28th Annual Environmental Permitting Summer School

Low Impact Development
(July 23, 2014)

Stephen M. Suau, P.E.
Fruitville @ i75 – Infill Project
Fruitville @ i75 – Infill Project

Sarasota Bay Watershed

LEGEND
- Watershed
- 1847 Government Land Office Plats

HYDRIC SOILS
- Pine Flatwoods
- Hammocks
- Scrub Flatwoods
- Freshwater Wetlands
- Tidal Marsh Wetlands
- Spoils
- Water
Fruitville @ i75 – Infill Project
Fruitville @ i75 – Infill Project
Celery Fields

Diversion Structure 1

Discharge Structure 1

Discharge Structure 2
Return of Wildlife Resources

- Listed of the Florida birding trail
- Over 200 species have been counted
- 14 breeding species - including 2 endangered - Bald Eagles and Least Terns
Historical Resources

- Fossils
- Indian canoes
Fruitville @ i75 – Celery Fields

Approved 400 Acre Park

Wide support for Celery Fields Natural Area Passive Recreational Plan
Fruitville @ I75 – Infill Project

Existing Land Use Designation – Major Employment Center

Celery Fields is also a Regional Floodplain Storage Area
Fruitville @ i75 – Planning

• Six MEC property owners including County

• Celery Fields public asset (Regional Floodplain Compensation) leveraged to coordinate planning with private MEC properties

• Public & private MEC property owners have been working together for 5 years
Fruitville @ i75 – Water Goals

✓ Showcase LID at the site level
✓ Utilize regional stormwater to meet floodplain management needs
✓ Provide for state of the art water conservation and efficiency
✓ Harvest stormwater to offset water demands (and reduce pollutant loads)
Fruitville @ i75 – Water Quality

• EPA TMDLs:
  70% reduction for TN & TP

• FDEP: Unable to link low DO violations to nutrients
  Delisted for nutrients.

• EPA Numeric Nutrient Criteria (NNC):
  TN = 1.65 mg/L
  TP = 0.49 mg/L
Fruitville @ i75 – Water Quality

Existing Land Use = Pasture
Area = +200 acres
Average annual runoff = 18”

TN conc. = 2.48 mg/L
TP conc. = 0.70 mg/L

Est. Average Annual TN Load = 2068 lbs/yr
Est. Average Annual TP Load = 571 lbs/yr
Fruitville @ i75 – Water Quality

Proposed Land Use = HIC Area = +200 acres
Average annual runoff = 42”

TN conc. = 2.48 mg/L
TP conc. = 0.23 mg/L

Est. Average Annual TN Load = 4721 lbs/yr
Est. Average Annual TP Load = 438 lbs/yr
LID Best Management Strategies

- Stormwater Landscapes
- Pervious Pavement
- Stormwater Harvesting
- Green Roof
Fruitville @ i75 – LID Opportunities

• Only need to provide for stormwater treatment - Floodplain/attenuation provided in regional facility

• Elevation - Sites will have 7.5 ft. from finished grade to Control Water Level

• No wetlands/high water table restrictions

• Land Use – Urban land use designation and form provides value proposition
LID – Across the Transect

LEGEND:
Primary purpose of LID technology:
\( wq \) = water quality
\( v \) = volume
\( pr \) = peak reduction
LID Streets - Pervious Pavers
LID Streets – Pervious Pavers
LID Walkway – Pervious Pavers
LID Walkway – Pervious Pavers
LID Walkway – Pervious Pavers
LID - Stormwater Harvesting
LID Buildings - Green Roof
Fruitville @ i75 – Water Quality

Gross Load = 4,721 lbs/yr
Reduction = 3,008 lbs/yr
Net Load = 1,712 lbs/yr

Exist. Load = 2,023 lbs/yr

Estimated TN Load Reductions from:
Stormwater Harvesting = 1,511 lbs/yr
Green Roofs @ 10% = 441 lbs/yr
Pervious Pavement @ 20% = 1,057 lbs/yr
Fruitville Urban Infill Plan
Fruitville Urban Infill Plan w/LID Overlay
Fruitville @ i75 – LID Next Steps

• Develop LID Design (Public Works) Standards

• Link Design Standards to Science

• Create Dashboard Menu

• Establish Permit Criteria w/WMD
LID Design (Public Works) Standards
LID Design (Public Works) Standards

MINIMUM PAVEMENT THICKNESSES

<table>
<thead>
<tr>
<th>PAYMENT ITEM</th>
<th>CLASS A</th>
<th>CLASS B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6&quot;</td>
<td>8&quot;</td>
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<tr>
<td>2</td>
<td>4&quot;</td>
<td>4&quot;</td>
</tr>
<tr>
<td>3</td>
<td>6&quot;, SEE NOTE 5</td>
<td>12&quot;, SEE NOTE 5</td>
</tr>
<tr>
<td>4</td>
<td>4&quot;</td>
<td>4&quot;</td>
</tr>
</tbody>
</table>

Class A: Alley, Parking Lane, Local Street Class B: Collector or Arterial (not currently allowed)

NOTES:
1. Detail to be used only when approved by ODOT RM&G and shall meet current approved ODOT specification for "Pervious Portland Cement Concrete Pavement".
2. Aggregate layers shall meet current approved ODOT specification for "Aggregates for Permeable Pavement and Bioretention".
3. See ODOT No. 621.10 for longitudinal and cross slope requirements.
4. Waterproof membrane to be used to promote water re-use protect nearby building foundations and avoid infiltration around utilities. See design plans.
5. Depth of reservoir layer as shown on design plans should be sized to address stormwater management and conveyance requirements, and pavement structural design.
6. Enhanced design contains a water storage layer and an infiltration sump beneath the underdrain sized to drain the design storm within 48 hours.
7. When filter layer is omitted, provide geotextile class I material beneath reservoir layer meeting current approved ODOT specification for "Geosynthetics for Stormwater Facilities".
8. Bottom of permeable pavement structure shall be at least 2" above the seasonal high water table or bedrock, as determined by geotechnical investigation.
9. Top of pavement should be designed to achieve 1% minimum slope in any direction.
10. For roadway joint layout, refer to ODOT DWG. No. 501.01. For alley joint layout, refer to ODOT DWG. No. 503.01.

PERVIOUS CONCRETE PAVEMENT
(ROADWAY AND ALLEY)

District of Columbia Department of Transportation

DWG. No. 621.01
LID Design (Public Works) Standards

LEGEND

1. PERVERSUS PORTLAND CEMENT CONCRETE
2. BASE COURSE, AASHTO *5T OR APPROVED EQUIVALENT
3. UNCOMPACTED SUBGRADE FOR AREAS DESIGNED AS INFILTRATION PRACTICES. FOR OTHER AREAS, COMPACT AS SPECIFIED IN SPECIFICATION CITED IN NOTE 2. FOR SOFT SOILS, INSTALL GEOGRID PER GEOTECHNICAL ENGINEER RECOMMENDATIONS.

NOTES:

1. DETAIL TO BE USED ONLY WHEN APPROVED BY DDOT IPMA AND SHALL MEET CURRENT APPROVED DDOT SPECIFICATION FOR "PERVERSUS PORTLAND CEMENT CONCRETE PAVEMENT."
2. AGGREGATE LAYERS SHALL MEET CURRENT APPROVED DDOT SPECIFICATION FOR "AGGREGATES FOR PERMEABLE PAVEMENT AND BIODETENTION."
3. WHERE INSITU SOILS ARE NOT CONDUCITIVE TO INFILTRATION OF 1.2" RETENTION VOLUME WITHIN 72 HOURS, UNDERDRAIN SHOULD BE CONSIDERED THROUGH COORDINATION WITH DDOT IPMA.
4. WATERPROOF MEMBRANE TO BE USED TO PROMOTE WATER RE-USE, PROTECT NEARBY BUILDING FOUNDATIONS AND AVOID INFILTRATION AROUND UTILITIES. SEE DESIGN PLANS.
5. AGGREGATE DEPTH MAY BE GREATER THAN MINIMUM, AS SHOWN IN DESIGN PLANS TO ACHIEVE ADDITIONAL STORMWATER STORAGE.
6. BOTTOM OF PERMEABLE PAVEMENT STRUCTURE SHALL BE AT LEAST 2" ABOVE THE SEASONAL HIGH WATER TABLE OR BEDROCK, AS DETERMINED BY GEOTECHNICAL INVESTIGATION.
7. TOP OF PAVEMENT SHOULD BE DESIGNED TO ACHIEVE 1% MINIMUM SLOPE IN ANY DIRECTION.
8. FOR SIDEWALK JOINT LAYOUT, REFER TO DDOT DWG. NO. 608.01. FOR TRAIL JOINT LAYOUT, REFER TO DDOT DWG. NO. 561.01.
LID Design (Public Works) Standards

PERMEABLE INTERLOCKING UNIT PAVER PAVEMENT (ROADWAY AND ALLEY)

NOTES:
1. DETAIL TO BE USED ONLY WHEN APPROVED BY DDOT IPWA AND SHALL MEET CURRENT APPROVED DDOT SPECIFICATION FOR "PERMEABLE UNIT PAVERS (NOT CURRENTLY ALLOWED ON COLLECTOR AND ARTERIAL).
2. AGGREGATE LAYERS SHALL MEET CURRENT APPROVED DDOT SPECIFICATION FOR "AGGREGATES FOR PERMEABLE PAVEMENT AND BIORETENTION".
3. SEE DWG NO. 621.10 FOR LONGITUDINAL AND CROSS SLOPE REQUIREMENTS.
4. WATERPROOF MEMBRANE TO BE USED TO PROMOTE WATER RE-USE, PROTECT NEARBY BUILDING FOUNDATIONS AND AVOID INFILTRATION AROUND UTILITIES. SEE DESIGN PLANS.
5. DEPTH OF RESERVOIR LAYER AS SHOWN ON DESIGN PLANS SHOULD BE SIZED TO ADDRESS STORMWATER MANAGEMENT AND CONVEYANCE REQUIREMENTS, AND PAVEMENT STRUCTURAL DESIGN.
6. ENHANCED DESIGN CONTAINS A WATER STORAGE LAYER AND AN INFILTRATION SUMP BENEATH THE UNDERDRAIN SIZED TO DRAIN THE DESIGN STORM WITHIN 48 HOURS.
7. WHEN FILTER LAYER IS OMITTED, PROVIDE GEOTEXTILE CLASS I MATERIAL BENEATH RESERVOIR LAYER MEETING CURRENT APPROVED DDOT SPECIFICATION FOR "GEOSYNTHETICS FOR STORMWATER FACILITIES".
8. BOTTOM OF PERMEABLE PAVEMENT STRUCTURE SHALL BE AT LEAST 2" ABOVE THE SEASONAL HIGH WATER TABLE OR BEDROCK, AS DETERMINED BY GEOFTECHNICAL INVESTIGATION.
9. TOP OF PAVEMENT SHOULD BE DESIGNED TO ACHIEVE A MINIMUM SLOPE IN ANY DIRECTION.
10. OTHER TYPES OF EDGE RESTRAINTS SUCH AS STEEL OR PLASTIC SHALL BE ALLOWED AS APPROVED BY THE ENGINEER AND BASED ON MANUFACTURER'S RECOMMENDATIONS.
LID Design (Public Works) Standards

SIDEWALK SECTION

* Steeper slope allowed if approved by DOT IPMA.

LEGEND

1. PERMEABLE INTERLOCKING CONCRETE PAVERS (PICP) OR SIMILAR, OR NON-INTERLOCKING PAVERS, AS NOTED.
2. BEDDING LAYER, AASHTO #8 OR APPROVED EQUIVALENT
3. DOUBLE WASHED AGGREGATE, AASHTO #57 OR APPROVED EQUIVALENT
4. CONCRETE EDGE RESTRAINT, MIN. 4" WIDE AND 1½" DEEP; MORTAR OR POLYMER ADHERED PAVERS TO TOP; ALTERNATIVELY, EXTEND EDGE RESTRAINT TO SURFACE; OTHER TYPES OF EDGE RESTRAINTS SUCH AS STEEL OR PLASTIC SHALL BE ALLOWED AS APPROVED BY THE ENGINEER AND BASED ON MANUFACTURER'S RECOMMENDATIONS.
5. UNCOMPACTED SUBGRADE FOR AREAS DESIGNED FOR INFECTION PRACTICES, FOR OTHER AREAS, COMPACT AS SPECIFIED IN SPECIFICATION CITED IN NOTE 2. FOR SOFT SOILS, INSTALL GEGRID PE EDEOTECHNICAL ENGINEER RECOMMENDATIONS. SEE NOTE 8 FOR ALTERNATE DESIGN.
6. JOINT TO HAVE 1/2 INCH MAXIMUM GAP IN ACCORDANCE WITH THE LATEST ADA REQUIREMENTS AND TO BE FILLED WITH AASHTO #8 OR APPROVED EQUIVALENT. MINIMUM GAP SHALL BE 1/4" OR PER MANUFACTURERS RECOMMENDATIONS FOR INTERLOCKING CONCRETE PAVERS.
7. GEOWEAVE, AS APPROVED BY DOT
8. SAND-BASED STRUCTURAL SOIL (SBSS)

NOTES:

1. DETAIL TO BE USED ONLY WHEN APPROVED BY DOT IPMA AND SHALL MEET CURRENT APPROVED DOT SPECIFICATION FOR "PERMEABLE UNIT PAVERS".
2. AGGREGATE LAYERS SHALL MEET CURRENT APPROVED DOT SPECIFICATION FOR "AGGREGATES FOR PERMEABLE PAVEMENT AND BIODETENTION".
3. WHERE IN SITU SOILS ARE NOT CONDUCTIVE TO INFILTRATION OF 1/2" OF RETENTION VOLUME WITHIN 72 HOURS, UNDERDRAINS SHOULD BE CONSIDERED THROUGH COORDINATION WITH DOT IPMA.
4. WATERPROOF MEMBRANE TO BE USED TO PROMOTE WATER RE-USE, PROTECT NEARBY BUILDING FOUNDATIONS AND AVOID INFILTRATION AROUND UTILITIES. SEE DESIGN PLANS.
5. AGGREGATE DEPTH MAY BE GREATER THAN MINIMUM, AS SHOWN IN DESIGN PLANS TO ACHIEVE ADDITIONAL STORMWATER STORAGE.
6. BOTTOM OF PERMEABLE PAVEMENT STRUCTURE SHALL BE AT LEAST 2" ABOVE THE SEASONAL HIGH WATER TABLE OR TO BEDROCK, AS DETERMINED BY GEOTECHNICAL INVESTIGATION.
7. TOP OF PAVEMENT SHOULD BE DESIGNED TO ACHIEVE 12 MINIMUM SLOPE IN ANY DIRECTION.
8. IN AREAS OF TREE PLANTINGS WHICH CALL FOR SAND-BASED STRUCTURAL SOIL (SBSS), THE SBSS MAY EXTEND UNDER THE AGGREGATE BASE LAYER OF THE SIDEWALK.
NOTES:

1. BIORETENTION MATERIALS AND CONSTRUCTION SHALL MEET CURRENT APPROVED DOT SPECIFICATION FOR "BIORETENTION, PLANTING, AND STRUCTURAL SOILS".

2. SCARIFY SUBGRADE 3" MIN. BEFORE INSTALLATION.

3. SIDE SLOPES STEEPER THAN 3:1 MAY BE ALLOWED; HOWEVER, MUST BE STABILIZED IN ACCORDANCE WITH DOT DESIGN REQUIREMENTS.

4. FOR ALTERNATIVE EDGE TREATMENT CONDITIONS, SEE DWG. NO. 621.30 TO 621.32

5. BOTTOM OF BIOSWALE SHALL BE AT LEAST 2" ABOVE THE SEASONAL HIGH WATER TABLE AND BEDROCK AS DETERMINED BY GEOTECHNICAL INVESTIGATION.

6. STONE DEPTH SHALL VARY PER DESIGN PLANS, TO ACHIEVE A WATER STORAGE LAYER/INfiltration tank, WHEN APPLICABLE.

7. PROVIDE UNDERDRAIN WHEN CALLED FOR PER DESIGN PLANS. SEE DWG. 605.01 FOR MIN. BEDDING REQUIREMENT.

8. DISTANCE TO ROADWAY MAY BE REDUCED WHEN SIDE OF PRACTICE IS LINED WITH WATERPROOF MEMBRANE, PER DESIGN PLANS.

9. SEE DWG. NO. 605.01 FOR CLEAN OUT AND OBSERVATION WELL DETAIL.

10. BIORETENTION FACILITY DEPICTED IS ONE WITH AN OVERFLOW STRUCTURE, "OFF-LINE" FACILITIES DESIGNED TO LIMIT INFLOW SO THAT OVERFLOW STRUCTURES ARE NOT REQUIRED, AS SHOWN ON DESIGN PLANS.

11. IF DEPTH FROM SURROUNDING GRADE TO LOW POINT OF FACILITY EXCEEDS 9 FEET, A FENCE IS REQUIRED AROUND ENTIRE FACILITY.

LEGEND:

1. BIORETENTION SOIL
2. CHORE LAYER, SAND & GRAVEL
3. AASHTO 457 STONE, DOUBLE WASHED
4. MULCH, PER PLANTING PLAN
5. GEOTEXILE, CLASS 2
6. PLANT BED SOIL

DISTRICT OF COLUMBIA
DEPARTMENT OF TRANSPORTATION

BIORETENTION IN OPEN AREA

DWG. NO. 621.20
LID Design (Public Works) Standards

NOTES:
1. BIOTENTION MATERIALS AND CONSTRUCTION SHALL MEET CURRENT APPROVED DDOOT SPECIFICATION FOR "BIOTENTION, PLANTING, AND STRUCTURAL SOILS".
2. SCARIFY SUBGRADE 3 MIN. BEFORE INSTALLATION.
3. STEP OUT ZONE REQUIRED WHEN PARALLEL PARKING IS PROVIDED. INSTALLATION MAY BE STANDARD CONCRETE SIDEWALK, SOD, MULCH OR PAVEMENT BASED ON SURROUNDING CONDITIONS.
4. SIDE SLOPES STEEPER THAN 3:1, MAY BE ALLOWED, HOWEVER, MUST BE INSTALLED IN ACCORDANCE WITH DDOOT SPECIFICATIONS.
5. TREES AND PLANTINGS SHALL BE INSTALLED IN ACCORDANCE WITH DESIGN PLANS.
6. BOTTOM OF BIOSWALE SHALL BE AT LEAST 2' ABOVE THE SEASONAL HIGH WATER TABLE AND BEDROCK AS DETERMINED BY GEOTECHNICAL INVESTIGATION.
7. INSTALL TRAFFIC BARRIER PER DWG. NO. 605.04, AS NECESSARY BASED ON ROADWAY DESIGN.
8. OFFSET TO SWALE MAY BE REDUCED IF ALTERNATE EDGE TREATMENT IS USED. SEE DWG. NO. 620.50 TO 620.32.
9. DEPTH OF INFILTRATION SUMP AS SHOWN ON DESIGN PLANS SHOULD BE SIZED TO ADDRESS STORMWATER MANAGEMENT REQUIREMENTS.

LEGEND:
1. BIOTENTION SOIL
2. CHOKER LAYER, SAND & GRAVEL
3. AASHTO #57 STONE, DOUBLE WASHED
4. INFILTRATION SUMP, AASHTO #57 STONE, DOUBLE WASHED
5. MULCH, PER PLANTING PLAN
6. GEOTEXILE, CLASS 2

BIOSWALE ADJACENT TO ROADWAY

DISTRICT OF COLUMBIA
DEPARTMENT OF TRANSPORTATION

DWG. NO. 621.21
LID Design (Public Works) Standards

NOTES:
1. BIORETENTION MATERIALS AND CONSTRUCTION SHALL MEET CURRENT APPROVED DOWT SPECIFICATION FOR “BIORETENTION, PLANTING, AND STRUCTURAL SOILS.”
2. SCARIFY SUBGRADE 3” MIN. BEFORE INSTALLATION.
3. STEP OUT ZONE REQUIRED WHEN PARALLEL PARKING IS PROVIDED. INSTALLATION MAY BE STANDARD CONCRETE SIDEWALK, 500’ MULCH OR PAVEMENT BASED ON SURROUNDING CONDITIONS.
4. FOR EDGE TREATMENT OPTIONS, SEE DWG. NO. 621.30 TO 621.32.
5. TREES AND PLANTINGS SHALL BE INSTALLED IN ACCORDANCE WITH DESIGN PLANS.
6. BOTTOM OF BIORETENTION SHALL BE AT LEAST 2” ABOVE THE SEASONAL HIGH WATER TABLE AND BEDROCK AS DETERMINED BY GEOTECHNICAL INVESTIGATION.
7. DEPTH OF INFILTRATION SUMP AS SHOWN ON DESIGN PLANS SHOULD BE SIZED TO ADDRESS STORMWATER MANAGEMENT REQUIREMENTS.
8. OUTLET REQUIRED AS SPECIFIED BY PLANS.

LEGEND:
- BIORETENTION SOIL
- CHOAKER LAYER, SAND & GRAVEL
- AASHTO #57 STONE, DOUBLE WASHED
- INFEITRATION SUMP, AASHTO #57 STONE, DOUBLE WASHED
- GERTEXTILE, CLASS 2
- MULCH, PER PLANTING PLANS
- WATERPROOF MEMBRANE

BIORETENTION PLANTER ADJACENT TO ROADWAY-2
(WITH STEP OUT ZONE)

DISTRICT OF COLUMBIA
DEPARTMENT OF TRANSPORTATION

DWG. NO. 621.23
LID Design (Public Works) Standards

STORMWATER FACILITY UNDERDRAIN BEDDING AND CATCH BASIN CONNECTION

NOTES:
1. CATCH BASIN CONNECTIONS FROM UNDERDRAINS SERVICING PRIVATE PROPERTY ARE PROHIBITED.
2. WHEN STORMWATER FACILITY IS LOCATED > 10 FEET FROM CATCH BASIN, PROVIDE ADDITIONAL CLEANTOUT OUTSIDE OF STORMWATER FACILITY WITHIN 10' OF CATCH BASIN.
3. STORMWATER FACILITY DEPICTED IS BIOTRETENTION PRACTICE; CONNECTIONS TO CATCH BASIN WILL ALSO APPLY TO PERMEABLE PAVEMENTS AND BIOFILTERS WITH UNDERDRAINS.
4. OPTIONAL PVC GATE VALVE TO BE USED TO REGULATE FLOW IN UNDERDRAIN PIPE AS INDICATED IN PLANS. VALVE MAY ALSO BE USED IN OVERFLOW RESERVOIR AS DIRECTED.
5. WHEN CONNECTING TO A COMBINED SEWER SYSTEM, A BACKFLOW VALVE WITH SERVICE ACCESS EXTENSION IS REQUIRED AT CONNECTION BETWEEN PERFORATED AND NON-PERFORATED PIPE.
6. PVC SLOPE SHALL BE PER DESIGN MANUAL SECTION 33.14.4.4.

RECOMMENDED: DEPUTY CHIEF ENGINEER

DATE APPROVED: REVISED:

ISSUED: CHIEF TRANSPORTATION ENGINEER

DISTRICT OF COLUMBIA
DEPARTMENT OF TRANSPORTATION

DWG. NO. 621.52
LID Design (Public Works) Standards

**SECTION A-A**

**SECTION B-B**

**NOTES:**
1. Minimum open tree planting space dimensions, 4’x6’.
2. Maximum watershed area: 6.0 times area of the open tree planting area.
3. See DWG. No. 621.74 for bottom sand layer and subsurface drainage requirements.
4. For sidewalk over structural soil detail options, see DWG. Nos. 621.75 and 621.76.
5. See DWG. No. 619.10 for tree installation requirements.

**PLAN VIEW**

**LEGEND:**
1. Sidewalk / Pavers
2. Root Approved Structural Soil - 30” min.
3. Planting Soil - 12”
4. Sand - 0” to 12” (as required)
5. Scarified Subsoil - 4”
6. Crushed Stone, Double Washed No. 57 - 6”
7. Choker Layer
8. Geotextile
9. Mulch - 3”

**District of Columbia**

**Department of Transportation**

**DWG. NO. 621.70**

**Structural Soil Under Sidewalk - Covered Tree Space**
LID Design (Public Works) Standards

SECTION A-A

SECTION B-B

NOTES:
1. Minimum open tree planting space dimensions, 4′x6′.
2. Maximum watershed area: 6.0 times area of the open tree planting area.
3. See DWG No. 621.74 for bottom sand layer and subsurface drainage requirements.
4. For sidewalk over structural soil detail options, see DWG Nos. 621.75 and 621.76.
5. See DWG No. 621.70 for tree installation requirements.

LEGEND:
1. Sidewalk / Pavers
2. Root approved structural soil - 30′ min.
3. Planting soil - 12′
4. Sand - 0′ to 12′ (as required)
5. Scarified subsoil - 4′
6. Crushed stone, double washed No. 57 - 6′
7. Choker layer
8. Geotextile
9. Mulch - 3′

PLAN VIEW

STRUCTURAL SOIL UNDER SIDEWALK - COVERED TREE SPACE
621.06. PERMEABLE UNIT PAVER PAVEMENT

(A) DESCRIPTION

This work shall consist of constructing permeable unit pavers on a prepared sub-grade in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical sections shown in the contract documents or as directed by the Chief Engineer.

The permeable unit pavers shall consist of a combination of unit pavers and aggregate for the joints and bedding layer, to form an integrated, structural wearing surface when compacted.

(B) REFERENCES

- ASTM C140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
- ASTM C418 – Standard Test Method for Abrasion Resistance of Concrete by Sandblasting
- ASTM C595 - Standard Specification for Blended Hydraulic Cements
- ASTM C936 – Solid Concrete Interlocking Paving Units
- ASTM C979 – Standard Specification for Pigments for Integrally Colored Concrete

(C) MATERIALS

Materials shall be approved in accordance with Section 106 requirements, and as described below:

1. All unit pavers shall meet surface requirements of the latest Americans with Disabilities Act (ADA) requirements and accessibility guidelines.
2. Unit pavers shall be of the type, style, color, and other details as described in the Contract Documents and in accordance with all manufacturer’s recommendations for the selected unit paver system.
   a. Shapes: rectangular, L-shaped, hexagonal, square as specified in design plans
   b. Thickness: 3 1/8 in. for vehicular use, 2 3/8 in. for pedestrian use.
   c. Colors will match surrounding conditions as specified in design plans: Light gray, brick
   d. Concrete Unit Pavers: The material and fabrication for the unit pavers shall meet or exceed the requirements of ASTM C936 “Solid Concrete Interlocking Paving Units” and must allow a minimum infiltration rate of 60 in/hr through the pavement upon installation.
   i. Portland cement: ASTM C150, Type 1.
   iii. Pigments: ASTM C979 and as specified in the Contract Documents.
   iv. Other constituents: Previously established by test or experience as suitable for use in concrete, in compliance with applicable ASTM standards or as otherwise approved by the Engineer
   v. Paver physical properties:
      (a) Provide only sound units free of defects that would allow proper placing of units to achieve the specified pavement strength and performance.
      (b) Compressive strength: ASTM C140, when delivered to the project site, average compressive strength of not less than 8,000 psi, with no individual unit less than 7,200 psi.
      (c) Absorption: ASTM C140, average absorption not greater than 5%, with no individual unit greater than 7%.
      (d) Resistance to freezing and thawing: ASTM C67, with no breakage and not greater than 1% loss in dry mass of any individual unit after 50 cycles of freezing and thawing.
      (e) Abrasion resistance: ASTM C418, maximum volume loss of 0.915 cubic inches / 7.75 sq. in. Average thickness loss of no more than 0.118” (3 mm) due to abrasion testing.
      (f) Dimension tolerances: Length +/- 1/16", Height +/- 1/8"

   e. Other Material Unit Pavers: Clay, brick, or other alternate materials shall be utilized as called for in the Contract Documents and shall meet physical properties described above in 2.d., unless otherwise specified in Contract Documents.

3. Bedding and Joints: AASHTO #8 aggregate or similar, as directed by the Contract Documents and in accordance with DDOT Specification for Aggregates for Stormwater Management.

(D) SUBMITTALS

Contractor shall submit drawings and documentation as required in this specification and obtain written acceptance of submittals before using the materials or methods requiring approval.
# LID Design Standards - Plants

## Bioretention - Low Level of Care

### DDOT Green Infrastructure Standards

**Plants for Use in Bioretention**

<table>
<thead>
<tr>
<th>Botanical Name (Common Name)</th>
<th>Height (ft.)</th>
<th>Spread (ft.)</th>
<th>Bloom Color</th>
<th>Bloom Time</th>
<th>Sun Shade</th>
<th>Salt Tolerance</th>
<th>Drought Tolerance</th>
<th>Type</th>
<th>Native</th>
<th>Zone</th>
<th>Spacing (ft.)</th>
<th>Minimum Container Size</th>
<th>Other Notes</th>
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<tbody>
<tr>
<td>Asclepias incarnata - Swamp Milkweed</td>
<td>4-5</td>
<td>2-3</td>
<td>White, Pink</td>
<td>July-Aug</td>
<td>☀️ L</td>
<td>●</td>
<td>●</td>
<td>Perennial</td>
<td>X</td>
<td>Bottom Side</td>
<td>1.5</td>
<td>1 gal.</td>
<td>Tolerates deer, clay soil, wet soil</td>
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<tr>
<td>Dianthus - Cheddar Pink* 'Feuerhexe'</td>
<td>0.25-0.5</td>
<td>0.5-1</td>
<td>Magenta</td>
<td>May-June</td>
<td>☀️ H</td>
<td>●</td>
<td>●</td>
<td>Perennial</td>
<td>X</td>
<td>Top Side</td>
<td>1.5</td>
<td>3 gal.</td>
<td>Tolerates deer</td>
</tr>
<tr>
<td>Hypericum calycinum - St. Johnswort</td>
<td>1-1.5</td>
<td>1.5-2</td>
<td>Yellow</td>
<td>July-Aug</td>
<td>☀️ ☀️ M</td>
<td>●</td>
<td>●</td>
<td>Deciduous Shrubs</td>
<td>Top Side</td>
<td>3 gal.</td>
<td>Tolerates drought, erosion, dry soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liriope muscari - Lily Turf* 'Big Blue'</td>
<td>1-2</td>
<td>1-2</td>
<td>Lavender</td>
<td>Aug-Sept</td>
<td>☀️ ☀️ M</td>
<td>●</td>
<td>●</td>
<td>Perennial</td>
<td>Top Side</td>
<td>1</td>
<td>1 gal.</td>
<td>Tolerates rabbit, deer, drought, erosion, air pollution; Intolerant of standing water</td>
<td></td>
</tr>
<tr>
<td>'Variegata'</td>
<td>1-1.5</td>
<td>1-2</td>
<td>Purple</td>
<td>Aug</td>
<td>☀️ ☀️ M</td>
<td>●</td>
<td>●</td>
<td>Perennial</td>
<td>X</td>
<td>Top Side</td>
<td>1.5</td>
<td>1 gal.</td>
<td>Tolerates deer</td>
</tr>
<tr>
<td>Pycnanthemum muticum - Smooth Toothed Mountain Mint</td>
<td>2-3</td>
<td>2</td>
<td>White</td>
<td>July-Sept</td>
<td>☀️ ☀️ M</td>
<td>●</td>
<td>●</td>
<td>Perennial</td>
<td>X</td>
<td>Top Side</td>
<td>1.5</td>
<td>1 gal.</td>
<td>Tolerates deer</td>
</tr>
<tr>
<td>Solidago spathulata - Goldenrod* 'Golden Fleece'</td>
<td>1-1.5</td>
<td>1.5-1.6</td>
<td>Yellow</td>
<td>Aug-Sept</td>
<td>☀️ H</td>
<td>●</td>
<td>●</td>
<td>Perennial</td>
<td>X</td>
<td>Top Side</td>
<td>1</td>
<td>1 gal.</td>
<td>Tolerates deer, drought, erosion, clay soil, dry soil, shallow rocky soil</td>
</tr>
</tbody>
</table>

### Ferns

| Adiantum pedatum - Northern Maidenhair Fern | 1-2.5        | 1-1.5        | N A         | N A        | ☀️ ● M     | ●              | ●                | Perennial | X      | Bottom Side | 1            | 1 gal.      | Tolerates heavy shade |
| Diplazium pycnocarpon - Glade Fern         | 2-3          | 2-3          | N A         | N A        | ☀️ ● M     | ●              | ●                | Perennial | X      | Bottom Side | 1            | 1 gal.      | Tolerates rabbit, deer, heavy shade, dry soil |
| Polystichum acrostichoides - Christmas Fern | 1-2          | 1-2          | N A         | N A        | ☀️ ● M     | ●              | ●                | Perennial | X      | Top Side    | 1            | 1 gal.      | Tolerates rabbit, deer, drought, heavy shade, erosion, dry soil, shallow rocky soil |
# LID Design Standards - Plants

## Bioretention - Medium Level of Care

### DDOT Green Infrastructure Standards

#### Plants for Use in Bioretention

Quarterly maintenance; some water available

<table>
<thead>
<tr>
<th>Botanical Name / Common Name</th>
<th>Height (Ft.)</th>
<th>Spread (Ft.)</th>
<th>Bloom Color</th>
<th>Bloom Time</th>
<th>Sun Shade</th>
<th>Salt Tolerance</th>
<th>Drought Tolerance</th>
<th>Type</th>
<th>Native</th>
<th>Zone</th>
<th>Spacing (Ft.)</th>
<th>Minimum Container Size</th>
<th>Other Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TREES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asimina triloba / Pawpaw</td>
<td>15-30</td>
<td>15-30</td>
<td>Purple</td>
<td>Apr-May</td>
<td>☀ ☀ ☀</td>
<td>L</td>
<td>✻ ✻</td>
<td>Small Tree</td>
<td>X</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates wet soil</td>
</tr>
<tr>
<td><em>Cercis canadensis</em> Eastern Redbud (single stem)*</td>
<td>20-30</td>
<td>25-35</td>
<td>Red-Purple, Rosy Pink / Rose-Purple</td>
<td>Mar-Apr</td>
<td>☀ ☀ ☀</td>
<td>L</td>
<td>♦</td>
<td>Small Tree</td>
<td>X</td>
<td>Side</td>
<td>Per Plan</td>
<td>2&quot; cal. OR Multi-stem by height: 8'-10&quot;</td>
<td>Tolerates deer, clay soil, black walnut</td>
</tr>
<tr>
<td>‘Forest Pansy’</td>
<td>25-40</td>
<td>20-25</td>
<td>Red-Purple, Pink</td>
<td>May-June</td>
<td>☀ ☀ ☀</td>
<td>L</td>
<td>♦</td>
<td>Med. Tree</td>
<td>X</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal. OR Multi-stem by height: 8'-10&quot;</td>
<td>Tolerates clay soil, wet soil, air pollution; fragrant</td>
</tr>
<tr>
<td><em>Magnolia x</em> ‘Galaxy’</td>
<td>35-40</td>
<td>15-18</td>
<td>White</td>
<td>May-June</td>
<td>☀ ☀ ☀</td>
<td>L</td>
<td>♦</td>
<td>Med. Tree</td>
<td>X</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal. OR Multi-stem by height: 8'-10&quot;</td>
<td>Tolerates clay soil, wet soil, air pollution</td>
</tr>
<tr>
<td><em>Magnolia virginiana</em> 'Jim Wilson’ *Moonglow'</td>
<td>70-100</td>
<td>12-25</td>
<td>N A</td>
<td>N A</td>
<td>☀ ☀ ☀</td>
<td>L</td>
<td>✻ ✻</td>
<td>Large Tree</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>8'-10' height</td>
<td>Tolerates deer, clay soil, wet soil, air pollution</td>
<td></td>
</tr>
<tr>
<td>Metasequoia glyptostroboides <em>Dawn Redwood</em></td>
<td>50-60</td>
<td>50-60</td>
<td>Yellow, Green</td>
<td>April</td>
<td>☀ ☀ ☀</td>
<td>H</td>
<td>✻</td>
<td>Large Tree</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates wet soil, drought</td>
<td></td>
</tr>
<tr>
<td>Quercus bicolor <em>Swamp White Oak</em></td>
<td>40-60</td>
<td>40-60</td>
<td>Yellow, Red</td>
<td>March-Apr</td>
<td>☀ ☀ ☀</td>
<td>H</td>
<td>✻ ✻</td>
<td>Large Tree</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates erosion, clay soil, wet soil</td>
<td></td>
</tr>
</tbody>
</table>

### SHRUBS

<table>
<thead>
<tr>
<th>Botanical Name / Common Name</th>
<th>Height (Ft.)</th>
<th>Spread (Ft.)</th>
<th>Bloom Color</th>
<th>Bloom Time</th>
<th>Sun Shade</th>
<th>Salt Tolerance</th>
<th>Drought Tolerance</th>
<th>Type</th>
<th>Native</th>
<th>Zone</th>
<th>Spacing (Ft.)</th>
<th>Minimum Container Size</th>
<th>Other Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buddleja davidii <em>Butterfly bush</em> <em>Blue Chip</em></td>
<td>1-2</td>
<td>1-2</td>
<td>Blue</td>
<td>June-Sept</td>
<td>☀ ☀ ☀</td>
<td>H</td>
<td>✻ ✻</td>
<td>Deciduous Shrub</td>
<td>Top Side</td>
<td>1</td>
<td>3 gal.</td>
<td></td>
<td>Tolerates rabbit, clay soil</td>
</tr>
<tr>
<td>Callicarpa americana <em>Beautyberry</em></td>
<td>3-6</td>
<td>3-6</td>
<td>Lavender, Pink</td>
<td>June-Aug</td>
<td>☀ ☀ ☀</td>
<td>L</td>
<td>✻ ✻</td>
<td>Deciduous Shrub</td>
<td>Bottom Side</td>
<td>3</td>
<td>3 gal.</td>
<td></td>
<td>Tolerates clay soil</td>
</tr>
<tr>
<td>Callicarpa dichotoma <em>Beautyberry</em> <em>Early Amethyst</em></td>
<td>3-4</td>
<td>4-5</td>
<td>Lavender, Pink</td>
<td>June-Aug</td>
<td>☀ ☀ ☀</td>
<td>L</td>
<td>✻ ✻</td>
<td>Deciduous Shrub</td>
<td>Top Side</td>
<td>4</td>
<td>3 gal.</td>
<td></td>
<td>Tolerates drought</td>
</tr>
<tr>
<td>Cephalanthus occidentalis <em>Buttonbush</em></td>
<td>5-12</td>
<td>4-8</td>
<td>White</td>
<td>June</td>
<td>☀ ☀ ☀</td>
<td>M L</td>
<td>✻ ✻</td>
<td>Deciduous Shrub</td>
<td>Bottom Side</td>
<td>4</td>
<td>3 gal.</td>
<td></td>
<td>Tolerates erosion, wet soil</td>
</tr>
</tbody>
</table>
## LID Design Standards - Plants

### BIRETENTION - HIGH LEVEL OF CARE

#### DDOT GREEN INFRASTRUCTURE STANDARDS

**PLANTS FOR USE IN BIRETENTION**

Monthly maintenance; site is routinely watered

<table>
<thead>
<tr>
<th>BOTANICAL NAME COMMON NAME</th>
<th>HEIGHT (FT.)</th>
<th>SPREAD (FT.)</th>
<th>BLOOM COLOR</th>
<th>BLOOM TIME</th>
<th>SUN SHADE</th>
<th>SALT TOL.</th>
<th>DROUGHT TOL.</th>
<th>TYPE</th>
<th>NATIVE</th>
<th>ZONE</th>
<th>SPACING (FT.)</th>
<th>MINIMUM CONTAINER SIZE</th>
<th>OTHER NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TREES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aesculus flava</td>
<td>50-75</td>
<td>30-50</td>
<td>Yellow</td>
<td>Apr-May</td>
<td>○</td>
<td>M</td>
<td>***</td>
<td>Large Tree</td>
<td>X</td>
<td>Top Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Messy, Install away from sidewalks &amp; walkways, best when planted in large areas</td>
</tr>
<tr>
<td>Chionanthus virginicus</td>
<td>12-20</td>
<td>10-20</td>
<td>White</td>
<td>May-June</td>
<td>○</td>
<td>L</td>
<td></td>
<td>Small Tree</td>
<td>X</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>8-10' height</td>
<td>Tolerates clay soil, air pollution; slightly fragrant</td>
</tr>
<tr>
<td>Ilex decidua</td>
<td>7-15</td>
<td>5-12</td>
<td>White</td>
<td>May</td>
<td>○</td>
<td>M</td>
<td>***</td>
<td>Small Tree</td>
<td>X</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates wet soil, clay soil, air pollution</td>
</tr>
<tr>
<td>Liquidambar styraciflua</td>
<td>60-80</td>
<td>40-60</td>
<td>Yellow, Green</td>
<td>Apr-May</td>
<td>○</td>
<td>M</td>
<td></td>
<td>Large Tree</td>
<td>X</td>
<td>Top Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates rabbit, deer, clay soil, extended flooding; messy</td>
</tr>
<tr>
<td>Oxycodendrum arboreum</td>
<td>20-50</td>
<td>10-25</td>
<td>White</td>
<td>June-July</td>
<td>○</td>
<td>M</td>
<td>***</td>
<td>Small Tree</td>
<td>X</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates deer, dry soil; fragrant</td>
</tr>
<tr>
<td>Quercus falcata</td>
<td>60-80</td>
<td>40-50</td>
<td>Green (female), Red (male)</td>
<td>Apr-May</td>
<td>○</td>
<td>M</td>
<td></td>
<td>Large Tree</td>
<td>X</td>
<td>Top Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates drought, air pollution, brief flooding, intolerant of root disturbance</td>
</tr>
<tr>
<td><em>Tilia americana</em></td>
<td>50-70</td>
<td>30-45</td>
<td>Yellow</td>
<td>June</td>
<td>○</td>
<td>L</td>
<td>***</td>
<td>Large Tree</td>
<td>X</td>
<td>Top Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates drought, clay soil; fragrant, attractive to bees</td>
</tr>
<tr>
<td><em>Tilia cordata</em> <em>Littleleaf Linden</em></td>
<td>50-70</td>
<td>35-50</td>
<td>Yellow</td>
<td>June</td>
<td>○</td>
<td>L</td>
<td>***</td>
<td>Large Tree</td>
<td>X</td>
<td>Bottom Side</td>
<td>Per Plan</td>
<td>2&quot; cal.</td>
<td>Tolerates drought, wet soil, dry soil, air pollution; fragrant; attractive to bees</td>
</tr>
<tr>
<td><strong>SHRUBS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Deciduous Shrub</td>
<td>Top Side</td>
<td>0.5</td>
<td>3 gal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forsythia x intermedia</td>
<td>1-2</td>
<td>1-4</td>
<td>Yellow</td>
<td>Mar-Apr</td>
<td>○</td>
<td>M</td>
<td></td>
<td>Deciduous Shrub</td>
<td>Top Side</td>
<td>0.5</td>
<td>3 gal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Forsythia</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Deciduous Shrub</td>
<td>Top Side</td>
<td>0.5</td>
<td>3 gal.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccinium angustifolium</td>
<td>.5-2</td>
<td>2-4</td>
<td>White</td>
<td>May-June</td>
<td>○</td>
<td>L</td>
<td>***</td>
<td>Deciduous Shrub</td>
<td>X</td>
<td>Bottom Side</td>
<td>1</td>
<td>3 gal.</td>
<td></td>
</tr>
<tr>
<td>Vaccinium corymbosum</td>
<td>6-12</td>
<td>8-12</td>
<td>White, Pink</td>
<td>May</td>
<td>○</td>
<td>H</td>
<td>***</td>
<td>Deciduous Shrub</td>
<td>X</td>
<td>Bottom Side</td>
<td>6</td>
<td>5 gal.</td>
<td>Tolerates wet soil</td>
</tr>
<tr>
<td><strong>Highbush Blueberry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Deciduous Shrub</td>
<td>Top Side</td>
<td>1</td>
<td>3 gal.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
LID Design Standards - Trees

**GREEN INFRASTRUCTURE STANDARDS**

**TREES FOR USE IN PUBLIC SPACE**

**TREE SPACE DESIGN**

Adequate soil space provides the nutrients, water, air, and root space that trees need to have a long, successful life. The soil volume required depends on the fully-grown tree size (generally two cubic feet of soil per one square foot of the tree’s mature drip line area). There are other categories that must be considered when selecting a location and species of tree (see Table 3 and Figure 2).

<table>
<thead>
<tr>
<th>Soil Dimensions</th>
<th>Soil for the trees should be three feet deep. The length and width must ensure appropriate volume for the tree species and size.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open space</td>
<td>Provide as much open space as possible to allow the tree to grow and access water.</td>
</tr>
<tr>
<td>Soil Extents</td>
<td>Structural soil, suspended sidewalks, or structural slabs should be provided to the edges of paved areas to encourage tree roots to extend further and into adjacent green areas (lawns, planting beds, etc.).</td>
</tr>
<tr>
<td>Overhead Utilities</td>
<td>When overhead utilities are present, only small trees can be planted to avoid interference in the future.</td>
</tr>
</tbody>
</table>

**UFA Minimum Tree Sizes**

<table>
<thead>
<tr>
<th>Single Stem</th>
<th>2” cal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-Stem</td>
<td>8-10’ height</td>
</tr>
</tbody>
</table>

**Table 3**

**Table 4**

**Figure 2**
# LID Design Standards - Trees

## TREES USED IN PUBLIC SPACE - SMALL TREES

### DDOT GREEN INFRASTRUCTURE STANDARDS

**TREES FOR USE IN PUBLIC SPACE**

**SMALL TREES**

- <35' tall, minimum soil volume = 600 cubic feet

<table>
<thead>
<tr>
<th>BOTANICAL NAME</th>
<th>COMMON NAME</th>
<th>HEIGHT (FT.)</th>
<th>SPREAD (FT.)</th>
<th>TRUE FLOWER</th>
<th>BLOOM TIME</th>
<th>FALL COLOR</th>
<th>GROWTH RATE</th>
<th>SUN/SHADE</th>
<th>SALT TOL.</th>
<th>DROUGHT TOL.</th>
<th>TYPE</th>
<th>NATIVE</th>
<th>OTHER NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagerstroemia indica</td>
<td>Crapemyrtle*</td>
<td>15-25</td>
<td>15-25</td>
<td>Various</td>
<td>July-Sept</td>
<td>Dark Yellow-Orange, Orange-Red, Red</td>
<td>Fast</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates drought, clay soil, air pollution</td>
<td></td>
</tr>
<tr>
<td>'Biloxi'</td>
<td>Biloxi Crapemyrtle</td>
<td>15-25</td>
<td>15-25</td>
<td>Pale Pink</td>
<td>Lavender Pink</td>
<td>Red</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates drought, clay soil, air pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Muskogee'</td>
<td>Muskogee Crapemyrtle</td>
<td>10-12</td>
<td>10-12</td>
<td>Lavender Pink</td>
<td>White</td>
<td>Red</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates drought, clay soil, air pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Natchez'</td>
<td>Natchez Crapemyrtle</td>
<td>15-20</td>
<td>15-20</td>
<td>White</td>
<td>Dark Coral Pink, Red</td>
<td>Orange-Red</td>
<td>Fast</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates drought, clay soil, air pollution</td>
<td></td>
</tr>
<tr>
<td>'Tuscarora'</td>
<td>Tuscarora Crapemyrtle</td>
<td>10-16</td>
<td>10-16</td>
<td>Dark Coral Pink, Red</td>
<td>Orange-Red</td>
<td>Orange-Red</td>
<td>Fast</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates drought, clay soil, air pollution</td>
<td></td>
</tr>
<tr>
<td>Maackia amurensis</td>
<td>Amur Maackia</td>
<td>20-30</td>
<td>20-30</td>
<td>White</td>
<td>June-July</td>
<td>Not Showy</td>
<td>Slow</td>
<td>○</td>
<td>Unknown</td>
<td>❌</td>
<td>Deciduous</td>
<td>Tolerates clay soil; fragrant, exfoliating bark</td>
<td></td>
</tr>
<tr>
<td>Magnolia 'Butterflies'</td>
<td>Hybrid Magnolia</td>
<td>18-20</td>
<td>18-20</td>
<td>White</td>
<td>June-July</td>
<td>Not Showy</td>
<td>Moderate</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates deer, air pollution; fragrant, pyramidal form</td>
<td></td>
</tr>
<tr>
<td>Magnolia denudata</td>
<td>Yulan Magnolia</td>
<td>30-40</td>
<td>30-40</td>
<td>Yellow</td>
<td>Apr</td>
<td>Not Showy</td>
<td>Moderate</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates air pollution, clay soil</td>
<td></td>
</tr>
<tr>
<td>Magnolia x soulangiana</td>
<td>Saucer Magnolia</td>
<td>20-30</td>
<td>20-30</td>
<td>White</td>
<td>Mar-Apr</td>
<td>Yellow-Brown</td>
<td>Moderate</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates clay soil; fragrant</td>
<td></td>
</tr>
<tr>
<td>Malus</td>
<td>Crabapple*</td>
<td>12-16</td>
<td>12-16</td>
<td>White, Red</td>
<td>Apr-Jun</td>
<td>Not Showy</td>
<td>Slow</td>
<td>○</td>
<td>M</td>
<td>❌</td>
<td>Deciduous</td>
<td>Tolerates air pollution; Tolerates frost; resistant to scab, fireblight, rust, mildew, columnar form</td>
<td></td>
</tr>
<tr>
<td>'Adirondack'</td>
<td>Adirondack Crabapple</td>
<td>12-16</td>
<td>12-16</td>
<td>White, Red</td>
<td>Apr-Jun</td>
<td>Not Showy</td>
<td>Slow</td>
<td>○</td>
<td>M</td>
<td>❌</td>
<td>Deciduous</td>
<td>Tolerates air pollution; Tolerates frost; resistant to scab, fireblight, rust, mildew, columnar form</td>
<td></td>
</tr>
<tr>
<td>'Donald Wyman'</td>
<td>Donald Wyman Crabapple</td>
<td>15-20</td>
<td>20-25</td>
<td>White</td>
<td>Amber-Gold</td>
<td>Moderate</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates air pollution; Tolerates frost; resistant to scab, fireblight, rust, mildew, columnar form</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxycodendrum arboreum</td>
<td>Sourwood</td>
<td>20-50</td>
<td>10-25</td>
<td>White</td>
<td>June-July</td>
<td>Yellow, Red, Purple</td>
<td>Slow</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous</td>
<td>Tolerates deer, dry soil; fragrant, pyramidal form</td>
<td></td>
</tr>
<tr>
<td>Parrotia persica</td>
<td>Persian Ironwood</td>
<td>20-40</td>
<td>15-50</td>
<td>Crimson</td>
<td>Mar-Apr</td>
<td>Yellow, Orange, Scarlet</td>
<td>Moderate</td>
<td>○</td>
<td>L</td>
<td>❌</td>
<td>Deciduous; SS/MS</td>
<td>Tolerates clay soil, air pollution</td>
<td></td>
</tr>
</tbody>
</table>
## LID Design Standards - Trees

### Trees Used in Public Space - Medium Trees

**DDOT Green Infrastructure Standards**

**Trees for Use in Public Space**

**Medium Trees**

35-50’ tall, minimum soil volume = 1000 cubic feet

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
<th>Height (ft.)</th>
<th>Spread (ft.)</th>
<th>True Flower</th>
<th>Bloom Time</th>
<th>Fall Color</th>
<th>Growth Rate</th>
<th>Sun/Shade</th>
<th>Salt Tolerance</th>
<th>Drought Tolerance</th>
<th>Type</th>
<th>Native</th>
<th>Other Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acer rubrum</em> ‘Franksred’</td>
<td>Red Sunset Maple</td>
<td>40-50</td>
<td>35-40</td>
<td>Red</td>
<td>Mar</td>
<td>Orange, Red</td>
<td>Moderate-Fast</td>
<td>☐</td>
<td>☀</td>
<td>L</td>
<td>3</td>
<td>Deciduous</td>
<td>X</td>
</tr>
<tr>
<td><em>Aesculus x carnea</em></td>
<td>Red Horsechestnut</td>
<td>40-50</td>
<td>40-50</td>
<td>Rose-Red, Yellowish</td>
<td>May</td>
<td>Not Showy</td>
<td>Slow</td>
<td>☐</td>
<td>☀</td>
<td>M</td>
<td>3</td>
<td>Deciduous</td>
<td></td>
</tr>
<tr>
<td><em>Betula nigra</em> ‘BNMTF’</td>
<td>Dura-Heat River Birch</td>
<td>30-40</td>
<td>25-35</td>
<td>Brownish-Green</td>
<td>Apr-May</td>
<td>Yellow</td>
<td>Fast</td>
<td>☐</td>
<td>☀</td>
<td>M</td>
<td>3</td>
<td>Deciduous; SS</td>
<td>X</td>
</tr>
<tr>
<td><em>Carpinus betulus</em> ‘Fastigiata’</td>
<td>European Hornbeam</td>
<td>30-40</td>
<td>20-30</td>
<td>Yellow (male), Green (female)</td>
<td>Mar</td>
<td>Yellow-Orange</td>
<td>Slow</td>
<td>☐</td>
<td>☀</td>
<td>L</td>
<td>3</td>
<td>Deciduous</td>
<td></td>
</tr>
<tr>
<td><em>Cercidiphyllum japonicum</em></td>
<td>Katsuratree</td>
<td>40-60</td>
<td>25-60</td>
<td>Green-Reddish, Green</td>
<td>Mar-Apr</td>
<td>Gold, Orange-Red</td>
<td>Moderate-Fast</td>
<td>☐</td>
<td>☀</td>
<td>M</td>
<td>3</td>
<td>Deciduous; SS/MS</td>
<td></td>
</tr>
<tr>
<td><em>Cladrastis kentukea</em></td>
<td>American Yellowwood</td>
<td>30-50</td>
<td>40-55</td>
<td>White</td>
<td>May-June</td>
<td>Yellow</td>
<td>Moderate</td>
<td>☐</td>
<td>☀</td>
<td>M</td>
<td>3</td>
<td>Deciduous</td>
<td>X</td>
</tr>
<tr>
<td><em>Corylus avellana</em></td>
<td>Turkish Filbert</td>
<td>40-50</td>
<td>20-35</td>
<td>Yellow</td>
<td>Mar</td>
<td>Yellow</td>
<td>Moderate</td>
<td>☐</td>
<td>☀</td>
<td>L</td>
<td>3</td>
<td>Deciduous</td>
<td></td>
</tr>
<tr>
<td><em>Ginkgo biloba</em></td>
<td>Princeton Sentry, Maidenhair Tree</td>
<td>40-50</td>
<td>20-30</td>
<td>Green</td>
<td>Apr</td>
<td>Golden Yellow</td>
<td>Fast</td>
<td>☐</td>
<td>☀</td>
<td>L/M</td>
<td>1</td>
<td>Deciduous</td>
<td></td>
</tr>
<tr>
<td><em>Metasequoia glyptostroboides</em> ‘Shademaster’</td>
<td>Shademaster Honeylocust</td>
<td>35-45</td>
<td>25-35</td>
<td>Golden Green</td>
<td>May-June</td>
<td>Yellow</td>
<td>Fast</td>
<td>☐</td>
<td>☀</td>
<td>M</td>
<td>3</td>
<td>Deciduous; SS/MS</td>
<td>X</td>
</tr>
<tr>
<td><em>Syringa vulgaris</em> ‘Spathe Manor’</td>
<td>Fruitless Kentucky Coffeetree</td>
<td>40-50</td>
<td>20-25</td>
<td>White</td>
<td>May-June</td>
<td>Yellow</td>
<td>Slow-Moderate</td>
<td>☐</td>
<td>☀</td>
<td>H/M</td>
<td>1</td>
<td>Deciduous</td>
<td>X</td>
</tr>
</tbody>
</table>
## LID Design Standards - Trees

### TREES USED IN PUBLIC SPACE - LARGE TREES

<table>
<thead>
<tr>
<th>BOTANICAL NAME</th>
<th>COMMON NAME</th>
<th>HEIGHT (FT.)</th>
<th>SPREAD (FT.)</th>
<th>TRUE FLOWER</th>
<th>BLOOM TIME</th>
<th>FALL COLOR</th>
<th>GROWTH RATE</th>
<th>SUN SHADE</th>
<th>SALT TOL.</th>
<th>DROUGHT TOL.</th>
<th>TYPE</th>
<th>NATIVE</th>
<th>OTHER NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer x freemanii ♦</td>
<td>Freeman Maple</td>
<td>40-60</td>
<td>20-40</td>
<td>Green-Red</td>
<td>Apr-May</td>
<td>Yellow or Red</td>
<td>Moderate-Fast</td>
<td>☀ ☀</td>
<td>L</td>
<td>SS</td>
<td>Deciduous</td>
<td>X</td>
<td>Tolerates clay soil, dry soil, wet soil</td>
</tr>
<tr>
<td>Aesculus flava ♦</td>
<td>Yellow Buckeye</td>
<td>50-75</td>
<td>30-50</td>
<td>Yellow</td>
<td>Apr-May</td>
<td>Yellow-Orange</td>
<td>Moderate</td>
<td>☀</td>
<td>M</td>
<td>SS</td>
<td>Deciduous</td>
<td>X</td>
<td>Messy (install away from sidewalks &amp; walkways), best when planted in large areas</td>
</tr>
<tr>
<td>Cedrus deodara ♦</td>
<td>Deodar Cedar</td>
<td>40-60</td>
<td>30-40</td>
<td>Non-Flowering</td>
<td>N/A</td>
<td>N/A</td>
<td>Moderate</td>
<td>☀</td>
<td>M</td>
<td>SS</td>
<td>Evergreen</td>
<td></td>
<td>Tolerates clay soil, humidity, drought; must be limbed up when used as a street tree</td>
</tr>
<tr>
<td>Celtis laevigata ♦</td>
<td>Sugierry</td>
<td>60-80</td>
<td>60-80</td>
<td>Green</td>
<td>Apr-May</td>
<td>Yellow</td>
<td>Fast</td>
<td>☀ ☀</td>
<td>H/M</td>
<td>SS</td>
<td>Deciduous</td>
<td>X</td>
<td>Tolerates clay soil, wet soil, air pollution, wind, extended flooding; can form large surface roots</td>
</tr>
<tr>
<td>Celtis occidentalis ♦</td>
<td>Hackberry</td>
<td>40-60</td>
<td>40-60</td>
<td>Green</td>
<td>Apr-May</td>
<td>Yellow, Yellow-Green</td>
<td>Moderate-Fast</td>
<td>☀ ☀</td>
<td>H/M</td>
<td>SS</td>
<td>Deciduous</td>
<td>X</td>
<td>Tolerates clay soil, wet soil, air pollution, drought, wind, extended flooding</td>
</tr>
<tr>
<td>Diospyros virginiana ♦</td>
<td>Persimmon</td>
<td>35-60</td>
<td>25-35</td>
<td>White, Yellow</td>
<td>May-June</td>
<td>Yellow-Green, Yellow, Yellow Reddish Purple</td>
<td>Slow-Moderate</td>
<td>☀ ☀</td>
<td>M</td>
<td>SS</td>
<td>Deciduous</td>
<td>X</td>
<td>Tolerates drought, clay soil, dry soil, shallow/rocky soil, air pollution; dioecious, install away from sidewalks &amp; walkways</td>
</tr>
<tr>
<td>Fagus sylvatica</td>
<td>European Beech</td>
<td></td>
<td></td>
<td>Yellowish-Green</td>
<td>Apr-May</td>
<td>Reddish-Bronze</td>
<td>Slow-Moderate</td>
<td>☀</td>
<td>L</td>
<td>SS</td>
<td>Deciduous</td>
<td></td>
<td>Tolerates deer; intolerant of wet soils, compaction, heat; messy fruit</td>
</tr>
<tr>
<td>’Atropunica’ ♦</td>
<td>Purple European Beech</td>
<td>50-75</td>
<td>40-60</td>
<td>Not Showy</td>
<td>N/A</td>
<td>Copper</td>
<td>Slow</td>
<td></td>
<td></td>
<td></td>
<td>MS</td>
<td></td>
<td>Tolerates clay soil, heat, dry soil</td>
</tr>
<tr>
<td>’Riversii’ ♦</td>
<td>Rivers Purple Beech</td>
<td>50-60</td>
<td>40-50</td>
<td>Yellowish-Green</td>
<td>Apr-May</td>
<td>Yellow</td>
<td>Slow-Moderate</td>
<td>☀</td>
<td>M</td>
<td>SS</td>
<td>Deciduous</td>
<td></td>
<td>Tolerates deer; intolerant of wet soils; do not always grow well in urban settings</td>
</tr>
<tr>
<td>Ginkgo biloba ♦</td>
<td>Ginkgo (male only)</td>
<td>50-80</td>
<td>30-40</td>
<td>Green</td>
<td>Mar-Apr</td>
<td>Yellow</td>
<td>Slow-Moderate</td>
<td>☀</td>
<td>M</td>
<td>SS</td>
<td>Deciduous</td>
<td></td>
<td>Fruitless, tolerates deer, clay soil, air pollution</td>
</tr>
</tbody>
</table>
Stormwater Swale
Landscape
Landscaping with Stormwater Swale
Landscaping in Stormwater Swales
Conventional Landscapes
Florida Friendly Landscapes
Florida Friendly Landscapes
Florida Friendly Landscapes
Landscaping w/Stormwater
Landscaping w/Stormwater
Landscaping w/Stormwater
Landscaping w/Stormwater
Stormwater Swale + Landscape
Stormwater Swale + Landscape + Trail
Stormwater Swale + Landscape + Trail
Swale + Landscape + Trail + Playground
Post LID
LID still requires basic Engineering
LID Stormwater Landscape “Framing”
LID Stormwater Landscape “Framing”
Bioswales - Lessons Learned

- Understand Potential Commitment to Maintenance
- Look for Multiple Use/Benefits
- Keep it Simple
- Engage people who will be directly affected
- Locate utilities, especially in urban areas
- Engage geotech for infiltration and water table
- Requires Stormwater Engineering
- Eye for Design
- Need landscape experience
- Right Vegetation in the Right Place
- Picture frame
The End