

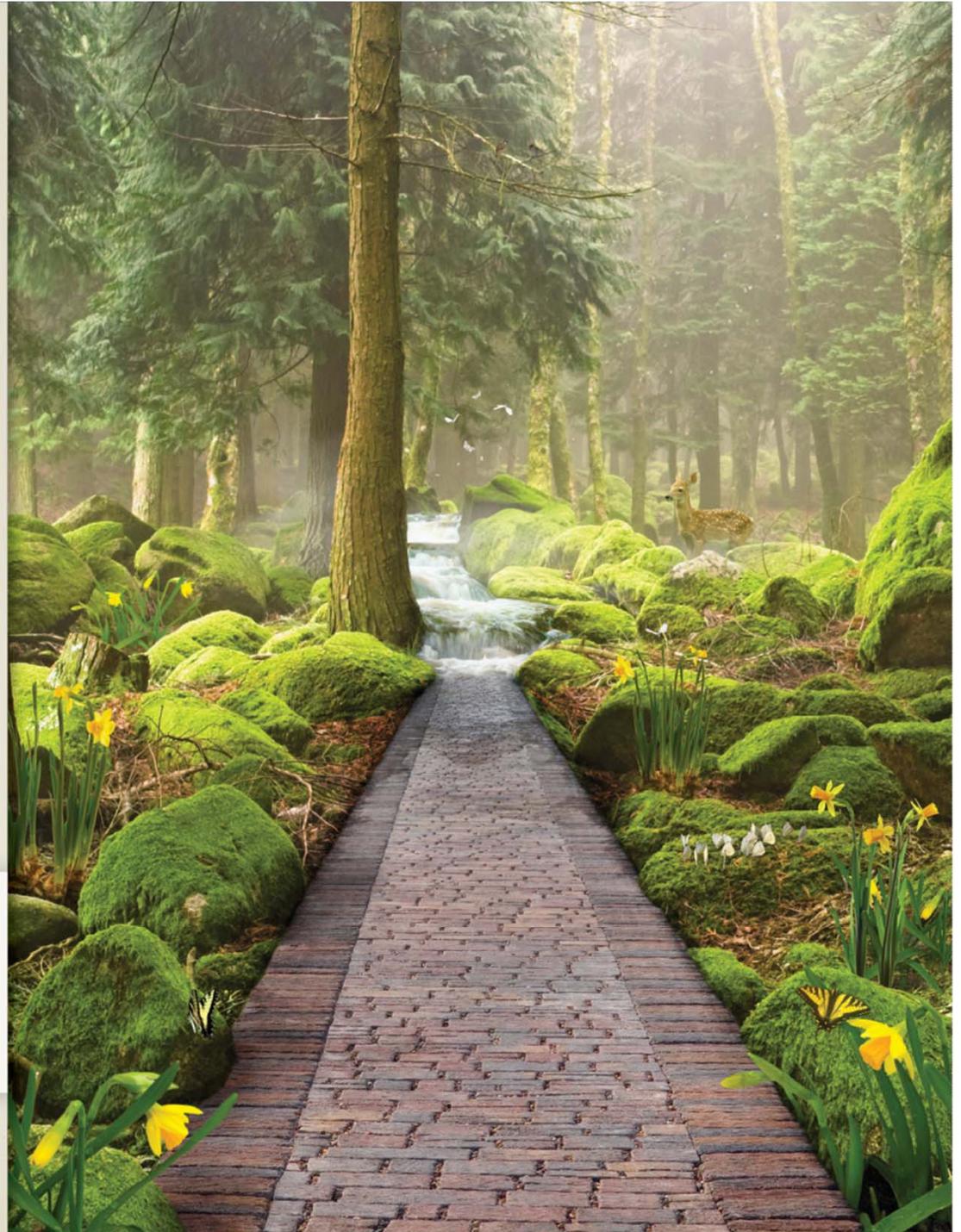
Sustainable Site Pavement Systems

Permeable Interlocking Concrete Pavement

Training for Design Professionals
ICPI Presentation #003



Presented by:
Brent Davis - Design Consultant
Belgard Engineered Solutions





This program is registered with the AIA/CES for continuing education professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation

Approved for 1HSW LU hour



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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Approved for 1 hour of CE

Permeable Interlocking Concrete Pavement

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Site
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The Interlocking Concrete Pavement Institute is a USGBC Education Provider committed to enhancing the professional development of the building industry and LEED Professionals through high-quality continuing education programs. As a USGBC Education Provider, we have agreed to abide by USGBC established operational and educational criteria, and are subject to course reviews and audits for quality assurance. Approved for 1 GBCI CE hour for LEED Professionals

The Interlocking Concrete Pavement Institute is committed to enhancing the professional development of the building industry and design professionals through high-quality continuing education programs. As an ICPI Education Provider, we have agreed to abide by established operational and educational criteria, and are subject to course reviews and audits for quality assurance. Questions related to specific materials, methods, and services can be addressed at the conclusion of this presentation. Approved for 1 PDH for design professionals.

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The Interlocking Concrete Pavement Institute is committed to enhancing the professional development of the building industry and ICPI Certified Installers through high-quality continuing education programs.

As an ICPI Installer Education Provider, we have agreed to abide by the established operational and educational criteria, and are subject to course reviews and audits for quality assurance. Approved for 1 installer CE credit for ICPI certified installers

This program provides an introduction to PICP and the ICPI manual, Permeable Interlocking Concrete Pavements. An overview is provided of base materials and designs for hydrological and structural requirements. The overall design approach is outlined so that the participant can explore it further in the ICPI manual. Construction specifications are explained by illustrating the construction process so that the participant can understand the critical components of a specification. Maintenance for infiltration and winter performance is also covered. Eligible LEED® credits are covered as well.

Permeable Interlocking Concrete Pavement

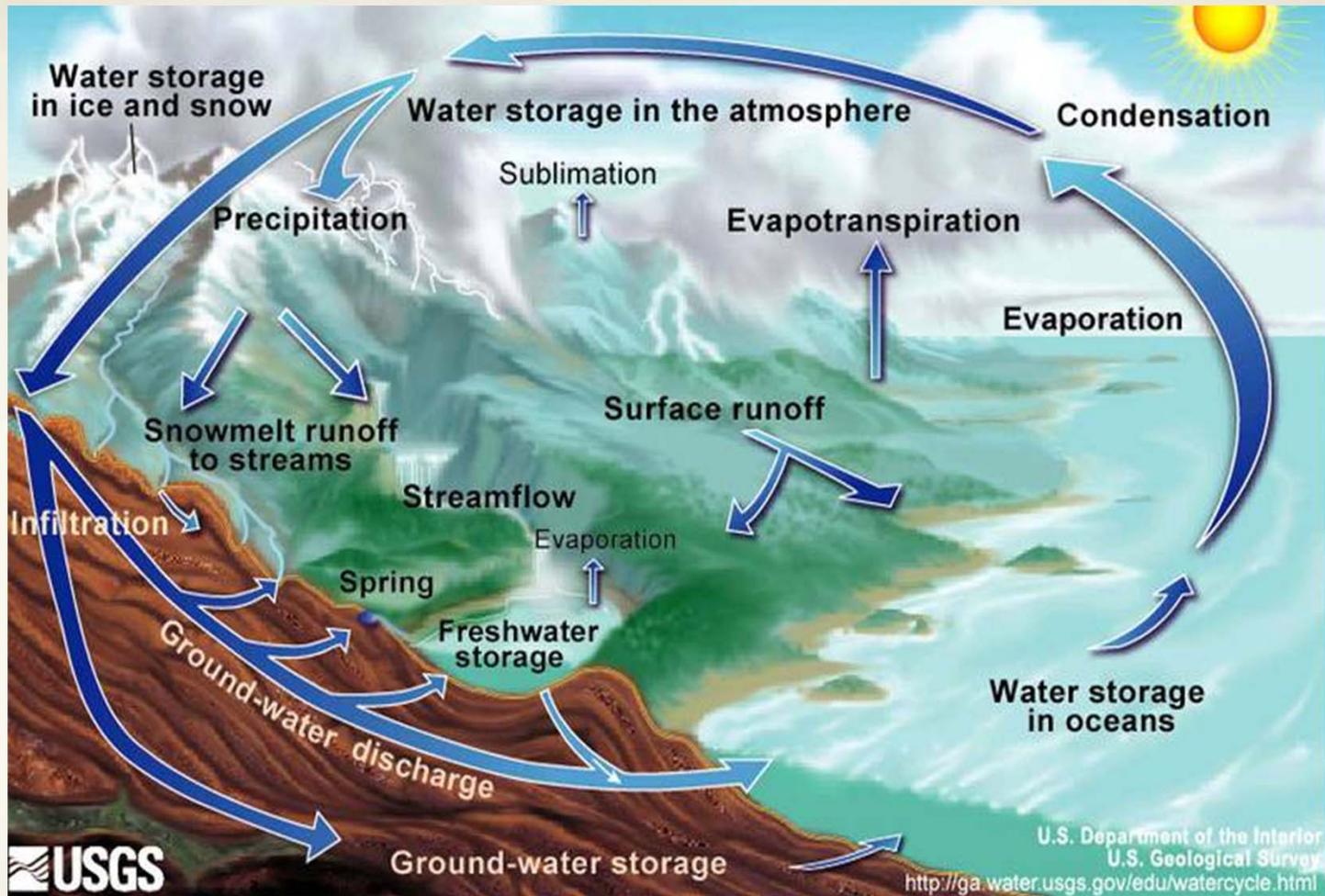
Sustainable
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- Stormwater management
- Pervious System Technologies
- PICP Design Principles
- PICP Construction / Maintenance
- PICP Cost Recovery

Learning Objectives

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The Water Cycle

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Nature

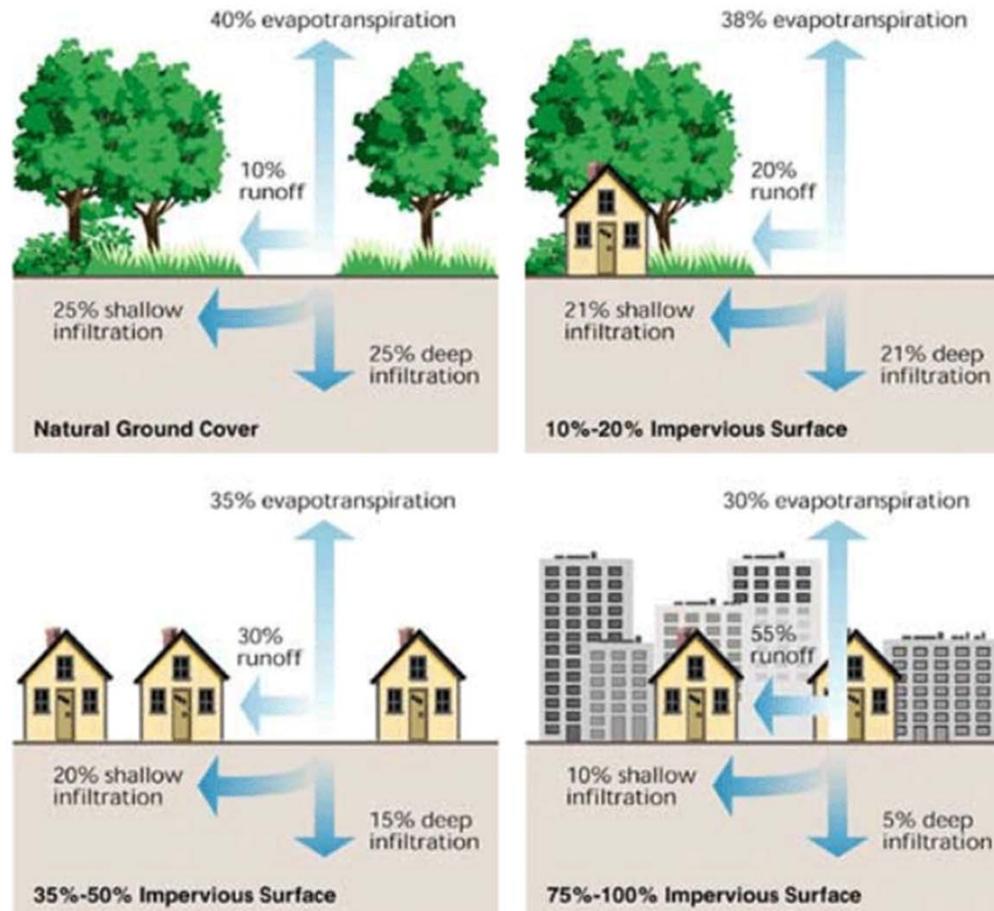
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Impacts of Population Growth

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Problems of Urban Watersheds



Annual Hydrology

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Increase Run Off And Downstream Erosion

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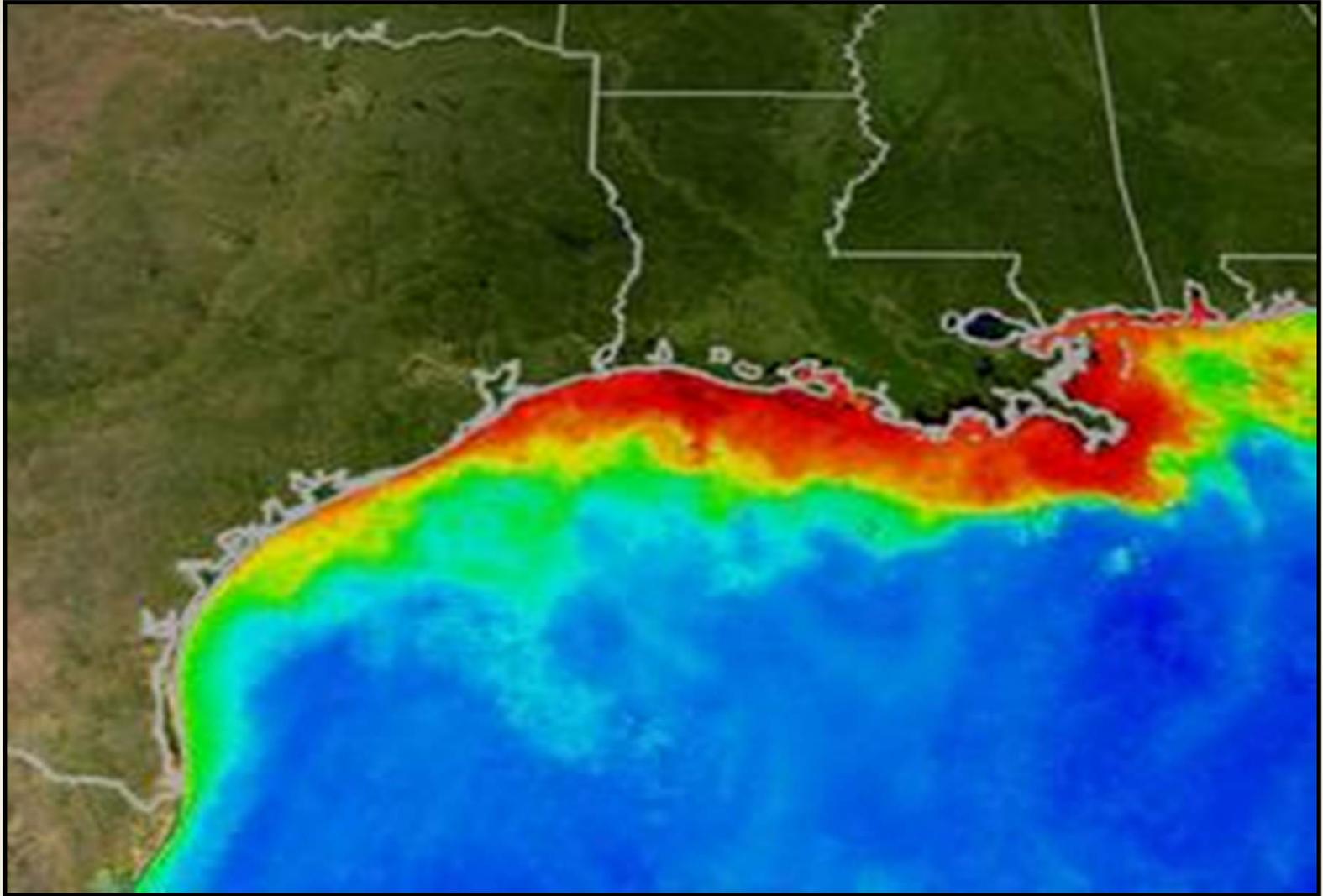
Increasing Peak Volumes/Flows

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Strain on Existing Stormwater Systems

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Run-off Temperatures

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The first one inch of runoff carries 90 percent of the pollution.



First Flush' Pollutants

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Today's Stormwater Management

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Detention Ponds

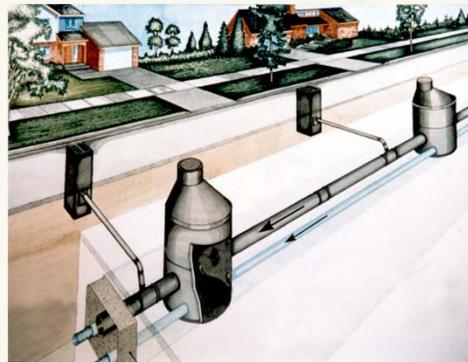
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SOURCE CONTROLS



Permeable Pavers

CONVEYANCE CONTROLS



Infiltration Systems

END-OF-PIPE CONTROLS



Wet Pond

SWM – Old - 3 C's – Collect, Convey, Centralize

New - Paradigm Shift – 3 D's – Disconnect, Distribute, Decentralize

Treatment Train Approach

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Need to minimize the hydrologic impacts of development through Sustainable Solutions

LID: An Innovative Approach

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Benefits of Bio-Aquifer Storm System

- **Design (100yr)** for stormwater runoff detention
- **Erosion control** (on-site)
- **First-flush** pollutant removal and treatment
- **Groundwater** recharge
- **Land use** and planning



Tomorrows Stormwater Management

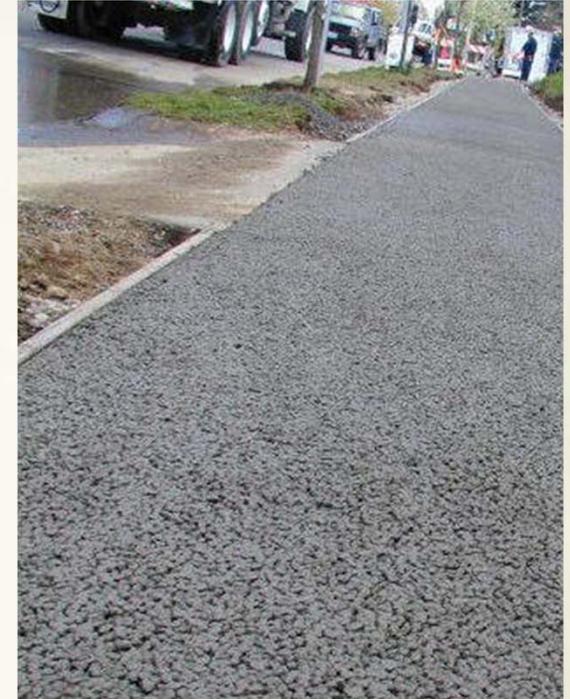
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Permeable Pavers



Porous Asphalt



Pervious Concrete

SIMILAR TECHNOLOGIES

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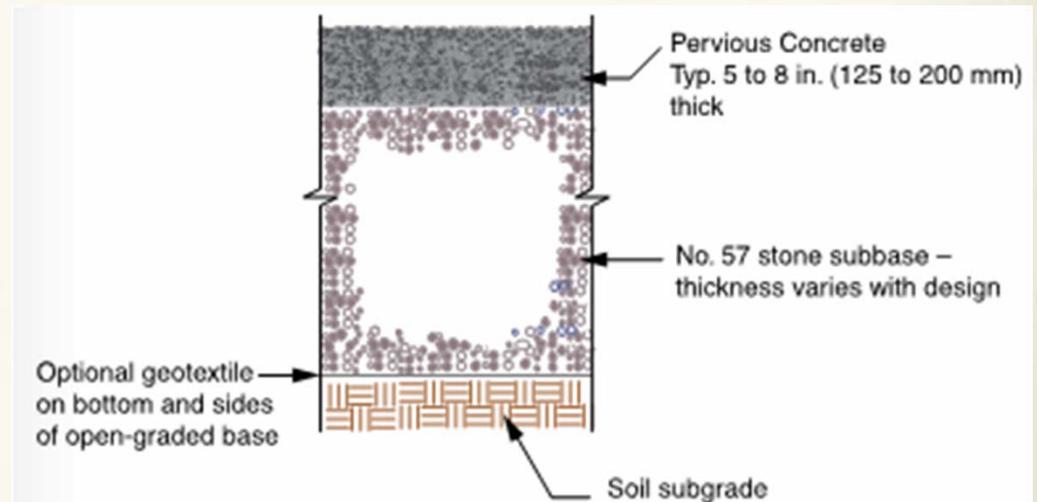


- **Construction Aspects-** Cast in place construction may yield varying concrete quality; requires formwork; on-site control of water/ cement content critical to lifetime performance; requires min. seven-day cure prior to traffic; 2,500 to 4,000 psi (17 to 18 MPa) concrete

- **Cost-** Competitive with PICP installation cost

- **ADA Compliant-**

- **Urban Heat Island Reduction-** Medium to high, can achieve SRI > 29 with selected aggregate color and cement



Pervious Concrete: National Ready Mixed Concrete Association

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- **Winter durability-** Deicing chemicals not recommended; saturation when frozen may damage concrete; snow melts and immediately drains, reducing ice hazards; plastic or rubber tipped snow plow blade recommended; sanding prohibited

- **Surface Cleaning-** Surface should be vacuumed and pressure washed to remove sediment and debris; difficult to open and restore deeply clogged surface

- **Repairs-** Damaged or highly clogged areas can be cut out and replaced with pervious concrete; repaired area needs to cure with no traffic; will not match surrounding surface

- **Water Quantity/ Quality Reduction-** High initial surface infiltration; can receive most design storms; reduces TSS, nutrients and metals; does not release oils into runoff.

Pervious Concrete: National Ready Mixed Concrete Association

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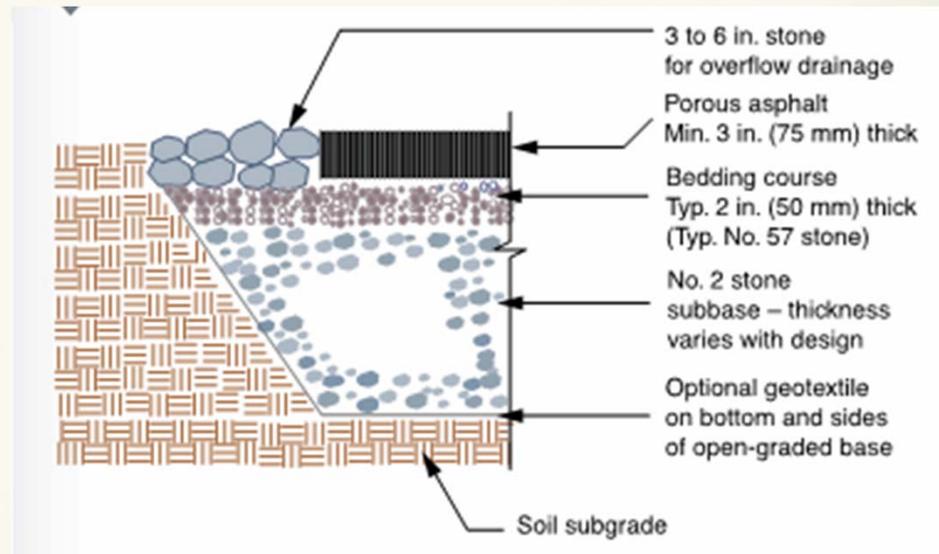


- **Construction Aspects**- Requires no formwork, maintaining mix temperature on site critical to lifetime performance; requires 24hour cure prior to traffic.

- **Cost**- Less expensive than PICP and pervious concrete pavements

- **ADA Compliant**-

- **Urban Heat Island Reduction**- Low; cannot achieve minimum SRI > 29



Porous Asphalt: National Asphalt Pavement Association

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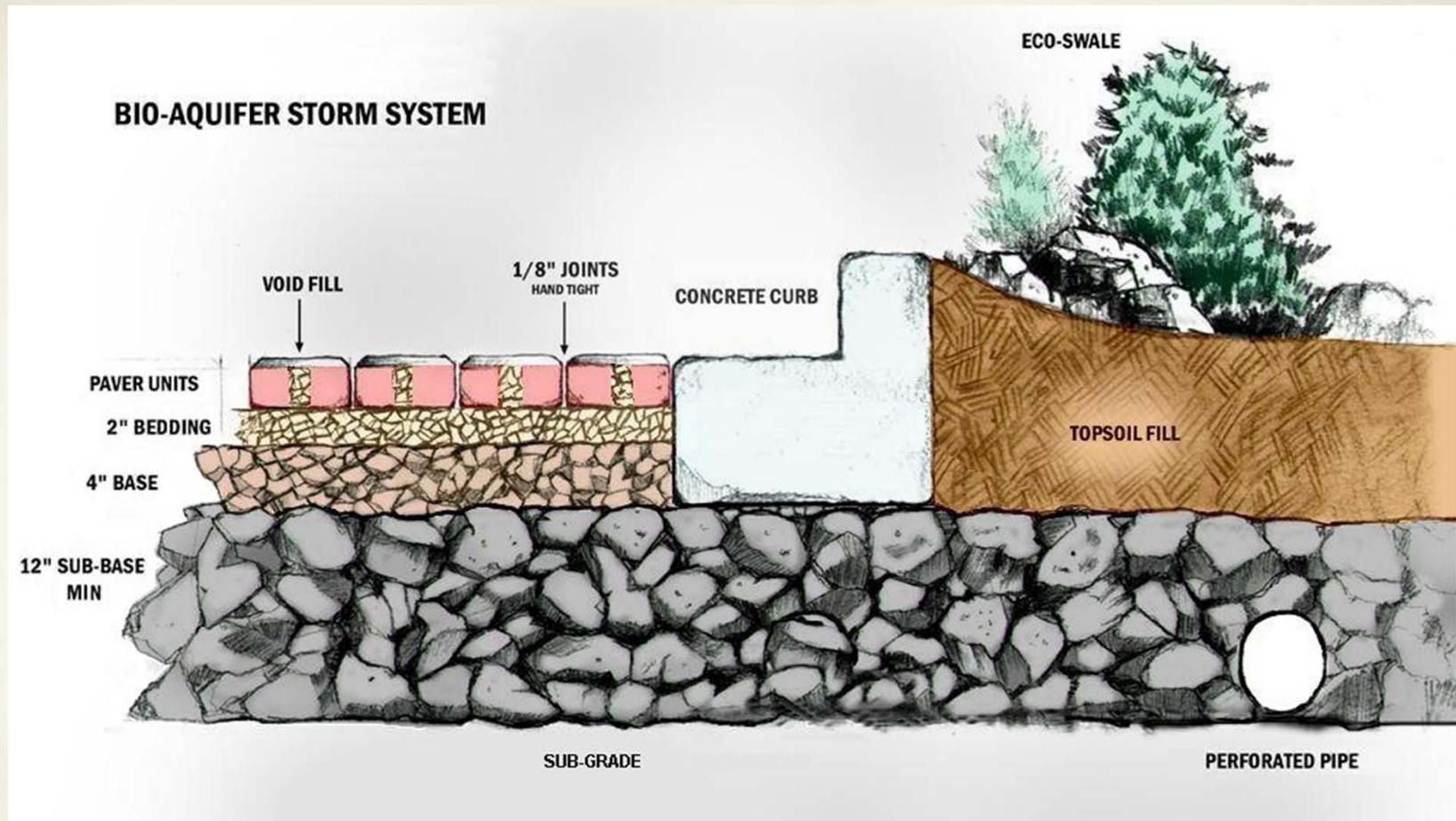


- **Winter durability-** Resists freeze-thaw; liquid deicing materials recommended; saturation when frozen may damage asphalt; snow melts and immediately drains, reducing hazards; sanding prohibited; less deicing materials needed

- **Surface Cleaning-** Surface should be power washed or vacuum swept to remove sediment and debris; difficult to open and restore deeply clogged surface

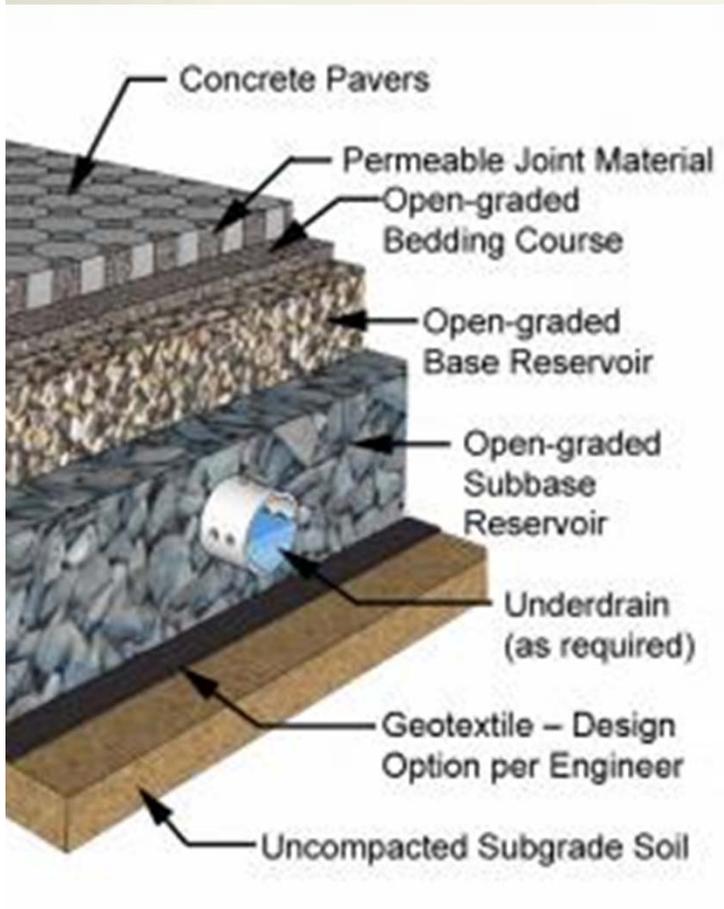
- **Repairs-** Limited repair potential; patch with impervious (conventional) asphalt up to 10% of pervious area; pavement cuts weaken pavement; repaired area will not match surrounding surface

- **Water Quantity/ Quality Reduction-** High initial surface infiltration; can receive most design storms; initially releases oils into runoff; reduces TSS, nutrients and metals.



PICP Stormwater Management System

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#8 (1/4")

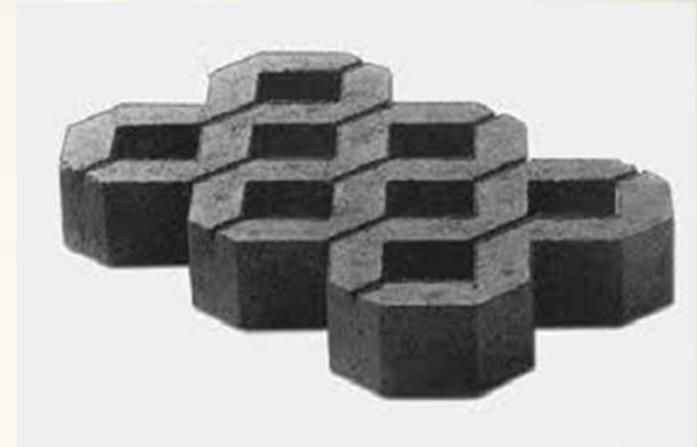
#57 (3/4")

#2,34 (2 1/2") -
40% Voids

All are clear
crushed stone



PICP



Open space

10%

40%

Fill material

#8 stone

topsoil

Infiltration rate of joint fill

2,000 inch/hr

1 inch/hr

Net infiltration

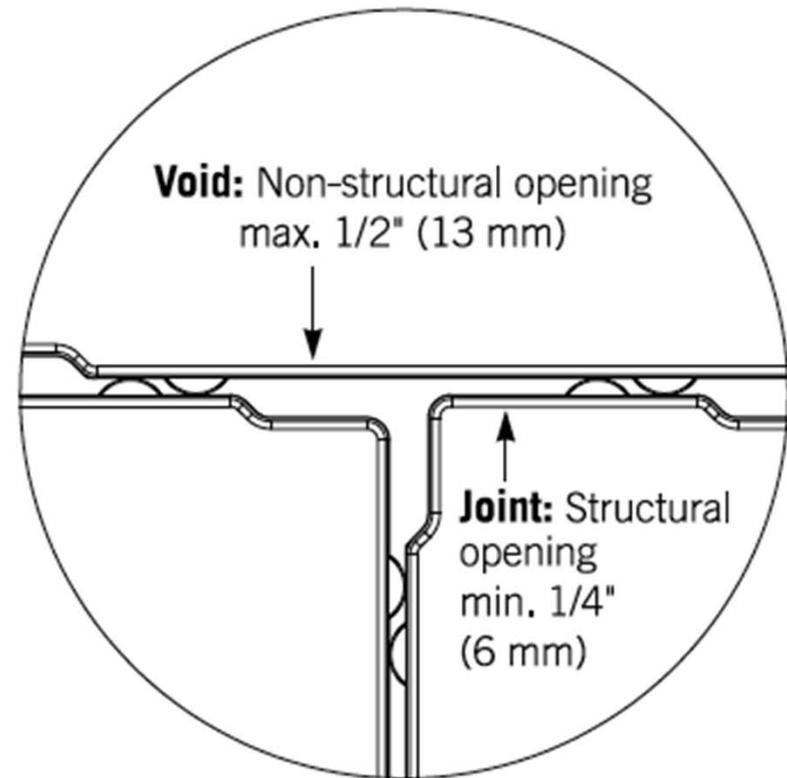
200 inch/hr

0.4 inch/hr

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Joints – structural, provide vertical and horizontal interlock between units

Voids – provide for infiltration between units



Measurements are nominal.

Joints vs. Voids

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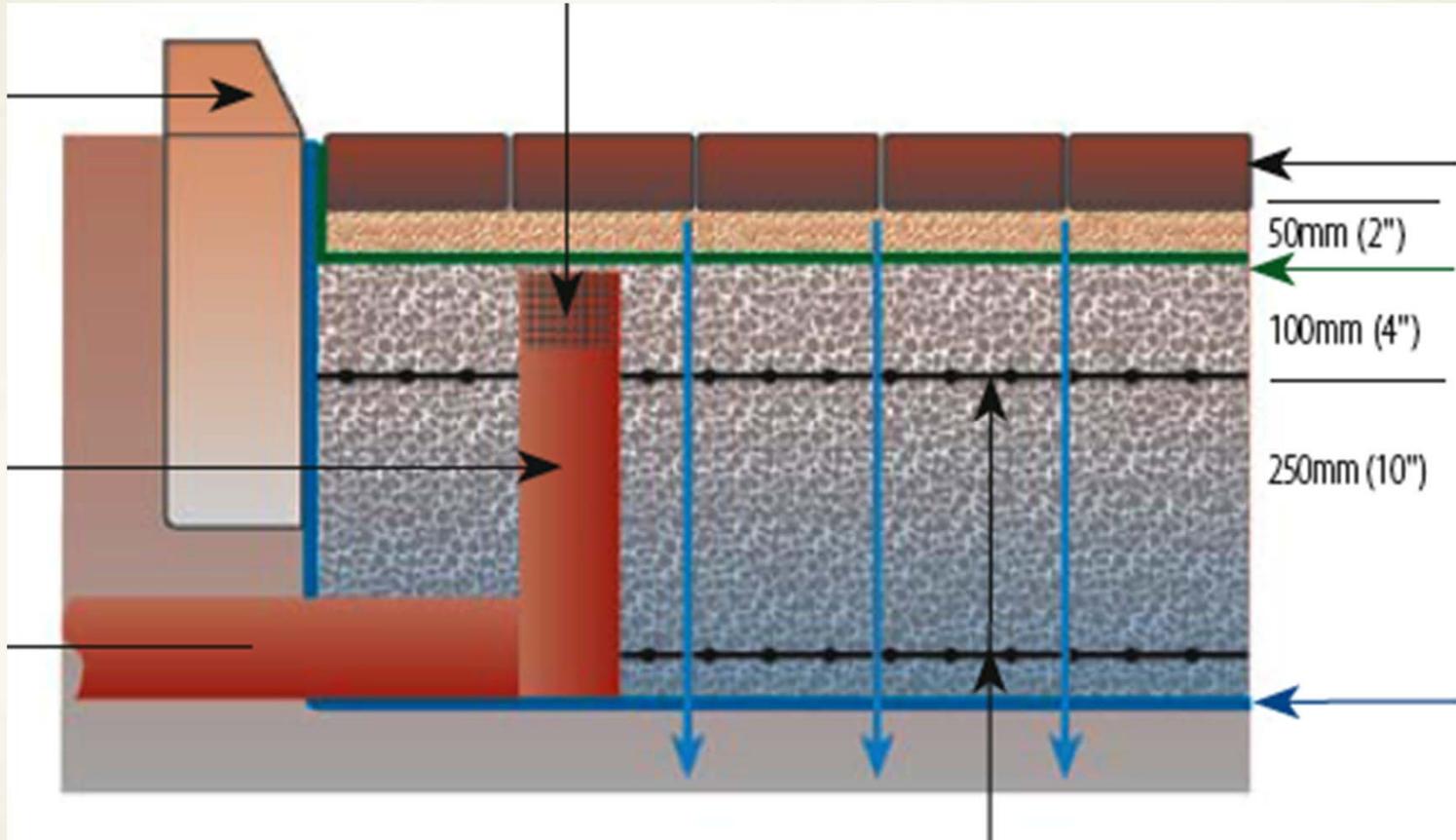
- ***Full base infiltration***
 - Permeable Sandy soils (>0.5 in/hr.)
 - No perforated drain pipes

- ***Partial – detention & infiltration***
 - Silt/clay soils (<0.5 in/hr.)
 - Perforated pipes at bottom of base

- ***None – detention only***
 - High rock, water table, poor soils
 - Water harvesting opportunities

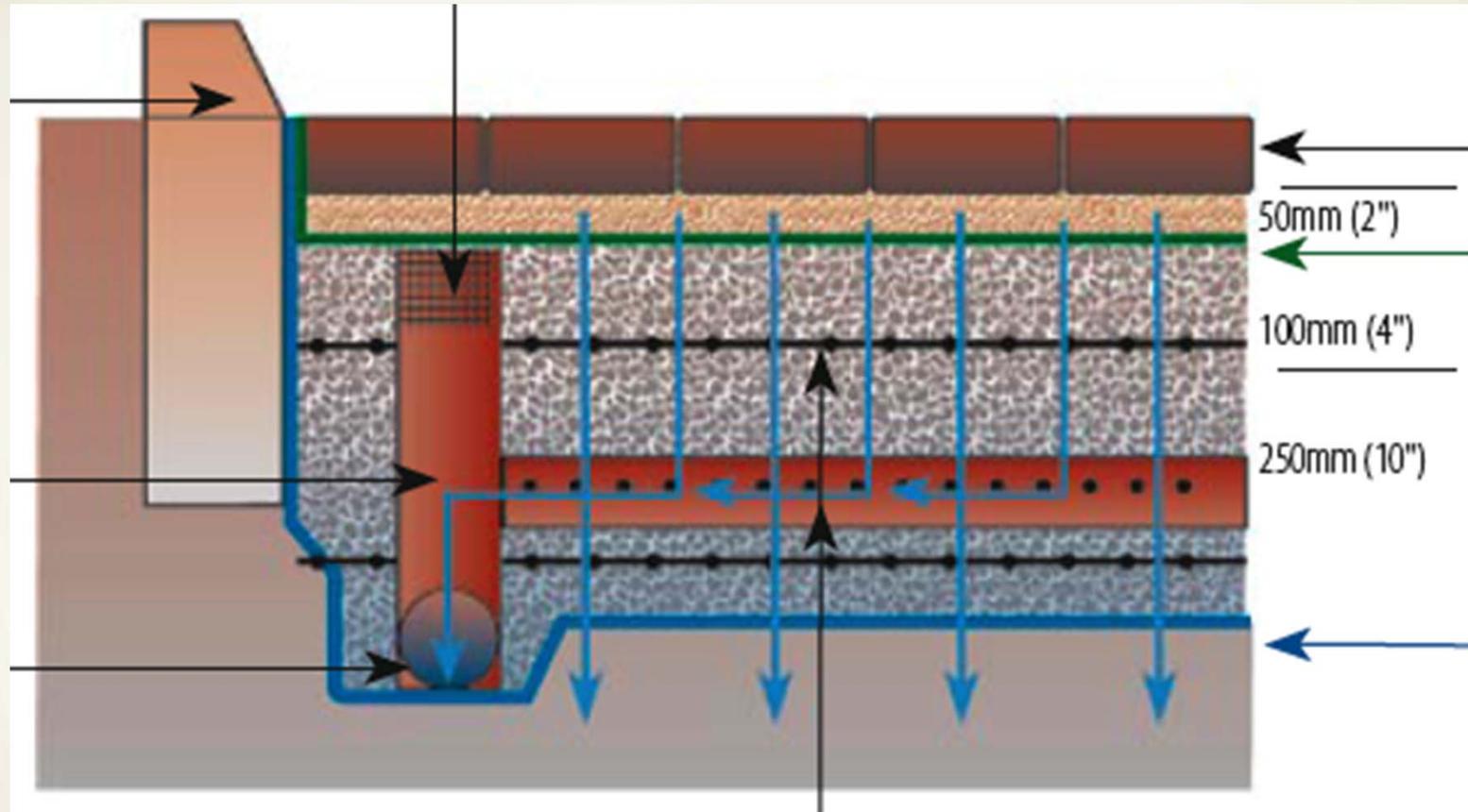


Full, Partial, or No Infiltration



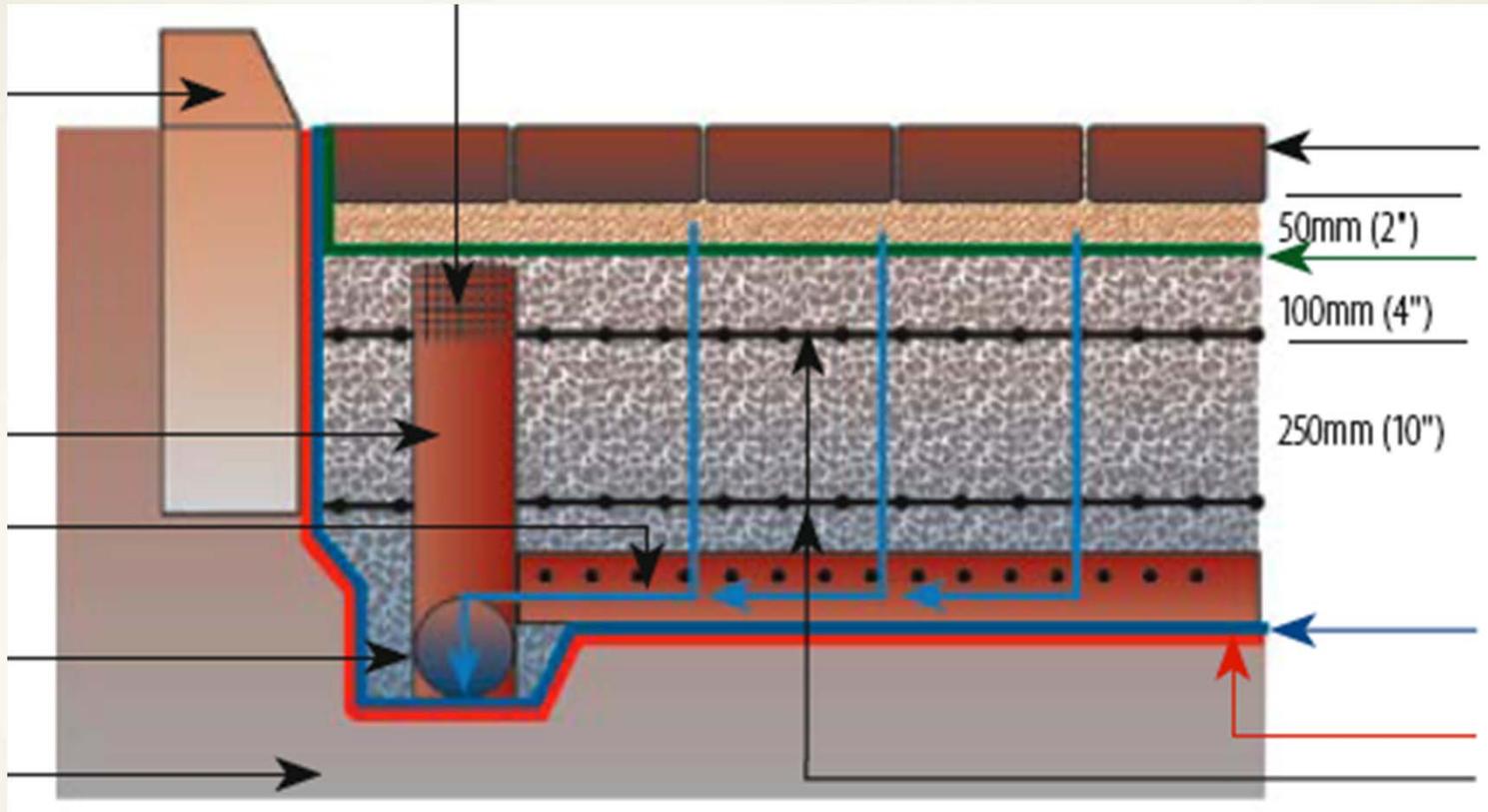
Permeable Sandy soils (>0.5 in/hr.)
No perforated drain pipes

Full, Partial, or No Infiltration



Silt/clay soils (<0.5 in/hr.)
Perforated pipes at bottom of base

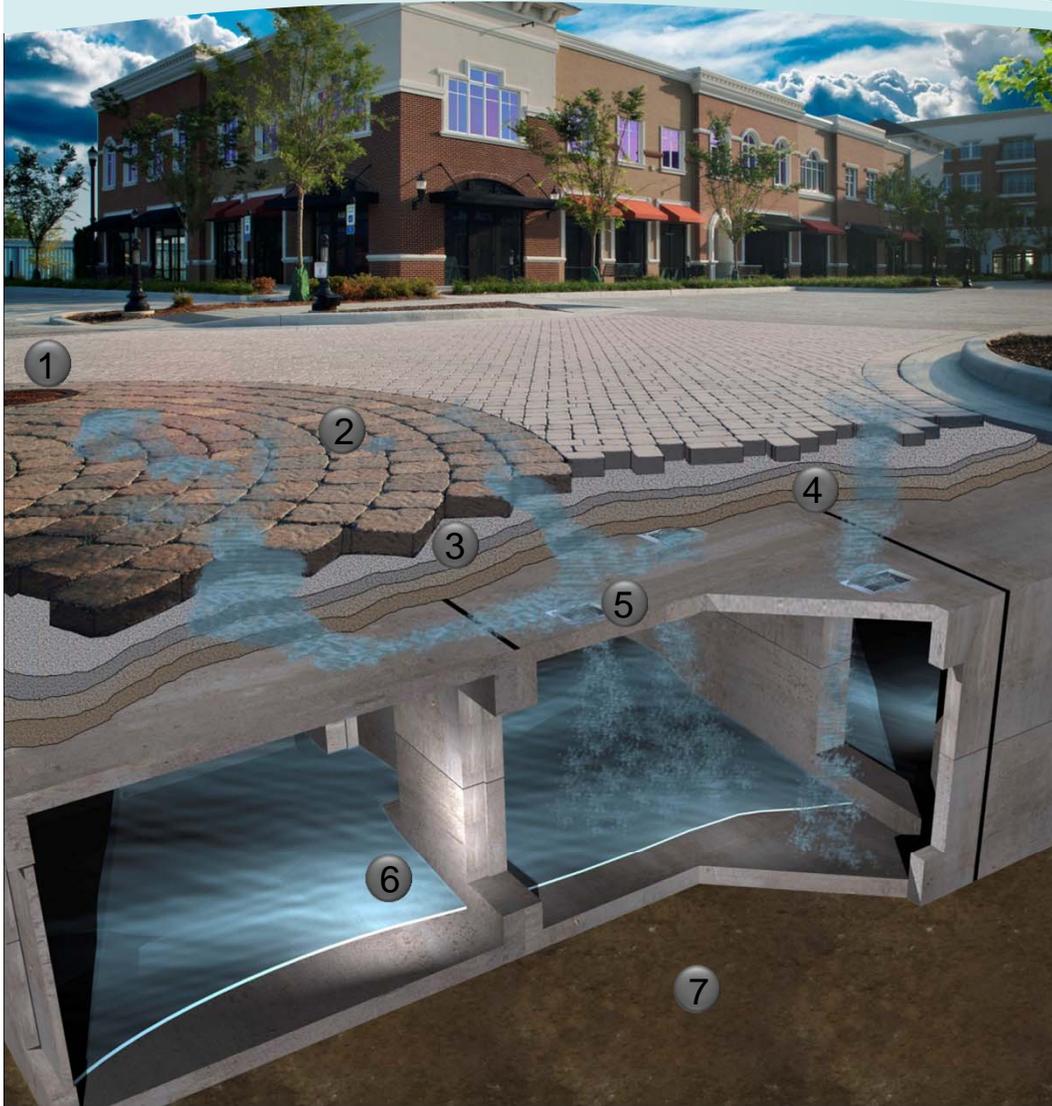
Full, Partial, or No Infiltration



High rock, water table, poor soils
Water harvesting opportunities

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PermeCapture™ Stormwater Management System

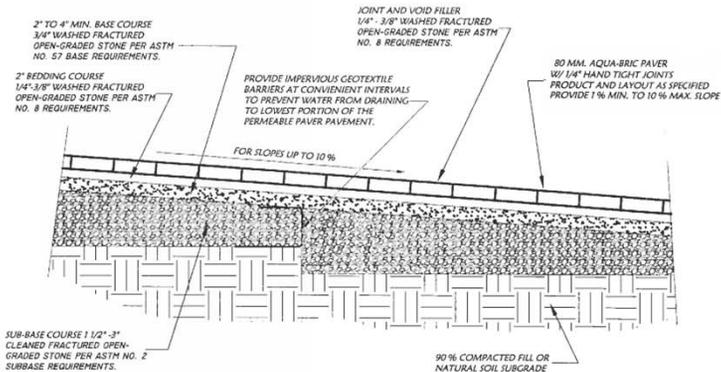
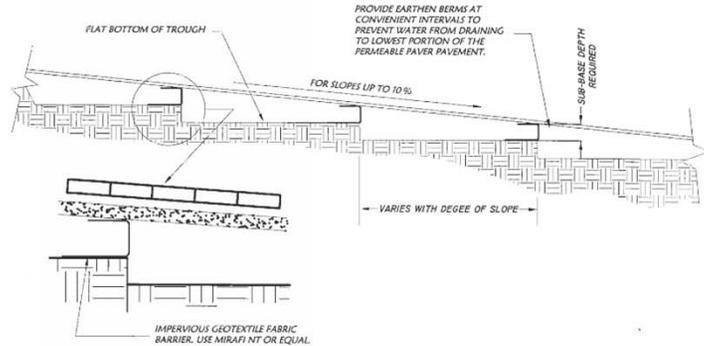


1. Maintenance Access
2. Permeable Pavers
3. Drainage Aggregate
4. Permeable Base
5. HydraPorts™
6. Storm Capture Modules
7. Subgrade Soils

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BELGARD

ENGINEERED SOLUTIONS



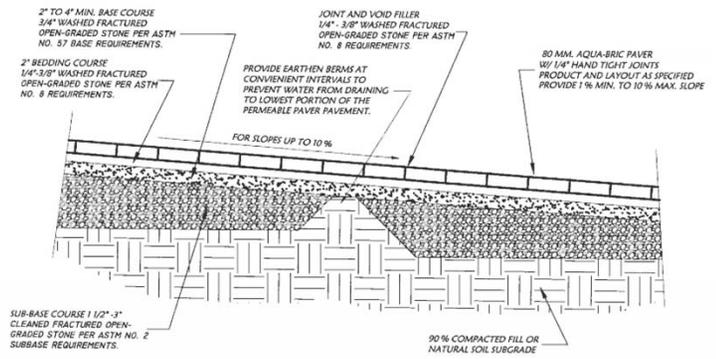
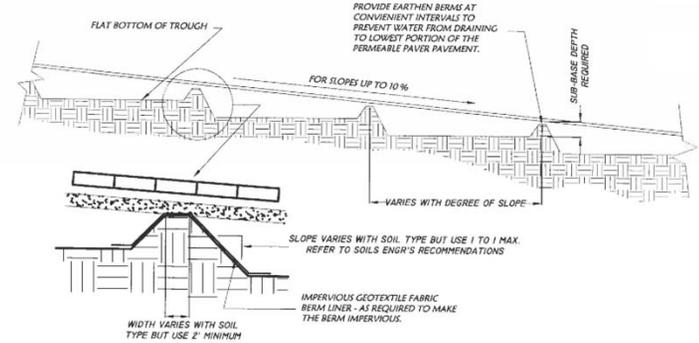
BASIC INSTALLATION ON SLOPING GROUND

Preliminary

10/29/2010 3:43:09 PM

BELGARD

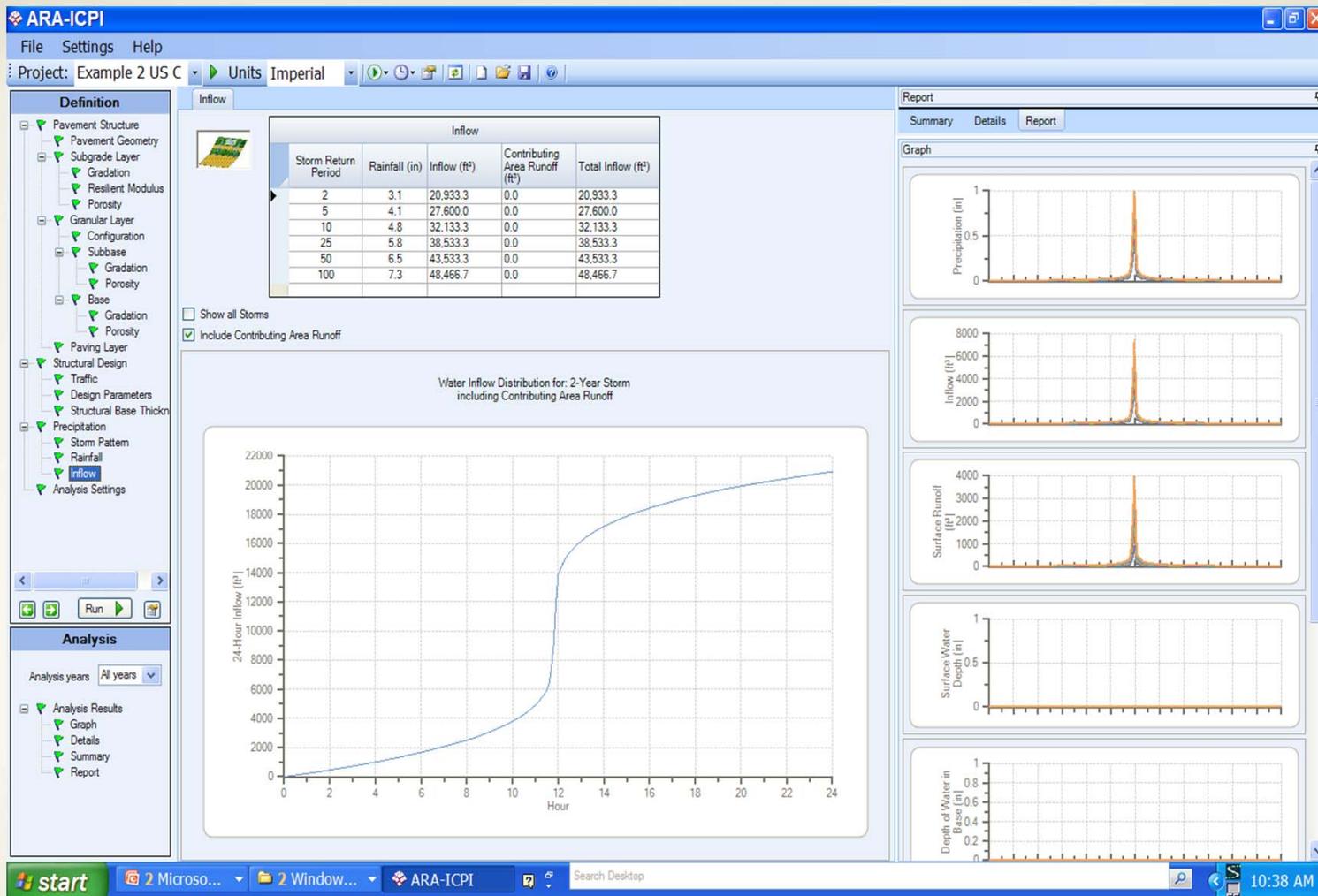
ENGINEERED SOLUTIONS



BASIC INSTALLATION ON SLOPING GROUND

What about slopes?

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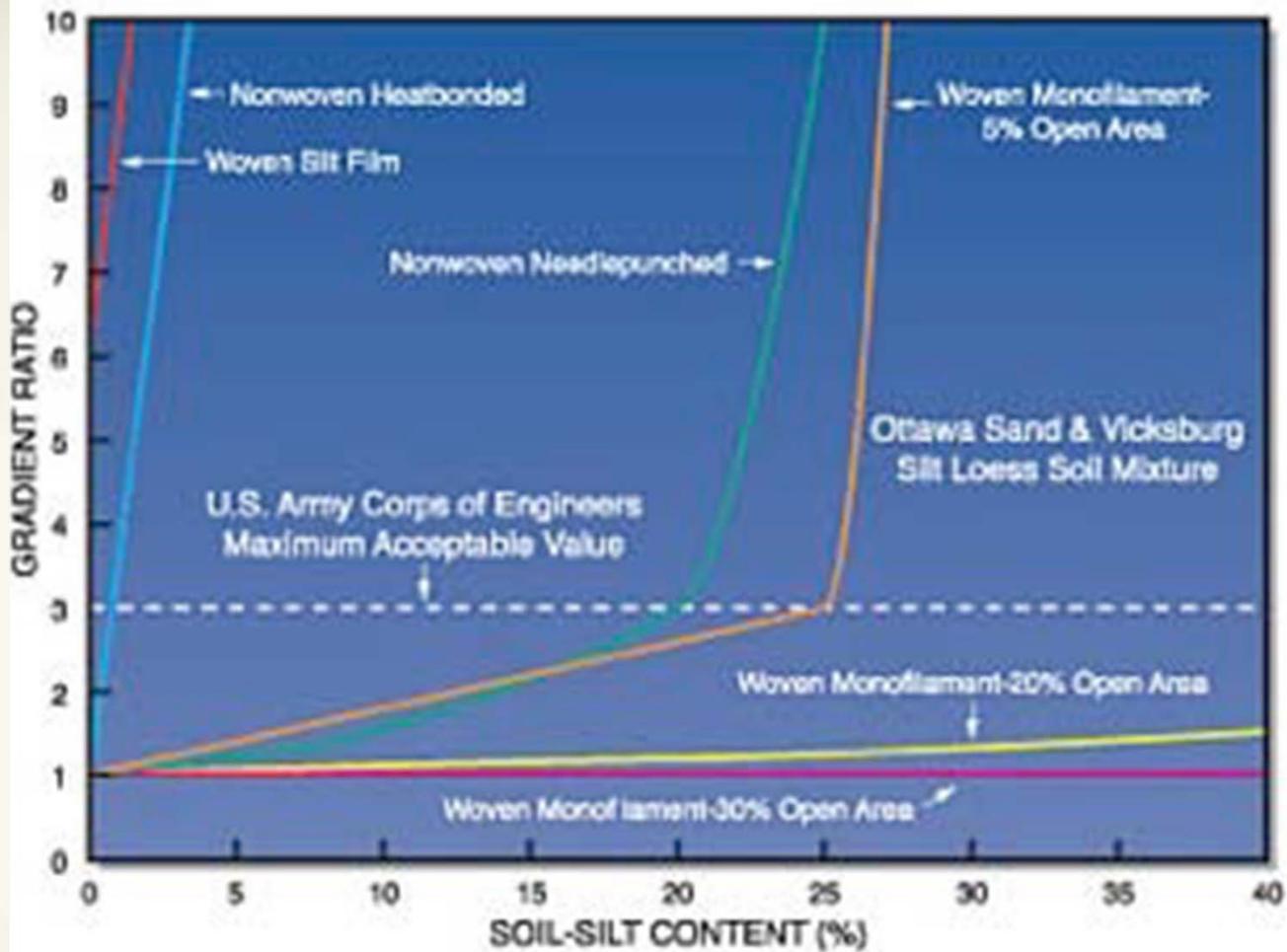
ICPI Software

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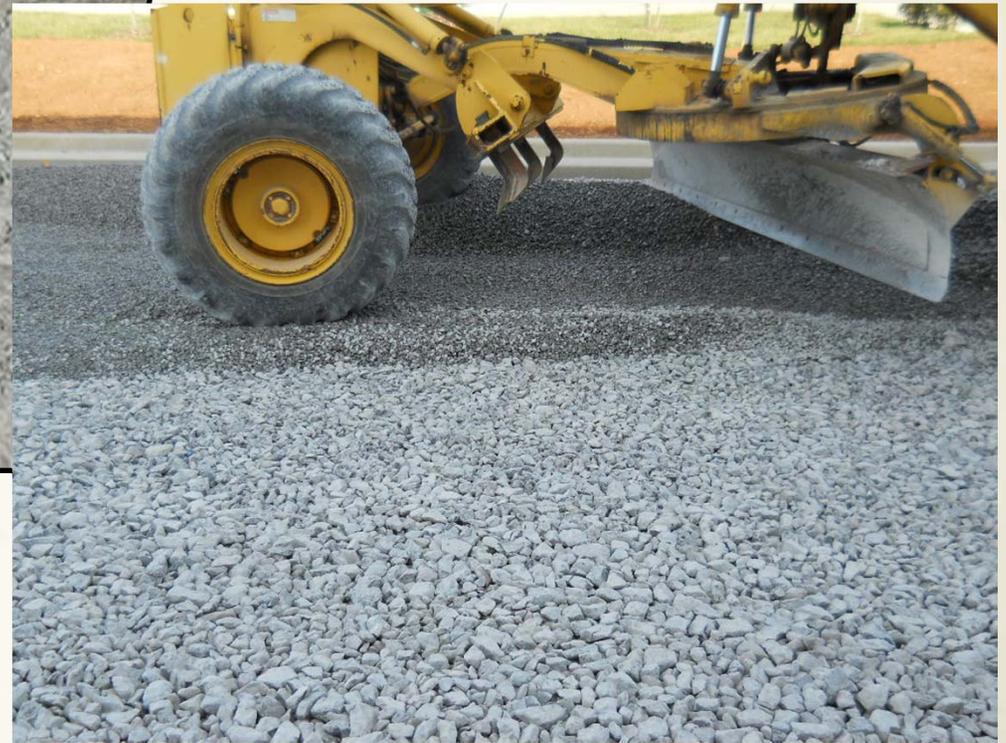
**#2, #34 Open Graded Sub-base Reservoir
Compacted in 4"-6" Lifts**

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Geomembranes

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**Choking Layer
#57 Stone
4" Thick on ALL Applications**

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**Bedding Layer
#8 Stone
1.5"-2" Thick – DO NOT COMPACT**

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Installation

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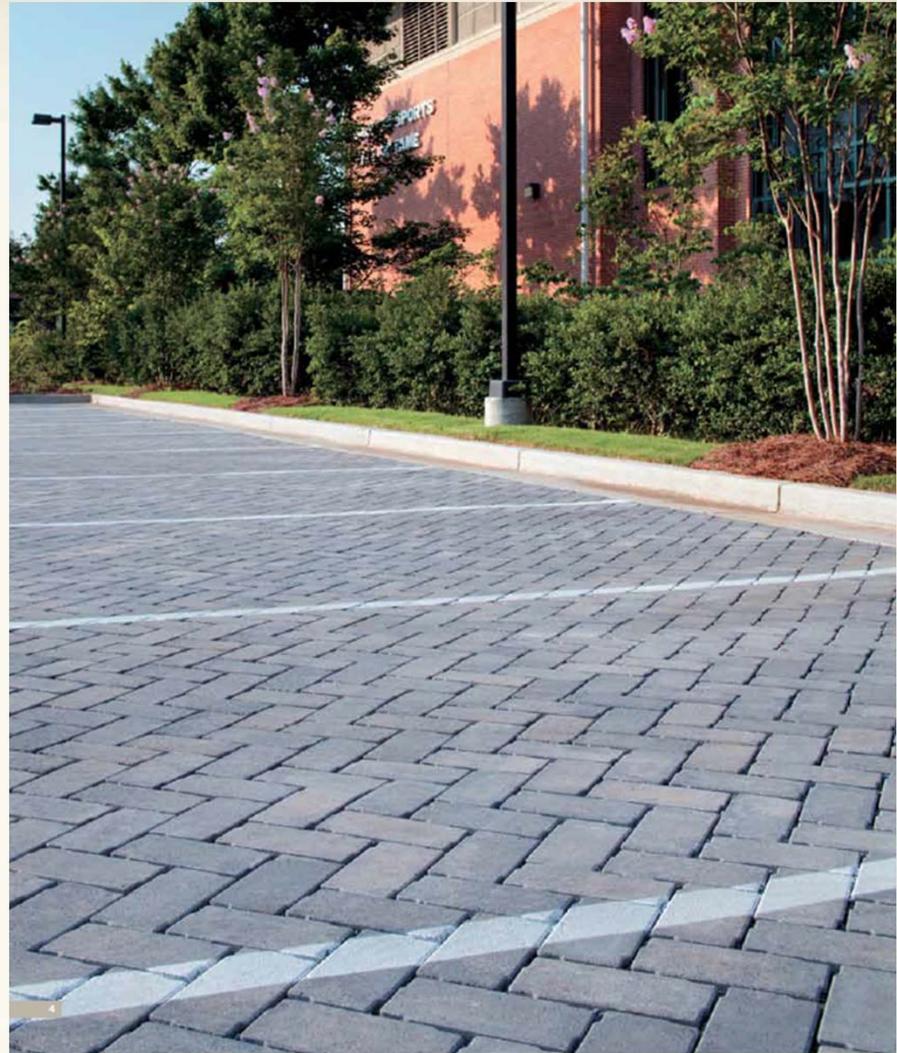
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Benefits of Picp

- **NPDES Phase 2 Compliance**

*National Pollutant Discharge
Elimination System*

- **PICPs are approved by the EPA as a
post-structural Best Management
Practice (BMP)**



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Recharges Groundwater Through Infiltration

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Preserves Existing Systems

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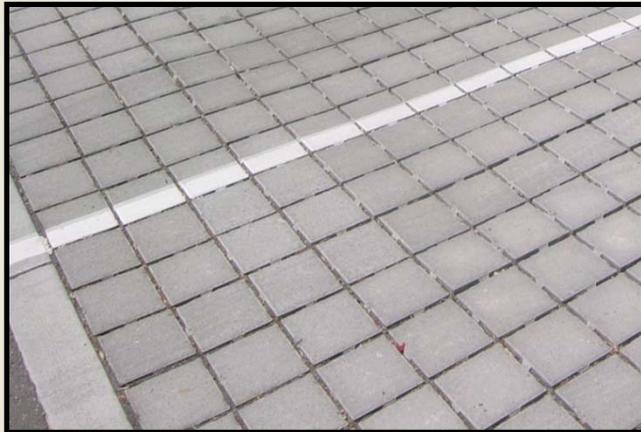
Eliminate Retention & Detention Facilities

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PICP contributes to LEED Credits

- Decrease pollution through sustainable sites (SS)
- Increase building water use efficiency (WE)
- Reduce energy and atmospheric pollutants (MR)
- Conserve materials and resources (MR)
- Improve air quality (EQ)
- Offer innovative ideas and designs (ID)



LEED Potential

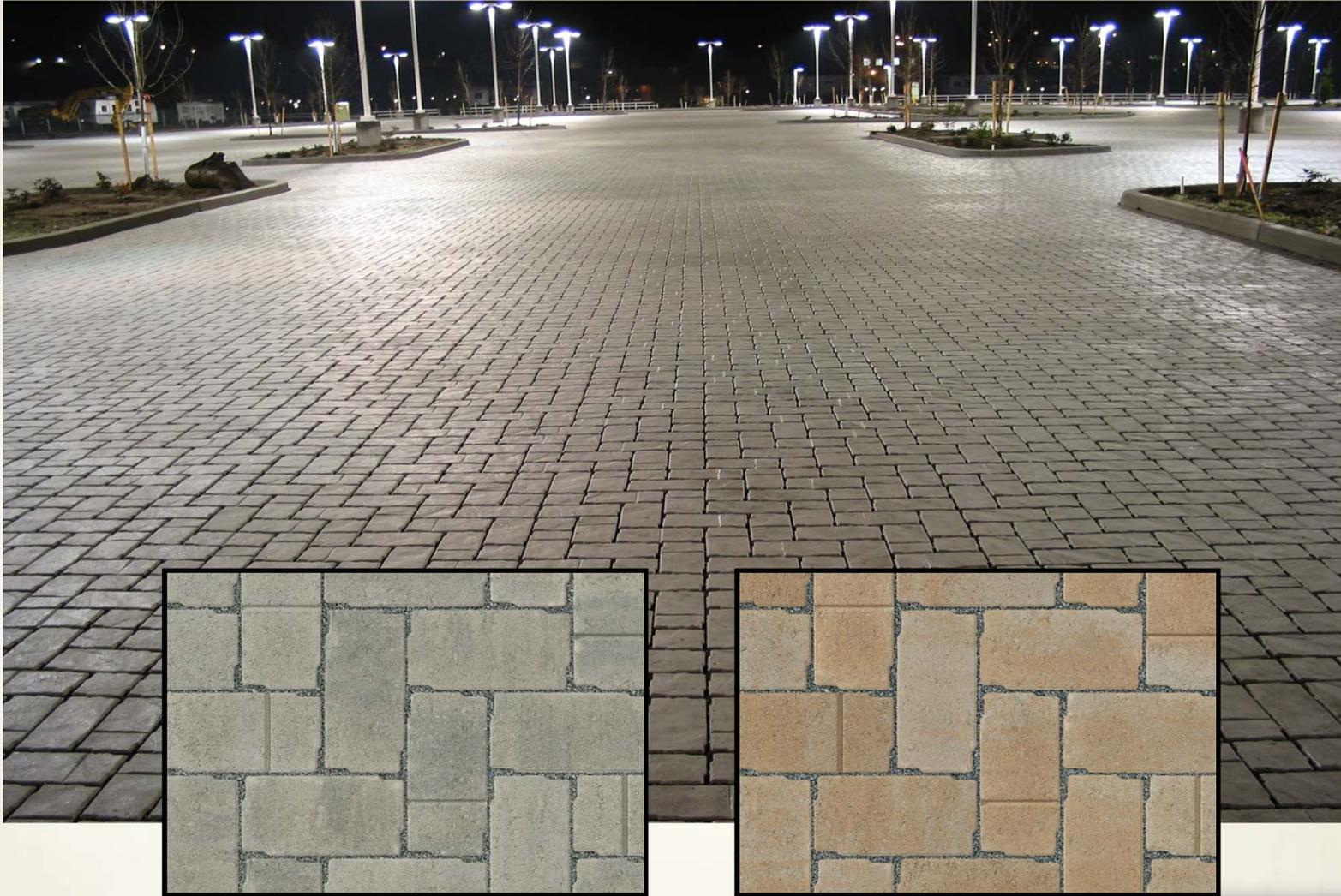
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Solar Power

Sustainable Design

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SRI- Security- Lighting

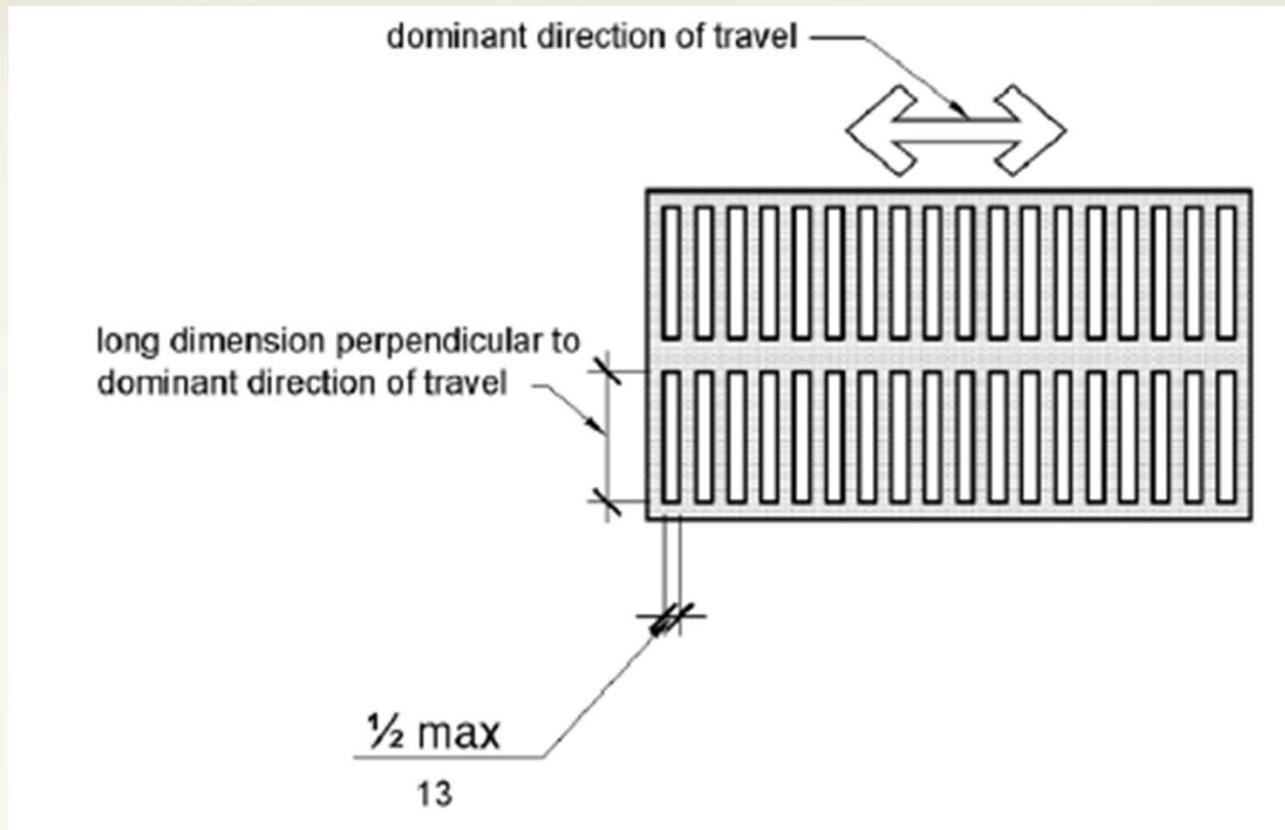
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Meets ADA Requirements

Pedestrian Friendly/ADA

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302.3 Openings. Openings in floor or ground surfaces shall not allow the passage of a sphere more than 1/2 inch (13mm) diameter.

ADA COMPLIANCE - OPENINGS

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1100 gals/min

Infiltration Rates

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Heavy Axle Loads

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1-2 times per year

Post-structural Inspection Report

Normal Maintenance

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Remediation

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Estimated 15-20 year cycles



Vacuum Type Sweeper

Remedial Maintenance

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Morton Arboretum Workshop
Dr. Wm. Hunt-NCSU 2009



Sediment travel limited to 1"-1 1/2"

Schmutzdecke

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Forensic Documentation



CA-16

Seven Years



CA-7

Sedimentation Travel

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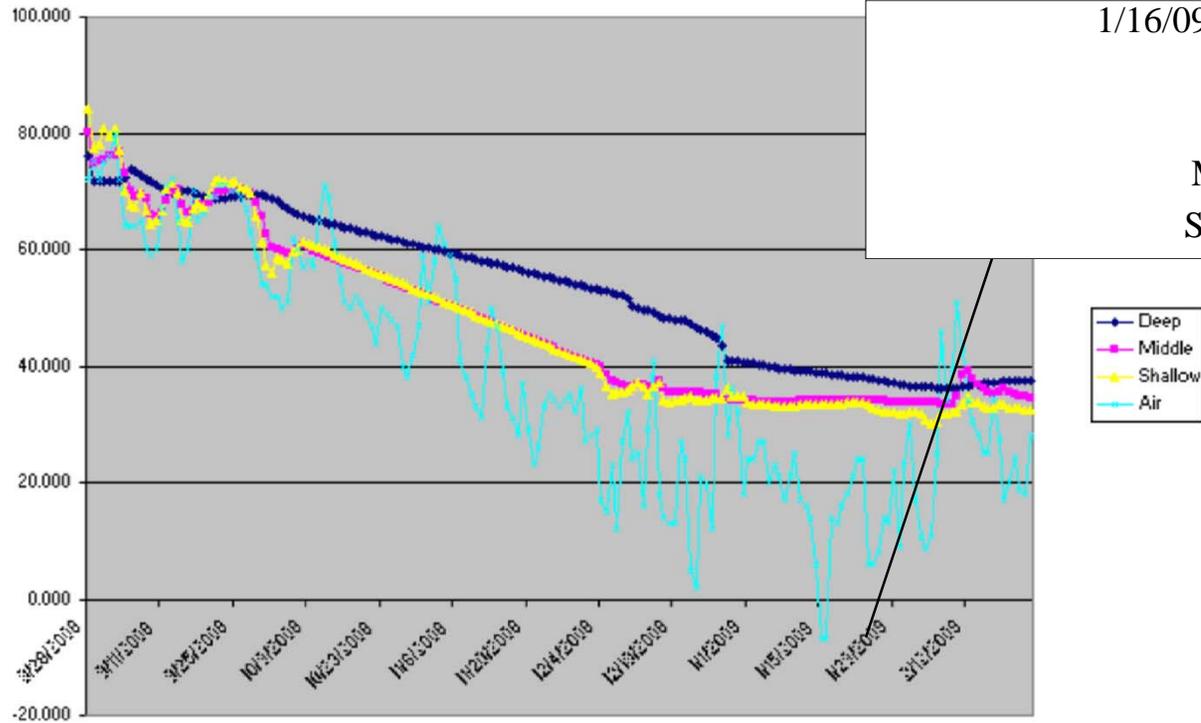
EPA Primary Research Questions

- Runoff Volume and Rate
- Surface Water Quality
- Ground Water Quality
- Freeze/Thaw Performance

Maxwell Street Permeable Market Plaza (CDOT)

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Temperature Data (Degrees Farenheit) from Probes at Location 1239946



1/16/09 (temp in degrees)

Air: -7.0

Deep: 38.6

Middle: 34.1

Shallow: 33.4

* Sept 2008- Feb 2009

Market Plaza: Preliminary Monitoring Results

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University of Tennessee

Knoxville Church Parking Plaza Dr. Tyner

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Dr. Heather Brown – MTSU
City of Murfreesboro

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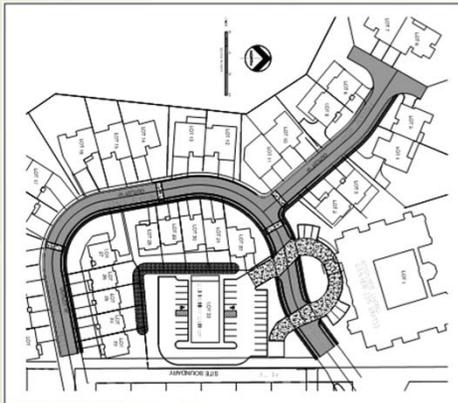
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- Initial Capitalization
- Maintenance Costs
- Design Life
- Infrastructure
- Water Quality
- Environmental Impact
- Quality of life

ROI

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Autumn Trails Subdivision – Pavement Cost

Moline, Illinois

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Item	PICP	Concrete	Asphalt
Paving/sf	\$2.25	\$8.00	\$3.00
Excavating/sf	\$1.00	\$1.00	\$1.00
Stone/sf	\$2.00	\$1.50	\$1.50
Installation/sf	\$4.00	(in paving cost)	\$1.50
Curbs	\$1.50	\$1.50	\$1.50
Maintenance	\$0.20	0	Not known
Replacement	None	None	Every 12 years
Detention/Retention required	None	Yes	Yes
Storm Sewer System/sf paving	None	\$3.00	\$3.00
Total/sf	\$10.95	\$14.00	\$11.50
Total/linear foot – municipal street	\$171	\$218	\$179
Total/linear ft for 30 ft wide street	\$230	\$280	\$230

Autumn Trails Subdivision – Pavement/SWM Costs

What is the True Economics?

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Making a Difference

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Indian Island - Eco Dublin by Flintstone

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8 acres Permeable Pavement Largest Installation in United States

McCord Toyota



A&M Dental Roswell, GA



Project Details:

PICP Installed: Eco-Dublin

Installation Method: Mechanical

Installed Cost: \$5.50/sf

PICP Installer: Flintstone Paving

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Toco Hills Library Decatur, GA



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Sharpshooters USA Roswell, GA



Project Details:

PICP Installed: Drainstone PICP

Installation Method: Mechanical

Installed Cost: \$5.10/sf

PICP Installer: Flintstone Paving

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Kennesaw Landing Kennesaw, GA



Project Details:

PICP Installed: Drainstone PICP

Installation Method: Mechanical

Installed Cost: \$5.00/sf

PICP Installer: Flintstone Paving

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This concludes the presentation!
What questions do you have?

For more information contact:

Brent Davis

770-695-3951