



STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

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May 26, 2021

Jay Holtz, P.E.
Oldcastle Infrastructure
700 Central Parkway
Suite 800
Atlanta, GA 30328

RE: TerraMod for Stormwater Runoff Filtration

Dear Mr. Holtz:

The Washington State Department of Ecology (Ecology) finds the TerraMod Modular Bioretention System (TerraMod) functionally equivalent to a bioretention planter or planter box. The media specifications for TerraMod System must adhere to the guidelines for Bioretention found in BMP T7.30 of the 2019 Stormwater Management Manual for Western Washington (SWMMWW) or BMP T5.31 in the 2019 Stormwater Management Manual for Eastern Washington (SWMMEW). The sizing procedure must also adhere to the procedure outlined in the Bioretention design criteria of the manuals mentioned above or the procedure Oldcastle submitted to Ecology for design of the TerraMod System using WWHM, dated May 2021.

Contractors may use the TerraMod System BMP at project sites without seeking additional Ecology approval to meet Minimum Requirement #6 or Core Element #5 (Water Quality Treatment). The TerraMod System is not equivalent to bioretention when using the list option of Minimum Requirement #5 in the SWMMWW.

Ecology does not endorse this product or its manufacturer. Users of the TerraMod must follow the manufacturer's installation, operation, and maintenance recommendations.

For more information, contact me at douglas.howie@ecy.wa.gov, or (360) 407-6444.

Sincerely

Douglas C. Howie, P.E.
Senior Stormwater Engineer
Water Quality Program

cc: Carla Milesi, TAPE Technical Lead, Washington Stormwater Center

Enclosure



TERRAMOD MODULAR BIORETENTION SYSTEM

Using WWHM2012 to Size and Evaluate
Stormwater Management Facilities

May 2021

Oldcastle Infrastructure
7000 Central Parkway, Suite 800
Atlanta, GA 30328
800-579-8819

TerraMod Modular Bioretention System – Using WWHM2012 to Size and Evaluate Stormwater Management Facilities

Introduction

The TerraMod® Modular Bioretention System (TerraMod) is a conventional, structural, vegetated bioretention system, designed as a series of modular precast concrete sections which are filled with layers of aggregate, bioretention media, plantings, and mulch (Figure 1). Standard components include trench and end sections as well as modules for inlet and pretreatment, and overflow and bypass. The trench sections can be provided with open bottoms to promote infiltration and retain water on site, or with closed bottoms and underdrains. The TerraMod system typically incorporates non-proprietary, low flow rate media, with materials and thicknesses specified by a local agency. A wide variety of plants and trees may be used in the TerraMod. Plantings appropriate for the local area are typically specified by the designer. The number and size of sections, as well as the overall configuration of each system, is determined on a project-specific basis.

In addition, the TerraMod could instead be configured as a planter box, consisting of a single concrete structure, as long as the single structure provides the needed bioretention surface area. Standard details for standard bioretention and bioretention with infiltration applications are attached. Also, an example detail drawing for a specific TerraMod project in California is attached.



Figure 1. TerraMod Schematic.

This document provides guidance on how the TerraMod can be designed to meet the Washington State Department of Ecology (Ecology) stormwater requirements presented in the 2014 Stormwater Management Manual for Western Washington (SWMMWW). The TerraMod is functionally equivalent to a Bioretention system and can be designed to meet the requirements outlined in BMP T7.30: Bioretention Cells, Swales, and Planter Boxes. This document provides guidance for demonstrating compliance with Ecology's Minimum Requirements as well as detailed instructions for sizing and evaluating the TerraMod using the Western Washington Hydrology Model, Version 2012 (WWHM2012).

Using TerraMod for Compliance with Minimum Requirements

The TerraMod can be designed for compliance with the SWMMWW Minimum Requirements, found in Volume I, Chapter 2 of the 2014 SWMMWW. The applicability of Ecology's Minimum Requirements to a specific project is determined based on the size and type of the proposed project. Detailed flow charts for determining the requirements for new development and redevelopment projects can be found in the SWMMWW. Typically, Minimum Requirements #6 (Runoff Treatment) and #7 (Flow Control) are the ones most likely to result in the use of the TerraMod. In some cases, Minimum Requirement #5 (On-Site Stormwater Management) may apply as well, since the TerraMod can be provided with an open bottom to allow for infiltration.

Minimum Requirement #6 – Runoff Treatment

Minimum Requirement #6 specifies the site condition thresholds that necessitate the use of stormwater treatment facilities and provides facility sizing, selection, design and maintenance guidelines for their use. The objective of this requirement is to reduce pollutant loads and concentrations in stormwater using physical, biological and chemical removal mechanisms to

protect the beneficial uses of receiving waters. Minimum Requirement #6 specifies that the flow rate at or below which 91% of the runoff volume occurs, as estimated by an approved continuous simulation model, must be treated. In addition, the system must be designed in accordance with the design criteria in Volume V of the 2014 SWMMWW; design requirements for bioretention systems can be found in Chapter 7. More detail about this Minimum Requirement can be found in Section I-2.5.6 of Volume I of the Manual.

Minimum Requirement #7 – Flow Control

Minimum Requirement #7 defines the applicability of flow control requirements to reduce the impacts of stormwater runoff from hard surfaces and land cover conversions. The flow control requirements vary depending on the both the conditions of the development site as well as the conditions of the receiving waters. The requirements state that stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. The pre-developed conditions to be matched shall be forested land cover unless certain requirements have been met. More detail can be found in Section I-2.5.7 of Volume I of the Manual.

Minimum Requirement #5 – On-site Stormwater Management

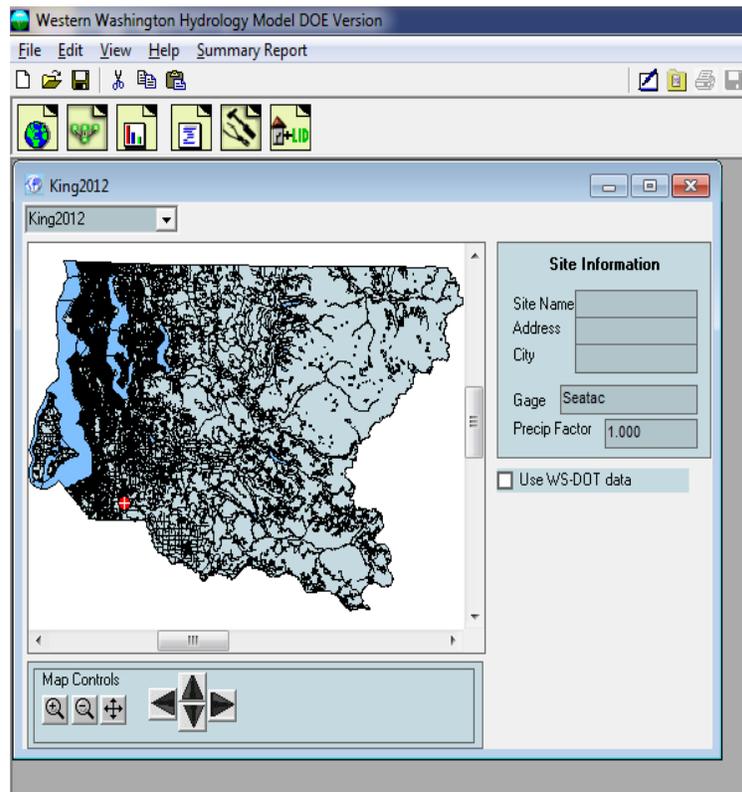
Minimum Requirement #5 states that projects must infiltrate, disperse and retain stormwater runoff on-site to the extent feasible without causing flooding or erosion impacts. Projects triggering Minimum Requirement #5 must either: use on-site stormwater management BMPs from one of the two lists depending on the size of the project (2014 SWMMWW, Volume 1, Chapter 2, page 56) or demonstrate compliance with the LID Performance Standard. The LID Performance Standard states that stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow. In addition, Minimum Requirement #5 requires that the bioretention facility's horizontally projected surface area below the overflow shall be at least 5% of the total impervious surface area draining to it. Although the TerraMod can be designed for infiltration with opening in the bottom of the structure and no underdrain, this option may not provide the most efficient design without infiltration through the side slopes of systems with open sides.

TerraMod Modeling Guidance – Western Washington

The following guidance applies to the sizing and evaluation of the TerraMod system when modeled using WWHM2012 and the “Bioretention” modeling element.

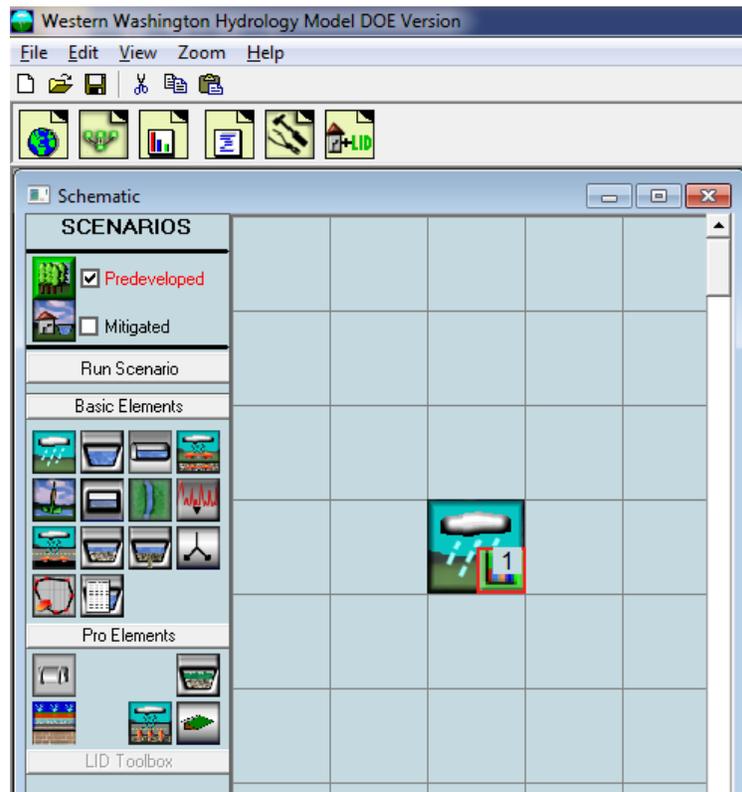
Step 1 – Define Precipitation Data

Use the County/City Map pulldown to select the region for the project. On the resulting map, click on the project location to select the site precipitation series in the Site Information dialog box.



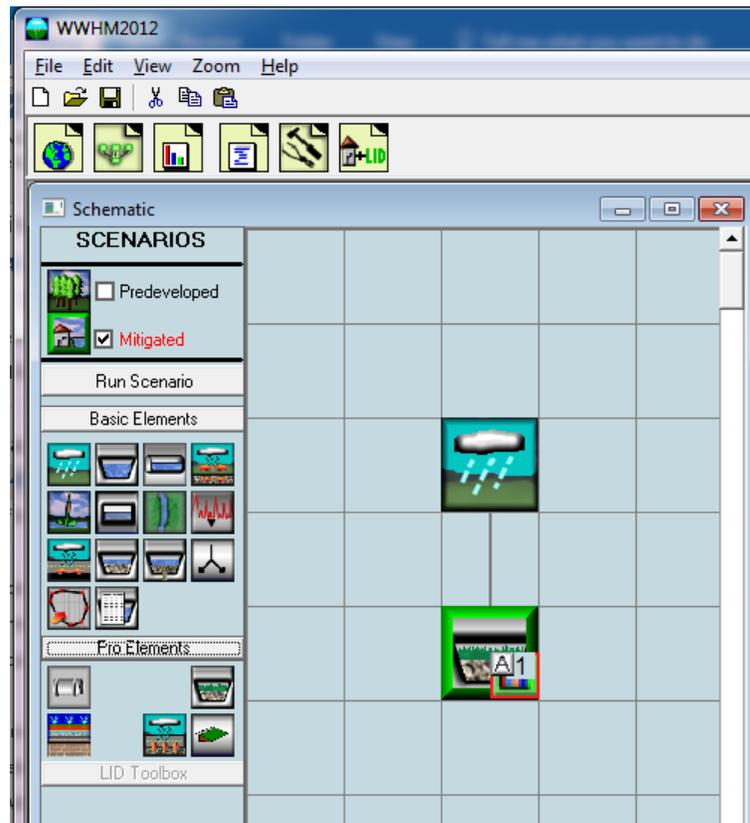
Step 2 – Define the Pre-Developed Scenario

- Click on the “General Project Information” button in the toolbar to open the Schematic window.
- Select the “Predeveloped Scenario” in the Schematic window to the left of the page
- Drag the “Land Use Basin” element (listed under Basic Elements) into the schematic window and drop into the grid.
- Click on the Basin and enter the pre-developed scenario drainage basin areas controlled by the TerraMod system by soil and land use types. The land use is typically forested.
- Right-click on the Basin and select “Connect to Point of Compliance”. Ensure Surface Flow and Interflow are checked and click “Connect”. Once the Basin is connected to the Point of Compliance (POC) a “1” will appear in the lower right corner of the basin.



Step 3 – Define the Mitigated Scenario

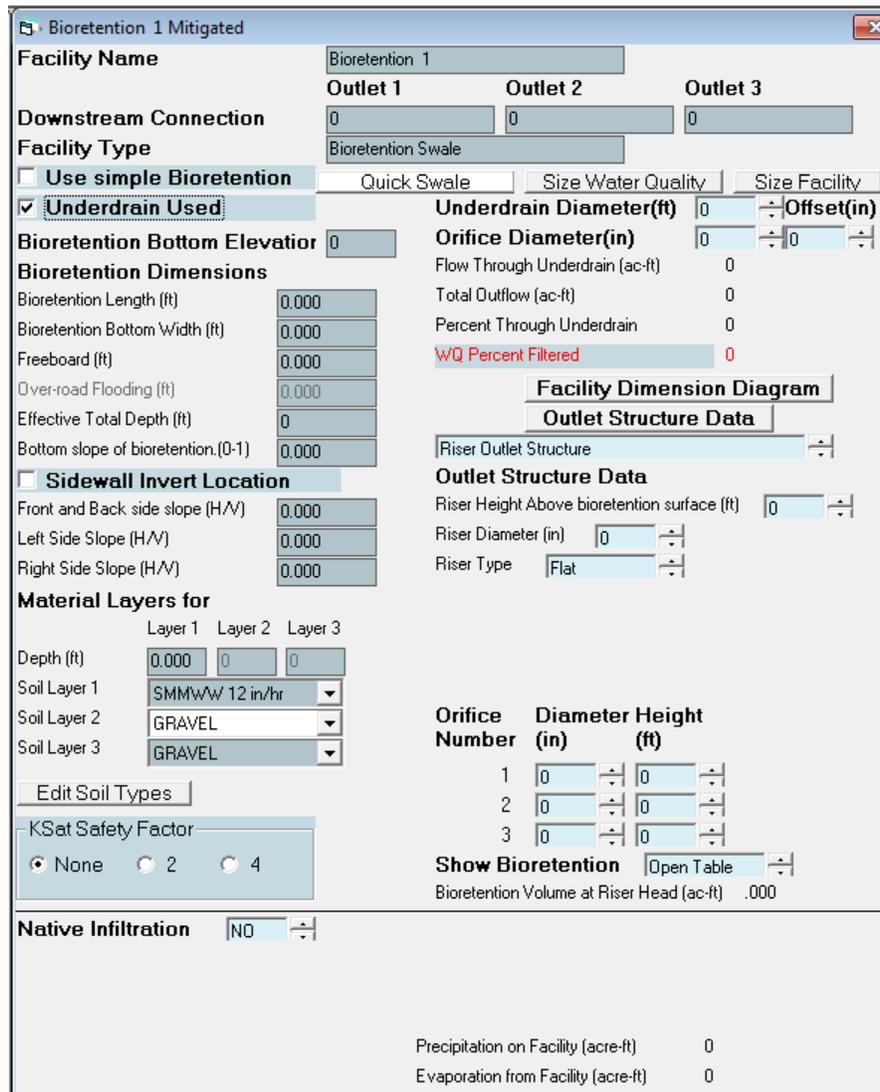
- Click on the “General Project Information” button in the toolbar to open the Schematic window.
- Select the “Mitigated Scenario” in the Schematic window to the left of the page
- Drag the “Land Use Basin” element (listed under Basic Elements) into the schematic window and drop into the grid.
- Click on the Basin and enter the mitigated scenario pervious and/or impervious areas by soil and land use type.
- Add the TerraMod BMP by dragging the “Bioretention” element (listed under Pro Elements) into the schematic window and dropping it into the grid, downstream of the Basin.
- Right-click on the Basin and select “Connect to Element”. When the connection line appears, click on the Bioretention element. Ensure Surface Flow and Interflow are both checked and click “OK”.
- Right-click on the Bioretention element and select “Connect to Point of Compliance”. Ensure Outlet 1 is checked and click “Connect”. Once the Bioretention element is connected to the Point of Compliance (POC) a “1” will appear in the lower right corner of the basin.



Step 4 – Define the TerraMod BMP

- Click on the “Bioretention” element to open the Bioretention editor window.
- Ensure the “Use Simple Bioretention” box is unchecked.
- Check the “Underdrain Used” box:
 - Since TerraMod does not require use of an orifice on the underdrain, enter the Orifice Diameter (in) equal to the Underdrain Diameter (ft), but note that the underdrain diameter is in feet while the orifice diameter is in inches. Typical TerraMod underdrain diameter would meet local minimum requirements. For Washington, the minimum underdrain diameter requirement is 4 inches, but 4 to 8 inches is common.
 - If an orifice is needed to meet flow control or LID requirements, enter the orifice diameter in inches. The Offset (in) from the invert of the underdrain can also be entered if needed.
- Define TerraMod dimensions – enter the TerraMod dimensions in the section labeled “Bioretention Dimensions”:
 - Bioretention Bottom Elevation (ft) – Enter the elevation of the proposed TerraMod or use the default value of 0.
 - Bioretention Length (ft) – Enter the length of the TerraMod system.
 - Bioretention Bottom Width (ft) – Enter the width of the TerraMod system. A TerraMod in Washington would typically be designed with a bottom width of 4 feet or 6 feet.

- Freeboard (ft) – Enter the freeboard required by per the design or the jurisdiction requirement. Ecology specifies a minimum of 6 inches unless otherwise specified.
- Over-road Flooding (ft) – Enter the over-road flooding if applicable. This value is not accessible while using the Riser Outlet Structure option.
- Effective Total Depth (ft) – No data entry required. This value represents the total depth of the facility, including filter media depth, ponding depth (riser height), and freeboard. Value is automatically entered by the model.
- Bottom slope of bioretention – Enter 0 for a flat facility.
- Front and Back side slopes (H/V) – Enter 0 to represent vertical walls for the front and back.
- Left Side Slope (H/V) – Enter 0 to represent vertical side walls.
- Right Side Slope (H/V) – Enter 0 to represent vertical side walls.



Bioretention 1 Mitigated

Facility Name: Bioretention 1

Outlet 1: 0 **Outlet 2:** 0 **Outlet 3:** 0

Downstream Connection: 0

Facility Type: Bioretention Swale

Use simple Bioretention Quick Swale Size Water Quality Size Facility

Underdrain Used: Underdrain Diameter(ft) 0 Offset(in)

Bioretention Bottom Elevation: 0 Orifice Diameter(in) 0 0

Bioretention Dimensions

Bioretention Length (ft) 0.000 Flow Through Underdrain (ac-ft) 0

Bioretention Bottom Width (ft) 0.000 Total Outflow (ac-ft) 0

Freeboard (ft) 0.000 Percent Through Underdrain 0

Over-road Flooding (ft) 0.000 **WQ Percent Filtered** 0

Effective Total Depth (ft) 0

Bottom slope of bioretention,(0-1) 0.000

Sidewall Invert Location

Front and Back side slope (H/V) 0.000

Left Side Slope (H/V) 0.000

Right Side Slope (H/V) 0.000

Material Layers for

| | Layer 1 | Layer 2 | Layer 3 |
|--------------|----------------|---------|---------|
| Depth (ft) | 0.000 | 0 | 0 |
| Soil Layer 1 | SMMwW 12 in/hr | | |
| Soil Layer 2 | GRAVEL | | |
| Soil Layer 3 | GRAVEL | | |

KSat Safety Factor

None 2 4

Native Infiltration: NO

Facility Dimension Diagram

Outlet Structure Data

Riser Outlet Structure

Outlet Structure Data

Riser Height Above bioretention surface (ft) 0

Riser Diameter (in) 0

Riser Type Flat

| Orifice Number | Diameter (in) | Height (ft) |
|----------------|---------------|-------------|
| 1 | 0 | 0 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |

Bioretention Volume at Riser Head (ac-ft) .000

Precipitation on Facility (acre-ft) 0

Evaporation from Facility (acre-ft) 0

- Define TerraMod Material Layers – enter the TerraMod material layers and dimensions in the section labeled “Material Layers”:
 - Soil Layer 1 – Select the SMMWW 12 in/hr soil type, as the standard bioretention media.
 - Soil Layer 2 – Select GRAVEL as the media for soil layer 2.
 - Layer 1 Depth (ft) – Enter 1.5 feet for depth of soil layer 1, to represent the 18” of bioretention media provided in the TerraMod.
 - Layer 2 Depth (ft) – Enter 0.5 feet for depth of soil layer 2, to represent the 6” of gravel provided in the TerraMod.
 - Soil Layer 3 and Layer 3 Depth – leave blank.
- Enter the KSat Safety Factor – Enter the appropriate safety factor to meet the required hydraulic conductivity. The manual states:

*“If the contributing area of the bioretention cell or swale is equal to or exceeds any of the following limitations:
5,000 square feet of pollution-generating impervious surface;
10,000 square feet of impervious surface;
¾ acre of lawn and landscape,
Use 4 as the infiltration rate (Ksat) safety factor. If the contributing area is less than all of the above areas, or if the design includes a pretreatment device for solids removal, use 2 as the Ksat safety factor.”*
- Enter Native Infiltration parameters – If native soils are not going to be used for infiltration, leave this value as NO. If native soils are going to be used for infiltration, select YES and enter the following parameters:
 - Measured Infiltration Rate (in/hr) – Enter the native soil infiltration rate.
 - Reduction Factor – Enter a reduction factor, if applicable.
 - Use Wetted Surface Area – Select No since TerraMod has vertical sidewalls.
- Enter the Outlet Structure Data – Enter information related to the outlet structure by first selecting the type of outlet structure. For TerraMod, select Riser Outlet Structure and then enter the following parameters:
 - Riser Height Above bioretention surface (ft) – Enter a riser height equal to the ponding depth above the soil media layer of the TerraMod. Ecology specifies a maximum ponding depth of 12 inches.
 - Riser Diameter (in) – A typical TerraMod overflow device is a square unit with dimensions of 18” x 18”. To approximate this overflow in WWHM, enter an equivalent riser diameter (20” diameter for an 18” x 18” square) to represent the overflow device.
 - Riser Type – Select the “Flat” riser type.

Step 5 – Analyze the Performance of the TerraMod

The next step is to analyze the performance of the specified TerraMod relative to the performance standards prescribed in Minimum Requirements #5, #6, and #7:

- Evaluate the water quality performance:

According to the 2014 SWMMWW, sites that trigger Minimum Requirement #6 (Water Quality Treatment) are required to infiltrate or filter at least 91 percent of the total runoff volume through a bioretention media that meets Ecology's requirements:

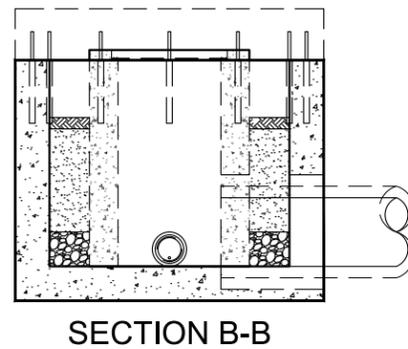
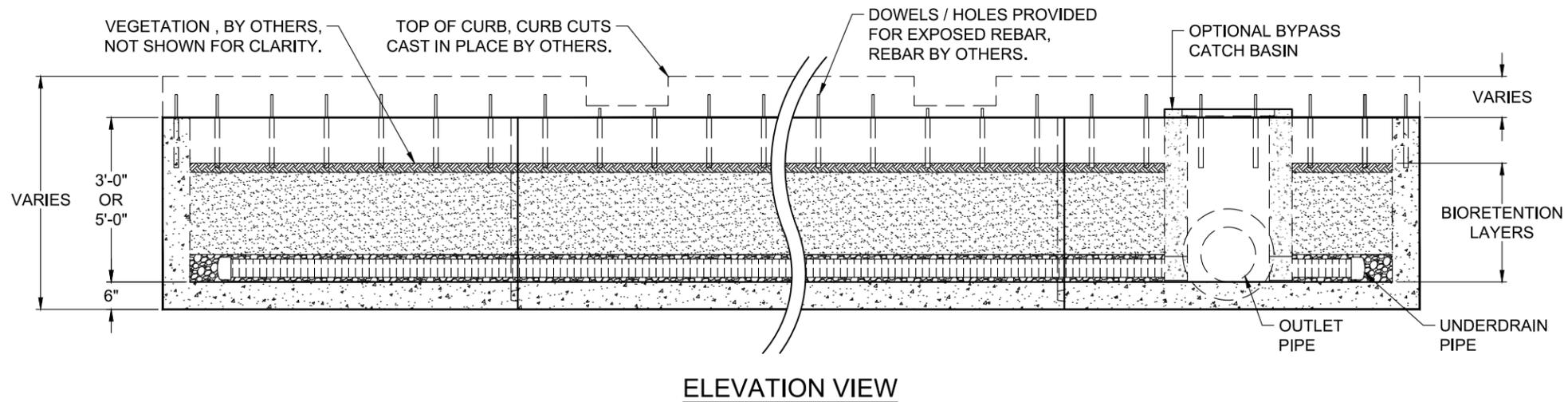
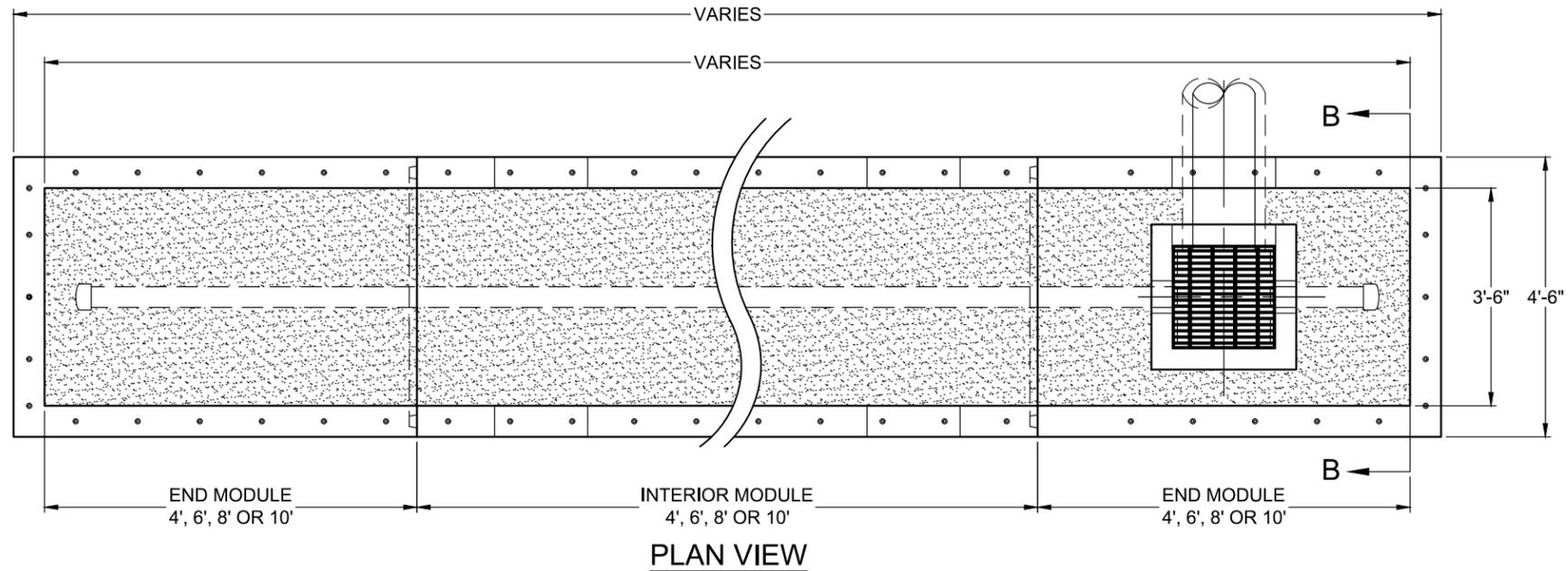
- In the Scenario Editor, check the box for "Predeveloped" scenario and then select Run Scenario.
 - Then, in the Scenario Editor, check the box for "Mitigated" scenario and then select Run Scenario.
 - If the facility uses an underdrain, confirm that the "WQ Percent Filtered" is equal to or greater than 91 percent.
 - If the facility uses infiltration instead of an underdrain, confirm that the "Percent Infiltrated" is equal to or greater than 91 percent.
 - If the facility does not reach the goal of 91 percent filtered or infiltrated, increase the size of the TerraMod or decrease the basin area draining to the facility until the standard is met.
- Evaluate the flow control performance:
Sites that trigger Minimum Requirement #7 (Flow Control) are required to match pre-developed stormwater discharges for a range of flows. Evaluate the flow control performance of the system using the following steps:
 - After running both Pre-developed and Mitigated scenarios, click on the "Analysis" button in the toolbar to open the Analysis window.
 - Select the desired point of compliance (typically POC 1) from the tabs at the bottom of the Analyze Datasets window (lower left portion of the screen).
 - Select the Stream Protection Duration tab from the upper left portion of the screen.
 - Use this information to determine if the system design meets the requirements for flow control.
 - If the facility does not meet the flow control performance requirements, increase the size of the TerraMod, decrease the basin area draining to the facility until the standard is met, or provide additional retention/detention downstream of the TerraMod system. If you change the post-development area, the pre-development area must be changed as well. A sufficient number of TerraMod modules shall be provided to treat runoff from the entire project area.
- Evaluate the LID performance:
Sites that trigger Minimum Requirement #5 (On-site Stormwater Management) are required to use stormwater management BMPs from one of the two lists or demonstrate compliance with the LID Performance Standard. Evaluate the LID performance of the system against the LID Performance Standard using the following steps:
 - After running both Pre-developed and Mitigated scenarios, click on the "Analysis" button in the toolbar to open the Analysis window.
 - Select the desired point of compliance (typically POC 1) from the tabs at the bottom of the Analyze Datasets window (lower left portion of the screen).
 - Select the LID Duration tab from the upper left portion of the screen.
 - Use this information to determine if the system design meets the requirements for flow control.
 - If the facility does not meet the LID performance requirements, increase the size of the TerraMod, decrease the basin area draining to the facility until the standard is met, or use the appropriate list option. Note: the TerraMod is not a substitute for bioretention when using the list options.

- Consider other factors that affect system sizing: finally, if there are any other governors that affect the size of the TerraMod (such as a surface area that is a minimum percent of the draining surface area), apply those to the TerraMod sizing in WWHM.

Eastern Washington Sizing Guidance

The TerraMod can also be used for projects in eastern Washington. Sizing for projects in eastern Washington must comply with the standard sizing criteria for bioretention facilities and design flow rates appropriate for eastern Washington jurisdictions.

| SITE SPECIFIC DATA | | | |
|------------------------------|-----------|-----------|------------------|
| Structure ID | ID | | |
| Treatment Media Surface Area | XX sf | | |
| Rim Elevation | X.XX' | | |
| TerraMod Module Height | 3' or 5' | | |
| Pipe Data | Pipe Size | Pipe Type | Invert Elevation |
| Outlet | XX" | XXX | X.XX' |
| Underdrain | XX" | XXX | X.XX' |
| Notes: | | | |
| - | | | |
| PERFORMANCE SPECIFICATIONS | | | |
| WA Ecology GULD Equivalency | | | |



- NOTES:**
- DESIGN LOADINGS:
 - 300 PSF PEDESTRIAN LOADING.
 - ASSUMED WATER TABLE = BELOW BOTTOM OF PRECAST.
 - DRY LATERAL EARTH PRESSURE (EPF) = 45 PCF.
 - LATERAL LIVE LOAD SURCHARGE=80 PSF.
 - NO LATERAL SURCHARGE FROM ADJACENT BUILDINGS, WALLS, PIERS, OR FOUNDATIONS.
 - CONCRETE 28 DAY COMPRESSIVE STRENGTH SHALL BE 5,000 PSI MINIMUM.
 - STEEL REINFORCEMENT: REBAR, ASTM A-615 OR A-706, GRADE 60.
 - MESH REINFORCEMENT: ASTM C-1064, GRADE 80.
 - CEMENT: ASTM C-150 SPECIFICATION.
 - REQUIRED NATIVE ALLOWABLE SOIL BEARING PRESSURE = 2,500 PSF.
 - REFERENCE STANDARD:
 - ASTM C 890
 - ASTM C 913
 - THIS STRUCTURE IS DESIGNED TO THE PARAMETERS NOTED HEREIN. PLEASE VERIFY THAT THESE PARAMETERS MEET PROJECT REQUIREMENTS. IF DESIGN PARAMETERS ARE INCORRECT, REVIEWING ENGINEER/AUTHORITY SHALL NOTIFY OLDCASTLE INFRASTRUCTURE UPON REVIEW OF THIS SUBMITTAL.
 - OVERSIZED HOLES TO ACCOMMODATE SPECIFIC PIPE TYPE MUST BE CONCENTRIC TO PIPE ID. AFTER PIPES ARE INSTALLED, ALL ANNULAR SPACES SHALL BE FILLED WITH A MINIMUM OF 3000 PSI CONCRETE FOR FULL THICKNESS OF PRECAST WALLS. PIPES ARE TO BE FLUSH WITH THE INSIDE SURFACE OF THE CONCRETE STRUCTURE.
 - CONTRACTOR RESPONSIBLE TO VERIFY ALL SIZES, LOCATIONS AND ELEVATIONS OF OPENINGS.
 - CONTRACTOR RESPONSIBLE TO ENSURE ADEQUATE BEARING SURFACE IS PROVIDED (I.E. COMPACTED & LEVEL PER PROJECT SPECIFICATIONS).
 - ALL EXTERIOR SURFACES SUPPLIED WITH "FORM FINISH."
 - SYSTEM SHIPPED EMPTY. UNDERDRAIN, SOIL/FILTER MEDIA, DRAIN ROCK PROVIDED & INSTALLED BY OTHERS.
 - ADAPTORS/ANGLES AND EXTERNAL PIPING BY OTHERS.



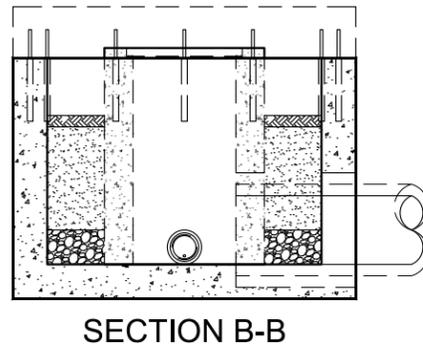
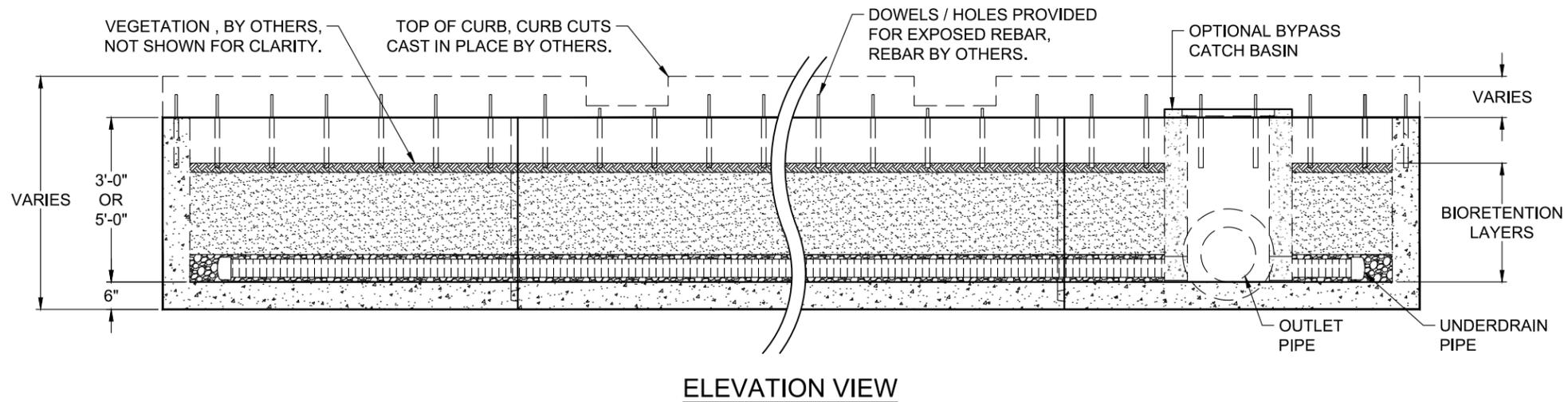
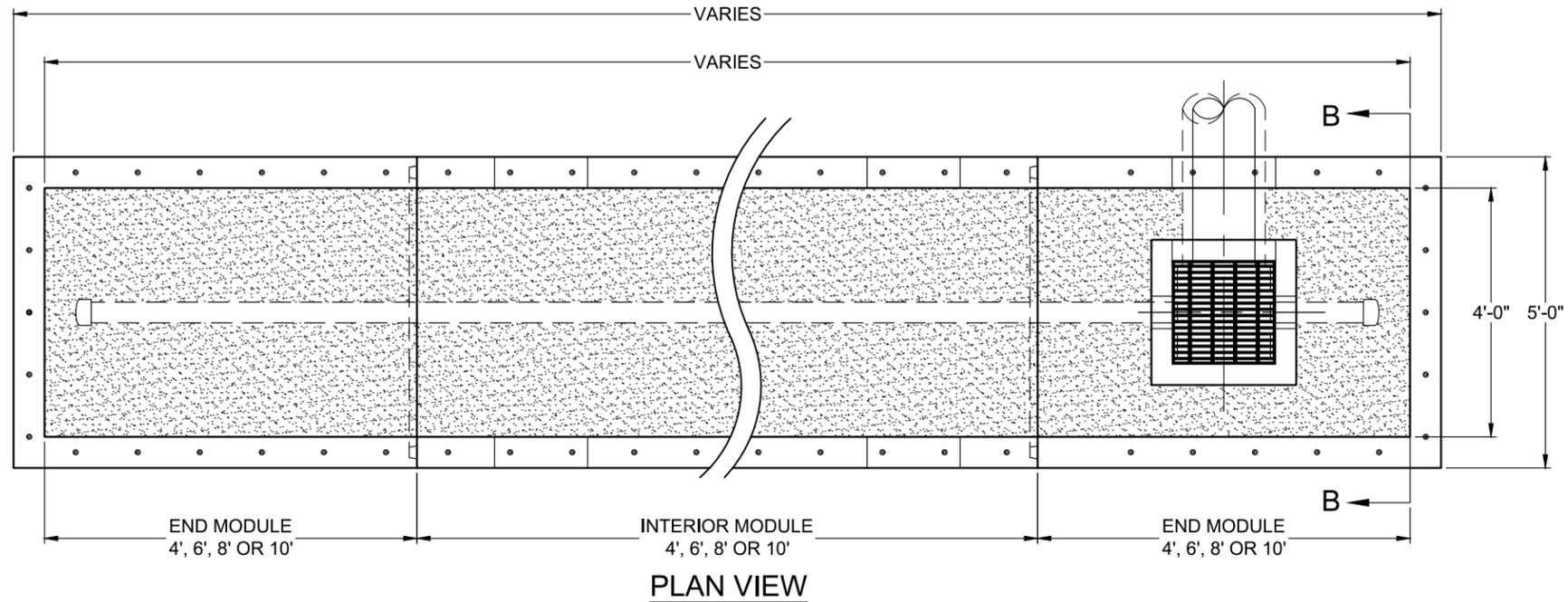
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TerraMod™ Modular (STANDARD)
 Bioretention System

| | | |
|-------------------|----------|--------|
| CUSTOMER | - | |
| PROJECT NAME | - | |
| SHEET NAME | REVISION | SHEET |
| Specifier Drawing | REV DATE | 1 OF 1 |
| TM-3.5 | - | - |



| SITE SPECIFIC DATA | | | |
|------------------------------|-----------|-----------|------------------|
| Structure ID | ID | | |
| Treatment Media Surface Area | XX sf | | |
| Rim Elevation | X.XX' | | |
| TerraMod Module Height | 3' or 5' | | |
| Pipe Data | Pipe Size | Pipe Type | Invert Elevation |
| Outlet | XX" | XXX | X.XX' |
| Underdrain | XX" | XXX | X.XX' |
| Notes: | | | |
| - | | | |
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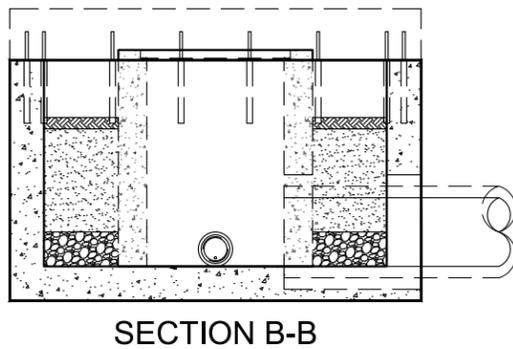
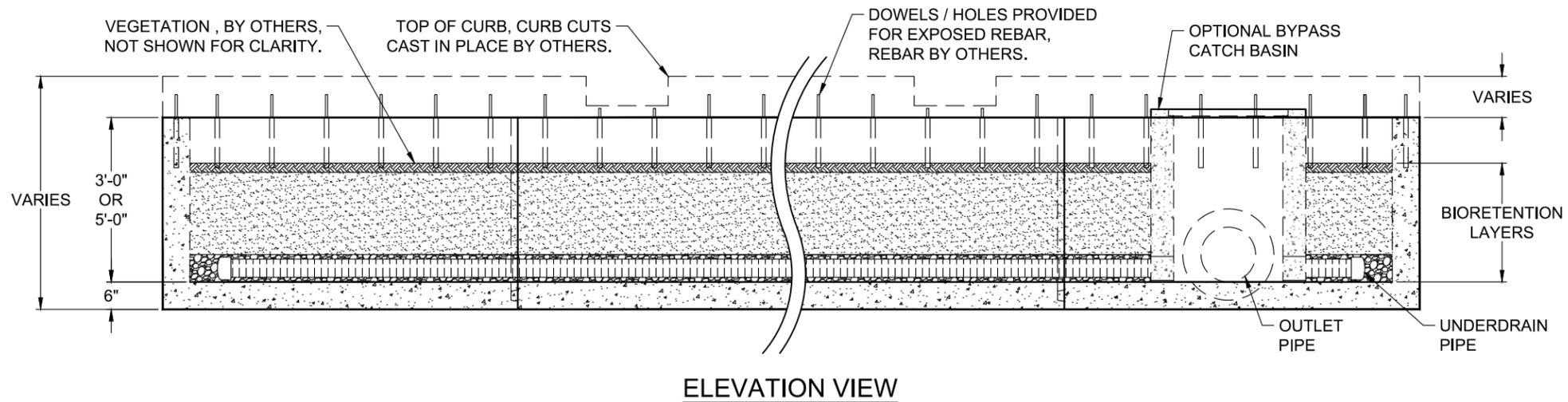
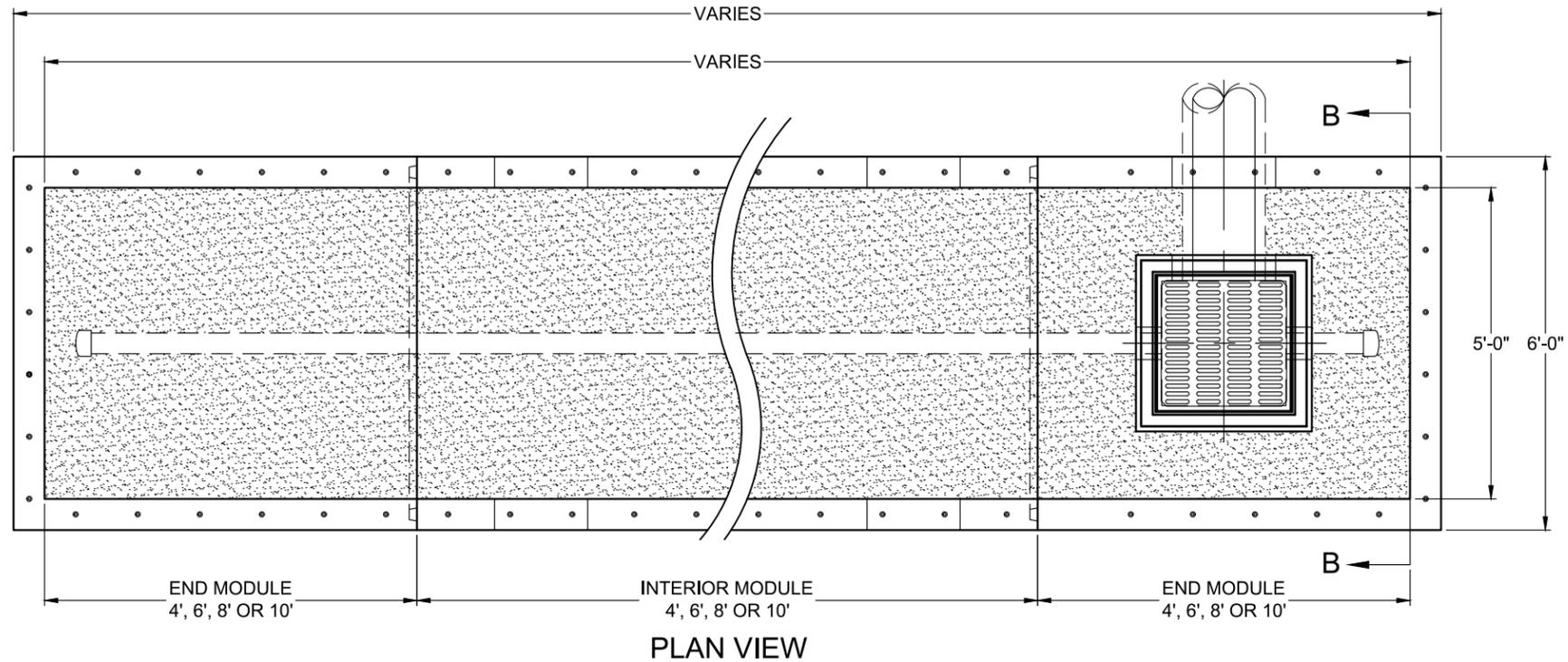
TerraMod™ Modular (STANDARD)
 Bioretention System

CUSTOMER
 -
 PROJECT NAME
 -

| SHEET NAME | REVISION | SHEET |
|---------------------------|----------|--------|
| Specifier Drawing TM-4 | REV DATE | 1 OF 1 |



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|------------------------------|-----------|-----------|------------------|
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| - | | | |
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 - LATERAL LIVE LOAD SURCHARGE=80 PSF.
 - NO LATERAL SURCHARGE FROM ADJACENT BUILDINGS, WALLS, PIERS, OR FOUNDATIONS.
 - CONCRETE 28 DAY COMPRESSIVE STRENGTH SHALL BE 5,000 PSI MINIMUM.
 - STEEL REINFORCEMENT: REBAR, ASTM A-615 OR A-706, GRADE 60.
 - MESH REINFORCEMENT: ASTM C-1064, GRADE 80.
 - CEMENT: ASTM C-150 SPECIFICATION.
 - REQUIRED NATIVE ALLOWABLE SOIL BEARING PRESSURE = 2,500 PSF.
 - REFERENCE STANDARD:
 - ASTM C 890
 - ASTM C 913
 - THIS STRUCTURE IS DESIGNED TO THE PARAMETERS NOTED HEREIN. PLEASE VERIFY THAT THESE PARAMETERS MEET PROJECT REQUIREMENTS. IF DESIGN PARAMETERS ARE INCORRECT, REVIEWING ENGINEER/AUTHORITY SHALL NOTIFY OLDCASTLE INFRASTRUCTURE UPON REVIEW OF THIS SUBMITTAL.
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 - CONTRACTOR RESPONSIBLE TO VERIFY ALL SIZES, LOCATIONS AND ELEVATIONS OF OPENINGS.
 - CONTRACTOR RESPONSIBLE TO ENSURE ADEQUATE BEARING SURFACE IS PROVIDED (I.E. COMPACTED & LEVEL PER PROJECT SPECIFICATIONS).
 - ALL EXTERIOR SURFACES SUPPLIED WITH "FORM FINISH."
 - SYSTEM SHIPPED EMPTY. UNDERDRAIN, SOIL/FILTER MEDIA, DRAIN ROCK PROVIDED & INSTALLED BY OTHERS.
 - ADAPTORS/ANGLES AND EXTERNAL PIPING BY OTHERS.



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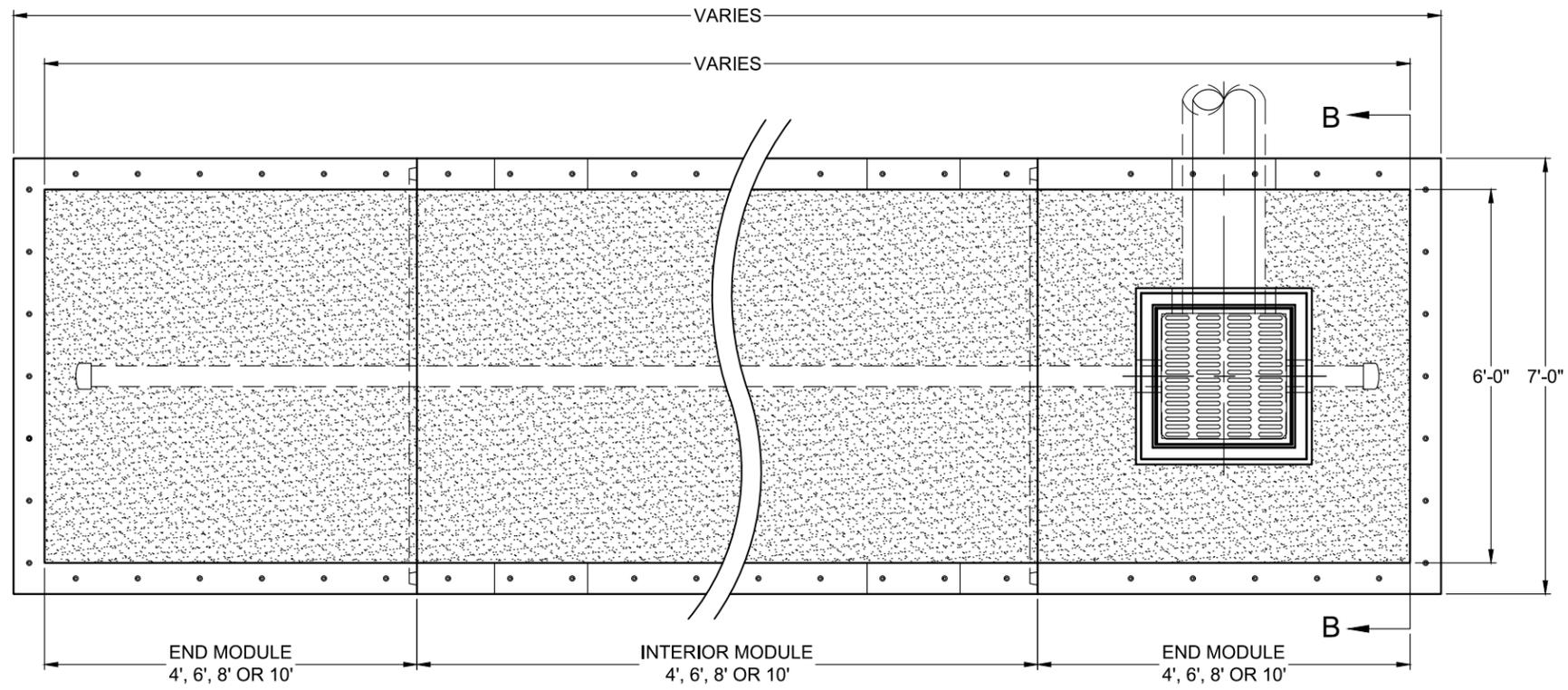
TerraMod™ Modular (STANDARD)
 Bioretention System

CUSTOMER
 -
 PROJECT NAME
 -

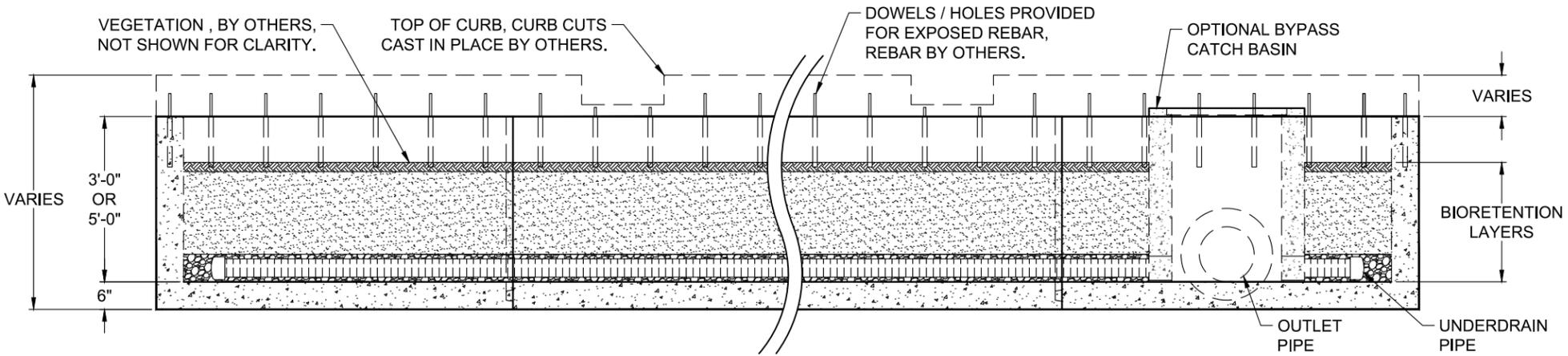
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|---------------------------|----------|--------|
| Specifier Drawing TM-5 | REV DATE | 1 OF 1 |



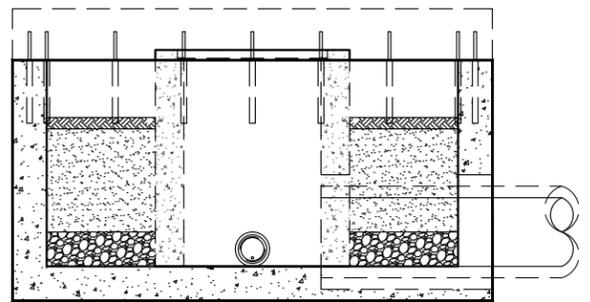
| SITE SPECIFIC DATA | | | |
|------------------------------|-----------|-----------|------------------|
| Structure ID | ID | | |
| Treatment Media Surface Area | XX sf | | |
| Rim Elevation | X.XX' | | |
| TerraMod Module Height | 3' or 5' | | |
| Pipe Data | Pipe Size | Pipe Type | Invert Elevation |
| Outlet | XX" | XXX | X.XX' |
| Underdrain | XX" | XXX | X.XX' |
| Notes: | | | |
| - | | | |
| PERFORMANCE SPECIFICATIONS | | | |
| WA Ecology GULD Equivalency | | | |



PLAN VIEW



ELEVATION VIEW



SECTION B-B

- NOTES:
- DESIGN LOADINGS:
 - 300 PSF PEDESTRIAN LOADING.
 - ASSUMED WATER TABLE = BELOW BOTTOM OF PRECAST.
 - DRY LATERAL EARTH PRESSURE (EPF) = 45 PCF.
 - LATERAL LIVE LOAD SURCHARGE=80 PSF.
 - NO LATERAL SURCHARGE FROM ADJACENT BUILDINGS, WALLS, PIERS, OR FOUNDATIONS.
 - CONCRETE 28 DAY COMPRESSIVE STRENGTH SHALL BE 5,000 PSI MINIMUM.
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 - ADAPTORS/ANGLES AND EXTERNAL PIPING BY OTHERS.

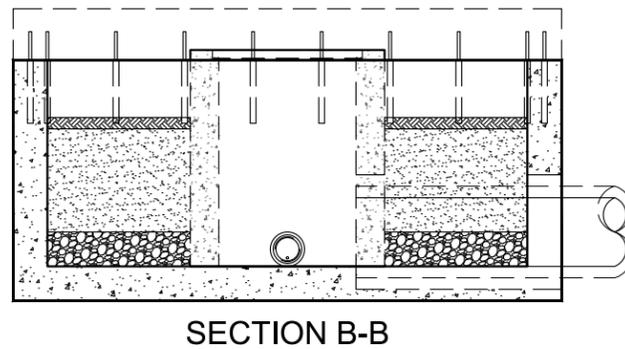
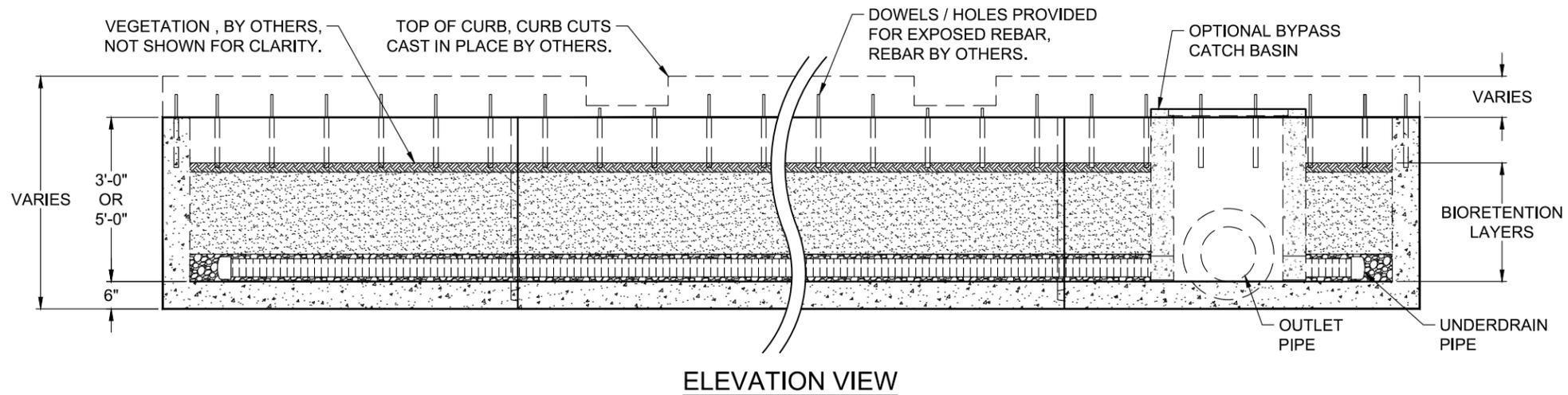
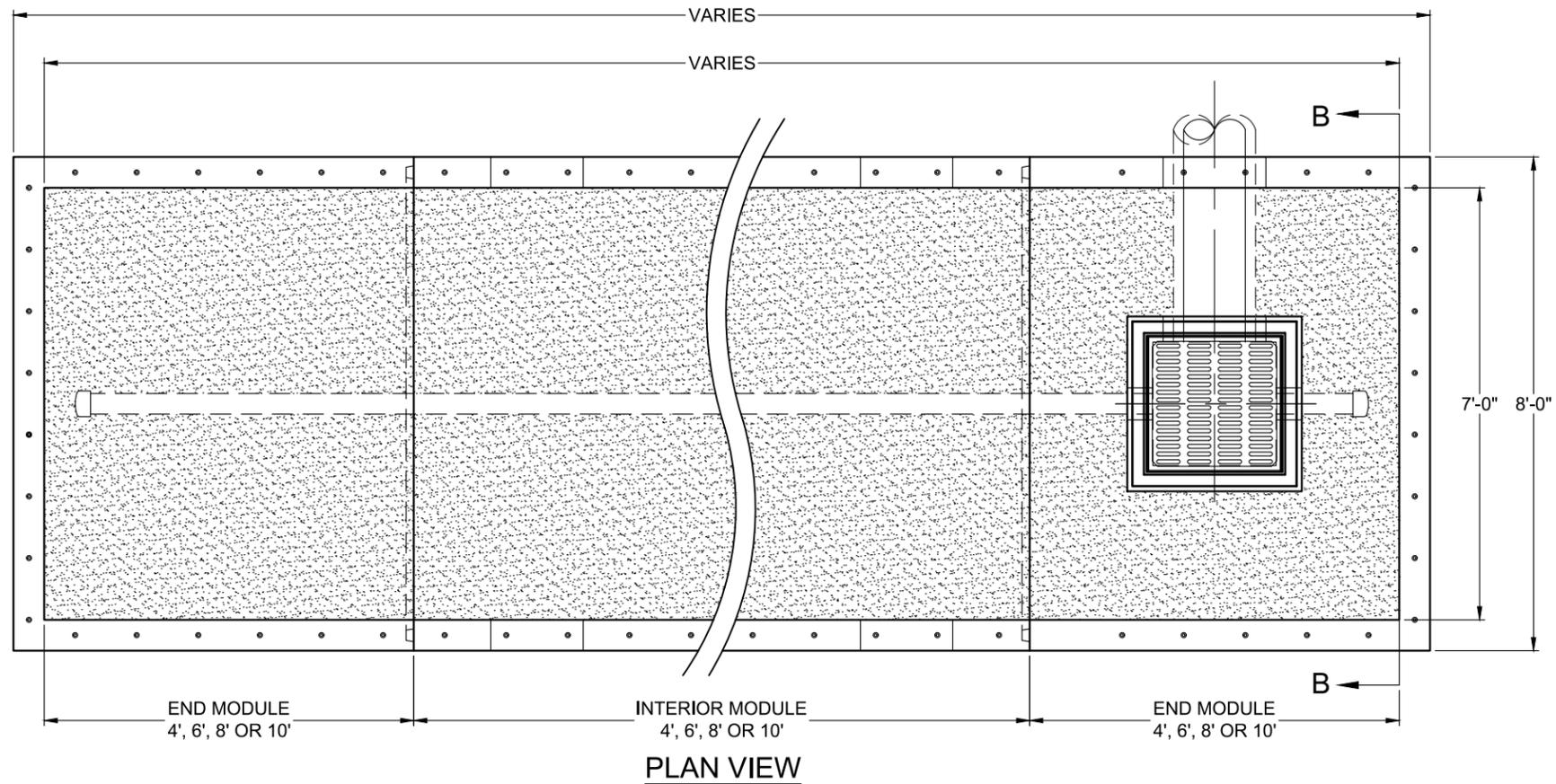


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| | |
|------------------------------|----------|
| TerraMod™ Modular (STANDARD) | |
| Bioretention System | |
| CUSTOMER | |
| - | |
| PROJECT NAME | |
| - | |
| SHEET NAME | REVISION |
| Specifier Drawing | REV DATE |
| TM-6 | - |
| SHEET | 1 OF 1 |



| SITE SPECIFIC DATA | | | |
|------------------------------|-----------|-----------|------------------|
| Structure ID | ID | | |
| Treatment Media Surface Area | XX sf | | |
| Rim Elevation | X.XX' | | |
| TerraMod Module Height | 3' or 5' | | |
| Pipe Data | Pipe Size | Pipe Type | Invert Elevation |
| Outlet | XX" | XXX | X.XX' |
| Underdrain | XX" | XXX | X.XX' |
| Notes: | | | |
| - | | | |
| PERFORMANCE SPECIFICATIONS | | | |
| WA Ecology GULD Equivalency | | | |



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 - ADAPTORS/ANGLES AND EXTERNAL PIPING BY OTHERS.

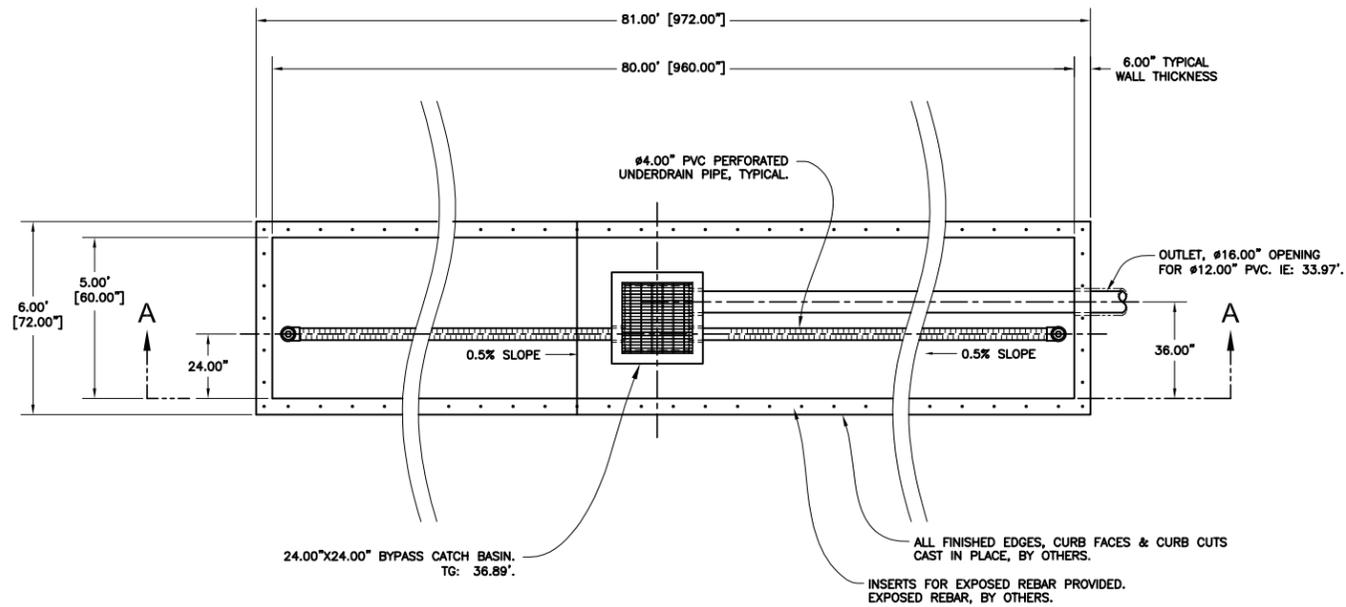
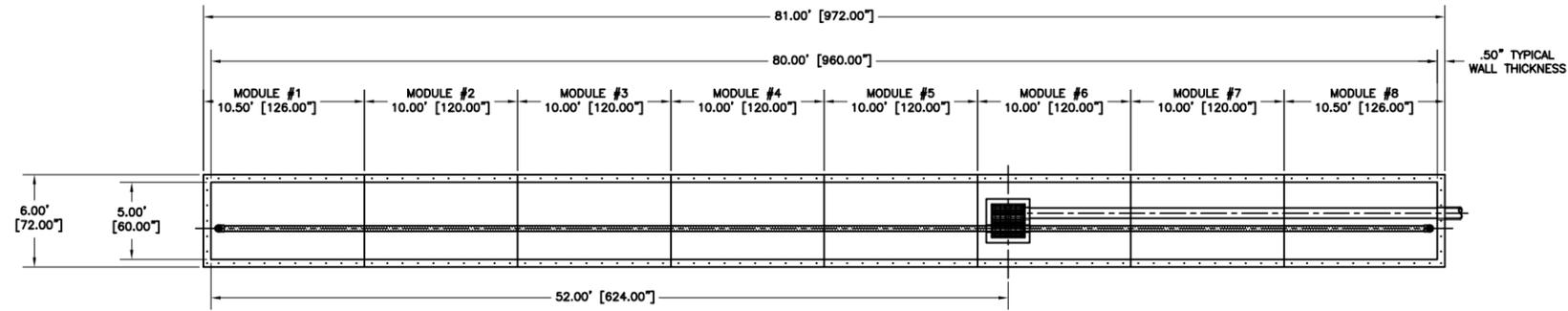


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| | | |
|---------------------|----------|------------|
| TerraMod™ Modular | | (STANDARD) |
| Bioretention System | | |
| CUSTOMER | | |
| - | | |
| PROJECT NAME | | |
| - | | |
| SHEET NAME | REVISION | SHEET |
| Specifier Drawing | REV DATE | 1 OF 1 |
| TM-7 | | |



EXAMPLE - TERRAMOD PROJECT APPLICATION - CALIFORNIA



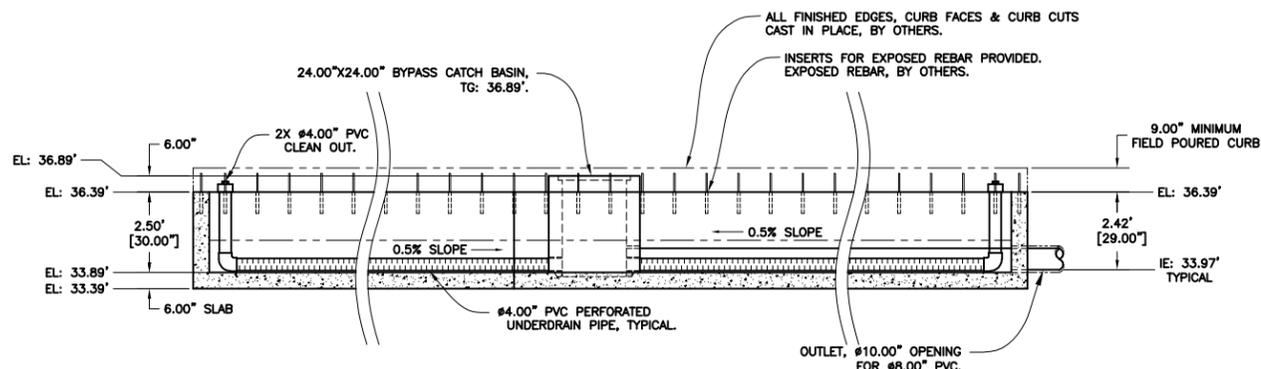
PLAN VIEW
SYSTEM SHOWN WITHOUT MEDIA, FOR CLARITY

SYSTEM: TCM 15

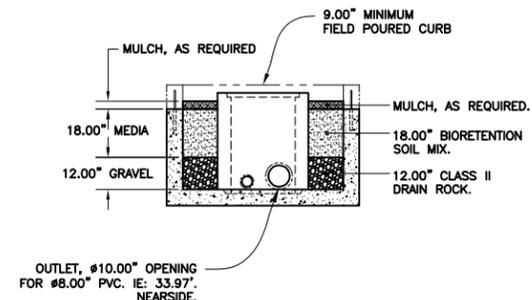
| BILL OF MATERIALS | |
|-----------------------------|---------------|
| ITEM | NOTES |
| MODULE #1 | 10,000 LBS |
| MODULE #2 | 8,500 LBS |
| MODULE #3 | 8,500 LBS |
| MODULE #4 | 8,500 LBS |
| MODULE #5 | 8,500 LBS |
| MODULE #6 | 8,500 LBS |
| MODULE #7 | 8,500 LBS |
| MODULE #8 | 10,000 LBS |
| 24"x24" CATCH BASIN | 2,250 LBS |
| 1 ROLLS - CS-102 CONSEAL | SHIPPED LOOSE |
| 5 ROLLS - CS-212 JOINT WRAP | SHIPPED LOOSE |

NOTES:

- CONCRETE COMPONENTS ARE MANUFACTURED IN ACCORDANCE WITH ASTM C890 & C913.
- DESIGN CONCRETE COMPRESSIVE STRENGTH IS 5,000 PSI (MIN.) AT 28 DAYS.
- PRECAST DESIGN DOES NOT INCLUDE ANY LATERAL OR SURCHARGE LOADS FROM OTHER BUILDINGS OR FOUNDATIONS ADJACENT TO THIS STRUCTURE. THIS STRUCTURE SHALL BE KEPT A MINIMUM OF 1:1 RATIO AWAY FROM OTHER FOOTINGS OR FOUNDATIONS.
- GROUND WATER TABLE FOR STRUCTURAL CALCULATIONS IS ASSUMED BELOW INVERT.
- THIS STRUCTURE IS DESIGNED TO THE PARAMETERS NOTED HEREIN. PLEASE VERIFY THAT THESE PARAMETERS MEET PROJECT REQUIREMENTS. IF DESIGN PARAMETERS ARE INCORRECT, REVIEWING ENGINEER/AUTHORITY SHALL NOTIFY OLDCASTLE PRECAST UPON REVIEW OF THIS SUBMITTAL.
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- ADAPTORS/ANGLES AND EXTERNAL PIPING BY OTHERS.



SECTION A-A
SYSTEM SHOWN WITHOUT MEDIA, FOR CLARITY



SECTION B-B



THIS MUST BE FILLED OUT BEFORE MANUFACTURING BEGINS

APPROVED W/ NO EXCEPTIONS TAKEN:

APPROVED AS NOTED:

REVISE AND RESUBMIT:

SIGNATURE _____ DATE _____



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| | | | | | |
|---------------------------------------|-------|-------|----------|-----------|-------------|
| TerraMod™ Modular Bioretention System | | | | | |
| Customer: _____ | | | | | |
| Job Name: _____, CA | | | | | |
| JOB DATE | SALES | DRAWN | ENGINEER | CHECKED | SALES ORDER |
| 9/29/17 | - | ZHD | MJT | JPR / JMH | |
| DRAWING NUMBER | | | | REVISION | SHEET |
| | | | | 0 | |
| | | | | REV DATE | 1 OF 1 |
| | | | | N/A | |

| | | | |
|------|-------------|----------|----------|
| 0 | NEW | N/A | N/A |
| REV. | DESCRIPTION | REV. BY. | APPROVED |