Stormwater Treatment with Vegetated Buffers

Conducted for the

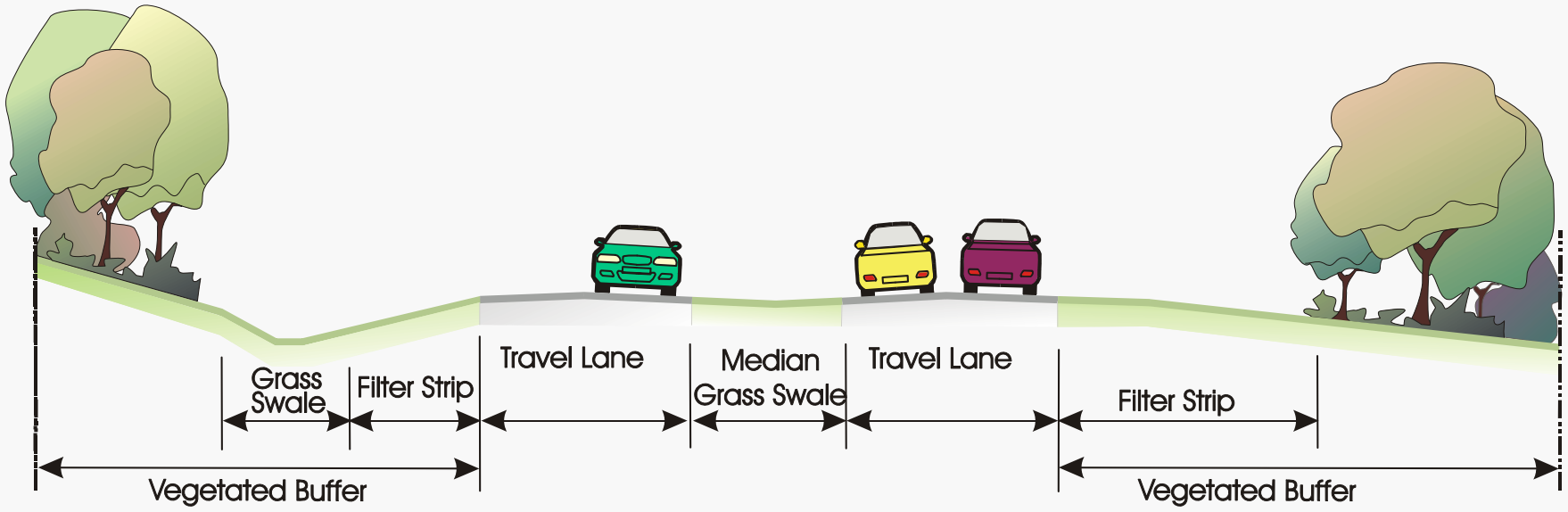
Standing Committee on Environment (SCOE)

American Association of State Highway and Transportation Officials (AASHTO)

NCHRP Project 25-25 Task 53

What are Vegetated Buffers?

- **Vegetated roadsides, either existing or designed, used as post-construction water quality treatment for removing stormwater runoff pollutants**



Project Objectives

- **Synthesize state agency use of vegetated buffers as *primary post-construction* stormwater treatments on *rural roadsides***
- **Provide transportation agencies with support and direction for gaining regulatory agency credit for and/or acceptance of vegetated buffer use**
- **Develop suggested practices**

Research Approach

- **Review current research data and state transportation, environmental and regulatory agency documents**
  - **Performance capabilities and design criteria**
- **Survey of Practice**
  - **Rationale behind regulatory acceptance/use or non-acceptance/use**

Research Results

- **Water quality performance of most standard roadside designs (**i.e. channels, ditches, swales, and slopes**) is comparable to roadsides specifically designed to perform as vegetated stormwater treatments**

- **Majority of research with positive performance results conducted on roadsides *not designed or intended for use* as primary stormwater treatment**

Research Results (continued)

- **Vegetated buffers and filter strips**
  - **Effective, consistent pollutant removal performance within 8m [26 ft] length (measured parallel to flow path)**
- **Grass swales**
  - **Use of permanent velocity controls (check dams) greatly increases pollutant removal performance**

Terminology Issues

- **Uniform terminology and more consistent design criteria may encourage greater support from environmental and regulatory agencies**
  - **Numerous terms for same application**
  - **Determination of length and width measurements**
    - inconsistent or non-existent
    - example - Is the length of the filter strip measured parallel or perpendicular to the flow path?
  - **Difficult to make direct performance comparisons**

State Agency Use

Over 50% of state agencies use some type of vegetated buffer, filter strip and/or grass swale as primary stormwater treatment

Agency	Vegetated Buffer and/or Filter Strip	Grass Swale
Regulatory and/or Environment	CO, DE, IA, ID, MD, ME, MN, MO, NC, NE, NJ, NM, SC, TN, TX, UT, VA, VT, WA, WI, WV	AK, CA, CO, CT, DE, FL, IA, ID, MA, MD, MI, MN, NC, NH, NY, OR, PA, UT, VA, VT, WA, WI
DOT	AZ, CA, CO, CT, DE, IA, MD ME, MO, MT, NC, NH, NV, NY, OH, OK, OR, RI, TX, UT, VA, WA, WI	CA, CT, DE, FL, HI, IA, IL, KY, MA, MD, MI, MO, NC, NH, NV, NY, OH, OK, OR, UT, VA, WI

From agency documentation and survey results

State Agency Rationale for Acceptance/Use

- **Adopted other state agency criteria from existing manuals, either environmental/ regulatory or DOT (most occurring)**
- **National and international research data that demonstrates effective performance**
- **Practical application or field demonstration**
- **Years of proven, successful use**

From agency documentation and survey results

State Agency Rationale for Non-Acceptance/Use

- **Does not require post-construction stormwater treatment for rural roadside applications**
- **Only regulates post-construction within urban areas**
- **Does not recommend specific practices, monitor, and/or require their use in these specific applications**
- **Region cannot support vegetation density levels required for effective pollutant removal due to minimal annual rainfall, high altitude, and/or extended winter seasons**

From agency documentation and survey results

Gaining Regulatory Acceptance

- Demonstrate acceptance of the same practice by other comparable states
- Demonstrate ability of practice to meet state and local water quality requirements
- Document performance efficiency of practice and economic/operational/maintenance benefits
- Monitor and evaluate the results

Suggested Practices

- Evaluation criteria for determining a "suggested practice" considered how well the physical characteristics relate to
  - Modeled pollutant removal efficiencies
  - Current research and state agency manuals
  - Documented practices
  - Survey results

Vegetated Buffer Suggested Practice

Slope	Preferred 2 to 6 % Minimum 1 % Maximum 20 %
Length (parallel to flow)	Minimum 8 m [26 ft]
Width (perpendicular to flow)	Usually equal to width of vegetated buffer
Contributing Drainage Area	Unlimited
Flow Type	Sheet flow only
Flow Velocity	Preferred 0.14 - 0.28 m/s [0.5 - 1 fps] Maximum 0.84 m/s [3 fps]
Flow Depth	12 to 25 mm [0.5 in to 1 in]
Vegetation Density	Preferred 90% Minimum 80 %
Vegetation Type	Grasses, shrubs, and trees
Vegetation Height	Keep vegetation height within safety parameters for the roadway and to maintain density
Preferred Soil Types	All - Types A and B effective due to infiltration rates

Filter Strip Suggested Practice

Slope	Preferred 2 to 6 % Minimum 1% Maximum 20%
Length (parallel to flow)	Minimum 8 m [26 ft]
Width (perpendicular to flow)	Width of contributing area
Contributing Drainage Area	Less than or equal to the width of the filter strip
Flow Type	Sheet flow only
Flow Velocity	Preferred 0.14 to 0.28 m/s [0.5 to 1 fps] Maximum of 0.84 m/s [3 fps]
Flow Depth	12 to 25 mm [0.5 in to 1 in]
Vegetation Density	Preferred 90% Minimum 80 %
Vegetation Type	Grasses and other low growing permanent vegetation
Vegetation Height	Keep vegetation height within safety parameters for the roadway and to maintain density
Preferred Soil Types	All - Types A and B effective due to infiltration rates

Grass Swale Suggested Practice

Design Storm	**2-year with 10-year capacity**
Longitudinal Slope	**Preferred 2 to 6% Minimum 1% Maximum 10%**
Side Slopes	**Preferred 5:1 to 4:1 (20 to 25%) Maximum 33%**
Length (parallel to flow)	**With check dams, base length on longitudinal slope to achieve hydraulic residence time of 9 minutes** **Without check dams, minimum of 30 m [100 ft] continuous swale before discharge**
Width (perpendicular to flow)	**Bottom between 0.6 to 2.4 m [2 to 8 ft]**
Cross Section Configuration	**Trapezoid or parabolic**
Contributing Drainage Area	**Preferred: Equal to 1% of swale surface area**
Flow Type	**Concentrated flow**
Flow Velocity	**Between 0.27 and 1.5 m/s [1 to 5 fps]**

Grass Swale Suggested Practice (continued)

Hydraulic Residence Time	9 minutes
Velocity Controls	Use of check dams to increase performance
Flow Depth	100 to 150 mm [4 to 6 in] or 2/3 grass height
Vegetation Density	Preferred 90% Minimum 80%
Vegetation Type	Select vegetation based upon soil type, inundation tolerance, filtering capabilities, typical mowing height and design flow velocities
Vegetation Height	Generally 100 to 150 mm [4 to 6 in]
Preferred Soil Types	A, B, or C Minimum 7 mm [0.27 in] per hour infiltration
Depth to Water Table	Minimum 0.6 m [2 ft]
Depth to Bedrock	Minimum 0.9 m [3 ft]

Conclusions

- Recent research demonstrates vegetated stormwater treatments have sufficient, reliable pollutant removal capabilities for use as primary stormwater treatment for rural roadside applications
- Some state agency documents may need updating to reflect current research results
- Need for uniform terminology, definitions and design criteria