The “Road” to Stormwater Management: Update on MDOT’s BMP Design Tools

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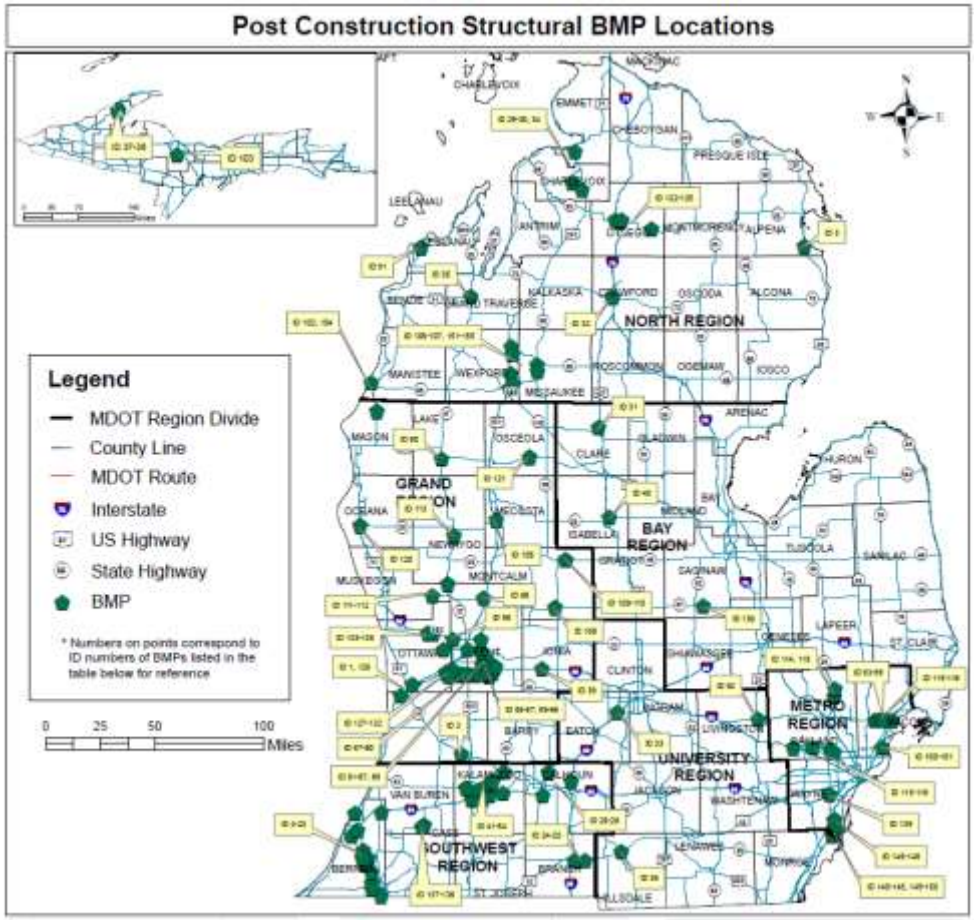
MDOT's Statewide MS4 Permit

- *Roads*
- *Buildings*
- *Garages*
- *Maintenance Facilities*
- *Laboratories*
- *BMPs*
- *Welcome Centers*
- *Rest Areas*
- *Scenic Turnouts*

Structural BMP Map



Initial BMP Map, Updated Annually

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Water Quality & Channel Protection

- Performance Criteria
  - WQv – Treat runoff from 90% (non-exceedance) storm events.
  - Channel Protection – maintain runoff volume for 2-yr, 24-hr event.
- Developing MDOT specific design standards for numerous BMP's.
- Anticipate development of tools to assist designers.
- MDOT looking to address water quality and quantity standards within project limits.

BMP Screening Tool

- Excel-based tool for BMP Screening based on:
  - New impervious area
  - Site Conditions (soils, urban v. rural)
  - Site Risks Impacting Cost/Constructability (high GW, utilities, ROW, accessibility)
  - Water Quality Requirements (TSS, metals, P, N, etc.)

Post-Construction BMP - Scoping Level Planning Tool

Does your project need BMPs?

Total Disturbed Area	100	acres
Is there a TMDL on the project? (Refer to mapping tool)	Yes	
	CONTINUE	

Project Summary

This section to provide general housekeeping notes for the project.

Project Name:	INSERT PROJECT DETAILS
Location:	INSERT PROJECT DETAILS
Date:	INSERT PROJECT DETAILS
Watershed:	INSERT PROJECT DETAILS
Additional Notes:	INSERT PROJECT DETAILS

Site Characteristics

This section asks the user to input characteristics about the site in Column C. For guidance, refer to comments in cells in Column B.

Project Area Within The Right of Way	1.0	acres
Proposed Impervious Area (Treatment Area)	1.0	acres
Existing Impervious Area	0.0	acres
New Impervious Area	1.0	acres
Are there existing structural BMPs onsite?		
Hydrologic Soil Group (Refer to mapping tool)	C/D	
Urban or Rural?	Urban	

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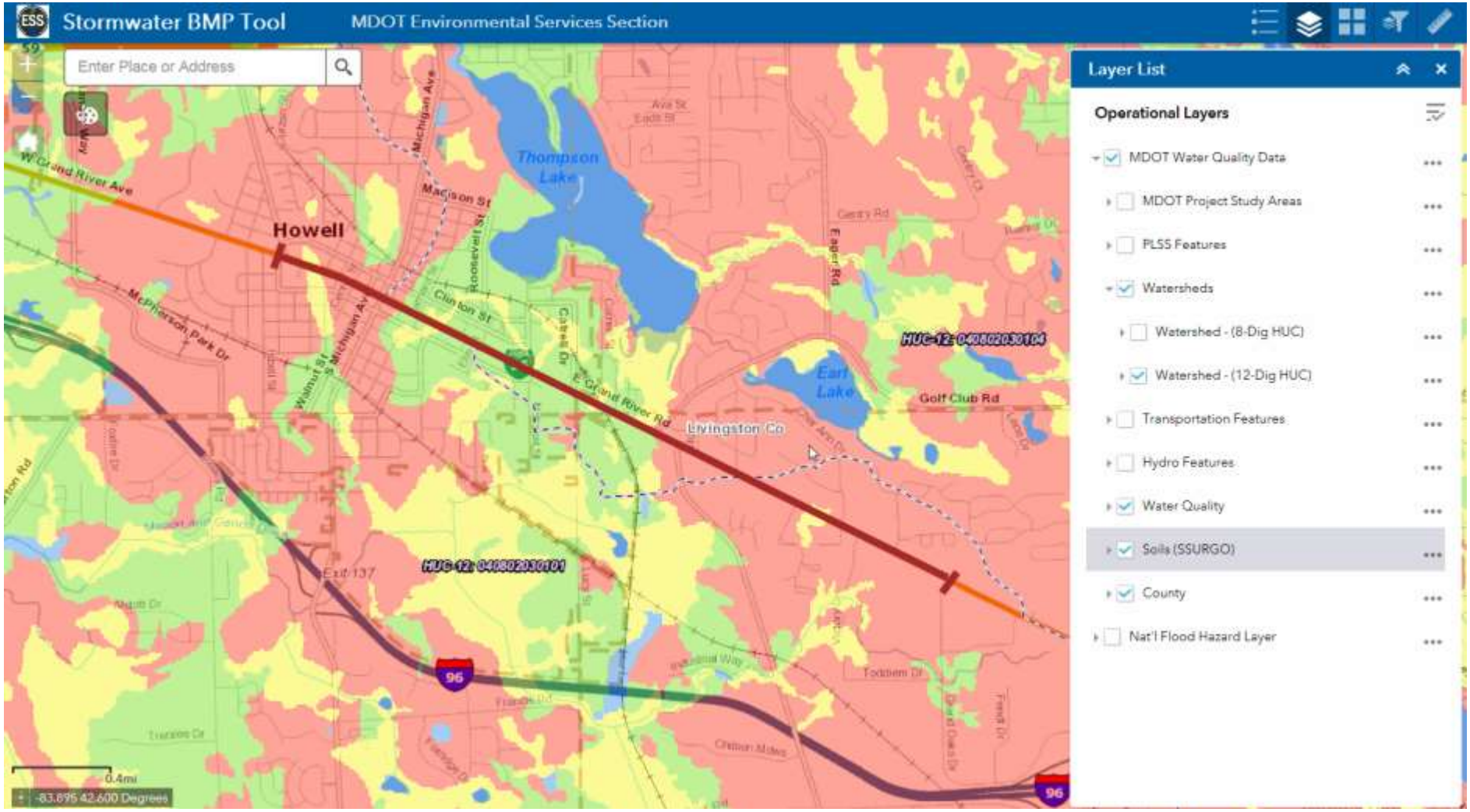

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Water Quality Requirements

This section asks the user to input the water quality requirements the project must meet. Water quality requirements based on outfall/stream impairments. Refer to the mapping tool.

TSS removal	No
Metals	No
Total Phosphorus	No
Total Nitrogen	No
Petroleum Hydrocarbons	No
Bacteria	No

Water Quality - Potential BMPs

This section returns the potential BMPs that should be considered in the scoping level analysis to meet water quality standards. BMPs in this section are based upon inputs in site characteristics and water quality requirements.

	Inlet Structural Device - Debris/Sediment/Hydrocarbons ($$)	Oil Water Separator ($$)	
			Underground Detention System (Pipe, Tank/Vault) ($$$$)
			Biofilters (e.g. StormTreat System) ($$$$)
Bottomless Catch Basin ($$)	Catch Basin Sump - Deep ($$)	Delaware Sand Filter (Underground sand filter) ($$$$)	
	Hydrodynamic Separator ($$) ($$)		Infiltration Trench with Perforated Pipe ($$$) ($$$)

Water Quality - Scoping Level Cost Estimate

This section asks the user to estimate the risk levels of various conditions. The cost range is a constant value determined by inputs in prior sections. The anticipated cost based on risks value will vary based on the user inputs in this section. The risk level assignment should consider a broad perspective. For example, instead of thinking just about the risk associated with the specific project area, reflect on the risk in relation to similar projects in the state.

Risk of ...	
Utility Conflicts	1
High Groundwater Table	1
Additional ROW Required **(If required, must talk to Real Estate)**	1
Additional Site Constraints (wetlands, floodplain, physical structures, archaeology, threatened and endangered species, protected areas)	1
Accessibility for construction & maintenance	1
Soil Conditions (permeability, stability, contamination)	1

Legend
[3] = High Risk
[2] = Medium Risk
[1] = Low Risk

Scoping Level Cost Range	Anticipated Cost Based on Risks
$2,500.50 - $25,000.00	$2,500.50

Channel Protection - Potential BMPs & Anticipated Costs

This section returns the potential BMPs that should be considered in the scoping level analysis to meet channel protection standards.There are BMPs that address both Water Quality and Channel Protection including: bioslope, roadside bioswale, roadside infiltration trench, vegetated swale, bioretention, and infiltration basin. If these BMPs are chosen, the costs between water quality and channel protection are not additive.

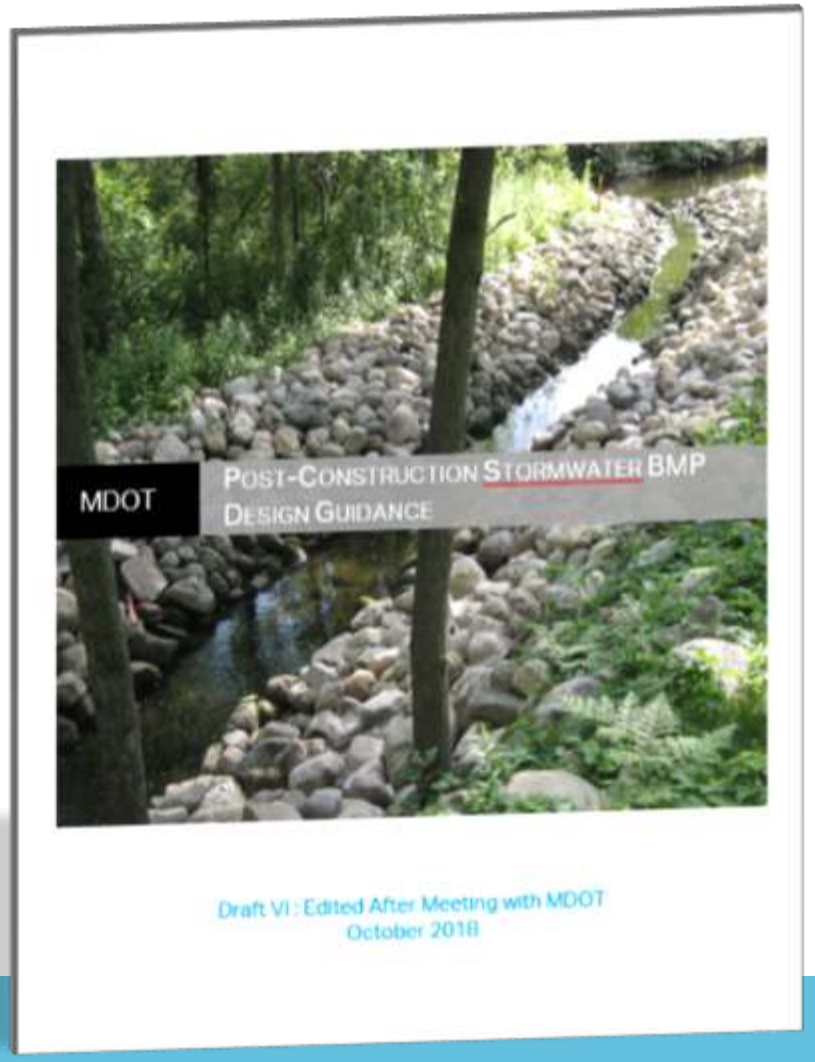
Potential BMPs	Permeable Pavement, Bottomless Catch Basin, Infiltration Trench w/ Perforated Pipe	
Infiltration Area (Area Needed to Infiltrate New Impervious Area)	0.20	acres
Scoping Level Cost Range	$5,001.00 - $50,000.00	
Anticipated Cost Based on Risk	$5,001.00	

List of Potential Water Quality BMPs	Associated Maintenance
Inlet Structural Device - Debris/Sediment/Hydrocarbons ($$)	Biannual inspection and removal of litter/debris. Quarterly inspection and removal of sediment, remove inserts. Quarterly inspection, changing of filters, inserts, or sorbent media.
Catch Basin Sump - Deep ($$)	Biannual inspection and removal of sediment. Visible sediment should be frequently removed.
Hydrodynamic Separator ($$)	Quarterly inspection and removal of sediment and debris.
In-Line Structural Device (baffle box, screen, hood) ($$)	Quarterly inspection and removal of sediment and debris.
Oil Water Separator ($$)	Quarterly inspection, removal of sediment, debris, oil/grease.
Delaware Sand Filter (Underground sand filter) ($$$$)	Quarterly inspection and removal of debris and sediment, rake top 1 inch of sand, replace sand as needed.
Underground Detention System (Pipe, Tank/Vault) ($$$$)	Annual inspection and removal of sediment as required.
Biofilters (e.g. StormTreat System) ($$$$)	Biannual mowing and removal of edge sediments/debris.

Anticipated Costs, Water Quality	List of Potential Channel Protection BMPs	Anticipated Costs, Channel Protection
$2,500.50	Permeable Pavement, Bottomless Catch Basin, Infiltration Trench w/ Perforated Pipe	$5,001.00
Cost Range, Water Quality		**Cost Range, Channel Protection**
$2,500.50 - $25,000.00		$5,001.00 - $50,000.00

PCBMP Design Manual

- Supplemental Manual to Aid in Design of Structural BMPs
- Augmented List of BMPs, compared to previous Drainage Manual
- “Cook book” approach to design
- Incorporates: pollutant removal, water quality and channel protection design equations, maintenance procedures, design details, etc.
- Draws from SEMCOG manual and BMP manuals for other states



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VEGETATED SWALES

A vegetated swale is a shallow stormwater channel that is densely planted with a variety of grasses or shrubs designed to slow, filter, and infiltrate stormwater. Swales are an excellent alternative to conventional curb and gutter conveyance systems because they provide both pre and primary treatment of stormwater.

Stormwater Management Benefits	
Peak Flow	☐
Metals	☒
Phosphorous	☒
Nitrogen	☒
Petroleum Hydrocarbons	☒
Bacteria	☒
TSS Removal Credit	75-90%

Vegetated Slope. Source: XP Drainage

Advantages/Benefits	Disadvantages/Limitations
Treat water quality using soil, vegetation, and microbes	Limited peak and volume control
Reduce total volume of stormwater runoff	Poor design may lead to standing water/mosq
Increase infiltration and groundwater recharge	Impractical on steep slopes
Aesthetically pleasing and increases biodiversity	Ponding concerns on zero slope

Treatment Effectiveness	
• Water Quality	High
• Channel Protection	Moderate
• Peak Discharge Reduction	Moderate

Applications	
• Median	• Rural Area
• Interchange	• Pre-Treatment
• Urban Area	• Primary Treatment

Water Quality and Channel Protection Volume Spreadsheet for Vegetated Swales

Project Name:	[illegible]
Job Number:	[illegible]
Calculated By:	[illegible]
Checked By:	[illegible]

Alignment:	[illegible]
Side:	[illegible]
Beginning Station:	[illegible]
End Station:	[illegible]

Individual Vegetated Swale Drainage Area Information	
Existing Pervious Area (ft2)	[illegible]
Primary Land Cover, Existing Pervious	Meadow
Hydrologic Condition, Existing Pervious	[illegible]
Runoff Curve Number for Exist. Perv. (CN)	71
Existing Impervious Area (ft2)	[illegible]
Primary Land Cover, Existing Impervious	Streets and Roads
Hydrologic Condition, Existing Impervious	Paved; open ditches
Runoff Curve Number for Exist. Imp. (CN)	92
Proposed Pervious Area (ft2)	[illegible]
Primary Land Cover, Prop Pervious	Meadow
Hydrologic Condition, Prop Pervious	[illegible]
Runoff Curve Number for Prop. Perv. (CN)	71
Proposed Impervious Area (ft2)	[illegible]
Primary Land Cover, Proposed Impervious	Streets and Roads
Hydrologic Condition, Proposed Impervious	Paved; open ditches
Runoff Curve Number for Prop. Imp. (CN)	92

Vegetated Swale Geometry	
Swale Beginning Elevation	[illegible]
Swale Ending Elevation	[illegible]
Bottom Width (ft)	[illegible]
Side Slope (horz:vert)	4
Length of Swale (ft)	[illegible]
Channel Slope (SR ft/ft)	0.02
Manning's Coefficient	0.09

Check Dam Geometry	
Dx (ft)	[illegible]

Watershed Information (All Calculated)	
C	0.70
Tc (See Right)	68.80
I (50 Year)	2.51

Manning's Equation - For Freeboard Calculations	
50 Year Depth of Flow (ft)	[illegible]
Q, Rational (ft3)	[illegible]
Q, Manning's (ft3)	[illegible]
V (ft/s)	1.88
R (ft)	0.26
A (ft2)	1.76
WP (ft)	8.72

Freeboard Calculations	
Swale Bottom Elev.	[illegible]
Shoulder Elevation	[illegible]
ROW Elevation	[illegible]
Freeboard, Road (ft)	1.8
Freeboard, ROW (ft)	1.7

Storage Requirement, Channel Protection Volume	
Swale Storage Volume (ft3)	4,715
WQV Required (ft3)	772
Percent of Total WQV Treated	[illegible]
CPV Required (ft3)	467
Percent of Total CPV Treated	1%

Time of Concentration Calculation						
Flow Type	Length	Upstream Elev.	Downstream Elev.	Slope (ft/ft)	Velocity (ft/s)	Tc (hours)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Waterway						
Waterway						
Waterway						
Waterway						
Waterway						
Waterway						
Waterway						
Waterway						
Waterway						
Waterway						
Waterway						

Tc, Hours	[illegible]
Tc, Minutes	[illegible]

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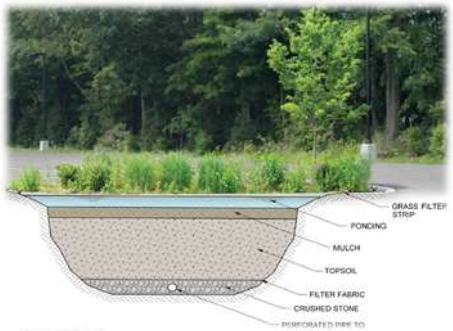
BIORETENTION

A bioretention system is a shallow surface depression planted with specially-selected native vegetation to capture and treat relatively small volumes of stormwater runoff. Stormwater filters through vegetation and engineered soil mix, removing suspended solids and pollutants.

Stormwater Management Benefits

Peak Flow	☐
Metals	☒
Phosphorous	☒
Nitrogen	☒
Petroleum Hydrocarbons	☒
Bacteria	☒
TSS Removal Credit	70-90%



Bioretention Area[1]

Advantages/Benefits	Disadvantages/Limitations
Flexible dimensions, excellent retrofit capability	Maintenance required for performance and aesthetics
Reduce total volume of stormwater runoff	Impractical on steep slopes – level area required
Increase infiltration and groundwater recharge	Limited impervious drainage areas
Aesthetically pleasing and creates habitat	Pretreatment concerns for sediments

Treatment Effectiveness

• Water Quality	High
• Channel Protection	High
• Peak Discharge Reduction	Moderate

Applications

• Median	▲ Rural Area
• Interchange	▲ Residential
• Urban Area	• Primary Treatment

Water Quality Volume & Channel Protection Volume Spreadsheet for Rain Gardens

Project Name:	-	Alignment:	
Job Number:	-	Side:	LT
Calculated By:	-	Beginning Station:	00+00.00
Checked By:	-	End Station:	00+00.00

Individual Rain Garden Drainage Area Information	
Existing Pervious Area (ft2)	8,000
Primary Land Cover, Existing Pervious	Meadow
Hydrologic Condition, Existing Pervious	-
Runoff Curve Number for Exist. Perv. (CN)	71
Existing Impervious Area (ft2)	1,000
Primary Land Cover, Existing Impervious	Streets and Roads
Hydrologic Condition, Existing Impervious	Paved, open ditches
Runoff Curve Number for Exist. Imp. (CN)	92
Proposed Pervious Area (ft2)	9,000
Primary Land Cover, Prop Pervious	Meadow
Hydrologic Condition, Prop Pervious	-
Runoff Curve Number for Prop. Perv. (CN)	71
Proposed Impervious Area (ft2)	48,502
Primary Land Cover, Proposed Impervious	Streets and Roads
Hydrologic Condition, Proposed Impervious	Paved, open ditches
Runoff Curve Number for Prop. Imp. (CN)	92

Loading Ratio	
Total Drainage Area (ft2)	53,502
Rain Garden Bottom Surface Area (ft2)	10,000

Rain Garden Parameters	
Filter Bed Depth (ft)	4.0
Underdrain Being Used?	Yes
Coefficient of Permeability (Filter Media (ft/day))	5
Average Height Water Above Filter Bed (ft)	0.5

Required Storage Volume - Water Quality	
Water Quality Volume Required (ft3)	3,668
Drain Time (hours)	1.6
% of Total Water Quality Treatment Required on Project	1%

Required Storage Volume - Channel Protection	
Channel Protection Volume Required (ft3)	6,011
Drain Time (hours)	2.6
% of Total Water Quality Treatment Required on Project	11%

Sediment Forebay Sizing	
Sediment Forebay Size (ft3)	1,000

If a sediment forebay is not feasible, choose an extra deep sump or pre-fabricated, engineered system for pre-treatment.

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INFILTRATION BASINS

An infiltration basin is a vegetated, depressed storage area which temporarily stores water, allowing it to infiltrate into surrounding soils. This BMP can be used for pollutant removal, channel protection, and groundwater recharge.

depthStormwater Management Benefits

Peak Flow	☒
Metals	☒
Phosphorous	☒
Nitrogen	☒
Petroleum Hydrocarbons	☐
Bacteria	☐
TSS Removal Credit	80%

Infiltration Basin, Source: AECOM

Advantages/Benefits	Disadvantages/Limitations
Reduces runoff volume	Good underlying soils need to be present for proper drainage (need geotechnical investigation)
High efficiency for pollutant removal	Susceptible to clogging if not maintained
Contributes to groundwater recharge	Large footprint required
Cost-effective	

Treatment Effectiveness	
• Water Quality	High
• Channel Protection	High
• Peak Discharge Reduction	Medium/High

Applications	
• Residential	• Rural Area
• Commercial	• Pre-Treatment
• Urban Area	• Primary Treatment

Water Quality Volume & Channel Protection Volume Spreadsheet for Infiltration Basins

Project Name:	-	Alignment:	
Job Number:	-	Side:	LT
Calculated By:	-	Beginning Station:	00+00.00
Checked By:	-	End Station:	00+00.00

Individual Infiltration Basin Drainage Area Information	
Existing Pervious Area (ft2)	2,000
Primary Land Cover, Existing Pervious	Woods
Hydrologic Condition, Existing Pervious	Fair
Runoff Curve Number for Exist. Perv. (CN)	73
Existing Impervious Area (ft2)	8,500
Primary Land Cover, Existing Impervious	Streets and Roads
Hydrologic Condition, Existing Impervious	Gravel
Runoff Curve Number for Exist. Imp. (CN)	89
Proposed Pervious Area (ft2)	50
Primary Land Cover, Prop Pervious	Meadow
Hydrologic Condition, Prop Pervious	-
Runoff Curve Number for Prop. Perv. (CN)	71
Proposed Impervious Area (ft2)	450,000
Primary Land Cover, Proposed Impervious	Streets and Roads
Hydrologic Condition, Proposed Impervious	Paved, open ditches
Runoff Curve Number for Prop. Imp. (CN)	92

Infiltration Basin Geometric Information - Channel Protection Volume	
Maximum Pond Depth (ft)	10.00
Minimum Surface Area, Basin Bottom (ft2)	141.02
Bottom Width of Basin (ft)	8.00
Bottom Length of Basin (ft)	20.00
Basin Side Slope (H:V)	4:1
Surface Storage Area (ft) (CPV)	8800.00
Bottom Slope of Basin (ft/ft)	0.005

Required Storage Volume - Water Quality	
WQV Required (ft3)	33,844
Required Storage Volume - Channel Protection	
CPV Required (ft3)	58,676
Which of the storms should I design for?	
Treat for the Channel Protection Design Storm	

Basin Drainage Site Information	
Infiltration Rate (inch/hour) (measured)	5.00
Desired Drain Time (hours)	48.00
Manning's n (-)	0.05

Pre-Treatment	
Sediment Forebay Volume (ft3)	880.00

If a sediment forebay is not feasible, choose an extra deep sump or pre-fabricated, engineered system for pre-treatment.

Freeboard Calculation	
Basin Bottom Elevation	819
Shoulder Elev.	833
ROW Elev.	830.5
Freeboard, Shoulder (ft)	2.0
Freeboard, ROW (ft)	1.5

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Conclusions

- Through a combination of ongoing MDOT activities developed in the previous permit cycle and new commitments in our upcoming permit, MDOT will strive to meet the requirements for stormwater water quality and channel protection

- Through this process, new deliverables will be available for not only MDOT but also the general public, “paving” the way for cleaner water

Questions?

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