APPENDIX F

ALL OTHER DEVELOPMENT SAMPLE DESIGN CALCULATIONS

A portion of the information provided in this appendix is referenced to the Los Angeles County Department of Public Works' *Low Impact Development Standards Manual* (LACDPW, 2014).

A map of the 85th percentile 24-hour rainfall depth and predominate soil type can be found at: http://dpw.lacounty.gov/wrd/hydrologygis/.

County of Los Angeles Department of Public Works, Analysis of 85th percentile 24-hour Rainfall Depth Analysis within the County of Los Angeles (February 2004) (http://ladpw.ord/wrd/publications).

County of Los Angeles Department of Public Works, HydroCalc may be downloaded at: http://dpw.lacounty.gov/wmd/dsp_LowImpactDevelopment.cfm.

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FLOW RATE AND VOLUME CALCULATION EXAMPLE

Volume must be calculated for each tributary area to size each BMP.

PROJECT NAME: Commercial Site (Intersection of Western Ave & Washington Blvd)

Provide proposed project characteristics

A_{Total}	**1.15 Acres**
Type of Development	**Commercial**
Flow Path Length	**200 ft**
Flow Path Slope	**.01 (1%)**
% of Project Impervious	**87 %**
Predominate Soil Type #	**13**
Design Storm*	**85th percentile**

***Projects are required to use the larger of the Stormwater Quality Design Storm.**

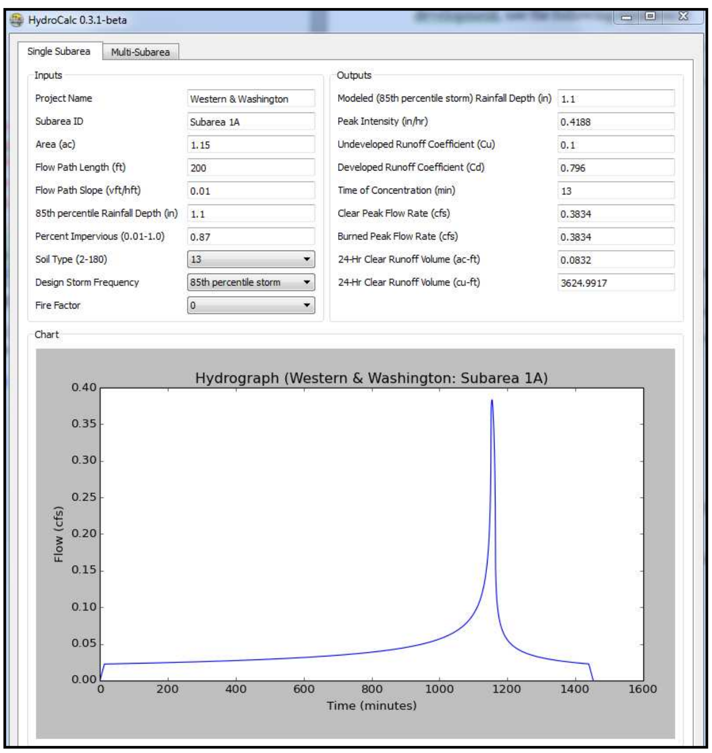
- *The volume of runoff produced from a 0.75 inch (or 0.0625 ft) storm event, or*
- *The 85th percentile, 24-hr runoff event at this location = 1.1 inch (or 0.91 ft)*

Refer to LA County Hydrology GIS Map
http://dpw.lacounty.gov/wrd/hydrologygis/

DETERMINING THE PEAK MITIGATED FLOW RATE (Q_{PM}):

Download HydroCalc Calculator (save onto your desktop). The HydroCalc Calculator allows the site designer/engineer to calculate runoff rates and volumes from the water quality storm.

http://dpw.lacounty.gov/wmd/dsp_LowImpactDevelopment.cfm



DETERMINING THE VOLUME (V_M)

In order to determine the volume (V_M) of stormwater runoff to be mitigated from the new development, use the larger storm volume from the following equation(s):

0.75 in Design Storm: $V_M\ (ft^3) = (\ 0.625\ Ft\ ) \bullet \text{Catchment Area}_{(Sq.\ Ft)}$

85th Percentile Design Storm: $V_M\ (ft^3) = \textit{(Storm Depth}_{(Ft)}\textit{)} \bullet \text{Catchment Area}_{(Sq.\ Ft)}$

> Refer to LA County Hydrology GIS Map
> http://dpw.lacounty.gov/wrd/hydrologygis/
>
> and
>
> http://ladpw.org/wrd/publication/engineering/Final_Report-Probability_Analysis_of_85th_Percentile_24-hr_Rainfall1.pdf

From Example, 1.1 inch > 0.75 inch, use
1.1 inch (0.91)Design Storm:

A_I = 1.0 acres

A_P = 0.15 acres

$V_M\ (ft^3) = (\ 0.091\ ft\ ) \bullet \text{Catchment Area}_{(in\ ft^2)}$

$$Catchment\ area\ (ft^2) = (impervious\ area \bullet 0.9) + [(pervious\ area + undeveloped\ area) \bullet 0.1]$$

$$Catchment\ area\ (ft^2) = 43{,}560\ ft^2 \bullet [(1\ ac \bullet 0.9) + [(0.15\ ac) \bullet 0.1] = 39{,}857.4\ ft^2]$$

$V_M\ (ft^3) = (\ 0.091\ ft\ ) \bullet 39{,}857.4\ ft^2$

$V_M = 3{,}627\ ft^3$ (verify results with Hydrocalc results)

BMP TYPE AND SIZE

10. List the BMP Type(s) to be used in managing the calculated V_m, and size it per the design criteria listen in Section 4.

    The following examples have been provided as a reference:

    Infiltration BMPs:
    - Infiltration Trench
    - Dry Well
    - Infiltration Basin

    Capture and Use
    - Rain Tanks
    - Above / Below Grade Cisterns

    Biofiltration
    - Vegetated Swale
    - Planter Box
    - Biofiltration with underdrain

<u>Infiltration BMP - Design for At Grade Infiltration Trench</u>

Givens:

- $V_m = 3{,}627\ ft^3$ *(from previous step)*
- $K_{Sat,\ Measured} = 2$ in/hr (Do not apply LA County reduction factor)
- T = 48 hrs *(from Table 4.4)*
- FS = 3 *(from Table 4.4)*
- Gravel void ratio = 40%

i. Determine $K_{Sat,\ Design}$

$$K_{Sat,Design} = \frac{K_{Sat,Measured}}{FS} = \frac{2\ in/hr}{3} = 0.667\ in/hr$$

ii. Determine Minimum Bottom Infiltration, A_{min}:

$$A_{min} = \frac{Vm \bullet 12\ in/ft}{K_{Sat,Design} \bullet T}$$

$$A_{min} = \frac{3{,}627\ ft^3 \bullet 12\ in/ft}{0.667\ in/hr \bullet 48\ hr} = 1{,}359\ ft^2$$

iii. Determine 3-hr infiltration volume, $V_{3\text{-}hr}$:

$$V_{3-hr} = A_{min} \bullet \left(\frac{K_{Sat,Design}}{12\ in/ft} \right) \bullet 3hrs = 1{,}359\ ft^2 \bullet \frac{0.667\ in/hr}{12\ in/ft} \bullet 3hrs = 226\ ft^3$$

iv. Determine the volume stored within the trench, $V_{Trench\ Storage}$:

$$V_{Trench\ Storage} = \frac{V_m}{Void\ ratio} = \frac{3{,}627\ ft^3}{0.4} = 9{,}067\ ft^3$$

v. Determine remaining volume of storage required:

$$V_{Storage} = V_{Trench\ Storage} - V_{3-hr} = 9{,}067\ ft^3 - 226\ ft^3 = 8{,}841\ ft^3$$

vi. Determine Design Depth:

$$D_{Design} = \frac{V_{Storage}}{A_{min}} = \frac{8{,}841\ ft^3}{1{,}359\ ft^2} = 6.5\ ft$$

Infiltration BMP – Design for Below Grade Dry Well

Givens:

- V_m = 3,627 ft^3 *(from previous step)*
- $K_{Sat,\ Measured}$ = 2 in/hr (Do not apply LA County reduction factor)
- Gravel void ratio = 40%
- Factor of Safety = 3 *(per table 4.4)*
- A_{min} = 934 ft^2
- D = 6 ft (r = 3 ft)

i. Required dry well depth for the infiltration zone, h:

$$h = \frac{A_{\min} - \pi r^2}{2\pi r}$$

$$h = \frac{934\,ft^2 - 28.26\,ft^2}{18.84\,ft} = 48\ \ ft\,*$$

* ***Multiple dry wells may be used to achieve the equivalent infiltration zone.***

ii. Determine the dry well storage volume, $V_{Storage}$:
(assuming entirely filled with gravel)

$$V_{Storage\ \ Dry\ \ Well} = V_{DryWell} \bullet Void\ \ Ratio$$
$$= \left[\pi r^2 h\right] \bullet 0.4 = [\pi \bullet (3\,ft)^2 \bullet 48\,ft] \bullet 0.4 = 543\,ft^3$$

iii. Determine 3-hr infiltration volume, $V_{3\text{-}hr}$:

$$V_{3-hr} = A_{\min} \bullet \left(\frac{K_{Sat,Design}}{12\, in/ft} \right) \bullet 3hrs = 934\,ft^2 \bullet \frac{0.667\, in/hr}{12\, in/ft} \bullet 3hrs = 156\,ft^3$$

iv. Determine the additional required storage volume, $V_{Additional\ Storage}$:

$$V_{Additional\ \ Storage} = V_m - \left(V_{Storage\ \ Drw\ \ Well} + V_{3-hr}\right) = 3{,}627\,ft^3 - \left(543\,ft^3 + 156\,ft^3\right) = 2{,}928\,ft^3$$

2,928 ft^3 of additional storage is required.

In order to satisfy the additional storage requirement, an upstream cistern or additional dry well chambers can be used. Some proprietary systems may provide additional storage capacity. Coordinate with manufactures.

<u>Infiltration BMP – Design for Below Grade Infiltration Basin</u>

Givens:

- V_m = 3,627 ft^3 *(from previous step)*
- $K_{Sat, Measured}$ = 2 in/hr (Do not apply LA County reduction factor)
- T = 96 hrs *(Table 4.4)*

i. Determine the design infiltration rate, $K_{Sat,Design}$:

$$K_{Sat,Design} = \frac{K_{Sat,Measured}}{FS} = \frac{2 \ in/hr}{3} = 0.667 \ in/hr$$

ii. Determine Minimum Bottom Infiltration, A_{min}:

$$A_{min} = \frac{Vm \bullet 12 \ in/ft}{K_{sat,Design} \bullet T}$$

$$A_{min} = \frac{3{,}627 \ ft^3 \bullet 12 \ in/ft}{0.667 in/hr \bullet 96 \ hr} = 680 \ ft^2$$

iii. Determine the Basin Design, D_{Basin}:

$$D_{Basin} = \frac{V_{Storage}}{A_{min}} = \frac{3{,}627 \ ft^3}{680 \ ft^2} = 5.3 \ ft$$

Design for: Capture & Use

Givens:

- $V_{Design} = 3{,}627\ ft^3$ *(from previous step)*
- 0.15 acres of pervious area
- Medium Planting Type → Planting Factor = 0.4

i. Determine the design volume in gallons:

$$V_{Design}(gal) = 3{,}627\ ft^3 \bullet 7.48\ {gal}/{ft^3} = 27{,}130\ gal$$

ii. Determine planting area (ft^2) within project limits:

$$Planting\ \ Area\ \ (ft^2) = 0.15\ \ ac\ \ \bullet\ \ 43{,}560\ {ft^2}/{ac} = 6{,}534\ \ ft^2$$

iii. Determine Planter Factor, PF, (ft^2):
(Planting factor may vary based on landscape design and plant types. Coordinate with Landscape Architect.)

$$Planter\ \ Factor\ \ (ft^2) = 0.4\ \ \bullet\ \ 6{,}534\ \ ft^2 = \ 2{,}614\ \ ft^2$$

iv. Determine the 7- month (Oct 1 – April 30) Estimated Total Water Use (ETWU):

$$ETWU_{(7-month)} = ET_7\ \bullet\ 0.62 \bullet\ PF$$

$$ETWU_{(7-month)} = 21.7\ \bullet\ 0.62 \bullet\ 2{,}614\ \ ft^2 = 35{,}163\ \ gal$$

v. Verify $ETWU_{(7\text{-month})}$ is greater than or equal to the $V_{Designed}$:

$$ETWU_{(7-month))} = 35{,}163\ \ gal\ \ \geq\ \ V_{Design}\ \ (gal) = 3{,}627\ \ gal$$

∴ CAPTURE & USE IS FEASIABLE

<u>Biofiltration BMP – Design for Vegetated Swale*</u>

Givens:

- base of swale = 5 ft
- Slope = 3%

i. Determine the swale base width and corresponding unit length:

- Per Table 4.6 → Select swale base of 5 ft with corresponding unit length of 470 ft/ac.

ii. Determine the total swale length:

$$L_{Swale(ft)} = 1.5 \bullet Catchment\ area\ (ft^2) \bullet \left(\frac{1\ acre}{43{,}560\ \ ft^2} \right) \bullet Swale\ lenght\ \ per\ \ catchment\ \ area\ \left(ft/acre \right)$$

$$Catchment\ area\ (ft^2) = \left(impervious\ area \bullet 0.9 \right) + \left[\left(pervious\ area + undeveloped\ \ area \right) \bullet 0.1 \right]$$

$$Catchment\ area\ (ft^2) = 43{,}560\ \ ft^2 \bullet \left[(1 \bullet 0.9) + \left[(0.15 + 0) \bullet 0.1 \right]\ \right]$$

$$Catchment\ area\ (ft^2) = 39{,}857.4\ \ ft^2$$

$$L_{Swale(ft)} = 1.5 \bullet 39{,}857.4\ \ ft^2 \bullet \left(\frac{1\ acre}{43{,}560\ \ ft^2} \right) \bullet\ 470\ \ ft/acre$$

$$L_{Swale(ft)} = 645\ \ ft$$

iii. Determine the distance between check dams:

- Per Table 4.7 → At a 3% slope, the distance between check dams is 33 ft.

iv. Determine total number of check dams:

$$Total\ \#\ of\ \ dams\ = \frac{645}{33} = 19.5 \rightarrow \underline{use\ \ 20}$$

* Depending on the location of the swale, a geotechnical report may need to be submitted and approval from LADBS may be required.

Design for: Planter Box

Givens:

- V_m = 3,627 ft^3 *(from previous step)*
- Soil media infiltration rate, k_{sat}: 5 in/hr *(Table 4.5)*
- Time to fill 3 ft of media (*24” soil, 12” gravel)* to ponding depth, T_{Fill} = 3 hrs *(Table 4.5)* *(per engineer, ex: 24” soil media, 12” gravel)*
- Drawdown time, T (hr) = 48 hrs *(Table 4.5)*
- Ponding Depth = 1 ft $_{(MAX)}$ (Table 4.5)

i. Determine the design volume:

$$V_{Design}(ft^3) = 1.5 \bullet V_m$$

$$V_{Design}(ft^3) = 1.5 \bullet 3{,}627\ ft^3 = 5{,}440\ ft^3$$

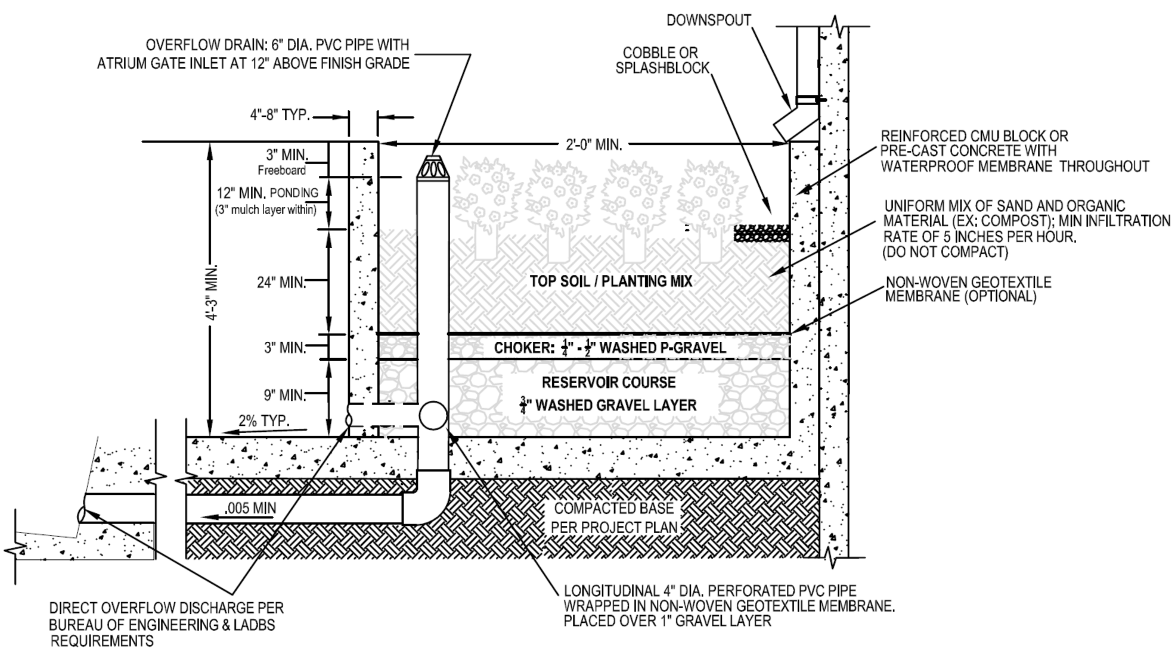
ii. Determine the design infiltration rate, $K_{Sat,Design}$:

$$K_{Sat,Design} = \frac{K_{Sat,Media}}{FS} = \frac{5\ {}^{in}/_{hr}}{2} = 2.5\ {}^{in}/_{hr}$$

iii. Calculate the BMP Surface Area, A_{min}*:

$$A_{min}(ft^2) = \frac{V_{Design}}{\left[\left(\frac{T_{Fill} \bullet k_{Sat,Design}}{12\ {}^{in}/_{ft}}\right) + d_p\right]} = \frac{5{,}440\ ft^3}{\left[\left(\frac{3\ hrs \bullet 2.5\ {}^{in}/_{hr}}{12\ {}^{in}/_{hr}}\right) + 1\,ft\right]} = 3{,}347\ ft^2$$

**** Rule of thumb: With a max ponding depth of 1 ft, area needed is 5 - 6% of impervious area***



SECTION NOT TO SCALE

Alternative Design I

If ponding depth is reduced to 6" (0.50 ft), and the planting media is maintained at 24" and 12" of washed gravel, the minimum planter surface area would then be as follows:

Givens:

- V_m = 3,627 ft^3 *(from previous step)*
- Soil media infiltration rate, k_{sat}: 5 in/hr *(Table 4.5)*
- Time to fill 3 ft of media (*24" soil, 12" gravel)* to ponding depth, T_{Fill} = 3 hrs *(Table 4.5) (per engineer, ex: 24" soil media, 12" gravel)*
- Drawdown time, T (hr) = 48 hrs *(Table 4.5)*
- Ponding Depth, d_p *(ft)* = 6" = 0.50ft (Table 4.5)

i. Determine the design volume:

$$V_{Design}(ft^3) = 1.5 \bullet V_m$$

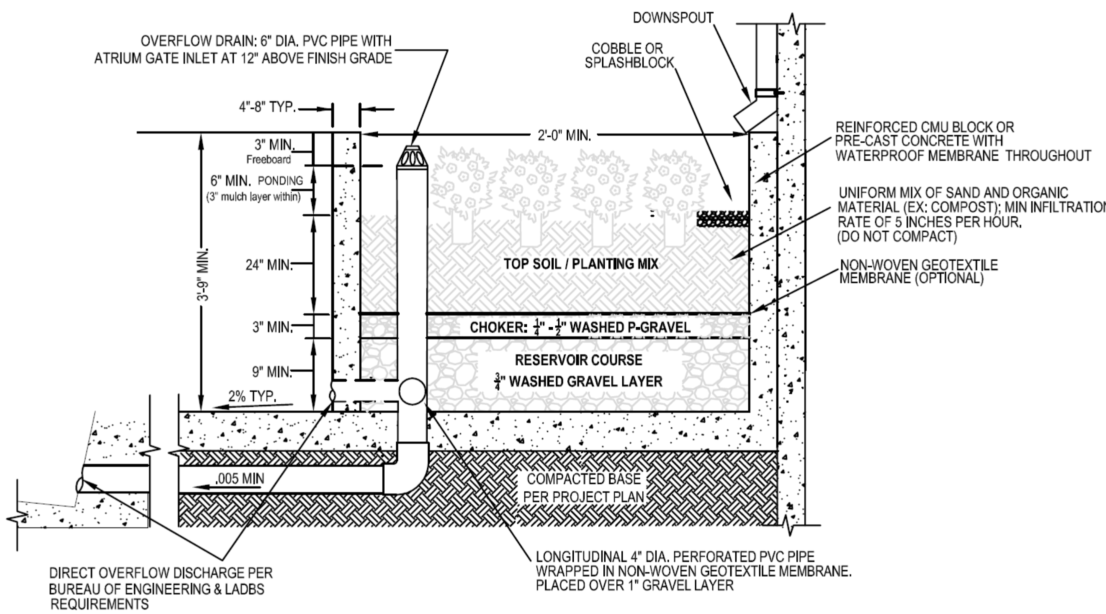
$$V_{Design}(ft^3) = 1.5 \bullet 3{,}627\, ft^3 = 5{,}440\, ft^3$$

ii. Determine the design infiltration rate, $K_{Sat,Design}$:

$$K_{Sat,Design} = \frac{K_{Sat,Media}}{FS} = \frac{5\ in/hr}{2} = 2.5\ in/hr$$

iii. Calculate the BMP Surface Area, A_{min}:

$$A_{\min}(ft^2) = \frac{V_{Design}}{\left[\left(\frac{T_{Fill} \bullet k_{Sat,Design}}{12\ in/ft}\right) + d_p\right]} = \frac{5{,}440\ ft^3}{\left[\left(\frac{3\ hr \bullet 2.5\ in/hr}{12\ in/ft}\right) + 0.50\, ft\right]} = 4{,}835\, ft^2$$



SECTION NOT TO SCALE

<u>Alternative Design II</u>

If ponding depth is reduced to 3" (0.25 ft) and planting media and gravel section total height are proposed to be 24" (2 ft), the minimum planter surface area would then be as follows:

Givens:
- V_m = 3,627 ft^3 *(from previous step)*
- Soil media infiltration rate, k_{sat}: 5 in/hr *(Table 4.5)*
- Time to fill 2 ft media (*18" soil, 6" gravel)* to ponding depth, T_{Fill} = 2 hrs *(Table 4.5) (per engineer: 18" soil media, 6" gravel)*
- Drawdown time, T (hr) = 48 hrs *(Table 4.5)*
- Ponding Depth, d_p *(ft)* = 3" $_{(MIN)}$ = 0.25 ft (Table 4.5)

i. Determine the design volume:

$$V_{Design}(ft^3) = 1.5 \bullet V_m$$

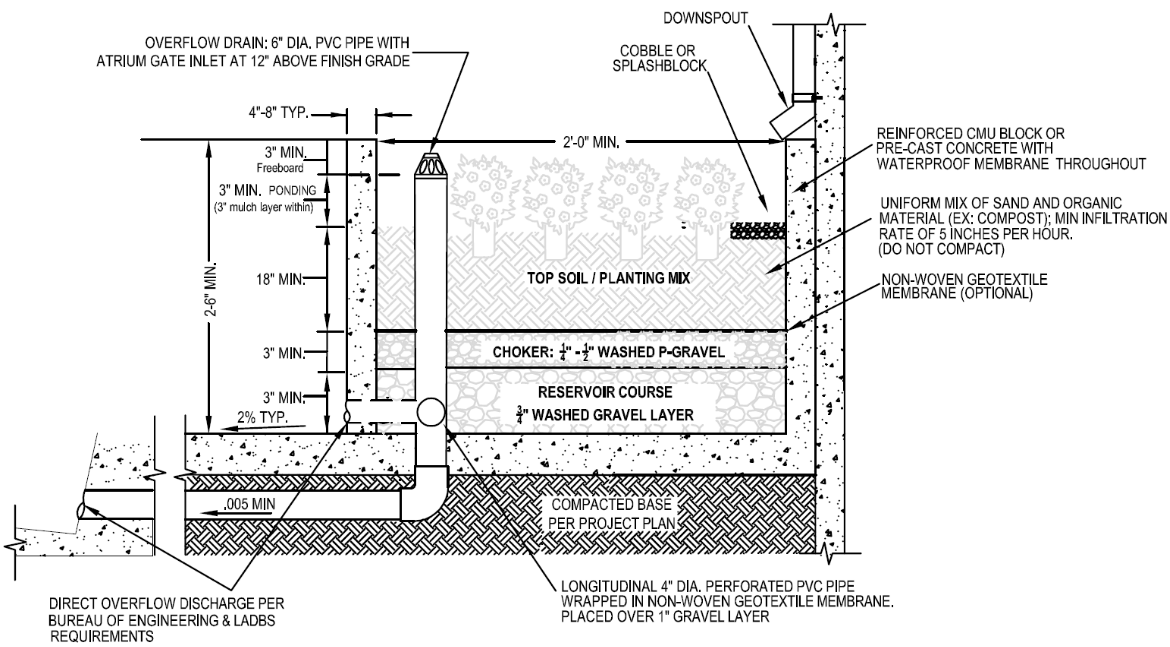
$$V_{Design}(ft^3) = 1.5 \bullet 3{,}627\ ft^3 = 5{,}440\ ft^3$$

ii. Determine the design infiltration rate, $K_{Sat,Design}$:

$$K_{Sat,Design} = \frac{K_{Sat,Media}}{FS} = \frac{5\ in/hr}{2} = 2.5\ in/hr$$

iii. Calculate the BMP Surface Area, A_{min}:

$$A_{min}(ft^2) = \frac{V_{Design}}{\left[\left(\frac{T_{Fill} \bullet k_{Sat,Design}}{12\ in/ft}\right) + d_p\right]} = \frac{5{,}440\ ft^3}{\left[\left(\frac{2\ hr \bullet 2.5\ in/hr}{12\ in/ft}\right) + 0.25\ ft\right]} = 8{,}160\ ft^2$$



<u>SECTION</u> NOT TO SCALE

Design for: Biofiltration with underdrain (at grade)

Givens:
- V_m = 3,627 ft^3 *(from previous step)*
- Soil media infiltration rate, k_{sat}: 5 in/hr *(Table 4.5)*
- Time to fill 3 ft of media (*24" soil, 12" gravel)* to ponding depth, T_{Fill} = 3 hrs *(Table 4.5) (per engineer, ex: 24" soil media, 12" gravel)*
- Drawdown time, T (hr) = 48 hrs *(Table 4.5)*
- Ponding Depth = 15 in. *(per engineer, 18 in max)* (Table 4.5)
- Side slopes = 3:1

iv. Determine the design volume:

$$V_{Design}(ft^3) = 1.5 \bullet V_m$$

$$V_{Design}(ft^3) = 1.5 \bullet 3{,}627\ ft^3 = 5{,}440\ ft^3$$

v. Determine the design infiltration rate, $K_{Sat,Design}$:

$$K_{Sat,Design} = \frac{K_{Sat,Media}}{FS} = \frac{5\ in/hr}{2} = 2.5\ in/hr$$

vi. Calculate the BMP Surface Area, A_{min}*:

$$A_{min}(ft^2) = \frac{V_{Design}}{\left[\left(\frac{T_{Fill} \bullet k_{Sat,Design}}{12\ in/ft}\right) + d_p\right]} = \frac{5{,}440\ ft^3}{\left[\left(\frac{3\ hrs \bullet 2.5\ in/hr}{12\ in/hr}\right) + 1.25\ ft\right]} = 2{,}901.3\ ft^2$$