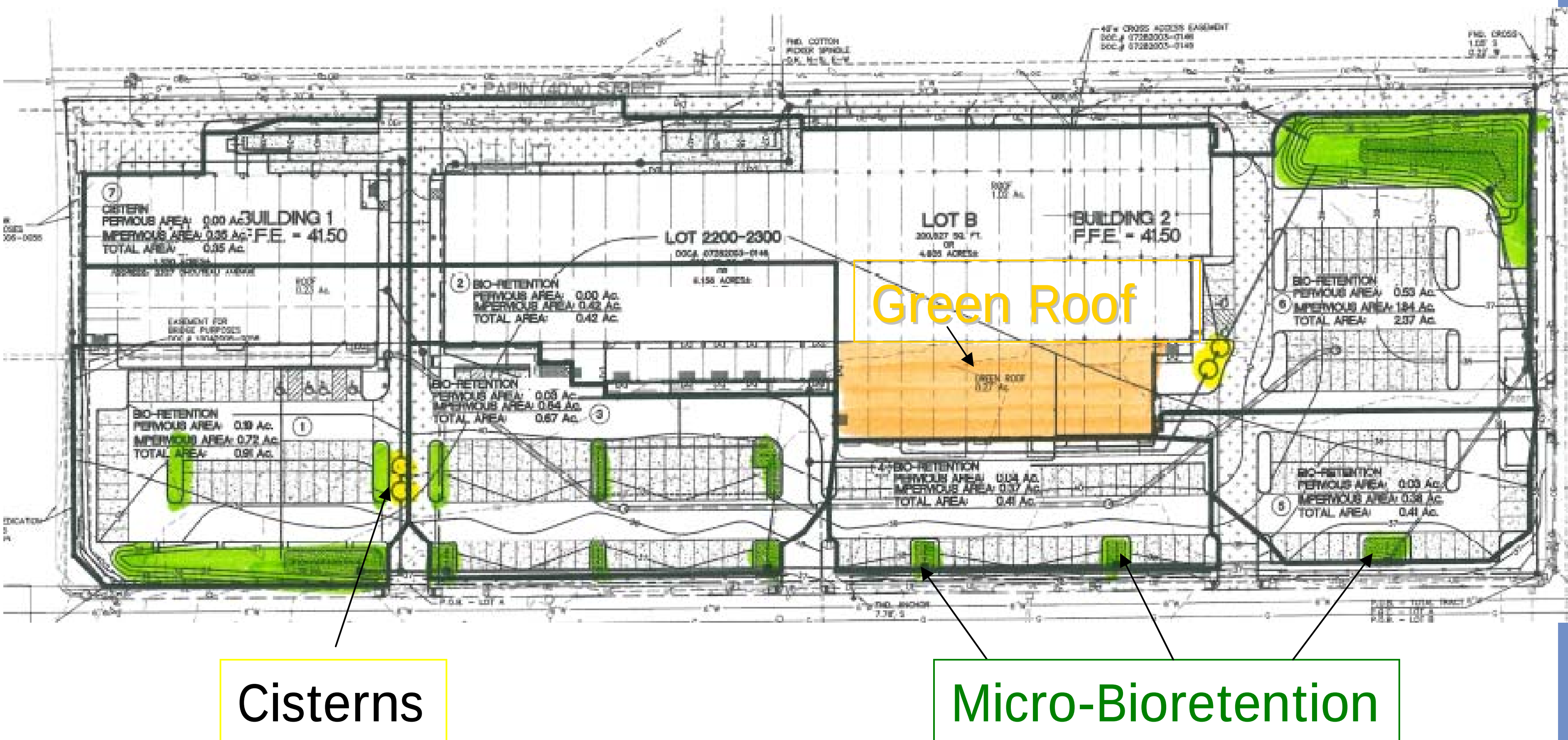


Bioretention

Example Site

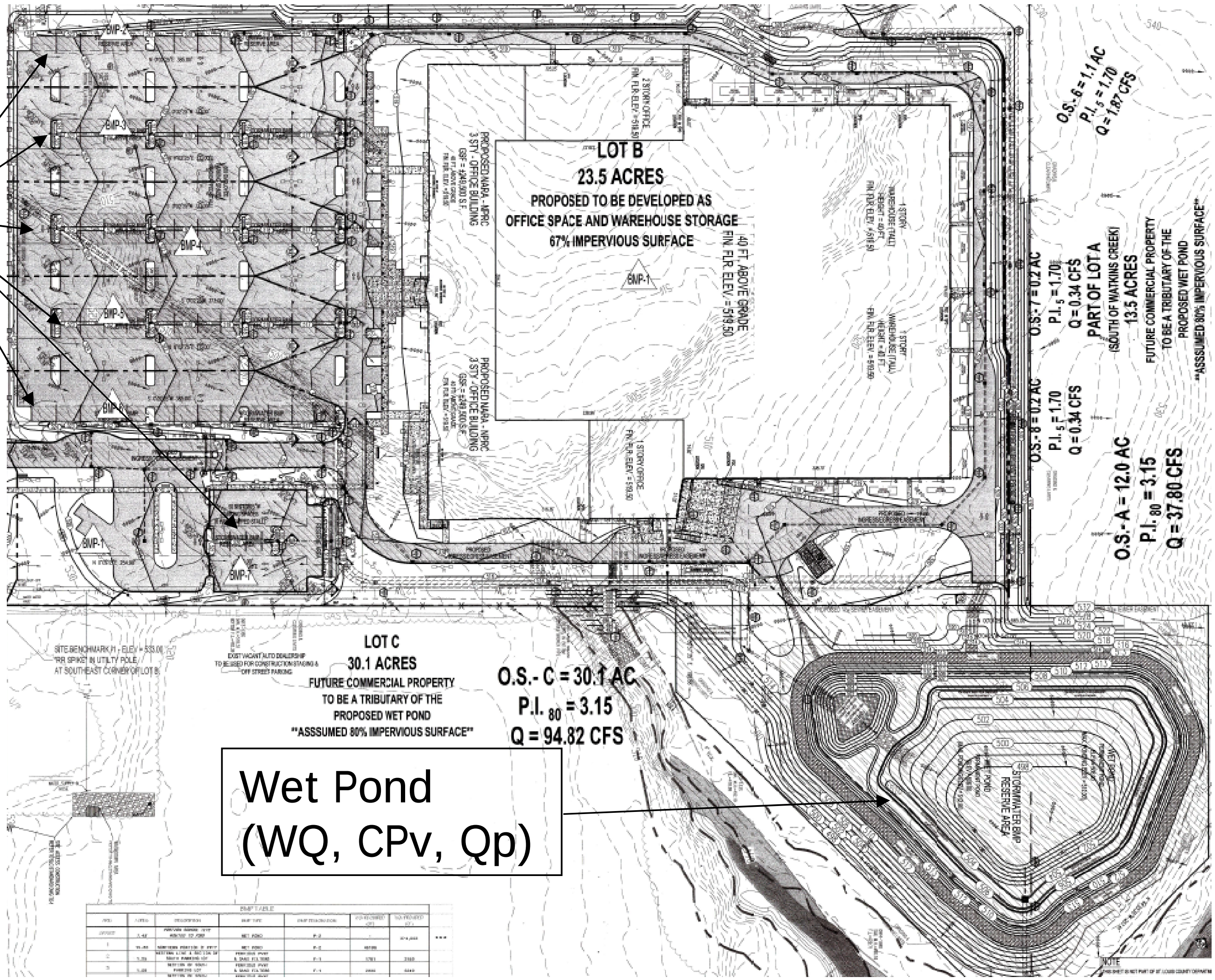


Example Site



Example Site

Porous Pavement & "Filter Swales"



Wet Pond (WQ, CPv, Qp)

Questions?

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  (Phase II under Programs)