Coastal
an Oldcastle® company

Permeable Interlocking Concrete Pavements for Stormwater Management

- Contents
- Regulatory Requirements
- Sustainable Design
- Structural Design
- Construction
- Maintenance
- Costs and Comparisons

Challenges Facing Port Expansion

Regulatory Requirements

- Reduce Runoff
- Treatment
- Storing and Infiltrating

Possible Solutions

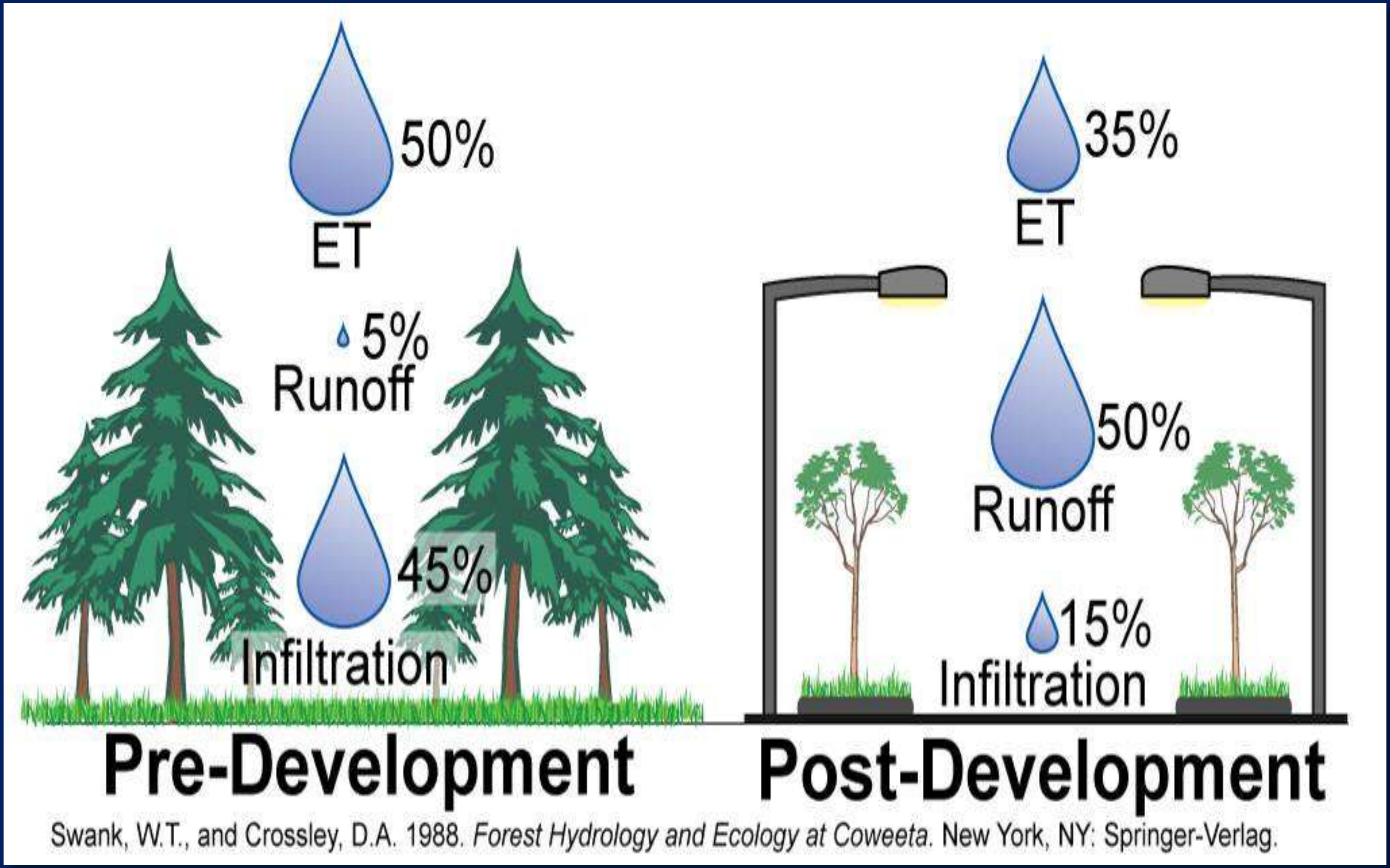
- LID
- Infiltration with BMP’s
- Design for Storage

The Result!

Loss of Land to Detention Facilities

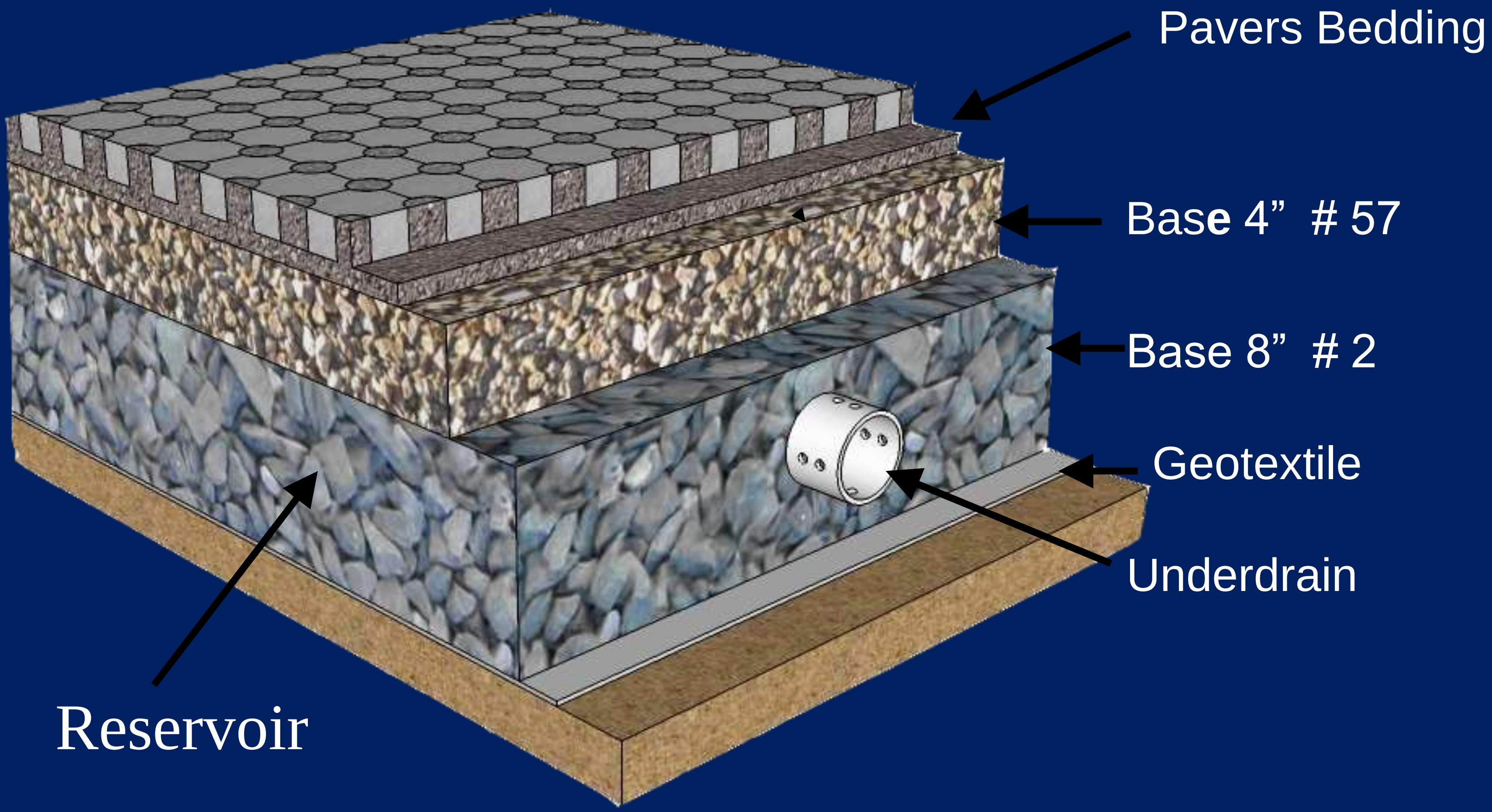
The Result!

Reducing or Eliminating Detention Ponds



Hydrology Comparison

Engineered System



Detention Under Pavement

1,000 trucks in 60 days

Water Quality

First Flush Pollutants

- Hydrocarbons
- Total Suspended Solids
- Nitrates
- Phosphates
- Heavy Metals

Conventional Pavement Promotes

Sustainable Site Pavement Systems

LID Treatment Train Approach

UCF Stormwater BMP Analysis Model

PERVIOUS PAVEMENT:	Blue Numbers =	Input data
	Red Numbers =	Answers

CONTRIBUTING WATERSHED AND PERVIOUS PAVEMENT CHARACTERISTICS:

GO TO STORMWATER TREATMENT ANALYSIS

VIEW TYPICAL PERVIOUS PAVEMENT SYSTEM SCHEMATIC

Pervious Pavement Section Storage Calculator (S')

Layer	Thickness (in):	Void Space (%):	Storage (in):
Permeable Pavers	3.13	10.00	0.313
Other Perv. Pvmt. (see note below)			
#57 rock	4.00	21.00	0.840
#89 pea rock	2.00	25.00	0.500
#4 rock	8.00	24.00	1.920
Recycled (crushed) concrete		21.00	
Bold and Gold™		9.00	
Other Sub Base (see note below)			

Contributing watershed area:	4.000	ac
Required treatment efficiency (**Nitrogen**):	-135.726	%
Required treatment efficiency (**Phosphorus**):	56.720	%
Storage provided in specified pervious pavement system:	3.573	in
Area of the pervious pavement system:	4.000	ac
Provided retention over the contributing watershed area:	3.573	in
Provided treatment efficiency (**Nitrogen**):	96.811	%
Provided treatment efficiency (**Phosphorus**):	96.811	%
Remaining treatment efficiency needed (**Nitrogen**):	0.000	%
Remaining treatment efficiency needed (**Phosphorus**):	0.000	%
Remaining retention depth needed if retention:	0.000	in

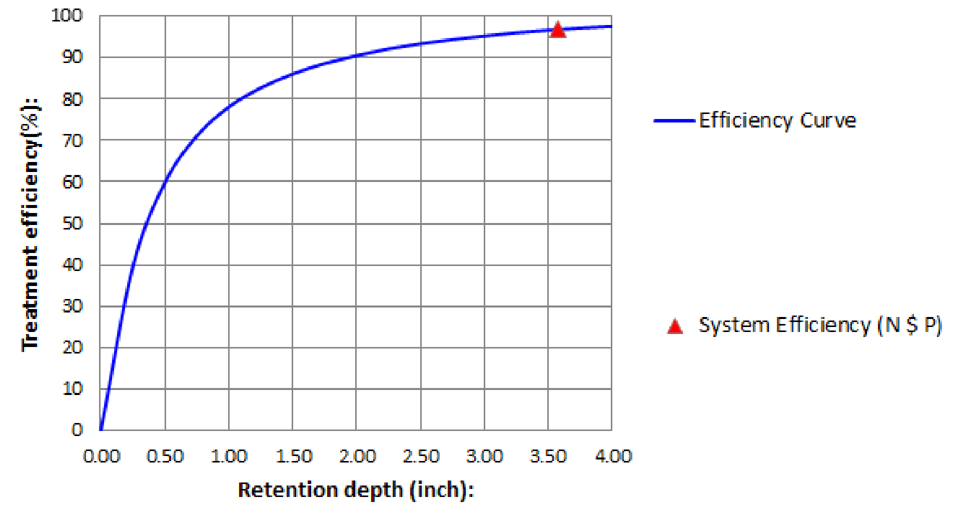
Product disclaimer: The mention, omission or reference of any proprietary products in this in the BMP2A© does not represent an endorsement, approval or rejection by any regulatory agency.

Note: For other pervious pavement sections and / or other sub-base sections, the user must have the appropriate certified "operational void space percentages" from a licensed geotechnical laboratory.

ERROR MESSAGE WINDOW FOR PERVIOUS PAVEMENT:

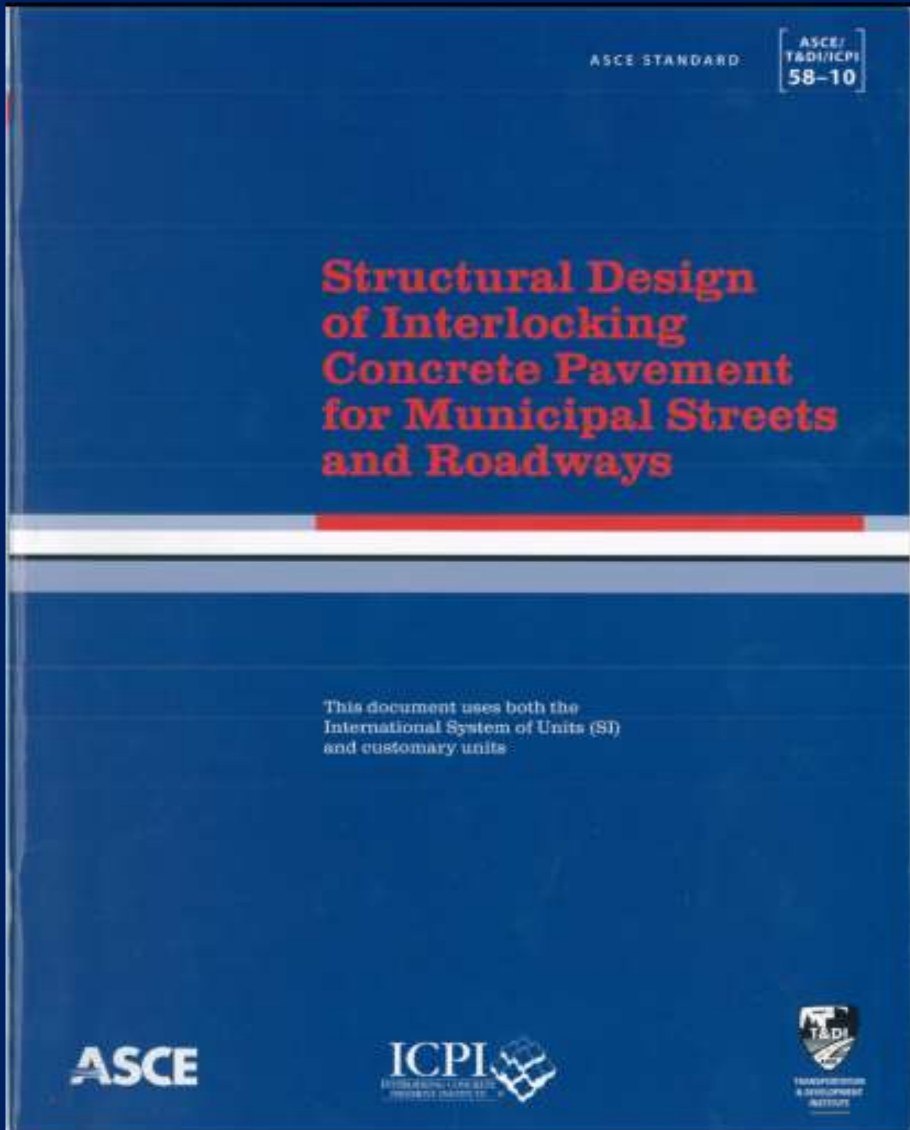
NOTE FOR TREATEMENT EFFICIENCY GRAPH:

The purpose of this graph is to help illustrate the treatment efficiency of the retention system as the function of retention depth. The graph illustrates that there is a point of diminished return as the retention depth is substantially increased. Therefore, to provide the most economical BMP treatment system, other alternatives such as "treatment trains" and compensatory treatment should be considered.



Underdrain Biofiltration | Underdrain Spacing Calculations | **Pervious Pavement** | Floating Island Wet Det | Stormwater Harvesting | Rainwater Harves

Pinellas Park Success Story
1.25 Acre feet of storage



Structural Design

Based on 1993 AASHTO – *Guide for Design of Pavement Structures.*

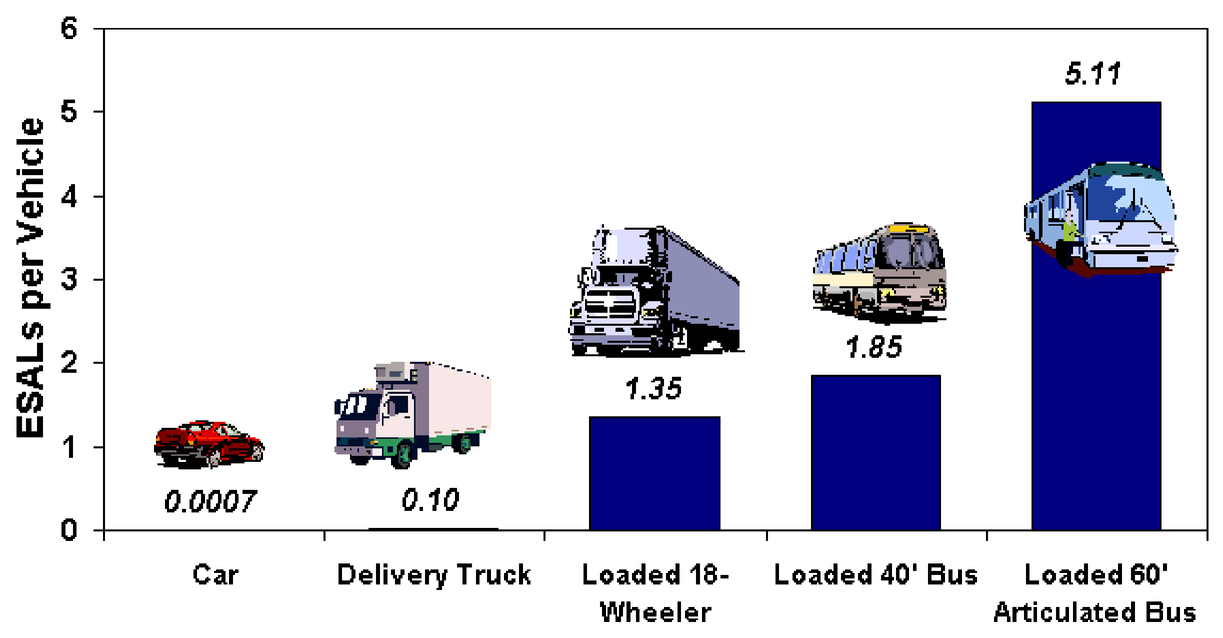
STRUCTURAL DESIGN for ICP: ASCE 58-10

PICP System Design in Florida

Climate	No Frost	No Frost	No Frost	No Frost	Frost	Frost	Frost	Frost
ESALs* (Traffic Index)	Soaked CBR Base Subbase (R-value)	>15 (>24)	10-14 (18-23)	5 to 9 (11-17)	Gravelly Soils	Clayey Gravels, Plastic Sandy Clays	Silty Gravel, Sand, Sandy Clays	Silts, Silty Gravel, Silty Clays
Pedestrian	No. 57 No. 2	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)	4 (100) 6 (150)
50,000 (6)	No 57 No. 2	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	**
150,000 (7.2)	No. 57 No. 2	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 10 (250)	**
600,000 (8.5)	No. 57 No. 2	4 (100) 8 (200)	4 (100) 8 (200)	4 (100) 10 (250)	4 (100) 8 (200)	4 (100) 14 (350)	4 (100) 18 (450)	**

SUBGRADE EVALUATION - CBR

ESAL (Estimated Standard Axle Load) / TI (Traffic Index)



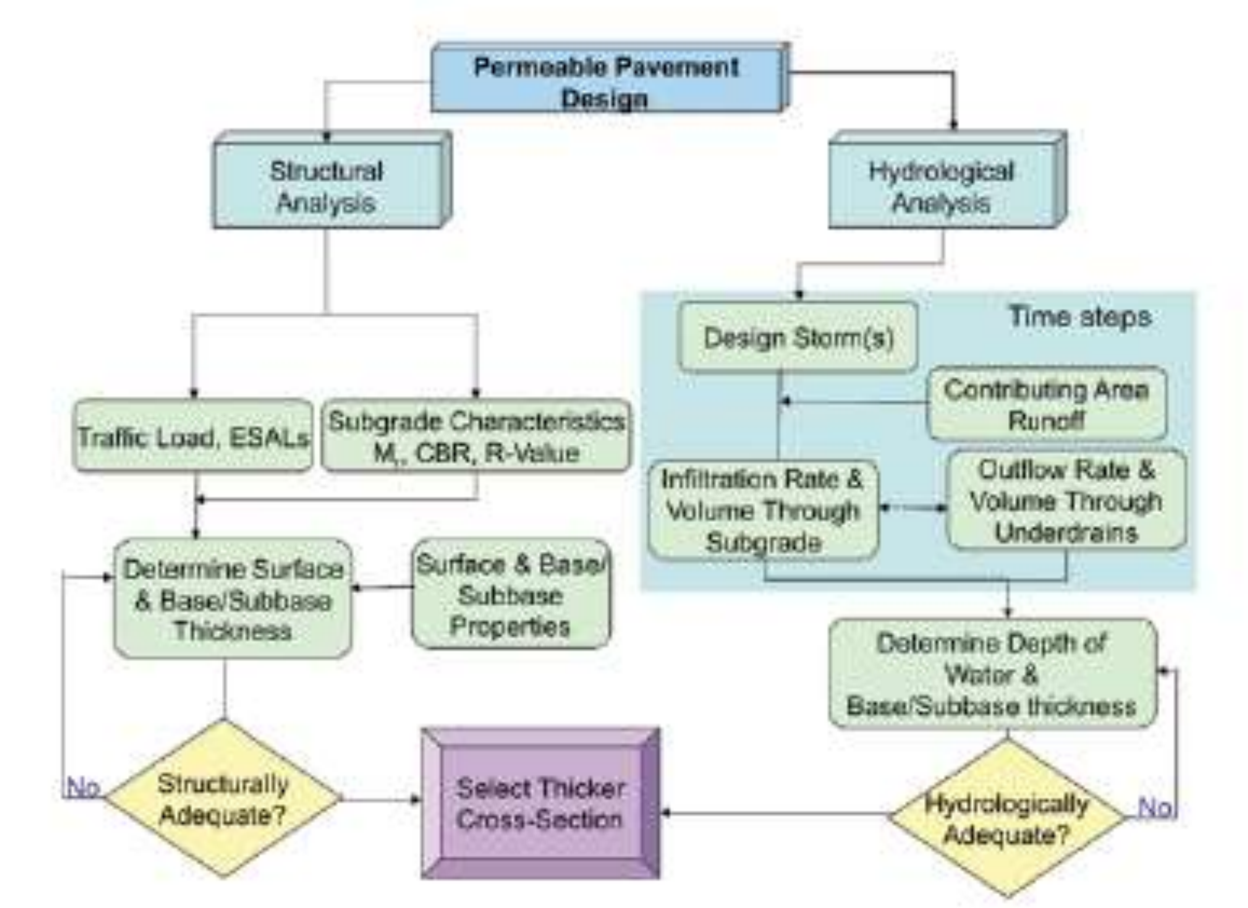
$$TI = 9.0 \times \left(\frac{ESAL}{10^6} \right)^{0.119}$$

ESALs	Traffic Index
10,000	5.2
20,000	5.7
50,000	6.3
100,000	6.8
200,000	7.4
500,000	8.3
1,000,000	9.0
2,000,000	9.8
5,000,000	10.9
10,000,000	11.8

Summation of the equivalent 18,000 lbs-f single axle loads over the design life

ESALS / TI

PICP System Design in Florida

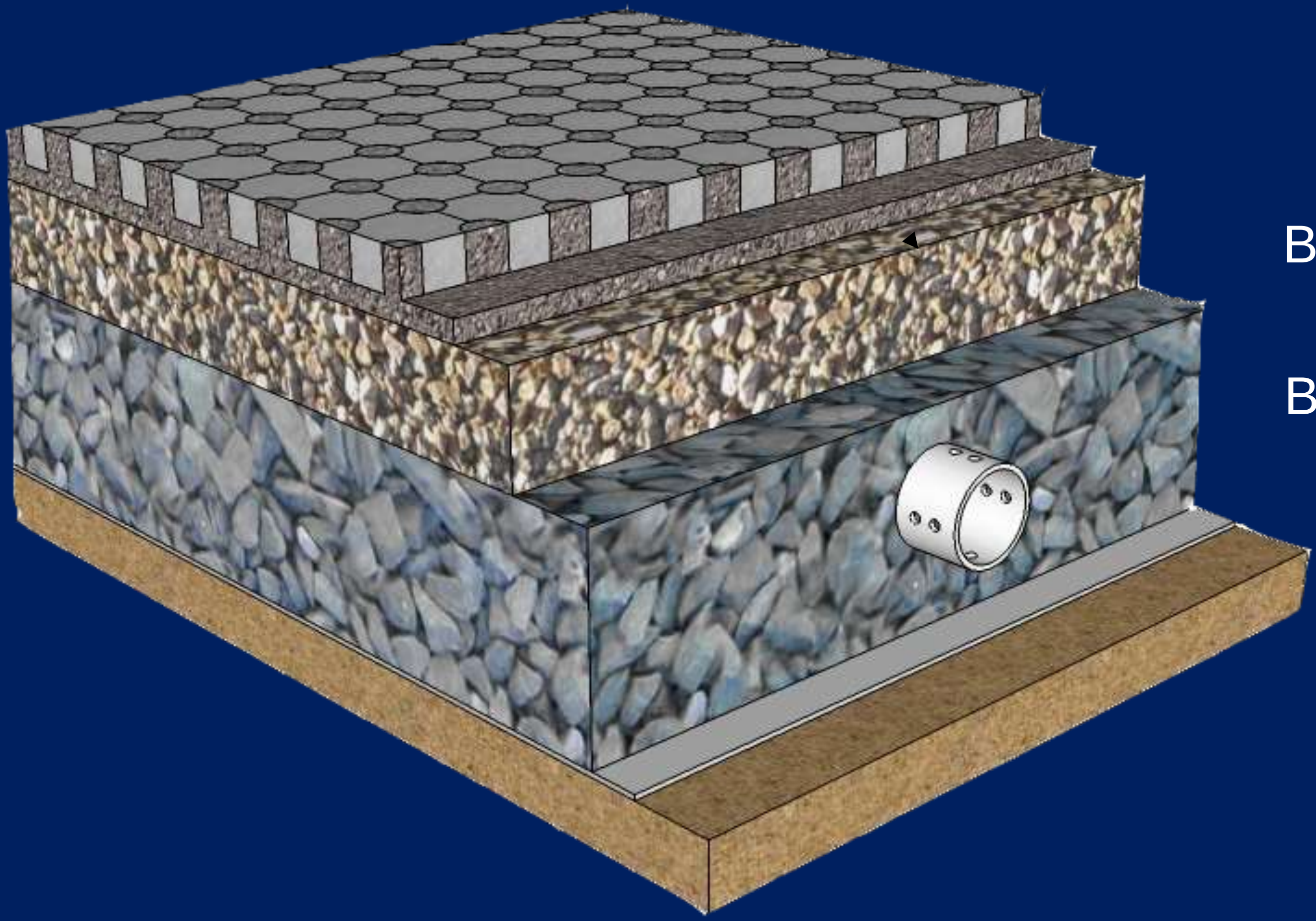


PICP systems serve as both a Structural and Hydrological Analyses - need to consider traffic, soil strength and infiltration, design storm, contributing area & storage volume.

SYSTEM DESIGN

PICP System Design & Utilization

Structural Number



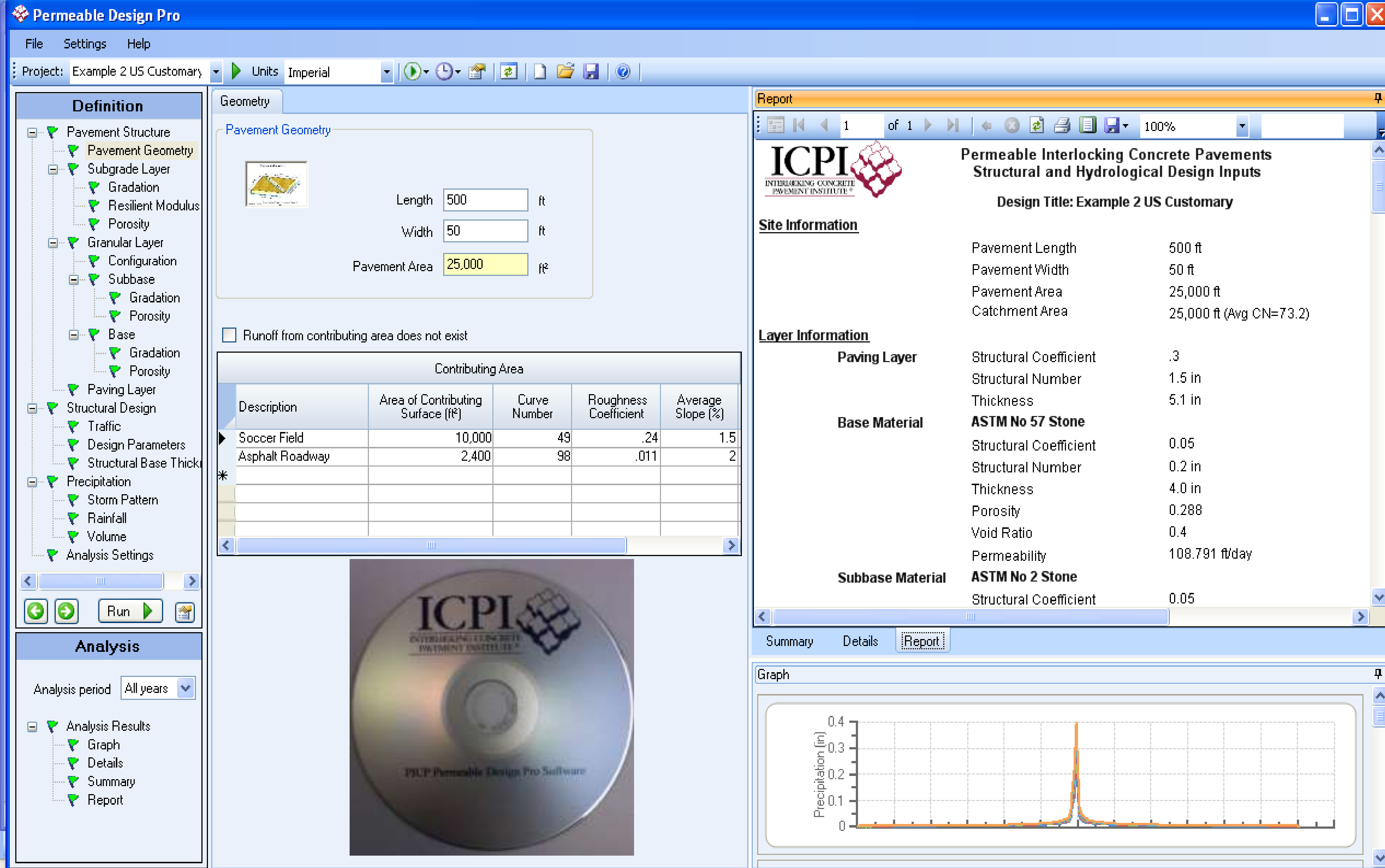
Pavers Bedding
5-1/8” ai 0.3 = 1.538

Base 4” ai 0.09 = 0.36

Base 10 ai 0.06 = 0.60

SN = 2.498

SN = structural number of the pavement, calculated as $\Sigma\, a_i \times d_i$, where
a_i = structural layer coefficient per layer i
d_i = layer thickness per layer i



PERMEABLE DESIGN PRO SOFTWARE
icpi.org

PICP System Design in Florida

HS 20 Rated

8 acres Permeable Pavement

McCord Toyota

Sustainable Site Pavement Systems

Construction

- **Interlocking Concrete Pavers**
  - **Min. 80 mm thick – conform to ASTM C936**
  - **45º or 90º herringbone pattern**
  - **ICPI Certified contractor**
- **Clean washed aggregate essential**

TECH SPECH 18

– Construction of Permeable Interlocking Concrete Pavement Systems. Available at: icpi.org

Use stakes (except with liners) to hold the material in place.

CONSTRUCTION – Geotextile


No. 57
No. 2


Construction

Mechanical placement

Construction

Edges cut, placed then compacted

Filling the openings with No. 8 stone

Final Compaction

Immediately ready for use

Immediately ready for traffic

Action	Frequency
Maintain perimeter vegetation	Ongoing
Check outlets are clear of debris	Ongoing
Sweep surface debris	Twice a year
Vacuum and replenish jointing material	When surface ponding observed (2-10 years)
Repair ruts/deformations exceeding ½” (13mm)	As required
Reset pavers that are more than ¼” (6mm) above adjacent	As required
Replace broken pavers	As required
Replenish jointing material if more than ½” (13mm) from chamfer bottom	As required

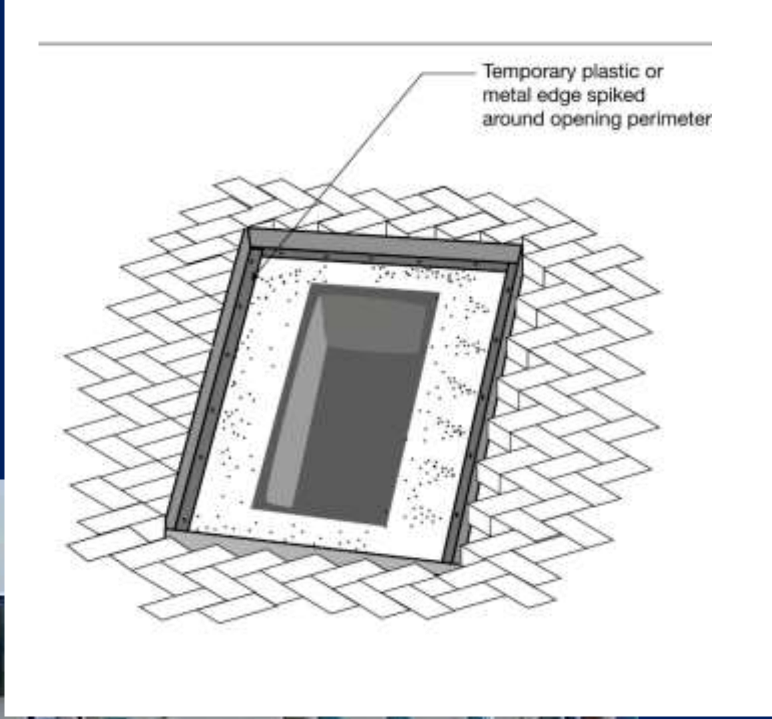
MAINTENANCE SCHEDULE

Estimated 15-20 year cycles

Vacuum Type Sweeper

Remedial Maintenance

Maintenance: Spot Repairs



Reinstate same pavers
No curing time – ready for traffic
Minimal operations interruption

Costs

Assumptions:

3 1/8 in. thick pavers

2 in. bedding layer

12 in. base with Geotextile

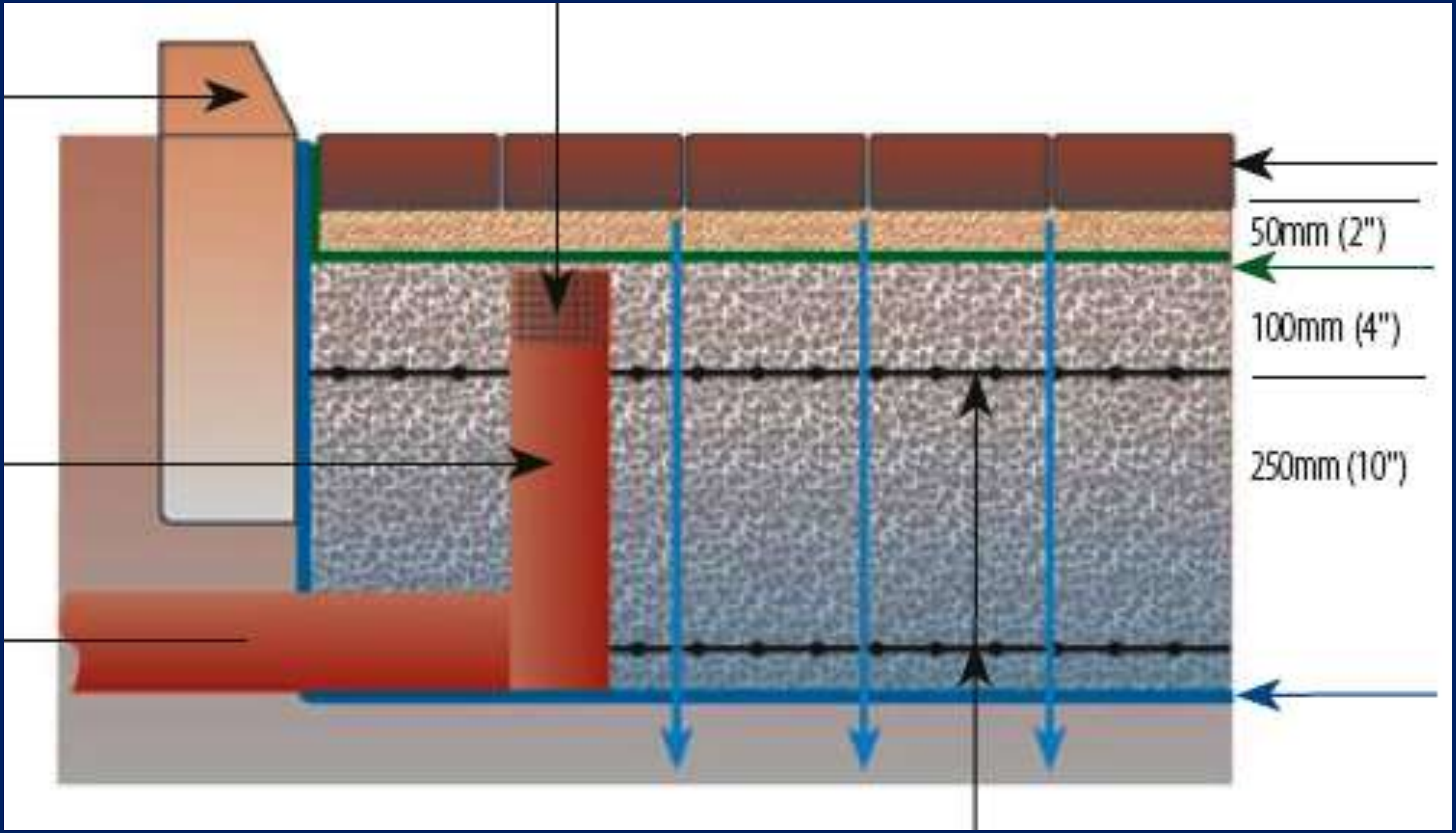
5,000 s/y

$55.00 s/y

Does *not* include concrete curbs

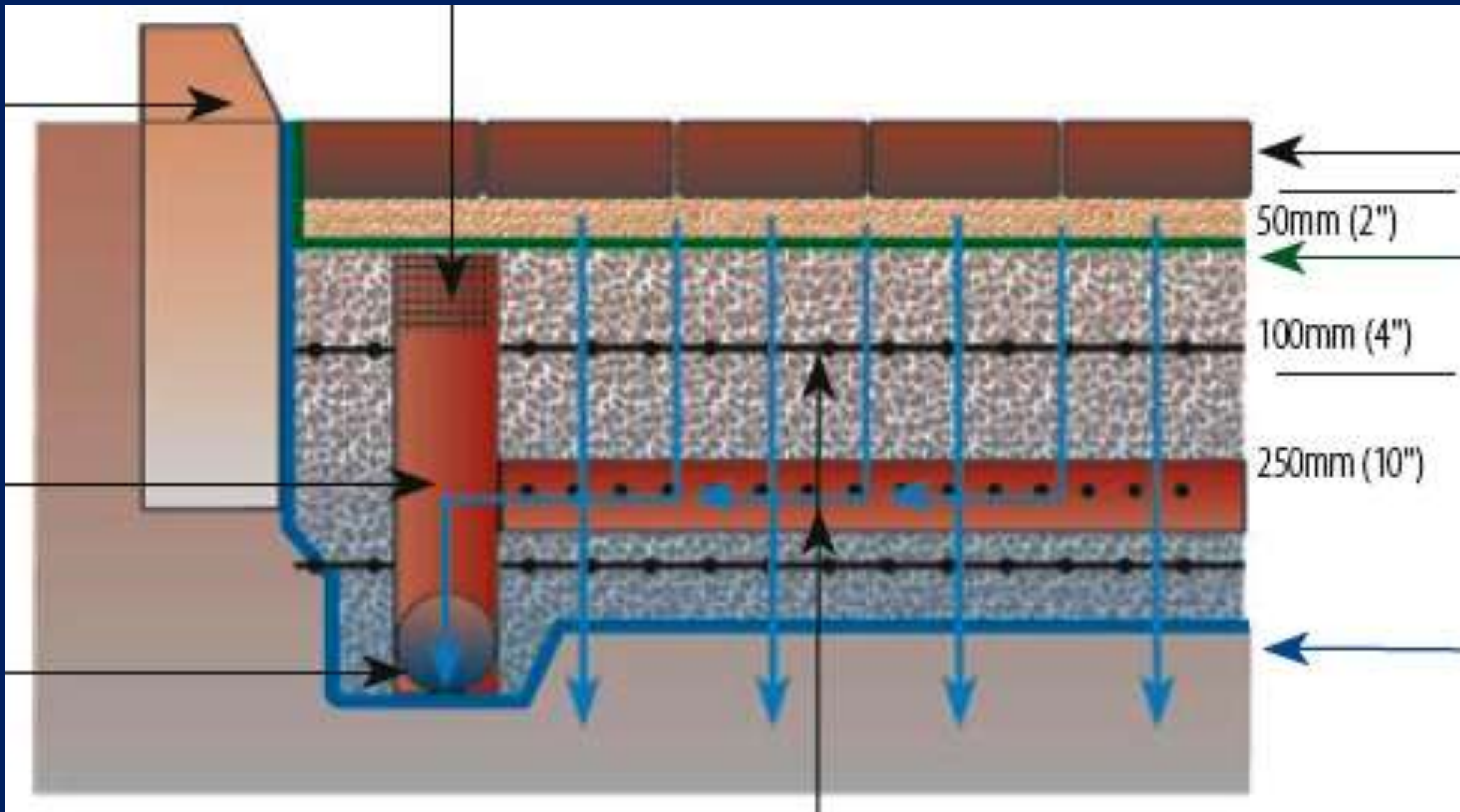
Cost Saving Opportunities

Eliminate Traditional Conveyance Systems
Reduce or Eliminate Detention Ponds



TERMINOLOGY – FULL EXFILTRATION

PICP System Design & Utilization



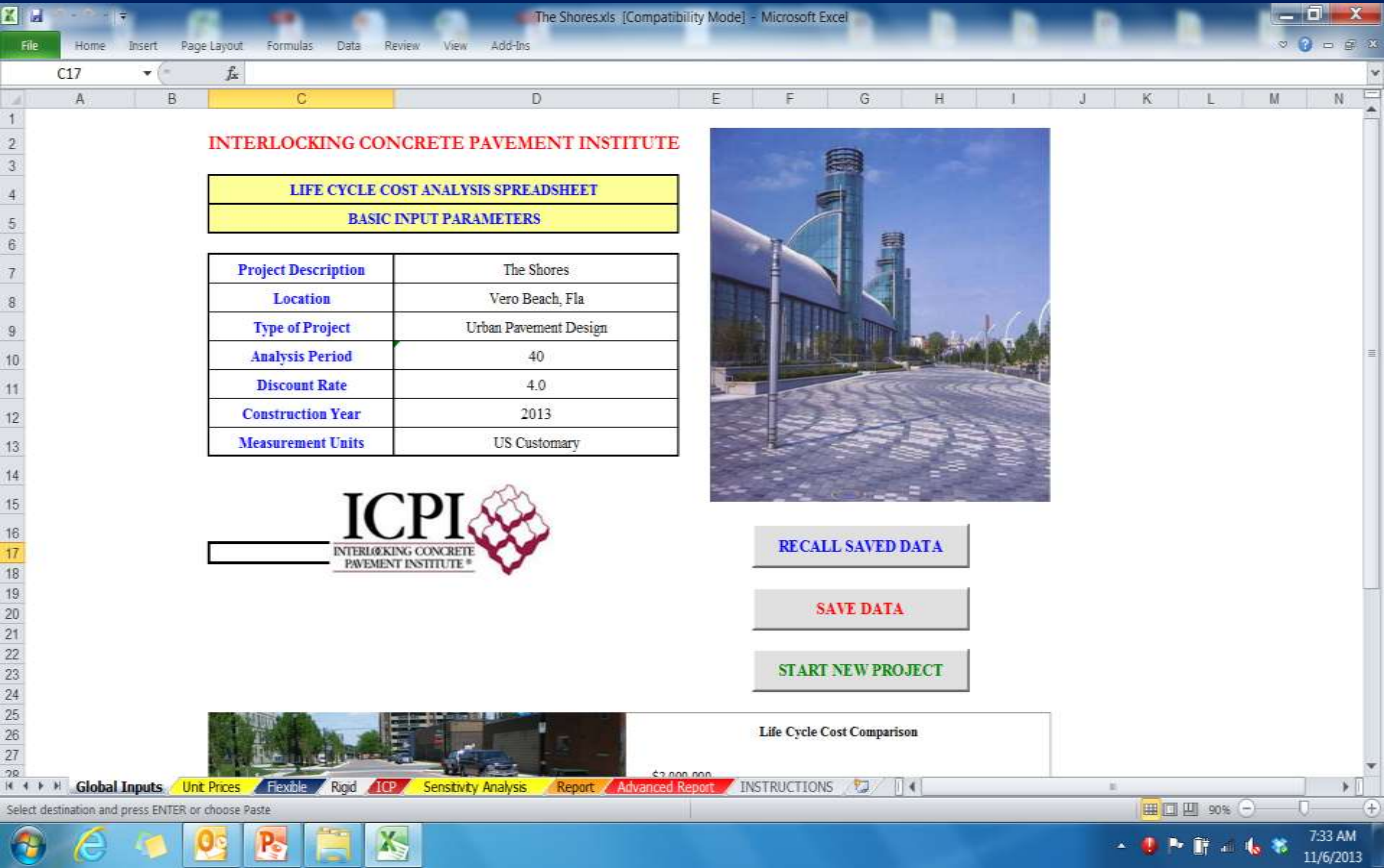
TERMINOLOGY – PARTIAL EXFILTRATION

PICP System Design & Utilization

“Old School Stormwater

When BMP = Big Muddy Pond

Life Cycle Cost Analysis

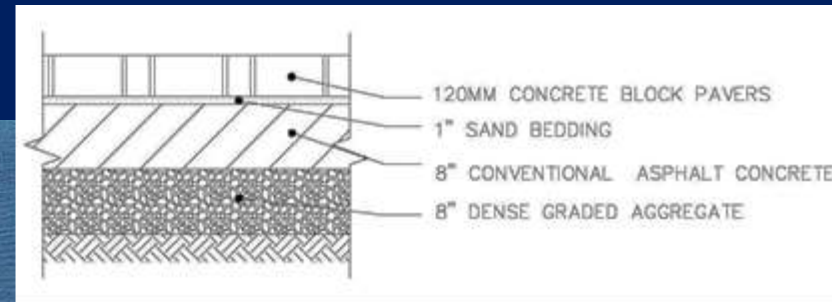


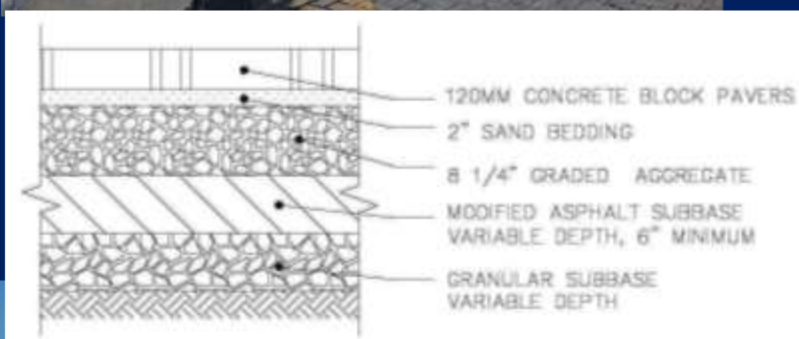
Port of Baltimore

Seagirt & Dundalk Terminals

190,000 m^2 1987-2005

Seagirt wharf





Dundalk wharf

Port of Oakland, CA

470,000 m^2 2001-04

Berths 55-59
Pavement section:
100 mm thick concrete pavers
25 mm thick bedding sand
75 mm asphalt
450 mm aggregate base
Soil subgrade 5% CBR

Container storage
FLTs & RTGs

Conclusions

High quality wearing course
Provides Stormwater Solutions

Design
Proven methods & solutions

Construction
Mechanized, QC protocols, experienced contractors

Ease of Maintenance & Management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