

Green Streets and Porous Pavement: Lessons for Sustainability, Savings, and Success

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LEARNING OBJECTIVES:

- **SUSTAINABILITY:** (AT LEAST) FIVE TECHNIQUES FOR STREET RUNOFF INFILTRATION
- **SAVINGS:** WHAT TO COMPARE & COSTS
- **SUCCESS:** POST-CONSTRUCTION PERFORMANCE



EVOLUTION OF WATER QUALITY

- 1972 – CLEAN WATER ACT
- 1970s-80s -- INDUSTRIAL POLLUTION TARGETED
- Late 1980's – present – SEWER OVERFLOWS
- Late 1990's – PHASE I TARGETS MS4 POINT/NON
- 2000's – present PHASE II – KEY QUESTIONS:
 - What is Non-Point Source (NPS) Pollution?
 - Will Public Education Take care of NPS?
 - Who can have the biggest impact on NPS?

WALT KELLY

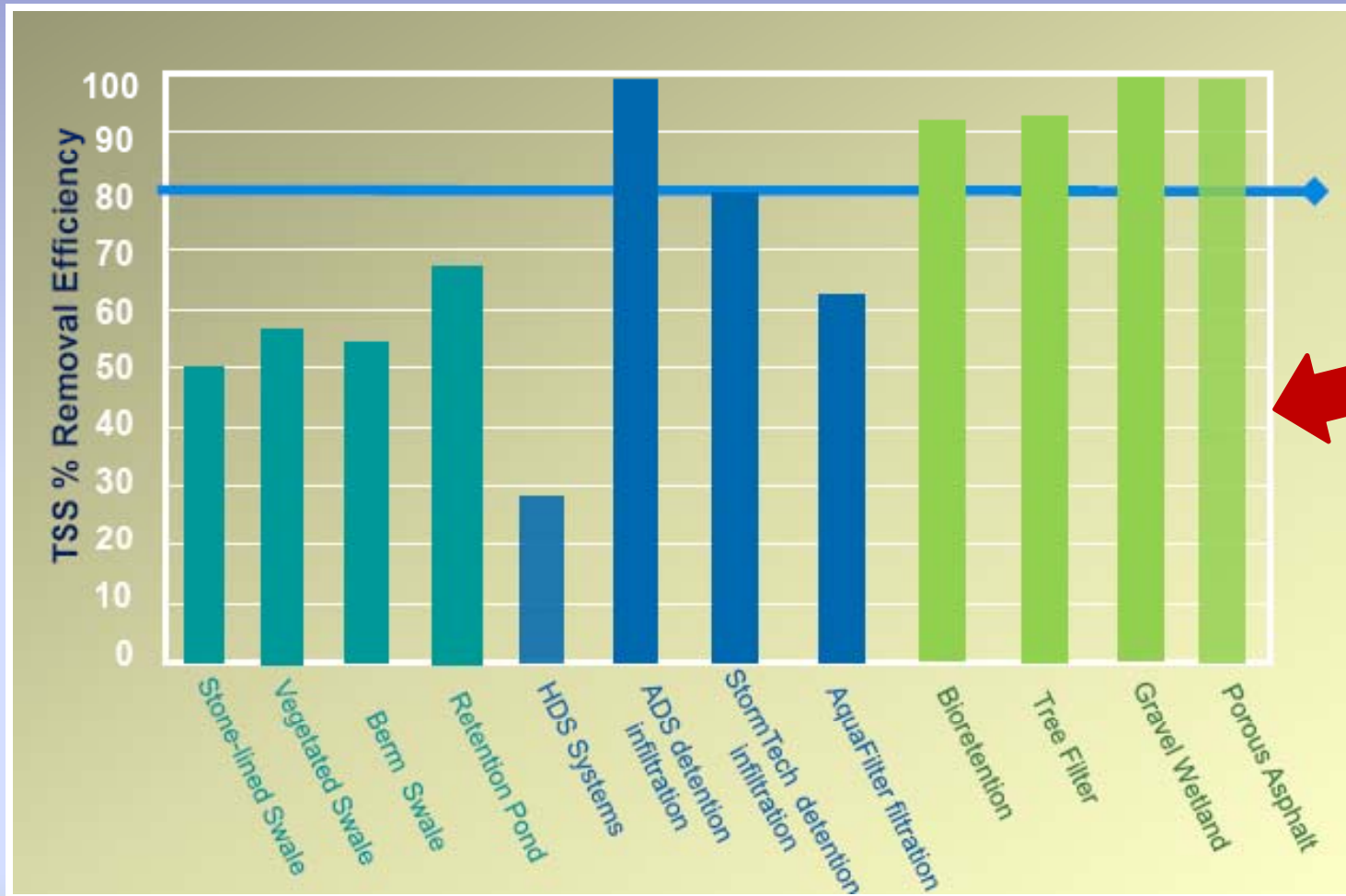
DEBUNKS “NON-POINT SOURCE”

- ANN ARBOR, MI: POP. ~115,000: 27.5+ SQ. MI.
- ROW = 2.9 SQUARE MILES IMPERVIOUS AREA
- =10.5% of total City area
- = 25.9% of the total impervious area within the City of Ann Arbor
- LARGELY UNTREATED!!
- =54% OF NPS POLLUTION – **IT IS US!!**

CITY =54% OF NPS POLLUTION

- HOW TO HANDLE THIS??
- DON'T BUY SWIRL CHAMBERS!!
- OPPORTUNISTIC INFILTRATION
 - CURB NOTCHES/RAINGARDENS, BUMP-OUTS, ETC
 - FIND SAND -- PERFORATED PIPE, CISTERN SHAFTS
 - POROUS BASE UNDER POROUS/PERVIOUS PVMT

TSS Removal Efficiencies



SOURCE: 2005 DATA REPORT, UNH STORMWATER CENTER

Top 5 TSS Removal Efficiencies

- POROUS PAVEMENT– 100%
- GRAVEL WETLAND – 100%
- STORAGE BASIN INFILTRATION– 100%
- TREE FILTER – 93%
- BIORETENTION – 92%

Performance of Porous Asphalt



*Willard Beach Park: Porous vs.
Regular Asphalt
Battle Creek, MI*



*Entrance to Pringle Creek
Community: Porous vs.
Regular Asphalt
Salem, OR*

POROUS vs. REGULAR ASPHALT

PAVER &
TRANSVERSE
JOINTS

POROUS



VS.

REGULAR

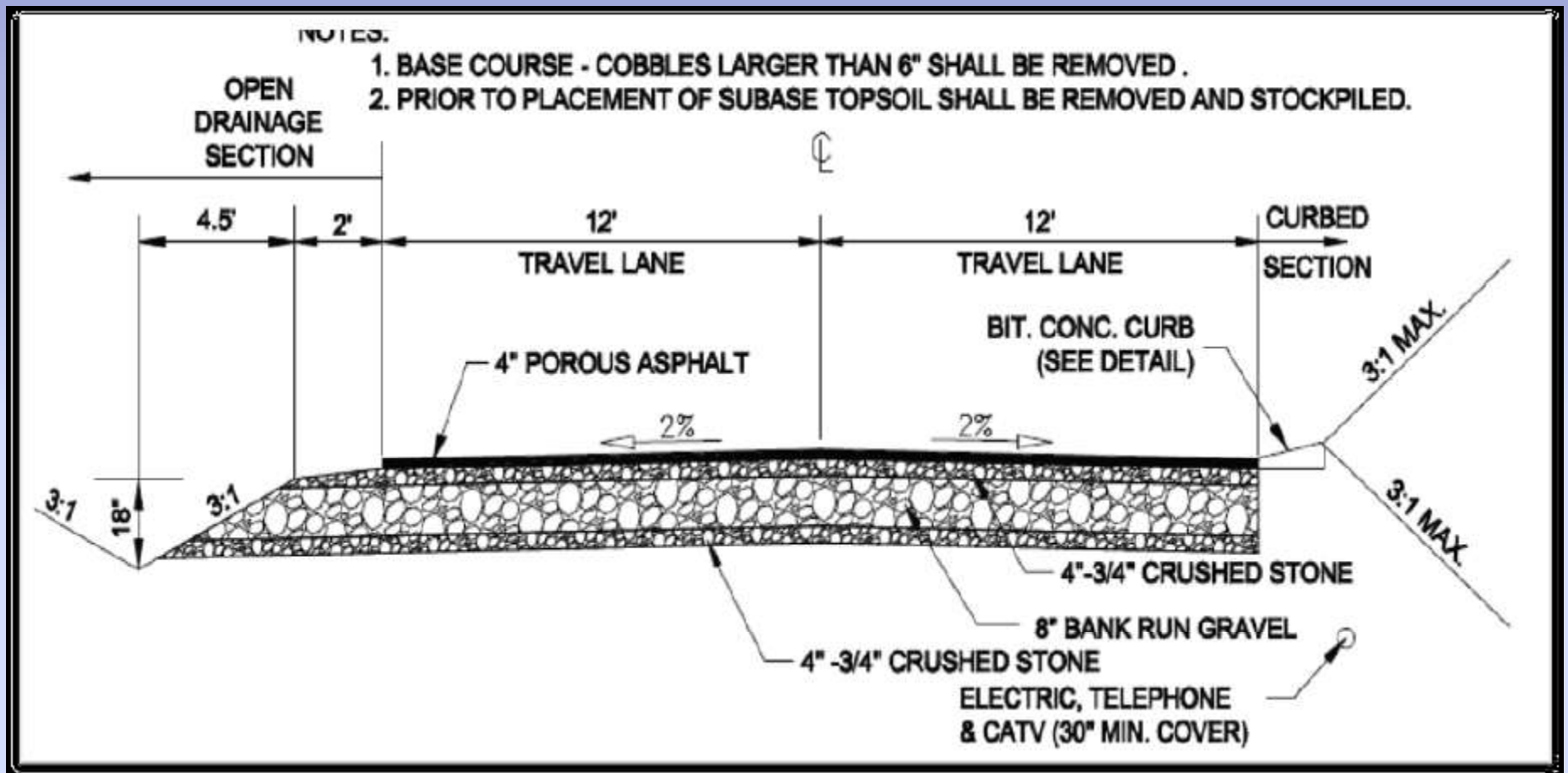


Case Study: Boulder Hills Pelham, NH



- 2009 -- 900' OF PRIVATE RESIDENTIAL PAVING IN NE
- SITE GOAL OF ZERO DISCHARGE
- 55+ ACTIVE ADULT COMMUNITY
- SANDY SOILS (NOT A MUST)

The Design



2009 SMALL PROJECT PAVING COSTS

900 FEET OF RESIDENTIAL PAVEMENT

- HMA \$100/ton (PLACED BY MACHINE)
- PA \$125/ton PLACED BY MACHINE
- COMPLEX/HANDWORK = \$170/ton



SOURCE: Boulder Hills Case Study

COST AVOIDANCE

- 1616' CONCRETE CURB
- 785' PIPE
- 8 CATCHBASINS
- 2 DETENTION BASINS & 2 OUTLET STRUCTURES
- SAVED 1.3 ACRES IN LAND CLEARING/CONSUMPTION
- CONVENTIONAL = \$789,500 vs. LID SWM= \$740,300
- **INFILTRATION COST SAVINGS = \$49,000 = (6.2%)**
- **O/M DISCUSSION LATER – ALSO LESS**

Comparison of Unit Costs

Item	Conventional	LID	Difference
SITE PREPARATION	\$23,200.00	\$18,000.00	-\$5,200.00
TEMP. EROSION CONTROL	\$5,800.00	\$3,800.00	-\$2,000.00
DRAINAGE	\$92,400.00	\$20,100.00	-\$72,300.00
ROADWAY	\$82,000.00	\$128,000.00	\$46,000.00
DRIVEWAYS	\$19,700.00	\$30,100.00	\$10,400.00
CURBING	\$6,500.00	\$0.00	-\$6,500.00
PERM. EROSION CONTROL	\$70,000.00	\$50,600.00	-\$19,400.00
ADDITIONAL ITEMS	\$489,700.00	\$489,700.00	\$0.00
BUILDINGS	\$3,600,000.00	\$3,600,000.00	\$0.00
PROJECT TOTAL	\$4,389,300.00	\$4,340,300.00	-\$49,000.00

Other Project Benefits

- LESS SALTING NEEDED - \$\$ AND ENVIRONMENTAL
- BETTER TRACTION THAN HMA
- SOUND REDUCTION USE BY CALTRANS, OTHERS
- ELIMINATED ICING & CRASHES IN ANDERSON CO, OH
- LESS MOSQUITO BREEDING AREA
- REDUCES THERMAL IMPACT TO STREAMS
- LESS IMPACT OVERALL TO RECEIVING STREAM



PREVENTING PITFALLS OF POROUS

- ✓ KNOW YOUR MIX DESIGN -- MULTIPLE OPTIONS IF LOADING OR RAVELING ARE CONCERNS
- ✓ SUB-BASE COMPACTION IS IMPORTANT TOO
- ✓ CHOKER LAYER IS KEY TO A WORKING PLATFORM
- ✓ NO SANDING FOR WINTER MAINTENANCE!!
- ✓ THE MYTH OF “MORE EXPENSIVE MAINTENANCE”

HOW POROUS O/M IS MUCH LESS



- WHAT IF YOU HAD PAVEMENT THAT NEVER CRACKED?

HOW POROUS O/M IS MUCH LESS



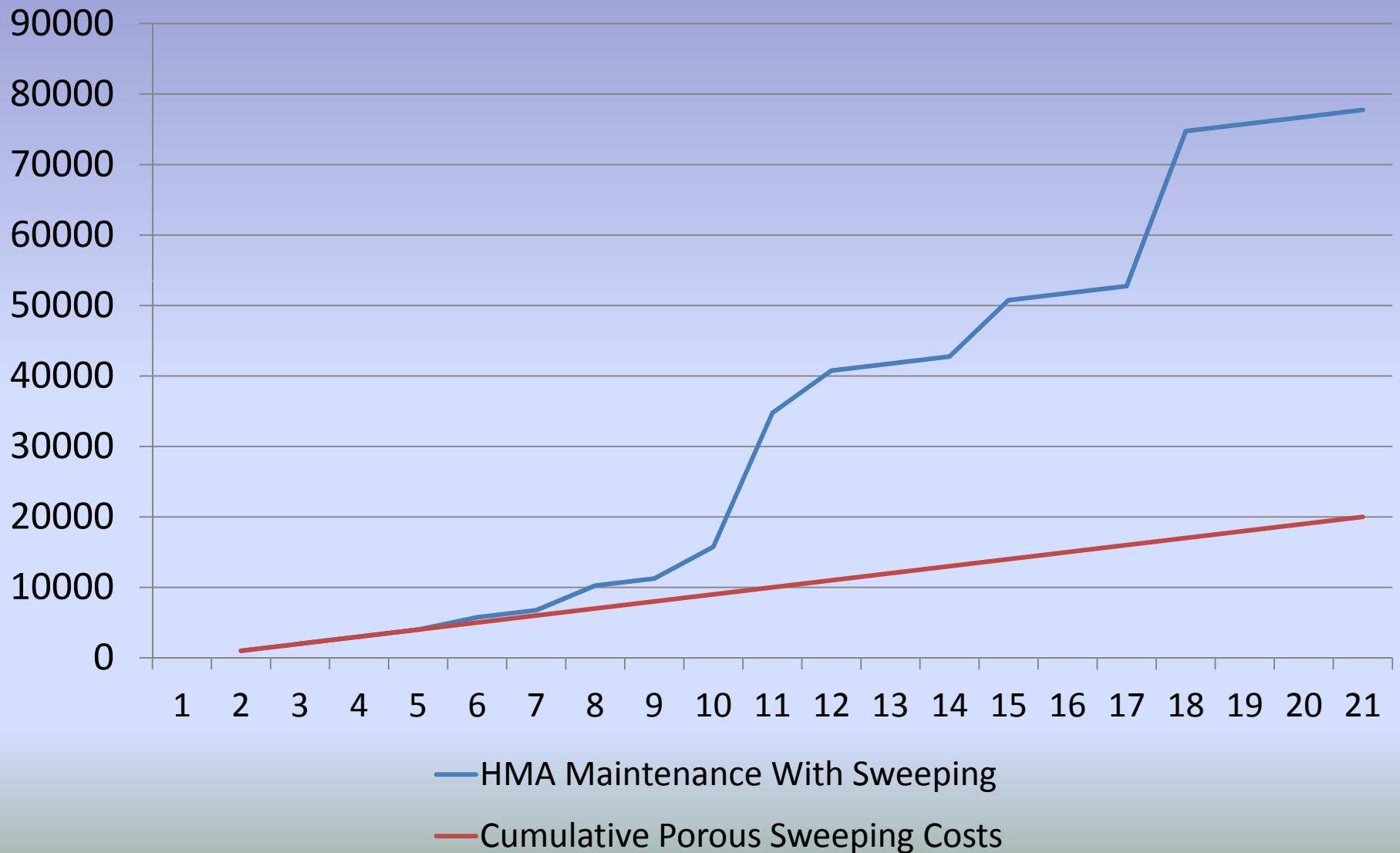
...AND IS SUPPOSED TO HAVE WATER IN THE BASE

HOW POROUS O/M IS MUCH LESS



- WHAT IF YOU HAD PAVEMENT THAT NEVER CRACKED?
- AND PAVEMENT THAT DIDN'T FAIL DUE TO WET BASE?
- WHO IS UNDER AN NPDES PERMIT?
- SWEEPING COSTS ARE ACTUALLY SIMILAR
- A MILE OF POROUS CAN COST **\$57,750 LESS IN O/M**

HOW POROUS O/M IS MUCH LESS



HOW POROUS O/M IS MUCH LESS

- *\$57,750/MILE HMA PAVEMENT MAINTENANCE COSTS
 - YEAR 0-4 – NO COSTS
 - YEAR 5: FIRST CRACK SEALING; \$750
 - YEAR 6-10: LIMITED PATCHING; \$6,000 (\$2,000/LANE MILE)
 - YEAR 6-10: 2ND CRACK SEAL; \$3,000, CHIPSEAL; \$15,000
 - YEAR 10-15: 3RD/4TH CRACK SEAL; \$12,000
 - YEAR 16-20: MAJOR PATCHING, POSSIBLE SEALCOAT; \$21,000
 - 4x ANNUAL STREET SWEEPING, \$1,000/YR--IF PERMIT REQ'S.

*YOU MAY WISH TO REVISE COSTS BASED ON YOUR AGENCY PRACTICES

BASED ON 20 YEAR CYCLE FOR 1 MILE RESIDENTIAL STREET WITH 36' PAVEMENT WIDTH

HOW POROUS O/M IS MUCH LESS

- **POROUS PAVEMENT MAINTENANCE COSTS:**
 - 2x ANNUAL STREET SWEEPING, \$1,000/YR REGEN VACUUM
 - NO CRACK SEALING
 - NO PATCHING DUE TO FROST HEAVE OR BASE FAILURE
 - NO RESURFACING DUE TO CRACKING, ETC
- **TOTAL LIFE CYCLE COST SAVINGS:**
 - **\$57,750** IF STREET SWEEPING IS DONE ON HMA ANYWAY
 - **\$37,750** IF NO HMA STREET SWEEPING

BASED ON 1 MILE RESIDENTIAL STREET WITH 36' PAVEMENT WIDTH

REPAIRS AND REPLACEMENT



- UTILITY CUTS, OTHER PATCHING NEEDS
- BASE FAILURES TYPICALLY RARE – BETTER BASE
- CAN REPAIR WITH REGULAR HMA
- CAN REPAIR BY HEATING AND RE-ROLLING
- TO REPLACE – MILL TO CHOKER COURSE

INFILTRATION TOOLKIT:

1. POROUS MIX DESIGNS ARE NOT ALL THE SAME
2. HMA WITH PAVERS OR POROUS IS AN OPTION
3. INFILTRATION UNDER TRADITIONAL HMA



Easy Street, Ann Arbor, MI

INFILTRATION TOOLKIT #1:

- MIX DESIGN IS IMPORTANT (STRENGTH & DURABILITY GOALS) – AZ-87 30,000vpd
- KEY VARIABLES:
 - AGG SIZE
 - FIBER/ADDITIVE
 - ASPHALT CONTENT
- SEE RESOURCES 1 & 2 FOR MIX **DESIGN** INFO – WASHINGTON DOT, UNH

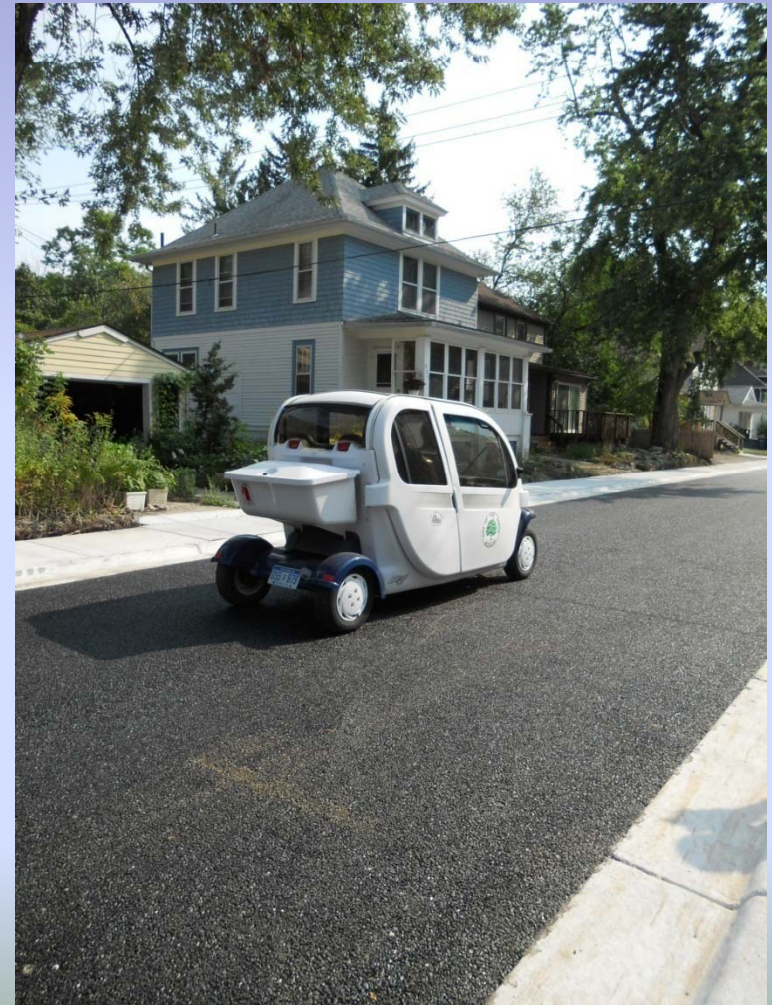
TOOLKIT #1: SYLVAN AVE, ANN ARBOR, MI

- Reconstructed in 2010
- Approx. 825' long; and 20' wide.
- Scope: Full reconstruction; full replacement of sidewalks, curb & gutter; construction of permeable HMA section; some infiltration at east 200' of project, but remainder had an impervious line to prevent flooding of adjacent basements; installation of underdrains below sidewalks with tees to allow connection of sump pumps from individual properties.
- Construction Cost: \$385,000

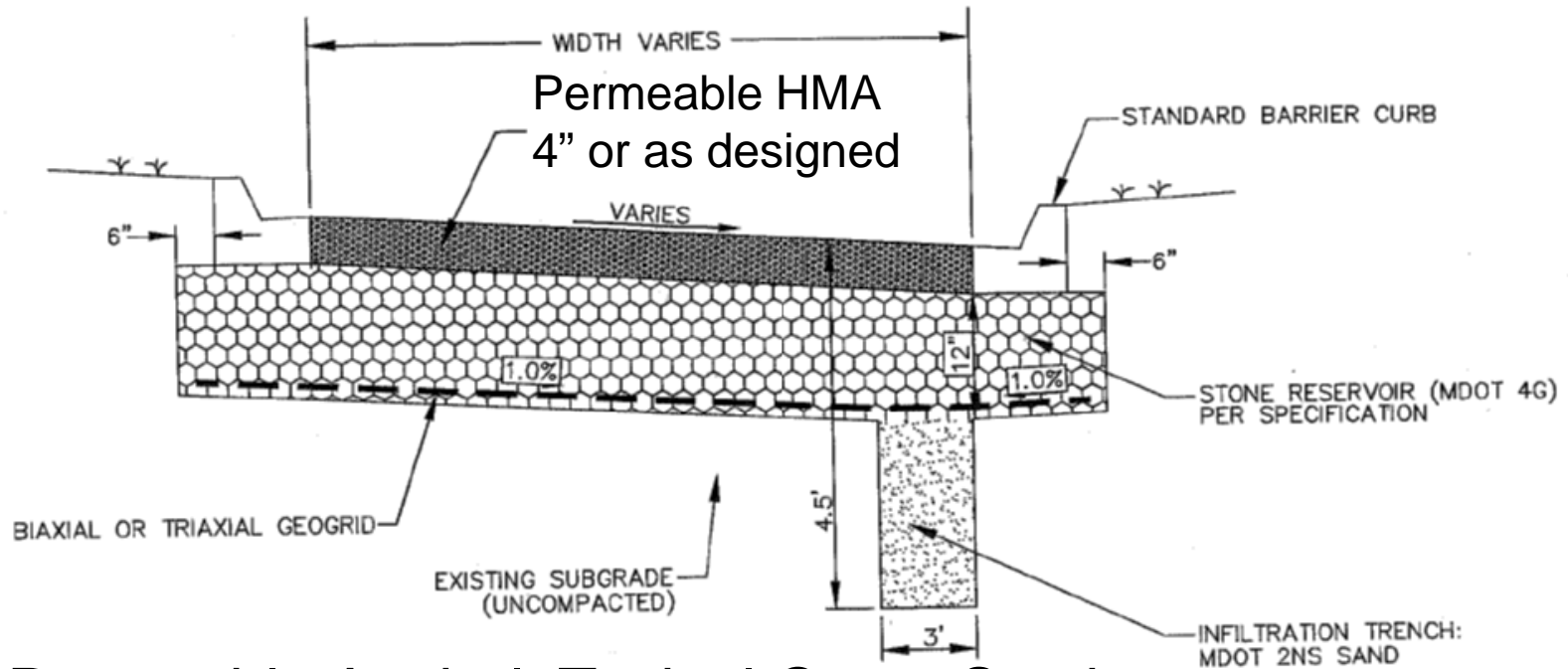
TOOLKIT #1: SYLVAN AVE, ANN ARBOR, MI



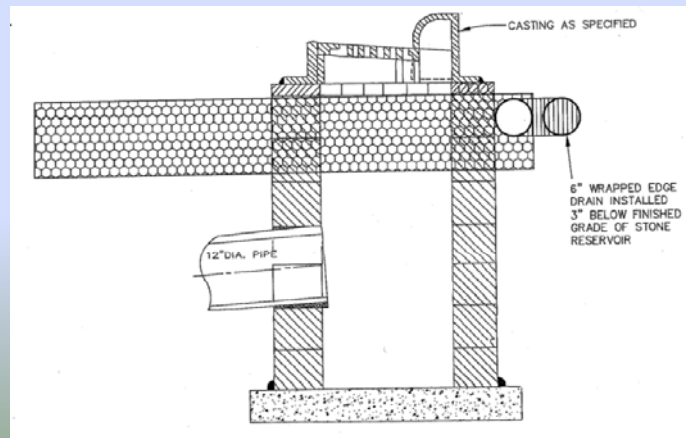
INFILTRATION TOOLKIT #1:



INFILTRATION TOOLKIT #2:



Permeable Asphalt Typical Cross Section



INFILTRATION TOOLKIT #3: NO POROUS PAVEMENT

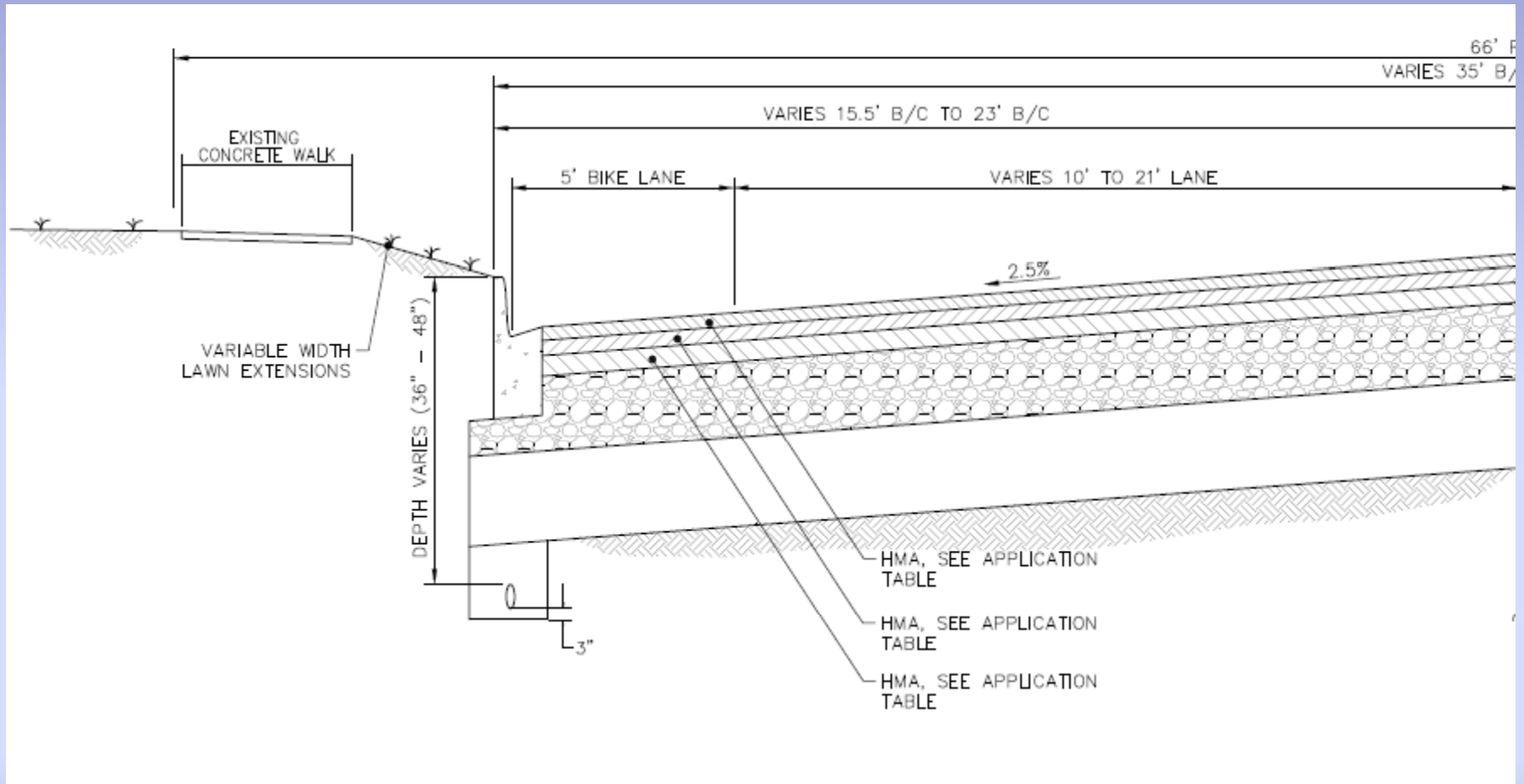
- CITY OF ANN ARBOR, MI 2013 INFILTRATION PAVING
- TRADITIONAL HMA WITH SITE-SPECIFIC BASE INFILTRATION

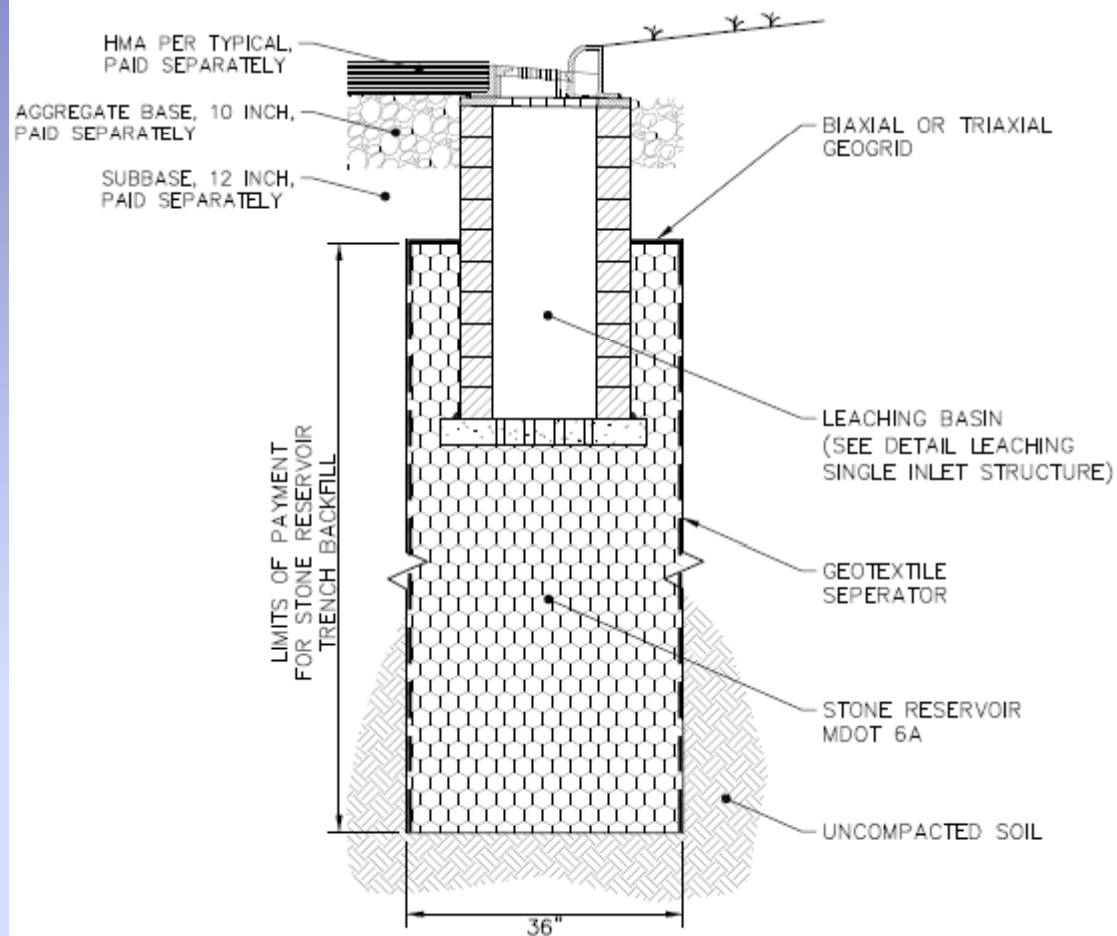
–**FOREST STREET**

–**FOURTH AVENUE**

–**MADISON STREET**

West Madison Street Cross Section





NOTE: DENSITY TESTING PER CITY ANN ARBOR
STANDARD SPECIFICATIONS

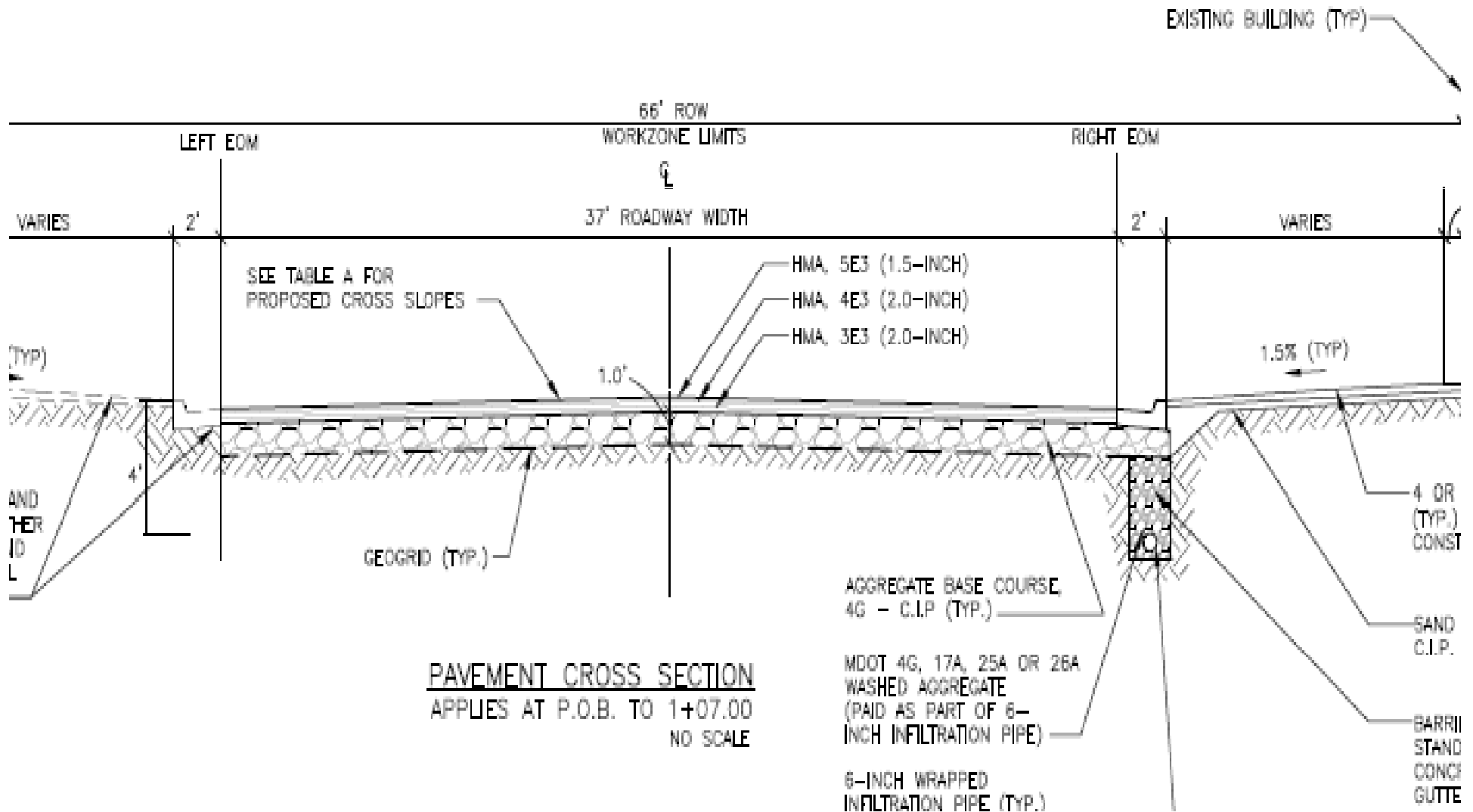
NOTE: TRENCH DETAILS SHOW TYPE
OF BACKFILL ONLY

NOTE: ALL TRENCHING TO CONFORM
TO ALL APPLICABLE M.I.O.S.H.A.
STANDARDS

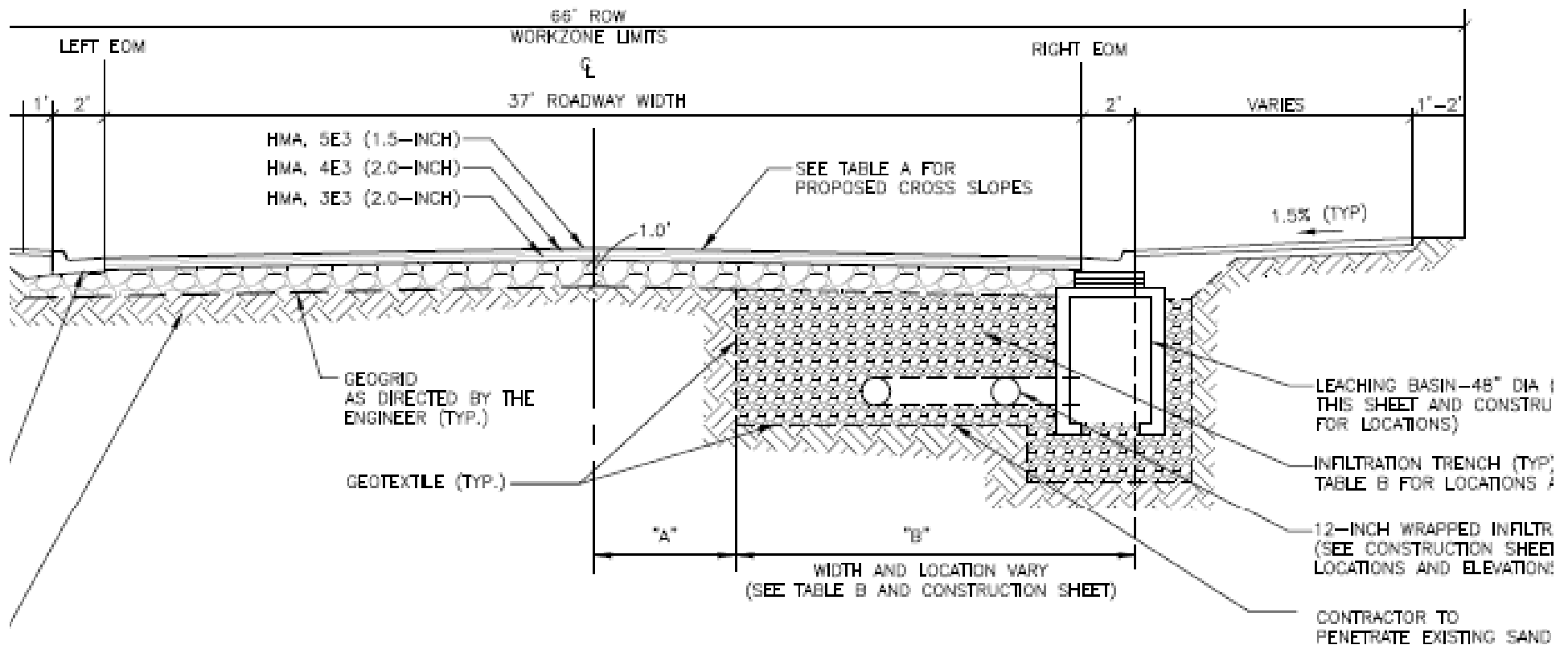
NOTE: SUBBASE, AGGREGATE BASE AND HMA
PAID SEPARATELY

STONE RESERVOIR TRENCH DETAIL

FOREST STREET X-SECTION 1

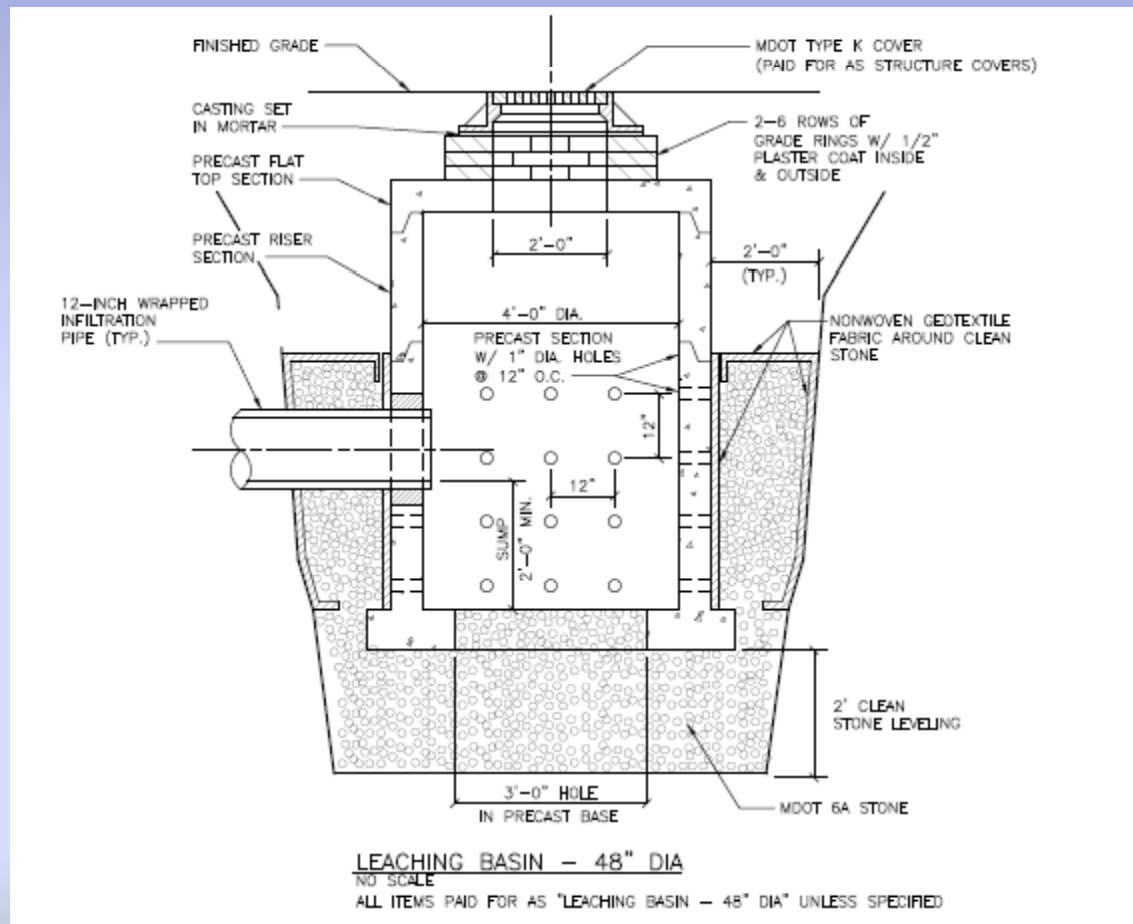


FOREST STREET X-SECTION 2

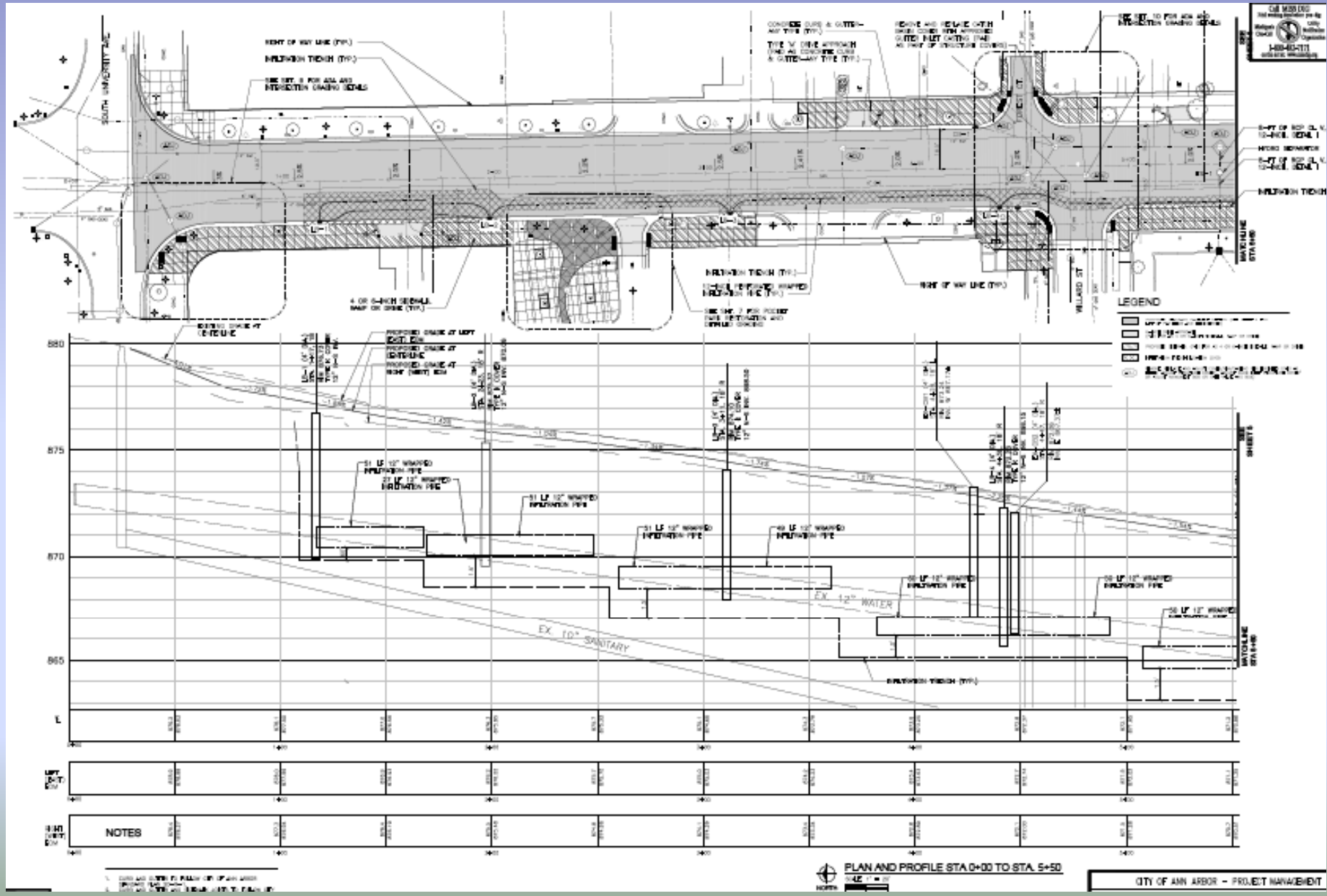


PAVEMENT CROSS SECTION
 APPLIES AT STA 1+07.00 TO P.O.E.
 NO SCALE

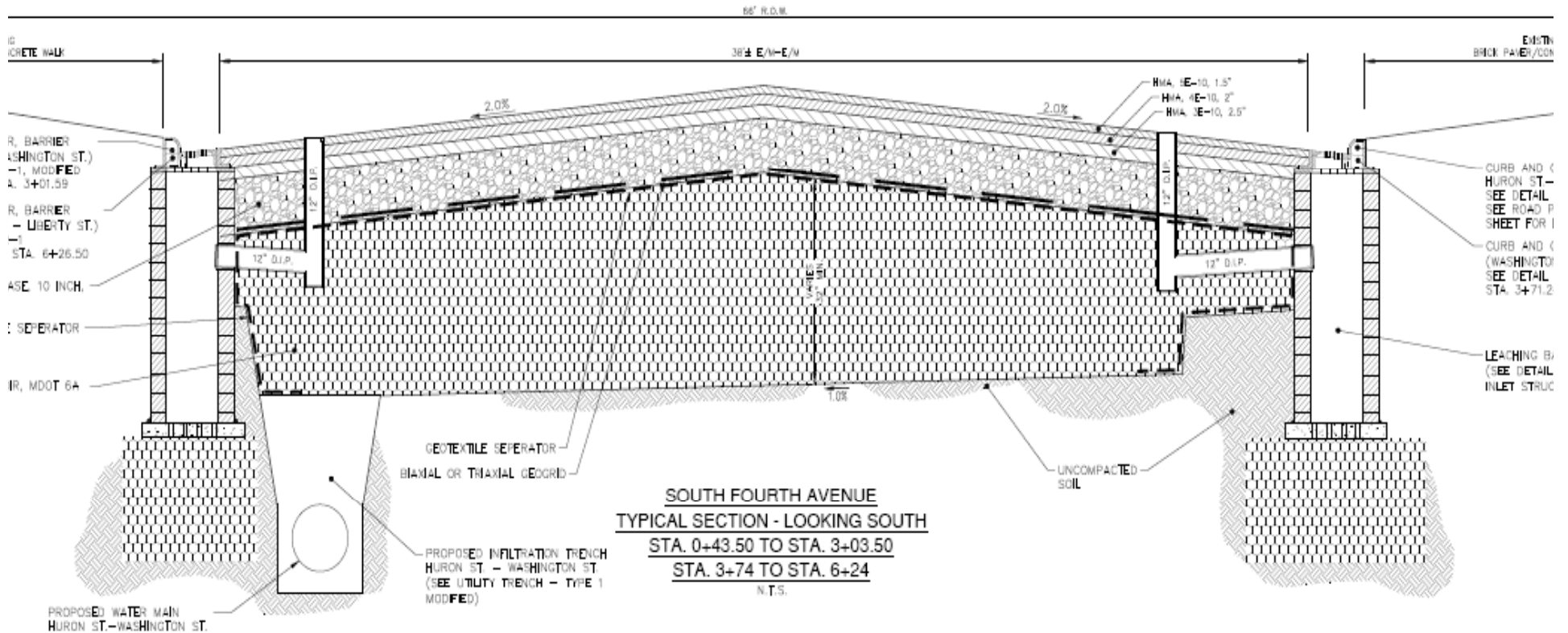
FOREST STREET LEACHING BASIN



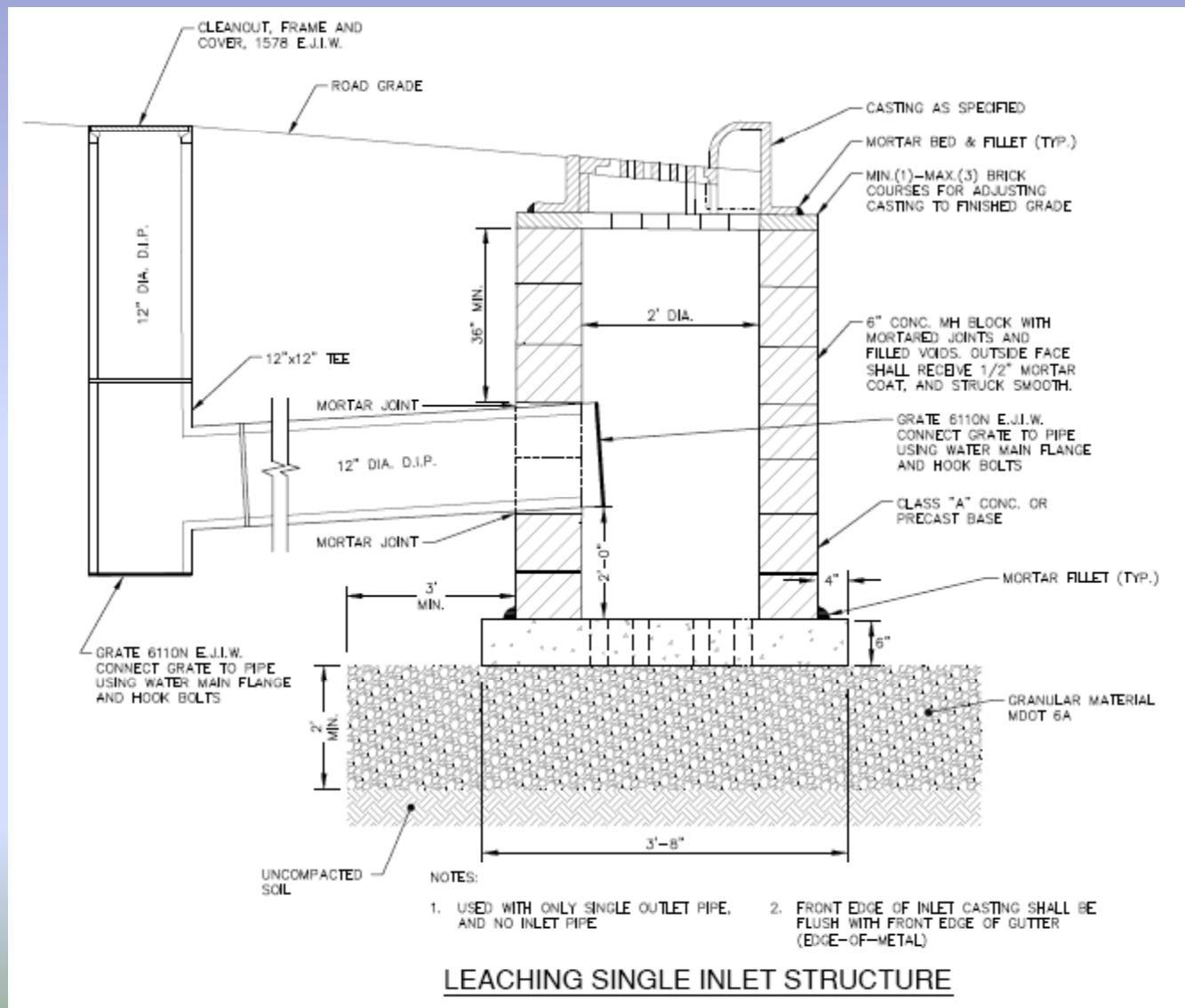
FOURTH AVE. PLAN AND PROFILE



FOURTH AVE. X-SECTION 1



FOURTH AVE. LEACHING BASIN



INFILTRATION TOOLKIT #3: NO POROUS PAVEMENT

- HMA PAVEMENT WITH POROUS BASE
- STRATEGIC INFILTRATION AREAS IN ROW

Curb & Gutter vs. Swales



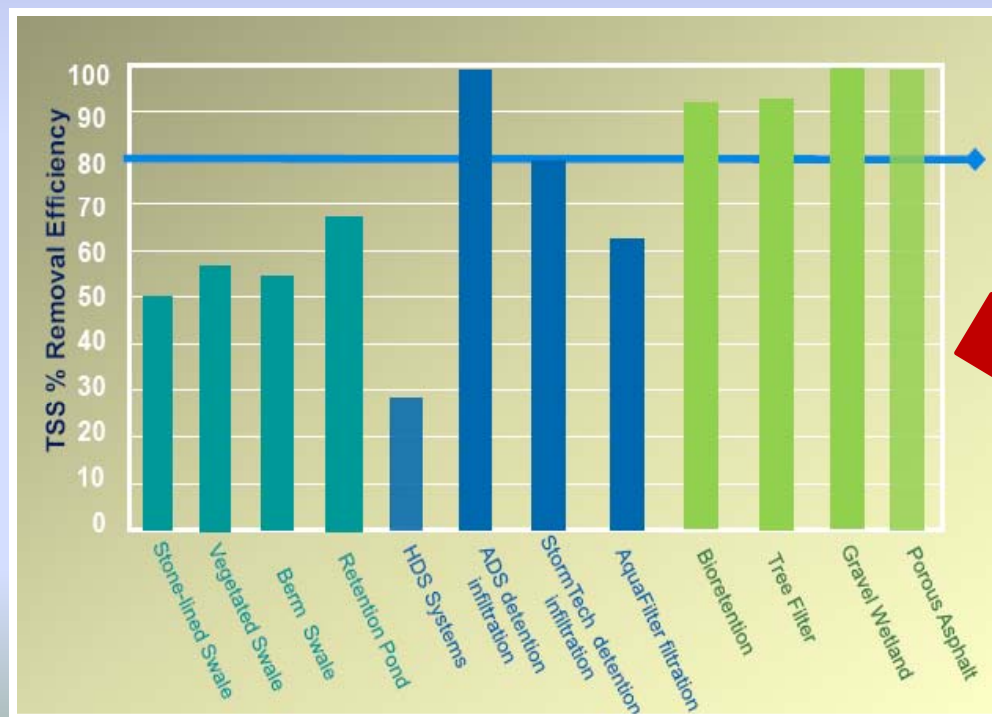
Street Trees and Planter Design

- Tree planting areas often too small
- Tree planting areas typically raised
- Can be lowered to accommodate stormwater
- Many design alternatives



IN CONCLUSION...

- UP TO 54% OF POLLUTANTS FROM STREETS
- INFILTRATION IS BEST, MOST SUSTAINABLE
- MANY OPTIONS FOR INFILTRATION



Acknowledgements



**Thank you to the City of Ann Arbor and the
University of New Hampshire Stormwater
Center for their support.**



References/Resources



- *Porous Pavement Presentation*, City of Puyallup, WA– Resource 1 under this session number on the conference website. Extra focus on mix design and aggregate selection for asphalt, choker, and base courses.
- Roseen Robert, Thomas Ballestro, et al. *Sustainable Stormwater Management in Road Environments: Porous Asphalt for Local Roads* (2010). Accessed 1 Apr. 2013. (University of New Hampshire Stormwater Center, Resource 2 under this session number on the conference website, or at <http://www.dot.state.oh.us/engineering/OTEC/2010/Presentations/23A-Roseen.pdf>)
- City of Ann Arbor. *Willard Street Permeable Pavement Project* (2012), *Madison, Fourth, and Forest Paving Projects* (2013). **(734) 794-6430**
- Resource 3 under this session number on the conference website includes a detailed listing of contacts at agencies that have porous pavement installations, and other helpful resources accessed for this presentation.