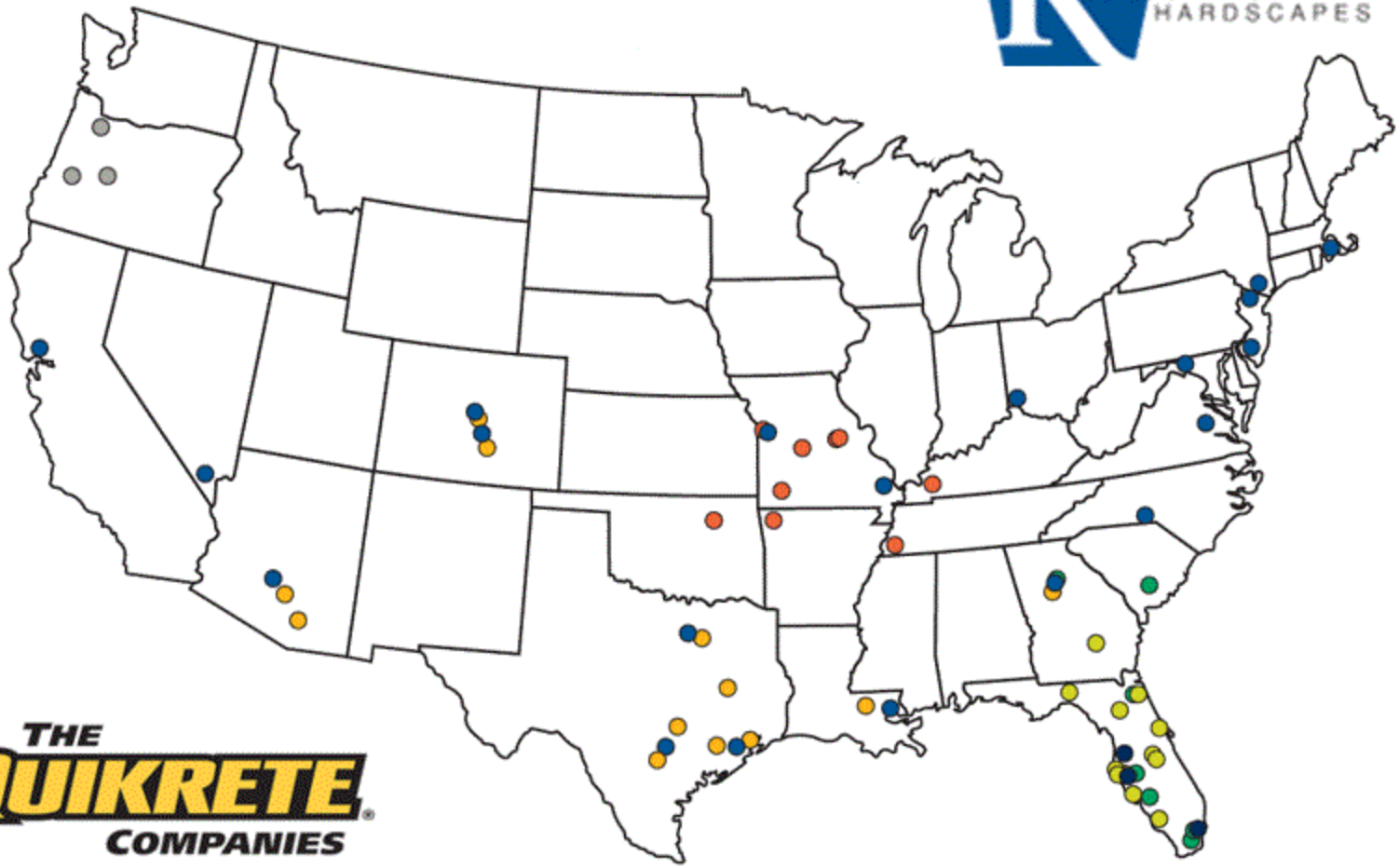
KEYSTONE® HARDSCAPES

Grow Green
Permeable Paver Installation & Maintenance

November 17, 2020

Presented By
Dave Hasness, P.E.

KEYSTONE® HARDSCAPES

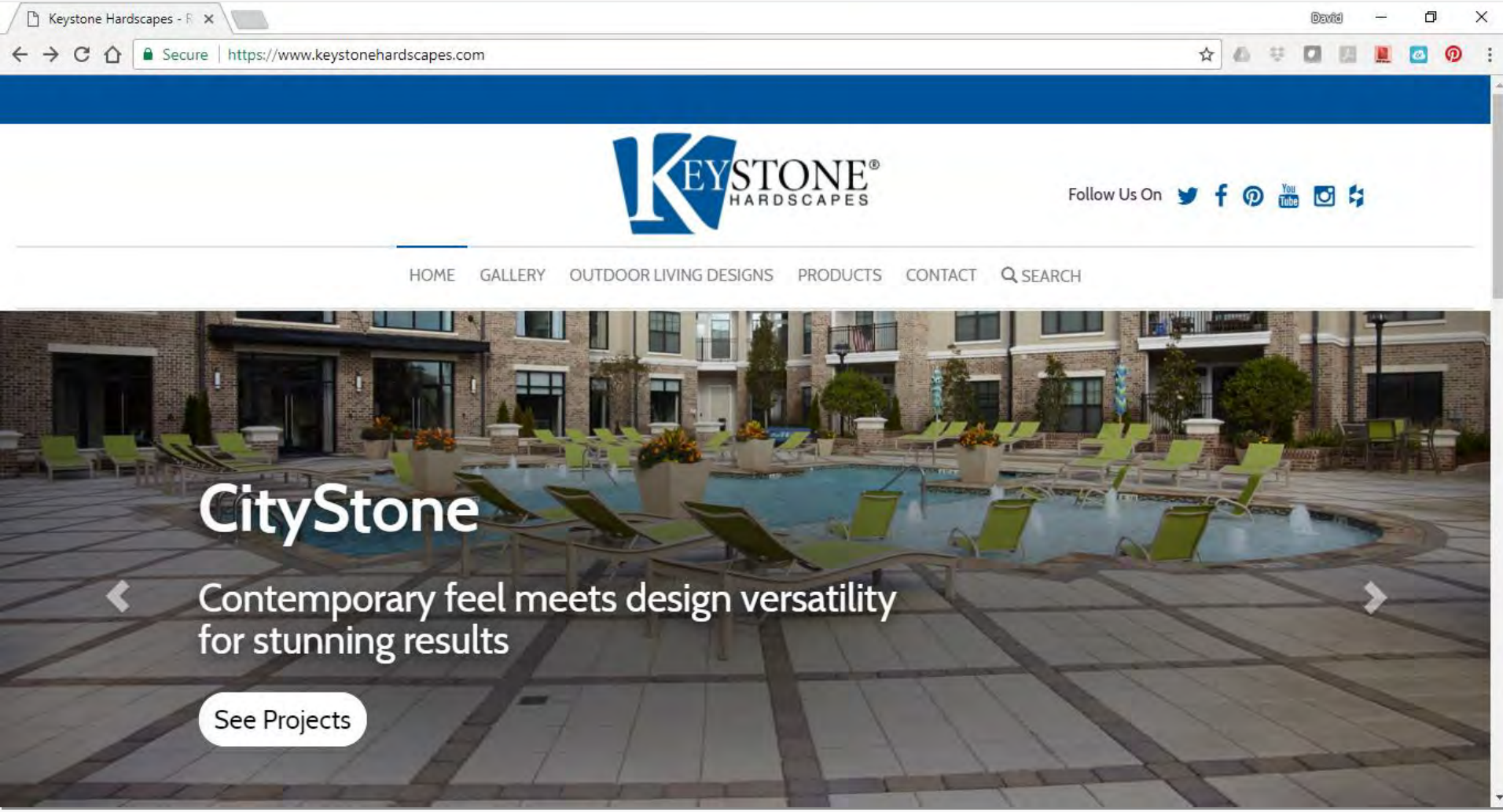


THE QUIKRETE® COMPANIES

- KEYSTONE HARDSCAPES PLANT
- BEST BLOCK PLANT
- TREMRON PLANT
- WILLAMETTE GRAYSTONE PLANT
- FLAGSTONE PAVERS PLANT
- MIDWEST BLOCK & BRICK PLANT
- ARGOS PLANT

www.keystonehardscapes.com

THE QUIKRETE COMPANIES | QUIKRETE CEMENT & CONCRETE PRODUCTS | PAVESTONE | CUSTOM | CONTECH ENGINEERED SOLUTIONS | Rinker MATERIALS | SPEC MIX



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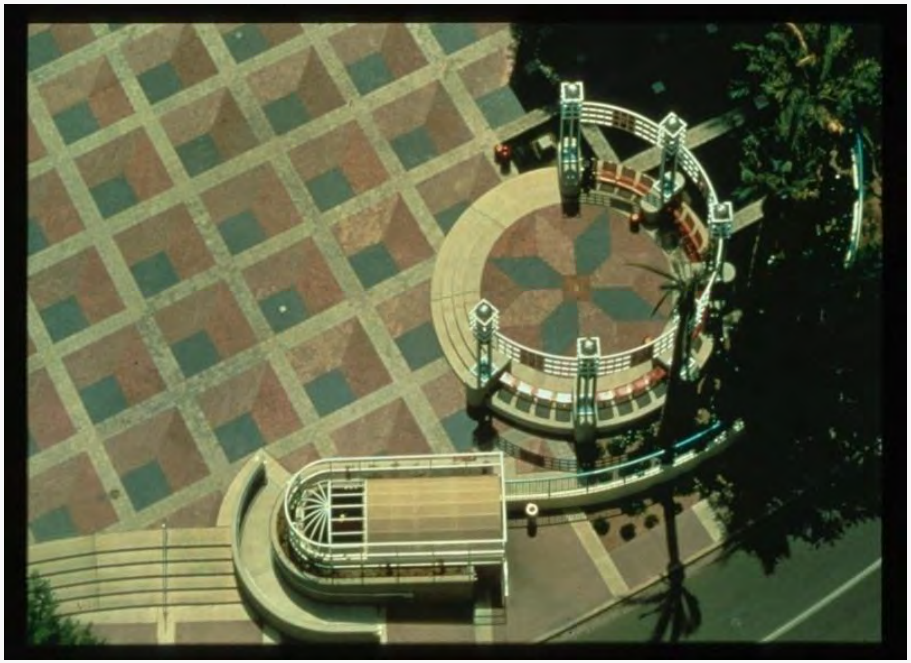
Interlocking Concrete Pavement (ICP)

Segmental Retaining Walls (SRW)



Permeable Interlocking Concrete Pavement

(PICP)


They paved paradise and put up a parking lot . . .
Joni Mitchell

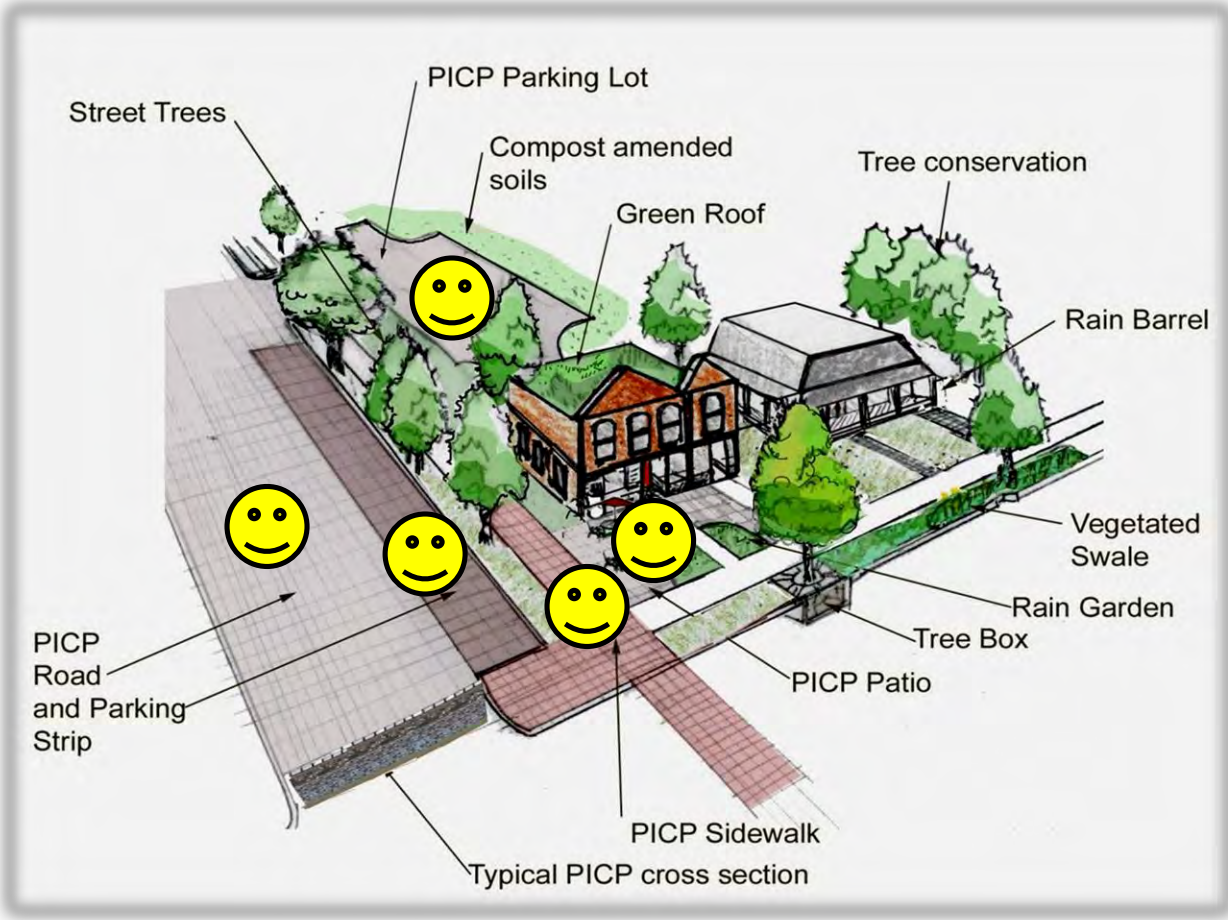
Traditional

Design:

A Shift in Thinking:
Low Impact Design (LID)

The 3 D's Paradigm

- **D**isconnect
- **D**istribute
- **D**ecentralize



Tech Spec 18

icpi
Interlocking Concrete Pavement Institute®

Construction of Permeable Interlocking Concrete Pavement Systems

INTRODUCTION

Permeable interlocking concrete pavement (PICP) is recognized by federal and state stormwater and transportation agencies as a Best Management Practice (BMP) and Low Impact Development (LID) tool to reduce runoff and water pollution. In addition, PICP offers unique design opportunities for addressing combined sewer overflows with green alleys and streets, as well as use in parking lot and pedestrian surfaces. Traditional stormwater management solutions focus on collecting, concentrating and centralizing the disposal of stormwater. As a key BMP and LID tool, PICP helps disconnect, decentralize and more widely distribute runoff through infiltration, detention, filtering and treatment.

The Interlocking Concrete Pavement Institute (ICPI) provides a comprehensive 92-page manual entitled *Permeable*

techniques outlined in the manual, as well as further guidance on best construction practices. This bulletin is intended for contractors and for project inspectors.

Figure 1 illustrates a typical PICP cross-section with the individual components defined below.

Concrete pavers—Solid concrete pavers with molded joints and/or openings that create an open area across the pavement surface. Concrete pavers should conform to ASTM C 936 (ASTM 2012) in the U.S. or CSA A231.2 (CSA 2006) in Canada. Pavers are typically a minimum of 3 1/8 in. (80 mm) thick for vehicular areas and pedestrian areas may use 2 3/8 in. (60 mm) thick units. Pavers are manufactured in a range of shapes and colors. Filled with permeable joint material, the openings allow water from storm events to freely infiltrate through the pavement surface. Figure 2 shows several paver

Permeable Paver Shape & Thickness

Products

Eco-CityLock® 4x12 10cm

Eco-CityLock® 4x16 10cm

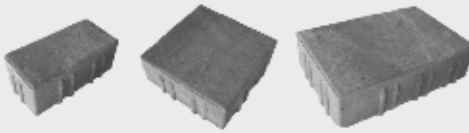
Eco-CityLock® 4x8 6cm

Eco-CityLock® 5x10 8cm

Eco-CityLock® Demi 8cm

Eco-CityLock® Herringbone 5x10 8cm

Eco-CityLock® L-10 8cm



Eco-Panorama™ Demi 8cm

PICP

Open Graded Aggregate Base Materials

ASTM #8, #9

ASTM #57

ASTM #2, #3, #4

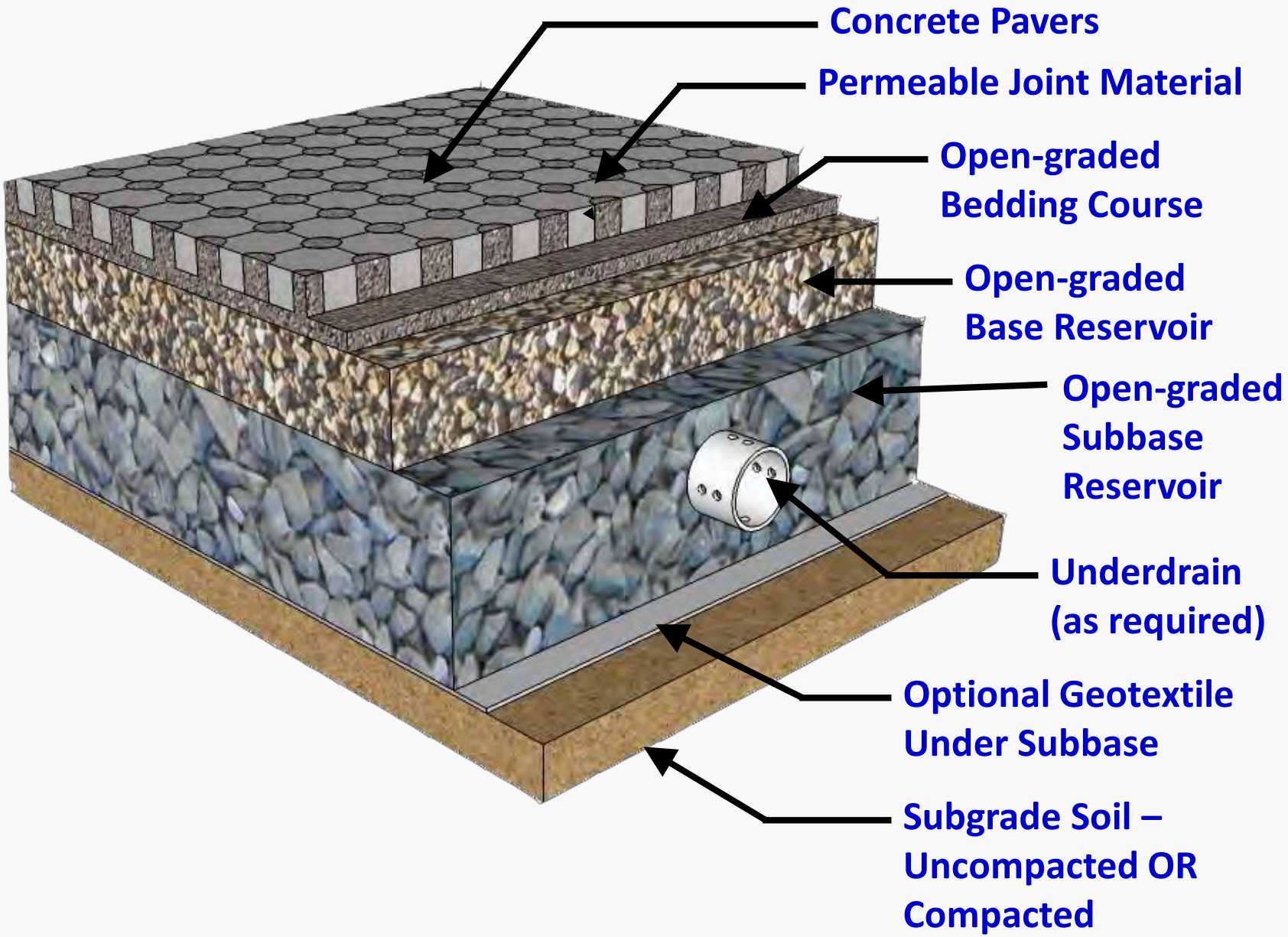
Washed - < 2% No. 200

Angular - 90% Fractured

Hard - < 40 LA Abrasion

ASTM Gradations Are Guidelines And May Be Substituted

System Components



Dell Seton Medical Center
Austin, TX

Eco-CityLock Demi 4x8, 8x8, 8x12 – $3^{1/8}$

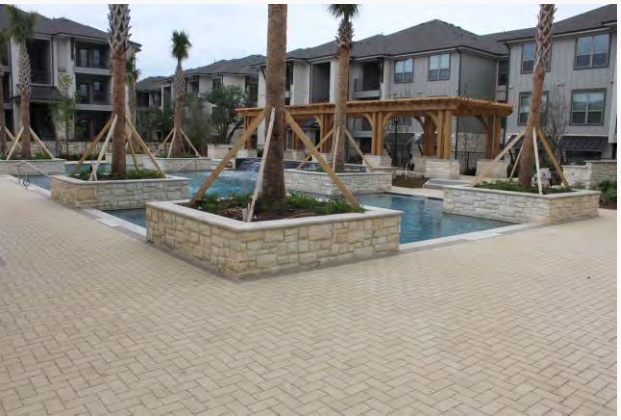
Mueller
Austin, TX

Belvedere
Austin, TX


MURFREESBORO FIRE & RESCUE
Pierce
9
LADDER CO. 9
MURFREESBORO
F.D.
MODEL
2nd FLOOR

Permeable Paver Thickness

60mm 2 3/8” **80mm 3 1/8”** **80mm-100mm 3 1/8” - 4”**



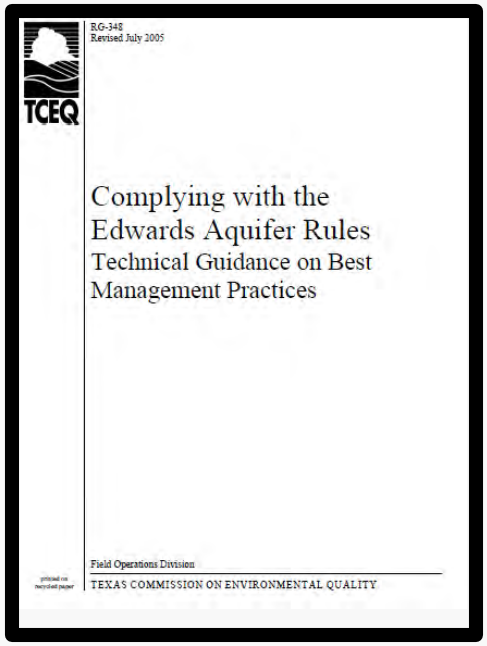
Light Duty **Medium Duty** **Heavy Duty**

TCEQ RG-348 Approval
Innovative Technology (Sections 3.2.20, 3.4.19, 3.5.23)

Addendum Issued 12/14/11 Includes Permeable Pavers

Provides the specific technical language that has been approved by the TCEQ Edwards Aquifer Protection Program. "The TSS removal of a properly constructed permeable paver pavement is 89%."

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY


RG-348
Revised July 2005

TCEQ

Complying with the
Edwards Aquifer Rules
Technical Guidance on Best
Management Practices

Field Operations Division

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

COA Environ. Criteria Manual 1.6.7

Porous pavement for pedestrian and vehicular uses counts as pervious cover when calculating the Water Quality Capture Volume outside the Barton Springs Zone.

Porous Pavement Adopted on 12/30/14 ECM 1.6.7E

- Expanded ECM to allow Water Quality credit for pedestrian and vehicular surface

- Open to <u>public and privately</u> maintained facilities such as parking lots, driveways, streets and alleys

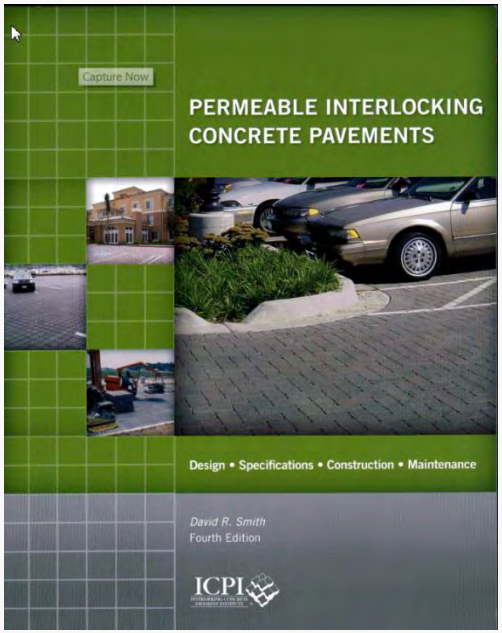
COA Land Development Code 25-8-63

Impervious Cover Calculations ***Exclude***

- **Porous pavement designed in accordance with the Environmental Criteria Manual, limited to only pedestrian walkways and multi-use trails, and located outside the Edwards Aquifer Recharge Zone.**

- **Fire lanes designed as prescribed by the Environmental Criteria Manual, that consist of interlocking pavers, and are restricted from routine vehicle access**

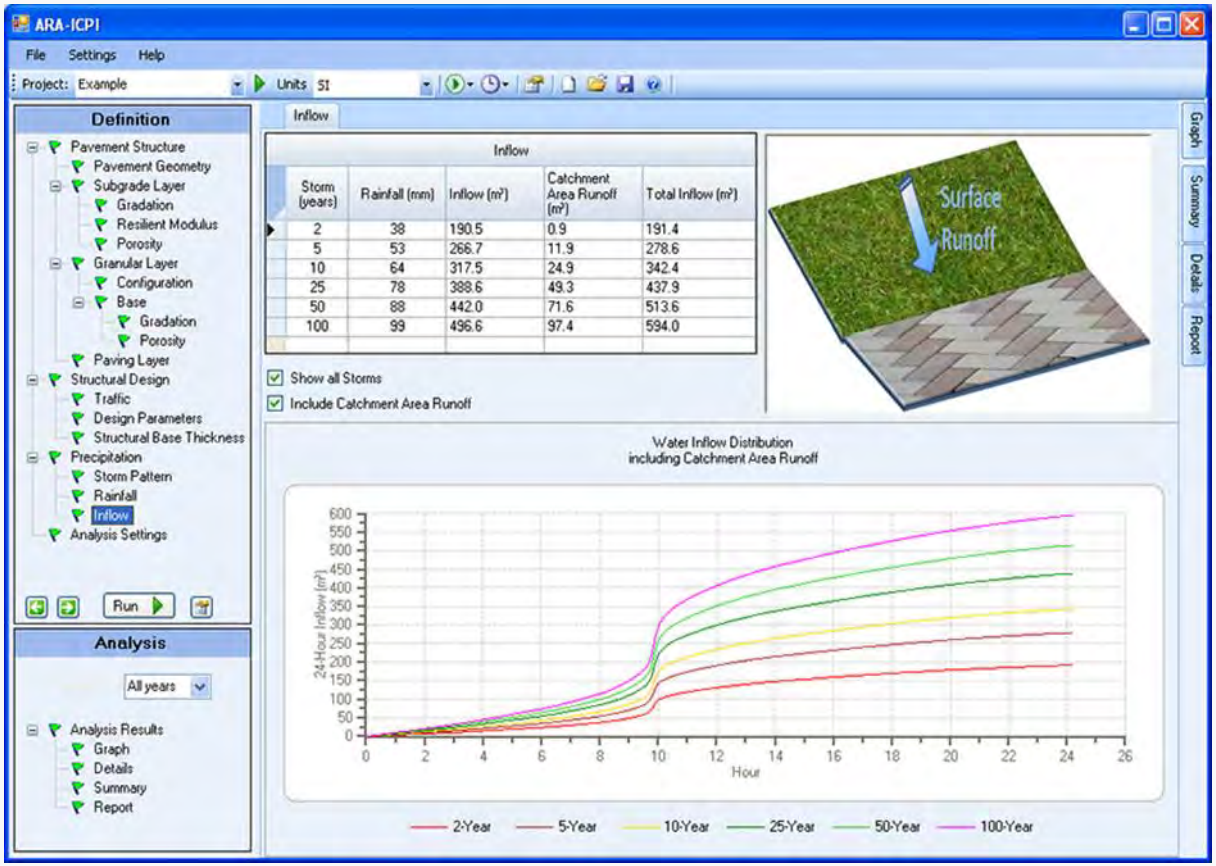
Industry Design Standard of Practices



Permeable Interlocking Concrete Pavements 5th Edition

Permeable Interlocking Concrete Pavements ASCE/T&DI/ICPI 68-18

Permeable Design Pro Engineering Software



AASHTO 1993 Guide & ASCE 68-18 Design Standard

Free Download from ICPI

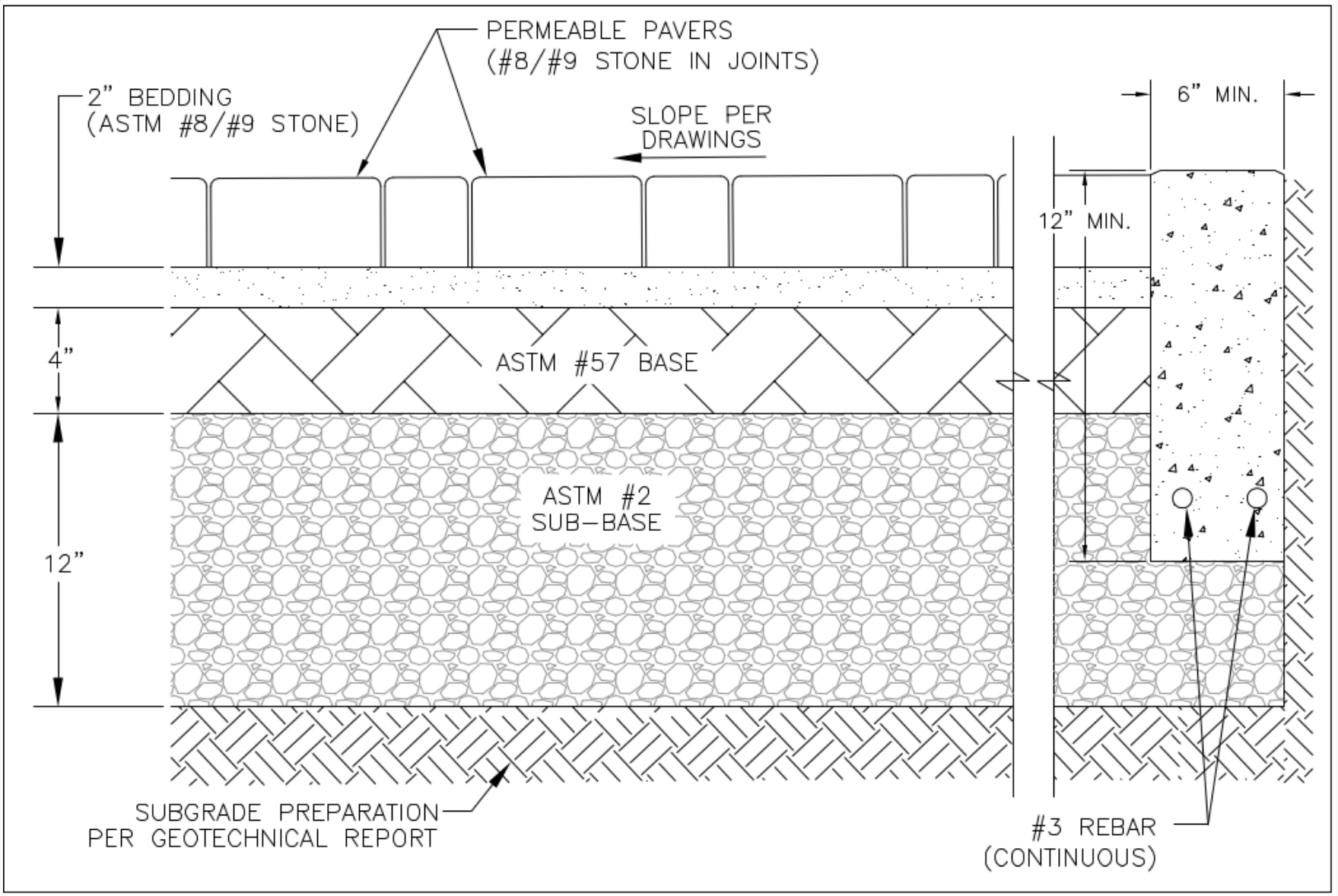
Construction / Installation Processes

- Preconstruction Meeting
- Erosion and Sediment Control Measures
- Prepare Subgrade

LID

Design:

Austin Animal Center
Austin, TX



Austin Animal Center

Geosynthetic Placement

Tech Spec 22

icpi
Interlocking Concrete Pavement Institute®

Geosynthetics for Segmental Concrete Pavements

This Tech Spec provides fundamental information on geosynthetics including a brief history, uses, and basic applications for interlocking concrete pavements (ICP) and permeable interlocking concrete pavements (PICP). While this Tech Spec provides some general guidelines on engineered applications, it is not intended to provide geosynthetic engineering design advice. While many of the general principles and applications of geosynthetics are easily understood, the field of geosynthetics and the technical information available is too voluminous for a single technical bulletin. This Tech Spec is presented as an introduction to the wide range of geosynthetic materials available, as shown in Figure 1, for readers interested in this subject and its application to segmental concrete

stabilize roadway soils and their edges. Natural fibers and fabrics were later mixed with soil to improve road quality, particularly when built on unstable soil. Such materials were also used to stabilize steep slopes and walls such as ancient ziggurats. While many of the earliest attempts to improve or reinforce soil were not recorded, there is some evidence. Some of the oldest roads in Britain utilized split logs, or a 'corduroy' road, laid over peat bogs to provide a stable platform. There is also evidence that in some cases a stabilized soil mixed with paving stones or paving blocks were placed over the corduroy road.

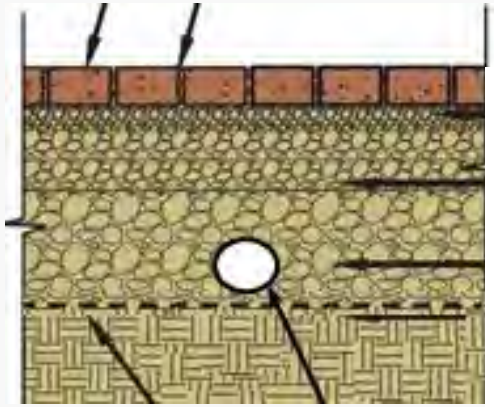
Obviously, natural materials in soils led to biodegradation from microorganisms. The advent of polymers in the mid-twentieth century provided longer lasting and more

Impermeable Liner & Geotextile Placement

Subbase Aggregate Placed (ASTM No. 2, 3, 4)

PICP Construction

Base and Subbase Compaction



ASTM #57

ASTM #2/#3/#4

ASTM #2/#3/#4

6" Lifts typical with surface tolerance +/- 2.5" over 10 ft

2 Passes Vibratory 10ton

2 Passes Static 10ton

ASTM #57

4" Lifts typical with surface tolerance +/- 0.75" over 10 ft

2 Passes Vibratory 10ton

2 Passes Static 10ton

To confirm compaction, use a light-weight deflectometer or a nuclear density gauge in backscatter mode

Placing Base on Subbase

Spreading the Base

Compacting the Base

Edge Restraint installed

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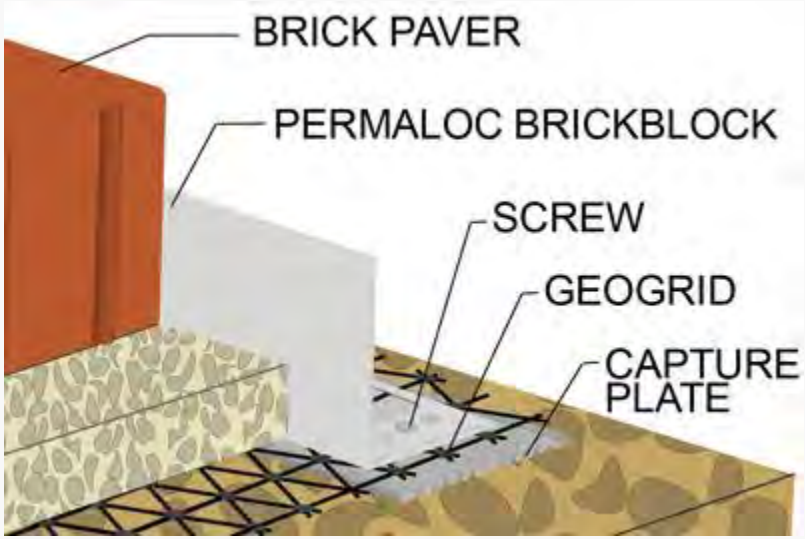
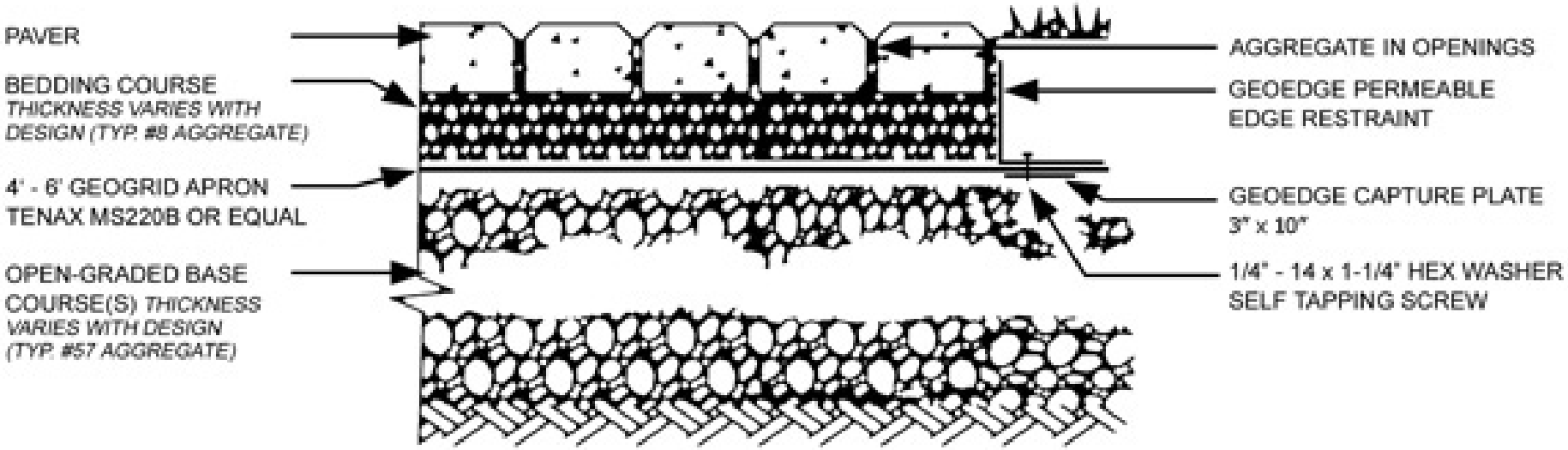
Table 1. Recommended edge restraints for PICP

Edge Restraint Type	Pedestrian Only	Residential Driveway	Parking lot or street
Cast-in-place concrete curb	Yes	Yes	Yes
Precast concrete curb	Yes	Yes	Yes
Cut stone curb	Yes	Yes	Yes
Compacted, dense-graded berms around PICP base perimeter with spiked metal or plastic edging to restrain Pavers	Yes	Yes	No


BRICK PAVER
PERMALOC BRICKBLOCK
SCREW
GEOGRID
CAPTURE PLATE


PAVER
BEDDING COURSE
THICKNESS VARIES WITH DESIGN (TYP. #8 AGGREGATE)
4' - 6' GEOGRID APRON
TENAX MS220B OR EQUAL
OPEN-GRADED BASE COURSE(S) THICKNESS VARIES WITH DESIGN (TYP. #57 AGGREGATE)
AGGREGATE IN OPENINGS
GEOEDGE PERMEABLE EDGE RESTRAINT
GEOEDGE CAPTURE PLATE 3" x 10"
1/4" - 14 x 1-1/4" HEX WASHER SELF TAPPING SCREW

Place Bedding on Base

Place Bedding and Screed to 1-1/2" to 2" thick

Hand place or Machine place Permeable Pavers

Placing Joint Aggregate and Compacting

PICP Construction

ASTM #8/#9 Vibration Into Joints

Plate Compactor Minimum 5000 lbf

Minimum 2 Repetitive Stoning / Sweeping / Vibrating Passes Prior To Continual Trafficking

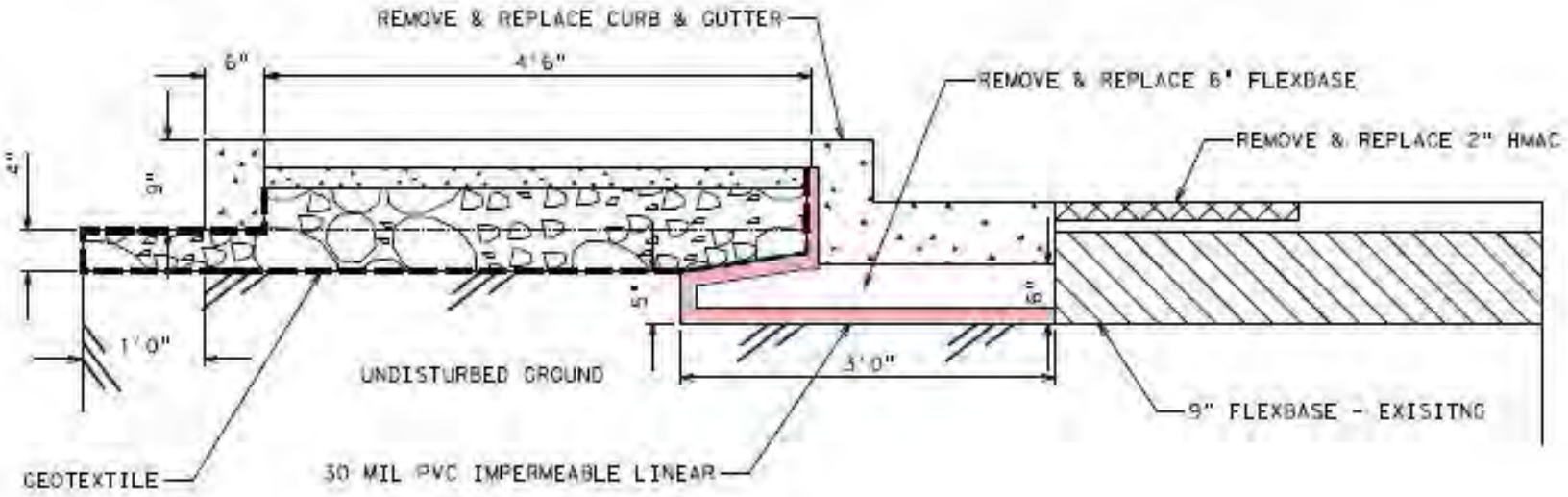
PICP Construction

Inspection during construction

PICP

Inspection during construction

PICP Construction



Green Infrastructure

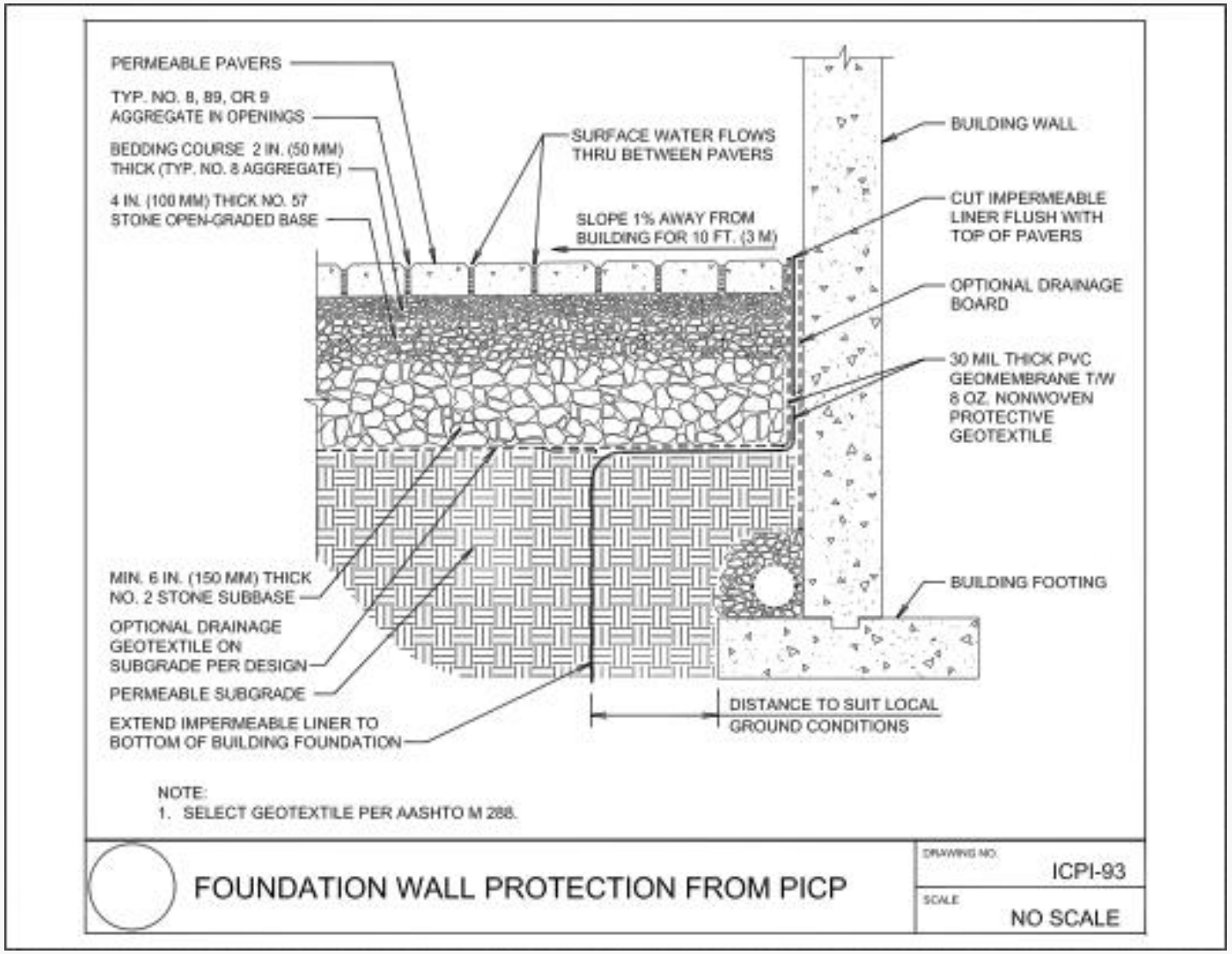
Chicago, IL & Portland, OR (Depaving)

- Reduced combined sewer overflows
- Less expensive than separating storm & sanitary sewers
- Supports tree growth
- Improves neighborhood character

Images courtesy of Chicago DOT

ICPI
INTERLOCKING CONCRETE PAVEMENT INSTITUTE

PICP Construction



Alleyway Construction

PICP Construction

Return 3 to 6 months after completion of construction to inspect pavement and refill joints with aggregate

PICP

Routine Maintenance

Periodic Inspection -

Testing ASTM C1781

Designation: C1781/C1781M – 14

Standard Test Method for
Surface Infiltration Rate of Permeable Unit Pavement Systems[1]

8. Procedure

8.1 *Infiltration Ring Installation*—Clean the pavement surface by only sweeping off trash, debris, and other non-seated material.

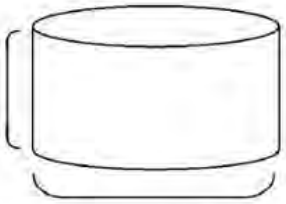


FIG. 1 Dimensions of Infiltration Ring

nfiltration Rate of Eco-CityLock Herringbone 5x10 Permeable Paver				
Test No.	**Head Water (inches)**	**Water Infiltrated (pounds)**	**Elapsed Time (seconds)**	**Infiltration Rate (inches per hour)**
1	0.4 - 0.6	40.0	40	881
2	0.4 - 0.6	40.0	39	904
3	0.4 - 0.6	40.0	38.6	913
Average	0.4 - 0.6	40.0	**39.2**	**899**

CONSTRUCTION TESTING SCIENCES

Construction Testing Sciences
2978 Congressman Ln. Dallas, TX 75220
Phone: 214.703.8911
www.ctsciences.com

Client: Pavestone, LLC
Project: Eco-CityLock 5x10 80 mm #324
Project No.: 20-00365-900-01

Report No.: 14306
Date of Service: 10/8/2020
Report Date: 10/27/2020

Respectfully submitted,

Kenneth L. Bownds, P.E.
Supervising Engineer

STATE OF TEXAS
KENNETH L. BOWNDS
76345
LICENSED
PROFESSIONAL ENGINEER

Jack Gary
General Manager

Tech Spec 23

icpi
Interlocking Concrete Pavement Institute®

Maintenance Guide for Permeable Interlocking Concrete Pavements

Introduction

Permeable interlocking concrete pavements (PICP) are a proven method for reducing stormwater runoff and pollutants while supporting pedestrian and vehicular traffic. Many laboratory and in-situ research projects over the past two decades by universities, government stormwater agencies, and industry have demonstrated significant runoff and pollutant reductions with cost-saving benefits. The U.S. Federal Highway Administration **www.fhwa.dot.gov/pavement/concrete/pubs/hif15006.pdf** has published information supporting PICP use in walkways, plazas, driveways, parking lots, alleys and streets.

Like all stormwater control measures, PICP requires maintenance as it traps sediment on its surface not unlike an air conditioning filter. Larger particles are initially trapped while allowing water to pass. Some enter the jointing stone and are trapped there. The jointing stone with larger particles eventually captures smaller particles and this decreases the infiltration rate over time. While still infiltrating water, many smaller particles are trapped within the surface and interior joints. Smaller particles are trapped and eventually decrease infiltration which results in surface ponding.

ICP (ASTM E2840)	Asphalt (ASTM D6433)	Rigid Concrete (ASTM D6433)
Damaged pavers	Alligator cracking Weathering & raveling	Corner break; D cracking; Scaling, map cracking and crazing; Shrinkage cracks; Spalling, corner /edge
Depressions	Depressions	
Edge restraint	Edge cracking; Lane/shoulder drop off	Lane/shoulder drop off
Excessive joint width	Longitudinal & transverse cracking	Divided slab
Faulting	Joint reflection cracking Slippage cracking	Faulting
Heave	Bumps and sags; Swell	Punchout
Horizontal creep	Corrugation; Shoving	
Joint sand loss/pumping	Bleeding	Joint seal damage / Pumping
Missing pavers	Potholes	Popouts
Patching	Patching & utility cut patching	Patching, large & small, utility cuts
Rutting	Rutting	Linear cracking
	Polished aggregate	Polished aggregate
	Railroad crossing	Railroad crossing

LID Design:

How's that

working out?

Brazos Street
Austin, TX

PICP - Routine Maintenance

Cleaning Small Pedestrian Areas and Driveways

- ***Hand-held Bristle Broom***
- ***Leaf Blower***
- ***Rotary Brush with Plastic Bristles***
- ***Wet/Dry Shop Vacuum or Walk-behind vacuum***
- ***Power Washer***

PICP - Routine Maintenance

<u>Cleaning Large PICP Areas</u>

- ***Street Sweeper***
- ***Regenerative Air Sweeper***


REGENERATIVE AIR SYSTEMS
TYMCO
WACO, TEXAS
600
AIR SWEEPER
REGENERATIVE AIR SYSTEMS
TYMCO
600
AIR SWEEPER

PICP

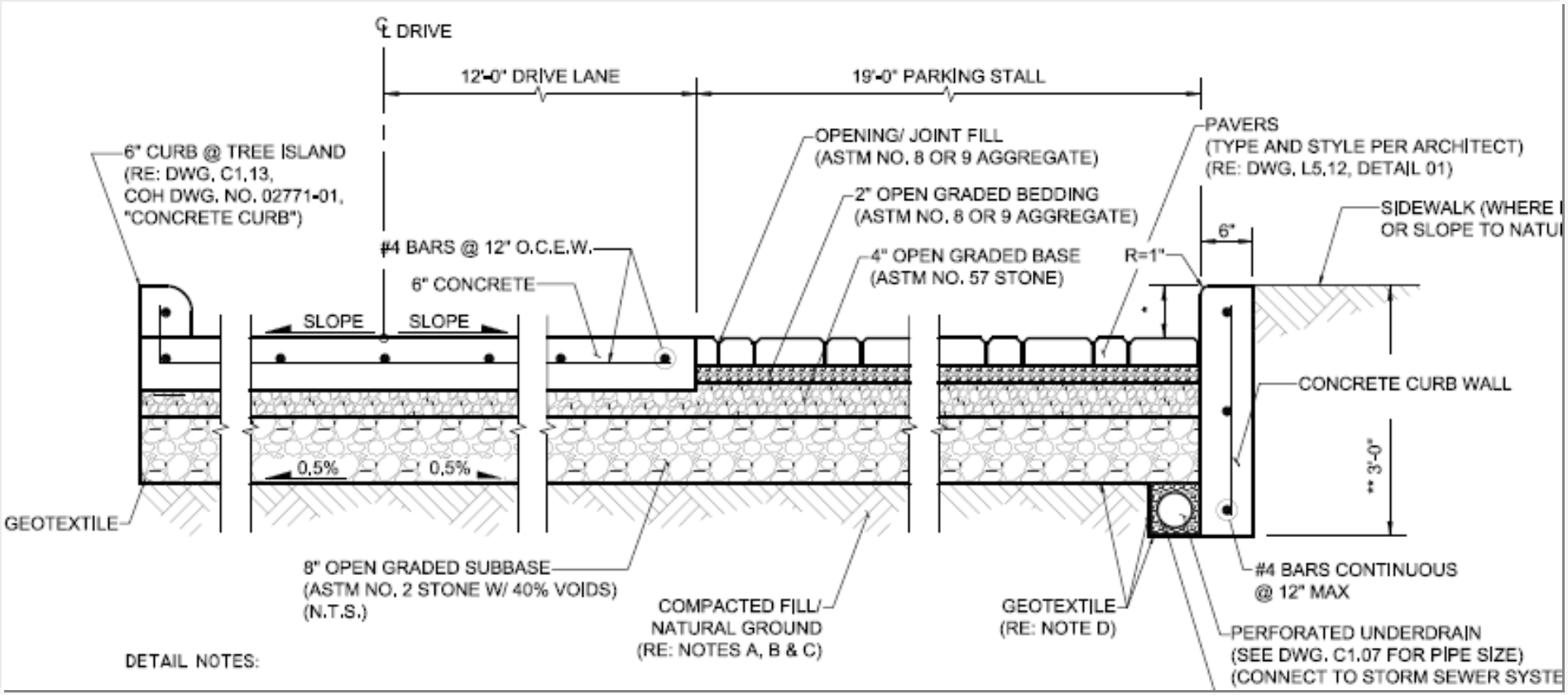
Routine Maintenance

Sweeping / Vacuuming Intervals

Recommended Minimum 1 - 2x Year

O&M Cost Estimated To Be ≈ $ .02 - .05 / sf

Gragg Park Complex - Houston, TX

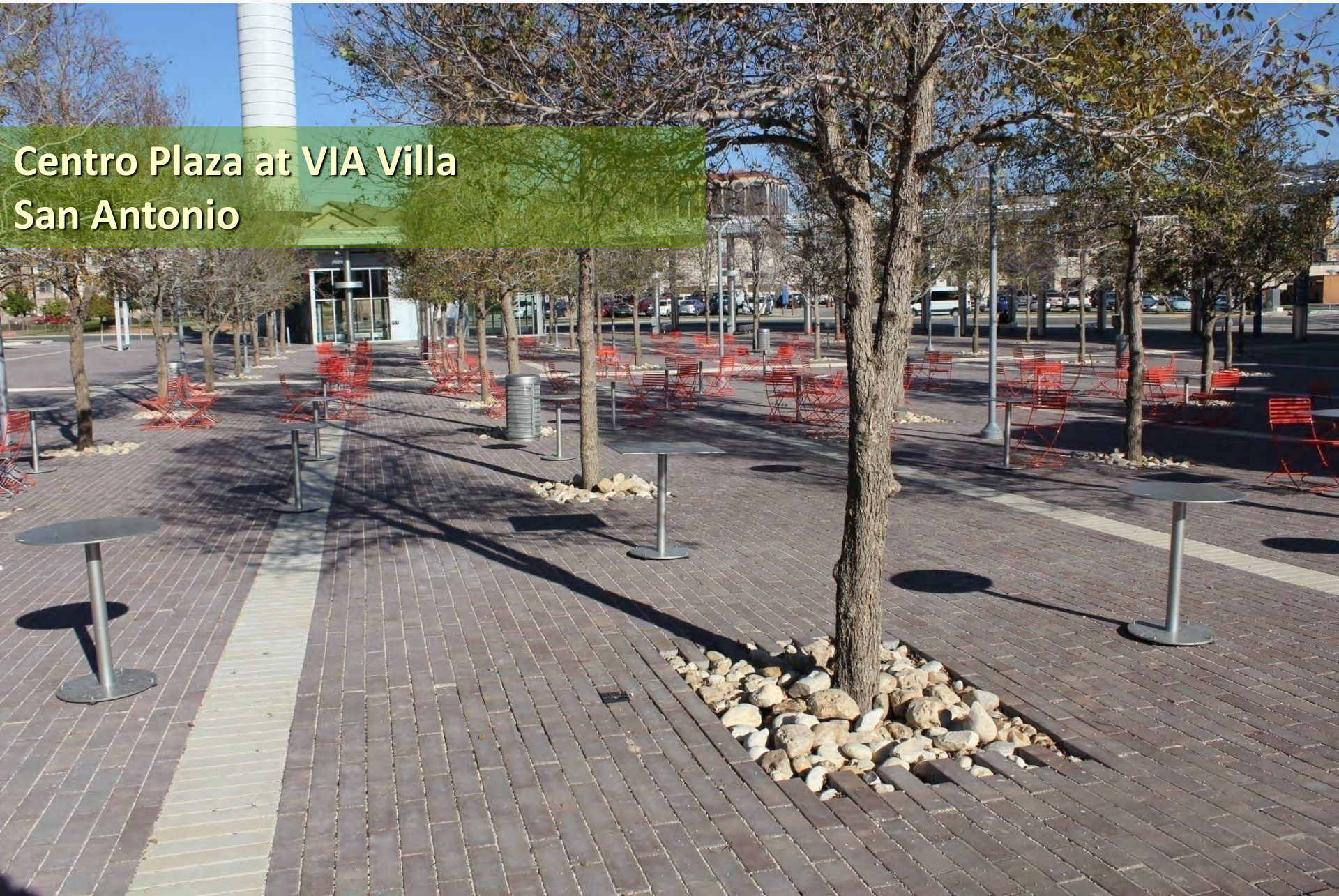


Gragg Park Complex - Houston, TX

Iberville Street
New Orleans, LA

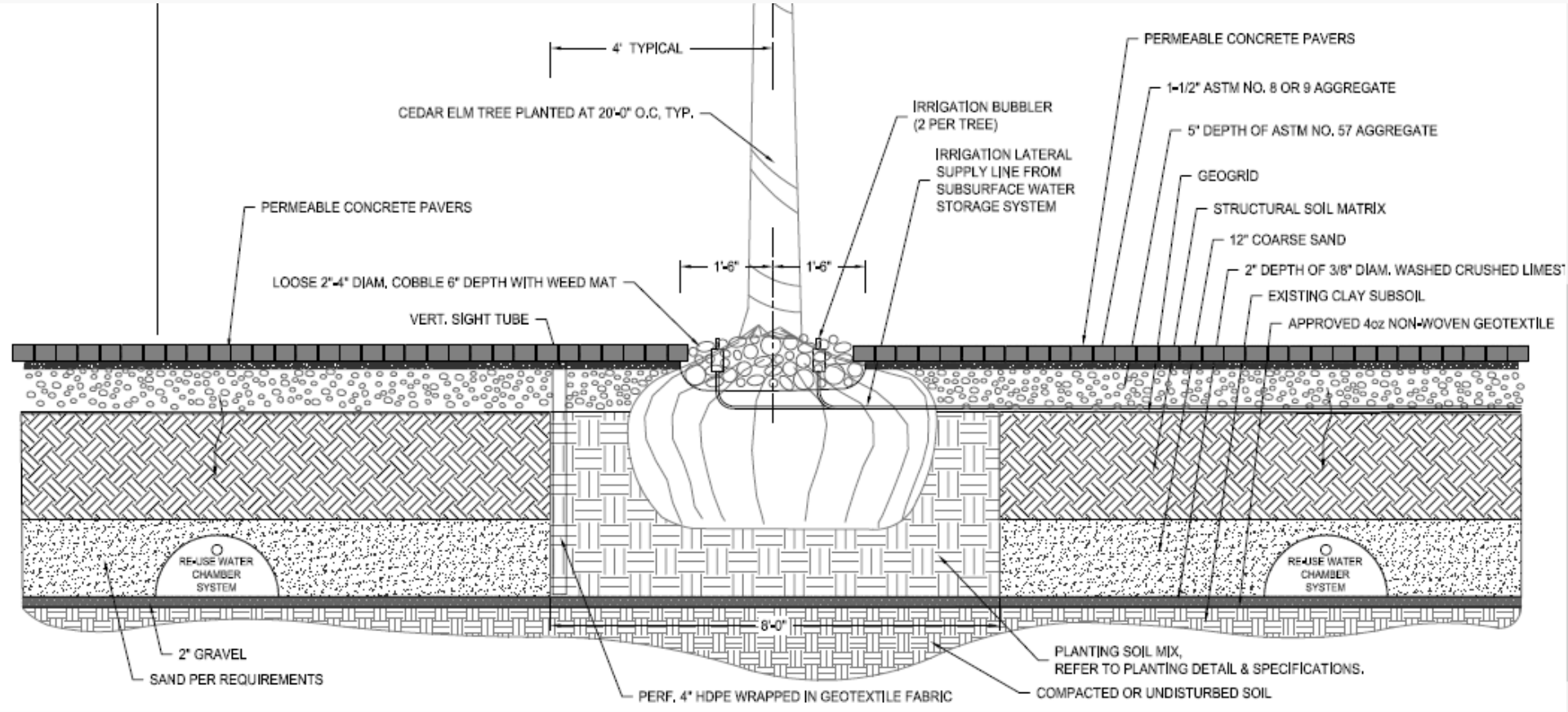

Allston Way
Berkeley, CA

Eco-CityLock Series



Eco-CityLock Series

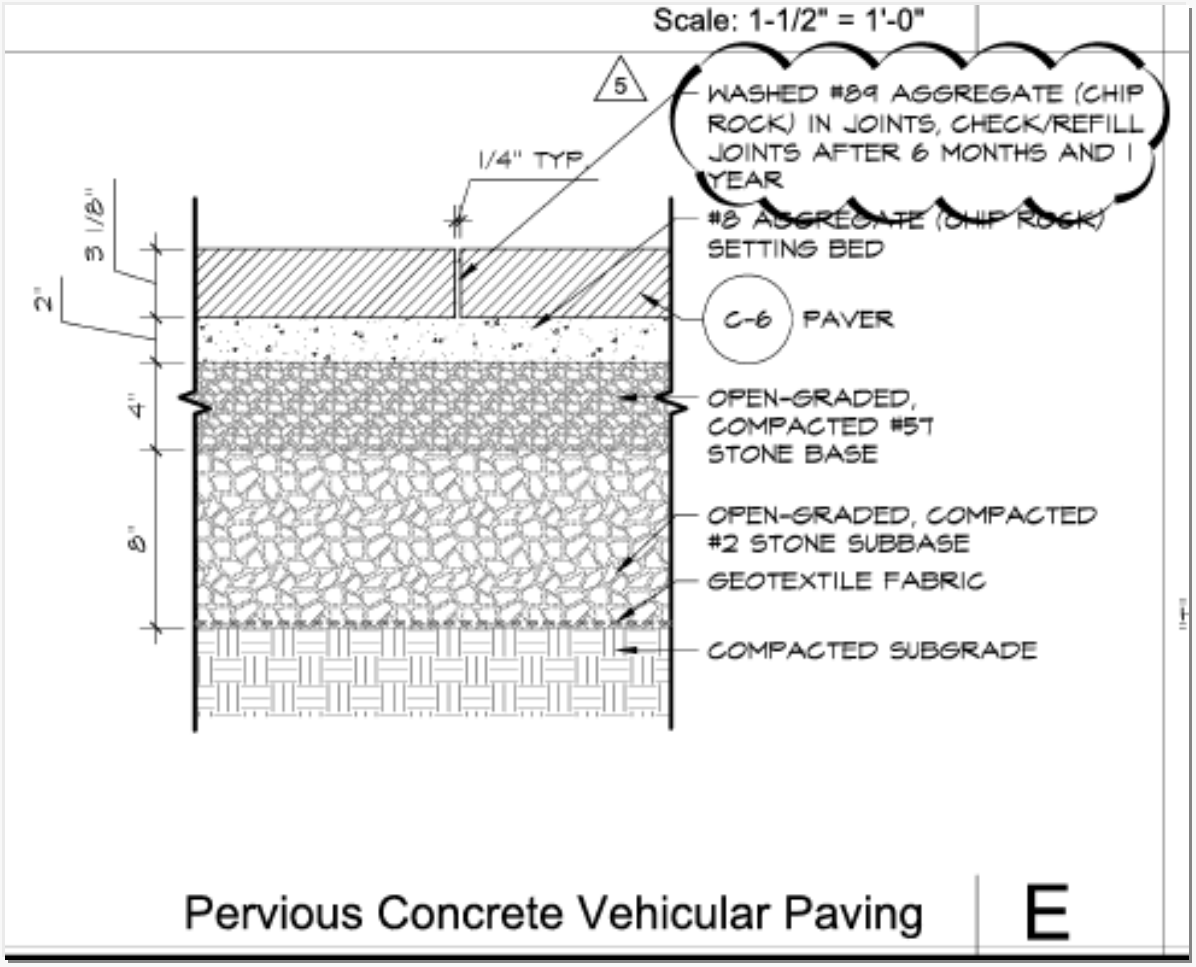
Centro Plaza at VIA Villa San Antonio



Sea Star Base - Galveston, TX

Quartex/ Shotblast/ Standard Finishes

LID Design:



Sea Star Base
Galveston, TX

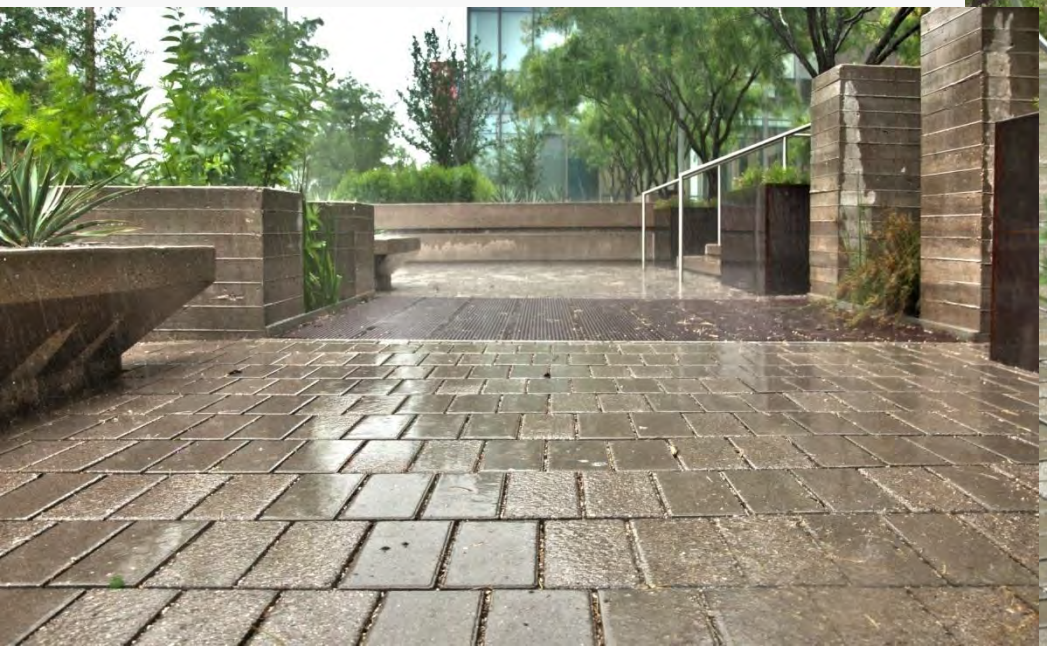
Eco-Panorama Demi
4x8, 8x8, 8x12 – 80mm

Austin, TX


St. Edwards University
Natural Sciences Center
Austin, TX


University of Texas
Liberal Arts
Austin, TX

Belo Center for New Media
University of Texas
Austin, TX



Arctex

Costs

Assumptions:

- **Paver Thickness: 3 in.**
- **Bedding Layer: 2 in.**
- **Base/subbase : 14 in.**
- **Total Area: 15,000-20,000 SF**
- **Prevailing Wages**
- **Does NOT include design and excavation**
- **$ 10 - 12/SF**

Technical Support

Specifications / Details / Marketing Materials

Facilitate Preliminary Design / Cost Estimation

Promote / Support Product Acceptance

Questions?

www.keystonehardscapes.com