INDOT DM Chapter 204: Post-Construction Stormwater BMPs

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Sandra Bowman

Manager, Ecology and Waterway Permitting Office

- Education
  - B.S. – Michigan State University
  - M.P.A. – Western Michigan University
  - J.D. & M.S.L. – Vermont Law School
- INDOT
  - October 2011 – Permit Specialist for LaPorte District
  - July 2015 – Manager, EWPO
- U.S. Army
  - 31.5 years
  - Retired as Lieutenant Colonel
  - Deployment - Djibouti

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Outline

- Legal Requirements
- INDOT as an MS4
- Post-construction structural BMPs
- Design Standards
- Target Pollutant
- BMP Selection
- Considerations
- Infeasibility Analysis
- Inspection and Maintenance
- Hydrologic and Hydraulic Design
- Best Management Practices
- Implementation

Legal Requirements

- Municipal Separate Storm Sewer System (MS4) General Permit
  - 4.6 SWQMP Post-Construction Stormwater Run-off MCM
  - New and re-development with land-disturbing activities of one or more acres or less than one acre if part of larger common plan of development with more than one acre disturbance
  - Establish design criteria to meet or exceed CSGP post-construction requirements
  - Develop stormwater management measures and standards to improve water quality (structural, non-structural, low impact, green infrastructure)
  - Address quality and quantity of stormwater run-off
  - Practices or control for volume reduction, infiltration, filtering, harvesting, evapotranspiration, vegetative practices or alternative treatment systems

Legal Requirements

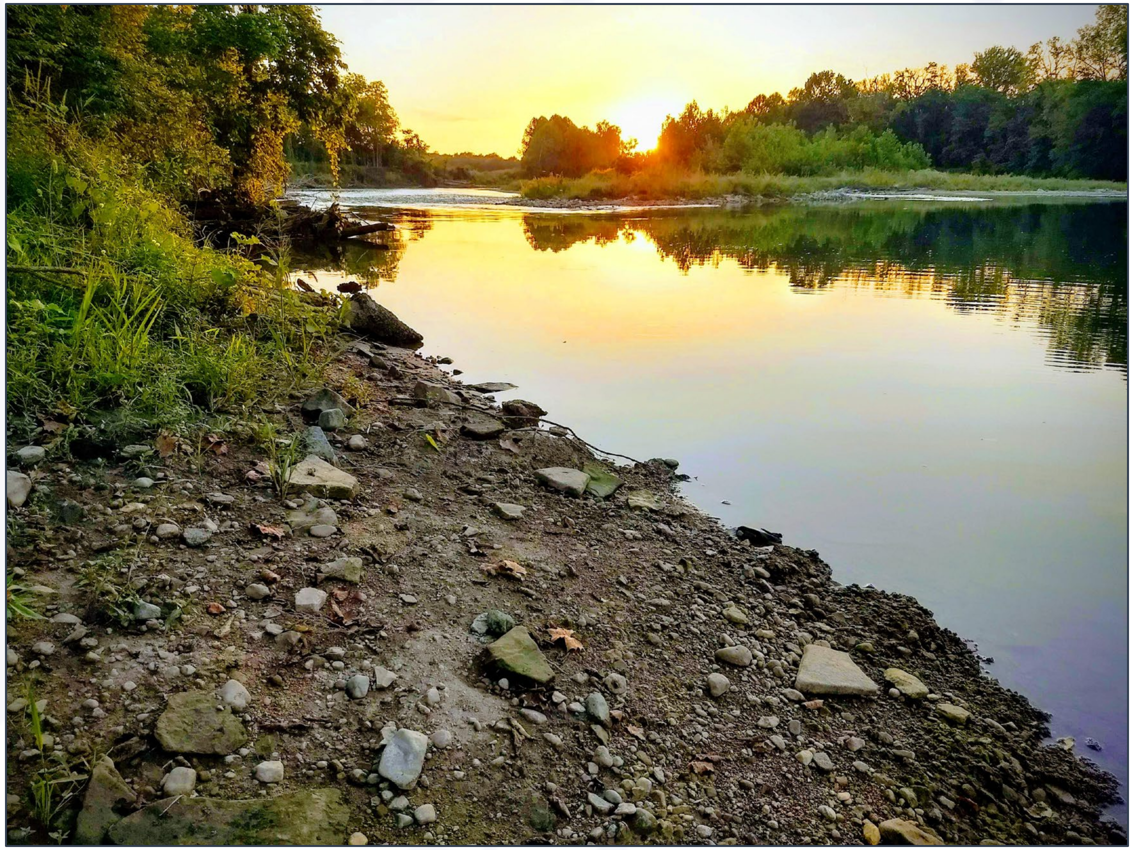
- Post-Construction Stormwater Run-off Design and Engineering Requirements 4.6(c)(3)
  - Control quality and quantity of runoff
  - Do not exceed pre-development discharge based on 2-, 10-, and 100-year peak storm events
  - Minimize pollutants associated with stormwater run-off from final land use
  - Size to Water Quality Volume (WQv) or water quality flow rate
  - Use of one or more measures in tandem or series
  - Infiltration measures must consider pollutants associated with run-off and potential to contaminate ground water
  - Use of alternative or pre-treatment if contamination is possible

Legal Requirements

- Construction Stormwater General Permit (CSGP)
  - Section 3.2(a)(9) – Post-construction stormwater management measures
  - Control quality and quantity of runoff
  - Not exceed pre-development discharge based on 2-, 10-, and 100-year peak storm events
  - Minimize pollutants associated with stormwater run-off from final land use
  - Size to Water Quality Volume (WQv) or water quality flow rate
  - Use of one or more measures in tandem or series
  - Use of infiltration measures to minimize discharge pollutants

INDOT as a MS4

- Characteristics
  - State of Indiana
  - Linear - 11,000 centerline miles
  - 4,800 miles within another MS4
  - Buildings and grounds (rest areas, district offices, maintenance facilities)
- Compliance
  - “ordinance or other regulatory mechanism”
  - “local requirements”
  - Design Manual, Standard Specifications
- Develop BMPs for post-construction stormwater run-off control
  - Total impacted area > 1 acre, or
  - ??? Under development (ft^2 and/or %)



West Fork White River, Morgan County, Indiana

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Post-Construction Structural BMPs

Dry Grass Swale, Hendricks County, Indiana

- BMP
  - Most effective and practical means of preventing or reducing non-point source pollution
  - Help reach water quality and quantity goals
- May be activity based, ex. reduced chloride application for road de-icing
- Post-Construction Structural BMPs are permanent designed features
- Used alone, tandem, or series

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Design Standards

- IDEM's Construction Stormwater General NPDES Permit applies to all qualifying INDOT projects
- Qualifying INDOT Projects: proposed land disturbance (in acres), including staging areas for construction, is greater than 1 acre and includes xx,xxx square feet or more of added impervious area

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Target Pollutant

- Sediment
  - Most common water pollutant (US EPA)
  - Primary pollutant in stormwater run-off from pavement
- Permanent BMPs target sediment removal
- 80 % - sediment removal rate target as Total Suspended Solids (TSS)

Sediment-laden run-off in Marsh River (MN) – pca.state.mn.us

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Structural BMP Selection

1. Dry turf grass swale
1. Dry native grass swale
1. Filter strip
1. Dry detention pond
2. Wet swale
2. Wet retention pond
3. Infiltration swale
3. Infiltration basin
4. Proprietary device

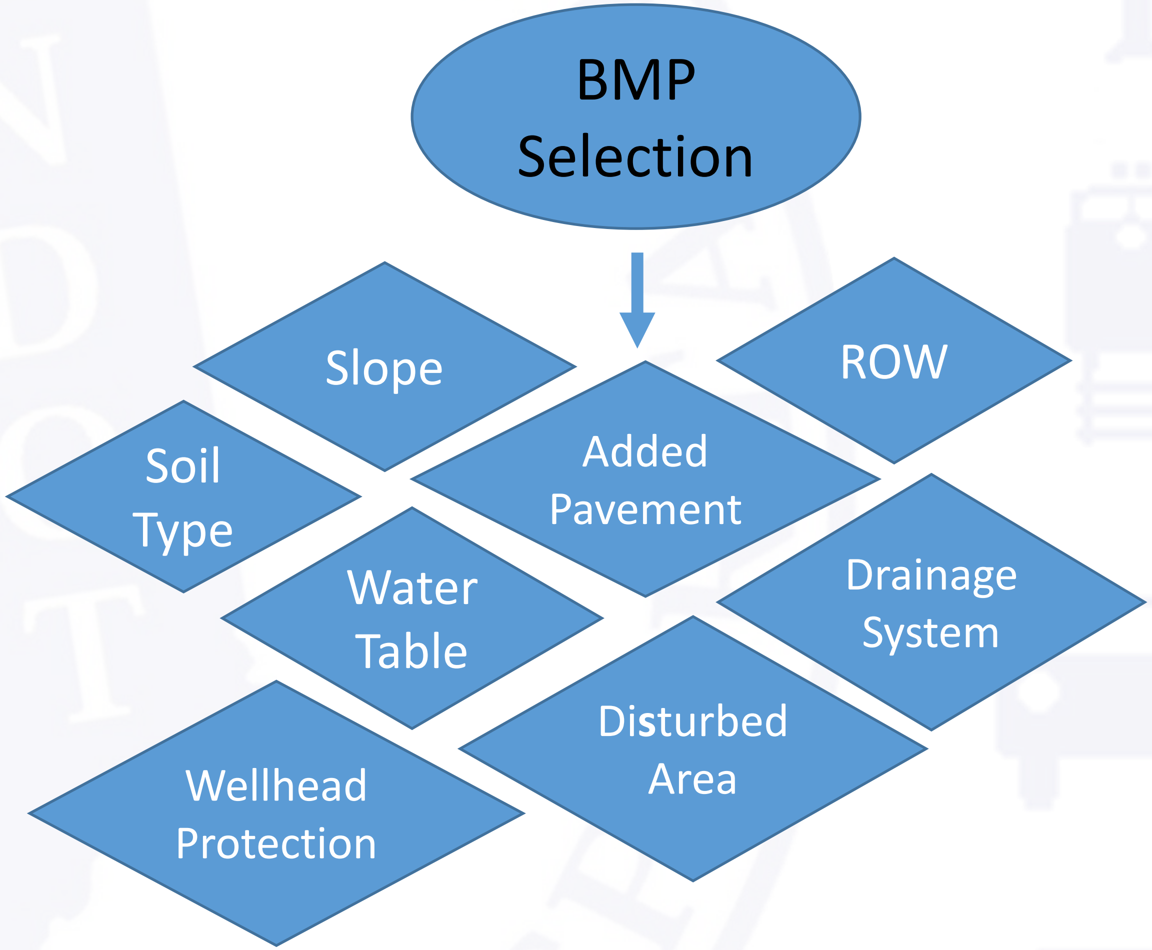
Structural BMP	Description	Pollutant Removal Mechanism	Priority
Dry Turf Grass Swale	A broad and shallow channel planted with grass. Fully drains between rainfall events.	Sedimentation, physical filtration, and biofiltration	1
Dry Native Grass Swale	A broad and shallow channel planted with dense specialized plants. Fully drains between rainfall events.	Sedimentation, physical filtration, and biofiltration	1
Filter Strip	A vegetated linear section of land. Also often referred to as a buffer strip.	Physical filtration, sorption, biofiltration	1
Dry Detention Pond	An engineered basin planted with grass. Fully drains between rainfall events. Includes an outlet structure to control flow.	Sedimentation, physical filtration, and biofiltration	1
Wet Swale	A broad and shallow channel planted with grass. Designed with a permanent pool and an elevated outlet structure.	Sedimentation, physical filtration, and biofiltration	2
Wet Retention Pond	Engineered basin designed to permanently store run-off. Designed with a permanent pool and an elevated outlet structure.	Sedimentation, physical filtration, and biofiltration	2
Infiltration Swale	A broad and shallow channel with permeable soil planted with grass. Designed to infiltrate run-off into the underlying soil.	Sedimentation, physical filtration, infiltration, sorption, and biofiltration	3
Infiltration Basin	An engineered basin with permeable soil planted with grass. Designed to infiltrate run-off into the underlying soil.	Sedimentation, physical filtration, infiltration, sorption, and biofiltration	3
Proprietary Device	Hydrodynamic separators.	Sedimentation and physical filtration	4

See INDOT guidance documents for references/definitions.

BMP Selection Flowchart

Considerations -

- Disturbed area, added pavement
- Available ROW
- Drainage system type
- Soil type
- Water table depth
- Slope
- Wellhead protection area
- Peak flow mitigation



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Roadway Project Layout/Site-Specific Conditions

Site-specific factors that limit post-construction BMP selection

- Available right-of-way
- Steep slopes and other topographic constraints
- Infiltration not allowed in karst areas
- High water-table, some BMPs must drain between rainfall events
- Bedrock near ground surface – expensive to excavate
- Large off-site areas draining to BMPs – require more space – can lead to high velocities
- Adjacent land-use draining to INDOT right-of-way
- Underlying soil type – affects infiltration and support for needed vegetation

Infeasibility Analysis

- Economically infeasible
  - Limited right-of-way, utility relocations, topographic constraints, and amount of added flow from offsite
  - Option to treat existing pavement instead of new added pavement in a different location within the same watershed
- TMDLs
  - Must consider receiving streams on the current 202(d) list of impaired waters
  - Pollutants not from INDOT ROW may be infeasible to remove in post-construction BMPs
- Documentation
  - Prior coordination with INDOT is required
  - Document decision (submit with permit application)

Inspection and Maintenance

- BMP given an asset ID number and added to inspection schedule
- Designer provide BMP inspection and maintenance plan
- Quarterly checks
- Maintenance as needed
- Editable maintenance plan templates

INDIANA DEPARTMENT OF TRANSPORTATION
POST-CONSTRUCTION BMP MAINTENANCE PLAN

Structure Type	Turf Grass Dry Swale	Number	
Design Criteria		Location	Coordinates, Driving Directions
This swale was designed to remove Total Suspended Solids (TSS) from stormwater runoff. Turf grass height should be at least 6 inches for adequate TSS removal. This swale was designed to be dry between rainfall events.			

Inspection Cycle

Twice per year during first year after construction, then one time per year.

Inspection Criteria

- Vegetation – cover should be approximately 90%
- Erosion and scour
- Trash and debris buildup
- Excessive ponding – stagnated water
- Inflow and outflow points and/or structures are not blocked or damaged
- Sediment buildup – should be ≤ 25% of original design volume

Typical Corrective Actions

- Vegetation – re-establish turf grass as needed so that cover is approximately 90%
- Erosion and scour – re-grade as needed, install erosion protection if required
- Trash and debris buildup – remove trash and debris as needed
- Excessive ponding – regrade as needed to drain excessive ponded or stagnated water
- Inflow and outflow points and/or structures – repair structures and remove debris or blockage as needed
- Sediment buildup – should be ≤ 25% of original design volume – remove sediment as needed

Maintenance Recommendations

Last Inspected		Current Inspection	

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Jessica Eichhorst, PE

Section Manager, Water Services, HNTB

- Education
  - MS, Civil Engineering, 2015, Environmental and Water Resources, Southern Illinois University, Edwardsville, IL
  - BS, Civil Engineering, 2012, Environmental and Water Resources, Southern Illinois University, Edwardsville, IL
  - AAS, Manufacturing and Industrial Technology, Ivy Tech, 2006, TerreHaute, IN
- HNTB Corporation – Project Manager and Section Manager
  - 2016 to Present
- WSP/Parsons Brinkerhoff – Design Engineer
  - 2013 to 2016
- American Bottoms Wastewater Treatment Plant – Intern Engineer
  - 2012
- Southern Illinois University Edwardsville / St. Louis MSD – Research Assistant – Bioretention Design
  - 2011-2013

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Hydrologic and Hydraulic Design

- Water Quality Event: A rainfall event of **1.0 inch**, assumed to remove a significant percentage of pollutant from the roadway
- Water Quality Volume: The volume of run-off generated by the Water Quality Event for treatment in BMPs
- Water Quality Treatment Rate: The peak flow rate of stormwater run-off generated by the Water Quality Event – for flow-through BMPs

Rain on grass – edu.rsc.org

Water Quality Volume

$WQv = (P * Rv * A) \div 12$

Where:

WQv = water quality volume, acre-feet

P = rainfall, inches (use 1.0 inches)

Rv = volumetric run-off coefficient

A = total proposed onsite drainage area, acres

And:

$Rv = 0.05 + (0.009 * I)$

Where:

I = percent new impervious cover, %

And:

$I = [(Pia - Eia) \div A] * 100$

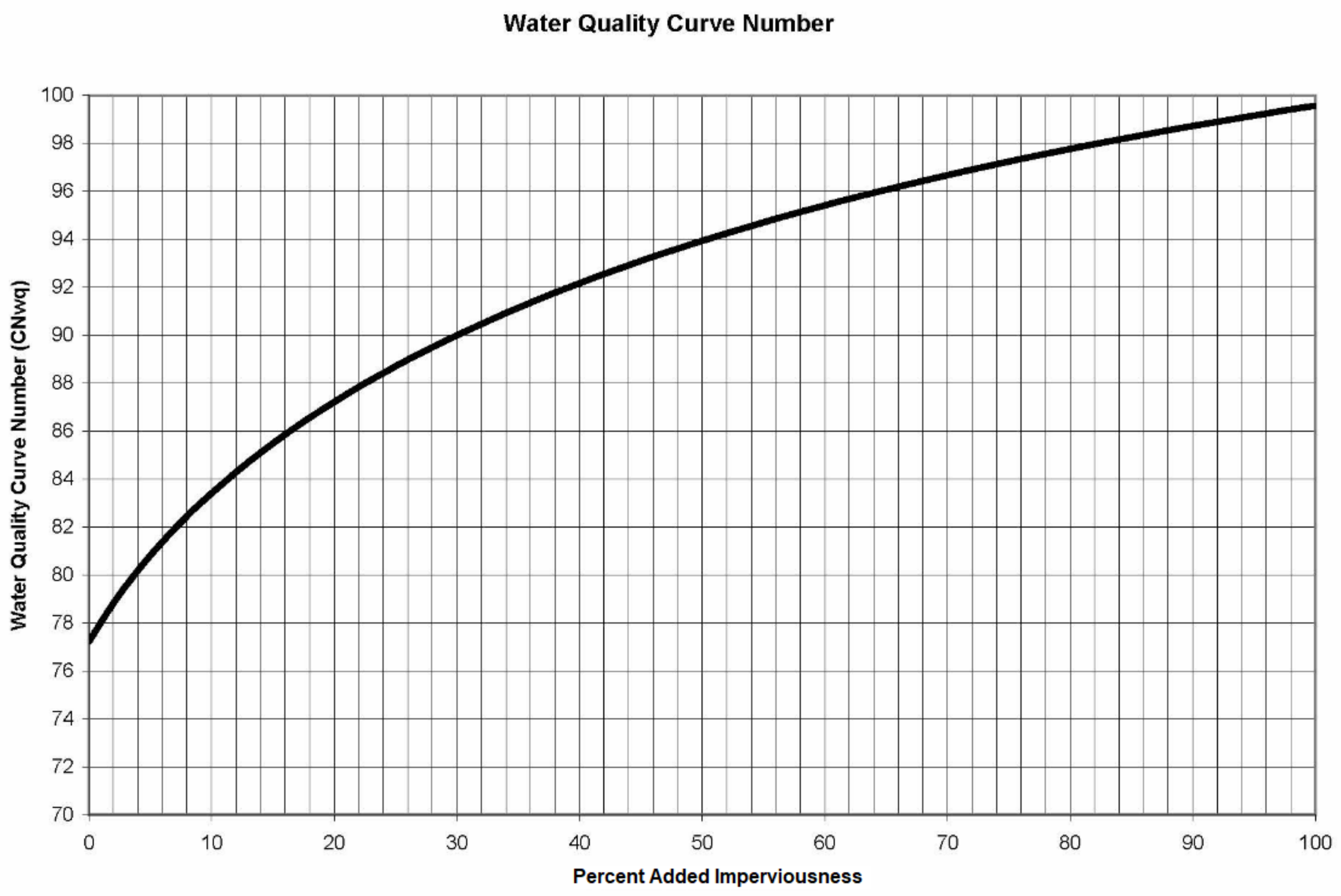
Where:

Pia = Proposed Onsite Impervious Area

Eia = Existing Onsite Impervious Area

Water Quality Treatment Rate

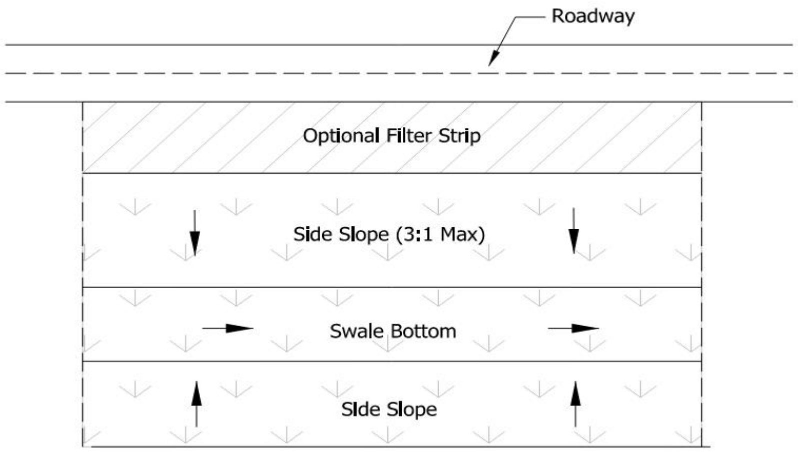
- Qwq Calculate Tc using TR-55 methodology
  - Calculate CNwq using provided graph
  - Use NRCS Type II rainfall and depth of 1 inch
  - Compute Qwq in cfs following hydrograph-oriented procedures approved in Chapter 203



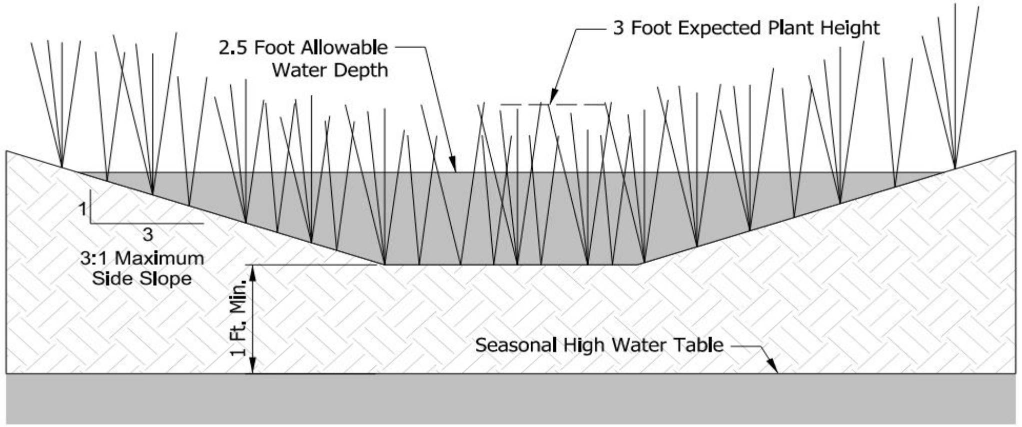
Dry Swales

- Designed to fully drain between rainfall events
- Planted with turf grass or native grasses
- Trapezoidal, V-shaped, or natural cross section
- No underdrain
- Water depth during Water Quality Event at or below grass height (6 inches for turf, 2.5 feet for native)
- Sized using Water Quality Treatment Rate and Hydraulic Residence Time

Tahr = (Lswale ÷ vwq) ÷ 60
Where:
Tahr = hydraulic residence time, minutes
Lswale = length of swale, feet
vwq = peak flow velocity at water quality event, ft/s
Tahr of 9 minutes = 80% TSS removal



Plan View



Cross Section View

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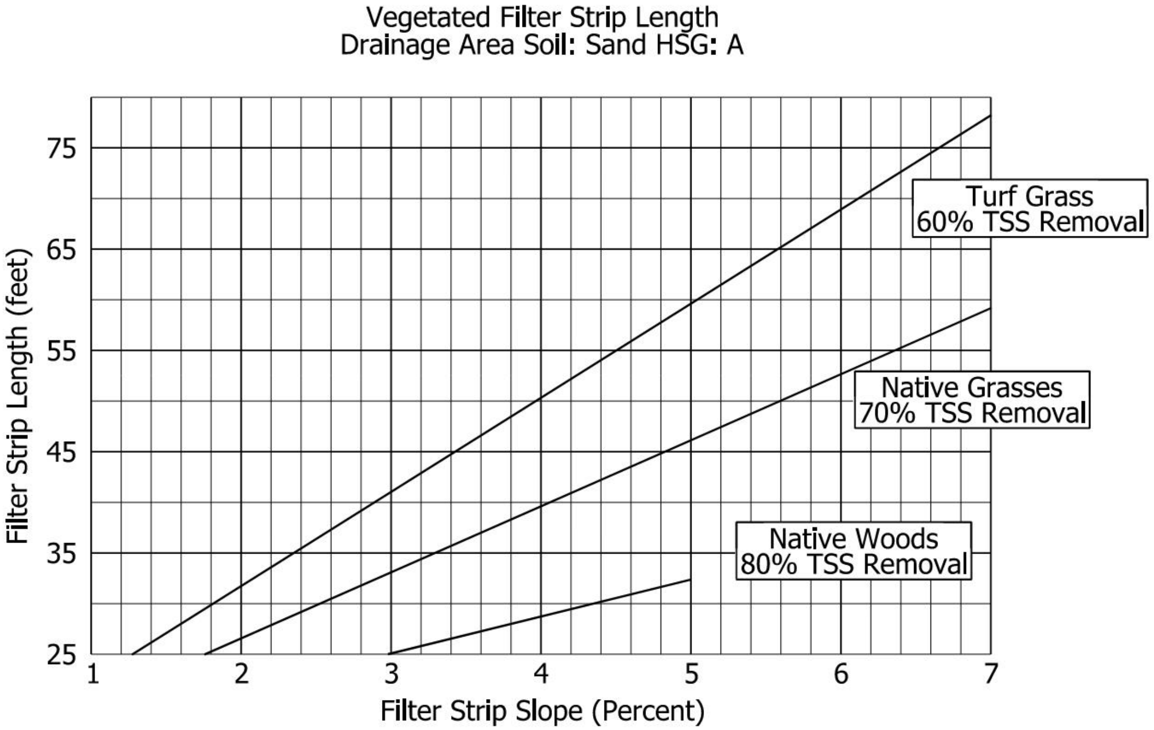
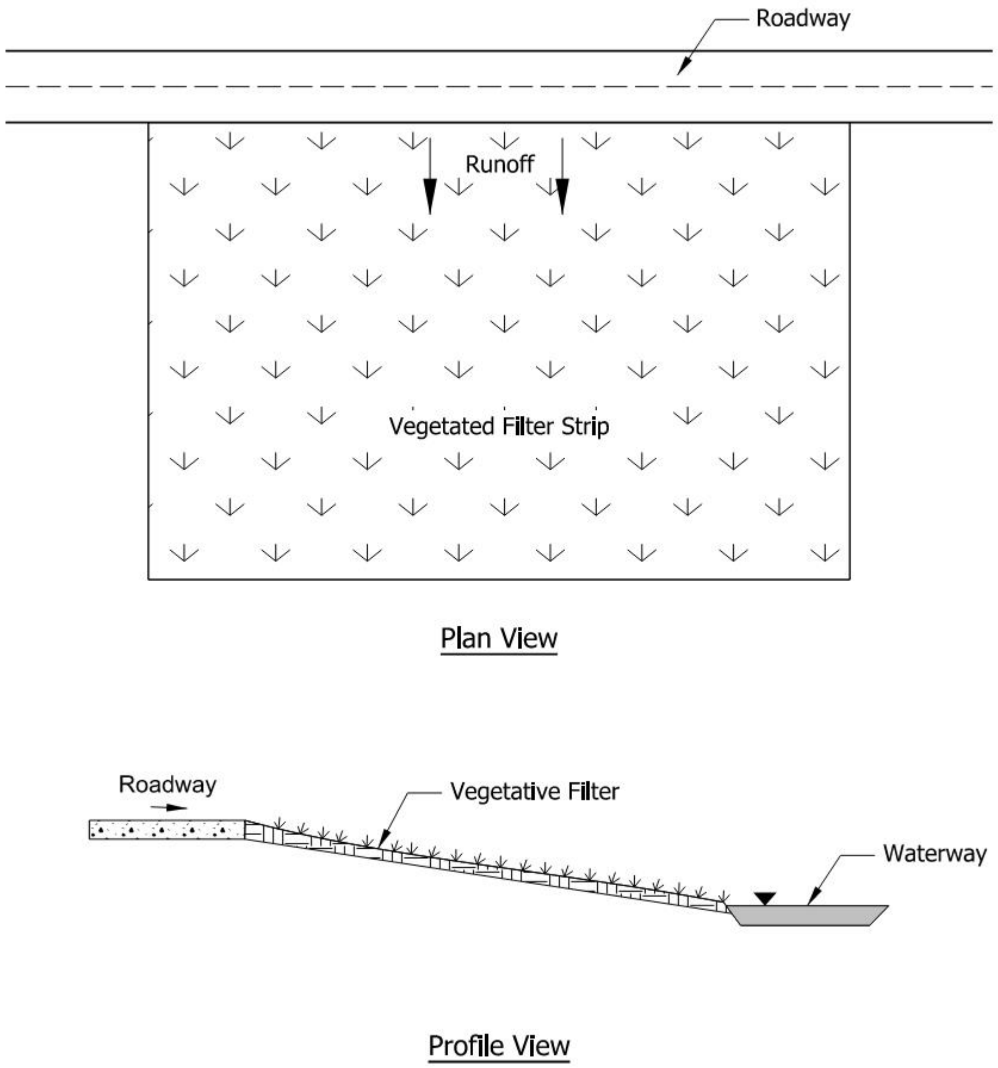
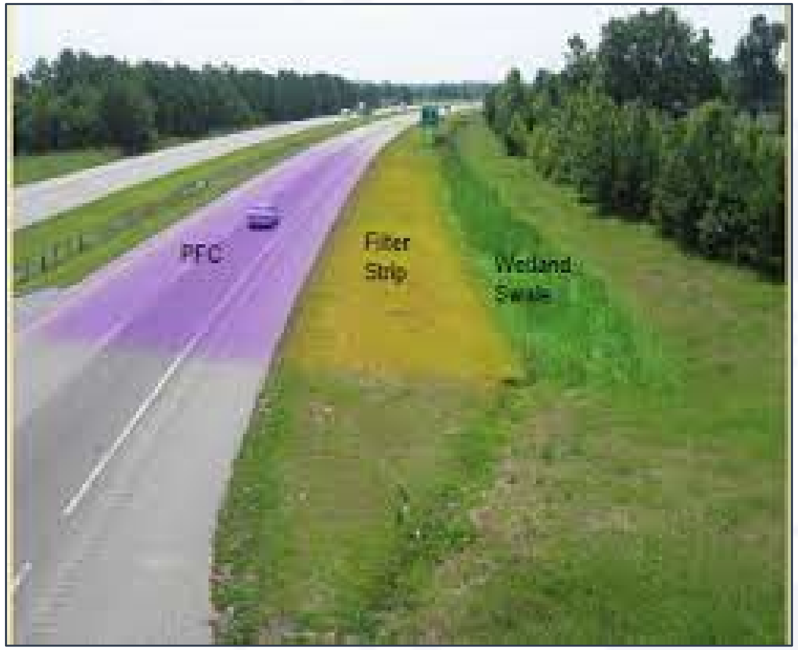
Filter Strips

- Vegetated, uniformly graded area
  - Planted with turf grass or native grasses
  - Can use existing native woods
- Mild slopes
- Typically located between roadway and another BMP or waterbody
- Effectiveness for TSS removal controlled by underlaying soil, type of vegetation, and cross-sectional slope
- Run-off sheet flows through the vegetation



Filter Strip Examples



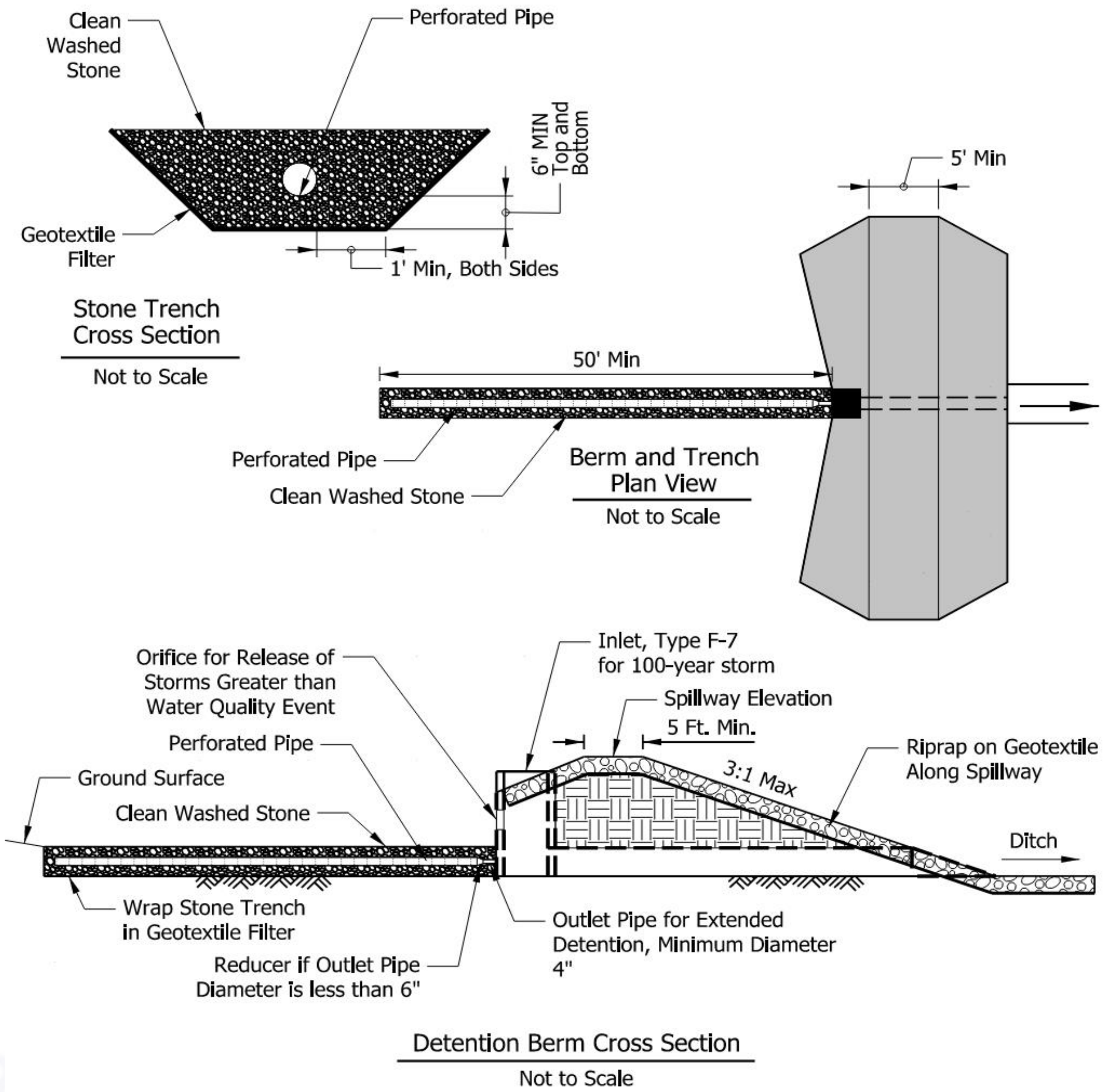


Vegetated Filter Strip – dot.state.oh.us

Dry Detention Ponds

- Capture and temporarily detain stormwater run-off
- Can be a peak flow mitigation BMP as well as water quality BMP
- 2 design options for TSS removal
- First option – model as a basin
  - Detain Water Quality Volume for 24 hours
  - If outlet pipe D is 10 inches or less, 50 feet of perforated pipe installed in stone trench and connected to outlet structure
- Second option – model as a swale
  - Construct a meandering pilot channel
  - Design using Water Quality Treatment Rate
  - Depth of flow in channel during water quality event at or below the grass height
  - Follow design process in dry swale section
- Plant with turf grass

Detention Pond with Underdrain



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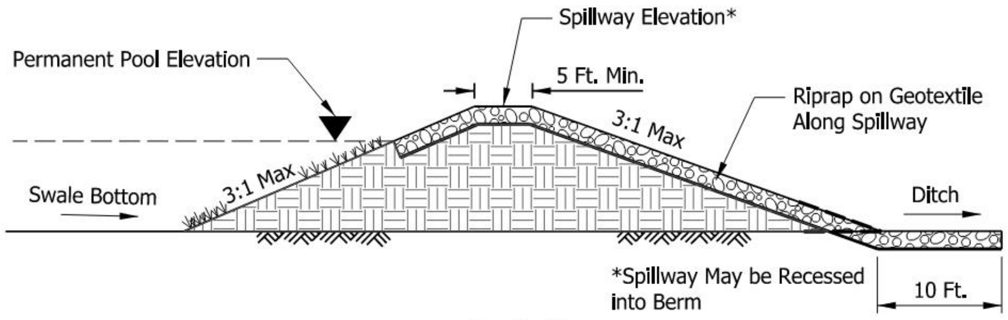
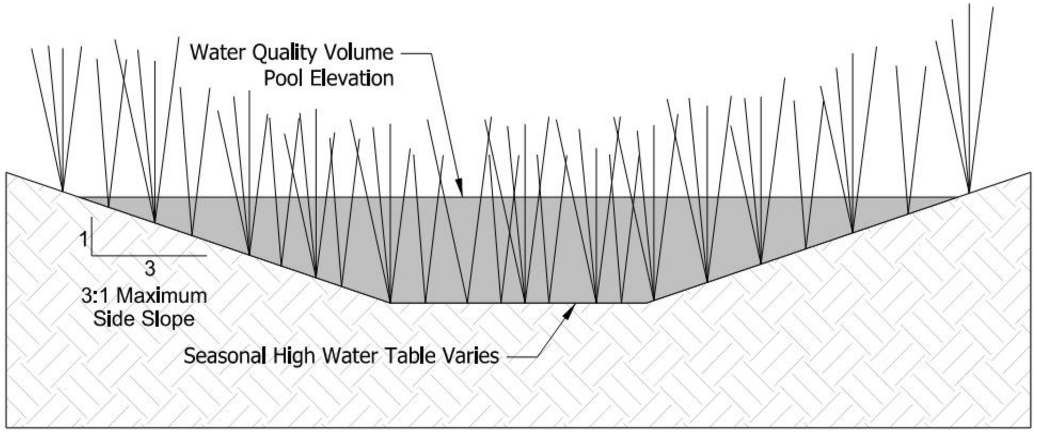
Wet Swales

- Natural or engineered
- High water table or poorly drained soils
- Permanently retain the Water Quality Volume
- Advantages – provide aquatic wildlife habitat, can require less linear space than a dry swale, can treat for other pollutants
- Disadvantages – water can be come stagnant, attract nuisance insects, vegetation requires proper pH levels



Profile View



Cross Section View

Wet Retention Ponds

- Maintains a permanent pool of water
- Can serve as peak flow mitigation BMP along with water quality BMP
- Promotes settling of TSS and biological uptake of suspended pollutants
- Design to permanently store the Water Quality Volume
- Outlet structure and emergency spillway are required

- Advantages –
  - Provide aquatic wildlife habitat
  - Can reduce velocities in downstream receiving water body
  - Can treat for other pollutants
- Disadvantages
  - Water can be come stagnant
  - Attract nuisance insects
  - Vegetation requires proper pH levels
  - Require more maintenance compared to some BMPs

Wet Retention Pond Example

Wet Retention Pond– stormwater.pca.state.mn.us

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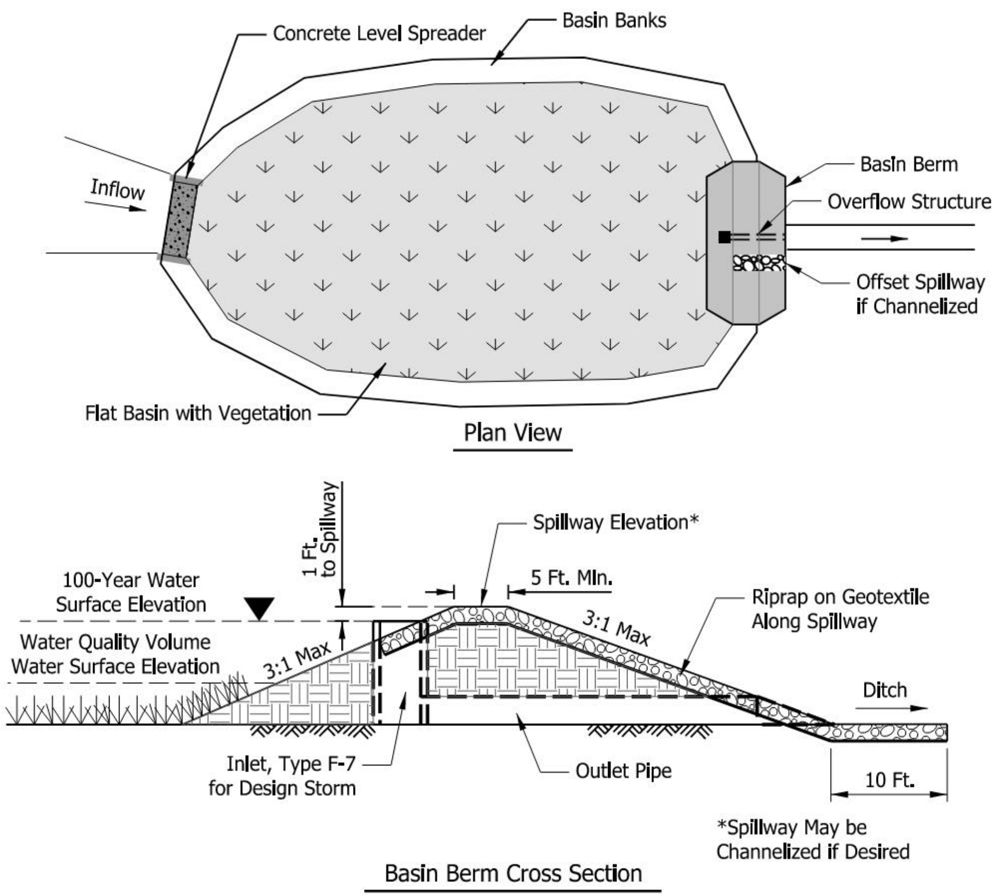
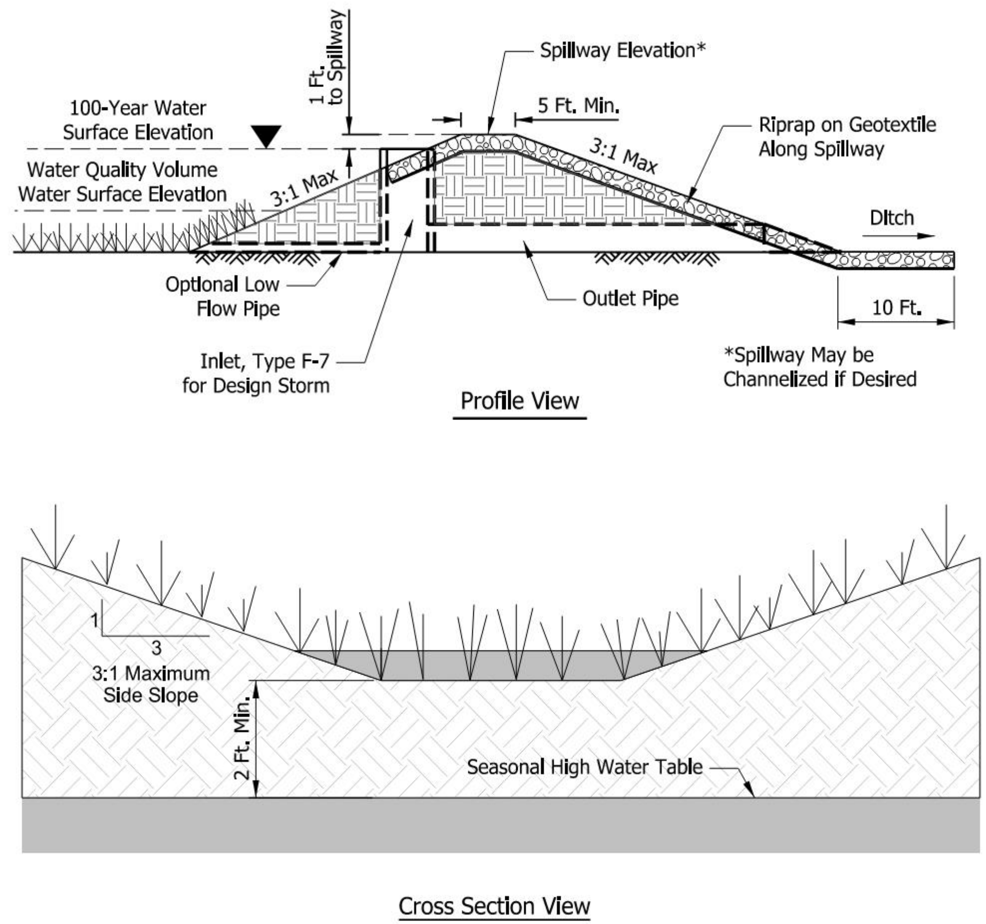
Infiltration

- Can be a swale or a basin
- Collect run-off and allow it to drain through the underlying soil
- Dependent on the existing underlying soil – soil testing required per guidelines provided in IDM Chapter 203
- Can be used to meet water quantity and water quality goals
- Designed to infiltrate the Water Quality Volume
- If used for peak flow mitigation, a computer model will be submitted per requirements in Chapter 203
- If used for Water Quality only, equations can be used to calculate volume infiltrated and time to drain (provided in Chapter 204)
- Demonstrate the Water Quality Volume is infiltrated
- Plant with Infiltration Seed Mixture

Infiltration Basin and Swale Details





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Hydrodynamic Separators

- Proprietary post-construction BMP device
  - Many types available
  - Hydrodynamic Separators preferred for INDOT projects
- Flow-through device
- Use a swirl or vortex to remove solids and trash via gravity from run-off
- Small size – relatively small footprint
- Maintenance is critical – frequent inspection and cleanout required
- Design criteria under development

Implementation (under development)

- DM Chapter 204 reference to Post-Construction BMP Guidance Document
  - Allow for modifications
  - Development of related modifications – standard specifications, pay items, other design manual chapters, standard specifications, USPs, RSPs, …
- Effective date/project development stage (TBD)
  - Evaluation to determine whether Post-Construction BMPs are required is a legal requirement now
  - Infeasible to apply to projects beyond – ROW, Stage 2/3 design, ….?
  - Include in all projects currently being scoped
  - Include in all future scoping

Questions

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