Stormwater Volume and Treatment Methods

Simplifying the Numbers

IAFSM

March 10, 2011

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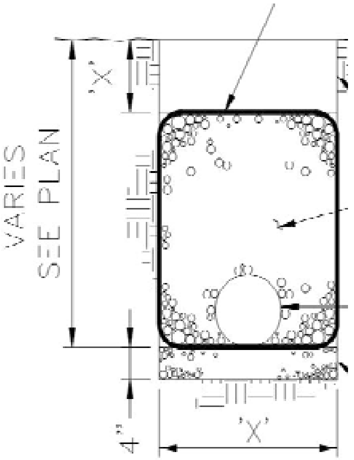
Introduction



GOALS:

- ✓ Improve understanding of Rate and Volume (Quantity) Stormwater Design
- ✓ Improve understanding of strategies to achieve points
- ✓ Share successful LEED documentation methodology
- ✓ Share past Lessons Learned

Rate & Volume Design

Agenda

I. Design intent

II. Design Goals requirements

III. Typical Strategies

IV. Sample calculation

V. Lessons learned

Rate & Quantity

General Intent

✓ Reduce net stormwater runoff rate and quantity leaving the site

Rate = Discharge rate (CFS)

Quantity = Runoff volume (Acre-FT) or (Cu.Ft.) or (Depth)

Typically quantity rules are set by regulatory group or professional guidance (LEED)

“Permanently” capture stormwater volume on site to meet quantity point intent

Rate & Quantity

Example Design Intents

LEED Version 3 :

- ✓ To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants. No stormwater increase or 25% reduction depending on % Impervious.
- ✓ City of Chicago

  Capture ½” first flush of new impervious runoff

Typical Strategies - Rate

Stormwater Design – Rate Control

Typical Strategies - Rate

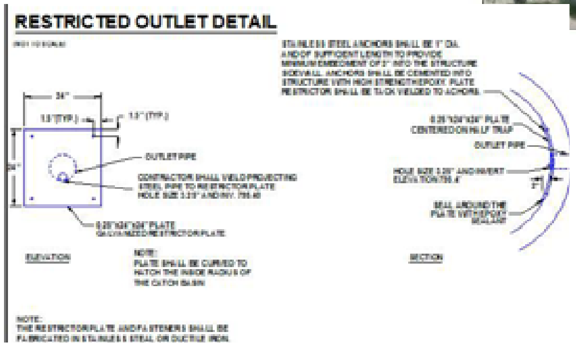
Reduced impervious – Synergy with Quantity

- Open Space
- Green roof

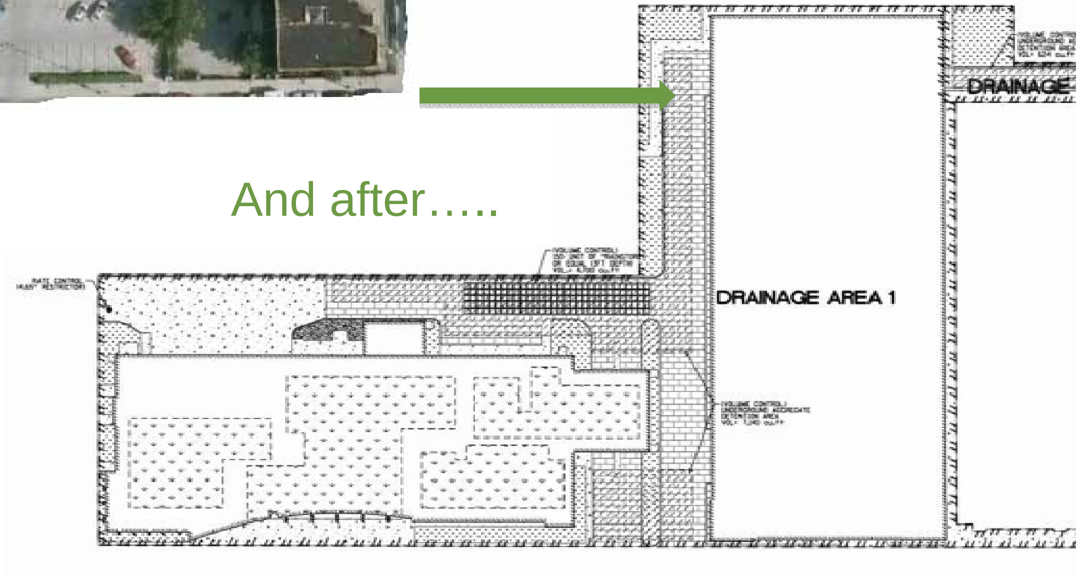
A. Restricted outflow (detention)

Add a greenroof and some landscaping to a dense urban site

Before….



And after…..



Rate control is often a standard regulatory requirement

Typical Strategies - Quantity

A. Reduced Impervious
   1. Open Space
   2. Green roof

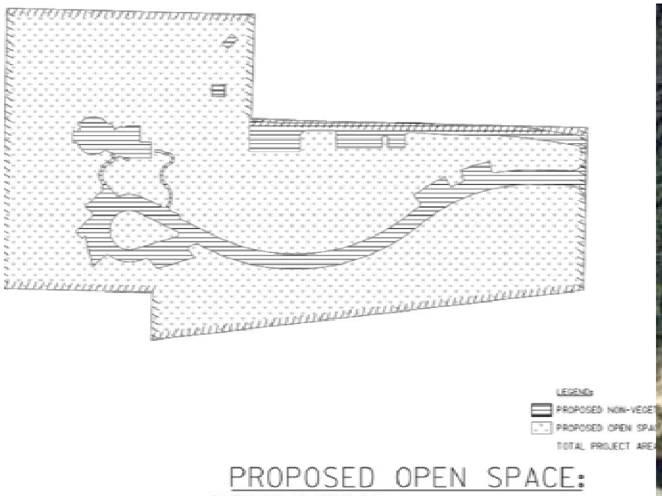
B. Infiltration
   1. Permeable pavement
   2. Soak aways
   3. Rain gardens
   4. Bio-infiltration

C. Stormwater Re-use/Rainwater Harvesting
   1. Cisterns

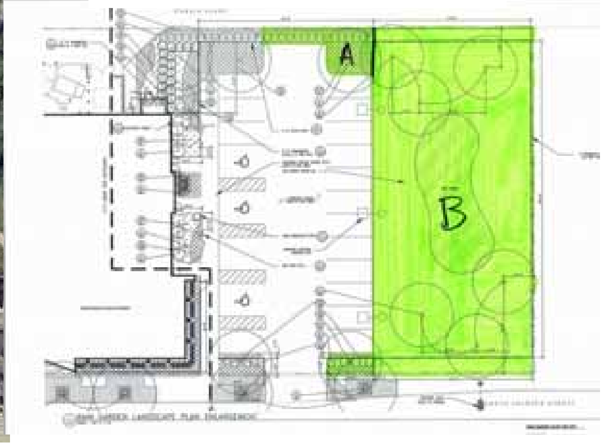
Dry Detention typically is not a quantity strategy (based on past CIR)

Typical Strategies – Quantity

Maximize Open Space | Protect Natural Areas



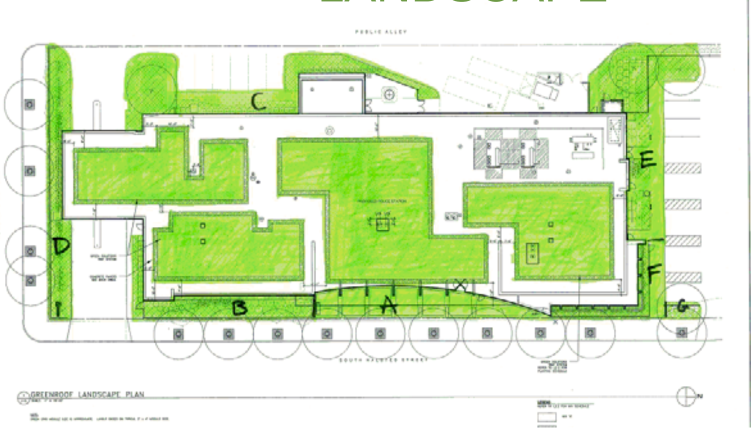
RAIN GARDENS



Reduced impervious

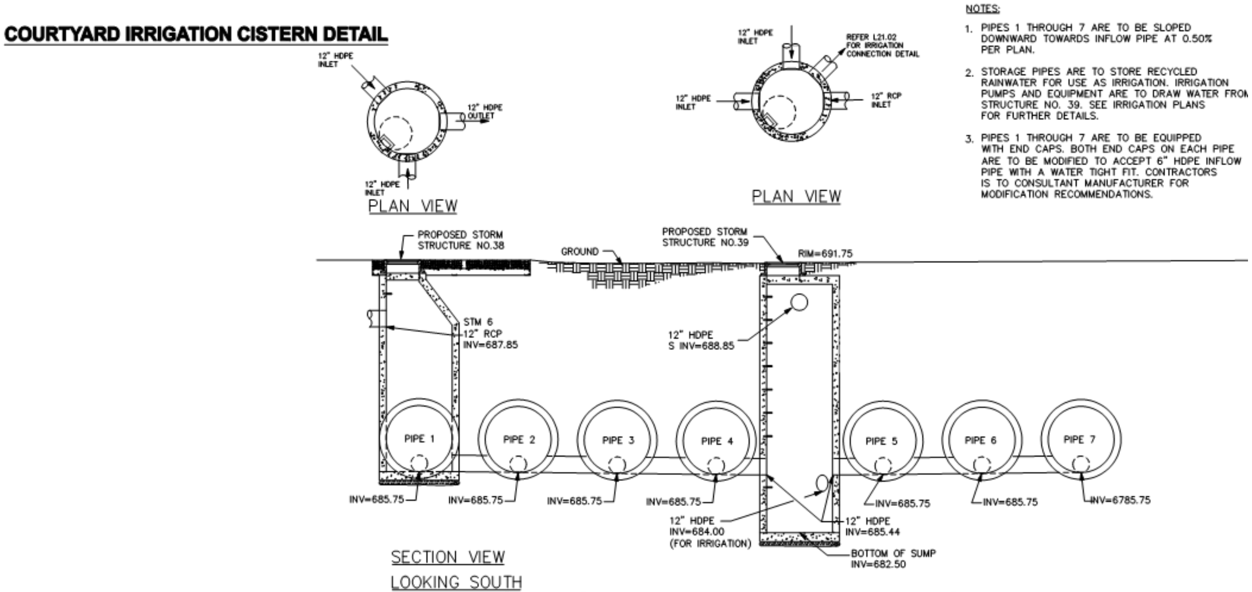
1. Increase Open Space
   - Reduce aisle widths and sidewalk widths
   - Increase planter islands widths
   - Undrained permeable pavement subgrade w/ appropriate freeboard
2. Green Roof
   - Intensive vs. extensive green roofs
   - Manufacturer test data

GREEN ROOFS AND LANDSCAPE



Applicable to wide open spaces and dense urban areas……

Convert Stormwater to Resource water



COURTYARD IRRIGATION CISTERN DETAIL

NOTES:

1. PIPES 1 THROUGH 7 ARE TO BE SLOPED DOWNWARD TOWARDS INFLOW PIPE AT 0.50% PER PLAN.
2. STORAGE PIPES ARE TO STORE RECYCLED RAINWATER FOR USE AS IRRIGATION. IRRIGATION PUMPS AND EQUIPMENT ARE TO DRAW WATER FROM STRUCTURE NO. 39. SEE IRRIGATION PLANS FOR FURTHER DETAILS.
3. PIPES 1 THROUGH 7 ARE TO BE EQUIPPED WITH END CAPS. BOTH END CAPS ON EACH PIPE ARE TO BE MODIFIED TO ACCEPT 6" HDPE INFLOW PIPE WITH A WATER TIGHT FIT. CONTRACTORS IS TO CONSULTANT MANUFACTURER FOR MODIFICATION RECOMMENDATIONS.

- ✓ Watertight system
- ✓ Sensors and control systems
- ✓ Pumps
- ✓ Overflow and backwater considerations
- ✓ Backflow protection
- ✓ Stormwater pre-treatment
- ✓ Maintenance and drain down

Stormwater Re-use/Rainwater Harvesting

1. Irrigation
   - Above ground and below ground cisterns available
   - Cistern sized based on July irrigation demand. Verify drainage area supports demand
   - Above ground fairy simple and extra benefit of visual feature
   - Below ground cistern involves complicated integrated design
2. Toilet Flushing and washdown

POTENTIAL IMPACT: Subtract irrigation tank volume from gross site runoff volume

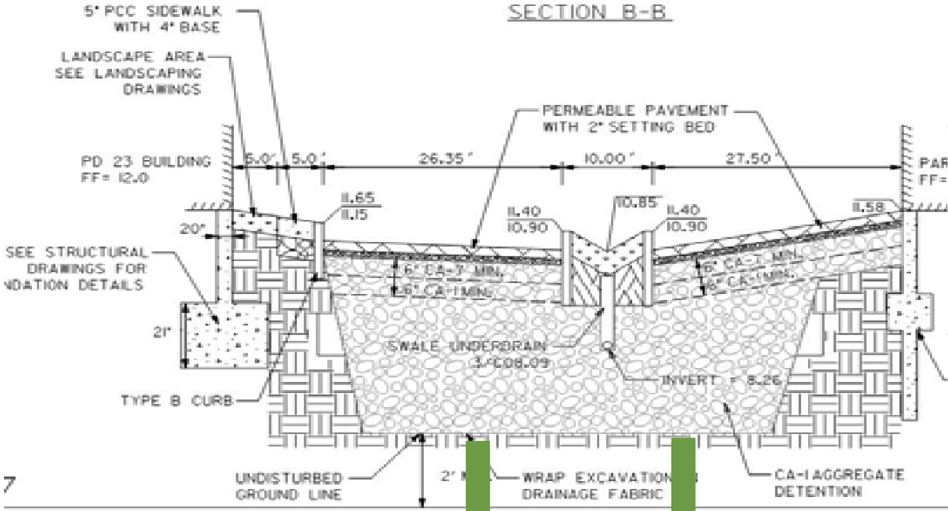
Typical Strategies - Quantity

Stormwater Design – Quantity Control

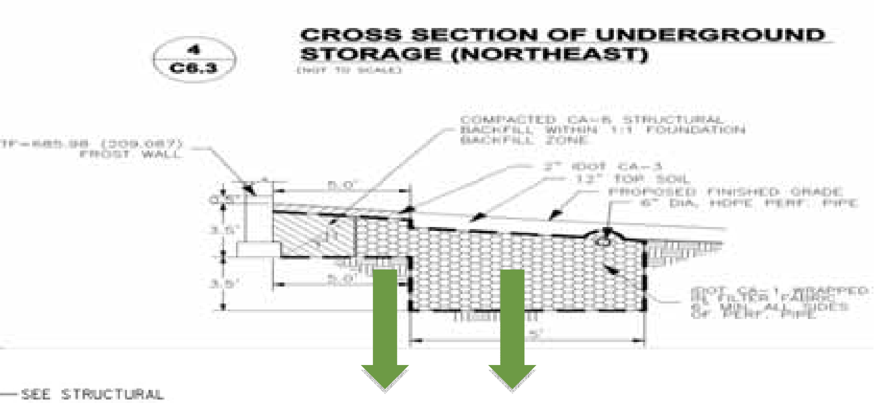
Infiltration Methods:

Permeable pavement

Soak aways/French Drain



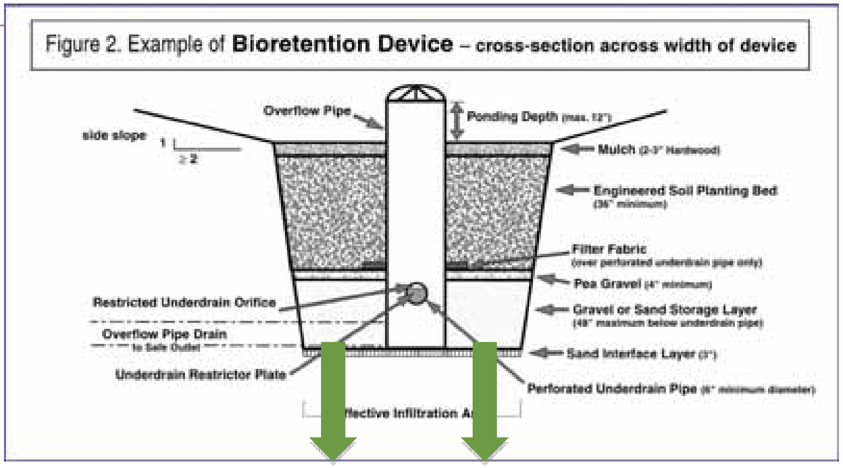
SEE STRUCTURAL DRAWINGS FOR FOUNDATION DETAILS



Maintain21" depth from surface to HWL

Bio-infiltration

Figure 2. Example of **Bioretention Device** – cross-section across width of device

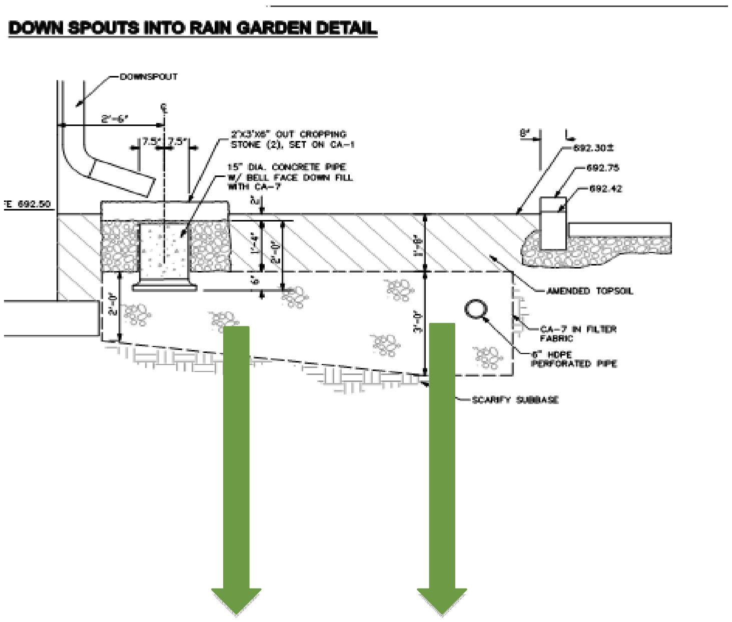


Infiltrate Stormwater
aka aquifer recharge

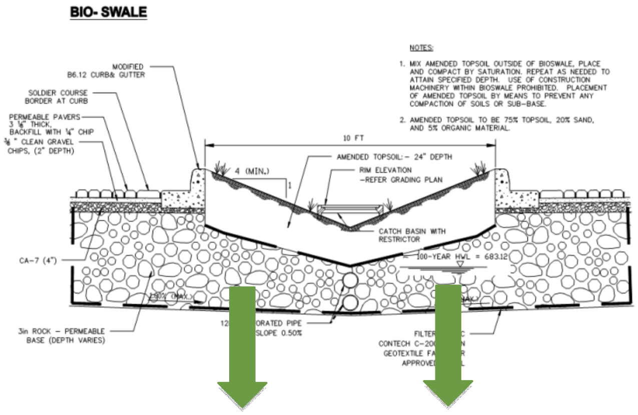
Infiltration

One of two typical scenarios:

- Soil support high rate of infiltration
- Soils do not support high rate of infiltration



DOWN SPOUTS INTO RAIN GARDEN DETAIL



BIO- SWALE

NOTES:

1. MIX AMENDED TOPSOIL OUTSIDE OF BIOSWALE, PLACE AND COMPACT BY SATURATION. REPEAT AS NEEDED TO ATTAIN SPECIFIED DEPTH. USE OF CONSTRUCTION MACHINERY WITHIN BIOSWALE PROHIBITED. PLACEMENT OF AMENDED TOPSOIL BY MEANS TO PREVENT ANY COMPACTION OF SOILS OR SUB-BASE.
2. AMENDED TOPSOIL TO BE 75% TOPSOIL, 20% SAND, AND 5% ORGANIC MATERIAL.

Infiltration Volume

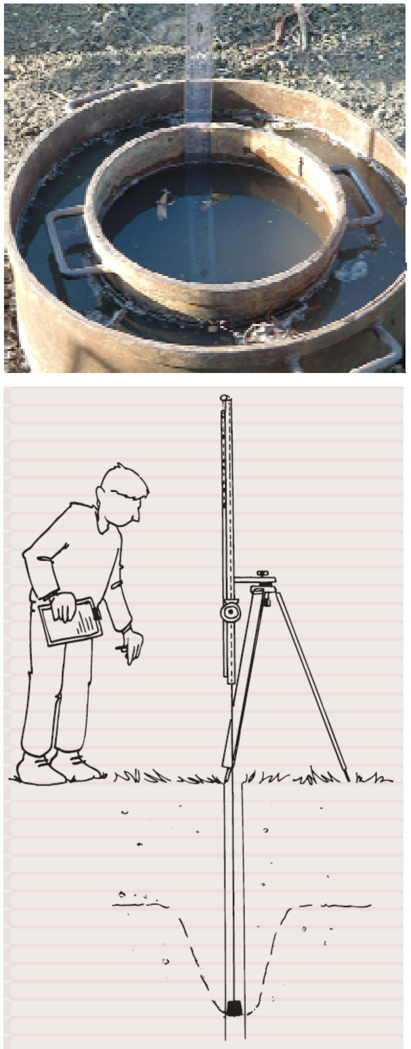


Image from Surechem.com

Infiltration - Soil supports infiltration

Test soils to establish infiltration rate. Double ring infiltrometer, Guelph Permeameter, Falling head test

Generally K factor in/hr is useful to determine if soils are suitable for infiltration but not useful for preparing a simple hand calculation…..

The infiltration volume over 24 hrs= ????

Do lower permability soils rule out infiltration?

Slow Infiltration - Soil does not support high rate of infiltration (aka Clay or Silt Loam)

Even with 0.1 in/hr rate of infiltration, it would appear there still is value as over time mounded water in infiltration basin will drain to water table…..

Infiltration volume is the volume of infiltration basin below overflow. Actual aquifer recharge during 24 hour period is generally neglected for quantity calculation purposes

IMPACT: Subtract infiltration volume from gross site runoff volume

Infiltration Volume

Common calculation methods:

Complex:

✓ Apply falling head rate at time steps through a design storm
✓ Green Ampt - Dynamic Differential Equation
✓ Darcy's Law - Dynamic Differential Equation

Simpler:

✓ Volume in vs. Volume out
Wv = (P * Rv * A) / 12
Rv=0.05+0.9Ia
RV = from studied value

Most Simple:

✓ Size infiltration basin based on small storm runoff volume and provide 100% storage. Treat as retention basin neglect infiltration and evapotranspiration

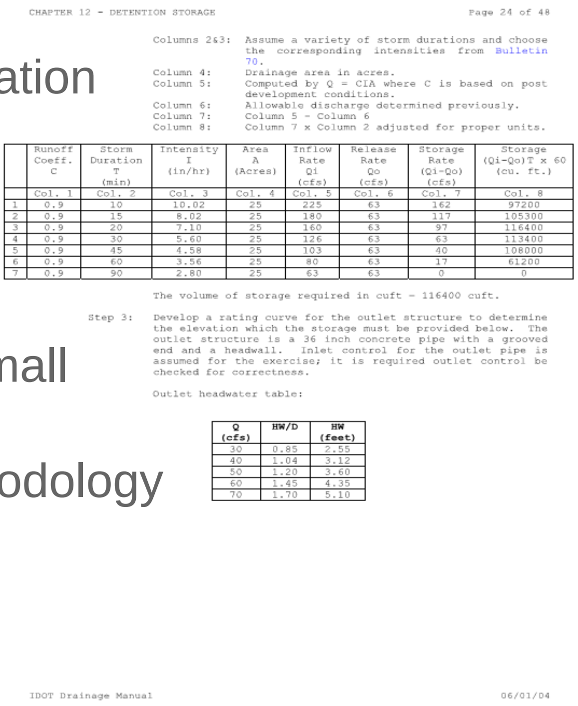
Rational Method to Size Infiltration Volume

Logic Behind Using Rational Method:

- ✓ Accepted by City of Chicago for infiltration calculation
- ✓ Duplicates Storm sewer calculations
- ✓ Conservative volume estimate and coefficients
- ✓ Accepted by MWRD and IDOT for small detention analysis
- ✓ Original USGBC recommended methodology

Drawbacks:

- ✓ Technically meant for conveyance calculations
- ✓ Old technology
- ✓ Potentially subjective
- ✓ Average infiltration outflow rate is not constant



CHAPTER 12 - DETENTION STORAGE   Page 24 of 48

Columns 2&3: Assume a variety of storm durations and choose the corresponding intensities from Bulletin 70.
Column 4: Drainage area in acres.
Column 5: Computed by Q = CIA where C is based on post development conditions.
Column 6: Allowable discharge determined previously.
Column 7: Column 5 - Column 6
Column 8: Column 7 x Column 2 adjusted for proper units.

	Runoff Coeff. C	Storm Duration T (min)	Intensity I (in/hr)	Area A (Acres)	Inflow Rate Qi (cfs)	Release Rate Qo (cfs)	Storage Rate (Qi-Qo) (cfs)	Storage (Qi-Qo)T x 60 (cu. ft.)
	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
1	0.9	10	10.02	25	225	63	162	97200
2	0.9	15	8.02	25	180	63	117	105300
3	0.9	20	7.10	25	160	63	97	116400
4	0.9	30	5.60	25	126	63	63	113400
5	0.9	45	4.58	25	103	63	40	108000
6	0.9	60	3.56	25	80	63	17	61200
7	0.9	90	2.80	25	63	63	0	0

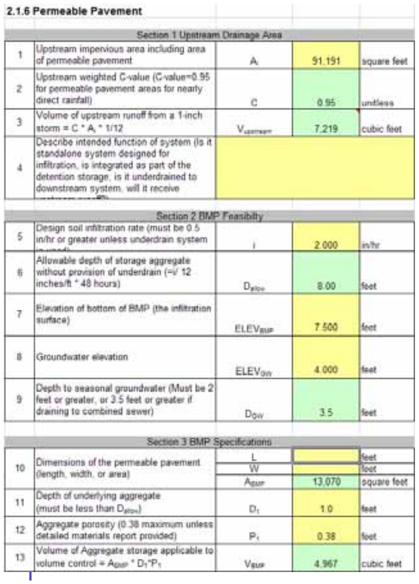
The volume of storage required in cuft - 116400 cuft.

Step 3: Develop a rating curve for the outlet structure to determine the elevation which the storage must be provided below. The outlet structure is a 36 inch concrete pipe with a grooved end and a headwall. Inlet control for the outlet pipe is assumed for the exercise; it is required outlet control be checked for correctness.

Outlet headwater table:

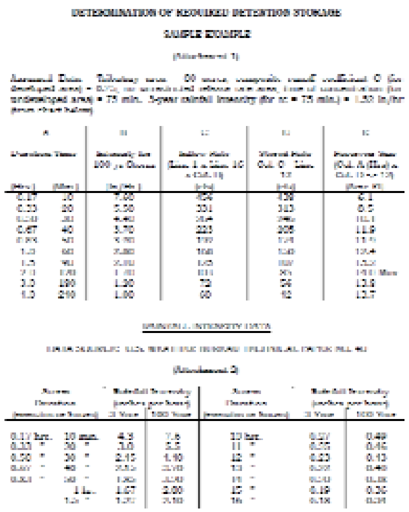
Q (cfs)	**HW/D**	**HW (feet)**
30	0.85	2.55
40	1.04	3.12
50	1.20	3.60
60	1.45	4.35
70	1.70	5.10

IDOT Drainage Manual   06/01/04



2.1.6 Permeable Pavement

Section 1 Upstream Drainage Area				
1	Upstream impervious area including area of permeable pavement	A_i	91,191	square feet
2	Upstream weighted C-value (C-value=0.95 for permeable pavement areas for nearly direct rainfall)	C	0.95	unitless
3	Volume of upstream runoff from a 1-inch storm = C * A_i * 1/12	$V_{upstream}$	7,219	cubic feet
4	Describe intended function of system (Is it standalone system designed for infiltration, is integrated as part of the detention storage, is it underdrained to downstream system, will it receive			
Section 2 BMP Feasibilty				
5	Design soil infiltration rate (must be 0.5 in/hr or greater unless underdrain system	i	2.000	in/hr
6	Allowable depth of storage aggregate without provision of underdrain (=i/ 12 inches/ft * 48 hours)	D_{allow}	8.00	feet
7	Elevation of bottom of BMP (the infiltration surface)	$ELEV_{BMP}$	7.500	feet
8	Groundwater elevation	$ELEV_{GW}$	4.000	feet
9	Depth to seasonal groundwater (Must be 2 feet or greater, or 3.5 feet or greater if draining to combined sewer)	D_{GW}	3.5	feet
Section 3 BMP Specifications				
10	Dimensions of the permeable pavement (length, width, or area)	L		feet
		W		feet
		A_{BMP}	13,070	square feet
11	Depth of underlying aggregate (must be less than D_{allow})	D_1	1.0	feet
12	Aggregate porosity (0.38 maximum unless detailed materials report provided)	P_1	0.38	feet
13	Volume of Aggregate storage applicable to volume control = A_{BMP} * D_1*P_1	V_{BMP}	4,967	cubic feet



DETERMINATION OF REQUIRED DETENTION STORAGE

SAMPLE EXAMPLE

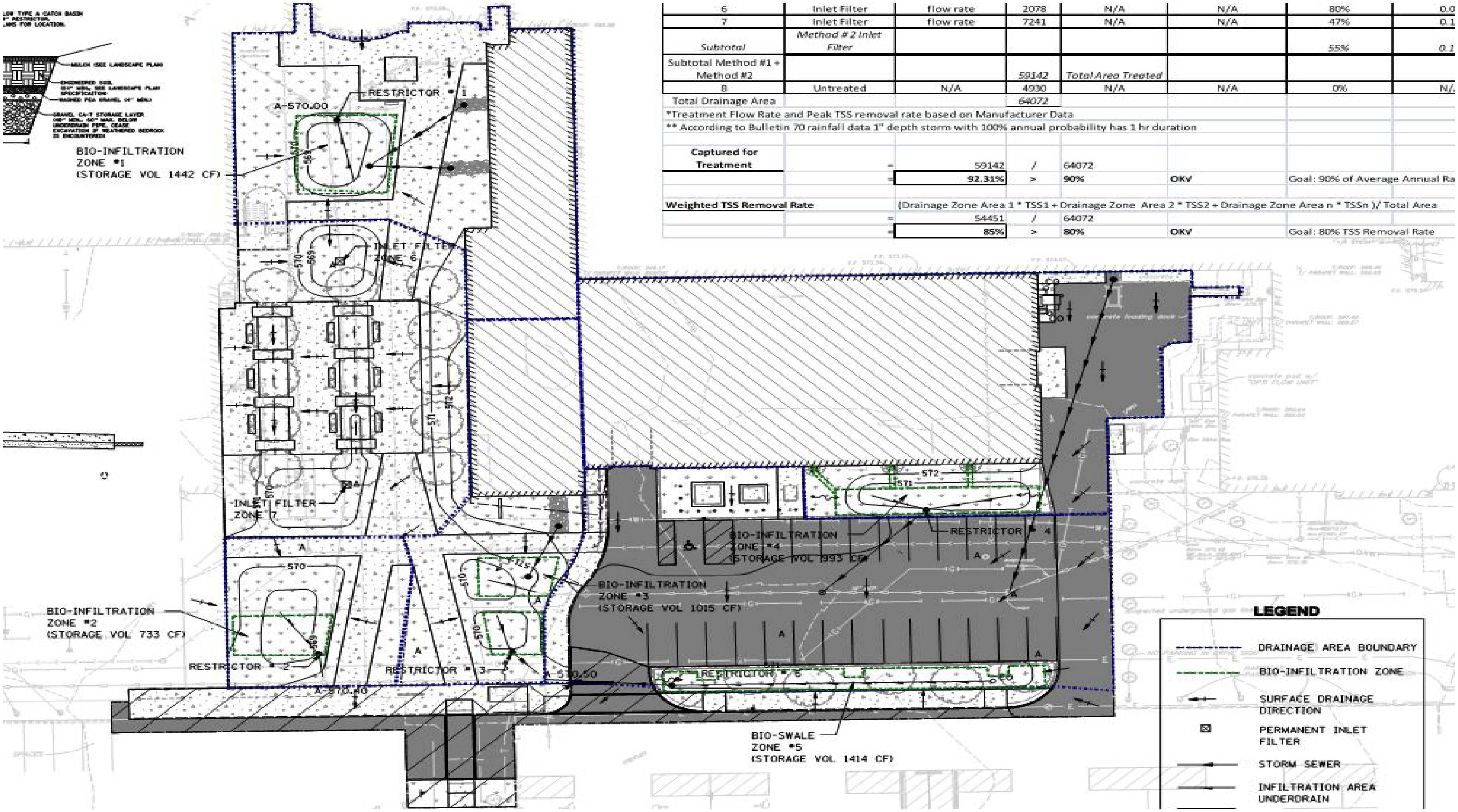
(Attachment 1)

RAINFALL INTENSITY DATA

(Attachment 2)

Sample Calculation

DELINEATE PROPOSED BMP DRAINAGE AREAS



6	Inlet Filter	flow rate	2078	N/A	N/A	80%	0.0
7	Inlet Filter	flow rate	7241	N/A	N/A	47%	0.1
Subtotal	*Method # 2 Inlet Filter*					*55%*	*0.1*
Subtotal Method #1 + Method #2			*59142*	*Total Area Treated*			
8	Untreated	N/A	4930	N/A	N/A	0%	N/
Total Drainage Area			*64072*				

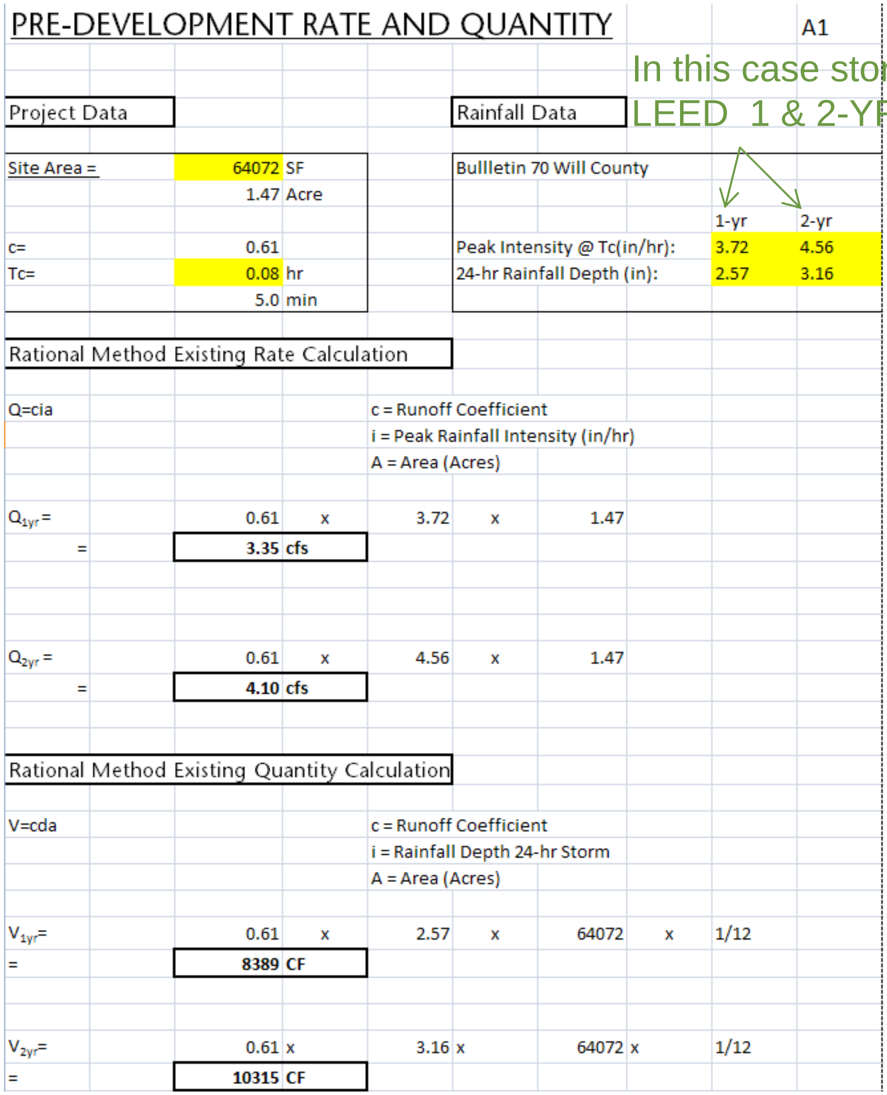
*Treatment Flow Rate and Peak TSS removal rate based on Manufacturer Data

** According to Bulletin 70 rainfall data 1" depth storm with 100% annual probability has 1 hr duration

Captured for Treatment		=	59142	/	64072		
		=	**92.31%**	>	**90%**	**OK√**	Goal: 90% of Average Annual Ra
Weighted TSS Removal Rate		(Drainage Zone Area 1 * TSS1 + Drainage Zone Area 2 * TSS2 + Drainage Zone Area n * TSSn)/ Total Area					
		=	54451	/	64072		
		=	**85%**	>	**80%**	**OK√**	Goal: 80% TSS Removal Rate

Sample Calculation
Determine gross rate and quantity

In this case storm criteria defined by LEED 1 & 2-YR 24 Hr



PRE-DEVELOPMENT RATE AND QUANTITY

A1

Project Data

Site Area =	64072	SF
	1.47	Acre
c=	0.61	
Tc=	0.08	hr
	5.0	min

Rainfall Data

Bulletin 70 Will County

	1-yr	2-yr
Peak Intensity @ Tc(in/hr):	3.72	4.56
24-hr Rainfall Depth (in):	2.57	3.16

Rational Method Existing Rate Calculation

Q=cia

c = Runoff Coefficient

i = Peak Rainfall Intensity (in/hr)

A = Area (Acres)

Q_{1yr} = 0.61 x 3.72 x 1.47

= **3.35 cfs**

Q_{2yr} = 0.61 x 4.56 x 1.47

= **4.10 cfs**

Rational Method Existing Quantity Calculation

V=cda

c = Runoff Coefficient

i = Rainfall Depth 24-hr Storm

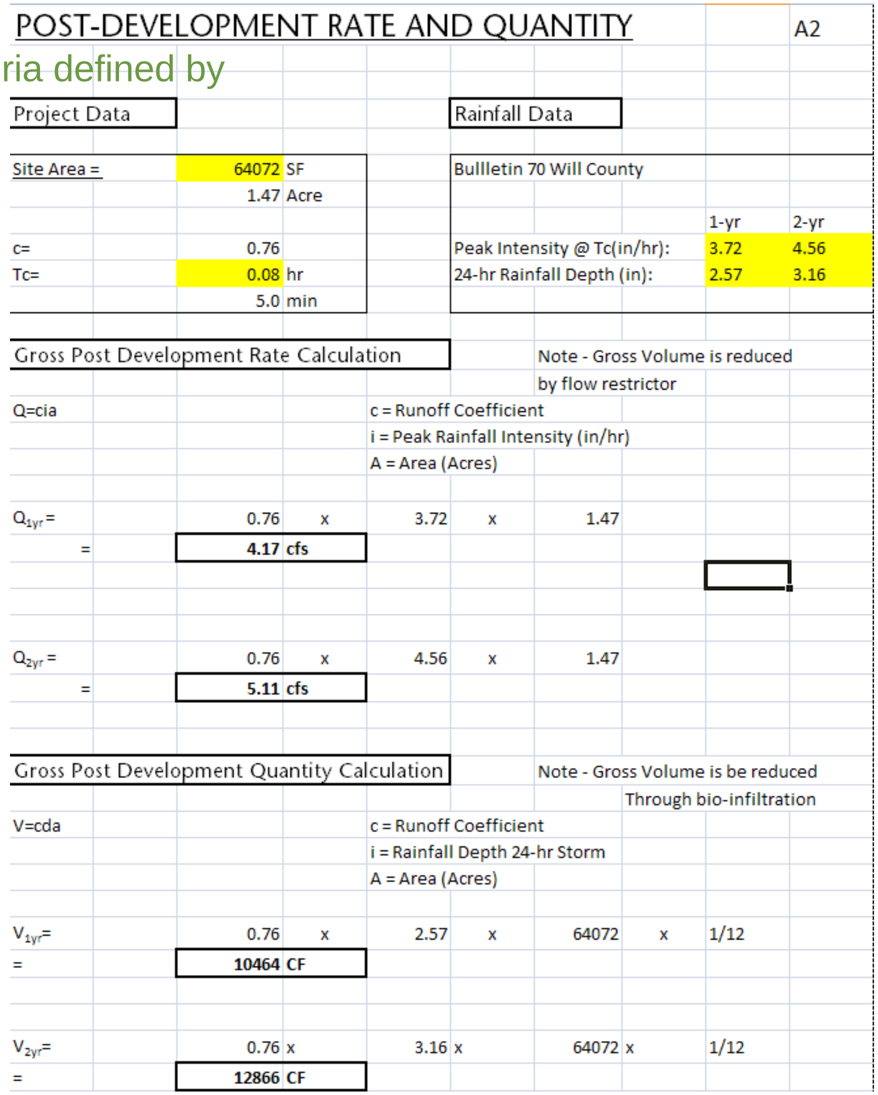
A = Area (Acres)

V_{1yr}= 0.61 x 2.57 x 64072 x 1/12

= **8389 CF**

V_{2yr}= 0.61 x 3.16 x 64072 x 1/12

= **10315 CF**



POST-DEVELOPMENT RATE AND QUANTITY

A2

Project Data

Site Area =	64072	SF
	1.47	Acre
c=	0.76	
Tc=	0.08	hr
	5.0	min

Rainfall Data

Bulletin 70 Will County

	1-yr	2-yr
Peak Intensity @ Tc(in/hr):	3.72	4.56
24-hr Rainfall Depth (in):	2.57	3.16

Gross Post Development Rate Calculation

Note - Gross Volume is reduced by flow restrictor

Q=cia

c = Runoff Coefficient

i = Peak Rainfall Intensity (in/hr)

A = Area (Acres)

Q_{1yr} = 0.76 x 3.72 x 1.47

= **4.17 cfs**

Q_{2yr} = 0.76 x 4.56 x 1.47

= **5.11 cfs**

Gross Post Development Quantity Calculation

Note - Gross Volume is be reduced Through bio-infiltration

V=cda

c = Runoff Coefficient

i = Rainfall Depth 24-hr Storm

A = Area (Acres)

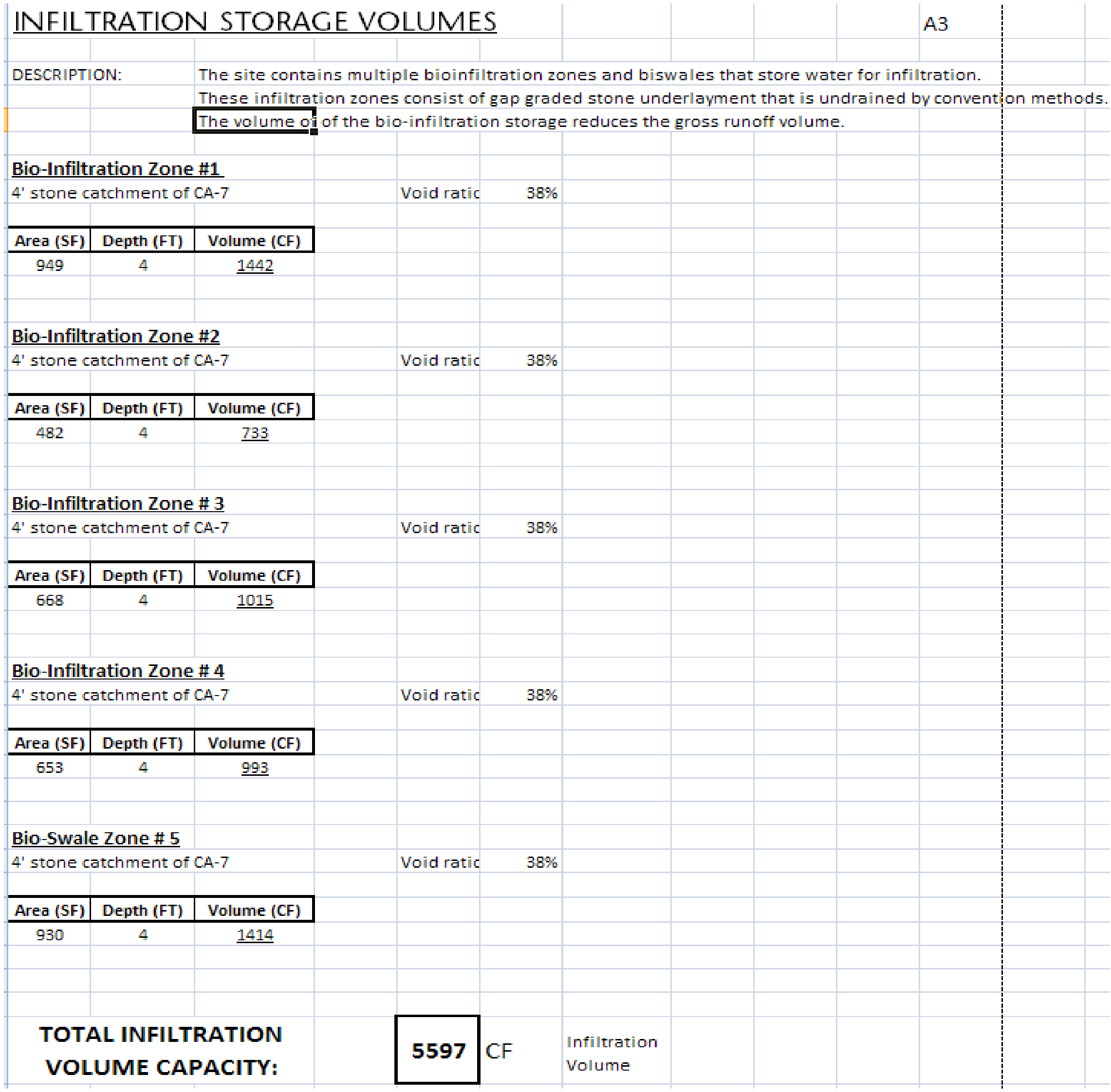
V_{1yr}= 0.76 x 2.57 x 64072 x 1/12

= **10464 CF**

V_{2yr}= 0.76 x 3.16 x 64072 x 1/12

= **12866 CF**

Sample Calculation



INFILTRATION STORAGE VOLUMES

A3

DESCRIPTION: The site contains multiple bioinfiltration zones and biswales that store water for infiltration.
These infiltration zones consist of gap graded stone underlayment that is undrained by convention methods.
The volume o of the bio-infiltration storage reduces the gross runoff volume.

Bio-Infiltration Zone #1

4' stone catchment of CA-7 — Void ratic 38%

Area (SF)	Depth (FT)	Volume (CF)
949	4	1442

Bio-Infiltration Zone #2

4' stone catchment of CA-7 — Void ratic 38%

Area (SF)	Depth (FT)	Volume (CF)
482	4	733

Bio-Infiltration Zone # 3

4' stone catchment of CA-7 — Void ratic 38%

Area (SF)	Depth (FT)	Volume (CF)
668	4	1015

Bio-Infiltration Zone # 4

4' stone catchment of CA-7 — Void ratic 38%

Area (SF)	Depth (FT)	Volume (CF)
653	4	993

Bio-Swale Zone # 5

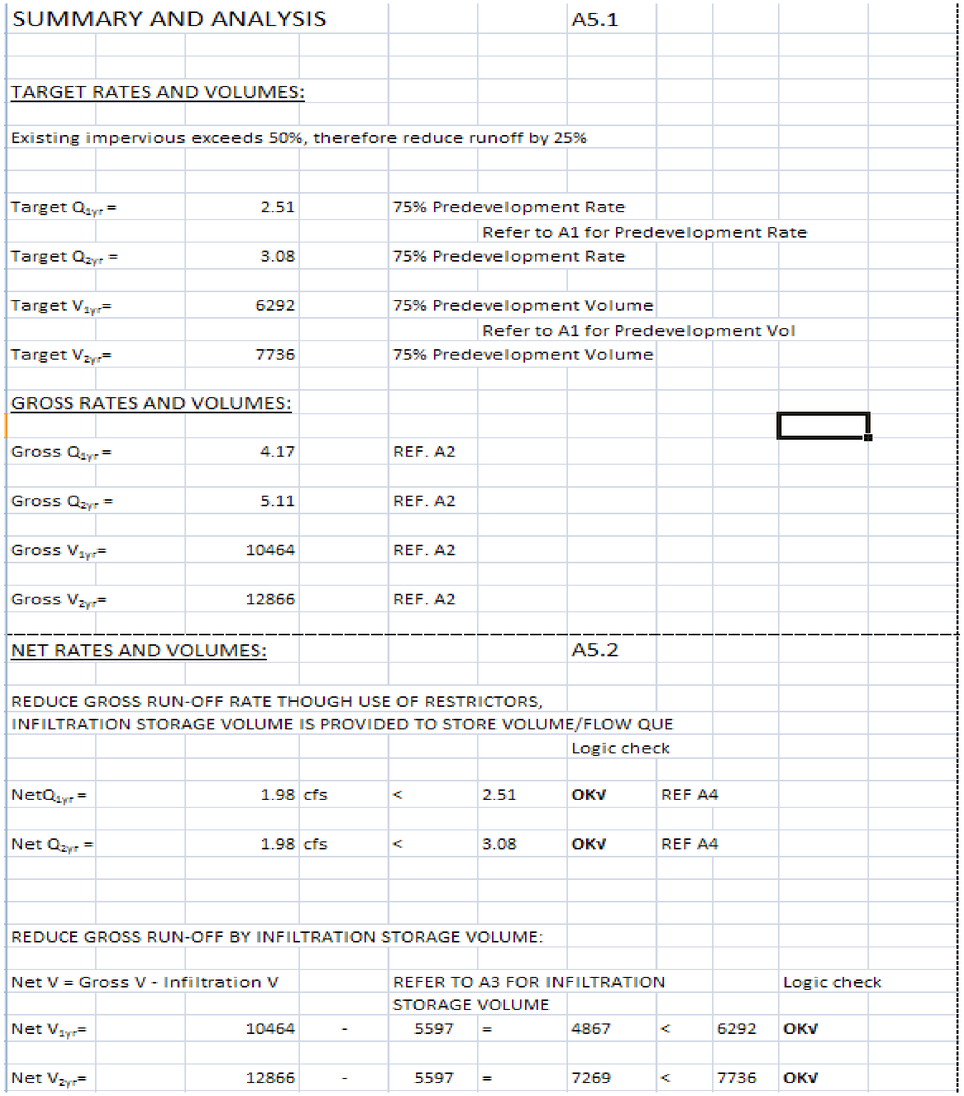
4' stone catchment of CA-7 — Void ratic 38%

Area (SF)	Depth (FT)	Volume (CF)
930	4	1414

TOTAL INFILTRATION VOLUME CAPACITY: **5597** CF Infiltration Volume

Sample Calculation

Check that goals are met…



SUMMARY AND ANALYSIS A5.1

TARGET RATES AND VOLUMES:

Existing impervious exceeds 50%, therefore reduce runoff by 25%

Target Q_{1yr} =	2.51	75% Predevelopment Rate
		Refer to A1 for Predevelopment Rate
Target Q_{2yr} =	3.08	75% Predevelopment Rate
Target V_{1yr}=	6292	75% Predevelopment Volume
		Refer to A1 for Predevelopment Vol
Target V_{2yr}=	7736	75% Predevelopment Volume

GROSS RATES AND VOLUMES:

Gross Q_{1yr} =	4.17	REF. A2
Gross Q_{2yr} =	5.11	REF. A2
Gross V_{1yr}=	10464	REF. A2
Gross V_{2yr}=	12866	REF. A2

NET RATES AND VOLUMES: A5.2

REDUCE GROSS RUN-OFF RATE THOUGH USE OF RESTRICTORS,
INFILTRATION STORAGE VOLUME IS PROVIDED TO STORE VOLUME/FLOW QUE

					Logic check	
NetQ_{1yr} =	1.98	cfs	<	2.51	OK√	REF A4
Net Q_{2yr} =	1.98	cfs	<	3.08	OK√	REF A4

REDUCE GROSS RUN-OFF BY INFILTRATION STORAGE VOLUME:

Net V = Gross V - Infiltration V

			REFER TO A3 FOR INFILTRATION STORAGE VOLUME					Logic check
Net V_{1yr}=	10464	-	5597	=	4867	<	6292	OK√
Net V_{2yr}=	12866	-	5597	=	7269	<	7736	OK√

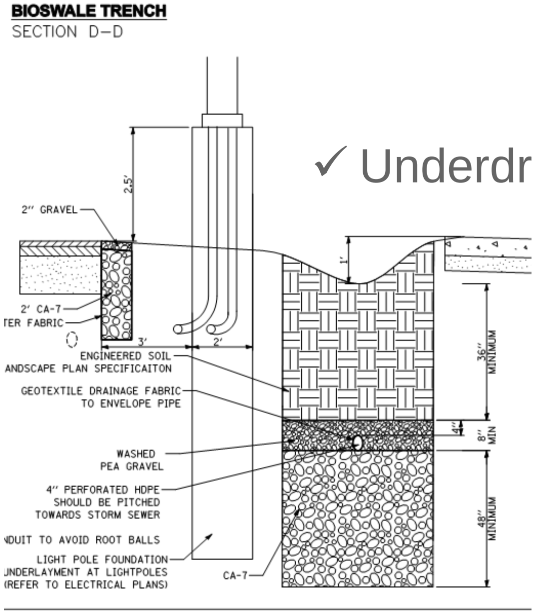
Lessons Learned

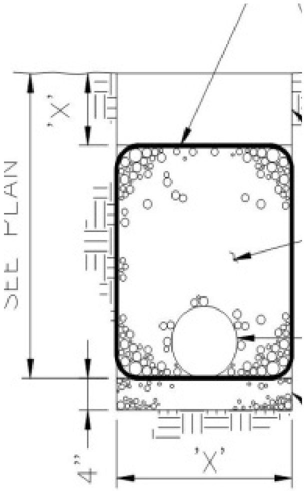
- ✓ Watch out for the goats tongue!

- ✓ Ice dams from Green roof

- ✓ Excessive erosive forces

- ✓ Underdrain Placement





R&Q
Other Modeling Methods

Pond Pack
- ✓ Infiltration rate option
- ✓ Multiple pond design

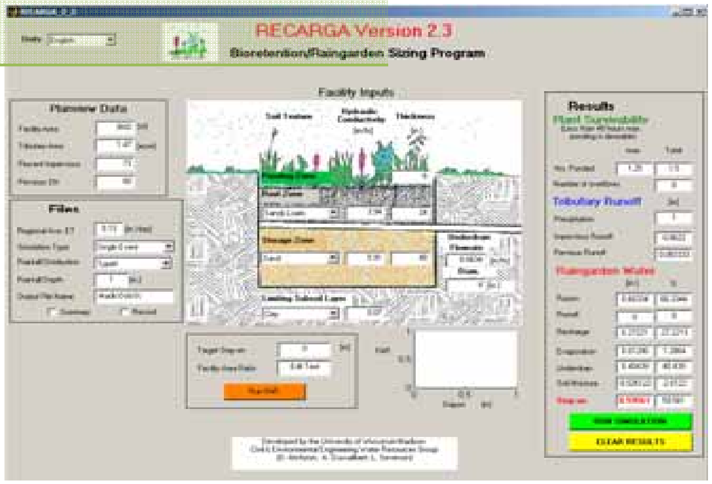
Recarga Bio-infiltration model
- ✓ University of Wisconsin Model
- ✓ Includes Evapotranspiration
- ✓ Suitable for wetland detention modeling
- ✓ Suitable for site and neighborhood scale models
- ✓ Does not model gap graded storage layer

EPA SWMM
XP SWMM
WINSLAMM
SUSTAIN

METHOD COMPARISON

1” Rainfall, 1.47 acres, C=0.76, Cn=90, Type D soil, clay sub soil

Method	Required Storage calculated
Rational Method	0.09 acre-ft ->0.24 Acre-ft soak away
TR-20	0.06 acre-ft ->0.16 Acre-ft soak away
Recarga	1.0 acre-ft (sand storage clay subsoil)



HYBRID
METHOD?

Stormwater Design – Quality Control

Typical LEED Requirement:
In plain english……

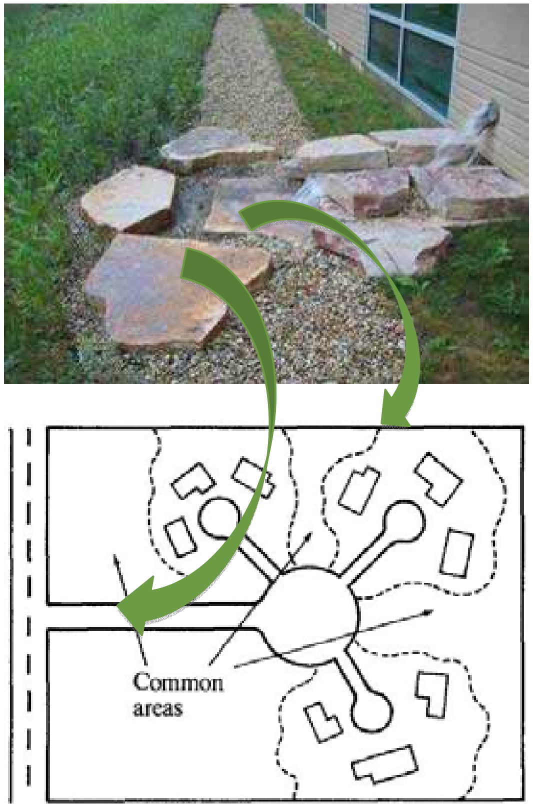
Remove 80% Total suspended soils (TSS) for 90% of the average annual rainfall

By designing BMP’s in accordance with local standards

OR

Provide product data to demonstrate compliance

Stormwater Design – Quality Control



Typical Strategies:

A. Planning and Development Strategies (Non Structural)
   1. Day lighting stormwater/disconnected Impervious
   2. Clustered development/maximized open space
   3. Preserve natural drainage features and depressions
   4. Xeriscape
   5. Reduce impervious
   6. Reduce disturbance
   7. Protecting other natural areas

But what is peculiar about these items?

Difficult to measure them for TSS removal with out before and calculations and detailed environmental analysis…..

Stormwater Design – Quality Control

Typical Strategies:

A. Structural Treatment train of BMP's

Including:

1. Bio Swales
2. Vegetative Filter strips
3. Rain gardens
4. Bio-Infiltration systems
5. Infiltration trenches
6. Soak Aways/French Drains
7. Permeable pavers
8. Level Spreaders
9. Wet Detention
10. Constructed Wetland Detention
11. Constructed Wetlands
12. Pre-engineering systems
    Manufactured systems
13. Inlet Filters

Notice what is not listed:

A. Greenroofs alone

B. Dry Bottom Detention alone

C. Native plantings alone

WATER QUALITY
Sample Calculation

Remember:

Remove 80% Total Suspended Soils (TSS) for 90% of the average annual rainfall

SO FIRST THINGS FIRST

CAPTURE 90% OF THE DRAINAGE AREA FOR TREAMENT!

OR IT’S ALL FOR NAUGHT…….

WATER QUALITY
Sample Calculation

Remember:

Remove 80% Total Suspended Soils (TSS) for 90% of the average annual rainfall

But what is TSS and how do you measures its removal…..

Due to the measurement difficulties designers typically look for TSS removal rate guidance from the local regulatory agency such as:

A. DuPage County
B. Lake County
C. LEED (As of Version3)

WATER QUALITY
Sample Calculation

DuPage BMP Manual is a great reference

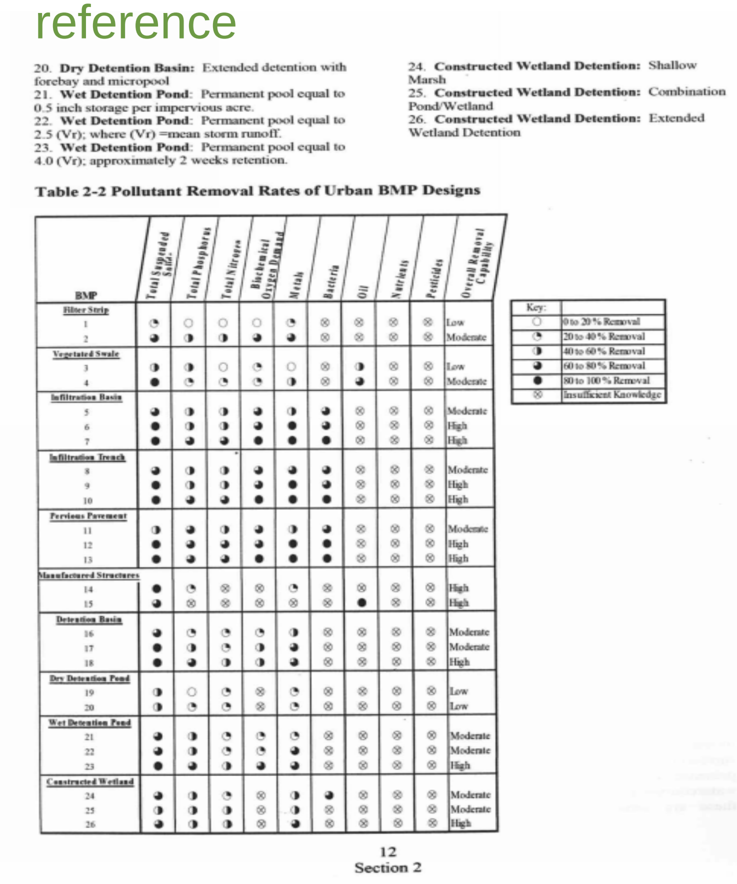


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Table 2-2 Pollutant Removal Rates of Urban BMP Designs

BMP	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Biochemical Oxygen Demand	Metals	Bacteria	Oil	Nutrients	Pesticides	Overall Removal Capability
Filter Strip										
1	◔	○	○	○	◔	⊗	⊗	⊗	⊗	Low
2	◕	◑	◑	◕	◕	⊗	⊗	⊗	⊗	Moderate
Vegetated Swale										
3	◑	◑	○	◔	○	⊗	◑	⊗	⊗	Low
4	●	◔	◔	◔	◑	⊗	◕	⊗	⊗	Moderate
Infiltration Basin										
5	◕	◑	◑	◕	◑	◕	⊗	⊗	⊗	Moderate
6	●	◑	◑	◕	●	◕	⊗	⊗	⊗	High
7	●	◕	◕	●	●	●	⊗	⊗	⊗	High
Infiltration Trench										
8	◕	◑	◑	◕	◕	◕	⊗	⊗	⊗	Moderate
9	●	◑	◑	◕	●	◕	⊗	⊗	⊗	High
10	●	◕	◕	●	●	●	⊗	⊗	⊗	High
Pervious Pavement										
11	◑	◕	◑	◕	◑	◕	⊗	⊗	⊗	Moderate
12	●	◕	◕	◕	●	●	⊗	⊗	⊗	High
13	●	◕	◕	●	●	●	⊗	⊗	⊗	High
Manufactured Structures										
14	●	◔	⊗	⊗	◔	⊗	⊗	⊗	⊗	High
15	◕	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	High
Detention Basin										
16	◕	◔	◔	◔	◑	⊗	⊗	⊗	⊗	Moderate
17	●	◑	◔	◑	◕	⊗	⊗	⊗	⊗	Moderate
18	●	◕	◑	◑	◕	⊗	⊗	⊗	⊗	High
Dry Detention Pond										
19	◑	○	◔	⊗	◔	⊗	⊗	⊗	⊗	Low
20	◑	◔	◔	⊗	◔	⊗	⊗	⊗	⊗	Low
Wet Detention Pond										
21	◕	◑	◔	◔	◔	⊗	⊗	⊗	⊗	Moderate
22	◕	◑	◔	◔	◕	⊗	⊗	⊗	⊗	Moderate
23	●	◕	◑	◕	◕	⊗	⊗	⊗	⊗	High
Constructed Wetland										
24	◕	◑	◔	⊗	◑	◕	⊗	⊗	⊗	Moderate
25	◑	◑	◑	⊗	◑	⊗	⊗	⊗	⊗	Moderate
26	◕	◑	◑	⊗	◕	⊗	⊗	⊗	⊗	High

Key:	
○	0 to 20 % Removal
◔	20 to 40 % Removal
◑	40 to 60 % Removal
◕	60 to 80 % Removal
●	80 to 100 % Removal
⊗	Insufficient Knowledge

12
Section 2

USGBC Reference Guide has a table too….

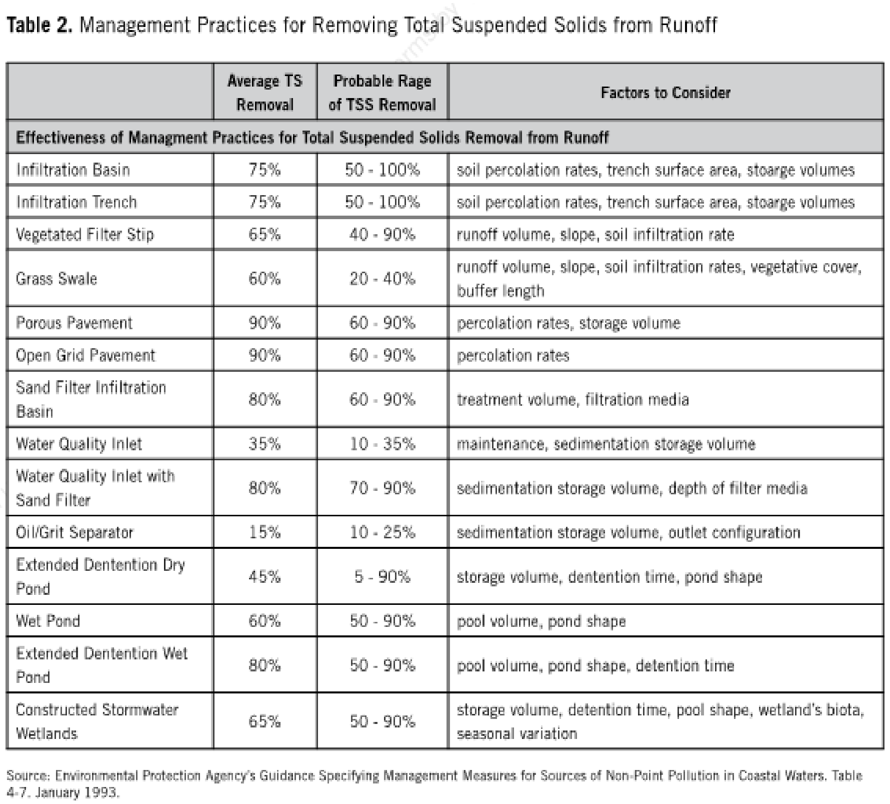


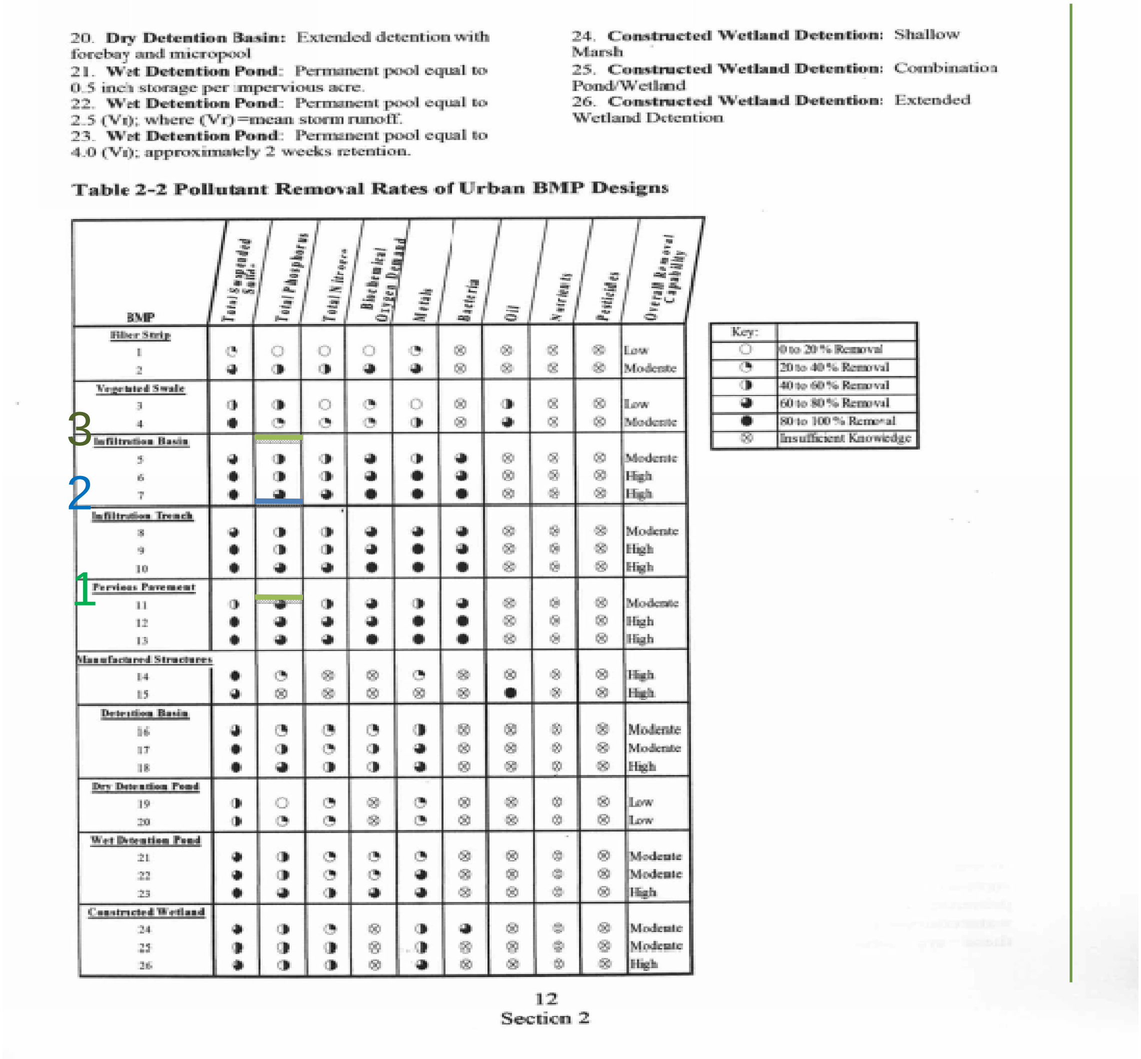
Table 2. Management Practices for Removing Total Suspended Solids from Runoff

	Average TS Removal	Probable Rage of TSS Removal	Factors to Consider
Effectiveness of Managment Practices for Total Suspended Solids Removal from Runoff			
Infiltration Basin	75%	50 - 100%	soil percolation rates, trench surface area, stoarge volumes
Infiltration Trench	75%	50 - 100%	soil percolation rates, trench surface area, stoarge volumes
Vegetated Filter Stip	65%	40 - 90%	runoff volume, slope, soil infiltration rate
Grass Swale	60%	20 - 40%	runoff volume, slope, soil infiltration rates, vegetative cover, buffer length
Porous Pavement	90%	60 - 90%	percolation rates, storage volume
Open Grid Pavement	90%	60 - 90%	percolation rates
Sand Filter Infiltration Basin	80%	60 - 90%	treatment volume, filtration media
Water Quality Inlet	35%	10 - 35%	maintenance, sedimentation storage volume
Water Quality Inlet with Sand Filter	80%	70 - 90%	sedimentation storage volume, depth of filter media
Oil/Grit Separator	15%	10 - 25%	sedimentation storage volume, outlet configuration
Extended Dentention Dry Pond	45%	5 - 90%	storage volume, dentention time, pond shape
Wet Pond	60%	50 - 90%	pool volume, pond shape
Extended Dentention Wet Pond	80%	50 - 90%	pool volume, pond shape, detention time
Constructed Stormwater Wetlands	65%	50 - 90%	storage volume, detention time, pool shape, wetland's biota, seasonal variation

Source: Environmental Protection Agency's Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters. Table 4-7. January 1993.

Use engineering judgment to select range of treatment… for instance if the design infiltrates100% of the tributary volume then it would be reasonable to assume 90-100% TSS removal….but if design infiltrates 50% of required volume then adjust rate down….

WATER QUALITY
Sample Calculation



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3 **Infiltration Basin**										
5	◕	◑	◑	◕	◑	◕	⊗	⊗	⊗	Moderate
6	●	◑	◑	◕	●	◕	⊗	⊗	⊗	High
2 7	●	◕	◕	●	●	●	⊗	⊗	⊗	High
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8	◕	◑	◑	◕	◕	◕	⊗	⊗	⊗	Moderate
9	●	◑	◑	◕	●	◕	⊗	⊗	⊗	High
10	●	◕	◕	●	●	●	⊗	⊗	⊗	High
1 **Pervious Pavement**										
11	◑	◕	◑	◕	◑	◕	⊗	⊗	⊗	Moderate
12	●	◕	◕	◕	●	●	⊗	⊗	⊗	High
13	●	◕	◕	●	●	●	⊗	⊗	⊗	High
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14	●	◔	⊗	⊗	◔	⊗	⊗	⊗	⊗	High
15	◕	⊗	⊗	⊗	⊗	⊗	●	⊗	⊗	High
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17	●	◑	◔	◑	◕	⊗	⊗	⊗	⊗	Moderate
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22	◕	◑	◔	◔	◕	⊗	⊗	⊗	⊗	Moderate
23	●	◕	◑	◕	◕	⊗	⊗	⊗	⊗	High
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24	◕	◑	◔	⊗	◑	◕	⊗	⊗	⊗	Moderate
25	◑	◑	◑	⊗	◑	⊗	⊗	⊗	⊗	Moderate
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12
Section 2

Treatments are cumulative:

Treatment Rate 1 = 80%
Treatment Rate 2 = 50%
Treatment Rate 3 = 80%

After T1 20% TSS remains
After T2 10% TSS remains
After T3 2% TSS remains

Cumulative TSS removal rate = 98%

Site typically have multiple treatment Trains, determine TSS rate by area….develop a “weighted” rate.

WATER QUALITY
Sample Calculation

Remember:

Remove **80%** Total suspended soils (TSS) for **90%** of the average annual rainfall

But what is the average annual rainfall…..?

USGBC LEED V3 defines treating a 1” storm event as treating the average annual rainfall for our region

Regulatory rules soon to come……

WATER QUALITY
Sample Calculation

50,000 SF site total

45,000 SF Captured by BMP's >90% OK

30,000 SF Permeable pavement drains to infiltration trench to dry basin with larger bio-infiltration at outlet
<u>Treatment Train 1</u>: 1) permeable pavement 80% 2) an infiltration trench, 50% 3) bio-infiltration basin 80% -> Treatment Rate = 98%

10,000 SF Building drains to small bio-infiltration basins to infiltration trench to larger bio-infiltration at outlet
<u>Treatment Train 2</u>: 1) bio-infiltration basin 70% 2) infiltration trench 50% 3) bio-infiltration basin 80% -> Treatment Rate = 97%

5,000 SF Native Landscape to larger bio-infiltration at outlet
<u>Treatment Train 3</u>: 1) Filter Strip 40% 2) bio-infiltration basin 80% Treatment Rate = 88%

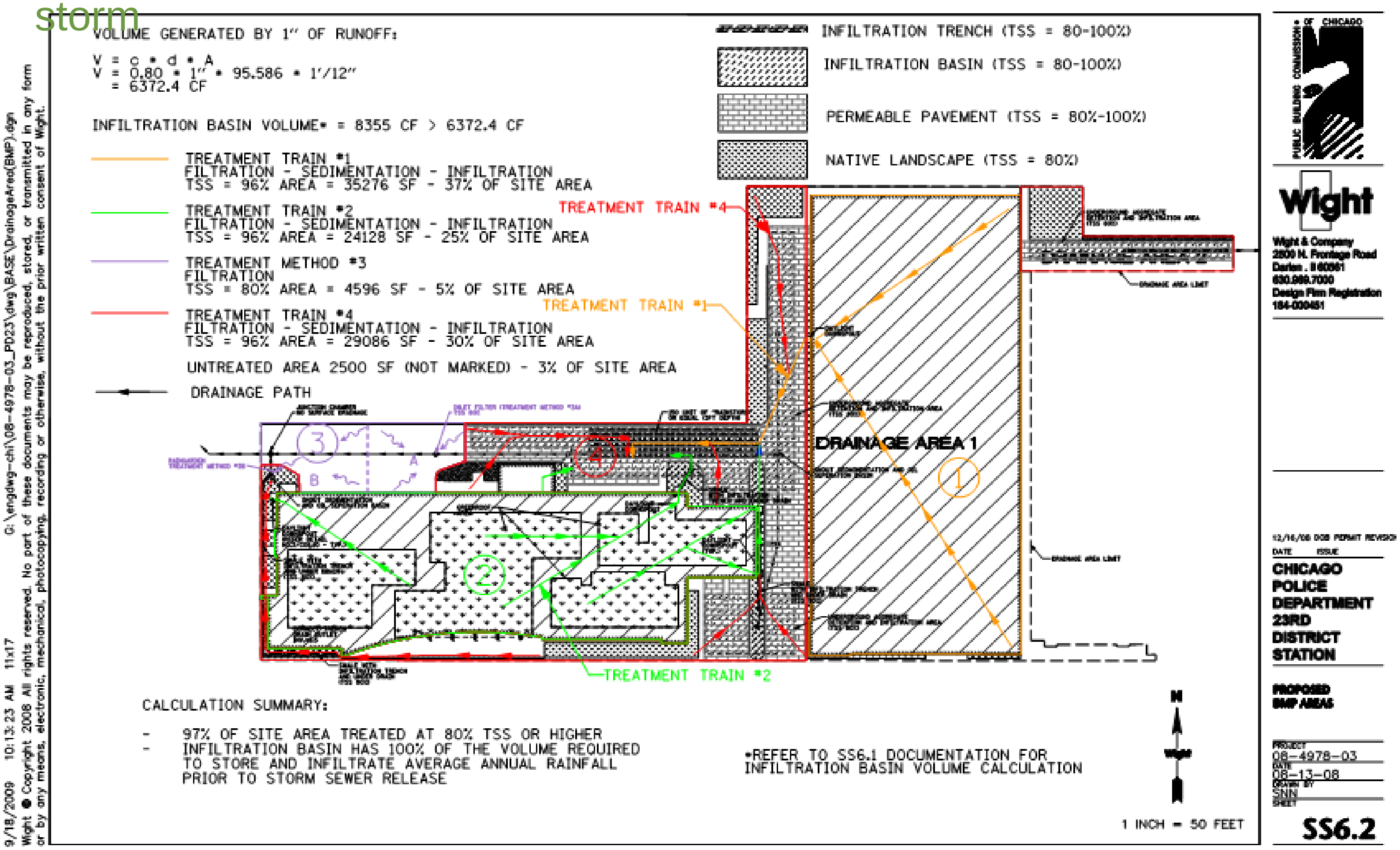
Weighted rate = {30000(.98) + 10000(.97) + 5000 (.88)}/ 45,000 = 97% TSS removal

Provide BMP volume information in appendix format to document capacity.

TSS Method Proposed By DuPage County Ordinance Revision follow similar methodology

WATER QUALITY
Sample Calculation

Trains 1,2,3 end at infiltration basin with 100% stay on for 1" design storm



VOLUME GENERATED BY 1" OF RUNOFF:

V = c * d * A
V = 0.80 * 1" * 95.586 * 1'/12"
= 6372.4 CF

INFILTRATION BASIN VOLUME* = 8355 CF > 6372.4 CF

🟧	TREATMENT TRAIN #1 FILTRATION - SEDIMENTATION - INFILTRATION TSS = 96% AREA = 35276 SF - 37% OF SITE AREA
🟩	TREATMENT TRAIN #2 FILTRATION - SEDIMENTATION - INFILTRATION TSS = 96% AREA = 24128 SF - 25% OF SITE AREA
🟪	TREATMENT METHOD #3 FILTRATION TSS = 80% AREA = 4596 SF - 5% OF SITE AREA
🟥	TREATMENT TRAIN #4 FILTRATION - SEDIMENTATION - INFILTRATION TSS = 96% AREA = 29086 SF - 30% OF SITE AREA
	UNTREATED AREA 2500 SF (NOT MARKED) - 3% OF SITE AREA
←	DRAINAGE PATH

▬	INFILTRATION TRENCH (TSS = 80-100%)
▨	INFILTRATION BASIN (TSS = 80-100%)
▦	PERMEABLE PAVEMENT (TSS = 80%-100%)
▩	NATIVE LANDSCAPE (TSS = 80%)

CALCULATION SUMMARY:

- 97% OF SITE AREA TREATED AT 80% TSS OR HIGHER
- INFILTRATION BASIN HAS 100% OF THE VOLUME REQUIRED TO STORE AND INFILTRATE AVERAGE ANNUAL RAINFALL PRIOR TO STORM SEWER RELEASE

*REFER TO SS6.1 DOCUMENTATION FOR INFILTRATION BASIN VOLUME CALCULATION

1 INCH = 50 FEET

PUBLIC BUILDING COMMISSION OF CHICAGO

Wight & Company
2500 N. Frontage Road
Darien . Il 60561
630.969.7000
Design Firm Registration
184-000451

12/16/08 DOB PERMIT REVISIO
DATE ISSUE

CHICAGO POLICE DEPARTMENT 23RD DISTRICT STATION

PROPOSED BMP AREAS

PROJECT
08-4978-03
DATE
08-13-08
DRAWN BY
SNN
SHEET
SS6.2

9/18/2009 10:13:23 AM 11x17 G:\engdwg-chi\08-4978-03_PD23\dwg\BASE\DrainageArea(BMP).dgn

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WATER QUALITY Sample Calculation

Remember:

Remove 80% Total suspended soils (TSS) for 90% of the average annual rainfall

We have captured 90% of the drainage area

We have determined a weighted treatment rate

Sized system to hold/treat 1” depth of rainfall similar to Quantity point

We have met the point requirements

Regulatory Trends

- City of Chicago – *Volume Based Design Component (SS6.1) retain ½" volume control for new impervious*
- DuPage County, IL – *Water Quality BMP Component (SS6.2)*
- *DuPage County, Lake, McHenry IL Future - Water Quantity BMP Component (SS6.1)*
- Cook County, IL MWRD Future – *Water Quality 1" treatment for Discharge to waterway (SS6.2)*
- Cook County, IL MWRD Future – *Water Quantity 1" treatment for Discharge to combined sewer (SS6.1)*
- Will County, IL - *BMP requirement to show no adverse impact (SS6.2)*
- USACE – *BMP requirement as part of 404 permit (SS6.1 & SS6.2)*
- Federal Projects – Energy Independence Act, restore natural condition (SS6.1 and SS6.2) Project over 5000 SF
- Wisconsin IDNR – Infiltration requirement 60%-90% average annual predevelopment infiltration volume
- New Jersey Stormwater Management– Maintain 100% of average annual preconstruction groundwater recharge.
- Ohio – Big Darby Watershed - overall site post-development groundwater recharge equals or exceeds the predevelopment groundwater recharge
- North Carolina - control and treat the stormwater runoff from all built upon areas of the site from the first 1.5 inches of rain
- West Virginia MS 4 - The first 1 inch of rainfall must be 100% managed with no discharge to surface water

Not just a LEED issue anymore, and it certainly isn't going away….

Thank you!

Wight & company | Wightco.com

Tom Powers *P.E., CFM, LEED AP, CPESC*
Tpowers@wightco.com