Stormwater Treatment Measure Sizing and Design Considerations

SMCWPPP C.3 Workshop
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Presentation Overview

- Sizing/Design of Self-Treating and Self-Retaining Areas
- Sizing/Design of Treatment Measures
  - Determining the Water Quality Design Flow and Volume
  - Bioretention and Flow-Through Planters
  - Pervious Pavement and Infiltration Trenches
  - High-Rate Media Filters

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Site Design Measures to Reduce Runoff Requiring Treatment

- Self-Treating Areas
- Interceptor Tree Credits
- Self-Retaining Areas

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Self-Treating Area

- Pervious area that treats rain falling on itself only, via ponding, infiltration and ET
  - Landscaping
  - Green roof
  - Pervious pavement
  - Artificial turf

- Landscaped areas must retain approx. 1” of rain
- Pervious pavement and artificial turf must be designed to store and infiltrate the C.3.d amount of runoff in order to qualify as self-treating areas

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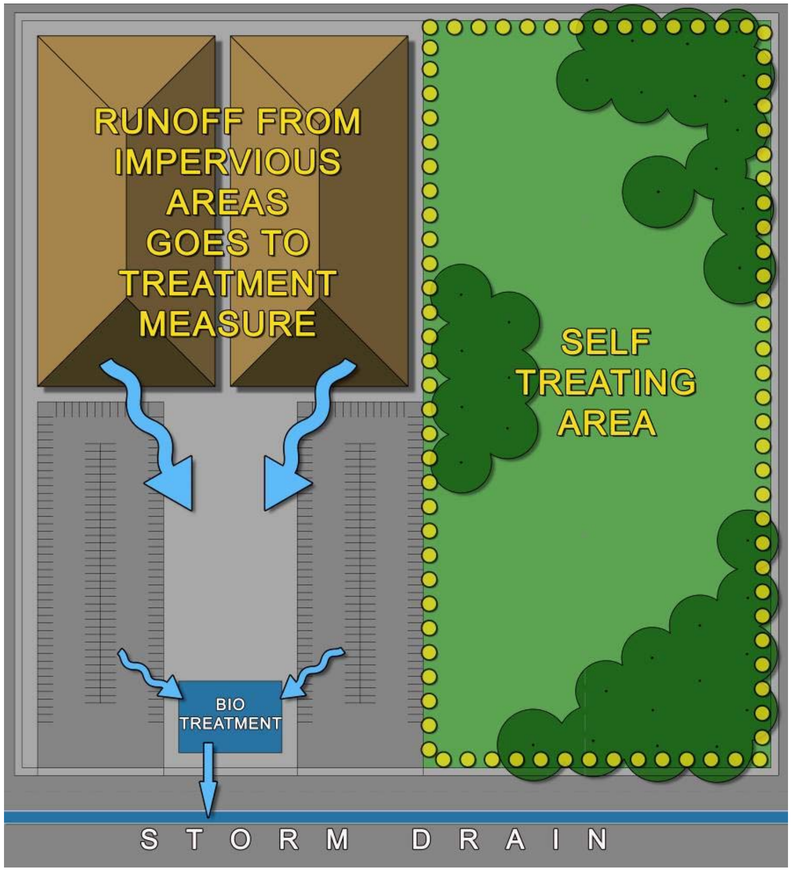
Self-Treating Areas Reduce the Area Requiring Treatment

- Runoff from **pervious** portions of the project (after infiltrating 1”) can flow directly to the storm drain (if not mixing with runoff from impervious areas)
- Runoff from **impervious** areas can flow to a smaller treatment measure



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“Interceptor” Tree Credits

- Self-treating area credit allowed based on the interception of rainwater by the tree canopy
- Intended for small areas that can’t be treated

Type of Tree Planted or Preserved	Square footage deducted from area requiring stormwater treatment
Evergreen: new planting	200 sq. ft. per tree
Deciduous: new planting	100 sq. ft. per tree
Preserve existing trees (either evergreen or deciduous)	Square footage beneath canopy

Self-Retaining Area

- Pervious area that retains first 1" of rainfall on itself and runoff from adjacent impervious area, up to a 2:1 ratio (impervious:pervious)
  - Roof runoff dispersion to depressed landscaped area
  - Partial green roofs
  - Pervious pavement (with adequate storage)
- No special soils required
- Area must be able to retain up to 3" of ponding

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Design of Self-Retaining Areas

- Landscaped areas
  - Plan sheet should indicate a relatively flat, concave, landscaped surface with ponding depth as follows:

    Depth = 1 inch + [(Imperv Area ÷ Perv Area) X 1 inch]
  - Elevation of any area drains should be set at top of ponding depth
- Partial green roofs and pervious pavement
  - Calculate depth of water quality volume using equation above
  - Determine depth of media/aggregate require to store the water quality volume

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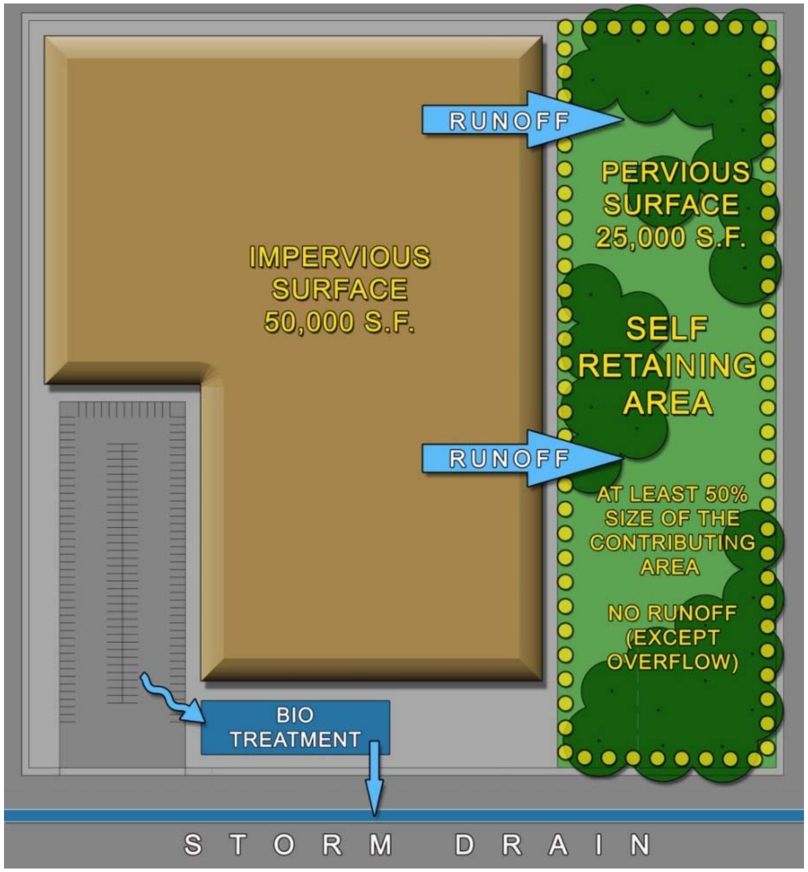
Self-Retaining Areas Reduce the Area that Requires Treatment

- Runoff from **impervious** portions of the project can flow directly to a **pervious** area that is at least 50% of the size of the contributing area
- Runoff from other impervious areas can flow to a smaller treatment measure



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C.3.d Sizing Criteria for Treatment Measures

- Volume-based sizing criteria:
  - URQM Method - use formula and volume capture coefficients in "Urban Runoff Quality Management", WEF/ASCE MOP No. 23 (1998), pages 175-178
  - CASQA BMP Handbook Method - Determine volume equal to 80% of the annual runoff, using methodology in Appendix D of the CASQA BMP Handbook (2003) using local rainfall data
    - **Additional sizing information was developed for San Mateo County rain gages (see C.3 Technical Guidance Appendix C)**

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Treatment Measure Design Criteria Regions for San Mateo County

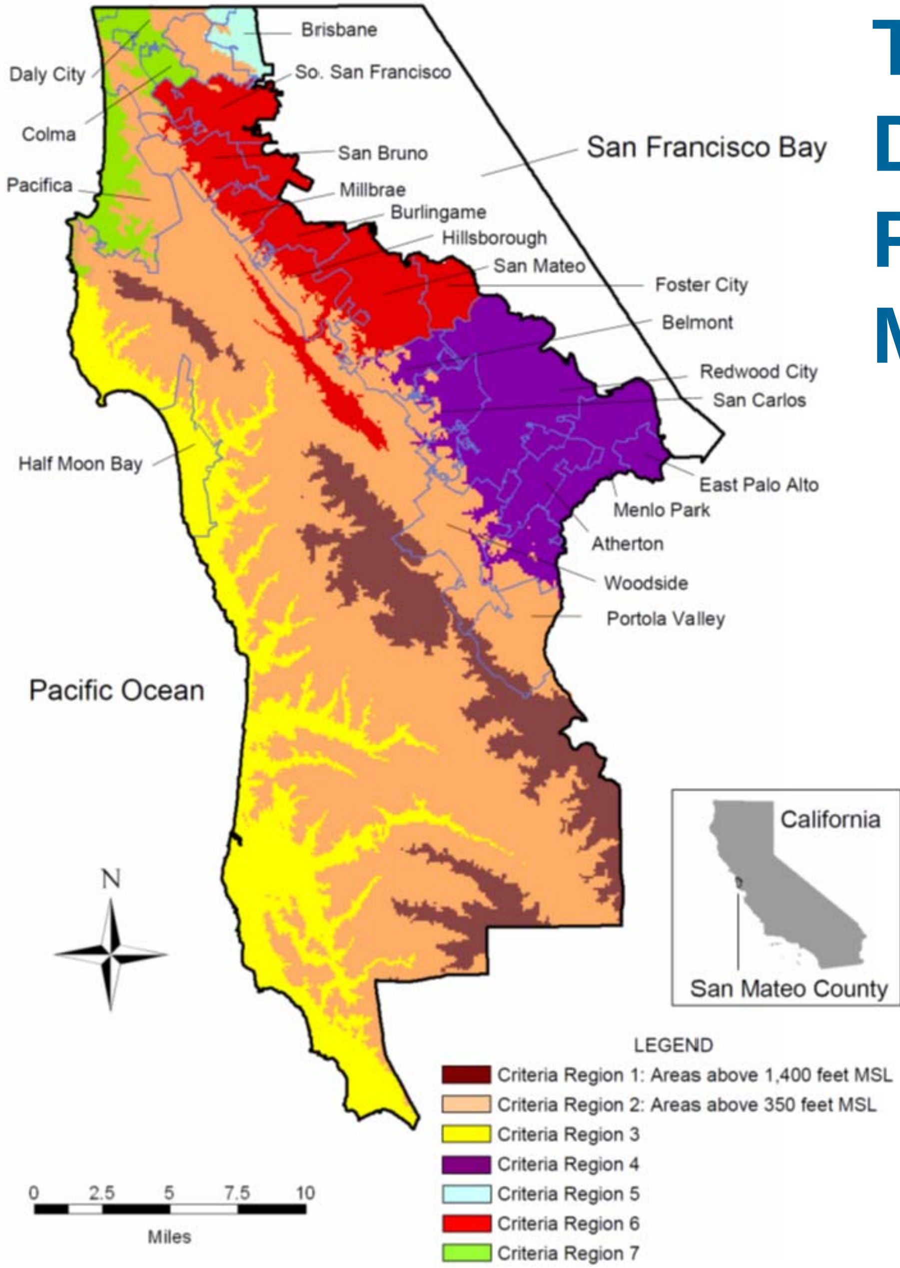

Figure 1 in Appendix 3 of the C.3 Technical Guidance

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C.3.d Sizing Criteria

- Flow-based sizing criteria:
  - Factored Flood Flow - 10% of the 50-year peak flow rate, determined using Intensity-Duration-Frequency curves from local flood control agency
    - **Not generally used**
  - Percentile Rainfall Intensity - Flow of runoff produced by a rain event equal to two times the 85th percentile hourly rainfall intensity
    - **No local data available for San Mateo County**
  - **Uniform Intensity - Flow of runoff resulting from a rain event equal to 0.2 inches per hour intensity**

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C.3.d Sizing Criteria

- Flow-based sizing criteria:
  - Simplified Sizing Approach – Variation of Uniform Intensity Method (0.2 in/hr)
    - Surface area of biotreatment measure is sized to be 4% of the contributing impervious area
    - Based on a runoff inflow of 0.2 in/hr (assume equal to the rainfall intensity), with an infiltration rate through the biotreatment soil of 5 in/hr

      (0.2 in/hr ÷ 5 in/hr = 0.04)
    - Conservative approach because does not account for surface ponding; but maximizes infiltration

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C.3.d Sizing Criteria

- Combination Flow & Volume Design Basis:
  - Treatment systems can be sized to treat "at least 80% of total runoff over the life of the project"
  - Option 1: Use a continuous simulation hydrologic model (typically not done for treatment measures)
  - Option 2: Show how treatment measure sizing meets both flow and volume-based criteria
    - Used for bioretention and flow-through planters
    - **See guidance in Chapter 5, Section 5.1 of C.3 Technical Guidance and Combination Flow-Volume Sizing Worksheet**

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Flow- or Volume-Based Sizing for Treatment Measures?

Table 5-1 Flow and Volume Based Treatment Measure Sizing Criteria		
Type of Treatment Measure	**LID?**	**Hydraulic Sizing Criteria**
Bioretention area	Yes	Flow- or volume-based or combination
Flow-through planter box	Yes	Flow- or volume-based or combination
Tree well filter	Some	Flow-based
Pervious pavement	Yes	Volume-based
Infiltration trench	Yes	Volume-based
Subsurface infiltration system	Yes	Volume-based
Rainwater harvesting/use	Yes	Volume-based
Media filter	No	Flow-based

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Sizing Guidance

- Appendix B of C.3 Technical Guidance
  - Sizing examples
- Appendix C of C.3 Technical Guidance
  - Figure 1: Treatment Measure Design Criteria Regions for San Mateo County
  - Figure 2: Mean Annual Precipitation
- Website: www.flowstobay.org/newdevelopment
  - Sizing worksheets for determining water quality design volume, and combination flow/volume

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Mean Annual Precipitation (inches)

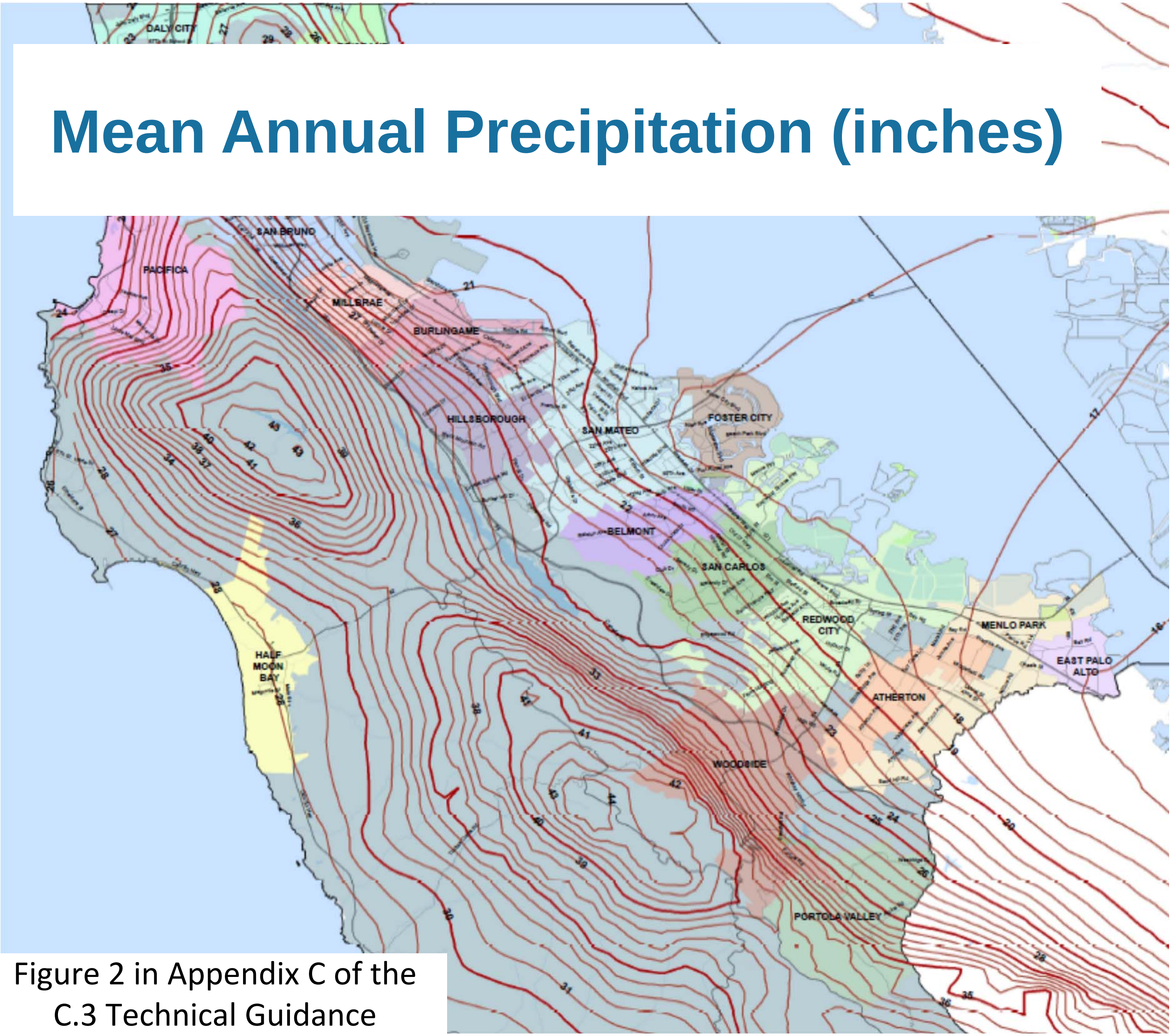
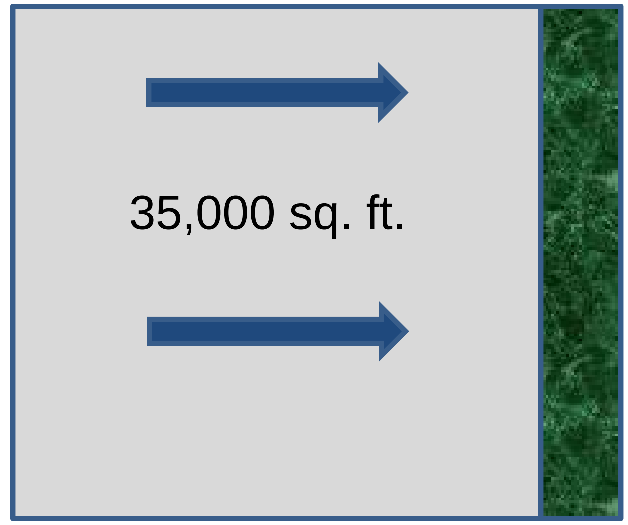


Figure 2 in Appendix C of the C.3 Technical Guidance

Sizing Example (Volume-based)

- Parking lot in Brisbane
  - Area = 35,000 sq. ft. (0.80 acres)
  - 100% impervious
  - Mean annual precipitation (MAP) = 23”
  - Rainfall Region #5, MAP = 21”



- Use the sizing worksheets to determine the water quality design volume (**V_{WQ}**)
- **Answer: V_{WQ} = 2,332 cu. ft.**

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Sizing Bioretention Facilities

- Simplified Sizing (Flow-Based) Approach
  - Surface area is 4% of contributing impervious area
  - Does not consider storage in surface ponding area
- Volume Based Approach
  - Store $\mathbf{V_{WQ}}$ in just surface ponding area
  - Store $\mathbf{V_{WQ}}$ in ponding area, soil media & drain rock
- Combination Flow and Volume Approach
  - Compute both $\mathbf{Q_{WQ}}$ and $\mathbf{V_{WQ}}$
  - "Route" through facility, allowing ponding

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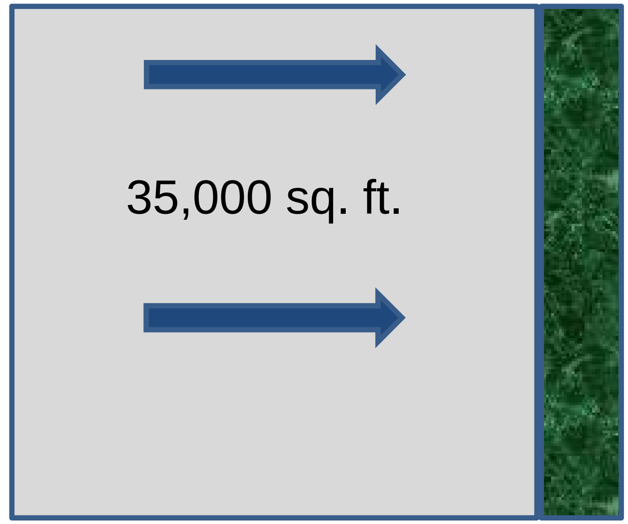
Simplified Sizing Example

- Parking lot in Brisbane
  - Area = 35,000 sq. ft. (0.80 acres)
  - 100% impervious
  - MAP – not needed
  - Uniform intensity = 0.2 in/hr



- Surface area of bioretention:
  - **Area X 0.04 = 1,400 sq. ft.**
  - Note: if drainage area contains pervious area, multiply pervious area by 0.1 and add to impervious area to get "effective impervious area"

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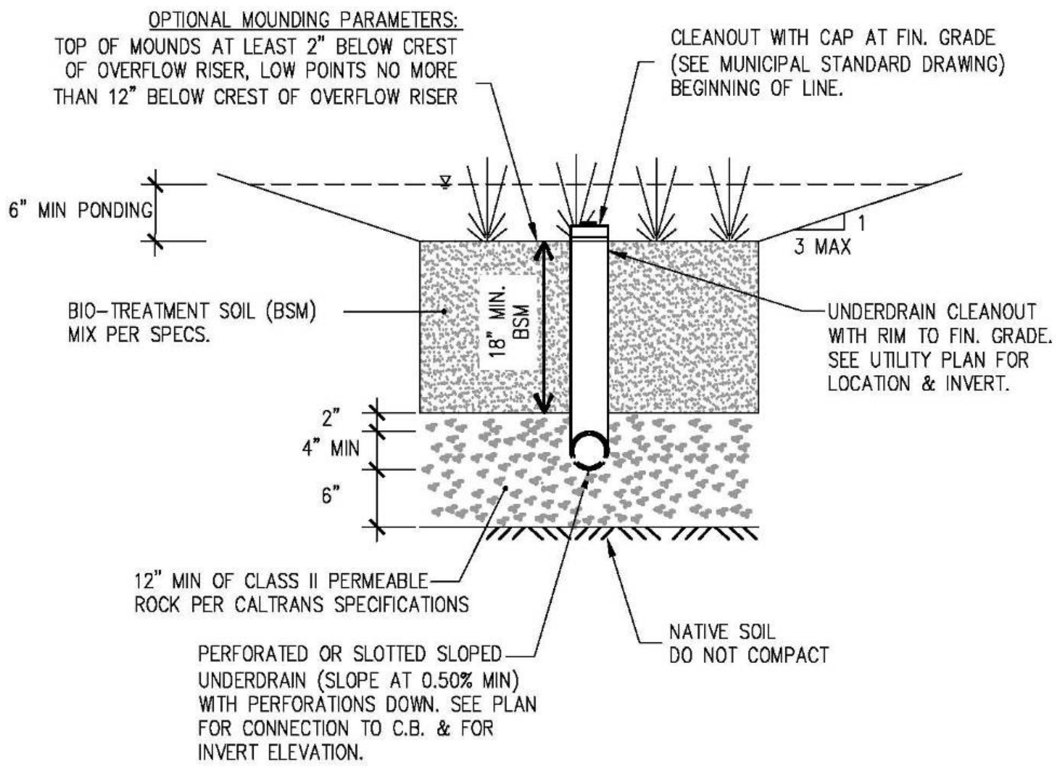
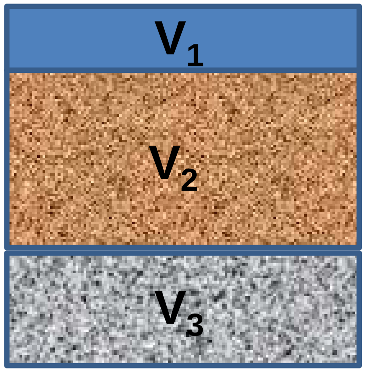
Sizing Bioretention Facilities: Volume-Based Approach





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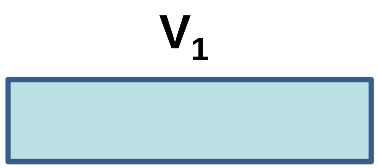
Sizing Bioretention Facilities: Volume-Based Approach

Method 1: Store entire volume in surface ponding area



Depth (ft)	Porosity	Volume per sq. ft. (cubic feet)
0.5	1.0	0.5

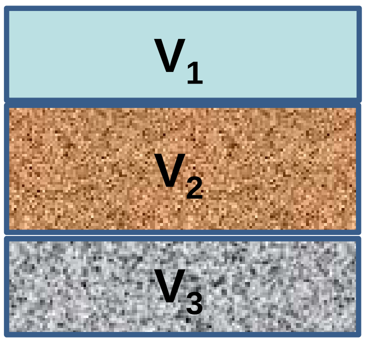
Surface Area = $\mathbf{V_{WQ}}$ (cu.ft.) ÷ 0.5 cu.ft./sq.ft.

Sizing Example:

- **2,332 cu.ft. ÷ 0.5 cu.ft./sq.ft. = 4,664 sq.ft.**

Sizing Bioretention Facilities: Volume-Based Approach

Method 2: Store volume in ponding area and media



Depth (ft)	Porosity	Volume per sq. ft. (cubic feet)
0.5	1.0	0.5
1.5	0.30	0.45
0.5*	0.40	0.20
	Total	1.15

*Depth below underdrain at 6” above bottom

Surface Area = $\mathbf{V_{WQ}}$ (cu.ft.) ÷ 1.15 cu.ft./sq.ft.

- **2,332 cu.ft. ÷ 1.15 cu.ft./sq.ft. = 2,028 sq.ft.**

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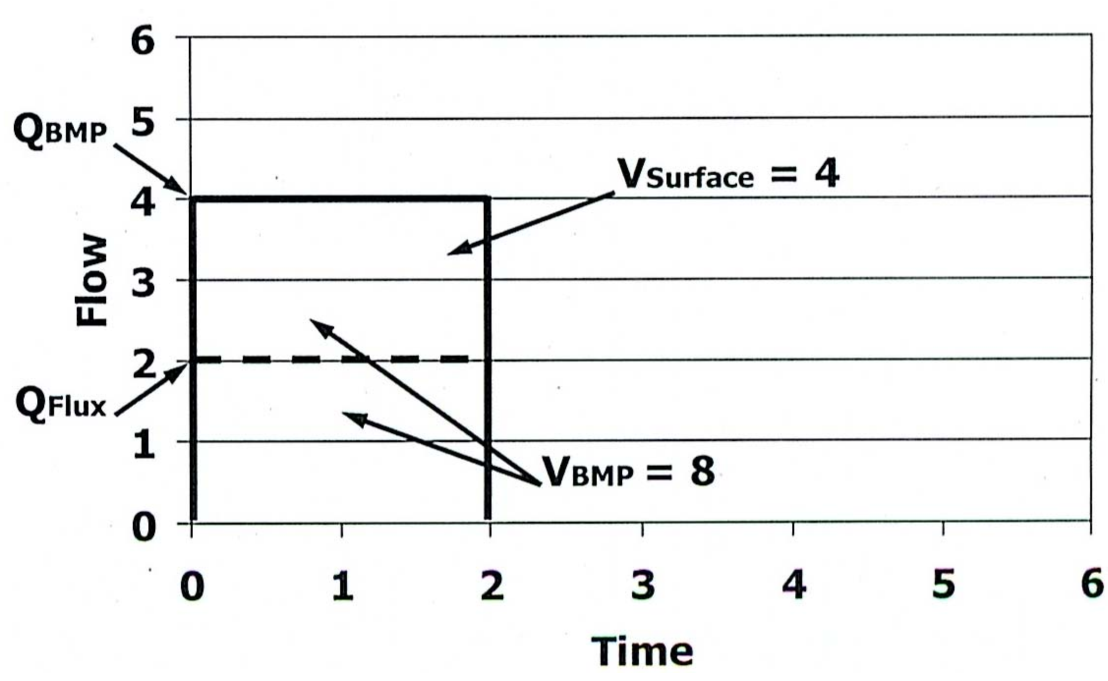
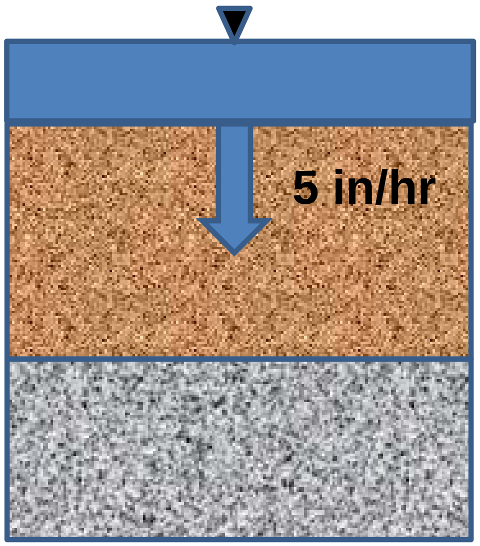
Sizing Bioretention Facilities: Flow & Volume Approach

- "Hydrograph Approach"
  - Runoff is "routed" through the treatment measure
  - Assume rectangular hydrograph that meets both flow and volume criteria



Sizing Bioretention Facilities: Flow & Volume Approach



- Determine VWQ
- Assume constant rainfall intensity of 0.2 in/hr continues throughout the storm (rectangular hydrograph)
- Calculate the duration of the storm by dividing the Unit Basin Storage by the rainfall intensity
- Calculate the volume of runoff that filters through the biotreatment soil at 5 in/hr over the storm duration
- Calculate the volume that remains on the surface and ponding depth

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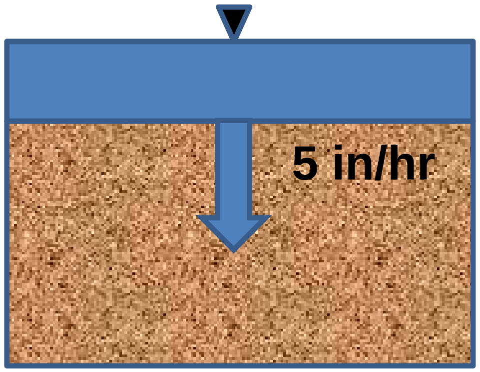
Sizing Bioretention Facilities: Flow & Volume Approach



- To start the calculation, you have to assume a surface area “$\mathbf{A_S}$” -- use 3% of the contributing impervious area as a first guess

- Determine volume of treated water “$\mathbf{V_T}$” during storm:

  $\mathbf{V_T = A_S}$ x 5 in/hr x duration (hrs) x 1 in/12 ft

- Determine volume remaining on the surface “$\mathbf{V_S}$”:

  $\mathbf{V_S = V_{WQ} - V_T}$

- Determine depth “**D**” of ponding on the surface:

  $\mathbf{D = V_S \div A_S}$

- Repeat until depth is approximately 6 inches

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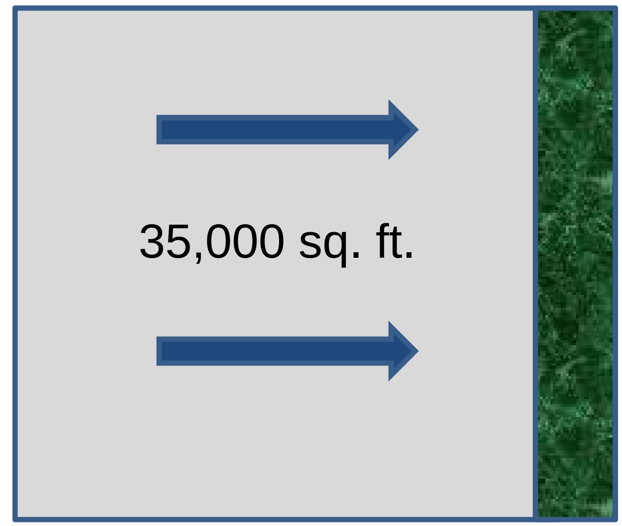
Sizing Example (Combo Method)

- Parking lot in Brisbane
  - Area = 35,000 sq. ft. (0.80 ac.)
  - 100% impervious
  - $\mathbf{V_{WQ}}$ = 2,332 cu. ft.
  - Adj. UBS Volume = 0.80 in.



- Use the combination flow and volume sizing worksheet to determine the bioretention surface area
- **Answer: 1,075 sq. ft. (with depth = 6.0")**

Sizing Bioretention Facilities: Comparison of Methods

Example: 35,000 sq. ft. parking lot in Brisbane
MAP= 23 inches, 100% impervious
V_{BMP} = 2,332 cu. ft. (80% of annual runoff)

Sizing Method	Surface Area (sq. ft.)
Simplified Method (flow-based)	1,400 ★
Volume ponded on surface	4,664
Volume stored in unit (V_1+V_2+V_3)	2,028
Combination flow & volume	1,075 ★

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Sizing Pervious Pavement and Infiltration Trenches

- General Principles
  - Store the $\mathbf{V_{WQ}}$ in void space of stone base/subbase and infiltrate into subgrade
  - Surface allows water to infiltrate at a high rate
  - Any underdrains must be placed above the void space needed to store and infiltrate the $\mathbf{V_{WQ}}$

Sizing Pervious Pavement and Infiltration Trenches

- Pervious Pavement
  - May be self-treating area or self-retaining area (accept runoff from other areas)
  - Can only be considered a “pervious area” if stone base/subbase sized to store the $\mathbf{V}_{\mathbf{WQ}}$
  - Can work where native soils have low infiltration rates (stored water depths are relatively small)
  - Surface area is usually predetermined
  - Base and subbase thickness usually determined by expected traffic load and saturated soil strength
  - Slope should be $\leq$ 3% (or use check dams/trenches in subbase)

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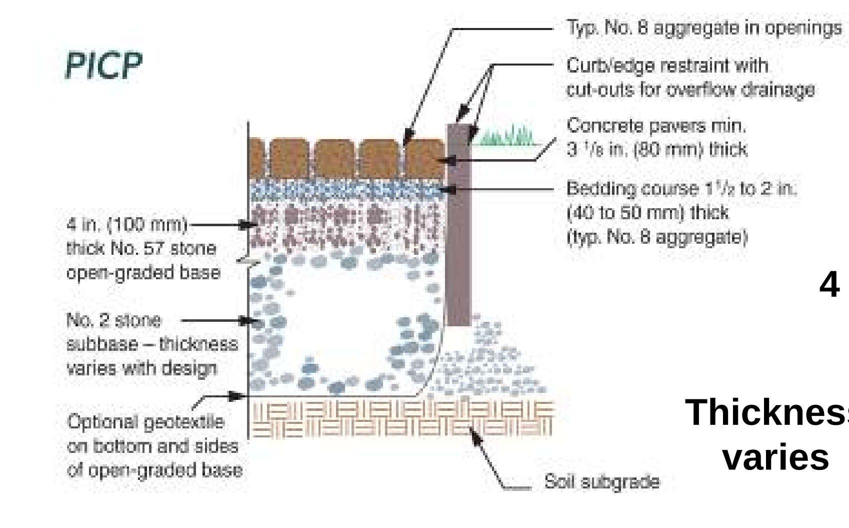
Pervious Pavement

Typical Section



- Base and subbase layers available for water storage
- Both typically have 40% void space

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Pervious Pavement

- Approach to Sizing Pervious Pavement
  - Self-Treating
    - Check the depth of the **V_{WQ}** in base/subbase:
      UBSV (in.) ÷ 0.40 = Depth (in.)

      Example: UBSV = 1.0 in., depth = 2.5 in.
      (Minimum depth for vehicular traffic is 10 in.)
    - Check the time required for stored water to drain:
      UBSV (in.) ÷ Infiltration rate (in/hr) = Drain time (hrs)
      (recommend < 48 hrs)

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Pervious Pavement

- Approach to Sizing Pervious Pavement
  - Self-Retaining (receives runoff from adjacent areas)
    - —Add the $\mathbf{V_{WQ}}$ for adjacent areas to the $\mathbf{V_{WQ}}$ for the pervious pavement, divide the total by pervious pavement area
    - —Do not exceed 2:1 ratio of contributing area to pervious area
    - —Check depth of total $\mathbf{V_{WQ}}$ in base/subbase: $\mathbf{V_{WQ}}$ (in.) ÷ 0.40 = Depth (in.)

      Example: $\mathbf{V_{WQ}}$ = 3.0 in., depth = 7.5 in.
    - —Check the time required for stored water to drain: v_{WQ} (in.) ÷ Infiltration rate (in/hr) = Drain time (hrs)

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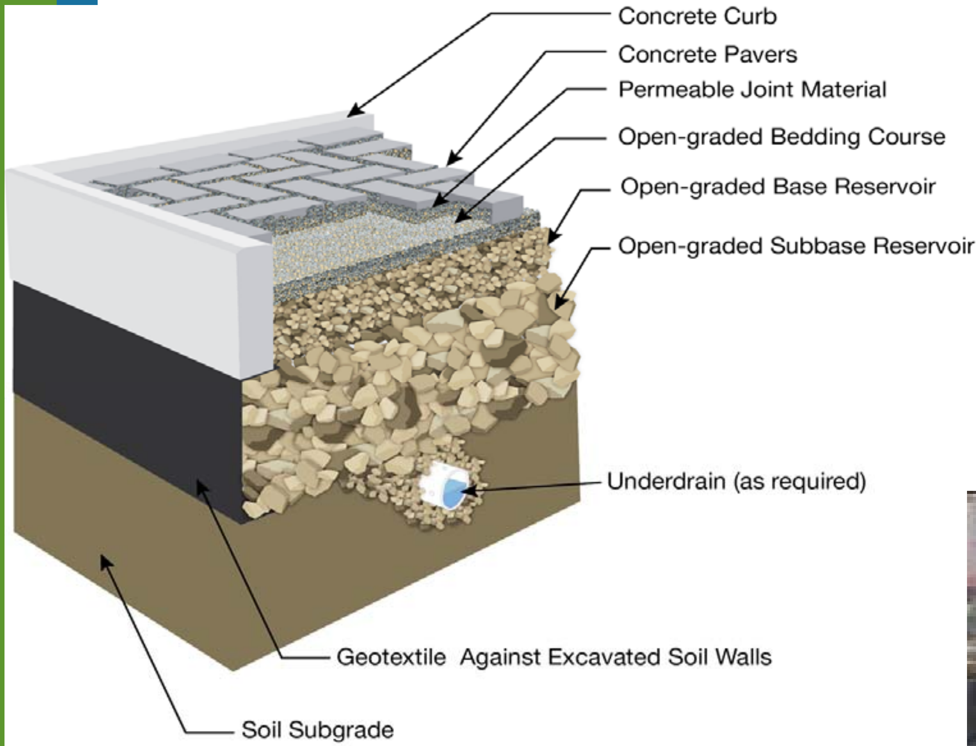
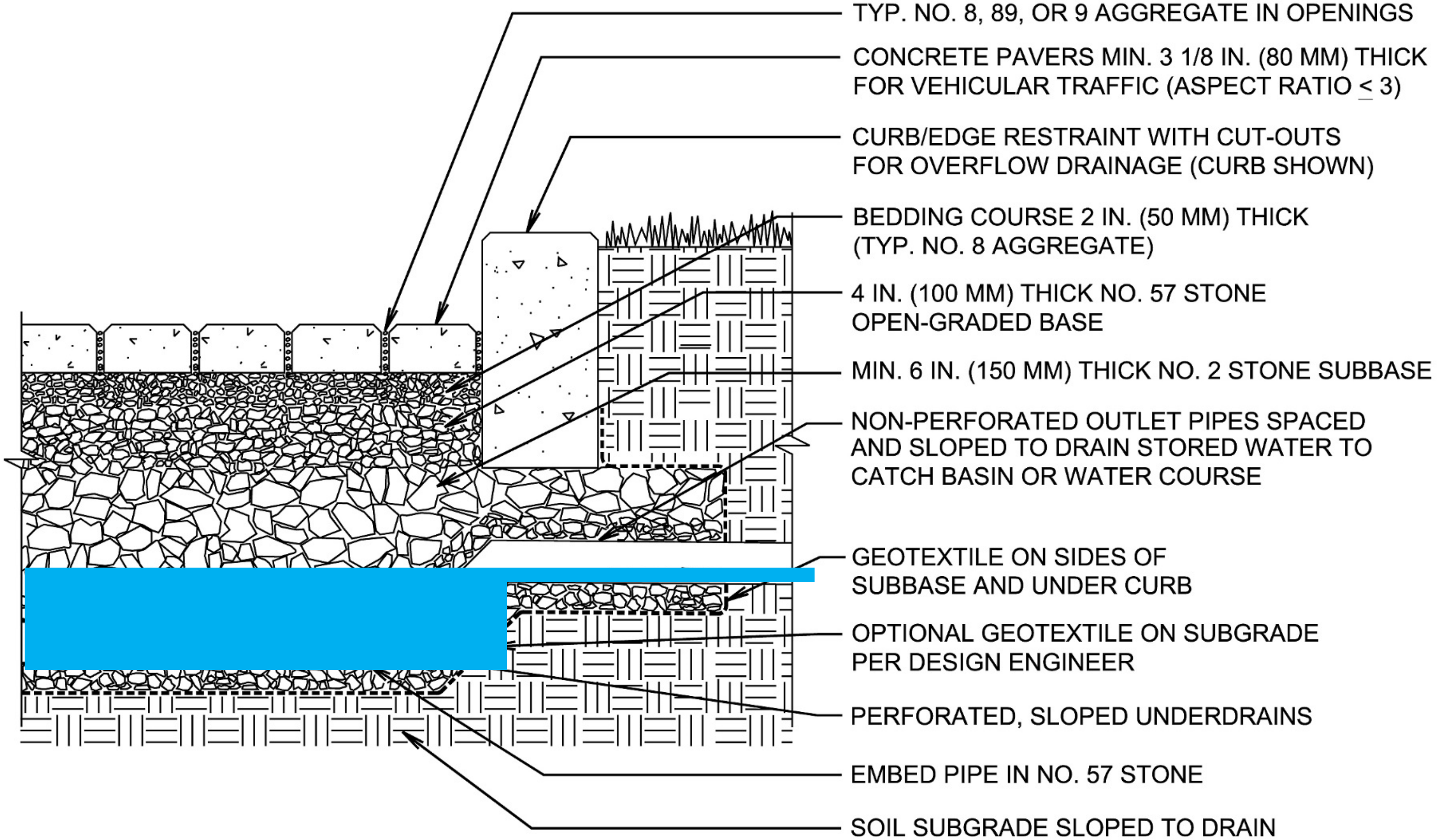
Underdrains: New Approach

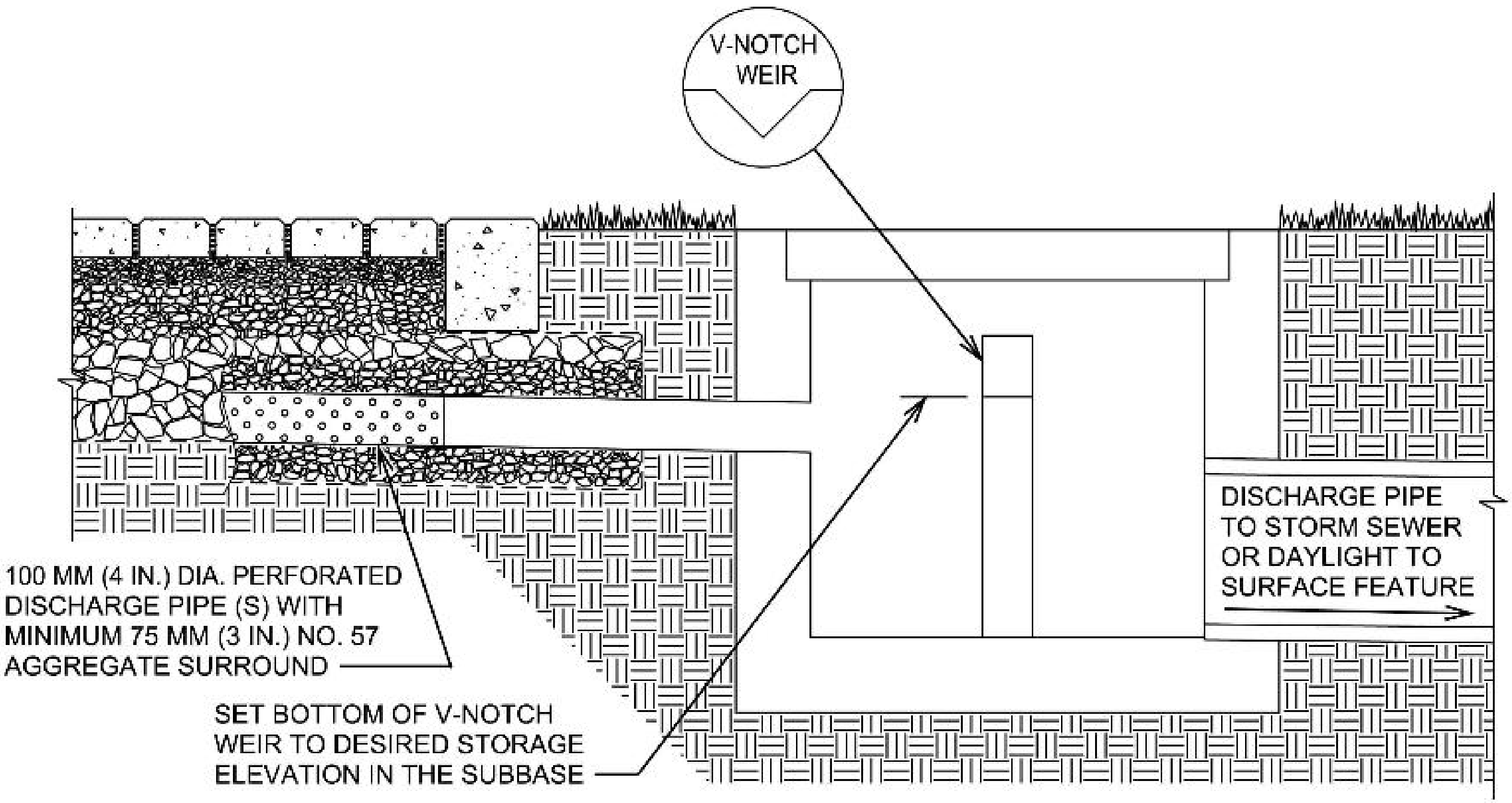


- Underdrain placed in trench at bottom of section with raised outlet to allow water storage in aggregate reservoir

Underdrain: Upturned Elbow



Underdrain: Connection to Catch Basin/Utility Structure



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Infiltration Trench Sizing

- Differences from Pervious Pavement
  - More runoff must infiltrate in a smaller footprint
  - Infiltration rate of site soils must be at least 0.5 in/hr (i.e., not suitable for "C" or "D" soils)
  - Trench depths are typically between 3 and 8 feet
  - Infiltration trench is an "infiltration device"
    - Minimum 10-foot separation from seasonal high groundwater level
    - Must meet other MRP requirements
    - Cannot be "deeper than wide" (definition of Class V injection well)

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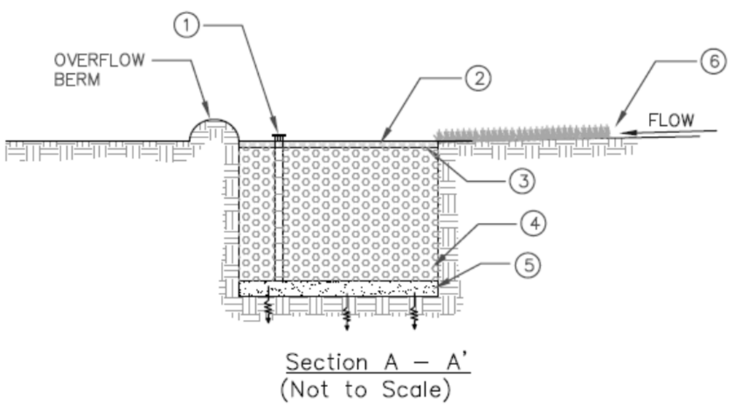
Infiltration Trench Sizing

- Design Parameters
  - Trench depth is calculated based on the soil infiltration rate, aggregate void space, and the trench storage time
  - The stone aggregate used in the trench is typically 1.5 to 2.5 inches in diameter, which provides a void space of approximately 35 %
  - Trenches should drain within 72 hours
  - Place underdrain above void space needed for storage of $\mathbf{V}_{\mathbf{WQ}}$



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Infiltration Trench Sizing

- Approach to Sizing Infiltration Trenches
  - Trench unit storage volume: $\mathbf{S = n \times d}$
    n = gravel porosity (0.35); d = gravel depth (ft)
  - Subsoil unit infiltration capacity: $\mathbf{S_i = k \times t \div 12}$
    k = subsoil permeability (in/hr); t = time (hrs) (recommend maximum of 72 hrs)
  - Check for trench drainage by infiltration:

    If $S \leq S_i$: Increase depth of media until $S = S_i$
    to match trench capacity to infiltration capacity (may decrease surface area needed)

    If $S > S_i$: Decrease depth of media until $S = S_i$
    (surface area may increase)

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Infiltration Trench Sizing

- Approach to Sizing Infiltration Trenches
  - Determine required trench area:
    - $\mathbf{A_T = V_{WQ} \div S}$

      A_T = Trench area required to store treatment volume (sq.ft.)

      V_{WQ} = Water quality design volume (cu. ft.)

      S = Trench unit storage volume (cu.ft./sq.ft.)
  - Determine required trench width:
    - $\mathbf{W = A_T \div L}$

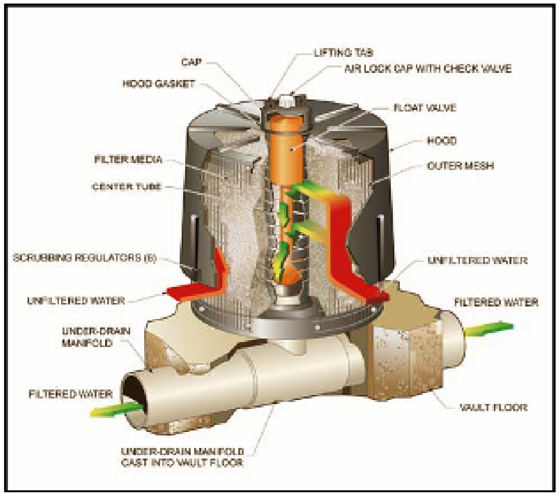
      W = Width of trench (ft.)

      A_T = Required trench area (sq. ft.)

      L = Length of trench (ft.) (normally length of treatment area)

Sizing High-Rate Media Filters

Media Filters (cartridge type)



- Flow-based Treatment Measure
- Determine $\mathbf{Q_{WQ}}$
- Select a product that is certified by Washington State TAPE program*
- Determine the TAPE-approved design flow rate per cartridge
- Divide $\mathbf{Q_{WQ}}$ by the cartridge flow rate to calculate the required number of cartridges (round up)

*General Use Level Designation (GULD) for Basic Treatment

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html

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Sizing High-Rate Media Filters

Proprietary Tree Box Filters

- Flow-based Treatment Measure
- Determine $\mathbf{Q}_{WQ}$
- Select a product that is certified by Washington State TAPE program
- Determine the TAPE-approved infiltration rate for the media
- Calculate the required surface area by dividing $\mathbf{Q}_{WQ}$ by the infiltration rate (ft/sec)
- A tree box filter that uses biotreatment soil media can be sized like a flow-through planter

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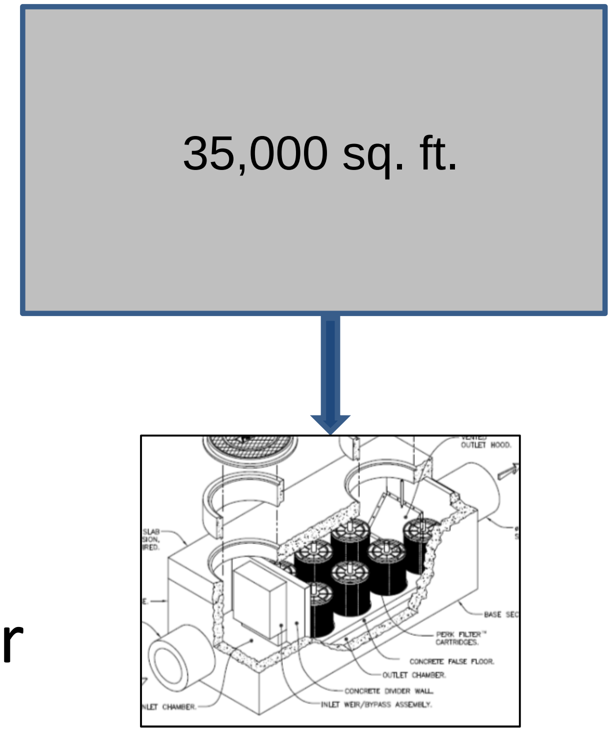
Sizing Example (Flow-based)

- Rooftop in Brisbane
  (Special Project)
  - Area = 35,000 sq. ft. (0.80 ac.)
  - 100% impervious
  - Uniform intensity = 0.2 in/hr
  - Runoff coefficient = 0.90
- Use the Rational Method (Q = CIA) determine the water quality design flow, $\mathbf{Q_{WQ}}$



- **Answer: Q_{WQ} = (0.9)(0.2)(0.8) = 0.144 cfs**

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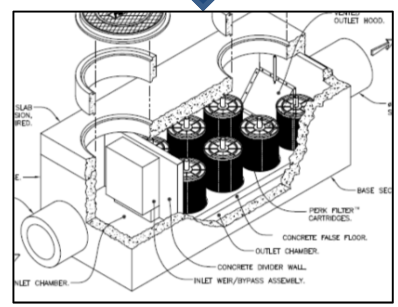
Sizing Example (Flow-based)

- Rooftop in Brisbane
  (Special Project)
  - **Q_{WQ}** = 0.144 cfs = 64.6 gpm
  - Select media filter type
  - Check for TAPE certification and allowable flow rate

35,000 sq. ft.



- Example: FloGard Perk Filter
  - "Size at hydraulic loading rate of ≤1.5 gpm/ft^2 of media surface area"
  - For 18" cartridge, loading rate is 10.2 gpm/cartridge
  - 64.6 gpm ÷ 10.2 gpm/cartridge = 6.3, or <u>7 cartridges</u>

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Questions?

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