DEPARTMENT OF
ECOLOGY
State of Washington

Low Impact Development

Permeable Paving

An education initiative funded by the Department of Ecology

June 11, 2013

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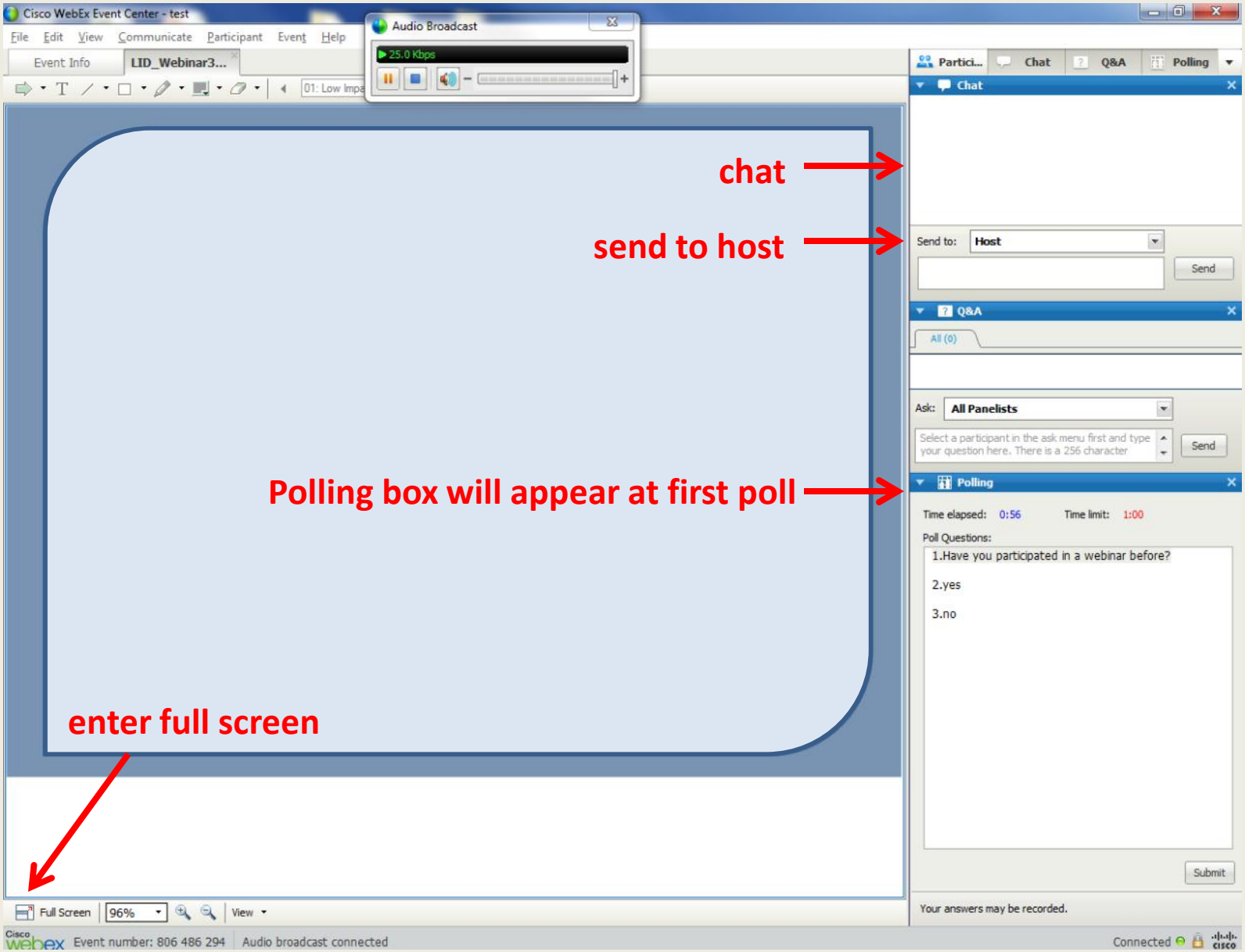

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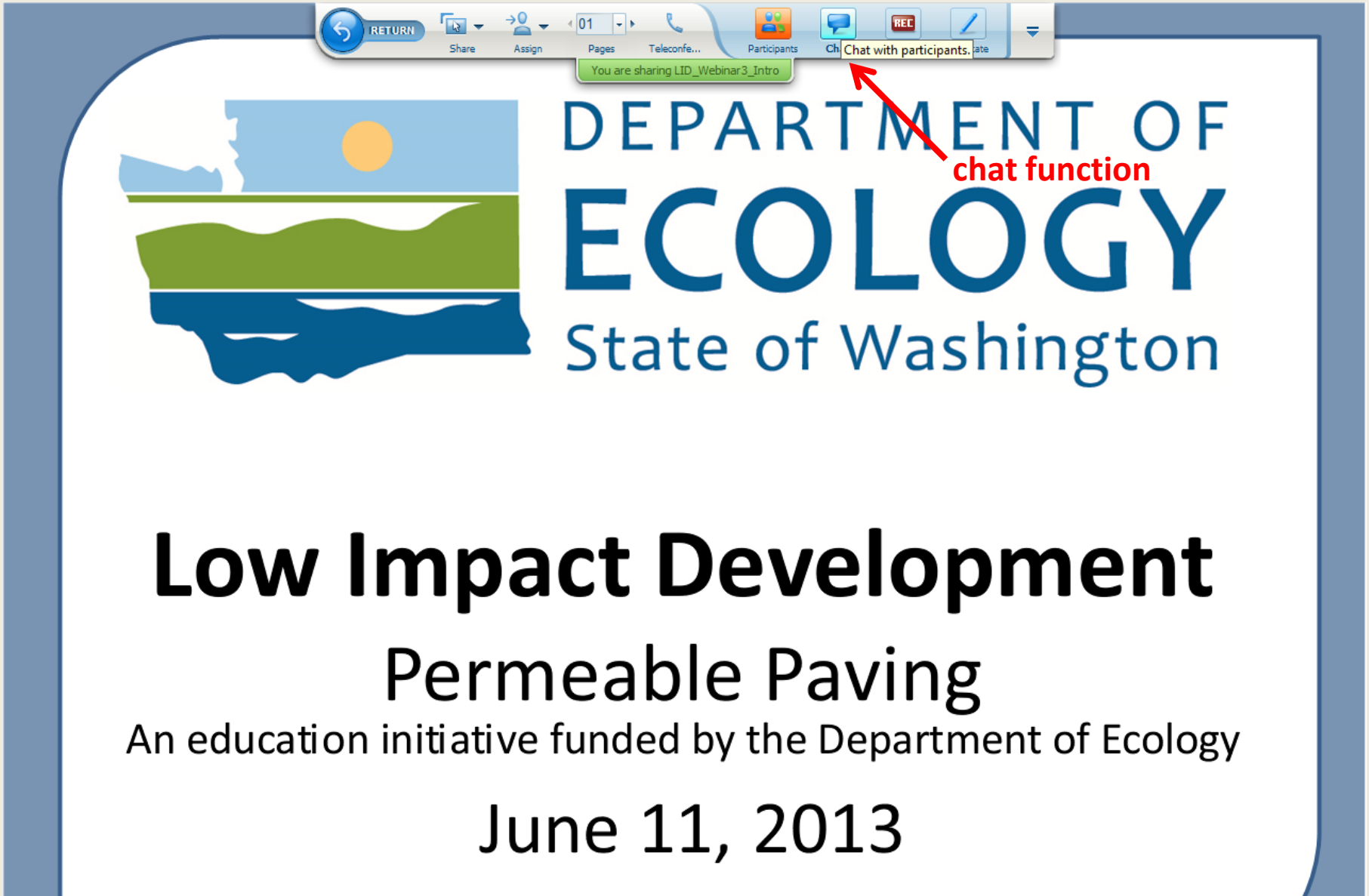
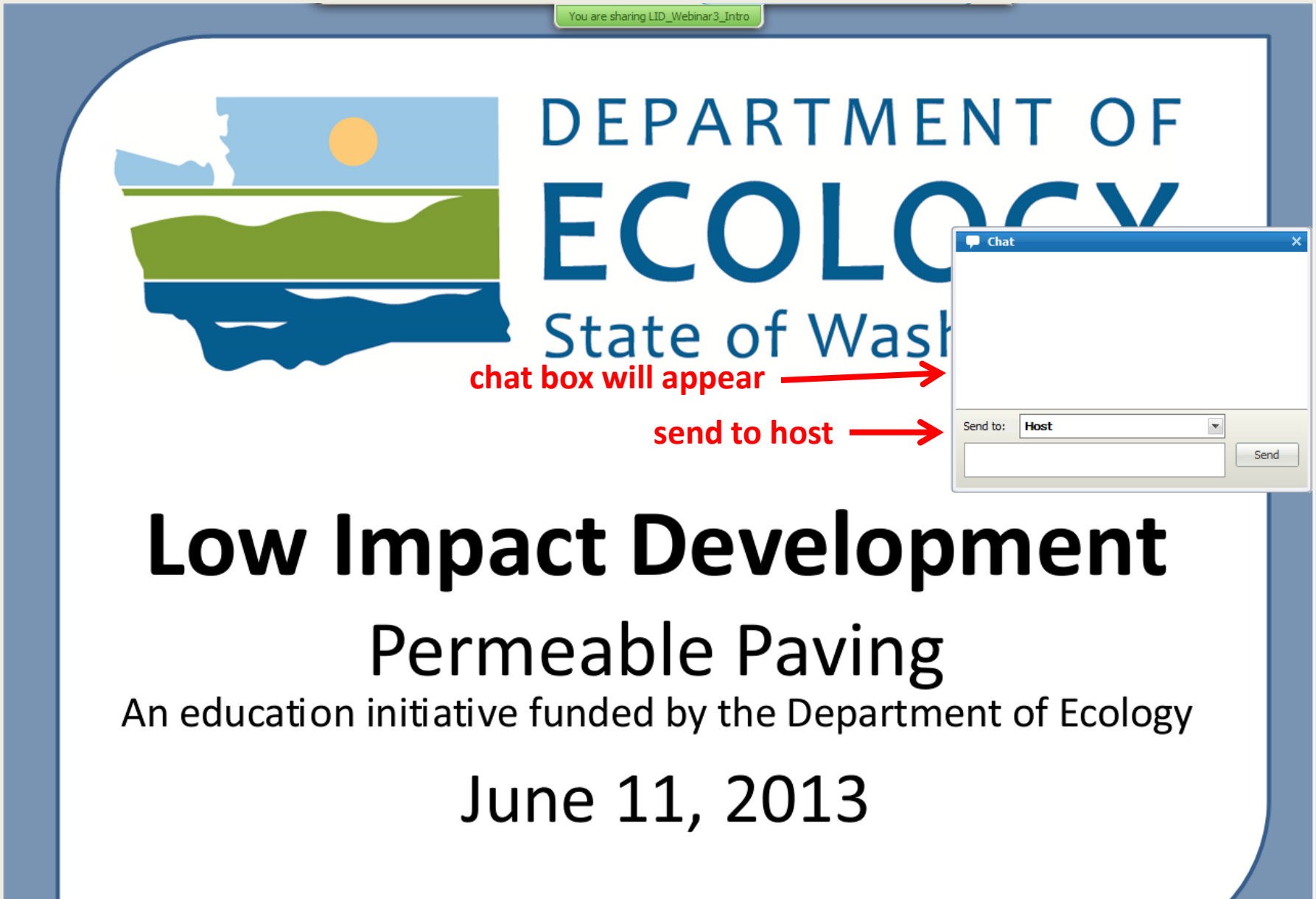


Chat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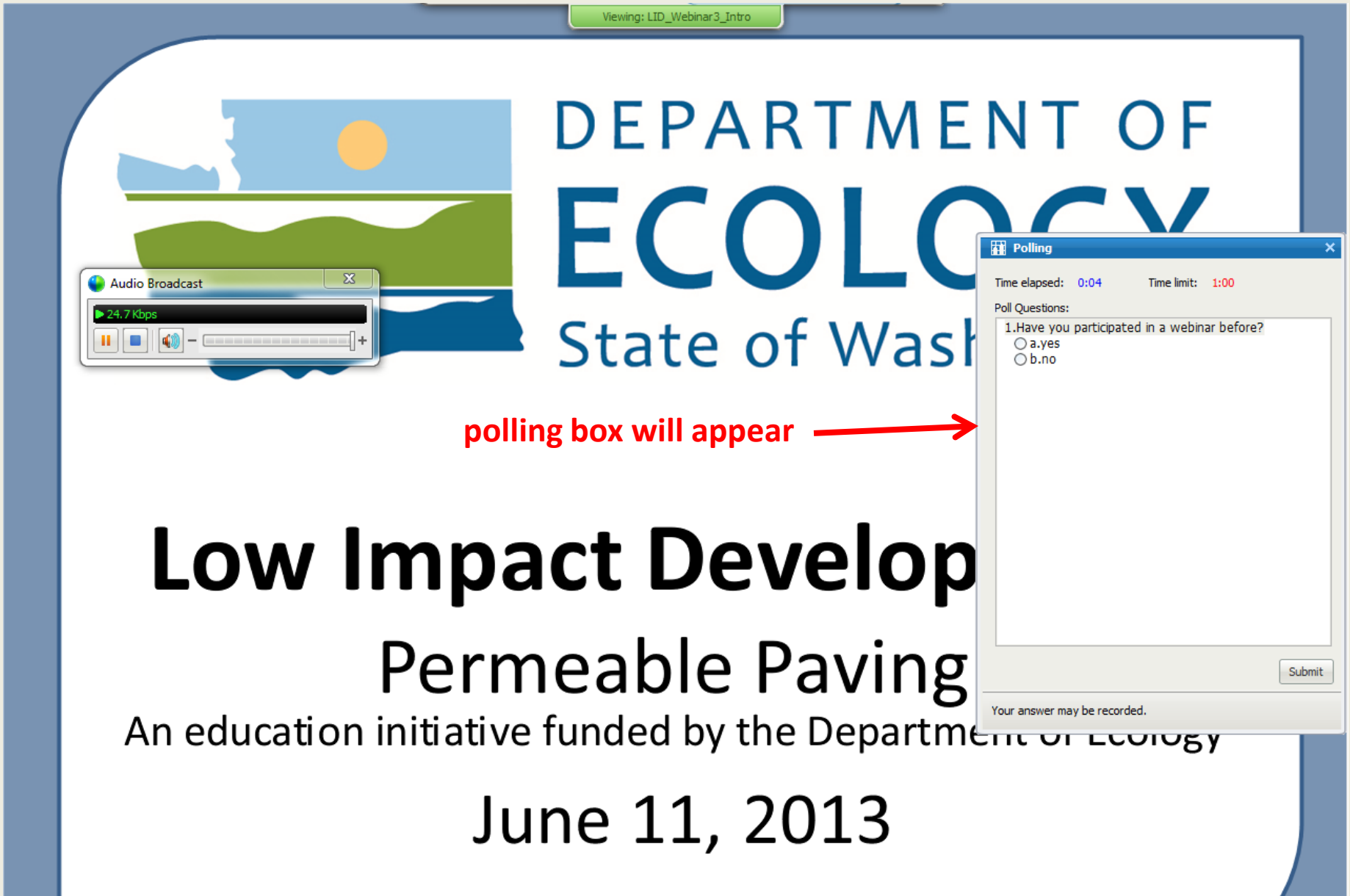
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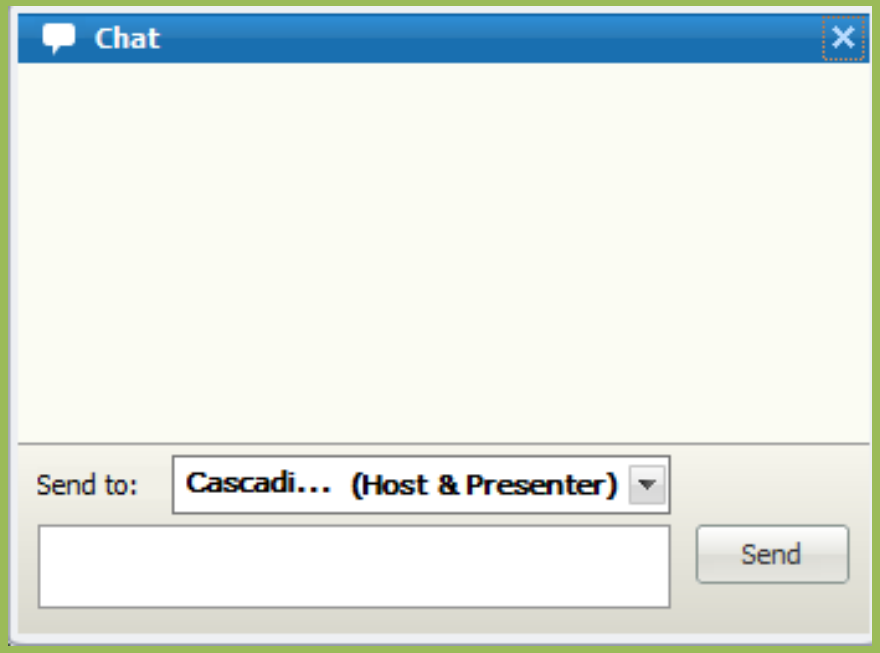
Question Answer Period

Please send questions via **Chat** throughout the presentation to be answered during the question period at the end of the presentation.



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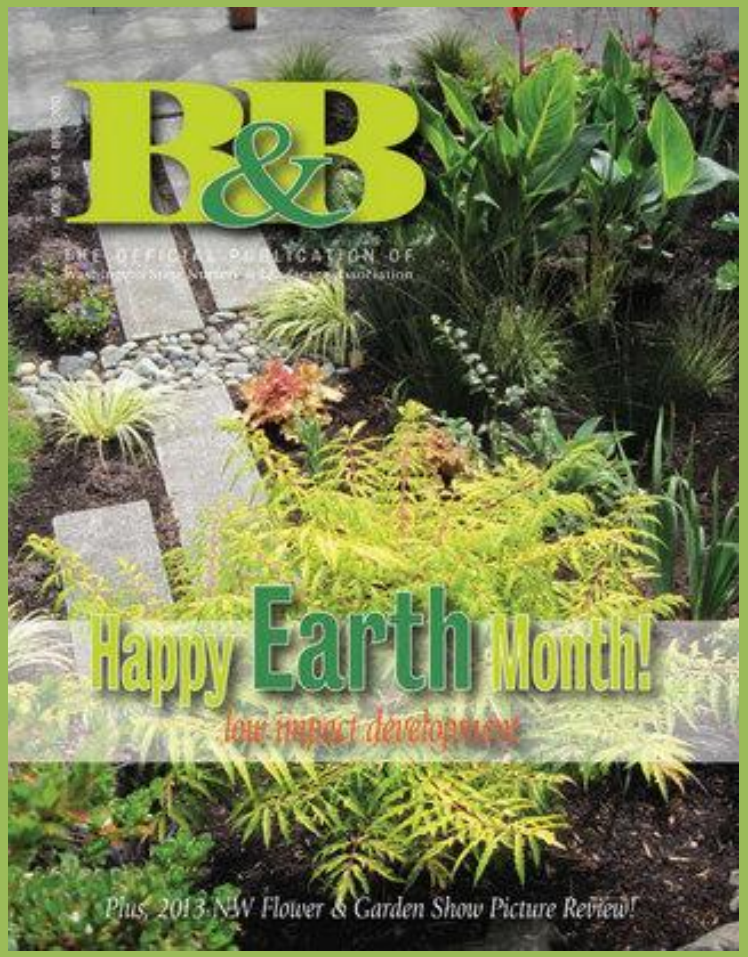
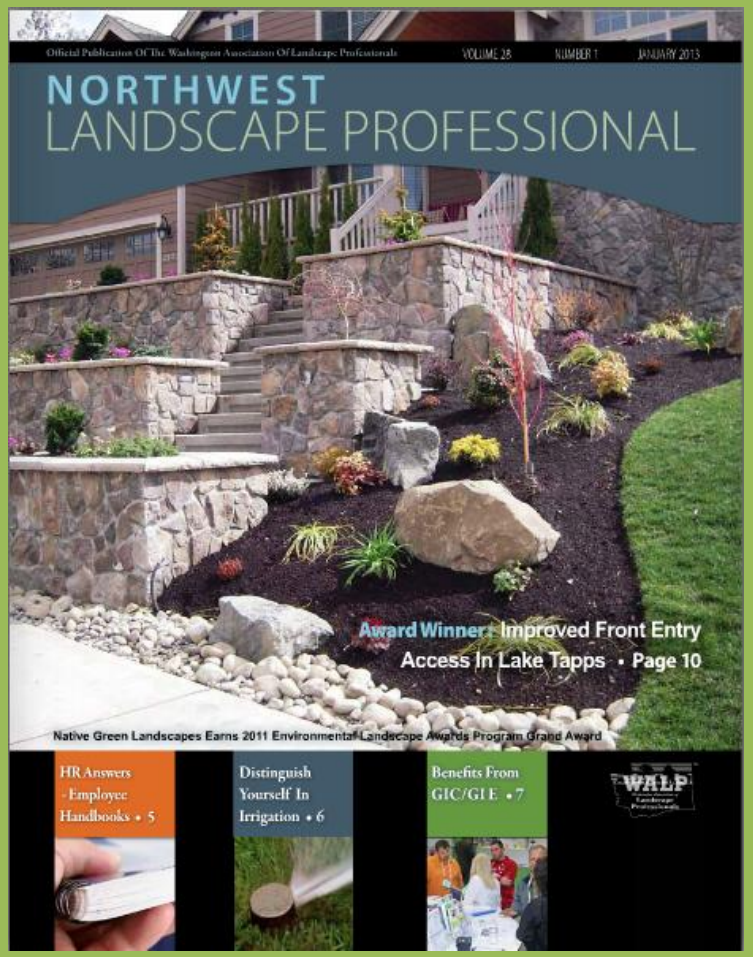
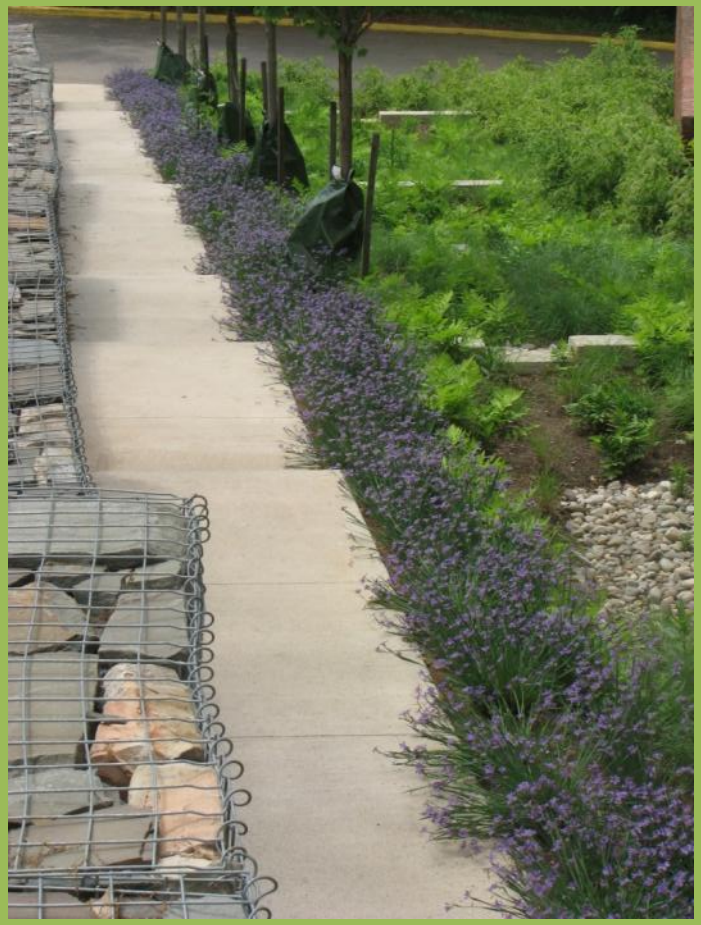




Low Impact Development

Introduction



Low Impact Development (LID)

Is a design, planning and engineering approach to managing stormwater runoff

LID includes:

- Rain gardens
- Bioretention
- Permeable pavement / pavers
- Green roofs
- Rain water harvesting
- Green walls

Stormwater Runoff

- **Impervious Surfaces**
  - Roads
  - Roof tops
  - Lawns and landscapes
- **Pollutants**
  - Oil
  - Heavy metals
  - Phosphorous
  - Silts
- **Affected Natural Areas**
  - Wetlands
  - Streams
  - Water bodies

Stormwater Runoff Can Lead To:

- Erosion
- Pollution of Soils and Water Bodies
- Sedimentation
- Combined Sewage Overflows
- Loss of Wildlife Habitat

LID principles

Conserve

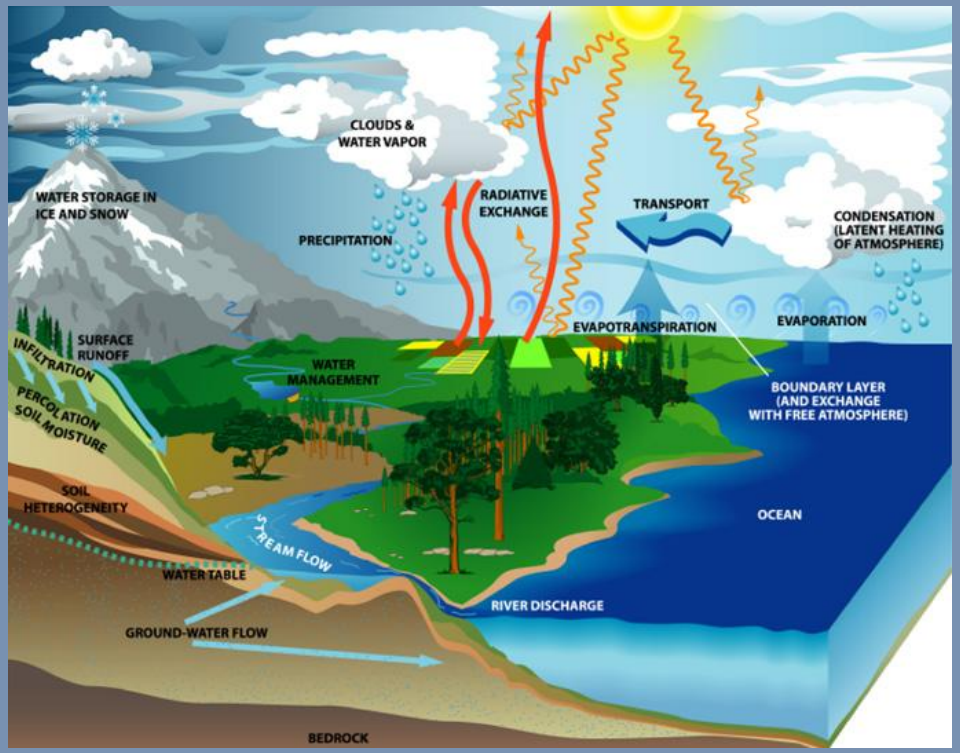
- trees
- plants
- healthy soils

Minimize

- impervious surfaces
- native vegetation loss
- stormwater runoff

Benefits of LID

- Reduces and slows stormwater runoff
- Protects water quality
- Restores ecosystem services including:
  - Water infiltration
  - Groundwater recharge
  - Pollution interception and filtration
  - CO2 sequestration
  - Protection of habitat for beneficial wildlife



Hydrologic (water) cycle

Stormwater is Regulated

- Clean Water Act
- National Pollution Discharge Elimination System (NPDES)
- Washington State Department of Ecology
- Municipal permits

DEPARTMENT OF ECOLOGY
State of Washington

City of Seattle

Permits for Clean Water
NPDES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Regulatory Changes are Coming

- Western Washington - LID will be required in new development and re-development
- Eastern Washington - LID allowed
- Deadlines depends on population size
  - Earliest: June 2015
  - Most will adopt by: Dec 2016
  - Latest: June 2018

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Give Input

Get in touch with your local officials while regulations are being made:
http://www.mrsc.org/research/research.aspx

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Have a question?

ask MRSC

Related Resources

- City Profiles
- County Profiles
- Budgets
- Business Forms
- Comprehensive Plans
- Council Meeting Broadcasts
- Email Notification / Alerts
- Ordinances and Resolutions
- Staff Directories

MRSC Tools and Resources

- Library Loan Request
- MRSC Index
- MRSC Publications List
- Research Request
- Sample Local Government Documents

Research Tools › City Resources

MRSC City and Town Resources

City and Town Profiles

MRSC's City and Town Profiles include population statistics, maps, selected documents, form of government, city class, and economic and demographic information for all cities in Washington State.

City and Town Officials

Our online version of city and town officials can be found through our City and Town Profiles page. You can also search the entire city/town online directory for officials by using our Search City & Town Officials page.

Directory of City and Town Officials, updated annually, contains lists of city officials including mayors, councilmembers, and city managers for all cities in Washington State.

City and Town Websites

City and Town Websites List contains links to all Washington City websites.

City and Town Codes

City and Town Codes page contains links to and publication information on all Washington City codes currently online.

Rick Crooks

- Civil Engineer
- **Mutual Materials Company**
- Director of Business Development
- Nationally respected instructor

Zsofia Pasztor

- Owner of **Innovative Landscape Technologies**
- Certified Professional Horticulturist
- Past president of Sustainable Development Task Force – Snohomish County
- Instructor at Edmonds Community College

Basics of Permeable Pavements

Sponsored by:

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WALP
Washington Association of Landscape Professionals

WASHINGTON STATE NURSERY & LANDSCAPE ASSOCIATION
WSNLA

Presented by:

Rick Crooks

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Outline and Learning Objectives

- Why use permeable pavement?
- Understand the basic components of the three most popular permeable pavement systems:

  Porous Asphalt

  Pervious Concrete

  Permeable Interlocking Pavers
- Understand available system information sources
- Review construction sequencing for each pavement
- Review maintenance requirements

Why Permeable Pavement?

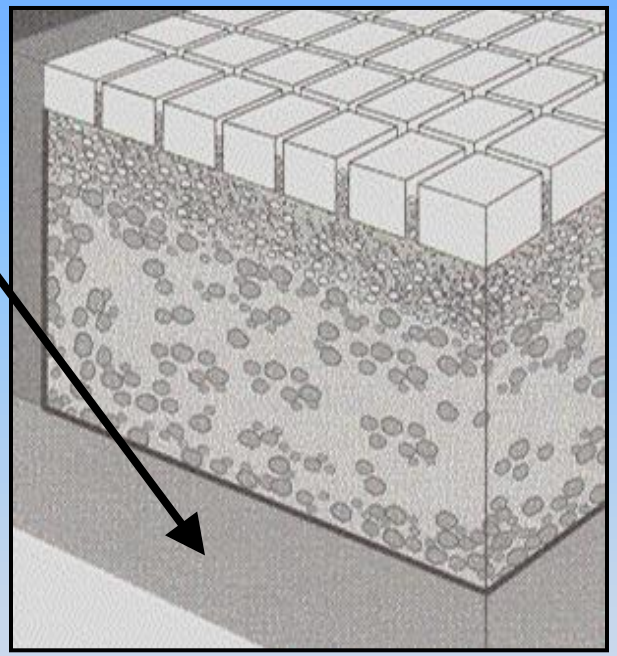
- Part of BMP mix, supports LID
- Conserves space: a functional pavement and a stormwater management facility
- 100% runoff reduction for high frequency storms, can help meet Ecology's flow control requirement.

Why Permeable Pavement? (cont.)

- Reduce retention/detention, drainage fees
- Together with subgrade soil, permeable pavement systems can help filter and reduce pollution from stormwater.
- Increase groundwater recharge

Determining Subgrade Soil Infiltration

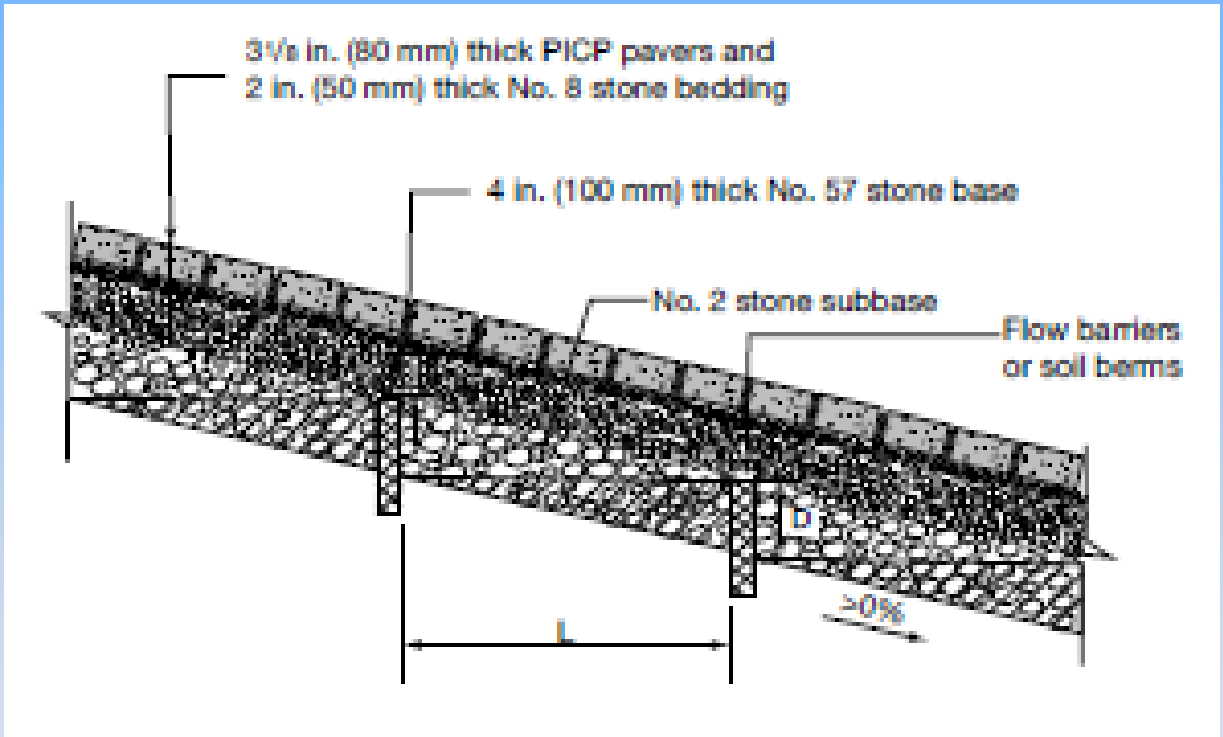
- Soil maps and soil classification systems (NRCS, USCS)
- Conduct on-site infiltration tests
- Use lowest (conservative) values for preliminary design.



Subgrade Infiltration

- Use site tests for accurate information
- Frequency and location based on geotechnical requirements (consult engineer)

Handling sloped sites

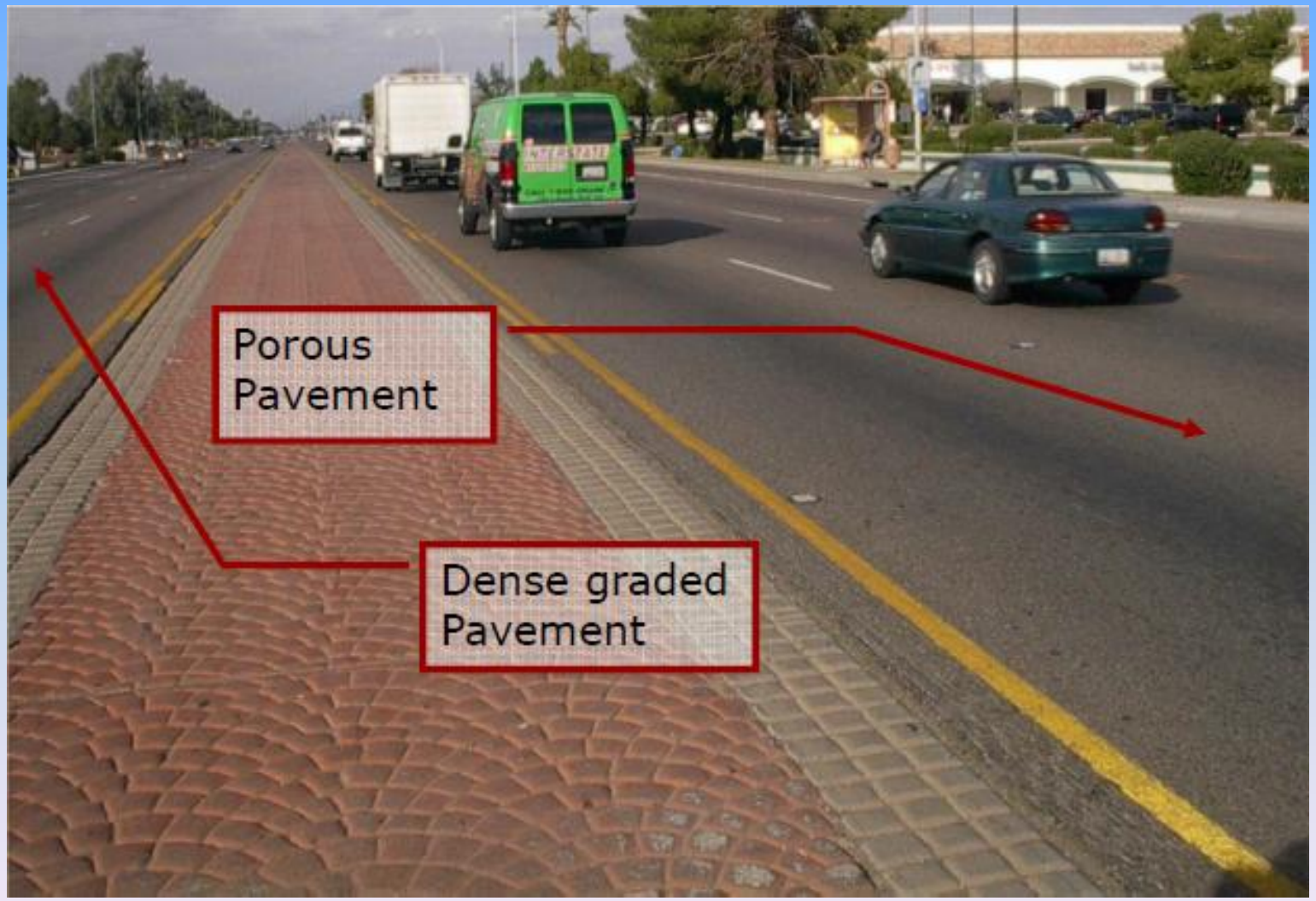


Depending on the slope of the project, use check dams to allow runoff to infiltrate into sub-soil.

Porous Asphalt

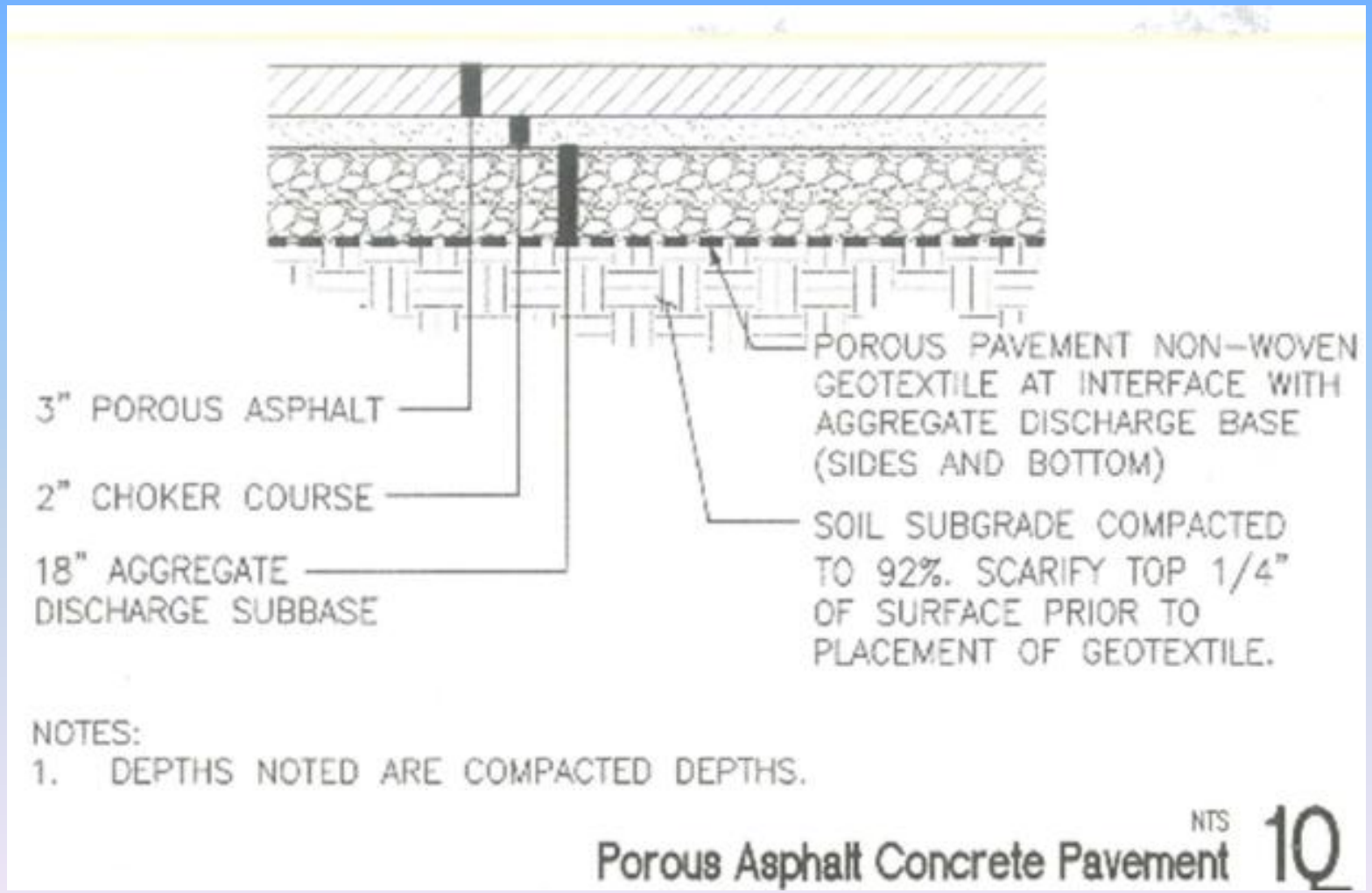
- Defined as full depth porous material – all materials in the road section are permeable.
- Historically used as porous friction course (PFC) overlay to reduce highway spray and minimizes traffic noise.
- Limited use on local residential projects, more typical on municipal streets.

Arizona SR-87



Slide courtesy Mark Palmer, City of Puyallup

Typical Porous Asphalt Cross-Section



Slide courtesy Mark Palmer, City of Puyallup

Materials and Specifications

- HMA (hot mix asphalt) complies with NAPA specifications for porous applications (polymer additive, 6%-9% asphalt cement binder). Use fibers and anti-stripping agents in binder to reduce drain-down potential.
- Aggregate for wearing course is typically 1/4” to 3/8”, though larger gradations have been used successfully.
- Choker course gradation depends on reservoir course gradation but is typically 3/4” to 1”. Some projects are eliminating (or minimizing) the choker course.
- Reservoir aggregate is 1” to 2” gradation (WSDOT Section 9-03.9(2) permeable ballast).
- All aggregates are durable, crushed and clean with no rounded rock (90-100% fractured face)

Base and Sub-base Aggregates

- Choker course –

  well-graded, crushed aggregates (no fines).

- Reservoir course –

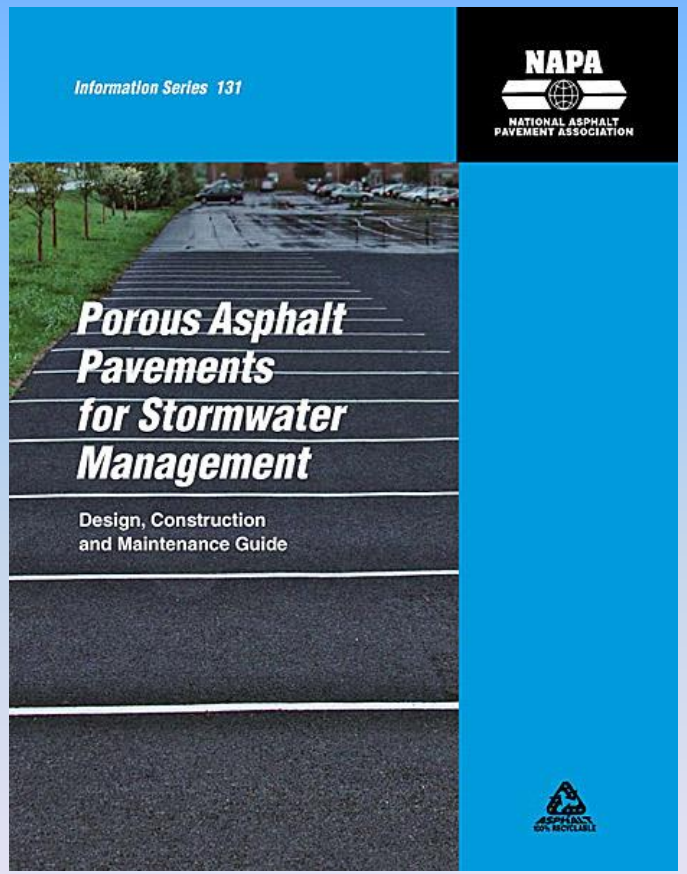
  Larger crushed aggregates (no fines).

Industry publication

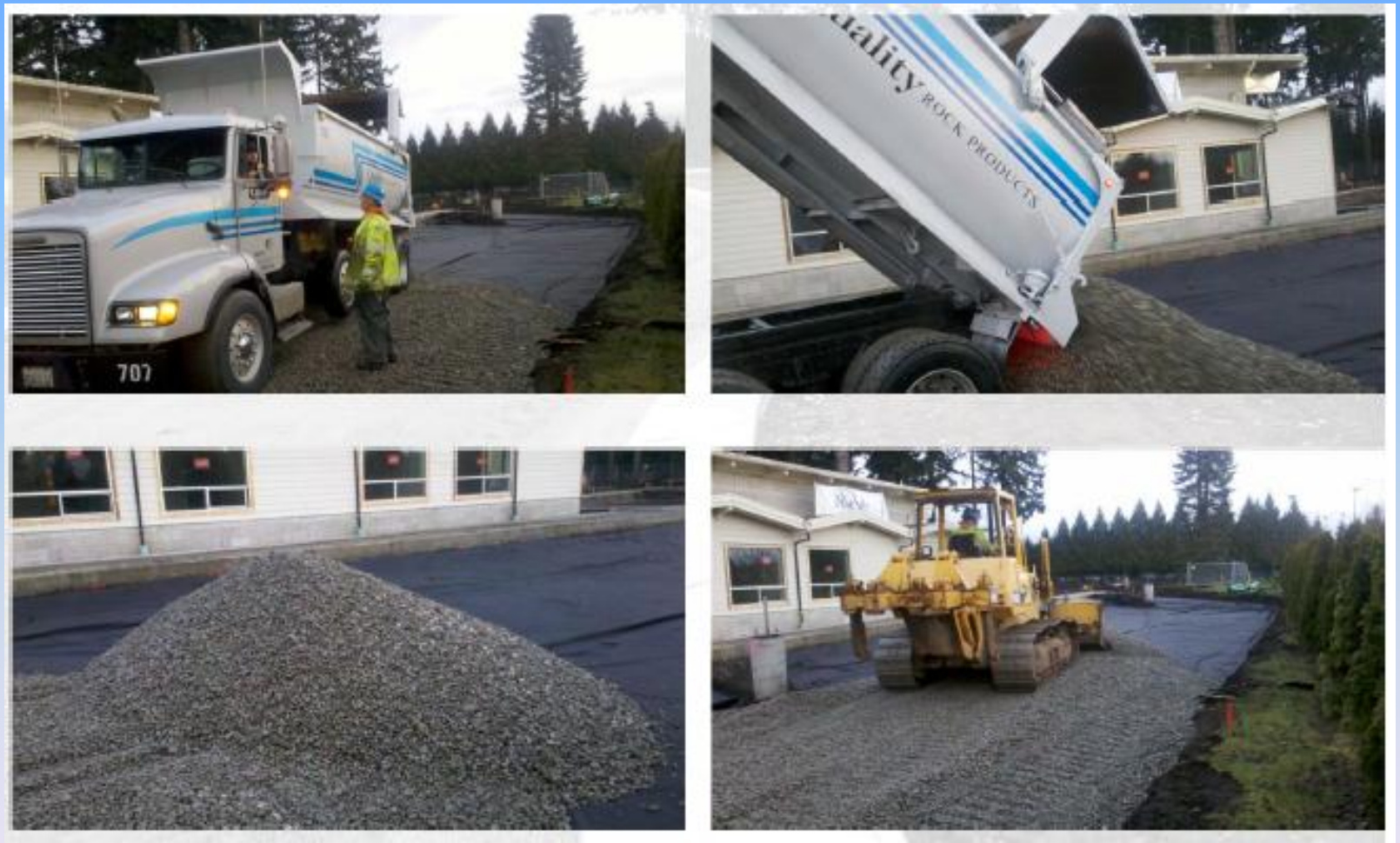
- National Asphalt Pavement Association (NAPA)
- Order number:

IS-131

www.asphaltpaving.org



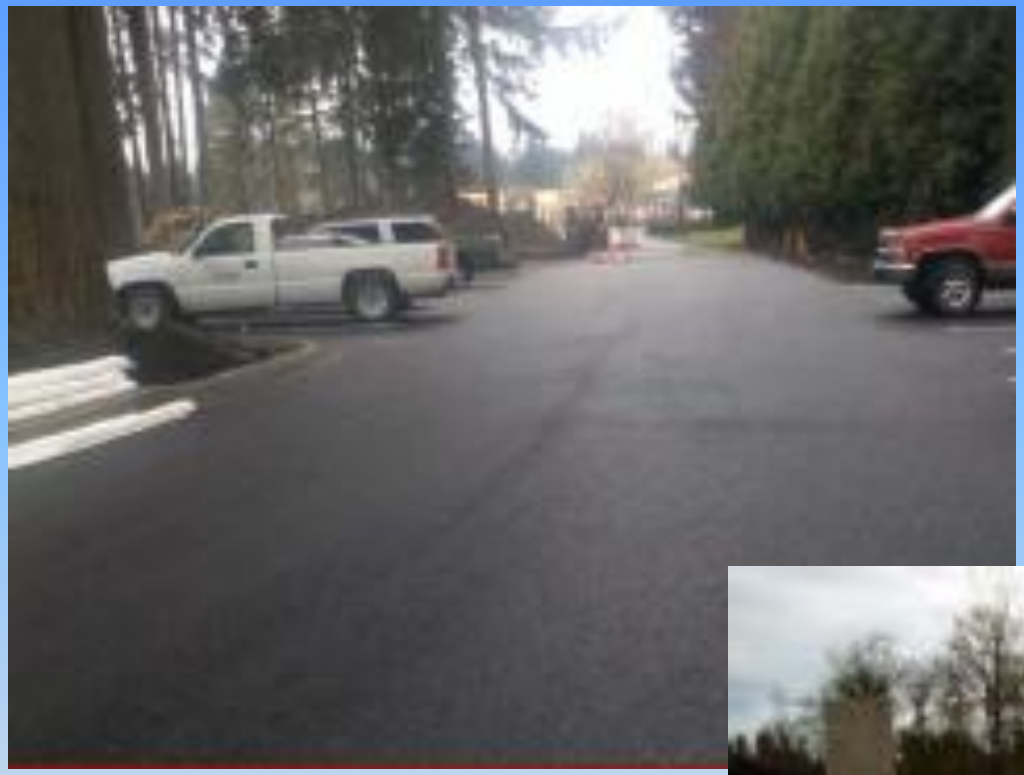
Porous Asphalt Construction Sequence



Slide courtesy Mark Palmer, City of Puyallup

Porous Asphalt Construction Sequence

Slide courtesy Mark Palmer, City of Puyallup



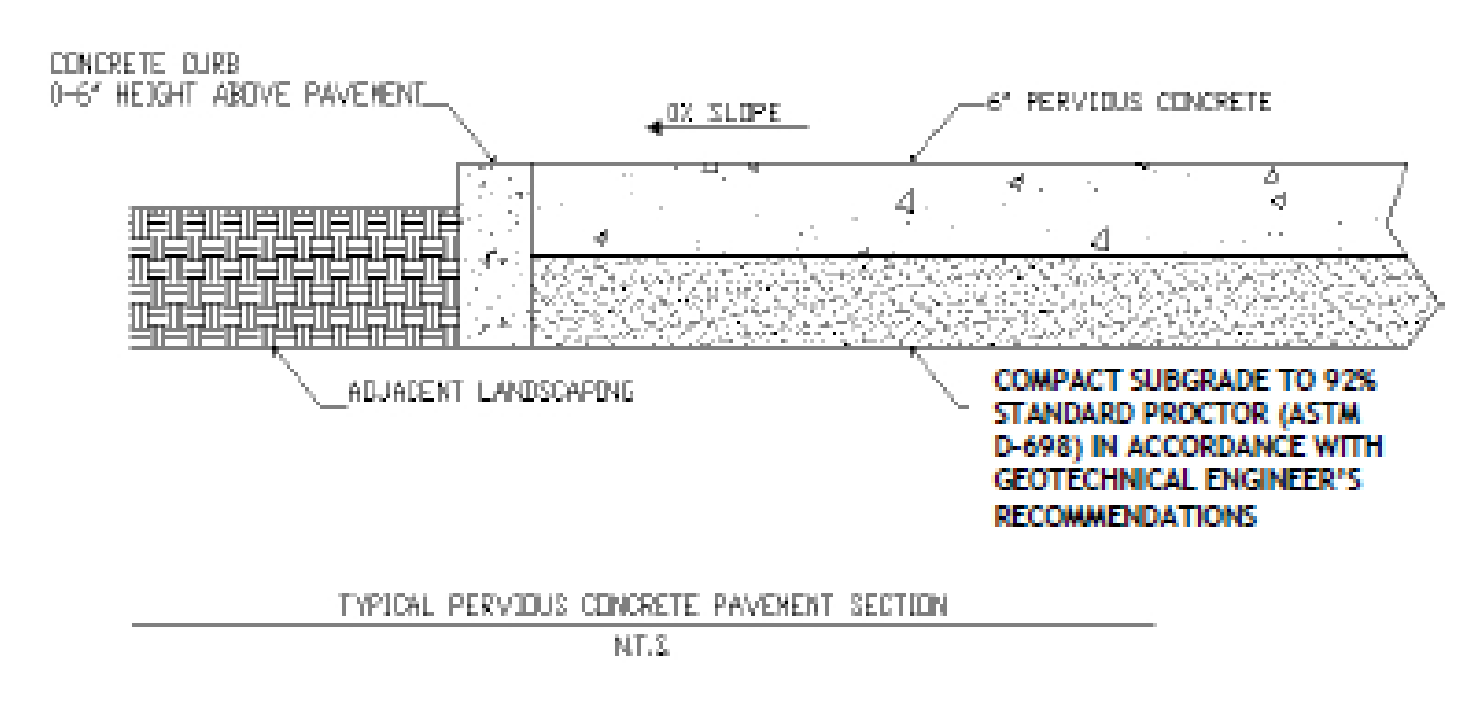
Examples of Porous Asphalt Installations

Pervious Concrete

- ‘No fines’ concrete creates void structure that allowing for quick drainage of water.
- Rigid pavement structure (different from asphalt or pavers which are flexible pavement systems)

Photo from www.perviouspavement.org

Typical Pervious Concrete Cross-Section



from Stormwater Management Academy, UCF (2007)

Materials and Specifications

- Rigid pavement typically requires less base aggregate than other systems for structure.
- Contractor certification and educational programs help promote proper installations.
- Differences from standard concrete:
  - stiff mix so no slump or strength testing
  - cannot be pumped
  - compact in place with vibratory roller
  - cover with plastic while curing

Industry Resources

- National Ready Mixed Concrete Association

  www.perviouspavement.org

- Puget Sound Concrete Specification Council

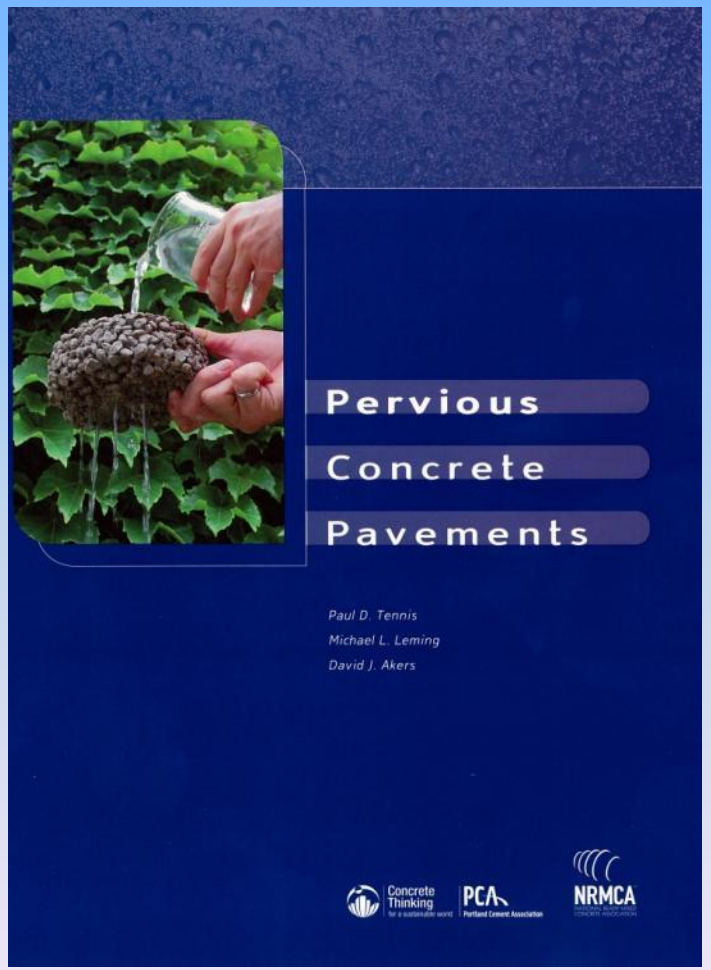
  www.theconcretecouncil.org

- Portland Cement Association

  www.cement.org

  "Pervious Concrete Pavements,"

  product code EB302



Pervious Concrete Construction Sequence

from www.perviouspavement.org

Examples of Pervious Concrete Projects

Examples of Pervious Concrete Projects

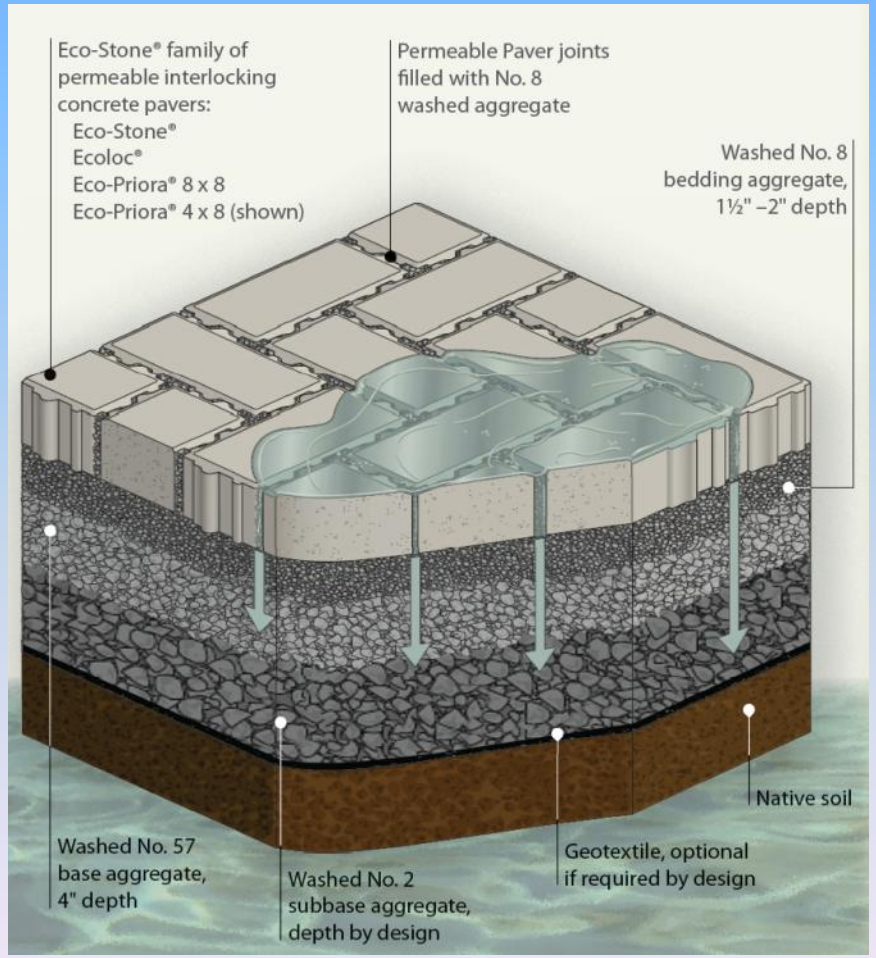
Examples of Pervious Concrete Projects

Permeable Interlocking Concrete Pavements (“PICP”)

- Unlike other systems, the paving stones that comprise the wearing surface of the pavement are not permeable.
- Permeability is achieved through openings in the pavers or the joint spaces between the blocks.
- Structurally, PICP is a flexible pavement (like asphalt)

PICP Cross-Section

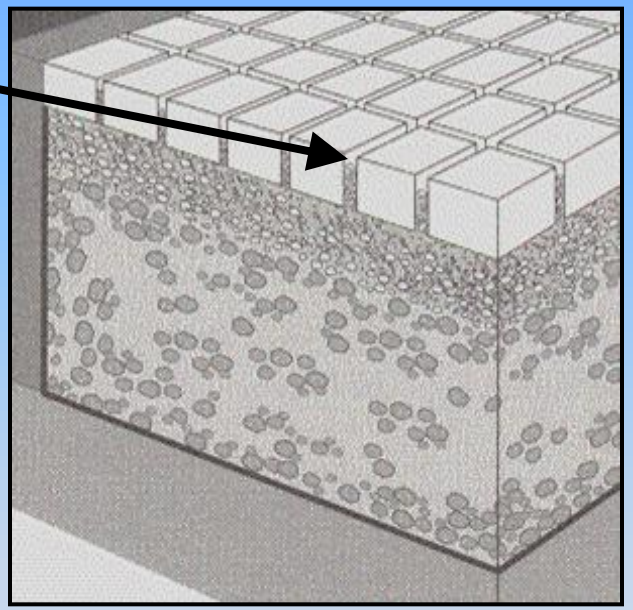
- Permeable paver wearing course
- No. 8 aggregate joint fill
- No. 8 aggregate bedding
- No. 57 'choke' course
- No. 2 reservoir course or 'permeable ballast'
- Geotextile (if required)



Types of PICP

Infiltration Rates --Surface, Joints & Bedding

- Infiltration rate of stone in openings: 300 to 1200+ in./hr
- Open surface area: varies with paver design/pattern, typically from 8% to 18%



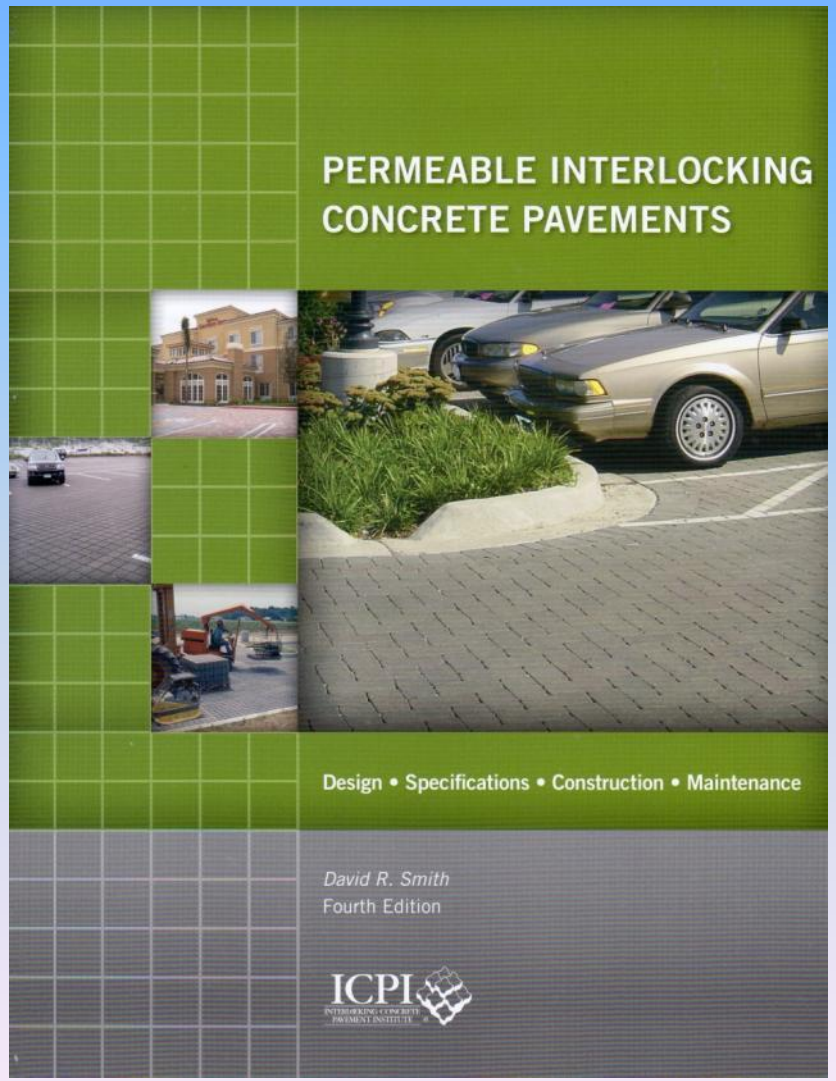
Initial surface infiltration calculation:

1,000 in/hr x 12% open area = 120 in/hr

Industry publication

- Interlocking Concrete Pavement Institute (ICPI)

  www.icpi.org



Construction

PICP Installation

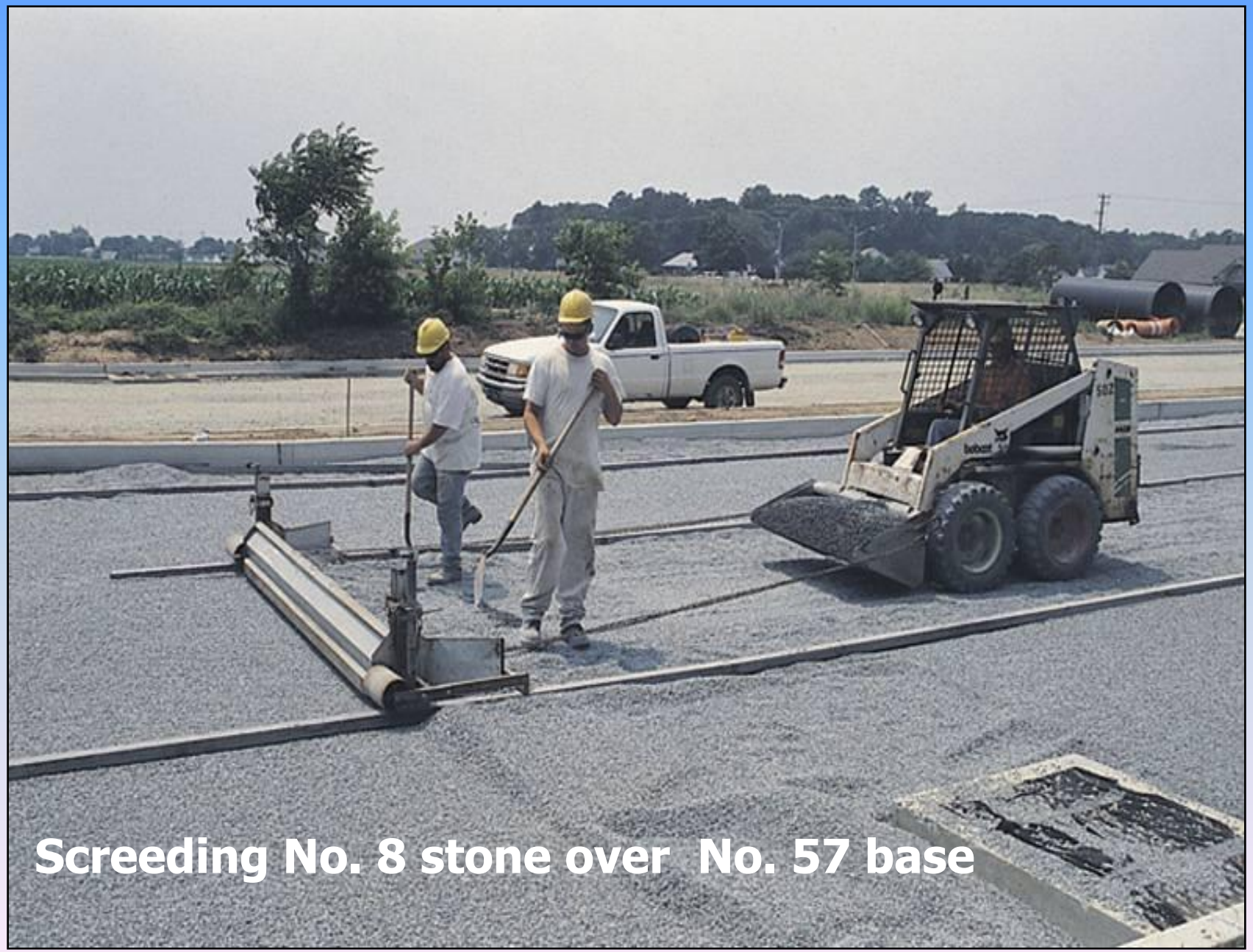
- During excavation, do not compact native soil
- Compacted soil is 30% to 90% less permeable than un-compacted soil

Keep delivery trucks off of native soil

Spreading Base Material

Final grading of base material

Compacting base material


Screeding No. 8 stone over No. 57 base

Mechanical placement

Mechanical Installation

Mechanical installation of PICP can decrease construction time 20-80% over manual installation

Manual paver installation:

1,000 – 2,000 sq. ft. per man per day

Mechanical paver installation:

3,000 – 10,000 sq. ft. per machine per day

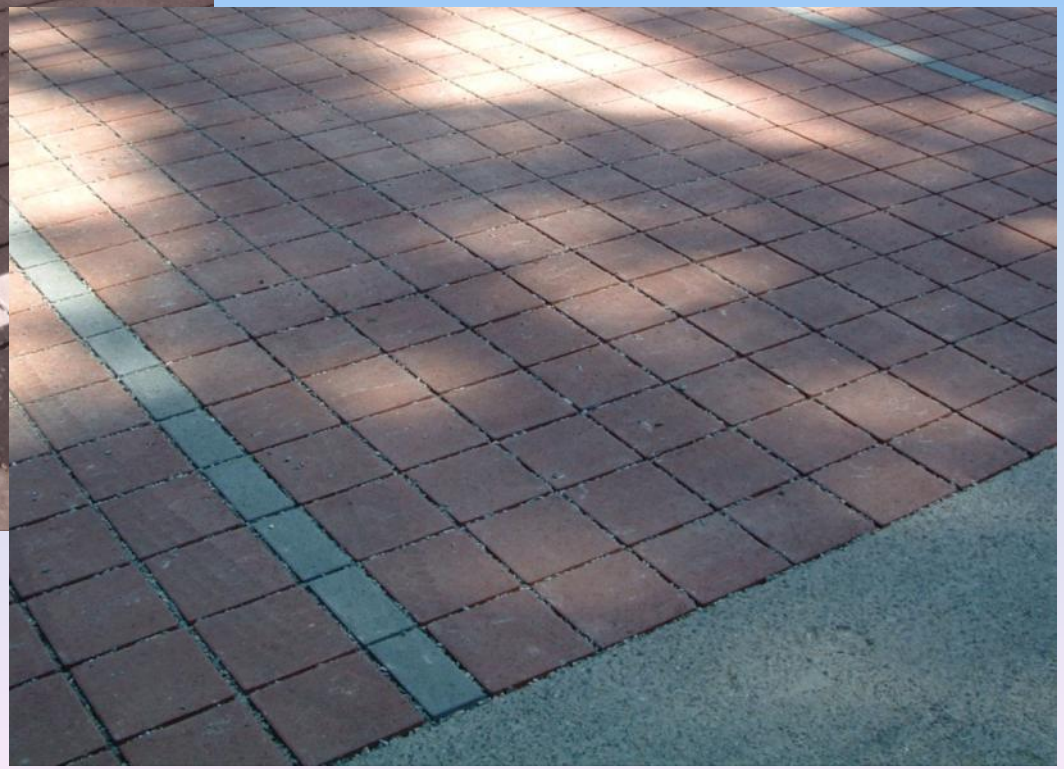
Edge pavers cut and placed, then compacted

Compact before sweeping in aggregate

Filling the openings with No. 8 stone, final compaction

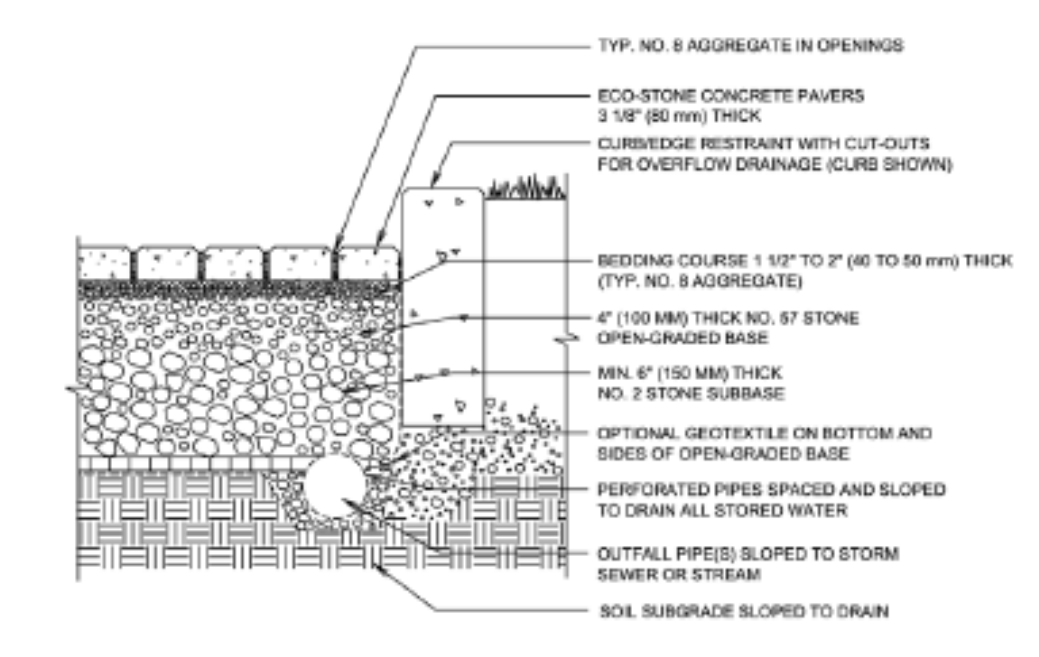
Excess stones removed, then final compaction

Keep sediment away from the permeable pavement



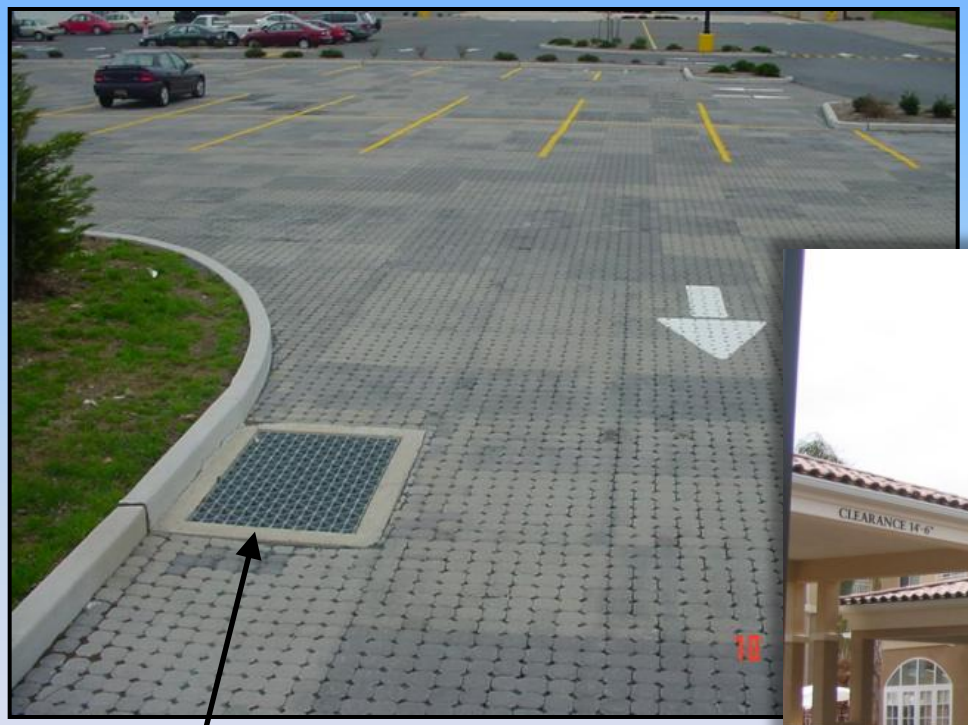
Partial Exfiltration Design Option

- When subgrade infiltration rates are low (less than 0.25 in/hr, consider 'partial exfiltration' design
- Uses perforated pipe 'under-drains to route excess water to outfall



Note: Full flow control credit is not allowed when underdrain systems are utilized.

Design Details



Overflow drain

Drain to grass swale

Maintenance

Annually: overall system performance inspection, check observation well , inspect after major storm, vacuum surface (once, twice, or more) to ensure optimum design life performance

Maintenance checklist (specific to each project)

Model maintenance agreement

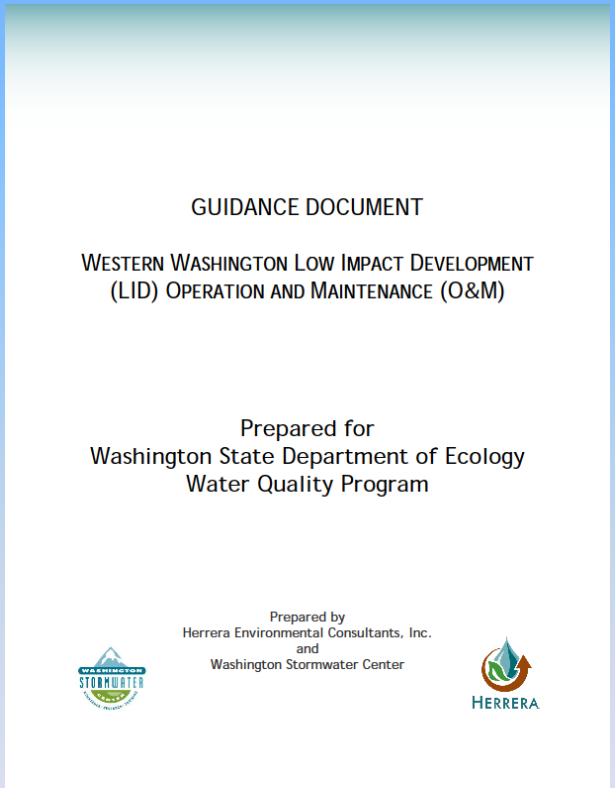
Monitor adjacent uses

Inspection Checklist

Vacuum surface	*1 to 2 times annually, adjust for sediment loading*
Replenish aggregate in PICP joints	*As needed*
Inspect vegetation surrounding pavement perimeter for cover & stability	*Annually, repair/replant as needed*
Check drain outfalls for free flow of water	*Annually and/or after a major storm event*

New Maintenance Document

A new O & M document is available from Ecology…



GUIDANCE DOCUMENT

WESTERN WASHINGTON LOW IMPACT DEVELOPMENT
(LID) OPERATION AND MAINTENANCE (O&M)

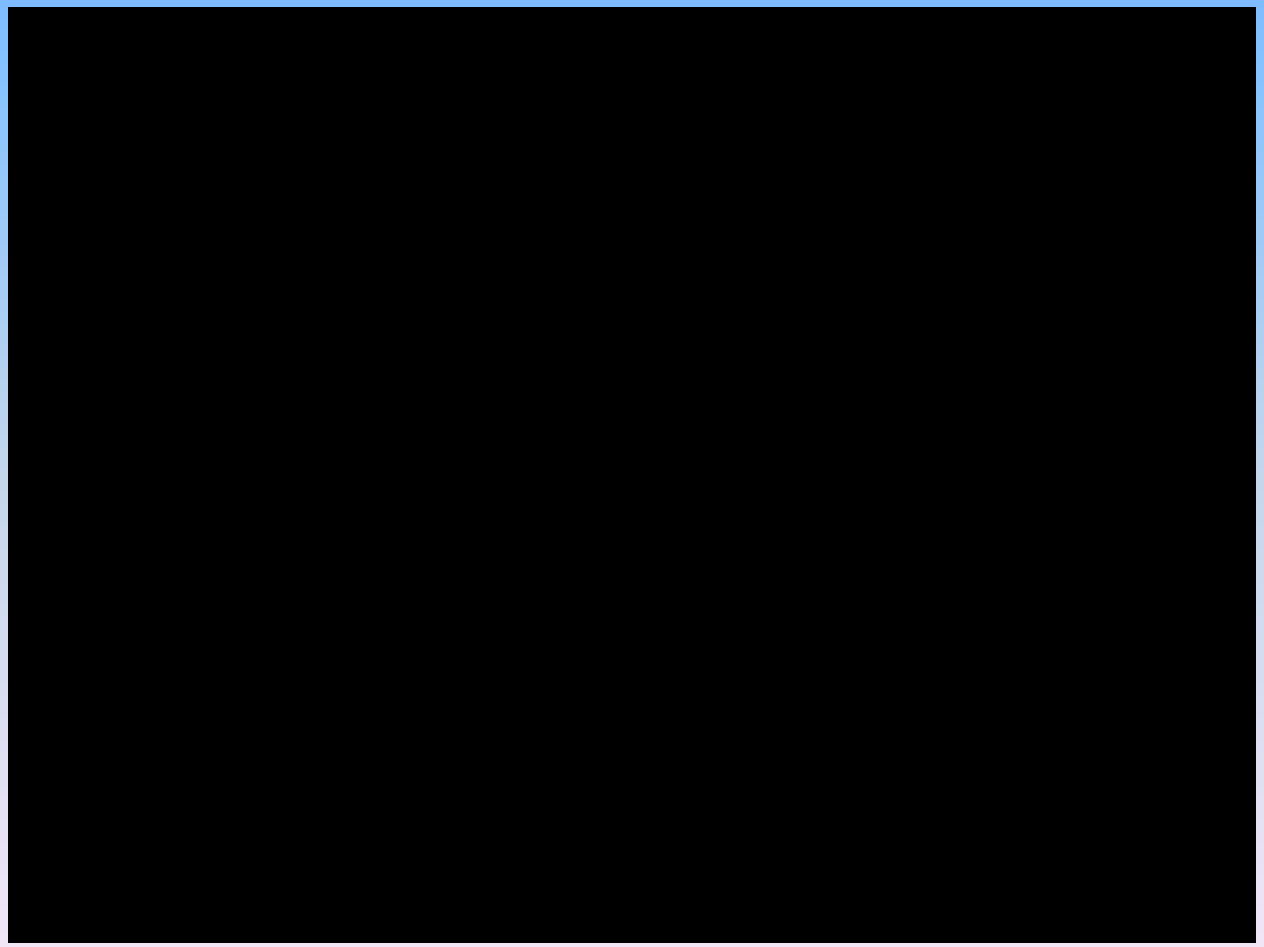
Prepared for
Washington State Department of Ecology
Water Quality Program

Prepared by
Herrera Environmental Consultants, Inc.
and
Washington Stormwater Center

http://www.ecy.wa.gov/programs/wq/stormwater/municipal/LID/TRAINING/OperationsAndMaintenance.html

Maintenance

Restoration Maintenance



Other products available

Grid pavement systems using concrete or other materials

Thank You !

Rick Crooks

Mutual Materials Company

rcrooks@mutualmaterials.com

Direct line: (425) 452-2344

PERMEABLE PAVERS

Acknowledgements

- **Some of the visual information for this presentation came from Stewardship Partners; David Hymel; Erica Guttman and Sharon Collman, members of the WSU Extension Faculty.**

Soils make or break the system

PERVIOUS CONCRETE

THEY ALSO LOOK GOOD

4 years later

THEY ALSO LOOK GOOD

CONCRETE VERSUS ASPHALT

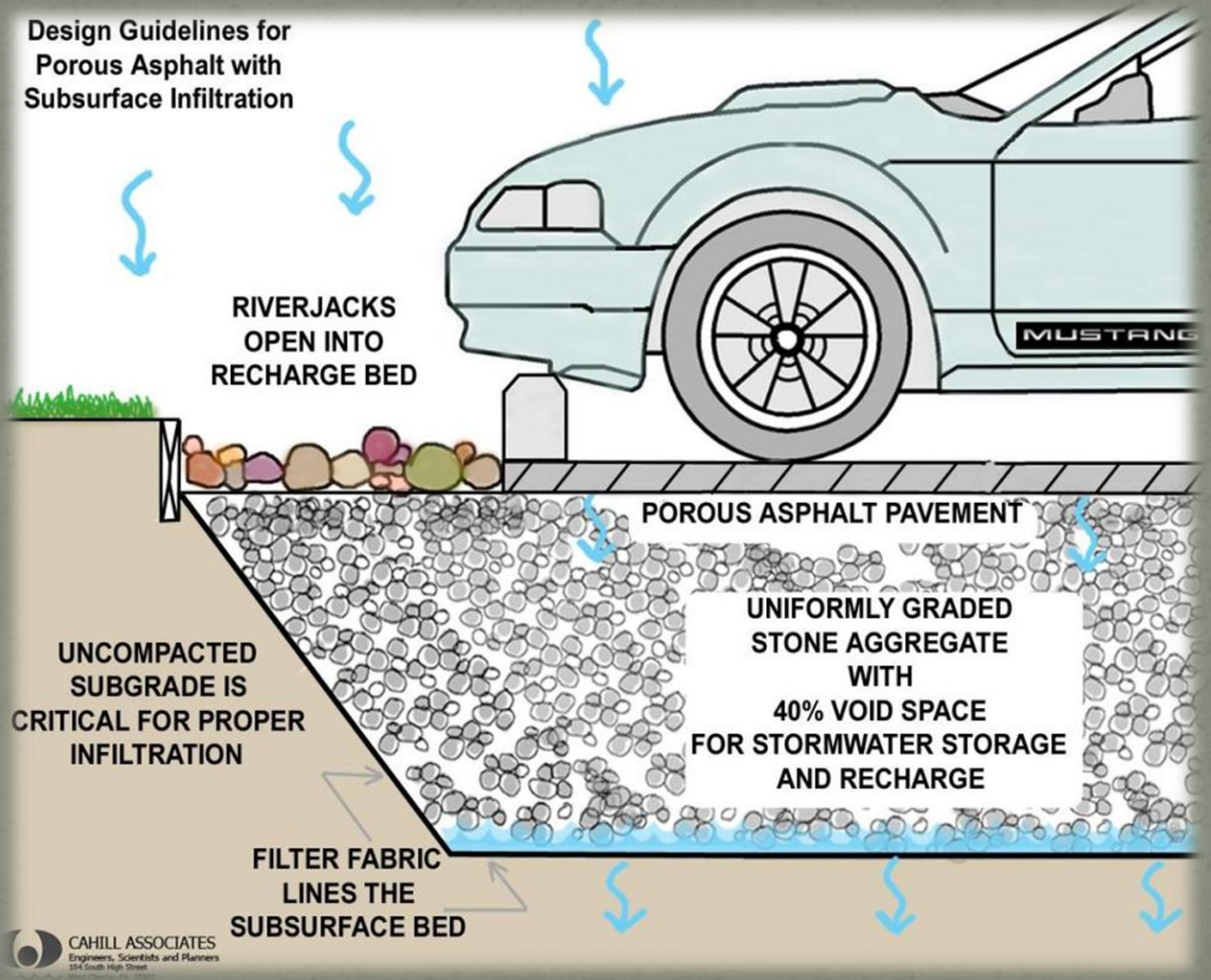
- Installation issues
- Cost per area
- Durability and longevity
- Lifetime performance
- Look and feel
- Short term and long term effects
- Short term and long term benefits
- Maintenance
- End-of-life solutions

NATURAL STONES

Specs are not created equal

- Check with your jurisdiction
- Things change
- Do not depend on old reference material

Always analyze specs



Creativity goes a long way

- Non-engineered projects
- Using specs for similar size pavers, but use flagstones or recycled concrete
- Deep layer of pea gravel up to 10 inches or more, slows walking, provides more exercise and reduces runoff – terrible as a main walking area
- Near steep areas or on heavy clay lots of organic material with steps
- Any size or shape when it comes to area can be utilized

GRAVEL

What retooling?

Material dependent

- May need new tools, new skills, new training, new certification
- Concrete for sure all of the above
- Asphalt new training, certification, skills and some new tools
- Pavers new skills, training, certification helps, no new tools

THE VALUE OF LID

- SPU's Venema Project estimated LID at $410K per block incl. 50 yr maintenance vs $720K per block
- traditional street design $425K per block

  SEA street design $325K per block
- traditional collector street $520K+ vs. Cascade street $285K

THE VALUE OF LID

- Aesthetics
- Property sales
- Attracting mission driven businesses
- A cost saving

Redefining Beauty

- move away from non-indigenous species
- focus on what occurs in nature
- consider what belongs in our environments
- use less ornamentals
- increase function
- improve habitat quality

Business as usual…or not anymore?

- Networking with other landscape professionals
- Networking with engineers
- Networking with suppliers
- New territory; explore and reassess
- For some solutions – open market; requires investment
- Flexibility, creativity, ability to learn are key
- FOR ME: this is who I am what I believe in so there is no other way. I centered my business around this theme. People only contact me if this is what they want.