# 8. TREE TRENCH/ PIT

## 8.1 DESCRIPTION

A tree trench is a type of bioretention facility located within street right-of-way (ROW) in the amenity zone between the street and the sidewalk. A tree trench that features a single tree is also called a tree pit. For the purposes of this fact sheet, it is assumed that multiple trees are included and so the terminology “tree trench” will generally be used. A tree trench provides water quality treatment of runoff from the street and adjacent pedestrian zone and may also be designed to treat runoff from adjacent private development. Stormwater runoff enters the tree trench through a curb opening and chase-type inlet, passes through a fine-gravel filter for pretreatment, is conveyed through an underdrain to one or more tree plantings, fills pore space around the tree roots, and exits through a water level control structure. Treatment processes include filtration, absorption and adsorption, and uptake by the roots of the trees. This fact sheet provides specific design guidance for the application of bioretention to a tree trench, as described in Urban Drainage and Flood Control District’s (UDFCD) Urban Storm Drainage Criteria Manual, Volume 3 (USDCM Vol. 3). Detailed drawings and notes are included in this fact sheet to further illustrate the design of tree trenches.

Figure 29 illustrates how a tree trench can be integrated into the amenity zone of a typical street section. The figure shows the basic elements of the tree trench in cross section and in perspective. Figure 30 provides a profile view of a tree trench.

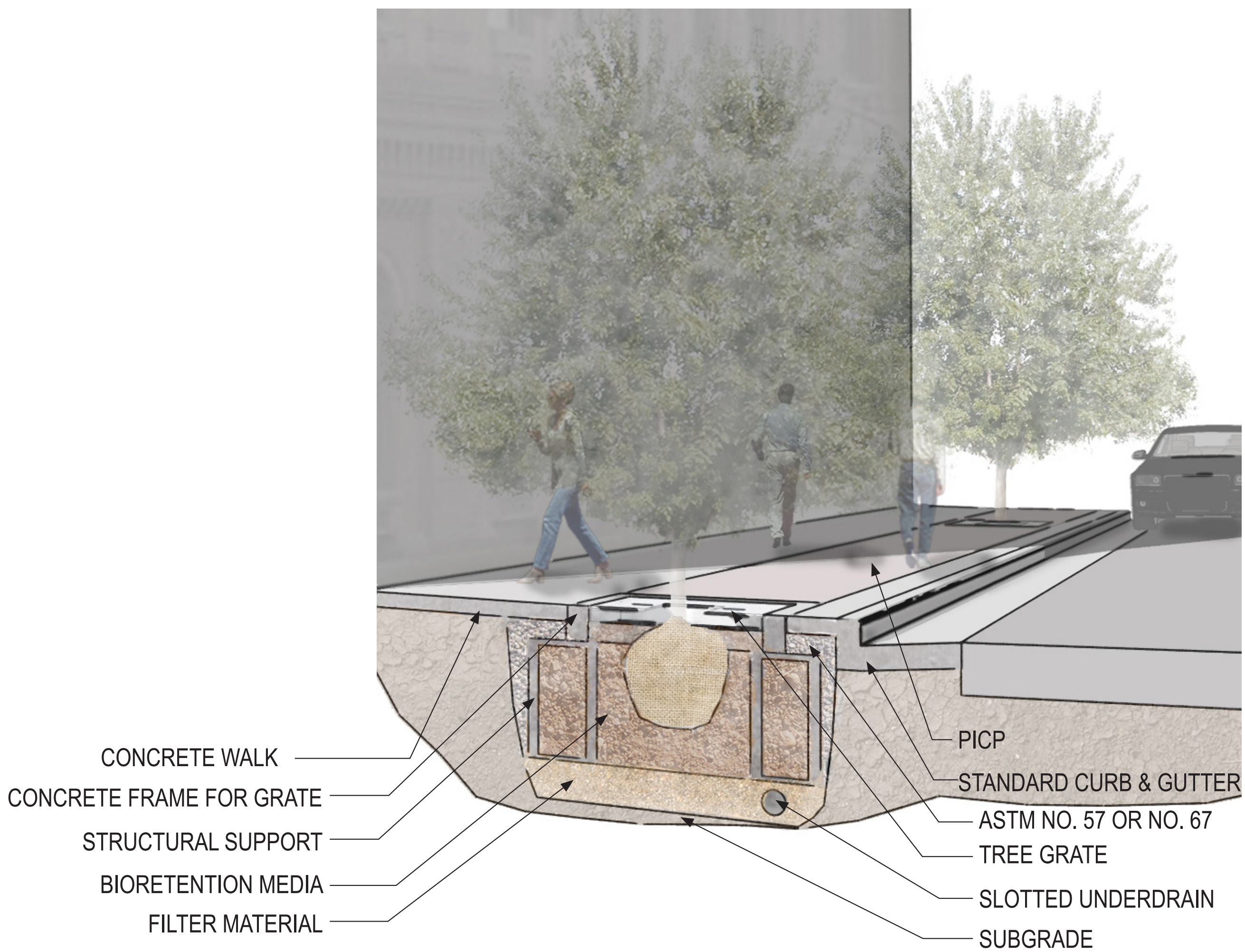



**FIGURE 29.** Tree Trench/Pit
(Source: Stream Design. 2015.)


**FIGURE 30 .** Tree Trench/Pit Profile View (Source: Stream Design. 2015.)

## 8.2 USES AND RECOMMENDATIONS

Tree trenches can be used along streets that do not receive a deleterious amount of deicing salts and when they can be placed to receive adequate tributary area. Sizing and locating tree trenches requires a determination of the area draining to the tree trench. There is a specific drainage area associated with a certain size of tree trench and it is necessary to place the tree trench in a location that has this upstream area draining to it. As such, the upstream end of a block is generally not an effective place to install a tree trench, while the middle or downstream end of a block is usually conducive. Adjustments can be made to locations and tree trench sizes to arrive at a properly sized facility in a desirable location. Siting tree trenches is also influenced by the presence of a storm drain system; ideally, a nearby inlet or manhole provides a convenient location for discharge of the underdrain.

If serving just the public ROW (street and pedestrian zone), three tree trenches with three trees each can satisfy the water quality requirements for an impervious area measuring 400 feet (a typical city block) by 30 to 34 feet (street crown to ROW) for Denver's local and collector street classifications. If a portion of the adjacent private development is also served or the street has a significantly wider ROW, additional tree trenches would be necessary. Figure 31 illustrates the layout of tree trenches for the drainage area shown in orange. This requires three tree trenches with three trees each and is based on a street crown to ROW distance of 40 feet.

Other types of green infrastructure described in these fact sheets can be implemented in combination with tree trenches. Table 1 in the Introduction provides information on approximate drainage areas that can be treated by various types of green infrastructure BMPs.

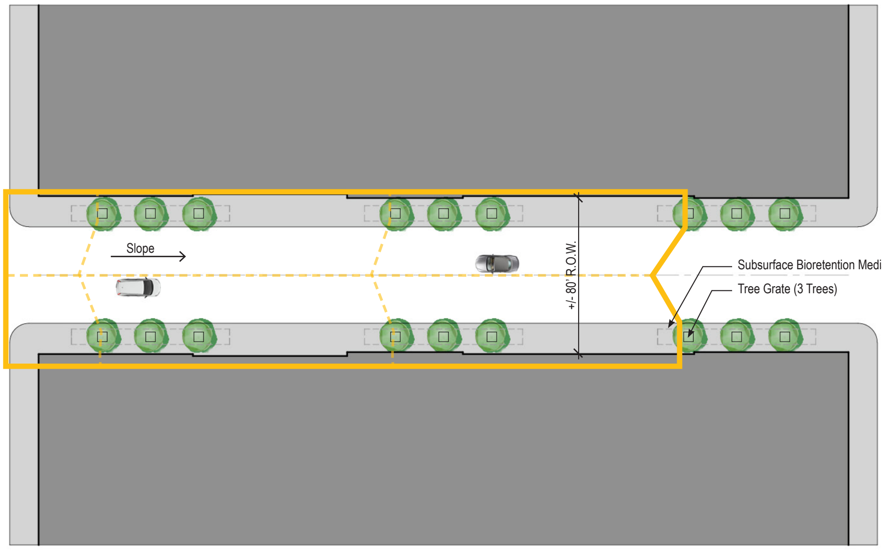



**FIGURE 31 .** Tree Trench/Pit City Block Diagram
(Source: Stream Design. 2015.)

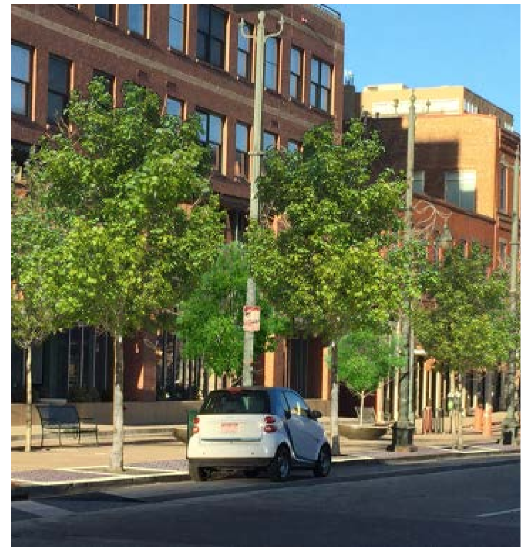


**FIGURE 32 .** Tree Trench/Pit in Urban Landscape
(Source: Tetra Tech. 2015.)

## 8.3 TREE TRENCH/PIT AESTHETICS AND URBAN DESIGN

From an urban design perspective, tree trenches have the same applications as urban street tree plantings and can be used interchangeably. Trees are typically located 4 to 6 feet from the back of curb. The amenity strip in which the tree trench is located should be continuously paved with permeable pavement, contributing to an attractive urban environment by adding color and texture and providing an attractive counterpoint to the surrounding concrete paving. Permeable pavement in this location also benefits tree health by providing air and rainwater to the root system. As with any elements in the public ROW the visible components of tree trenches (grates and permeable pavement) should match or complement the larger urban context, as well as add value to the adjacent properties. Design detailing should be uniform within each block, and preferably, within each district or neighborhood. Figure 32 illustrates how tree trenches can be integrated into the urban landscape.

## 8.4 USE OF GRATES

The preferred treatment surrounding the tree is a 4 inch curb with no tree grate. This allows the soil surrounding the tree to be visible while protecting the soil from compaction. This also allows for the area surrounding the tree to be planted with other vegetation. CCD staff has observed that trees surrounded by other vegetation are more frequently watered by nearby residents. Additionally, tree grates can damage the tree when not properly maintained.

When tree grates are used, a minimum separation of 4 inches between the grate and the tree trunk should be maintained. Grates shall be easily maintainable and need to be inspected on an annual basis. Another option is to use permeable interlocking concrete pavement (PICP) on top of the tree trench and continuing this to within 6 to 12 inches of the tree trunk. Examples of tree grates are shown in Figures 33-35. All designs should comply with the City of Denver Streetscape Design Manual, as well as the Public Works Transportation Standards and Details. In the event of conflicting criteria, these criteria supersede when constructing BMPs included in this manual. Cover plates meeting ADA accessibility requirements are necessary over the pre-treatment filter. The cover over the filter may consist of multiple sections that must be able to be lifted and slid to the side by maintenance staff to allow access to the filter media for cleaning. Additional information is provided in the design notes preceding the details.

**FIGURE 33.** Tree Trench Example A (Source: Starburst tree grate unfinished. http://www.ironsmith.cc/PROJECTS-TREEGRATES.html. 2015)

**FIGURE 34.** Tree Trench Example B (Source: Glackin Thomas Panzack, Inc.)

**FIGURE 35.** Tree Trench Example C. (Source: Pervious Pavers over Silva Cells. http://www.deeproot.com/blog/blog entries/advantages-pf-using-pervious-pavers-over-silva-cells. 2015.)

## 8.5 GEOMETRY

The conceptual design details at the back of this fact sheet illustrate the geometry and design features of a tree trench. The details are intended to provide a basis for the designer's final construction documents, although a site-specific design will be necessary addressing geotechnical issues, structural design, utility protection and relocation, tying in underdrain to a downstream storm drain or outfall, irrigation design, vegetation plan, and associated final design and construction document preparation tasks. Trees in this type of application require an uncompacted rooting volume of 750 to 1000 cubic feet per tree.

### WIDTH

The tree trench is typically centered approximately 4 to 6 feet behind the back of curb in a manner that preserves the step-out zone on the curb side of the trees and the sidewalk on the other. The width of excavation for the tree trench is approximately nine feet, and final tree planting areas must be a minimum of 5 feet in width.

Permeable pavement approximately 6 feet wide (as wide as the concrete grate rings) is recommended above the tree trench to intercept additional stormwater and help to provide oxygen to the roots of the tree.

### LENGTH

It is recommended that each tree trench section be constructed with a maximum of three trees with an overall tree trench length of about 66 to 86 feet, depending on tree spacing. Tree trench sections can be constructed back to back for any length desired; however, an inlet and water control structure is recommended for every three trees.

## 8.6 TREE TRENCH / PIT DESIGN CONSIDERATION

### WQCV ZONE

In accordance with USDCM Vol. 3 criteria for bioretention facilities, a tree trench is designed to capture the WQCV based on a 12-hour drain time. The required WQCV for the upstream area draining to a tree trench shall be computed using the procedures in USDCM Vol. 3.

In a departure from USDCM bioretention criteria, the water quality capture volume (WQCV) is comprised of the pore volume within the tree trench. A pore volume equivalent to 14 percent of the media and filter material volume can be counted toward the required WQCV in the ultra-urban green infrastructure BMPs documented in this manual. This pore space volume was selected based on testing of media approximately 24 hours after saturation. For the tree pit/ tree trench, this media porosity is reduced to an overall value of 13 percent to account for the volume occupied by the structural supports.

The available WQCV is calculated based on Equation 1, below:

**Equation 1**

WQCV provided = (Davg * Wavg * L) * P, where

Davg = average depth of media below the elevation of the water control structure weir crest (wetted depth), ft

Wavg = average media width, ft

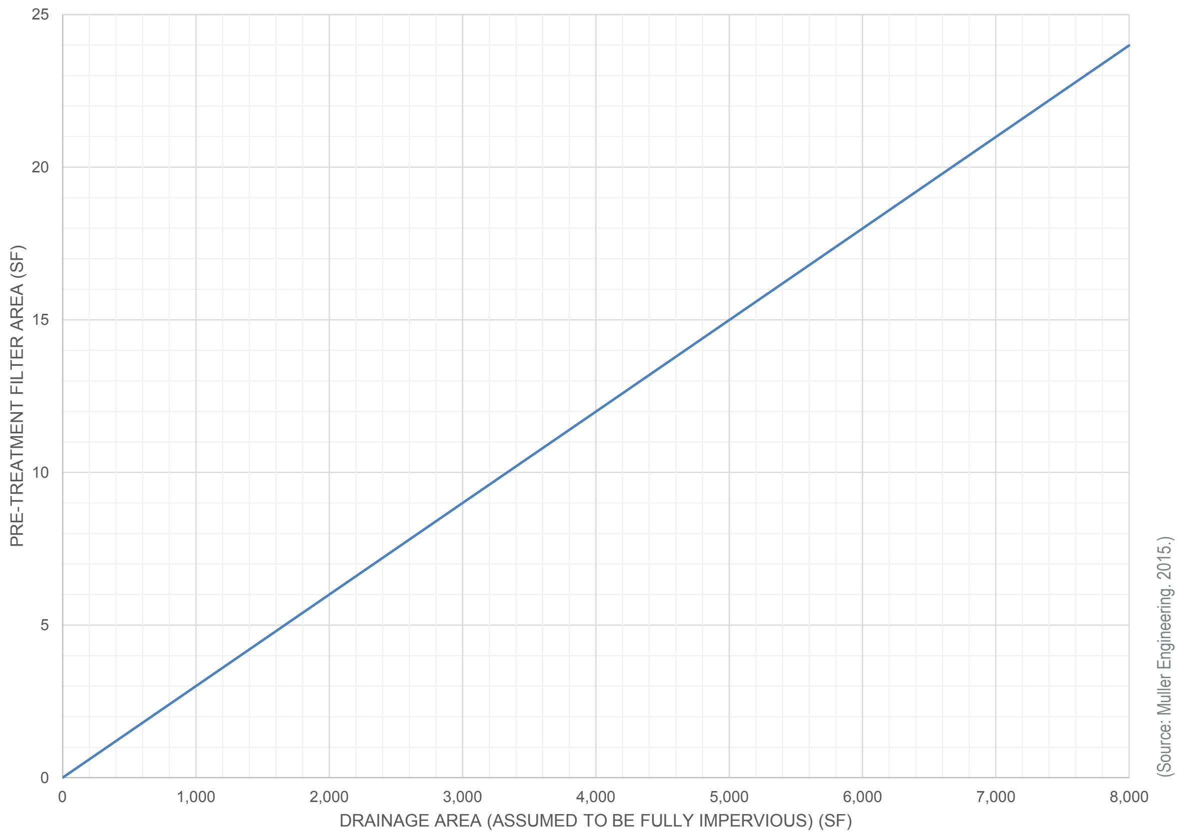
L = media length, ft

P = media porosity = 0.13

For steep street slopes, the media depth below the water control structure weir crest may be substantially less at the upstream end of the tree trench than at the downstream end; this needs to be taken into account when estimating the average media depth below the weir crest. It is possible that for very steep streets and long tree trenches, the elevation of the water control structure weir crest may be below the bottom of the media at the upstream end of the tree trench; in this case the length of media below the weir crest must be adjusted to be less than the total length of the facility.

In addition to sizing a tree trench to contain the WQCV, a tree trench must be designed to capture the peak discharge expected during the water quality storm event, neglecting the backwater effects of the water control structure. This capacity is intended to allow the pore volume in the tree trench to fill. The peak discharge during the water quality event is to be calculated using the Rational Method as described in Section 2.2 Design Criteria.

**FIGURE 36.** Pre-Treatment Filter Area based on Drainage Area




## INLET AND PRETREATMENT FILTER

The inlet must be designed to function in concert with a pretreatment filter. The pretreatment filter contains a filter media made up of ASTM No. 8 aggregate to provide a relatively high flow-through capacity. The filter is to be covered by removable grate panels meeting ADA requirements. Maintenance operations are necessary on a regular basis to remove litter, debris, and accumulated sediment. Figure 36 can be used to estimate the surface area of a pretreatment filter for a given upstream drainage area (assumed to be fully impervious). The details illustrate an inlet and filter combination in section. Additional information on inlet layout and sizing is provided in Section 2.2 Design Criteria.

## STRUCTURAL SUPPORTS

The tree trench relies on the placement of underground structural supports to provide a firm foundation for the permeable pavement, tree grates, and adjacent concrete pavement while at the same time keeping the bioretention media from becoming overly compacted. Dimensions and placement of these structural supports are represented in the details and a product description is provided in the Design Notes.

## OTHER PLANTER COMPONENTS

Section 2.2 Design Criteria section information regarding the following components of a tree trench:

- bioretention media
- underdrain system
- flow control structure
- liner

## 8.7 VEGETATION

### GENERAL

Tree trenches are designed to provide a favorable growing environment for trees, and provide much more uncompacted soil and air space for healthy tree root development than typical for urban street trees. As such, a wide variety of trees should thrive in tree trenches. Designers should consult the Office of the City Forester's list of approved street trees for reference, provided in Appendix D. This resource also provides information on recommended tree spacing for different types of trees, which will vary between 25 and 35 feet in tree trenches as shown in the details. Grasses or perennials should not be planted above the root balls of trees, but are encouraged around the open soil perimeter.

### TREE FORM

When selecting shade trees for use in urban situations, designers should specify trees with strong central leaders that can be trained over time to branch out 6 feet high or higher to avoid creating barriers and hazards to pedestrians. Smaller ornamental trees (from approved list) may be planted in areas with overhead power lines, or potentially in areas with low pedestrian traffic, however these are not recommended in high pedestrian volume, ultra-urban conditions. Proposed trees in the city ROW must be approved by the Office of the City Forester and right-of-way tree planting permits are required.

## 8.8 TREE TRENCH / PIT DETAILS

Typical designs of a tree pit and a tree trench are illustrated in a series of detail drawings in this section. The details indicate various elements of the tree pit/trench and representative dimensions. The designer is responsible for preparing final construction drawings suitable for the specific conditions, water quality requirements, utilities and constraints existing in the location where the BMP is to be sited. A geotechnical engineer shall consult on soil conditions and recommendations for lining. A structural engineer, with input from the geotechnical engineer shall design concrete elements, including wall thickness, reinforcing (reinforcing shown in details is representative only), any foundation components such as footings or bottom slab, and subgrade/bedding/backfill specifications. A site-specific design will also be necessary addressing utility protection and relocation, outlet of the underdrain to a downstream storm drain, selecting tree species, and associated final design and construction document preparation tasks. The following design notes apply to the detail drawings.

## DESIGN NOTES

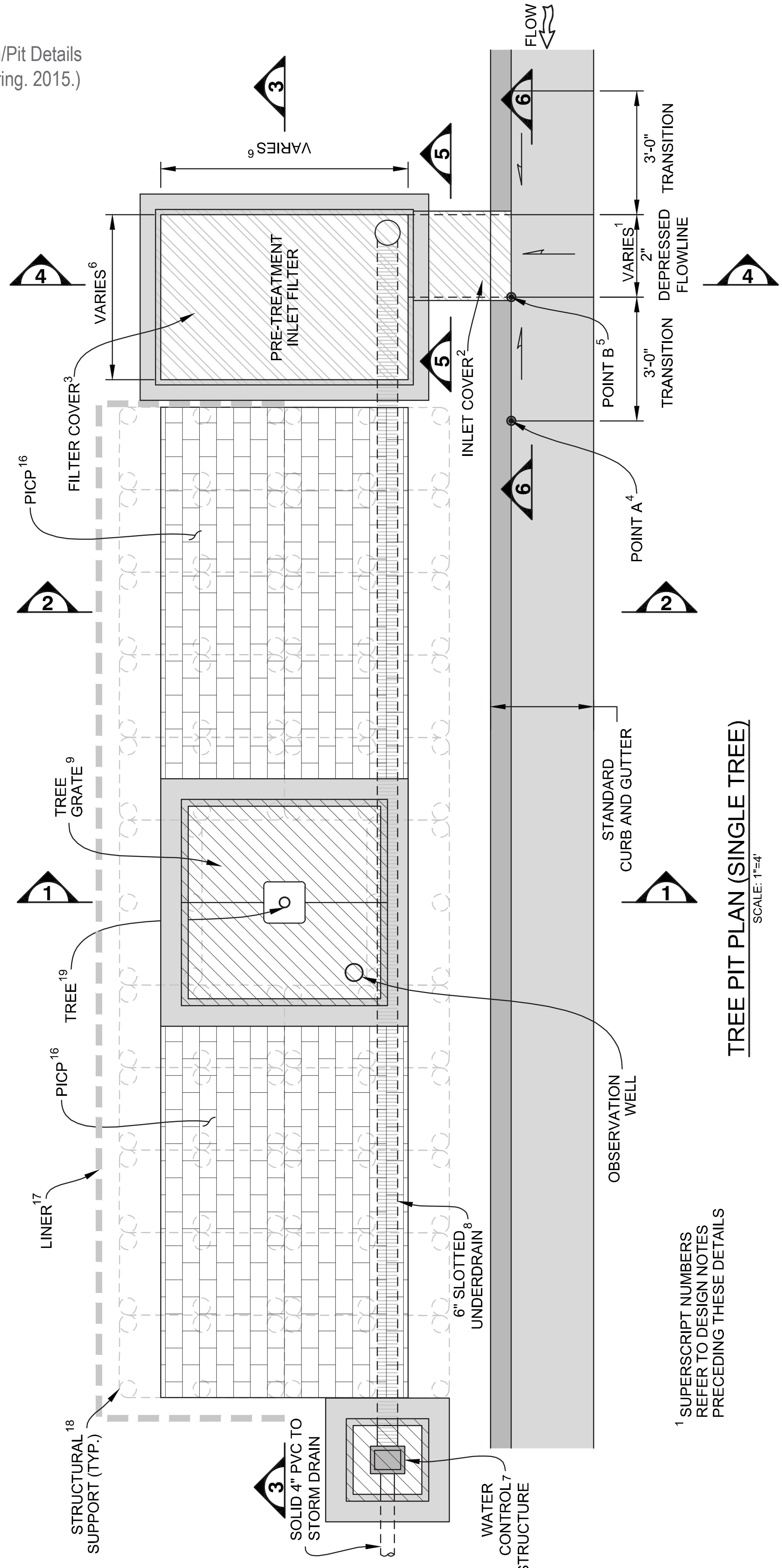
1. INLET WIDTH VARIES BASED ON UPSTREAM IMPERVIOUS AREA AND STREET SLOPE, WITH A MINIMUM WIDTH OF 2 FEET AND A MAXIMUM WIDTH OF 3 FEET. SEE CRITERIA FOR SIZING INLET WIDTH.
2. INLET COVER SHALL MEET ADA ACCESSIBILITY REQUIREMENTS AND CONSIST OF NEENAH R-4999 HEAVY DUTY BOLTED TRENCH GRATE TYPE D (SOLID) OR APPROVED EQUIVALENT – CATALOGUE NO. R-4999-HX FOR SPAN OF 2 FEET AND R-4999-MX FOR SPAN OF 3 FEET. THE LENGTH OF THE INLET COVER SHOULD BE FIELD CUT TO EXTEND CONTINUOUSLY FROM THE FACE OF CURB TO BACK OF PLANTER WALL AND SHOULD BE RECESSED FROM THE FACE OF THE CURB SO THAT THE CORNERS OF THE PLATE DO NOT PROTRUDE BEYOND THE TOP OF CURB.
3. FILTER COVER SHALL MEET ADA ACCESSIBILITY AND CONSIST OF NEENAH R-4999 HEAVY DUTY BOLTED TRENCH GRATE TYPE D (SOLID) OR APPROVED EQUIVALENT – CATALOGUE NO. R-4999-HX FOR SPAN OF 2 FEET, R-4999-MX FOR SPAN OF 3 FEET, AND R-4999- OX FOR SPAN OF 4 FEET. COVER MAY BE MADE UP OF SEPARATE PANELS AND EACH PANEL SHALL BE REMOVABLE. LENGTH AND WIDTH OF CONCRETE FILTER BOX SHALL BE ADJUSTED TO ALLOW STANDARD SIZE GRATES AND FRAME TO BE USED WHILE MAINTAINING REQUIRED SURFACE AREA. INDIVIDUAL GRATE SIZE SHALL BE NO GREATER THAN 8 SQUARE FEET.
4. FOR STREET SLOPES LESS THAN 5.5 PERCENT, THE ELEVATION OF THE FLOW LINE AT POINT A REPRESENTS THE WATER SURFACE ELEVATION ABOVE WHICH WATER IN THE INLET FILTER WOULD START TO FLOW OUT AND BE CONVEYED DOWN THE GUTTER. THIS ELEVATION IS EQUAL TO THE WATER QUALITY WATER SURFACE AND IS THE TOP OF THE WATER QUALITY CAPTURE VOLUME (WQCV).
5. FOR STREET SLOPES GREATER THAN 5.5 PERCENT, THE ELEVATION OF THE FLOW LINE AT POINT B REPRESENTS THE WATER SURFACE ELEVATION ABOVE WHICH WATER IN THE INLET FILTER WOULD START TO FLOW OUT AND BE CONVEYED DOWN THE GUTTER. THIS ELEVATION IS EQUAL TO THE WATER QUALITY WATER SURFACE AND IS THE TOP OF THE WATER QUALITY CAPTURE VOLUME.
6. THE PRE-TREATMENT FILTER SIZE IS TO BE SPECIFIED BY THE DESIGNER BASED ON THE MINIMUM SURFACE AREA SHOWN IN FIGURE 3. PRETREATMENT FILTER MEDIA SHALL BE ASTM NO. 8 AGGREGATE.
7. THE WATER CONTROL STRUCTURE IS COMPRISED OF AN INLINE WATER LEVEL CONTROL STRUCTURE AS SHOWN IN THE DETAILS. THIS STRUCTURE HOUSES A CONTROL ORIFICE DESIGNED TO RELEASE THE WQCV IN 12 HOURS AND A WEIR SET WITHIN 2 INCHES BELOW TO 0 INCHES ABOVE THE WATER QUALITY WATER SURFACE. THE WATER CONTROL STRUCTURE SHALL BE AN AGRI DRAIN

   INLINE WATER LEVEL CONTROL STRUCTURE AS MANUFACTURED BY AGRI DRAIN CORPORATION, OR APPROVED EQUIVALENT.
8. THE UNDERDRAIN SHALL MEET THE MATERIAL AND SLOT SPECIFICATIONS IDENTIFIED IN USDCM VOLUME 3.
9. THE TREE GRATE, WHEN USED, IS TO BE SPECIFIED BY THE DESIGNER AND MAY NEED TO CONSIDER LOCAL AREA DESIGN GUIDELINES IF APPLICABLE.
10. THE WATER QUALITY WATER SURFACE IS THE TOP OF THE WQCV AND IS EQUAL TO THE ELEVATION OF THE WEIR CREST OF THE WATER CONTROL STRUCTURE (6 TO 8 INCHES BELOW THE ELEVATION OF THE SIDEWALK AT THE WATER CONTROL STRUCTURE). THE WQCV IS COMPRISED OF THE PORE VOLUME OF THE MEDIA BELOW THE WATER QUALITY WATER SURFACE BASED ON AN OVERALL POROSITY OF 13 PERCENT (ACCOUNTS FOR VOLUME OCCUPIED BY STRUCTURAL SUPPORTS). IN ADDITION, SIZING OF TREE TRENCH IS BASED ON PROVIDING A FLOW-THROUGH CAPACITY THROUGH THE PRE-TREATMENT FILTER AND UNDERDRAIN AT LEAST AS GREAT AS THE PEAK DISCHARGE OF THE WATER QUALITY EVENT (NEGLECTING THE BACKWATER

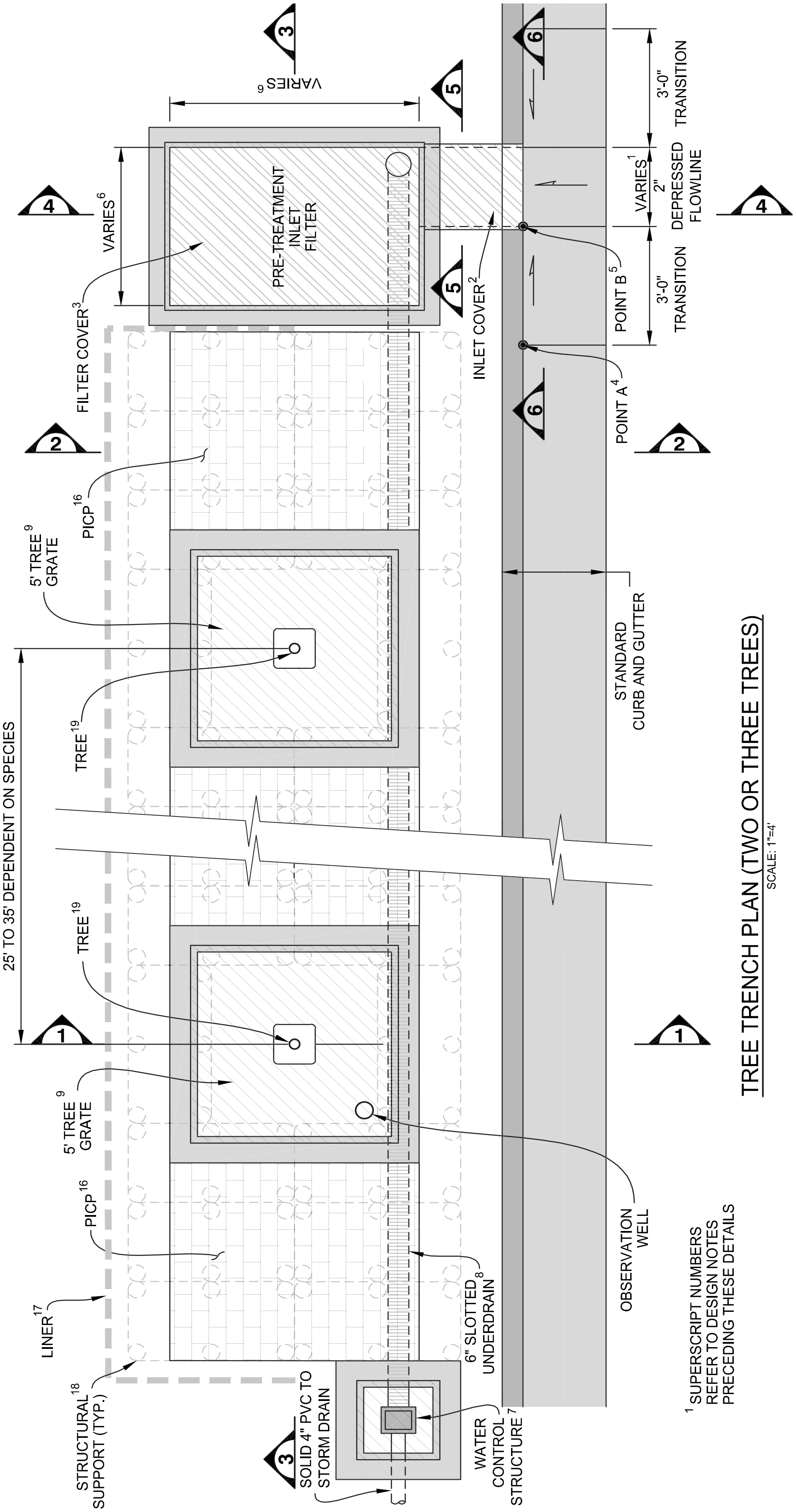
EFFECTS OF THE WATER CONTROL STRUCTURE.

11. BIORETENTION MEDIA SHALL MEET THE SPECIFICATIONS IDENTIFIED IN THE DESIGN CRITERIA SECTION OF THE INTRODUCTION. THE ROOTBALL SHALL BE PLACED ON NATIVE SOIL OR BIORETENTION MEDIA, AS SPECIFIED BY DESIGNER, COMPACTED TO 85 TO 90 PERCENT OF MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D698 TO REDUCE THE LIKELIHOOD OF SETTLEMENT UNDER THE TREE.
12. GEOGRID SHOWN ON DETAILS SHALL BE BX1100 AS MANUFACTURED BY TENSAR INTERNATIONAL CORPORATION, INC. OR APPROVED EQUIVALENT. AN ADDITIONAL LAYER OF MICROGRID AS MANUFACTURED BY STRATA SYSTEMS SHALL BE PLACED ON TOP OF THE HORIZONTAL LAYER OF GEOGRID ON THE TOP OF THE STRUCTURAL SUPPORTS AND BELOW THE LAYER OF ASTM NO. 2 AGGREGATE.
13. FILTER MATERIAL SHALL MEET THE SPECIFICATIONS IDENTIFIED IN USDCM VOLUME 3. FILTER MATERIAL SHALL BE COMPACTED TO A DENSITY OF NOT LESS THAN 70 PERCENT OF RELATIVE DENSITY DETERMINED IN ACCORDANCE WITH ASTM D4253 AND D4254 (FOR FINES CONTENT LESS THAN 5 PERCENT). THE UNDERDRAIN CLEANOUT SHALL CONSIST OF 4 INCH POLYVINYL CHLORIDE (PVC) PIPE WITH TWO 45 DEGREE BENDS AND A THREADED CAP SET 2 INCHES ABOVE THE TOP OF THE BIORETENTION MEDIA. A REMOVABLE PLATE OR GRATE FLUSH WITH PAVEMENT SHALL BE PROVIDED ABOVE THE CLEANOUT.
14. CDOT CLASS 1 OR 2 STRUCTURE BACKFILL, AS DETERMINED BY ENGINEER AND COMPACTED TO AT LEAST 95 PERCENT OF MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D698.
15. PICP AND UNDERLYING MATERIALS SHALL MEET THE REQUIREMENTS OF USDCM VOLUME 3.
16. LINER AS SPECIFIED BY GEOTECHNICAL ENGINEER SHALL BE MINIMUM 30 MIL THICK PVC GEOMEMBRANE FABRICATED IN ONE PIECE.
17. STRUCTURAL SUPPORTS SHALL BE SILVA CELL 2 AS MANUFACTURED BY DEEPROOT GREEN INFRASTRUCTURE OR APPROVED EQUIVALENT, INSTALLED ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.
18. STRUCTURAL ENGINEER, WITH INPUT FROM GEOTECHNICAL ENGINEER, SHALL DESIGN WALL DIMENSIONS, REINFORCING, ANY FOUNDATION COMPONENTS SUCH AS FOOTINGS OR BOTTOM SLAB, AND SUBGRADE/BEDDING/BACKFILL SPECIFICATIONS.
19. TREES SHALL BE STAKED WITH THREE GUY LINES. GUY LINES SHALL BE FASTENED TO TREE GRATE OR TO EYEBOLTS INSTALLED IN CONCRETE TREE RING.

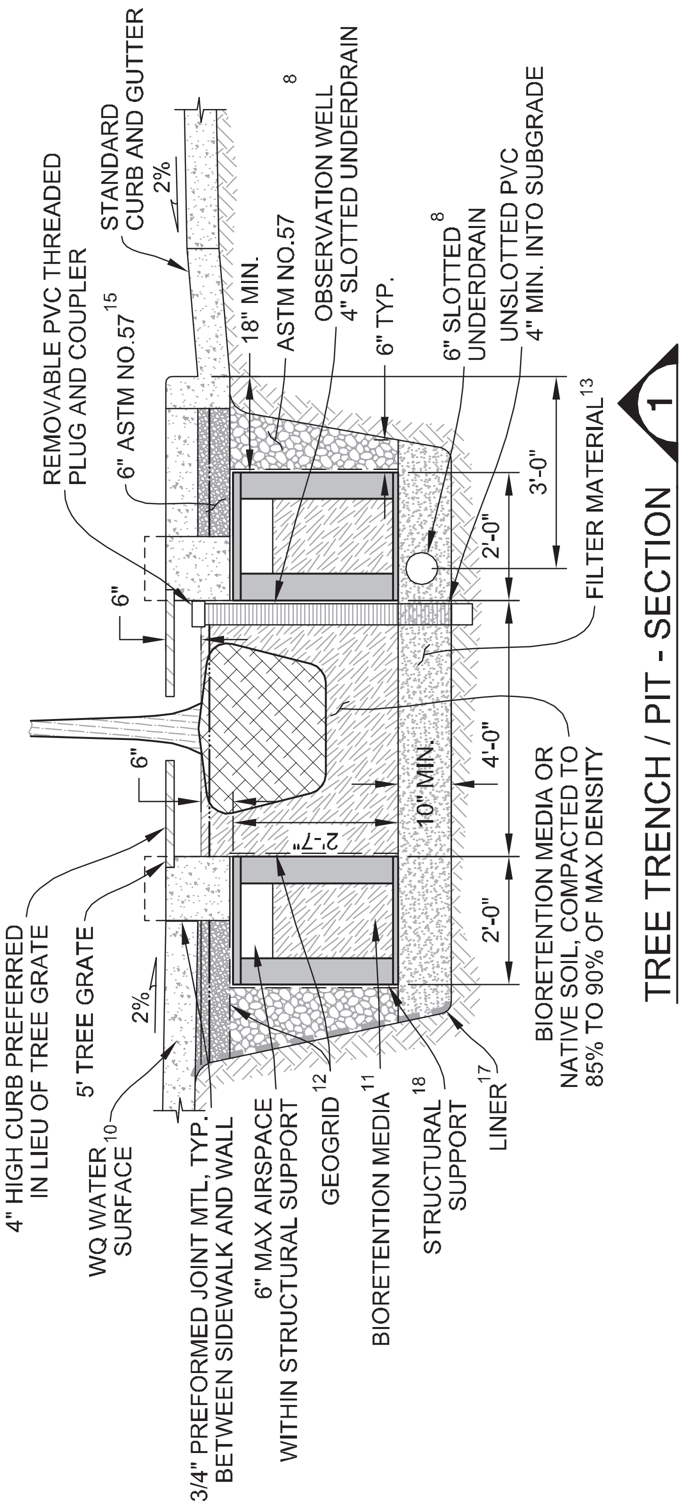
**FIGURE 37.** Tree Trench/Pit Details
(Source: Muller Engineering. 2015.)



## 8. TREE TRENCH / PIT

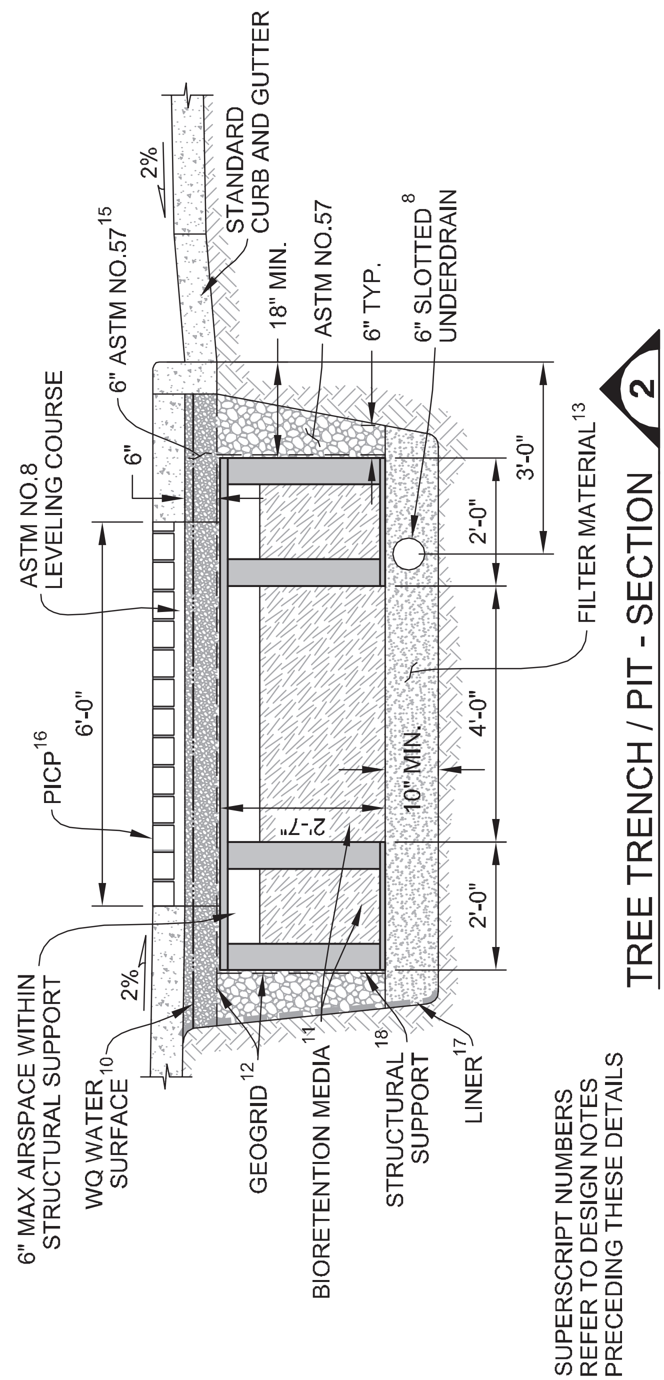



TREE TRENCH PLAN (TWO OR THREE TREES)
SCALE: 1"=4'




TREE TRENCH / PIT - SECTION 1

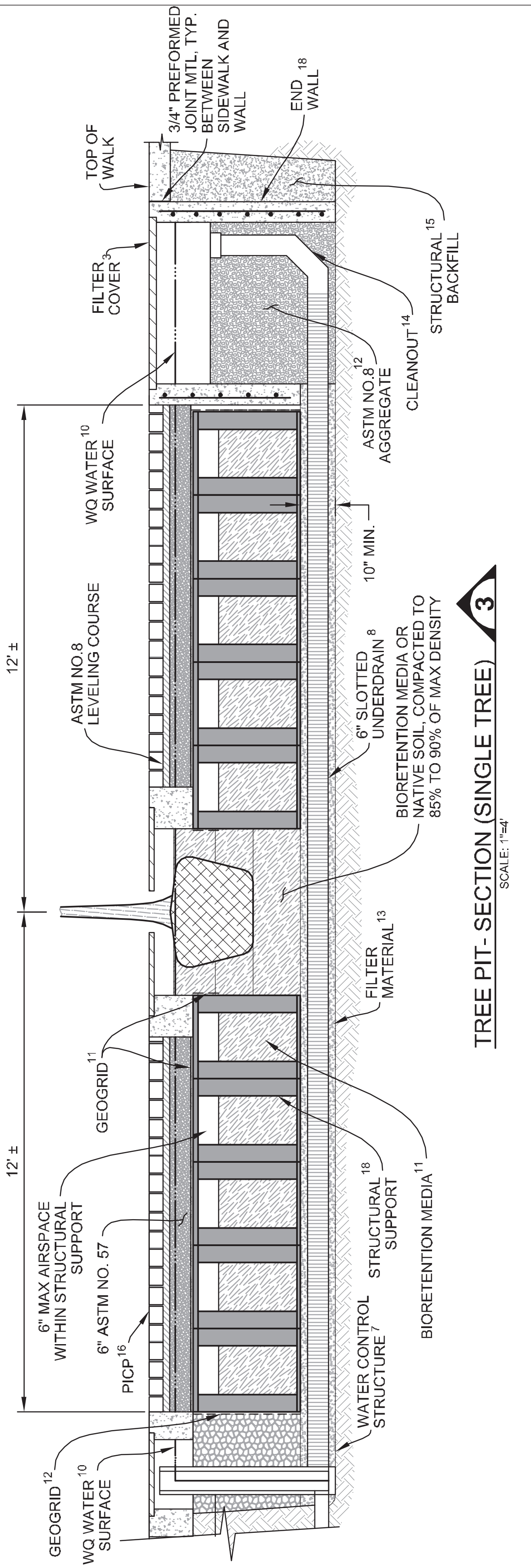
SCALE: 1"=3'



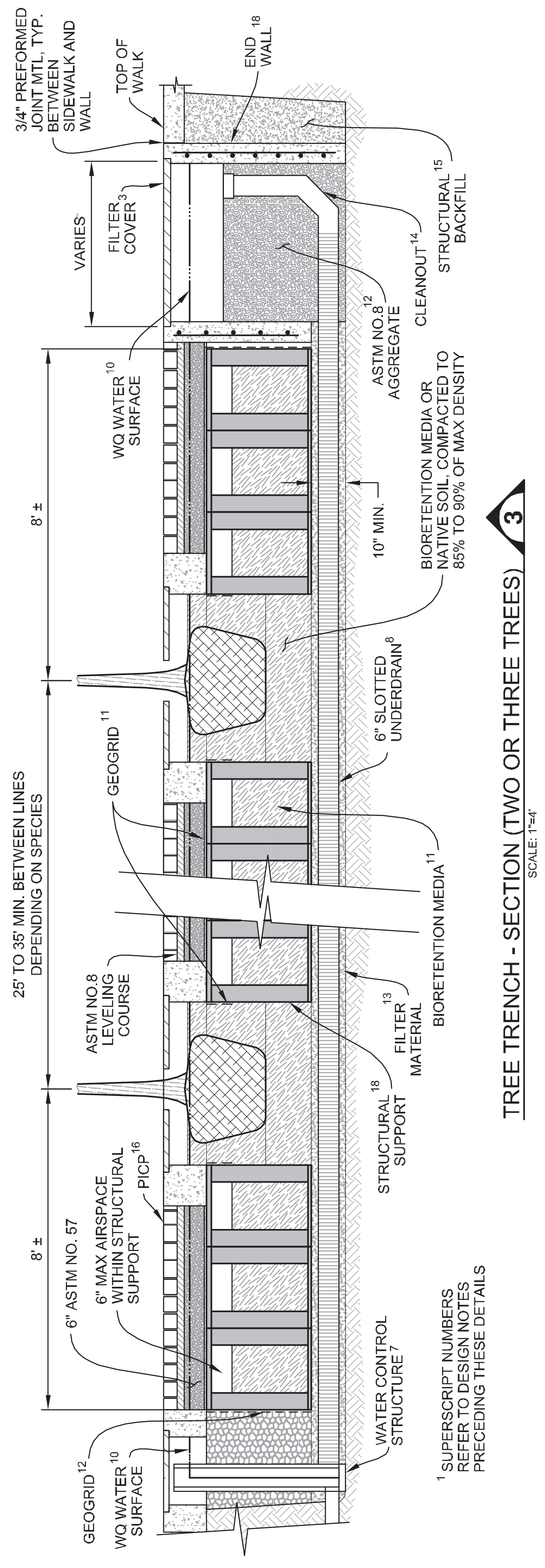

TREE TRENCH / PIT - SECTION 2

SCALE: 1"=3'

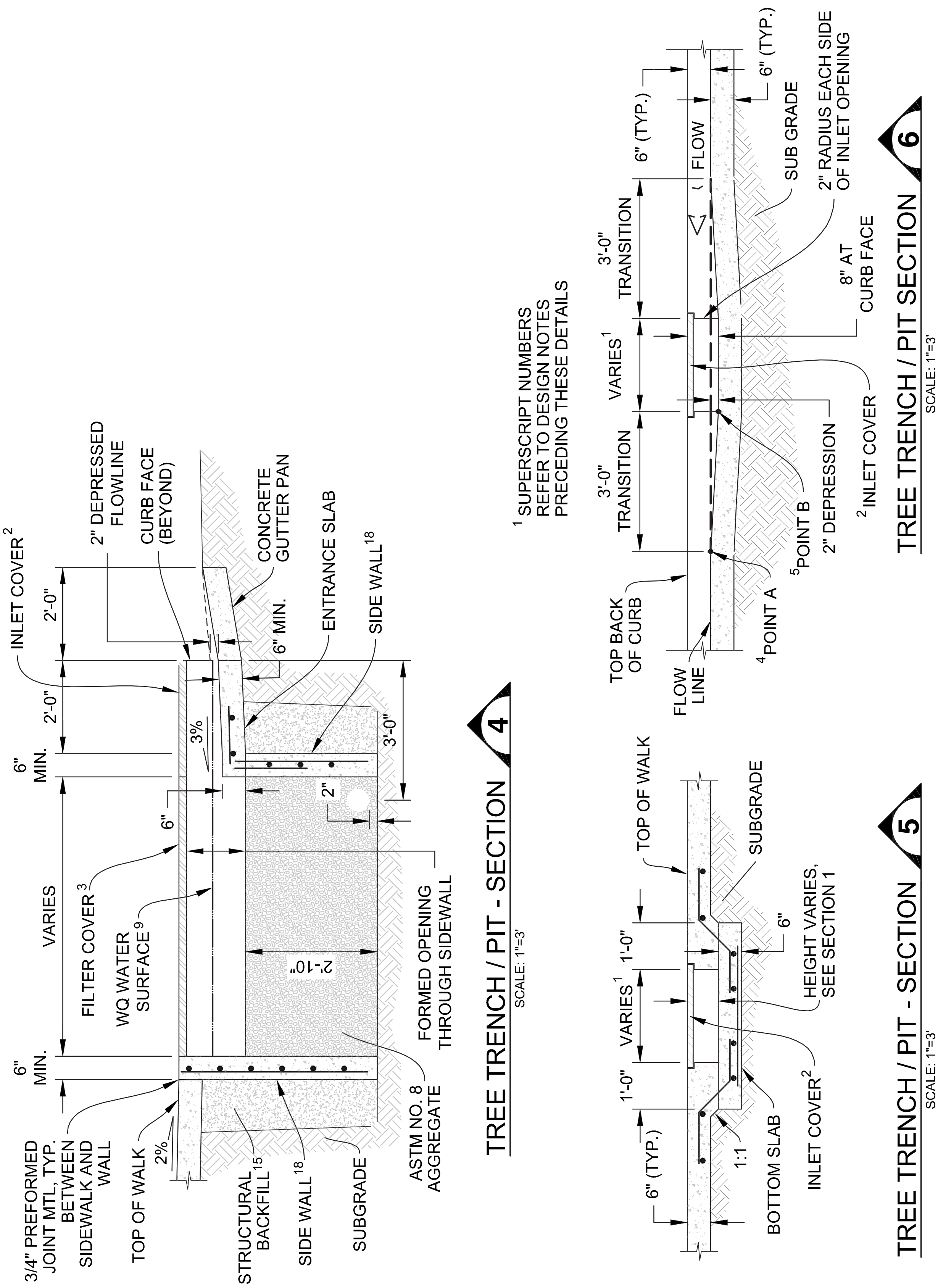
[1] SUPERSCRIPT NUMBERS REFER TO DESIGN NOTES PRECEDING THESE DETAILS

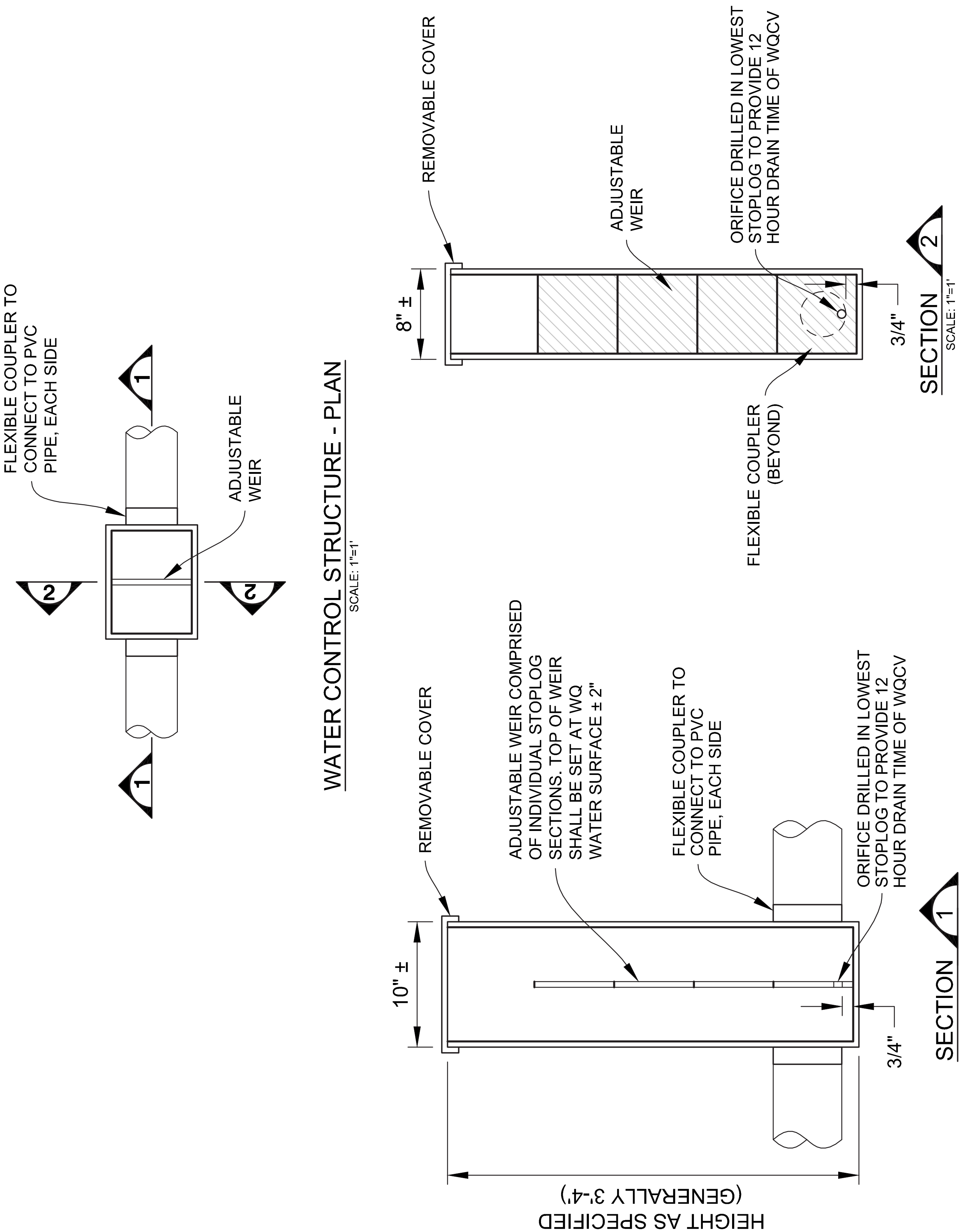


TREE PIT- SECTION (SINGLE TREE)
SCALE: 1"=4'



TREE TRENCH - SECTION (TWO OR THREE TREES)
SCALE: 1"=4'


INLET COVER 2
2'-0"
2" DEPRESSED FLOWLINE
CURB FACE (BEYOND)
CONCRETE GUTTER PAN
6" MIN.
ENTRANCE SLAB
SIDE WALL 18
2'-0"
6" MIN.
3%
3'-0"
2"
VARIES
FILTER COVER 3
WQ WATER SURFACE 9
6"
2'-10"
FORMED OPENING THROUGH SIDEWALL
6" MIN.
3/4" PREFORMED JOINT MTL, TYP. BETWEEN SIDEWALK AND WALL
TOP OF WALK
2%
STRUCTURAL BACKFILL 15
SIDE WALL 18
SUBGRADE
ASTM NO. 8 AGGREGATE
TREE TRENCH / PIT - SECTION
SCALE: 1"=3'
4
1 SUPERSCRIPT NUMBERS REFER TO DESIGN NOTES PRECEDING THESE DETAILS
6" (TYP.)
1'-0"
VARIES 1
1'-0"
TOP OF WALK
SUBGRADE
6"
HEIGHT VARIES, SEE SECTION 1
1:1
BOTTOM SLAB
INLET COVER 2
TREE TRENCH / PIT - SECTION
SCALE: 1"=3'
5
TOP BACK OF CURB
FLOW LINE
3'-0" TRANSITION
VARIES 1
3'-0" TRANSITION
6" (TYP.)
FLOW
6" (TYP.)
SUB GRADE
2" RADIUS EACH SIDE OF INLET OPENING
8" AT CURB FACE
2 INLET COVER
2" DEPRESSION
5 POINT B
4 POINT A
TREE TRENCH / PIT SECTION
SCALE: 1"=3'
6


FLEXIBLE COUPLER TO CONNECT TO PVC PIPE, EACH SIDE
ADJUSTABLE WEIR
1
2
WATER CONTROL STRUCTURE - PLAN
SCALE: 1"=1'
REMOVABLE COVER
ADJUSTABLE WEIR
ORIFICE DRILLED IN LOWEST STOPLOG TO PROVIDE 12 HOUR DRAIN TIME OF WQCV
FLEXIBLE COUPLER (BEYOND)
8" ±
3/4"
SECTION
SCALE: 1"=1'
REMOVABLE COVER
ADJUSTABLE WEIR COMPRISED OF INDIVIDUAL STOPLOG SECTIONS. TOP OF WEIR SHALL BE SET AT WQ WATER SURFACE ± 2"
FLEXIBLE COUPLER TO CONNECT TO PVC PIPE, EACH SIDE
ORIFICE DRILLED IN LOWEST STOPLOG TO PROVIDE 12 HOUR DRAIN TIME OF WQCV
10" ±
3/4"
SECTION
HEIGHT AS SPECIFIED (GENERALLY 3'-4')