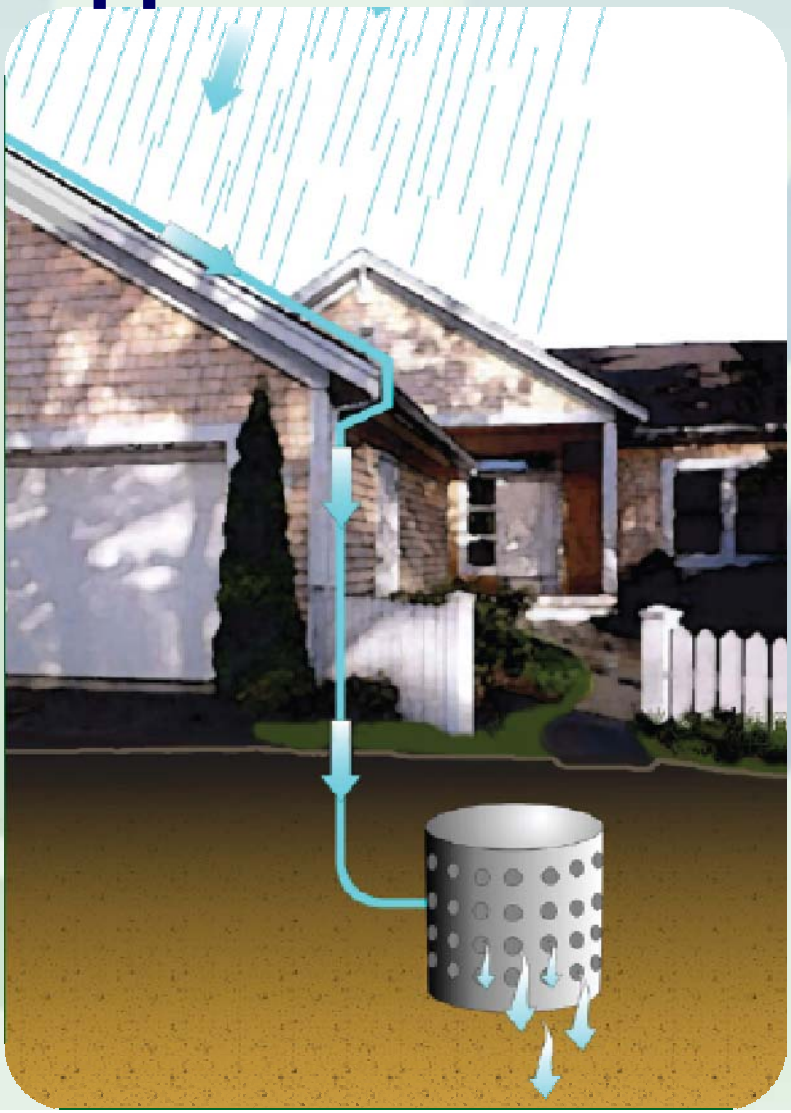
Rhode Island Stormwater Design and Installation Standards Manual

Public Workshop
Infiltration
(Including Permeable Paving)
March 24, 2011

Horsley Witten Group, Inc.

Infiltration

Section 5.3:
Appendix F.3 & H.1



Infiltration - Design Notes

- Field verification of soil permeability/texture essential
- Pretreatment essential – minimum 25% of WQv
- Bottom of infiltration facility cannot be located in fill*, must have 3' separation from gw and bedrock*
- Size based on design infiltration rates (Table 5-3)
- Guidance: Keep drainage areas to each practice small, may reduce some potential problems

* Reduced requirements for residential areas (2')

Table 5-3 Design Infiltration Rates for Different Soil Textures (Rawls et al., 1982)

USDA Soil Texture	Design Infiltration Rate (f_c) (in/hr)	Design Infiltration Rate (f_c) (ft/min)
Sand	8.27	0.0115
Loamy Sand	2.41	0.0033
Sandy Loam	1.02	0.0014
Loam	0.52	0.0007
Silt Loam	0.27	0.0004

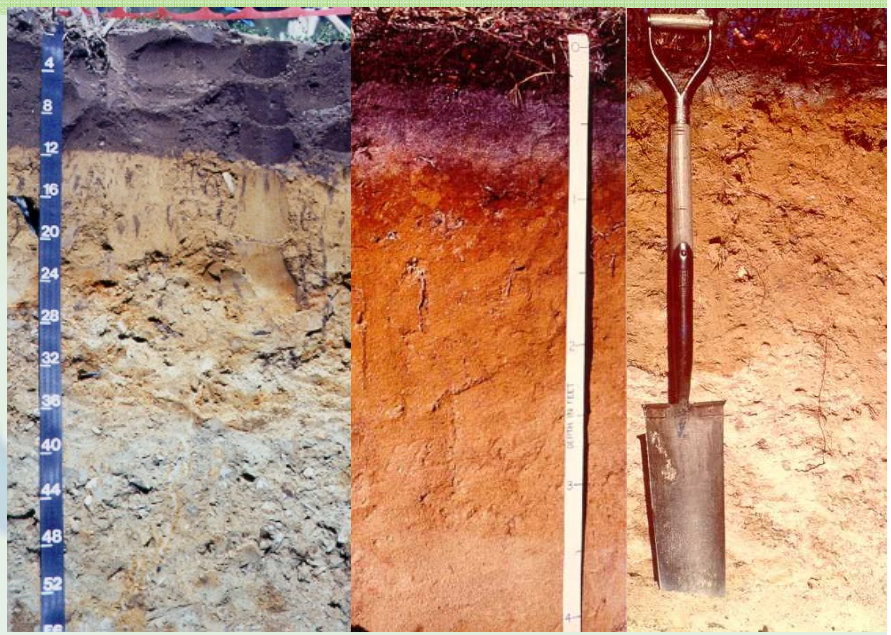
Design Notes (cont'd)

- Cannot be used if contributing drainage is a LUHPPL
- Higher maintenance burden
- Stabilize site prior to installation
- Must meet variety of setbacks* (Table 5-2)
- May be used for larger storm events if infiltration rate > 8.3 in/hr**, mounding analysis may be required

* Reduced requirements for small-scale BMPs in res. areas

** 100% WQv treatment required by separate BMP in these areas

Soil Testing Requirements



- Appendix H
- Required?
  - Infiltration Practice
  - Filter Practice*
  - Dry Swale*
- What does it tell us?
  - Feasibility of proposed BMP (too high or too low inf rate, depth to SHGT)
  - Design infiltration rate for sizing and models
- Who can do the soil testing?
  - DEM-licensed Class IV soil evaluator or RI-registered P.E.

Table H-1 Infiltration Testing Summary

Type of Facility	Design Testing
Infiltration Practice*/Infiltrating Permeable Pavement Practices	1 infiltration test and 1 test pit per 5,000 ft^2
Filter Practice**	1 infiltration test and 1 test pit per 5,000 ft^2 (no underdrains required if infiltration rate > 0.5 in/hr***)
Dry Swale**	1 infiltration test and 1 test pit per 1,000 ft of dry swale (no underdrains required if infiltration rate > 0.5 in/hr ***)

*For use with residential rooftop runoff, testing requirements are reduced to 1 infiltration test and 1 test pit per 5 lots assuming consistent terrain and NRCS soil series. If terrain and soil series are not consistent, then requirements increase to 1 infiltration test and 1 test pit per 1 lot.

**When proposed as a treatment/infiltration system. If proposed as strictly a filtration practice, infiltration testing analysis not strictly required but a test pit or boring is required to verify depth to seasonal high groundwater or bedrock.

***Underdrain installation still strongly suggested.

Test Pit/Boring Requirements

- Excavate a test pit or dig a standard soil boring to a depth of 4 ft below the proposed facility bottom.
- Determine depth to SHGT. May establish in test pits based on redoximorphic features.
- Soil borings: conduct Standard Penetration Testing (SPT) every 2 ft to a depth of 4 ft below facility bottom.
- Determine USDA textures at the proposed bottom and 4 ft below the bottom of the proposed BMP.
- Determine depth to bedrock.
- The soil description should include all soil horizons.
- The location of the test pit or boring shall correspond to the BMP location.

Field Infiltration Testing

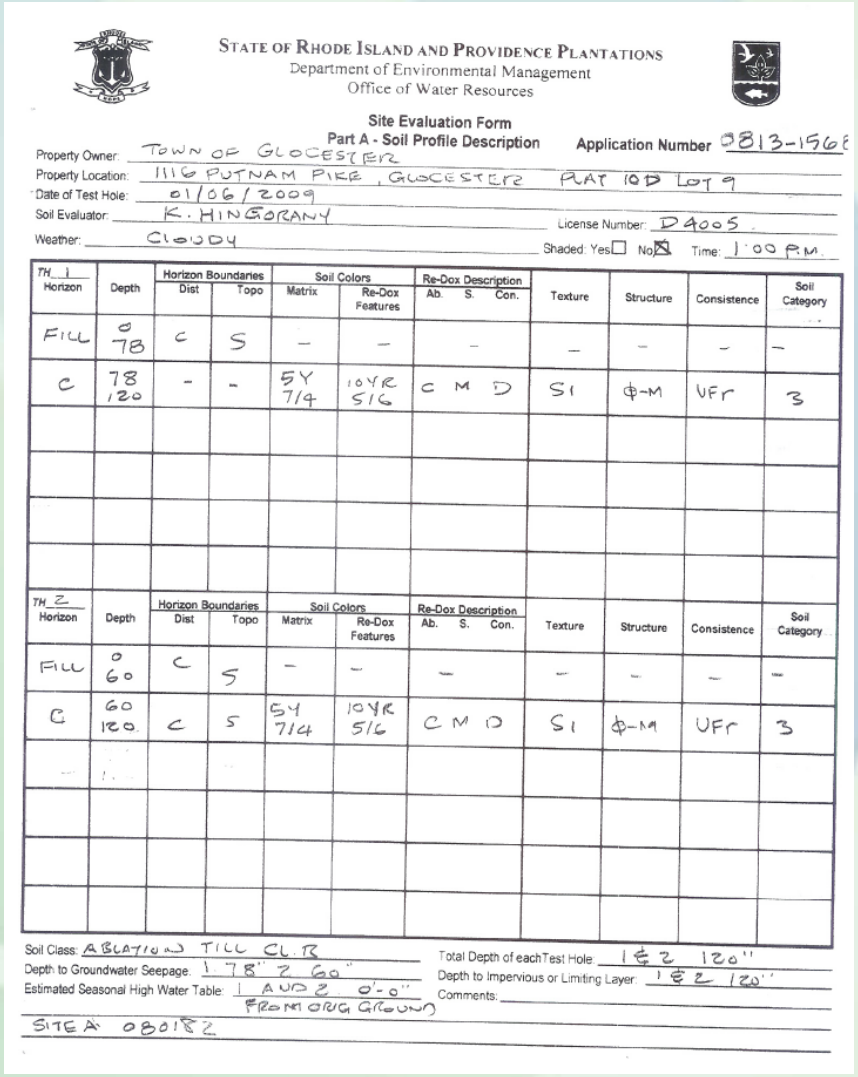
Acceptable field test methods to assess saturated hydraulic conductivity

- Guelph permeameter - ASTM D5126-90 Method
- Falling head permeameter – ASTM D5126-90 Meth
- Double ring permeameter/infiltrometer - ASTM D3385-033, D5093-024, D5126-90 Methods
- Amoozemeter or Amoozegar permeameter – Amoozegar 1992

* Apply Safety Factor=2 to field-derived value

** Use of lab test to establish infiltration rates is prohibited

Soil Evaluation Form



STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
Department of Environmental Management
Office of Water Resources

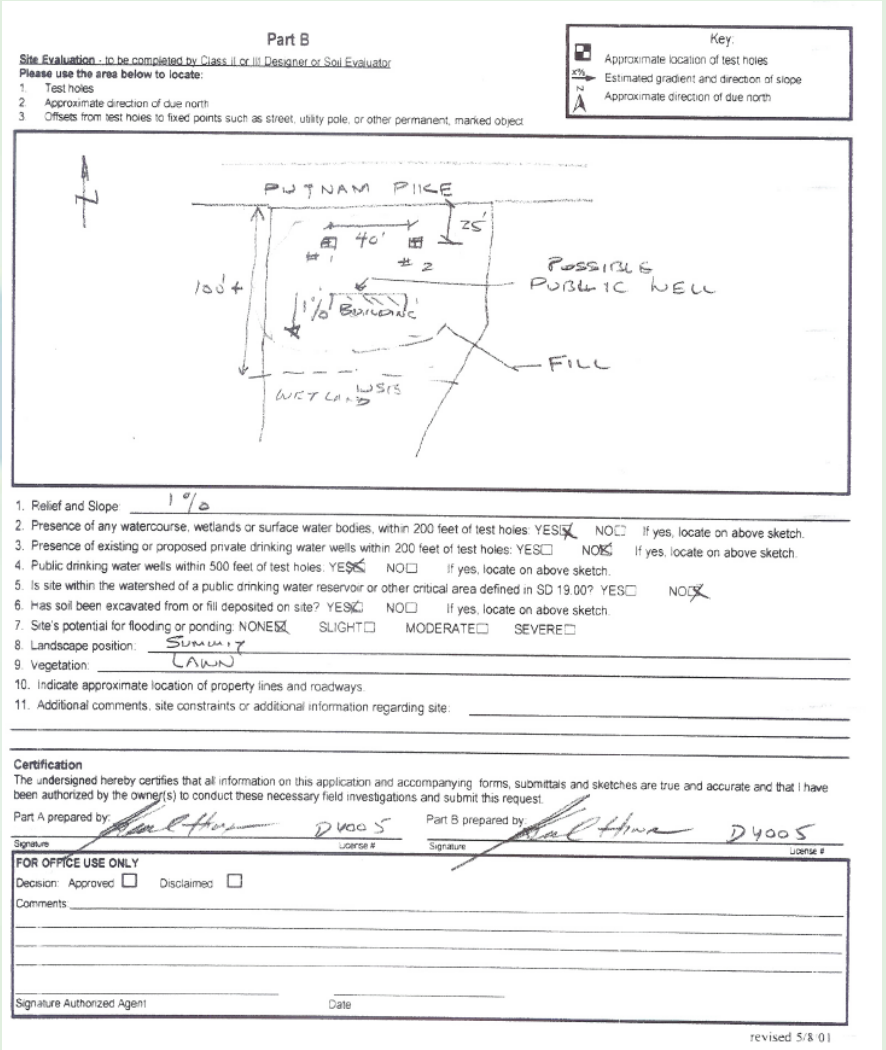
Site Evaluation Form
Part A - Soil Profile Description Application Number 0813-1566

Property Owner: TOWN OF GLOCESTER
Property Location: 1116 PUTNAM PIKE, GLOCESTER PLAT 10D LOT 9
Date of Test Hole: 01/06/2009
Soil Evaluator: K. HINGORANY License Number: D4005
Weather: CLOUDY Shaded: Yes☐ No☒ Time: 1:00 P.M.

TH 1 Horizon	Depth	Horizon Boundaries Dist	Horizon Boundaries Topo	Soil Colors Matrix	Soil Colors Re-Dox Features	Re-Dox Description Ab. S. Con.	Texture	Structure	Consistence	Soil Category
FILL	0 78	C	S	–	–	–	–	–	–	–
C	78 120	-	-	5Y 7/4	10YR 5/6	C M D	SI	ϕ-M	VFr	3

TH 2 Horizon	Depth	Horizon Boundaries Dist	Horizon Boundaries Topo	Soil Colors Matrix	Soil Colors Re-Dox Features	Re-Dox Description Ab. S. Con.	Texture	Structure	Consistence	Soil Category
FILL	0 60	C	S	–	–	–	–	–	–	–
C	60 120	C	S	5Y 7/4	10YR 5/6	C M D	SI	ϕ-M	VFr	3

Soil Class: ABLATION TILL CL. B
Depth to Groundwater Seepage: 1 78" 2 60"
Estimated Seasonal High Water Table: 1 AND 2 0'-0" FROM ORIG GROUND
Total Depth of each Test Hole: 1 & 2 120"
Depth to Impervious or Limiting Layer: 1 & 2 120"
Comments:
SITE A 080182



Part B

Site Evaluation - to be completed by Class II or III Designer or Soil Evaluator
Please use the area below to locate:
1. Test holes
2. Approximate direction of due north
3. Offsets from test holes to fixed points such as street, utility pole, or other permanent, marked object

Key:
- Approximate location of test holes
- x% → Estimated gradient and direction of slope
- Approximate direction of due north

1. Relief and Slope: 1%
2. Presence of any watercourse, wetlands or surface water bodies, within 200 feet of test holes: YES☒ NO☐ If yes, locate on above sketch.
3. Presence of existing or proposed private drinking water wells within 200 feet of test holes: YES☐ NO☒ If yes, locate on above sketch.
4. Public drinking water wells within 500 feet of test holes: YES☒ NO☐ If yes, locate on above sketch.
5. Is site within the watershed of a public drinking water reservoir or other critical area defined in SD 19.00? YES☐ NO☒
6. Has soil been excavated from or fill deposited on site? YES☒ NO☐ If yes, locate on above sketch.
7. Site's potential for flooding or ponding: NONE☒ SLIGHT☐ MODERATE☐ SEVERE☐
8. Landscape position: SUMMIT
9. Vegetation: LAWN
10. Indicate approximate location of property lines and roadways.
11. Additional comments, site constraints or additional information regarding site:

Certification
The undersigned hereby certifies that all information on this application and accompanying forms, submittals and sketches are true and accurate and that I have been authorized by the owner(s) to conduct these necessary field investigations and submit this request.

Part A prepared by: Signature D4005 License # Part B prepared by: Signature D4005 License #

FOR OFFICE USE ONLY
Decision: Approved ☐ Disclaimed ☐
Comments:

Signature Authorized Agent Date

revised 5/8/01

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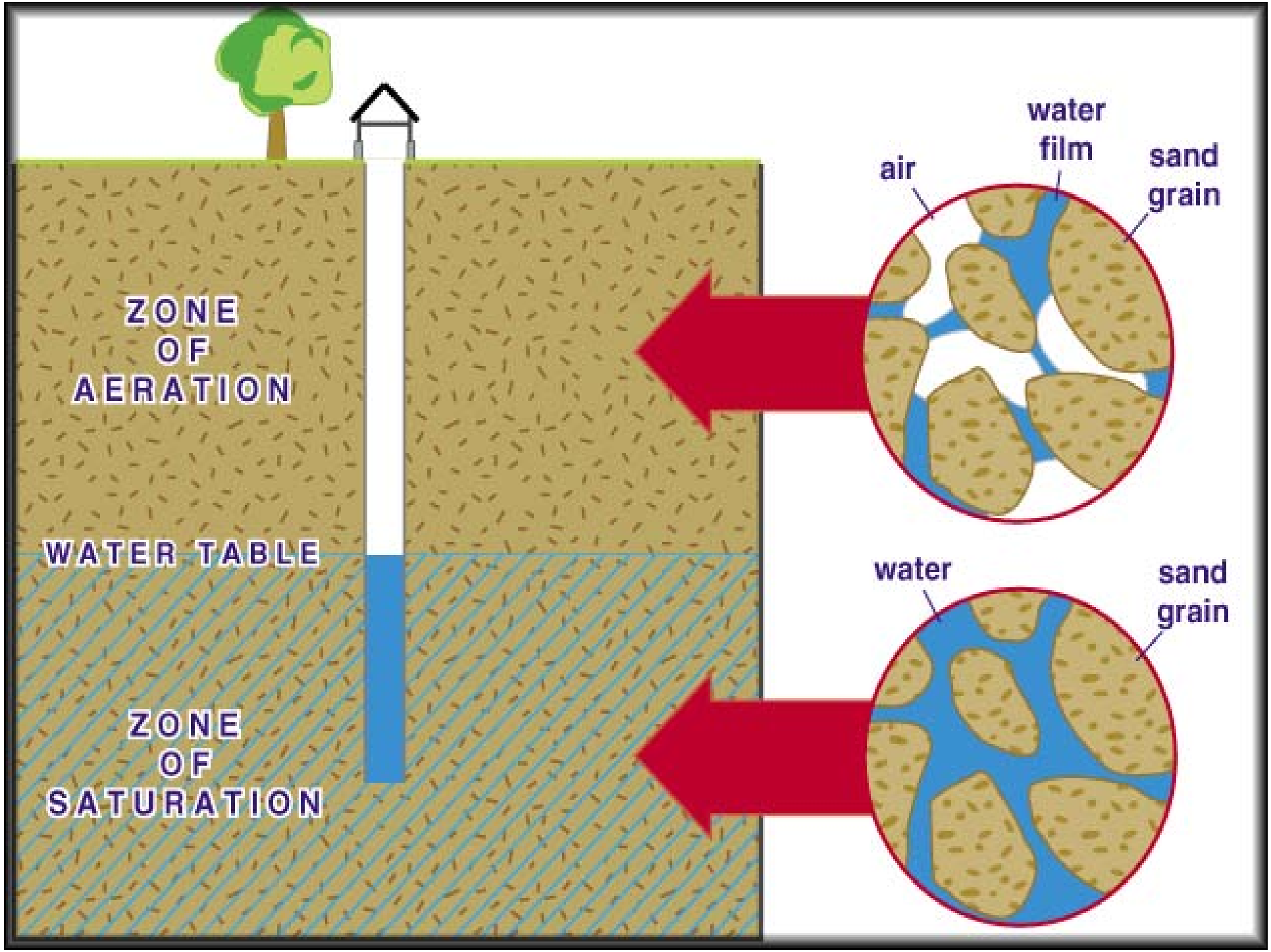
ZONE
OF
AERATION
WATER TABLE
ZONE
OF
SATURATION
air
water
film
sand
grain
water
sand
grain

Permeability Testing (double ring infiltrometer)

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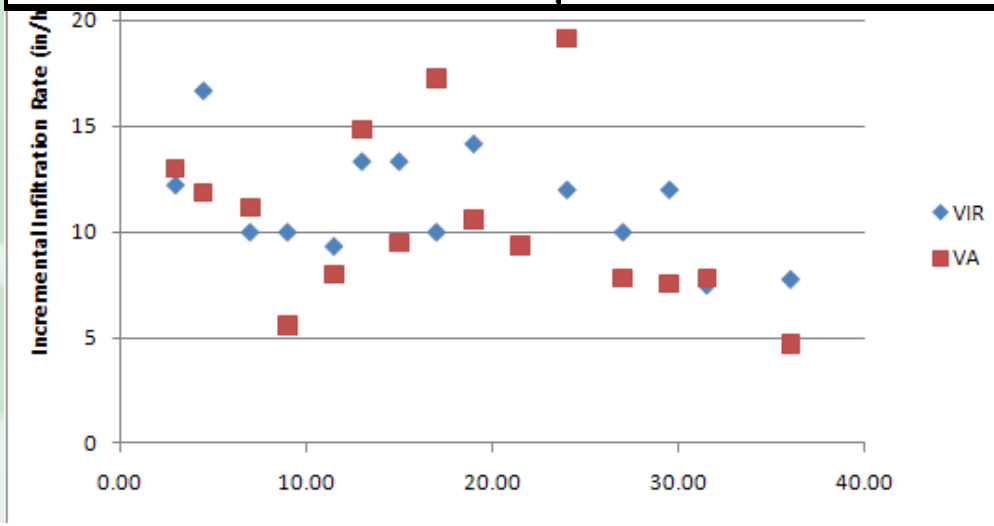
Sample Calculation

$V_{IR} = \Delta V_{IR}/(A_{IR}*\Delta t)$	Inner ring incremental infiltration velocity (cm/h)
ΔV_{IR}	Volume of liquid used during time interval to maintain constant head in the inner ring (cm3)
A_{IR}	Internal area of inner ring (cm2)
Δt	Time interval (h)
$V_A = \Delta V_A/(A_A*\Delta t)$	Annular space increment infiltration velocity (cm/h)
ΔV_A	Volume of liquid used during time interval to maintain constant head in the annular space between the ring I(cm3)
A_A	Area of annular space between the rings



00	3100	25.4648	43.85603	10.026	17.26615
00	1900	36.0751	26.8795	14.203	10.58248
00	2100	23.7671	23.76714	9.3571	9.357141
00	4300	30.5577	48.66604	12.031	19.15986
00	2100	25.4648	19.80595	10.026	7.797618
00	1700	30.5577	19.24006	12.031	7.574828
00	1400	19.0986	19.80595	7.5191	7.797618
00	1900	19.8059	11.94645	7.7976	4.703325
	Average	28.464	26.78309	11.206	10.54452

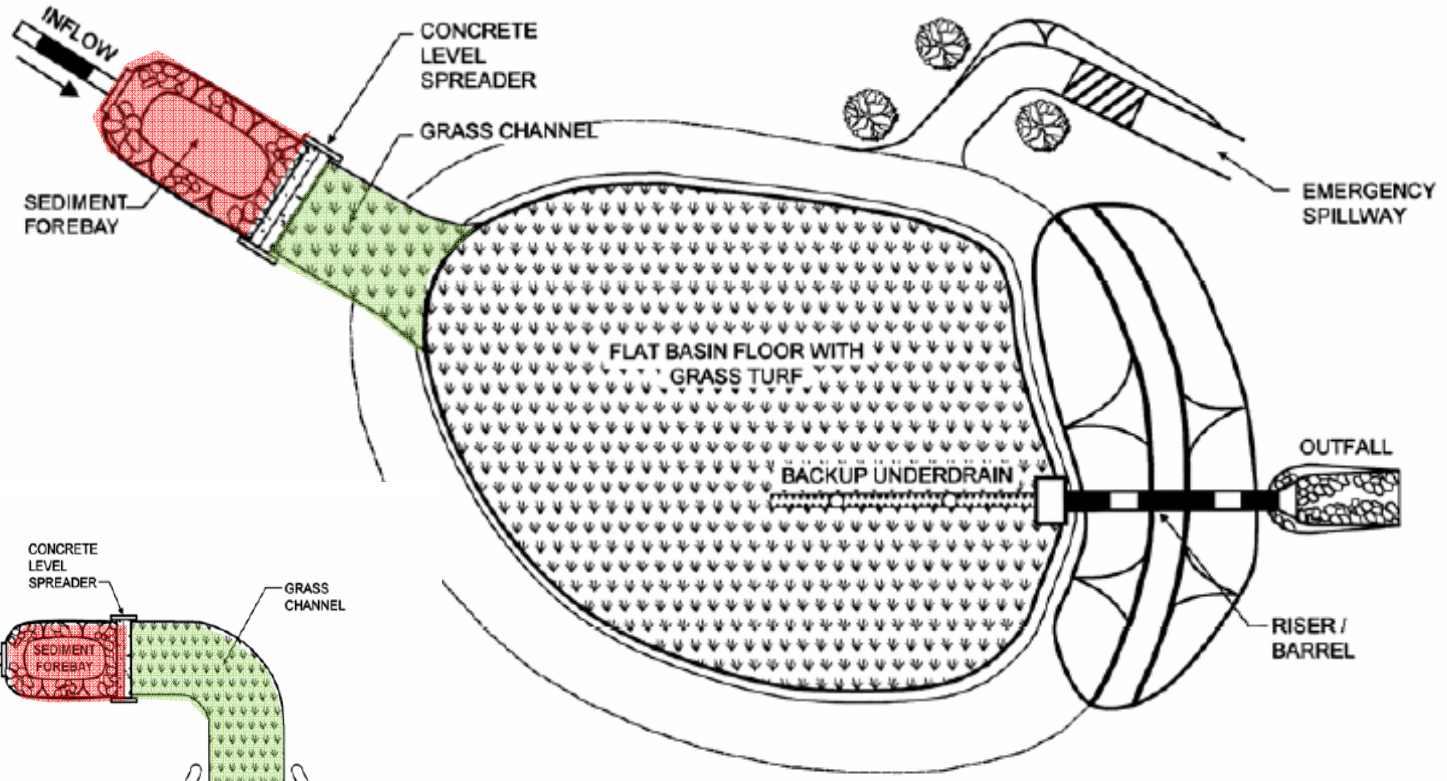
BMP Pretreatment Requirements

BMP Group	Required %WQ_v	Notes
WVTS	10%	• Provided at each inlet, unless inlet provides <10% of inflow
Infiltration	25%	• Grass channel, filter strip, sediment forebay, proprietary device • Deep sump catch basin combined with one of the following: – Upper sand layer; or – Washed pea gravel (1/8" to 3/8") • Not required for permeable pavements (unless there is "run-on") or drywells
Filtering Practices	25%	• Deep sump catch basins may not be used as sole pretreatment.
Green Roofs	Not Applicable. No pretreatment required for direct rainfall.	
Open Channels	10%	• forebays/checkdams at pipe inlets and/or driveway crossings. • filter strip

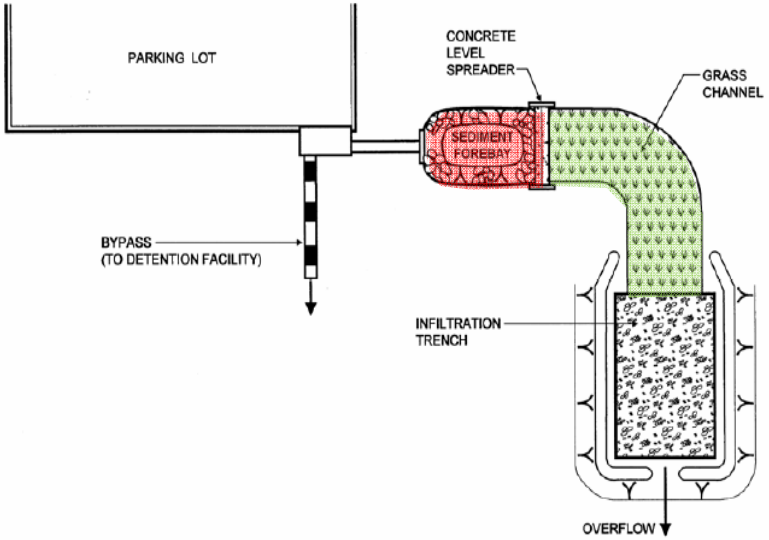
Infiltration: Basins & Trenches

ed WQ BMPs

Figure 5-6 Infiltration Basin



PLAN VIEW



PLAN VIEW

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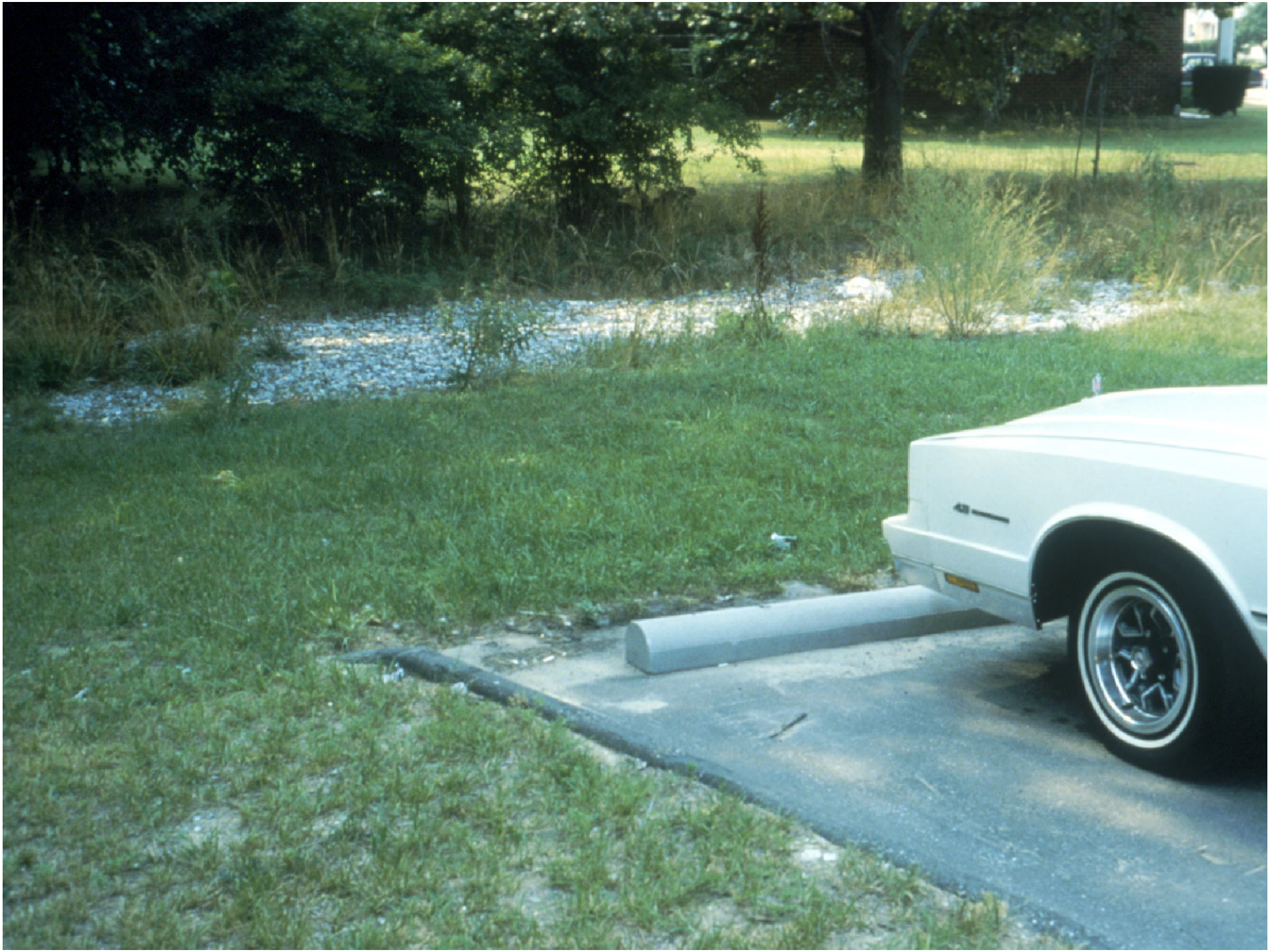
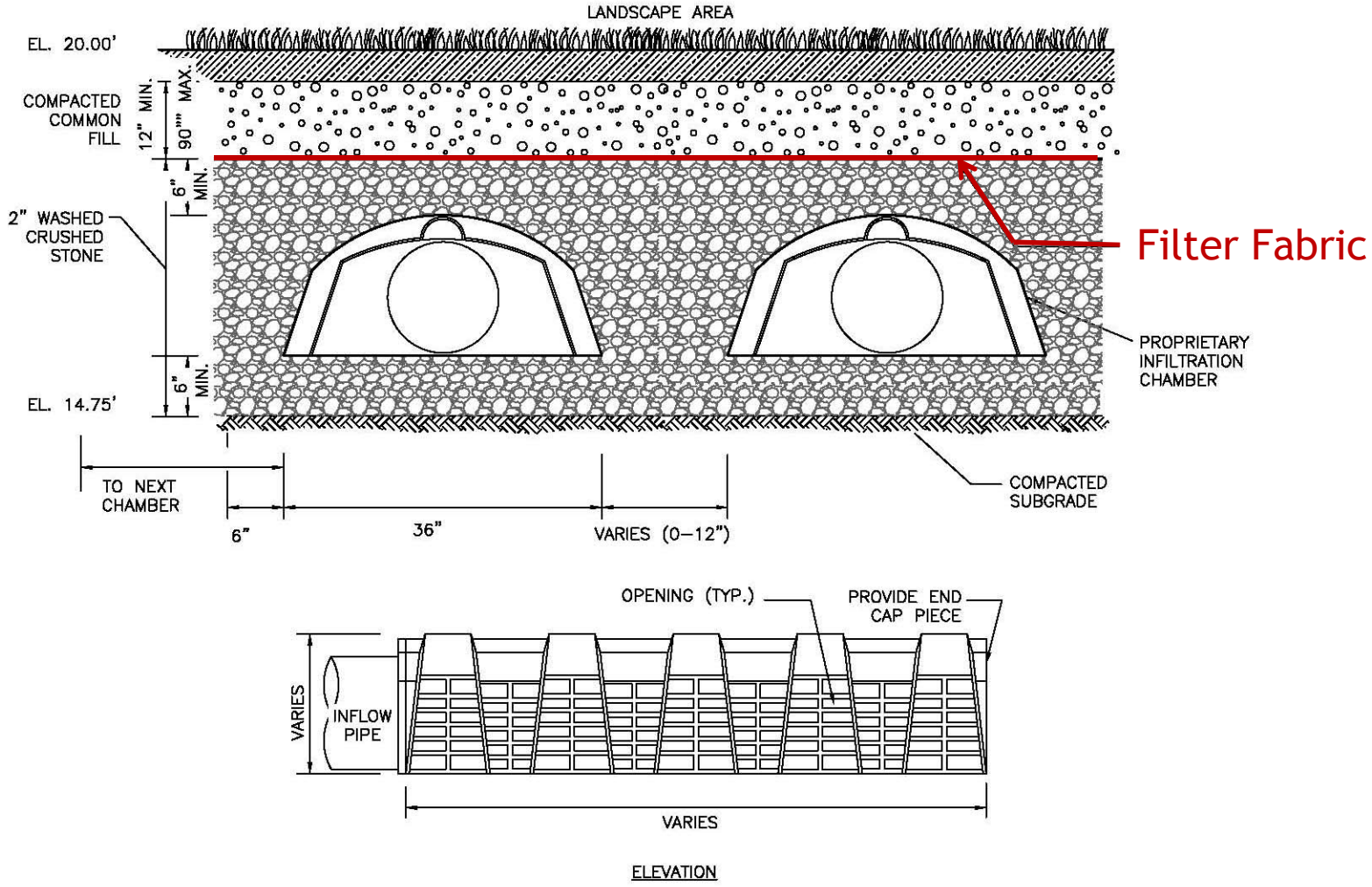


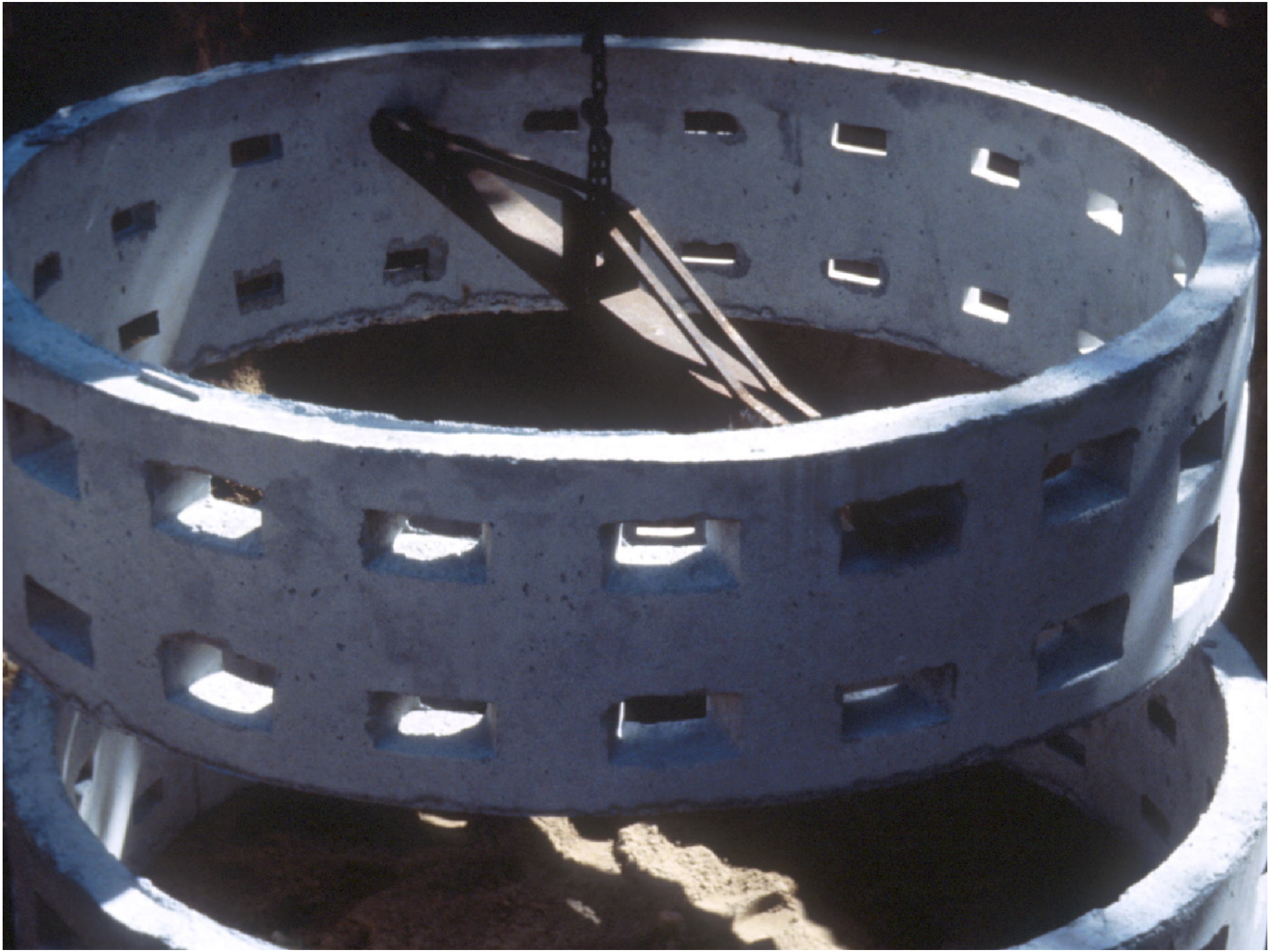
Cross-section Views of Chambers

Approved WQ BMPs



Infiltration Chambers

Horsley Witten Group, Inc.



Filter Fabric

- Non-woven geotextile fabric with a flow rate of > 110 gal./min./sf.

- For use over the underdrain (where applicable) and along the side walls

Gravel (Underdrains and Storage)

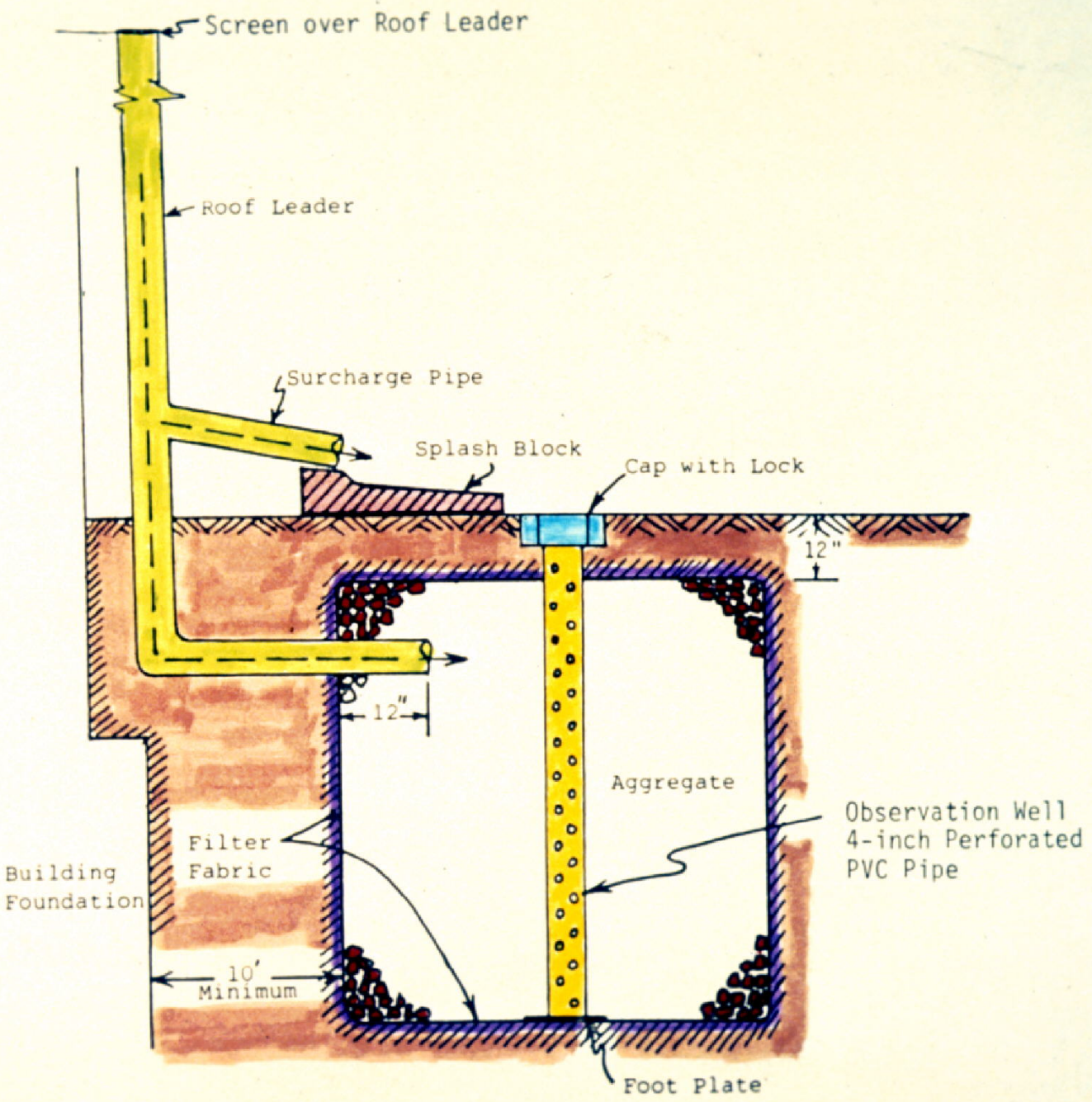
- Porosity = 33%
- AASHTO M-43 standard
- Washed, clean and open graded
- Size Varies;
  - ASTM # 2 or 3 Stone (<2 to2 ½")
  - ASTM #57 Stone (<1½")
  - ASTM #8 (1-2")

Storage Chambers

- Injection molded from virgin polypropylene resin;
- Rows shall provide continuous, unobstructed internal space with no internal support panels;
- Chambers shall be open-bottomed.
- Shall incorporate an overlapping corrugation joint system.

When Fill is Required

- Medium Concrete Sand (AASHTO M-6 or ASTM C-33)
- Clean
- No substitutions such as Diabase, rock dust, etc.
- Compaction (Standard Proctor) – AASHTO Method T-99


Screen over Roof Leader
Roof Leader
Surcharge Pipe
Splash Block
Cap with Lock
12"
12"
Aggregate
Observation Well
4-inch Perforated
PVC Pipe
Filter
Fabric
Building
Foundation
10'
Minimum
Foot Plate


Dry
Well

Infiltration Practices
Landscaping Requirements

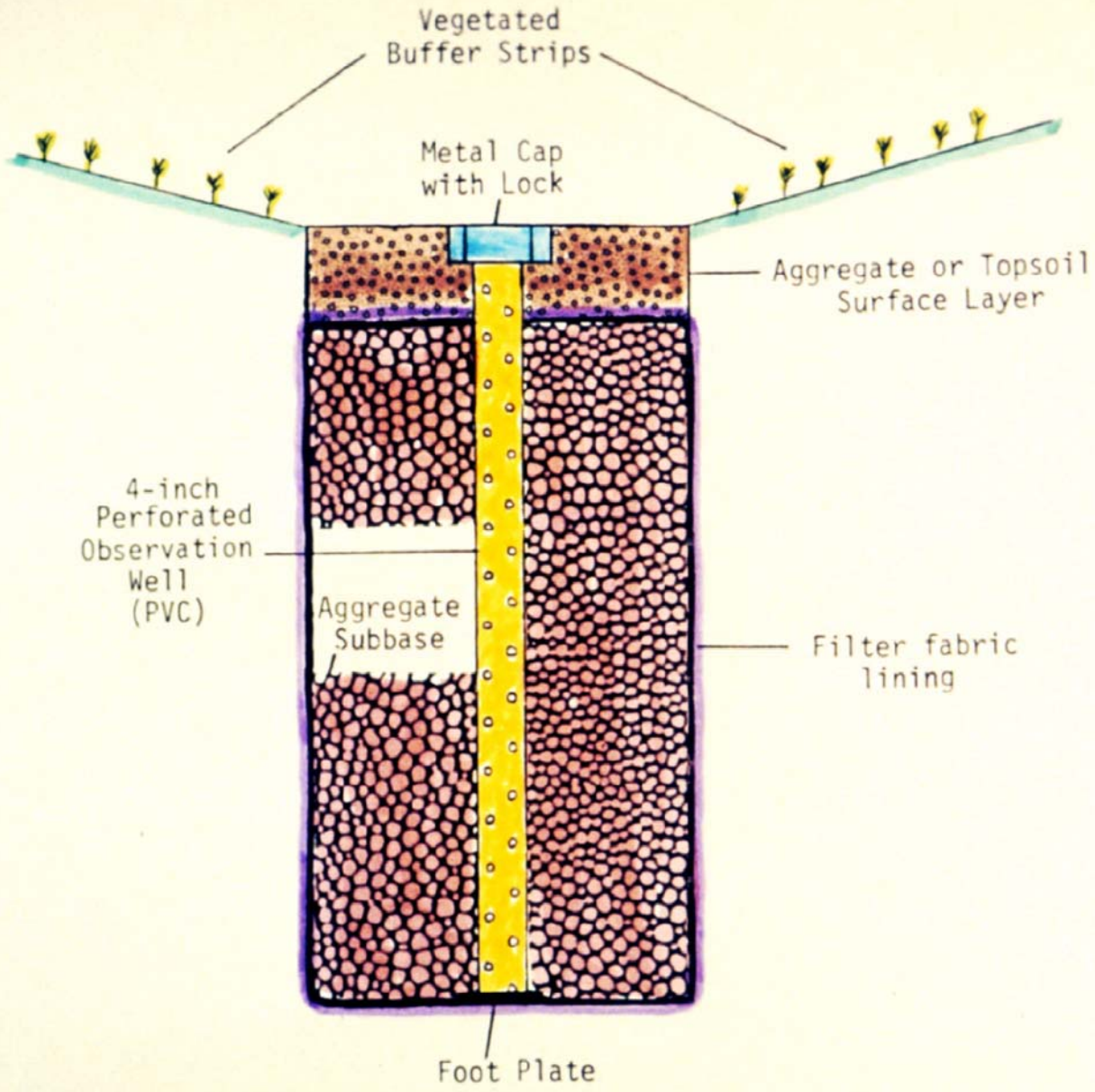
- Drainage area completely stabilized prior to bringing infiltration facility on-line. A dense and vigorous vegetative cover is needed over pervious areas.
- Routine mowing of facility and adjacent areas

Buckman Heights courtyard with infiltration garden

Cascade Station (NE Airport Way & I-205)

Infiltration Practices Maintenance Requirements

- Never use basin or area as temporary E&SC facility
- Provide observation well in all trenches
- Provide direct access for maintenance/rehab
- Follow OSHA standards for excavation
- Designs should consider dewatering alternatives should failure occur



Cross Section of Infiltration Trench with
Observation Well Detail

Observation Wells

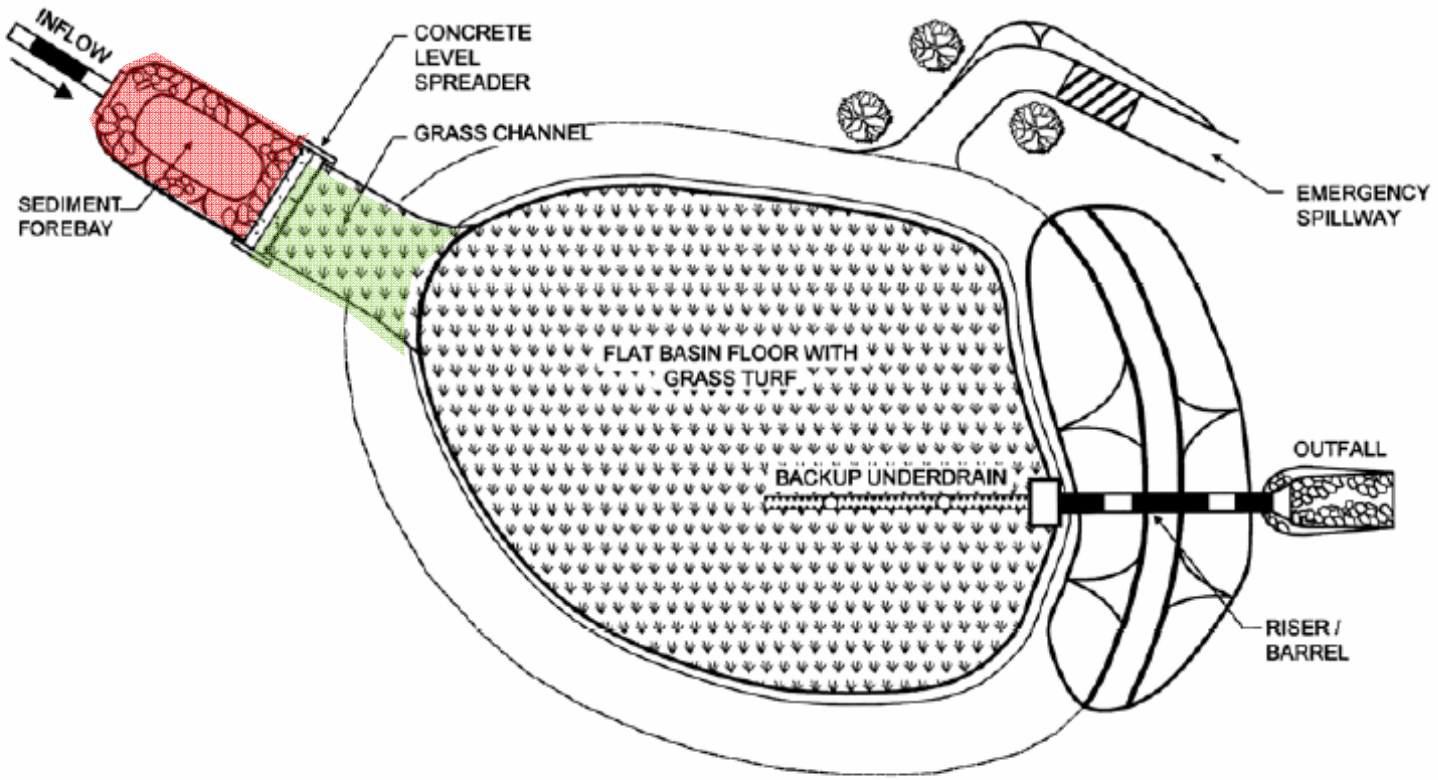
- Rigid schedule 40 PVC pipe with 5/8” perforations @ 6” O.C. meeting ASTM D 1785 (burrs removed)
- Lockable Cap (should coordinate method with maintenance authority.

Maintaining a Permeable Basin Surface

- Large surface area of practice
- Avoid compaction
- Apply/retain organic material in basin floor
- Incorporate micro topography

Infiltration Basin with back-up Underdrain

Figure 5-6 Infiltration Basin



Construction

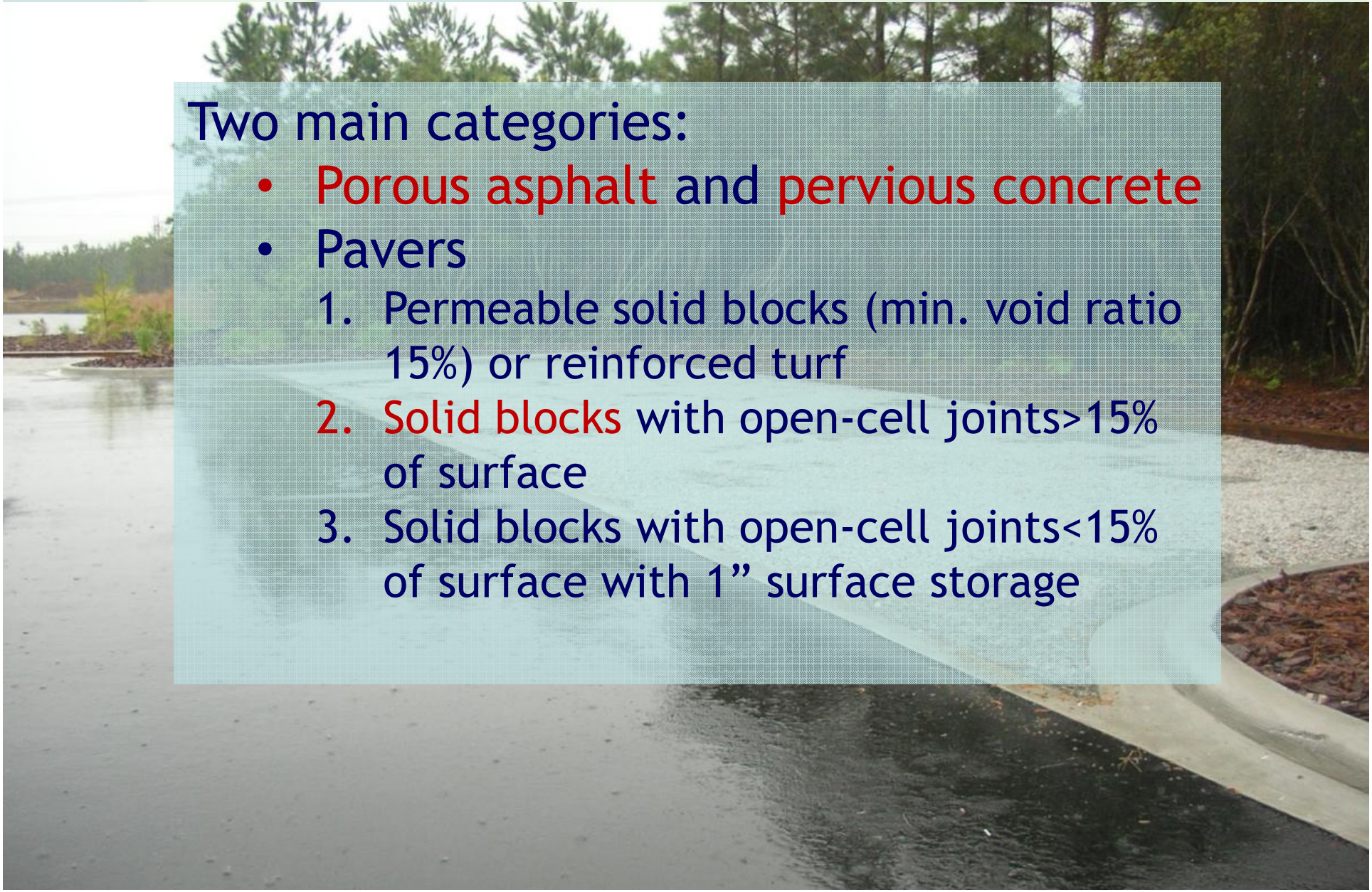
- Good erosion & sediment control
- Sequence of construction
- Stabilized drainage area
- Protect infiltration site

Infiltration Maintenance Requirements/Guidelines

- Basin: Routine sediment cleanout, mowing (2x/yr), re-vegetate bare areas, litter & debris removal, & rejuvenation (roto-till surface soils).
- Trench: Pretreatment and trench sediment cleanout, & mowing. Check 2 days after storm.
- Drywell: Pretreatment cleanout. Gutter / downspout system cleaning if needed.


patio
ENCLOSURES, INC.

Section 5.3: Permeable Paving



Two main categories:

- Porous asphalt and pervious concrete
- Pavers
  1. Permeable solid blocks (min. void ratio 15%) or reinforced turf
  2. Solid blocks with open-cell joints>15% of surface
  3. Solid blocks with open-cell joints<15% of surface with 1” surface storage

Permeable Pavements – Design Notes

Approved WQ BMPs

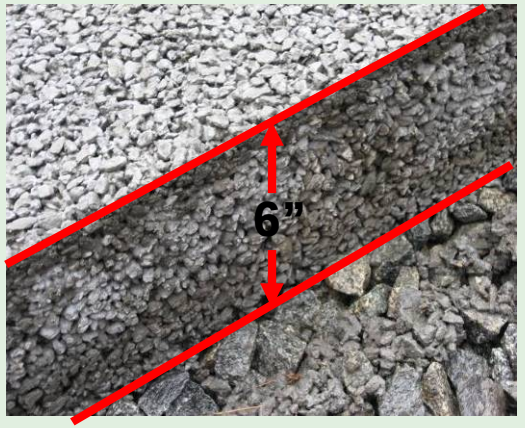
- May be used as infiltration and/or detention system
- For infiltrating practices:
  - Field verification of soil permeability/texture essential
  - Bottom of facility cannot be located in fill* and must have 3' separation from gw and bedrock*
  - Size based on design infiltration rates (Table 5-3)
  - Cannot be used if contributing drainage is a LUHPPL
  - Must meet variety of setbacks* (Table 5-4)
- Frequent maintenance necessary to retain permeability (vacuum)
- Use on low traffic/speed areas with gentle slopes (<5%)
- Generally not designed to accept runoff from other areas

* Reduced requirements for resid. areas

Porous Pavements

Porous Pavements (General)

- Aggregate gradation: No fines added to mix
- Air voids: 18-20%
- Cold climate and WQ functionality dependent on sub base design



Pervious Concrete

- Placement is challenging and requires certified installers
- Compressive strength:
  3000 psi at 7 days
- Concrete is very resistant to aging

Porous Asphalt

- Modification of Open Grade Friction Course (OGFC)
- Asphalt binder often modified (polymers, fibers) but not necessary
- QC production at plant is crucial, install is simple

Permeable Pavers

3 1/8 in. (80 mm) thick pavers with permeable joints

Open-graded bedding course

Open-graded base course (OGB)

Open-graded subbase on non-compacted soil subgrade

Courtesy PICP and LIDC

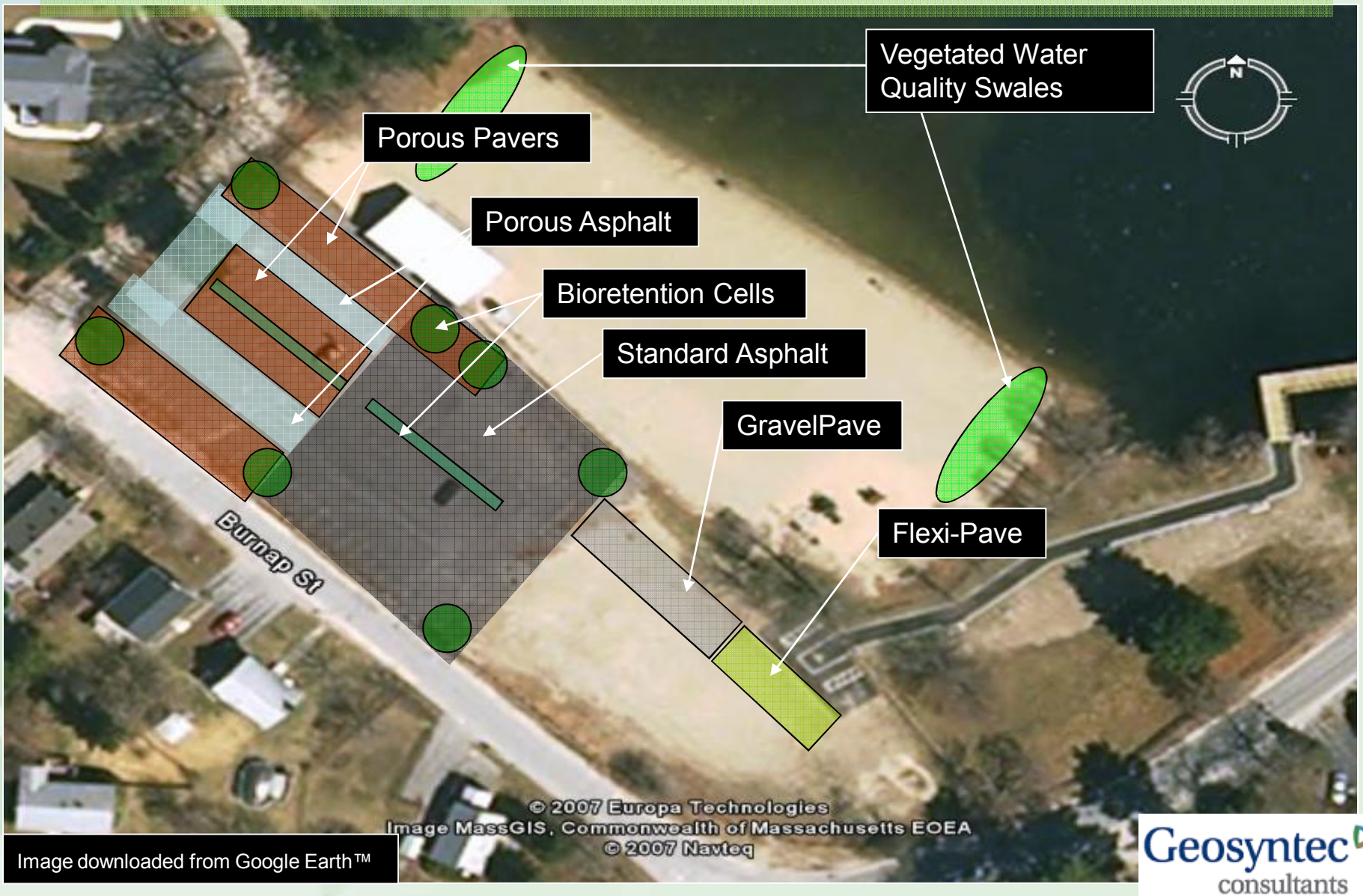
Typical Applications

Typical Applications

Typical Applications

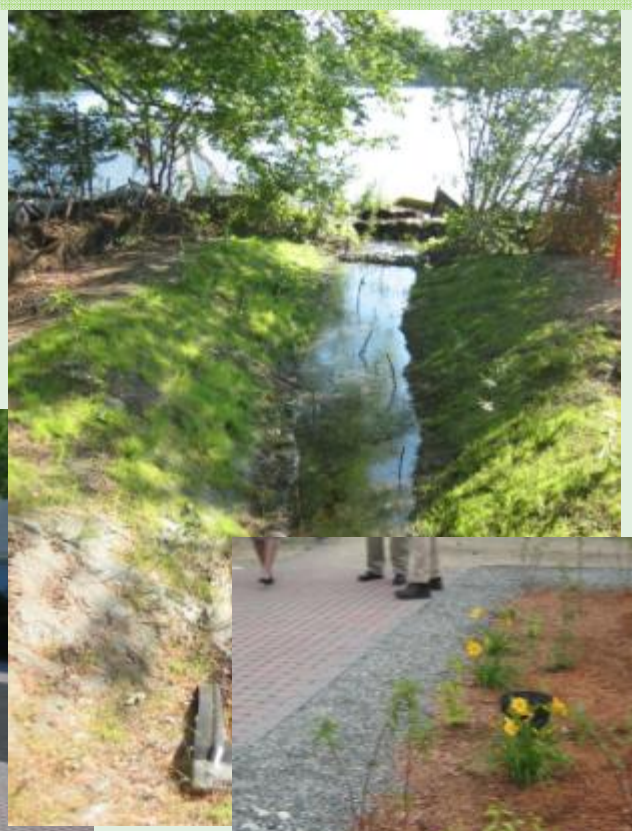
Typical Applications

Pre-Construction Conditions



Geosyntec consultants

LID Technologies Demonstrated



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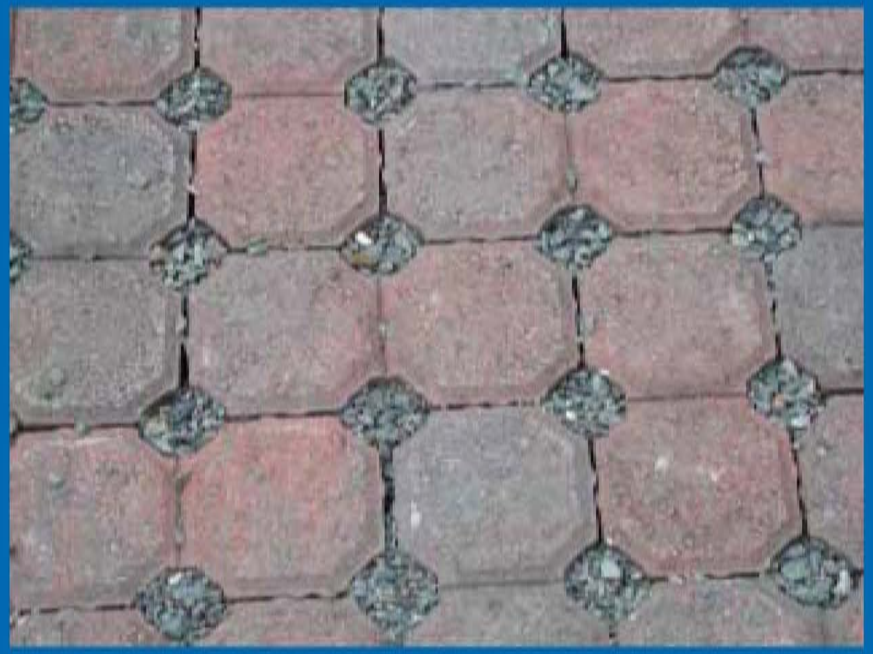
Geosyntec consultants



Porous Pavers

GravelPave

FlexiPave

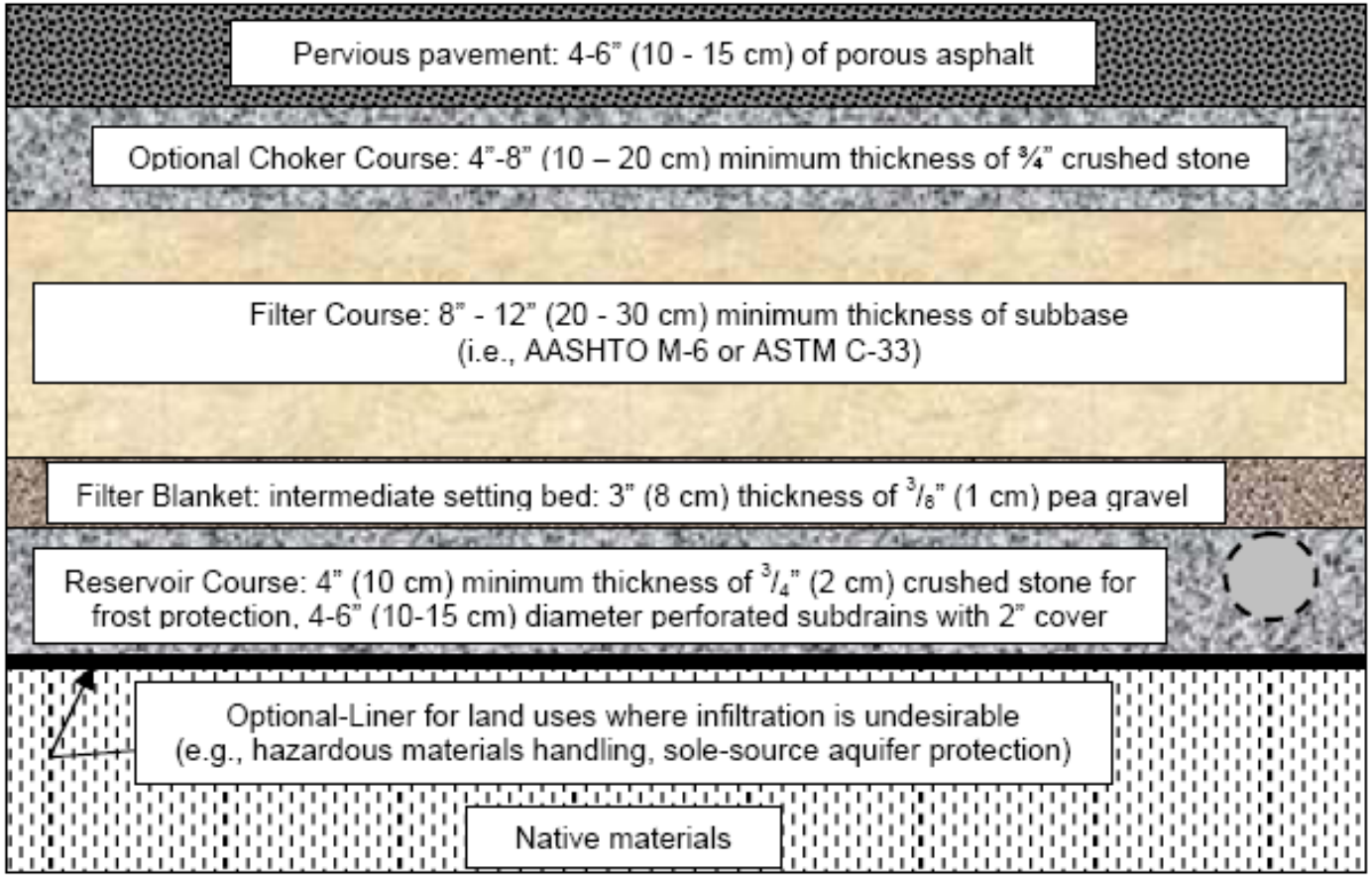

JCPenney

Typical Section: Porous Asphalt

- 4-6 inch surface asphalt course (no fines)
- 4-8 inch granular filter layer (No. 57 Stone)
- 24 inch upper reservoir (bank run gravel, sand mix)
- Up to 24 inch crushed gravel layer with 6 inch optional underdrain (underdrain raised 12 inches above bottom)

Typical Porous Pavement Parking Lot System Cross-Section

Figure F-2 Typical Parking Area Cross-Section for Pervious Pavement System



Design Steps

1. Assess site and soil conditions
2. Compute increased runoff depth from area contributing to the permeable pavement
3. Compute the depth of the base for storage

Design (continued)

5. Determine the base thickness for traffic
   - Provide sufficient pavement thickness to protect the sub-grade from being over-stressed by traffic loads
   - Provide quality base and subbase materials that can support the applied loads
6. Compare to base thickness for water storage:
   - Always use thicker base
7. Check clearance from bottom of base to seasonal high water table
8. Check geotextile filter criteria

Soil Design Strength

Design assumptions

Subgrade strength for vehicular traffic:

- **Min. 96-hour soaked CBR = 5%**
- **(Min. R-value = 24)**

What if < 5%CBR?

- **Capping layer of geotextile and aggregate base**
- **Stabilize soil with cement**

Stone Gradation by Course

Table F-7 Gradations and compaction of choker, filter, and reservoir course materials.

US Standard Sieve Size (inches/mm)	Percent Passing (%)			
	Choker Course (AASHTO No. 57)	Filter Course (AASHTO No. M-6)	Reservoir Course (AASHTO No.3)	Reservoir Course Alternative* (AASHTO No.5)
6/150	-		-	
2½/63	-		100	-
2 /50	-		90 – 100	-
1½/37.5	100		35 – 70	100
1/25	95 - 100		0 – 15	90 – 100
¾/19	-		-	20 - 55
½/12.5	25 - 60		0 - 5	0 - 10
3/8/9.5	-	100	-	0 - 5
#4/4.75	0 - 10	70-100	-	
#8/2.36	0 - 5		-	
#200/0.075		0 – 6**		
% Compaction ASTM D698 / AASHTO T99	95	95	95	95

* Alternate gradations (e.g. AASHTO No. 5) may be accepted upon Engineer's approval.

** Preferably less than 4% fines

Porous Asphalt Mix

- Pages F-44 through F-48 for Material Specs;
  - Mix Materials;
  - Performance Graded Asphalt Binder (PGAB);
  - Anti-Stripping Mix Additives;
  - Course Aggregate;
  - Fine Aggregate;

Pervious Concrete Surfaces

- Pages F-62 through F-69
  - Suppliers
  - General (ASTM References, QC, Testing, etc);
  - Materials; and
  - Execution;

Maintenance

- Areas shall not to be used for temporary ESC;
- Minimize use of sand and salt
- Keep adjacent landscape areas well maintained and stabilized
- Clean surface with vacuum sweepers
- Post signs identifying permeable pavement
- Do not repave with impermeable materials
- Grass pavers need mowing and often need reseeding of bare areas.

Reinforced turf

Application and location important

Compaction and Backfill Soils

PICP near Disturbed Area

n Group, Inc.

Limitations

- Not appropriate for high traffic/high speed areas – load bearing limitations and clogging potential
- Stormwater LUHPPLs and any area with a modest to high spill potential
- Areas with heavy winter sanding
- Expansive and fill soils
- Periodic maintenance a must (vacuum sweeper, mowing, paver block repair)
- To avoid frost heave: base designed to drain quickly (depth > 24 inches)