

Appendix 6B:

WSDOT Media Filter Drain from June 2008 edition of the *WSDOT Highway Runoff Manual*

RT.07 – Media Filter Drain (formerly known as the Ecology Embankment)



Media Filter Drain Along SR 167 in King County.

Introduction

General Description

The media filter drain (MFD), previously referred to as the *ecology embankment*, is a linear flow-through stormwater runoff treatment device that can be sited along highway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. The media filter drain can be used where available right of way is limited, sheet flow from the highway surface is feasible, and lateral gradients are generally less than 25% (4H:1V). The media filter drain has a General Use Level Designation (GULD) for basic, enhanced, and phosphorus treatment. Updates/changes to the use-level designation and any design changes will be posted in the [Postpublication Updates](#) section of the [HRM Resource web page](#).

Media filter drains (MFDs) have four basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the MFD mix. This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surfacing base course (CSBC). This layer of CSBC must be porous enough to allow treated flows to freely drain away from the MFD mix.

Typical MFD configurations are shown in [Figures RT.07.1, RT.07.2, and RT.07.3](#).

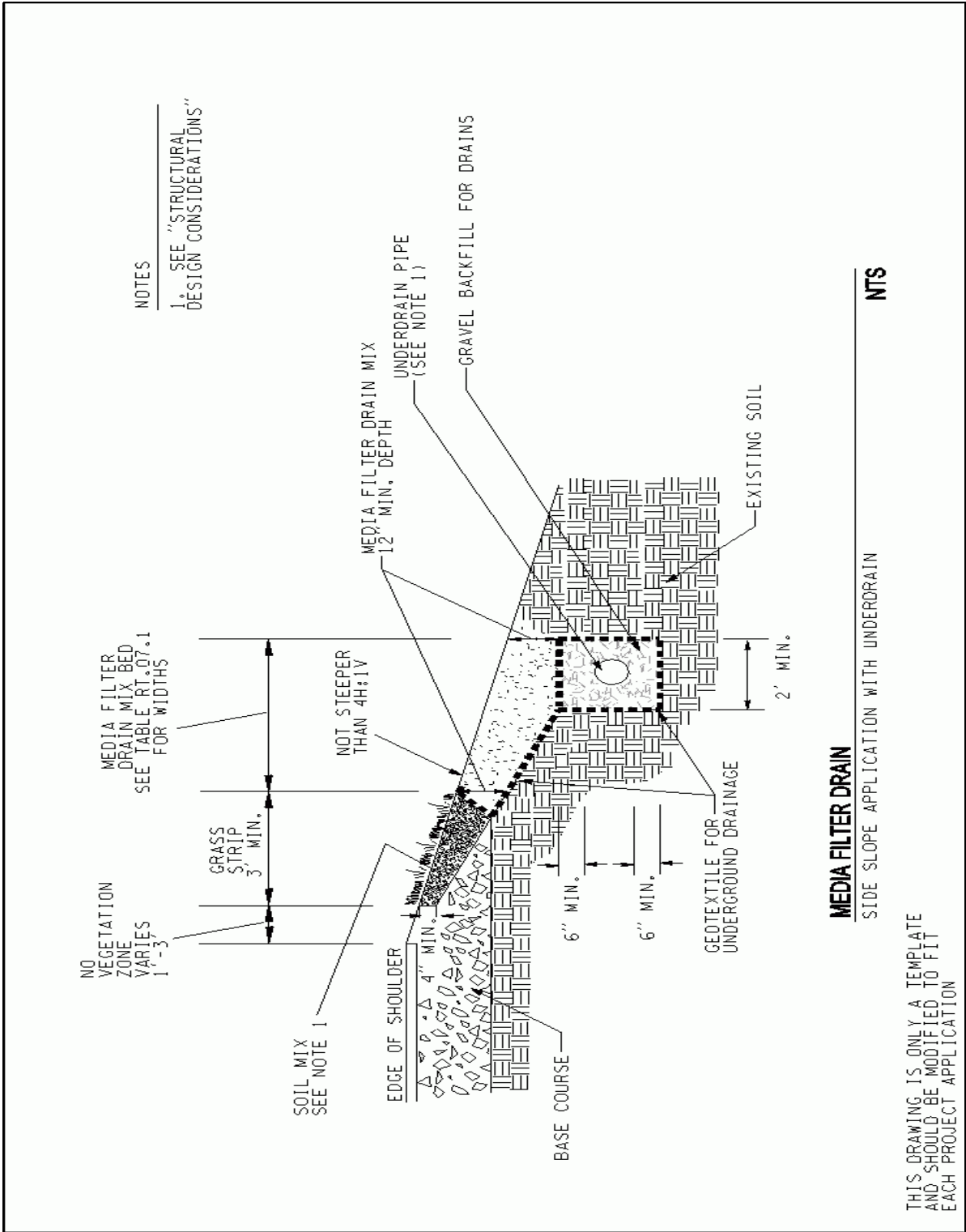


Figure RT.07.1. Media filter drain: Cross section.

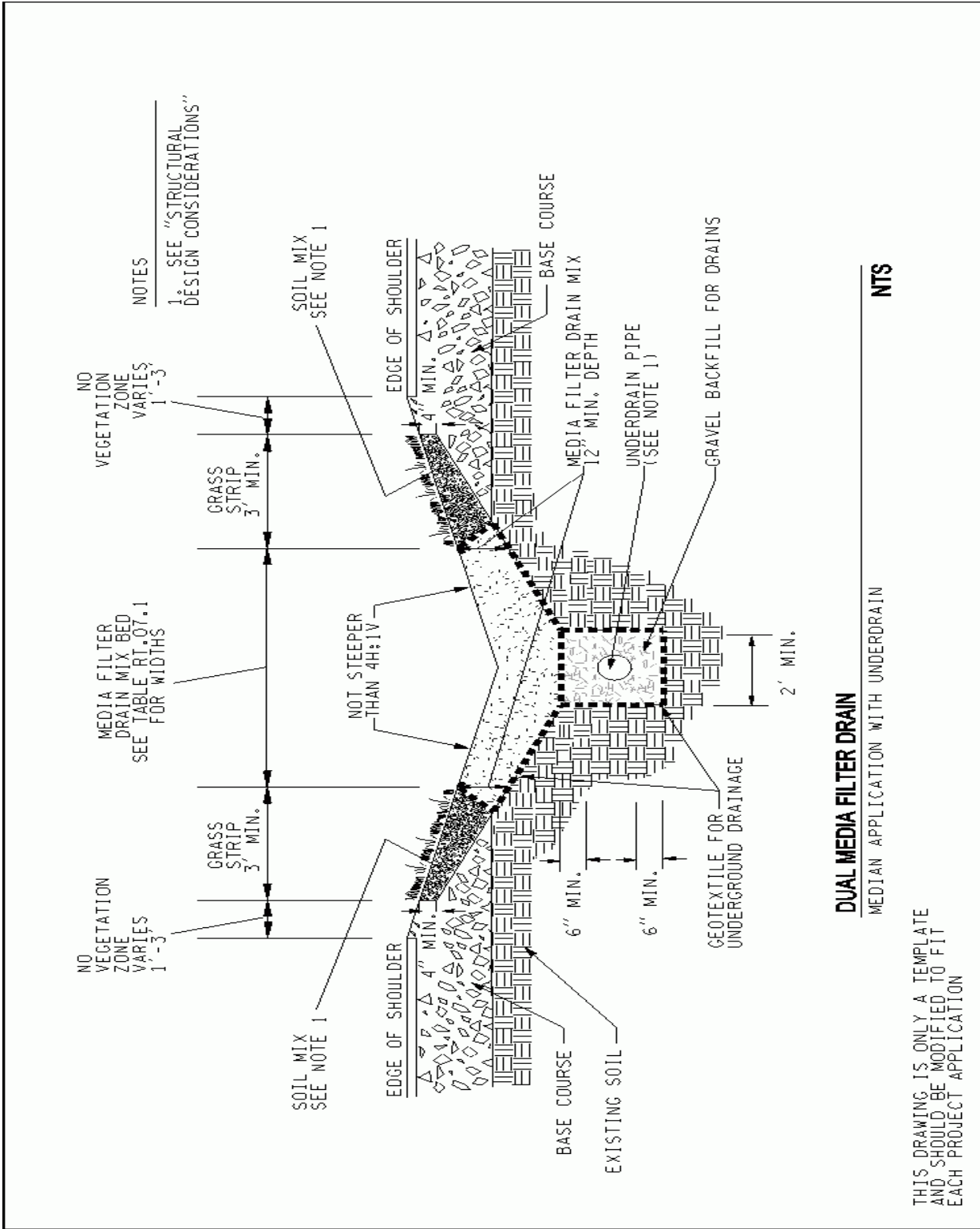


Figure RT.07.2. Dual media filter drain: Cross section.

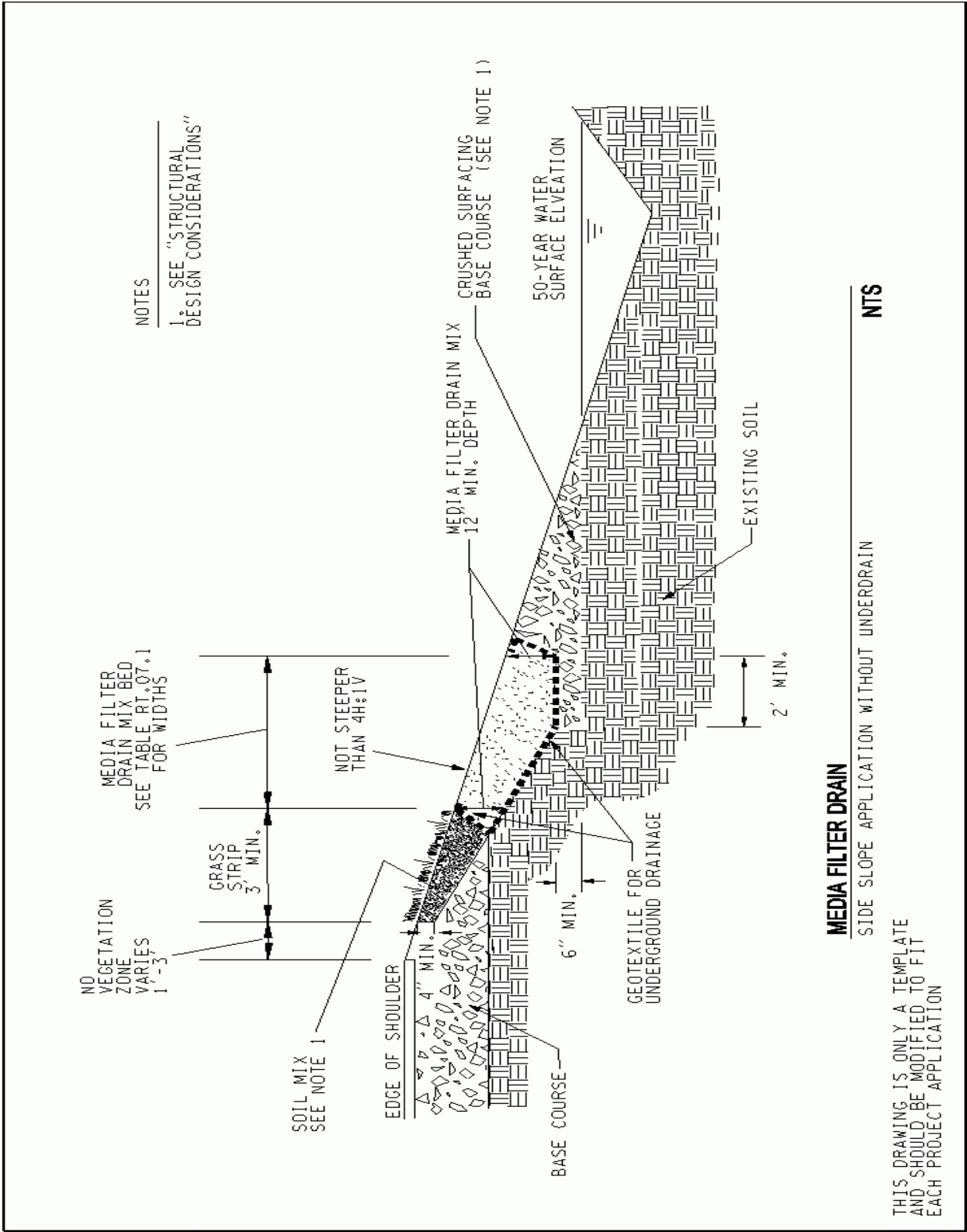


Figure RT.07.3. Media filter drain without underdrain trench.

Functional Description

The media filter drain removes suspended solids, phosphorus, and metals from highway runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration.

Stormwater runoff is conveyed to the media filter drain via sheet flow over a vegetation-free gravel zone to ensure sheet dispersion and provide some pollutant trapping. Next, a grass strip, which may be amended with compost, is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system. The runoff is then filtered through a bed of porous, alkalinity-generating granular medium—the media filter drain mix. Media filter drain mix is a fill material composed of crushed rock (sized by screening), dolomite, gypsum, and perlite. The dolomite and gypsum additives serve to buffer acidic pH conditions and exchange light metals for heavy metals. Perlite is incorporated to improve moisture retention, which is critical for the formation of biomass epilithic biofilm to assist in the removal of solids, metals, and nutrients. Treated water drains from the media filter drain mix bed into the conveyance system below the media filter drain mix. Geotextile lines the underside of the media filter drain mix bed and the conveyance system.

The underdrain trench is an option for hydraulic conveyance of treated stormwater to a desired location, such as a downstream flow control facility or stormwater outfall. The trench's perforated underdrain pipe is a protective measure to ensure free flow through the media filter drain mix. It may be possible to omit the underdrain pipe if it can be demonstrated that the pipe is not necessary to maintain free flow through the media filter drain mix and underdrain trench.

It is critical to note that water should sheet flow across the media filter drain. Channelized flows or ditch flows running down the middle of the dual media filter drain (continuous off-site inflow) should be minimized.

Applications and Limitations

In many instances, conventional runoff treatment is not feasible due to right of way constraints (such as adjoining wetlands and geotechnical considerations). The media filter drain and the dual media filter drain designs are runoff treatment options that can be sited in most right of way confined situations. In many cases, a media filter drain or a dual media filter drain can be sited without the acquisition of additional right of way needed for conventional stormwater facilities or capital-intensive expenditures for underground wet vaults.

Applications

Media Filter Drains

The media filter drain can achieve basic, phosphorus, and enhanced water quality treatment. Since maintaining sheet flow across the media filter drain is required for its proper function, the ideal locations for media filter drains in highway settings are highway side slopes or other long, linear grades with lateral side slopes less than 4H:1V and longitudinal slopes no steeper than 5%. As side slopes approach 3H:1V, without

design modifications, sloughing may become a problem due to friction limitations between the separation geotextile and underlying soils. The longest flow path from the contributing area delivering sheet flow to the media filter drain should not exceed 150 feet.

Dual Media Filter Drain for Highway Medians

The dual media filter drain is fundamentally the same as the side-slope version. It differs in siting and is more constrained with regard to drainage options. Prime locations for dual media filter drains in a highway setting are medians, roadside drainage or borrow ditches, or other linear depressions. It is especially critical for water to sheet flow across the dual media filter drain. Channelized flows or ditch flows running down the middle of the dual media filter drain (continuous off-site inflow) should be minimized.

Limitations

Media Filter Drains

- **Steep slopes.** Avoid construction on longitudinal slopes steeper than 5%. Avoid construction on 3H:1V lateral slopes, and preferably use less than 4H:1V slopes. In areas where lateral slopes exceed 4H:1V, it may be possible to construct terraces to create 4H:1V slopes or to otherwise stabilize up to 3H:1V slopes. (For details, see *Geometry, Components and Sizing Criteria, Cross Section* in the Structural Design Considerations section below).
- **Wetlands.** Do not construct in wetlands and wetland buffers. In many cases, a media filter drain (due to its small lateral footprint) can fit within the highway fill slopes adjacent to a wetland buffer. In those situations where the highway fill prism is located adjacent to wetlands, an interception trench/underdrain will need to be incorporated as a design element in the media filter drain.
- **Shallow groundwater.** Mean high water table levels at the project site need to be determined to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow groundwater.
- **Unstable slopes.** In areas where slope stability may be problematic, consult a geotechnical engineer.

Dual Media Filter Drains for Highway Medians

In addition to the above limitations on the media filter drain:

- **Wetlands.** Do not construct in wetlands and wetland buffers.
- **Areas of seasonal groundwater inundations or basement flooding.** The hydraulic and runoff treatment performance of the dual media filter drain may be compromised due to backwater effects and lack of sufficient hydraulic gradient.

Design Flow Elements

Flows to Be Treated

The basic design concept behind the media filter drain and dual media filter drain is to fully filter all runoff through the media filter drain mix. Therefore, the infiltration capacity of the medium and drainage below needs to match or exceed the hydraulic loading rate.

Structural Design Considerations

Geometry

Components

No-Vegetation Zone

The no-vegetation zone (vegetation-free zone) is a shallow gravel trench located directly adjacent to the highway pavement. The no-vegetation zone is a crucial element in a properly functioning media filter drain or other BMPs that use sheet flow to convey runoff from the highway surface to the BMP. The no-vegetation zone functions as a level spreader to promote sheet flow and a deposition area for coarse sediments. The no-vegetation zone should be between 1 foot and 3 feet wide. Depth will be a function of how the roadway section is built from subgrade to finish grade; the resultant cross section will typically be triangular to trapezoidal. Within these bounds, width varies depending on WSDOT maintenance spraying practices. Contact the area maintenance office for this information.

Grass Strip

The width of the grass strip is dependent on the availability of space within the highway side slope. The baseline design criterion for the grass strip within the media filter drain is a 3-foot-minimum-width, but wider grass strips are recommended if the additional space is available. The designer should consult with the Region Landscape Architect for soil mix recommendations. The designer may consider adding aggregate to the soil mix to help minimize rutting problems from errant vehicles. The soil mix should ensure grass growth for the design life of the media filter drain.

Media Filter Drain Mix Bed

The media filter drain mix is a mixture of crushed rock (screened to 3/8" to #10 sieve), dolomite, gypsum, and perlite. The crushed rock provides the support matrix of the medium; the dolomite and gypsum add alkalinity and ion exchange capacity to promote the precipitation and exchange of heavy metals; and the perlite improves moisture retention to promote the formation of biomass within the media filter drain mix. The combination of physical filtering, precipitation, ion exchange, and biofiltration enhances the water treatment capacity of the mix. The media filter drain mix has an estimated initial filtration rate of 50 inches per hour and a long-term filtration rate of 28 inches per hour due to siltation. With an additional safety factor, the rate used to size the length of the media filter drain should be 10 inches per hour.

Conveyance System Below Media Filter Drain Mix

The gravel underdrain trench provides hydraulic conveyance when treated runoff needs to be conveyed to a desired location such as a downstream flow control facility or stormwater outfall.

In Group C and D soils, an underdrain pipe would help to ensure free flow of the treated runoff through the media filter drain mix bed. In some Group A and B soils, an underdrain pipe may be unnecessary if most water percolates into subsoil from the underdrain trench. The need for underdrain pipe should be evaluated in all cases. The underdrain trench should be a minimum of 2 feet wide for either the conventional or dual media filter drain.

The gravel underdrain trench may be eliminated if there is evidence to support that flows can be conveyed laterally to an adjacent ditch or onto a fill slope that is properly vegetated to protect against erosion. The media filter drain mix should be kept free draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

Sizing Criteria

Width

The width of the media filter drain mix bed is determined by the amount of contributing pavement routed to the embankment. The surface area of the media filter drain mix bed needs to be sufficiently large to fully infiltrate the runoff treatment design flow rate using the long-term filtration rate of the media filter drain mix. For design purposes, a 50% safety factor is incorporated into the long-term media filter drain mix filtration rate to accommodate variations in slope, resulting in a design filtration rate of 10 inches per hour. The media filter drain mix bed should have a bottom width of at least 2 feet in contact with the conveyance system below the media filter drain mix.

Length

In general, the length of a media filter drain or dual media filter drain is the same as the contributing pavement. Any length is acceptable as long as the surface area media filter drain mix bed is sufficient to fully infiltrate the runoff treatment design flow rate.

Cross Section

In profile, the surface of the media filter drain should preferably have a lateral slope less than 4H:1V (<25%). On steeper terrain, it may be possible to construct terraces to create a 4H:1V slope, or other engineering may be employed if approved by Ecology, to ensure slope stability up to 3H:1V. If sloughing is a concern on steeper slopes, consideration should be given to incorporating permeable soil reinforcements, such as geotextiles, open-graded/ permeable pavements, or commercially available ring and grid reinforcement structures, as top layer components to the media filter drain mix bed. Consultation with a geotechnical engineer is required.

Inflow

Runoff is conveyed to a media filter drain using sheet flow from the pavement area. The longitudinal pavement slope contributing flow to a media filter drain should be less than 5%. Although there is no lateral pavement slope restriction for flows going to a media filter drain, the designer should ensure flows remain as sheet flow.

Media Filter Drain Mix Bed Sizing Procedure

The media filter drain mix should be a minimum of 12 inches deep, including the section on top of the underdrain trench.

For runoff treatment, sizing the media filter drain mix bed is based on the requirement that the runoff treatment flow rate from the pavement area, $Q_{Highway}$, cannot exceed the long-term infiltration capacity of the media filter drain, $Q_{Infiltration}$:

$$Q_{Highway} \leq Q_{Infiltration}$$

For western Washington, $Q_{Highway}$ is the flow rate at or below which 91% of the runoff volume for the developed TDA will be treated, based on a 15-minute time step (see [Section 4-3.1.1](#)), and can be determined using the water quality data feature in MGSFlood. For eastern Washington, $Q_{Highway}$ is the peak flow rate predicted for the 6-month, short-duration storm under post-developed conditions for each TDA (see [Appendix 4C](#)), and can be determined by selecting the short-duration storm option in StormSHED.

The long-term infiltration capacity of the media filter drain is based on the following equation:

$$\frac{LTIR * L * W}{C * SF} = Q_{Infiltration}$$

- where: $LTIR$ = Long-term infiltration rate of the media filter drain mix (use 10 inches per hour for design) (in/hr)
- L = Length of media filter drain (parallel to roadway) (ft)
- W = Width of the media filter drain mix bed (ft)
- C = Conversion factor of 43200 ((in/hr)/(ft/sec))
- SF = Safety Factor (equal to 1.0, unless unusually heavy sediment loading is expected)

Assuming that the length of the media filter drain is the same as the length of the contributing pavement, solve for the width of the media filter drain:

$$W \geq \frac{Q_{Highway} * C * SF}{LTIR * L} \quad (RT.07-1)$$

Western Washington project applications of this design procedure have shown that, in almost every case, the calculated width of the media filter drain does not exceed 1.0 foot. Therefore, Table RT.07.1 was developed to simplify the design steps and should be used to establish an appropriate width.

Table RT.07.1. Western Washington design widths for media filter drains.

Pavement width that contributes runoff to the media filter drain	Minimum media filter drain width*
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet

* Width does not include the required 1–3 foot gravel vegetation-free zone or the 3-foot filter strip width (see [Figure RT.07.1](#)).

Materials

Media Filter Drain Mix

The media filter drain mix used in the construction of media filter drains consists of the amendments listed in [Table RT.07.2](#). Mixing and transportation must occur in a manner that ensures the materials are thoroughly mixed prior to placement and that separation does not occur during transportation or construction operations.

These materials should be used in accordance with the following *Standard Specifications*:

- Gravel Backfill for Drains, 9-03.12(4)
- Underdrain Pipe, 7-01.3(2)
- Construction Geotextile for Underground Drainage, 9-33.1

Crushed Surfacing Base Course (CSBC)

If the design is configured to allow the media filter drain to drain laterally into a ditch (see [Figure RT.07.3](#)), the crushed surfacing base course below the media filter drain should conform to Section 9-03.9(3) of the *Standard Specifications*.

Berms, Baffles, and Slopes

See *Geometry, Components and Sizing Criteria, Cross Section* under Structural Design Considerations above.

Table RT.07.2. Media filter drain mix.

Amendment	Quantity																
<p>Mineral aggregate: Crushed screenings 3/8-inch to #10 sieve</p> <p>Crushed screenings shall be manufactured from ledge rock, talus, or gravel in accordance with Section 3-01 of the <i>Standard Specifications for Road, Bridge, and Municipal Construction</i> (2002), which meets the following test requirements:</p> <p style="margin-left: 40px;">Los Angeles Wear, 500 Revolutions 35% max. Degradation Factor 30 min.</p> <p>Crushed screenings shall conform to the following requirements for grading and quality:</p> <table border="0" style="margin-left: 40px;"> <thead> <tr> <th align="left">Sieve Size</th> <th align="left">Percent Passing (by weight)</th> </tr> </thead> <tbody> <tr> <td>1/2" square</td> <td>100</td> </tr> <tr> <td>3/8" square</td> <td>90-100</td> </tr> <tr> <td>U.S. No. 4</td> <td>30-56</td> </tr> <tr> <td>U.S. No. 10</td> <td>0-10</td> </tr> <tr> <td>U.S. No. 200</td> <td>0-1.5</td> </tr> <tr> <td>% fracture, by weight, min.</td> <td>75</td> </tr> <tr> <td>Static stripping test</td> <td>Pass</td> </tr> </tbody> </table> <p>The fracture requirement shall be at least one fractured face and will apply to material retained on the U.S. No. 10 if that sieve retains more than 5% of the total sample.</p> <p>The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious materials.</p> <p>Crushed screenings shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exists on more than 50% of the surface area of any size between successive laboratory sieves.</p>	Sieve Size	Percent Passing (by weight)	1/2" square	100	3/8" square	90-100	U.S. No. 4	30-56	U.S. No. 10	0-10	U.S. No. 200	0-1.5	% fracture, by weight, min.	75	Static stripping test	Pass	3 cubic yards
Sieve Size	Percent Passing (by weight)																
1/2" square	100																
3/8" square	90-100																
U.S. No. 4	30-56																
U.S. No. 10	0-10																
U.S. No. 200	0-1.5																
% fracture, by weight, min.	75																
Static stripping test	Pass																
<p>Perlite:</p> <ul style="list-style-type: none"> ▪ Horticultural grade, free of any toxic materials) ▪ 0-30% passing US No. 18 Sieve ▪ 0-10% passing US No. 30 Sieve 	1 cubic yard per 3 cubic yards of mineral aggregate																
<p>Dolomite: CaMg(CO₃)₂ (calcium magnesium carbonate)</p> <ul style="list-style-type: none"> ▪ Agricultural grade, free of any toxic materials) ▪ 100% passing US No. 8 Sieve ▪ 0% passing US No. 16 Sieve 	10 pounds per cubic yard of perlite																
<p>Gypsum: Noncalcined, agricultural gypsum CaSO₄•2H₂O (hydrated calcium sulfate)</p> <ul style="list-style-type: none"> ▪ Agricultural grade, free of any toxic materials) ▪ 100% passing US No. 8 Sieve ▪ 0% passing US No. 16 Sieve 	1.5 pounds per cubic yard of perlite																

Site Design Elements

Landscaping (Planting Considerations)

Landscaping is the same as for biofiltration swales (see [BMP RT.04](#)) unless otherwise specified in the special provisions for the project's construction documents.

Operations and Maintenance

Maintenance will consist of routine roadside management. While herbicides will not be applied directly over the media filter drain, it may be necessary to periodically control noxious weeds with herbicides in areas around the media filter drain as part of WSDOT's roadside management program. The use of pesticides may be prohibited if the media filter drain is in a critical aquifer recharge area for drinking water supplies. The designer should check with the local area water purveyor or local health department. Areas of the media filter drain that show signs of physical damage will be replaced by local maintenance staff in consultation with region hydraulics/water quality staff.

Signing

Nonreflective guideposts will delineate the media filter drain. This practice allows WSDOT personnel to identify where the system is installed and to make appropriate repairs should damage occur to the system. If the media filter drain is in a critical aquifer recharge area for drinking water supplies, signage prohibiting the use of pesticides must be provided.