Water Quality Swale

Description: Vegetated open channels designed to capture and infiltrate stormwater runoff within a dry storage layer beneath the base of the channel.

Components:

- Open trapezoidal or parabolic channel to store entire treatment volume, which is ultimately infiltrated
- Filter bed of permeable, engineered soils
- Underdrain system for impermeable soils
- Check dams every 50 feet, if length exceeds 100 feet

Advantages/Benefits:

- Stormwater treatment combined with conveyance
- Less expensive than curb and gutter
- Reduces runoff velocity
- Promotes infiltration

Disadvantages/Limitations:

- Higher maintenance than curb and gutter
- Cannot be used on steep slopes
- High land requirement
- Requires 3 feet of head

Design considerations:

- Longitudinal slopes ideally less than 2%
- Bottom channel width of 2 to 8 feet
- Underdrain required for subsoil infiltration rates less than 0.5 inches/hour
- Max 2.5 acres of impervious drainage area
- Side slopes of 3:1 or flatter; 4:1 recommended
- Must convey the 10-year storm event with a minimum of 6 inches of freeboard

Selection Criteria:

Level 1 – 40% Runoff Reduction Credit

Level 2 – 60% Runoff Reduction Credit

Land Use Considerations:

X **Residential**

X **Commercial**

X **Industrial** (with CITY approval)

Maintenance:

- Maintain grass height
- Remove sediment from forebay and channel
- Remove accumulated trash and debris
- Re-establish plants as needed

M **Maintenance Burden**
L = Low M = Moderate H = High

SECTION 1: DESCRIPTION

Water quality swales are essentially bioretention cells that are shallow, linear channels covered with grasses or other surface material (other than mulch and ornamental plants). The water quality swale is a soil filter system that temporarily stores and then filters the desired Treatment Volume (T_v). Water quality swales rely on a pre-mixed soil media filter below the channel that is similar to that used for bioretention. If soils are extremely permeable, runoff infiltrates into underlying soils. Otherwise, the runoff treated by the soil media flows into an underdrain, which conveys treated runoff back to the conveyance system further downstream. The underdrain system consists of a perforated pipe within a gravel layer on the bottom of the swale, beneath the filter media. Water quality swales may appear as simple dense grass channels with the same shape and turf cover, while others may have more elaborate landscaping. Swales can be planted with medium to tall meadow grasses, decorative herbaceous cover or trees.

SECTION 2: PERFORMANCE

The primary pollutant removal mechanisms operating in swales are settling, filtering infiltration and plant uptake. The overall runoff reduction capabilities of water quality swales are summarized in **Table 5.1**.

Table 5.1. Runoff Volume Reduction Provided by Water Quality Swales

Stormwater Function	Level 1 Design	Level 2 Design
Runoff Volume Reduction (RR)	40%	60%

SECTION 3: DESIGN TABLE

Swales can be oriented to accept runoff from a single discharge point, or to accept runoff as lateral sheet flow along the swale's length.

Table 5.2. Water Quality Swale Design Criteria	
Level 1 Design (RR:40)	**Level 2 Design (RR:60)**
Sizing: See Section 6.1	**Sizing**: See Section 6.1
Surface Area (sq. ft.) = Tv/ Storage depth[1]	**Surface Area** (sq. ft.) = (1.1*Tv) / Storage Depth[1]
Effective swale slope: ≤ 2%	**Effective swale slope**: ≤ 1 %
Media Depth: minimum = 18 inches; recommended maximum = 36 inches	**Media Depth**: minimum = 24 inches; recommended maximum = 36 inches
Infiltration Testing (Section 6.2): one per 50 linear feet, 2 minimum; min. infiltration rate must be > 0.5 inch/hour to remove the underdrain requirement	
Underdrain (Section 6.7): Schedule 40 PVC or HDPE with clean-outs with 3/8 inch perforations on center	
Underground Storage Layer: (Section 6.7): a minimum 12-inch stone sump below the invert; OR none if the soil infiltration requirements are met (see **Section 6.2**)	
Filter Media (Section 6.6): 85% to 88%; 8% to 12% soil fines; 3% to 5% organic matter	
Inflow: sheet or concentrated flow with appropriate pretreatment	
Pretreatment: (Section 6.4): a pretreatment cell, level spreader, grass filter strip, gravel diaphragm, or gravel flow pretreatment structure.	
Planting Plan: medium to tall meadow grasses, decorative herbaceous cover, and trees are encouraged. Avoid sod or seeding overlain with straw.	

[1]The storage depth is the sum of the porosity (n) of the soil media and gravel layers multiplied by their respective depths, plus the surface ponding depth (Refer to Section 6.1)

SECTION 4: TYPICAL DETAILS

Figures 5.2 through 5.4 below provide typical schematics for water quality swales.

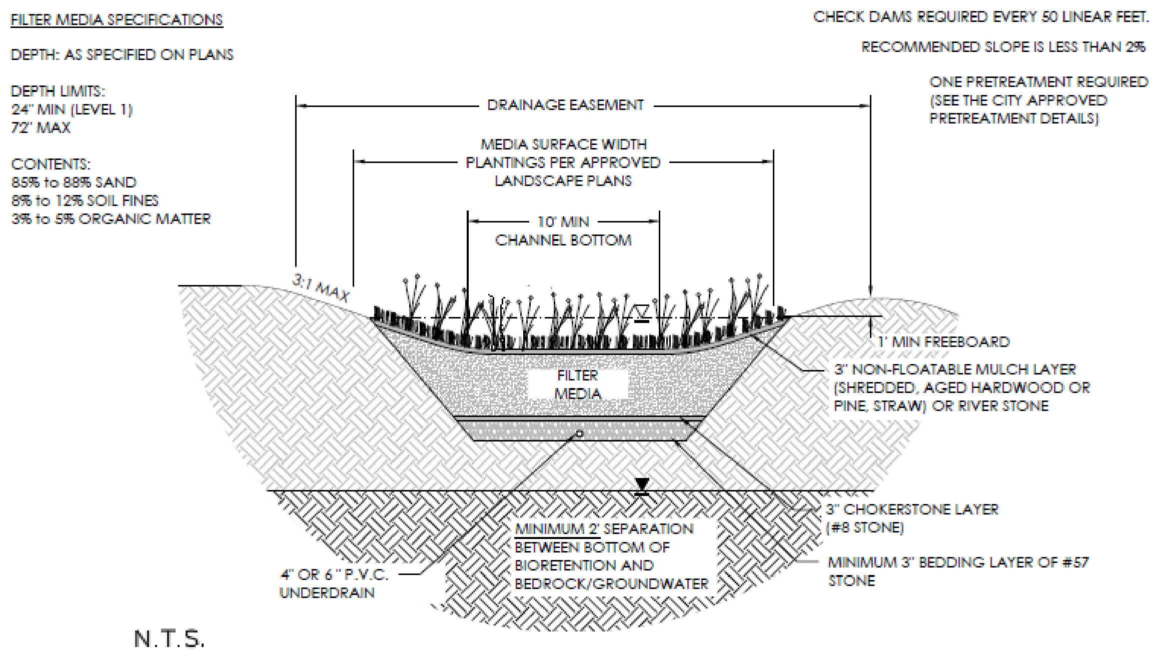

Figure 5.2. Typical Detail for Level 1 Water Quality Swale

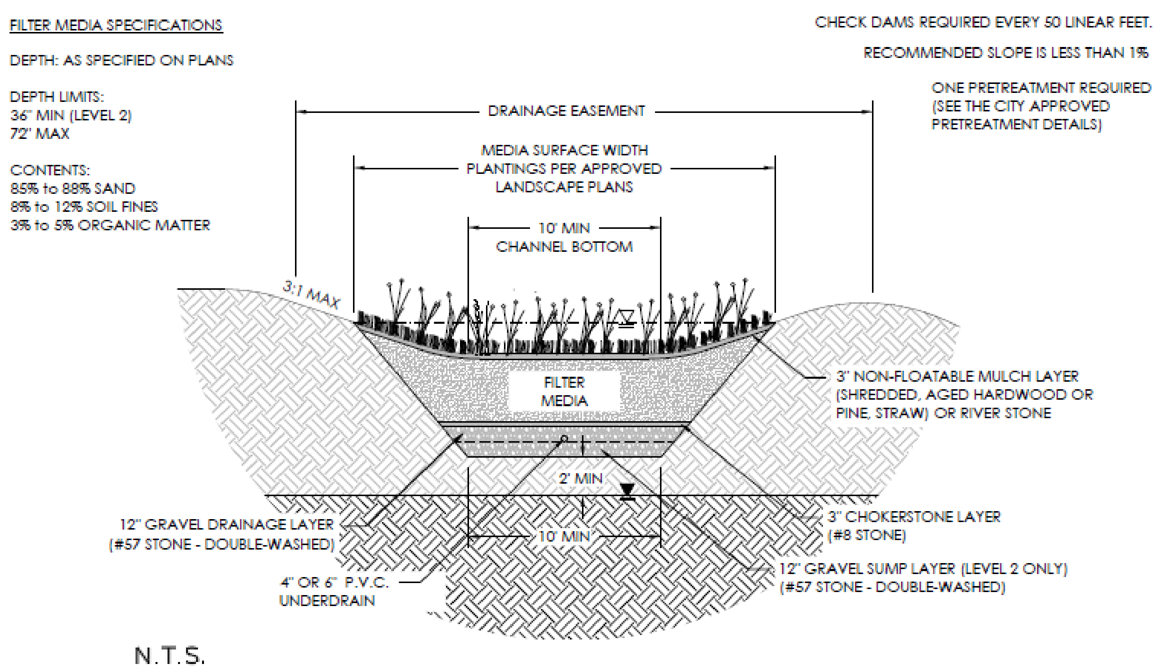

Figure 5.3. Typical Detail for Level 2 Water Quality Swale

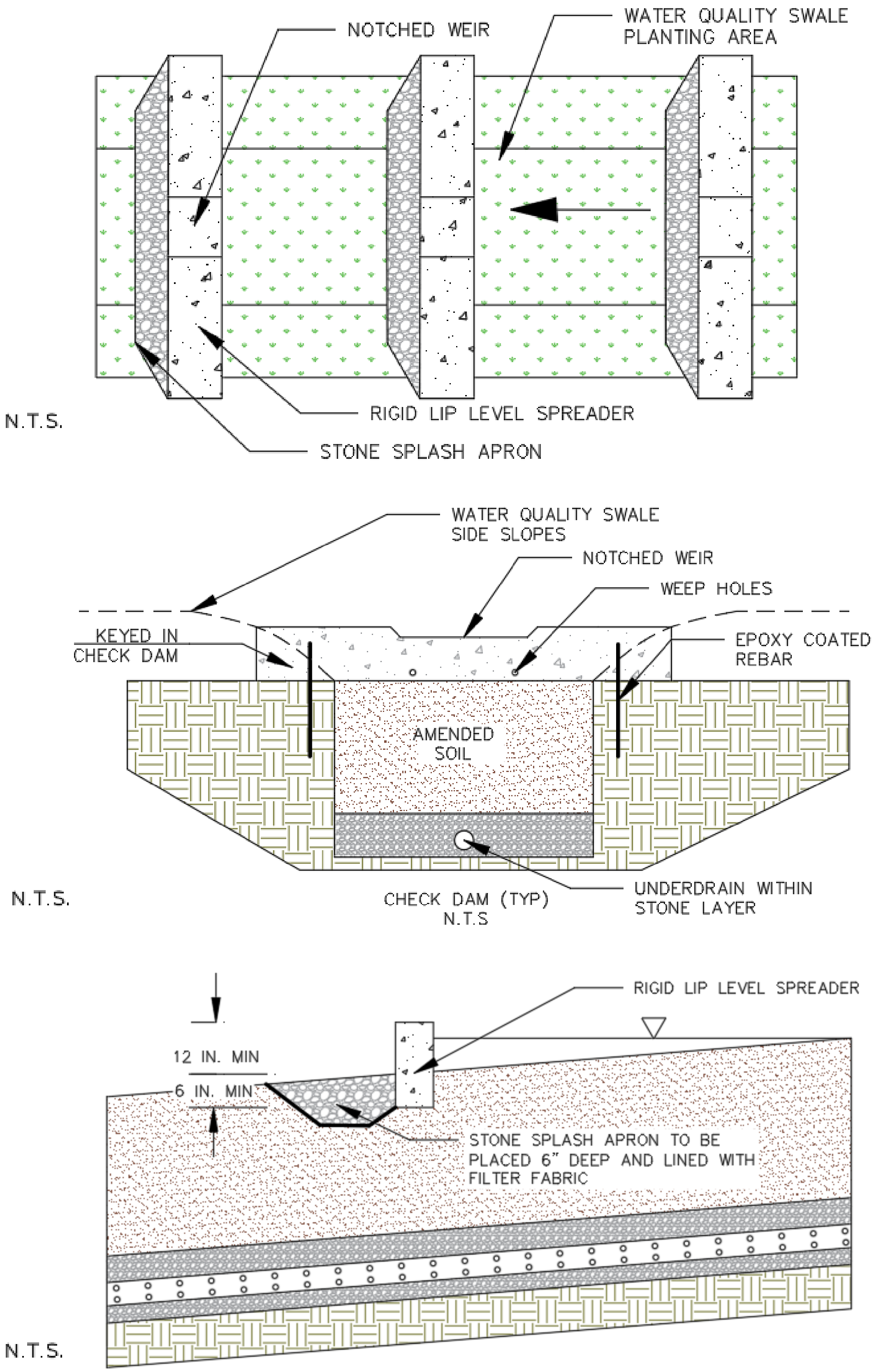

Figure 5.4. Typical Detail for Water Quality Swale Check Dam

SECTION 5: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

Water quality swales can be implemented on a variety of development sites where density and topography permit their application. Some key feasibility issues for water quality swales include the following:

Accessibility. Water quality swales require periodic maintenance and shall be accessible to various types of equipment. A path of travel for equipment no less than 12 feet in width shall be provided for the water quality swale. Each water quality swale shall have one point of vehicle access.

Available Hydraulic Head. A minimum amount of hydraulic head is needed to implement water quality swales, measured as the difference in elevation between the inflow point and the downstream storm drain invert. Water quality swales typically require 3 feet of hydraulic head.

Available Space. Water quality swale footprints can fit into relatively narrow corridors between utilities, roads, parking areas, or other site constraints. Water quality swales shall at a minimum be 3% of the size of the contributing drainage area, depending on the amount of impervious cover.

Contributing Drainage Area. The maximum impervious contributing drainage area to a water quality swale should be 2.5 acres. When water quality swales treat larger drainage areas, the velocity of flow through the surface channel often becomes too great to treat runoff or prevent erosion in the channel. Similarly, the longitudinal flow of runoff through the soil, stone, and underdrain may cause hydraulic overloading at the downstream sections of the water quality swale. An alternative is to provide a series of inlets or diversions that convey the treated water to an outlet location.

Depth to Water Table. Designers should ensure that the bottom of the water quality swale is at least 2 feet above the seasonally high groundwater table, to ensure that groundwater does not intersect the filter bed, since this could lead to groundwater contamination or practice failure.

Hydraulic Capacity. Water quality swales that are an on-line practice must be designed with enough capacity to (1) convey runoff from the 100-year design storms at non-erosive velocities, and (2) contain the 10-year flow within the banks of the swale. This means that the swale's surface dimensions are more often determined by the need to pass the 10-year storm events, which can be a constraint in the siting of water quality swales within existing right of way (e.g., constrained by sidewalks).

Irrigation or Baseflow. Water quality swales should be located to avoid inputs of springs, irrigation systems, chlorinated wash-water, or other dry weather flows. Irrigation can be used to help vegetation growth within the first growing season and during droughts. A soil moisture sensor shall be installed. Irrigation plan shall be submitted for review.

Setbacks. It is not recommended to lace bioretention areas immediately adjacent to structures. to avoid the risk of seepage, a licensed PE should be consulted to determine the appropriate setbacks necessary to prevent bioretention infiltration from compromising structural foundations or pavement. At a minimum, bioretention basins should be located a horizontal distance of 100 feet from any water supply well and 50 feet from septic systems. Horizontal separation of 5 feet or the overall depth of the bioretention, whichever is greater, is required between the amended soils of the bioretention and any adjacent hardscape (i.e. parking lots or sidewalks). The bottom elevation of swales should be at least 1 foot below the invert of an adjacent roadbed.

Site Topography. Water quality swales should be used on sites with longitudinal slopes of less than 4%, but preferably less than 2%. Check dams can be used to reduce the effective slope of the swale and lengthen the contact time to enhance filtering and/or infiltration. Steeper slopes adjacent to the swale may generate rapid runoff velocities into the swale that may carry a high sediment loading (refer to pretreatment criteria in **Section 6.4**).

Utilities. Designers should consult local utility design guidance for the horizontal and vertical clearance between utilities and the swale configuration. No utility lines shall cross under water quality swales.

SECTION 6: DESIGN CRITERIA

6.1 SIZING OF WATER QUALITY CONVEYANCE AND WATER QUALITY TREATMENT SWALES

Sizing of the surface area (SA) for water quality swales is based on the computed Treatment Volume (T_v) of the contributing drainage area and the storage provided within the swale media and gravel layers and behind check dams. The required surface area (in square feet) is computed as the Treatment Volume (in cubic feet) divided by the equivalent storage depth (in feet). The equivalent storage depth is computed as the depth of the soil media, the gravel, and surface ponding (in feet) multiplied by the accepted porosity.

The accepted porosities are:

Table 5.3. Water Quality Swale Accepted Porosities	
Material	**Porosity Value (n)**
Gravel (#57) Stone	0.40
Choker (#8) Stone Layer	0.40
Soil Media	0.25
Surface Layer	0.00
Surface Storage	1.00

The equivalent storage depth for a typical Level 1 design with a 4-inch gravel sump layer, 2 feet of media, and a 6-inch surface ponding depth is computed as:

Equation 5.1. Equivalent Storage Depth – Level 1

$$\text{Equivalent Storage Depth} = D_E = n_1(D_1) + n_2(D_2) + \cdots$$

$$D_E = (2 \text{ ft. x } 0.25) + (0.25 \text{ ft. x } 0.40) + (.5 \text{ ft. x } 1.00) = 1.7\text{ft.}$$

The equivalent storage depth for a typical Level 2 design with a 12-inch gravel sump layer, 3 feet of media, and a 6-inch surface ponding depth is computed as:

Equation 5.2. Equivalent Storage Depth – Level 2

$$D_E = (3 \text{ ft. x } 0.25) + (1.0 \text{ ft. x } 0.40) + (.5 \text{ ft. x } 1.00) = 2.1 \text{ ft}$$

The effective storage depths will vary according to the actual design depths of the soil media and gravel layer.

Note: When using Equations 3 or 4 below to calculate the required surface area of a water quality swale that includes surface ponding (with check dams), the storage depth calculation (Equation 1 or 2) should be adjusted accordingly.

The Level 1 Water Quality Swale Surface Area (SA) is computed as:

Equation 5.3. Surface Area – Level 1

$$SA\ (sq.\ ft.) = T_v/D_E\ ft.$$

And the Level 2 Water Quality Swale SA is computed as:

Equation 5.4. Surface Area – Level 2

$$SA\ (sq.\ ft.) = (1.1 * T_v)/D_E$$

NOTE: The volume reduced by upstream PTPs is supplemented with the anticipated volume of storage created by check dams along the swale length.

Where:
SA =Minimum surface area of Water Quality Swale (sq. ft.)
T_v =Treatment Volume (cu. ft.) = [(1 inch) (R_v)(A)]*3630,
A = Area in acres

The final water quality swale design geometry will be determined by dividing the SA by the swale length to compute the required width; or by dividing the SA by the desired width to compute the required length.

6.2 SOIL INFILTRATION RATE TESTING

The second key sizing decision is to measure the infiltration rate of subsoils below the water quality swale area to determine if an underdrain will be needed. The infiltration rate of the subsoil must exceed 0.5 inches per hour to avoid installation of an underdrain. The acceptable methods for on-site soil infiltration rate testing are outlined in **Appendix B**. A soil test shall be conducted for every 50 linear feet of water quality swale, with a minimum of two tests per swale.

6.3 WATER QUALITY SWALE GEOMETRY

Check dams. Check dams must be firmly anchored (keyed) into the side-slopes to prevent outflanking and be stable during the 10 year storm design event. The height of the check dam relative to the normal channel elevation should not exceed 12 inches. Each check dam should have a minimum of one weep hole or a similar drainage feature so it can dewater after storms. Armoring may be needed behind the check dam to prevent erosion. The check dam must be designed to spread runoff evenly over the water quality swale's filter bed surface, through a centrally located depression with a length equal to the filter bed width. In the center of the check dam, the depressed weir length should be checked for the depth of flow, sized for the appropriate design storm (see **Figure 5.3**). Check dams should be constructed of stone or concrete.

Drawdown. Water quality swales should be designed so that the desired Treatment Volume is completely filtered within 24 hours or less. This drawdown time can be achieved by using the soil media mix specified in **Section 6.6** and an underdrain along the bottom of the swale, or native soils with adequate permeability, as verified through testing (see **Section 6.2**).

Ponding Depth. Drop structures or check dams can be used to create ponding cells along the length of the swale. The maximum ponding depth in a swale should not exceed 12 inches at the most downstream point.

Shape. A parabolic shape is preferred for water quality swales for aesthetic, maintenance and hydraulic reasons. However, the design may be simplified with a trapezoidal cross-section, as long as the soil filter bed boundaries lay in the flat bottom areas.

Side Slopes. The side slopes of water quality swales shall be no steeper than 3H:1V for maintenance considerations. Flatter slopes are encouraged where adequate space is available, to enhance pretreatment of sheet flows entering the swale. Swales should have a bottom width of from 2 to 8 feet to ensure that an adequate surface area exists along the bottom of the swale for filtering. If a swale will be wider than 8 feet, the designer should incorporate berms, check dams, level spreaders or multi-level cross-sections to prevent braiding and erosion of the swale bottom.

Swale Longitudinal Slope. The longitudinal slope of the swale should be moderately flat to permit the temporary ponding of the Treatment Volume within the channel. The recommended swale slope is less than or equal to 2% for a Level 1 design and less than or equal to 1% for a Level 2 design, though slopes up to 4% are acceptable if check dams are used. The minimum recommended slope for an on-line water quality swale is 0.5%. Refer to **Table 5.4** for check dam spacing based on the swale longitudinal slope.

Table 5.4. Typical Check Dam (CD) Spacing to Achieve Effective Swale Slope

Swale Longitudinal Slope	LEVEL 1	LEVEL 2
	Spacing[1] of 12-inch high (max.) Check Dams[2] to create an Effective Slope of 2%	Spacing[1] of 12-inch high (max.) Check Dams[2] to create an Effective Slope of 0 to 1%
0.5%	–	200 ft. to –
1.0%	–	100 ft. to –
1.5%	–	67 ft. to 200 ft.
2.0%	–	50 ft. to 100 ft.
2.5%	200 ft.	40 ft. to 67 ft.
3.0%	100 ft.	33 ft. to 50 ft.
3.5%	67 ft.	30 ft. to 40 ft.
4.0%	50 ft.	25 ft. to 33 ft.

[1] The spacing dimension is half of the above distances if a 6-inch check dam is used.

[2] Check dams require a stone energy dissipater at the downstream toe.

6.4 PRETREATMENT

Several pretreatment measures are feasible, depending on whether the specific location in the water quality swale system will be receiving sheet flow, shallow concentrated flow, or fully concentrated flow. See **Appendix A** for details.

6.5 CONVEYANCE AND OVERFLOW

The bottom width and slope of a water quality swale should be designed such that the velocity of flow from a 1-inch rainfall will not exceed 3 feet per second. Check dams may be used to achieve the needed runoff reduction volume, as well as to reduce the flow. Check dams should be spaced based on channel slope and ponding requirements, consistent with the criteria in **Table 5.5**.

The swale shall also convey the 2- and 10-year storms at non-erosive velocities with at least 6 inches of freeboard. The analysis should evaluate the flow profile through the channel at normal depth, as well as the flow depth over top of the check dams.

Water quality swales may be designed as off-line systems, with a flow splitter or diversion to divert runoff in excess of the design capacity to an adjacent conveyance system. Or, strategically placed overflow inlets may be placed along the length of the swale to periodically pick up water and reduce the hydraulic loading at the downstream limits.

6.6 FILTER MEDIA

The recommended bioretention soil mixture is generally classified as a loamy sand on the USDA Texture Triangle, with the following composition by volume: **85% to 88% sand; 8% to 12% soil fines; and 3% to 5% organic matter**. Sand shall consist of silica-based aggregate and shall meet the sieve sizes shown in **Table 5.5**. No substitutions for alternative materials such as "engineered sand" or recycled materials will be accepted.

Table 5.5. Sand sieve size requirements

Sieve	Size	% Passing
3/8 in	9.50 mm	100
No. 4	4.75 mm	95 to 100
No. 8	2.36 mm	80 to 100
No. 16	1.18 mm	45 to 85
No. 30	0.60 mm	15 to 60
No. 50	0.30 mm	3 to 15
No. 100	0.15 mm	0 to 4
Effective Particle Size (D10) > 0.30 mm Uniformity Coefficient (D60/D10) < 0.40		

It may be advisable to start with an open-graded coarse silica sand material and proportionately mix in topsoil that will likely contain anywhere from 8% to 12% soil fines (sandy loam, loamy sand) to achieve the desired ratio of sand and fines. An additional 3% to 5% organic matter can then be added. (The exact composition of organic matter and topsoil material will vary, making particle size distribution and recipe for the total soil media mixture difficult to define in advance of evaluating the available material.)

6.7 UNDERDRAIN AND UNDERGROUND STORAGE LAYER

The underdrain should be constructed of 4 or 6-inch diameter perforated HDPE or PVC, which is placed on either a 3-inch layer of double-washed gravel (TDOT #57) for Level 1 or directly on a 12-inch sump layer of 1-inch stone for Level 2. The underdrain shall be encased in a gravel layer extending at least 3 inches above the surface of the pipe. This gravel layer should be covered with a 3-inch layer of choker stone (TDOT #8 or #89).

Some Level 2 water quality swale designs will not use an underdrain [(where soil infiltration rates meet minimum standards (see **Section 6.2**)]. For Level 2 designs with an underdrain, an underground storage layer, consisting of a minimum 12 inches of stone, shall be incorporated below the invert of the underdrain. The depth of the storage layer will depend on the target treatment and storage volumes needed to meet water quality criteria. The storage layer shall consist of clean, washed #57 stone.

If the underdrain is to daylight instead of tying into a storm structure, scour protection shall be provided based of the velocity, in feet per second, exiting the underdrain during the 10 year storm event.

All water quality swales shall include observation wells. The observation wells should be tied into any T's or Y's in the underdrain system, and should extend upwards to be above the surface, with a vented cap. In addition, cleanout pipes shall be provided.

6.8 LANDSCAPING AND PLANTING PLAN

Designers should choose grasses, herbaceous plants or trees that can withstand both wet and dry periods and relatively high velocity flows for planting within the channel. Salt tolerant grass species should be chosen for water quality swales receiving drainage from areas treated for ice in winter. Taller and denser grasses are preferable, although the species is less important than good stabilization and dense vegetative cover. Grass species should have the following characteristics: a deep root system to resist scouring; a high stem density with well-branched top growth; water-tolerance; resistance to being flattened by runoff; and an ability to recover growth following inundation. A qualified landscape designer should be consulted for selection of appropriate plantings. See **Appendix C** for landscape plan requirements and all native plant lists.

6.9 WATER QUALITY SWALE MATERIAL SPECIFICATIONS

Table 5.6 outlines the standard material specifications for constructing water quality swales.

<table>
<tr><th colspan="3">Table 5.6. Water Quality Swale Material Specifications</th></tr>
<tr><th>Material</th><th>Specification</th><th>Notes</th></tr>
<tr><td>Surface Layer</td><td>• Shredded hardwood mulch
• River stone
• Native grasses</td><td>Lay a 3-inch layer on the surface of the filter bed to suppress weed growth and prevent erosion</td></tr>
<tr><td>Filter Media Composition</td><td>Filter Media to contain (by volume):
• 85% to 88% sand
• 8% to 12% soil fines
• 3% to 5% organic matter</td><td>The volume of filter media is based on 110% of the product of the surface area and the media depth, to account for settling.</td></tr>
<tr><td>Choking Layer</td><td colspan="2">A 3- inch layer of choker stone (typically #8 or # 89 washed gravel) laid above the underdrain stone.</td></tr>
<tr><td>Stone and/or Storage Layer</td><td colspan="2">A 12 to 18 inch layer (depending on the desired depth of the storage layer) of #57 stone should be double-washed and clean and free of all soil and fines.</td></tr>
<tr><td>Underdrains, Cleanouts, and Observation Wells</td><td>6-inch PVC or HDPE pipe, with 3/8-inch perforations.</td><td>If needed, install perforated pipe for the full length of the water quality swale. Use non-perforated pipe, as needed, to connect with the storm drain system.</td></tr>
<tr><td>Check Dams</td><td colspan="2">Use non-erosive material such as wood, gabions, riprap, or concrete. All check dams should be underlain with filter fabric and include weep holes. Wood used for check dams should consist of pressure-treated logs or timbers, or water-resistant tree species such as cedar, hemlock, swamp oak or locust.</td></tr>
<tr><td>Erosion Control Fabric</td><td colspan="2">Where flow velocities dictate, use woven biodegradable erosion control fabric or mats that are durable enough to last at least 2 growing seasons.</td></tr>
</table>

SECTION 7: SPECIAL CASE DESIGN ADAPTATIONS

7.1 SHALLOW BEDROCK AND GROUNDWATER CONNECTIVITY

Many parts of Franklin have shallow bedrock and groundwater, which can constrain the application of deeper water quality swales (particularly Level 2 designs). If bedrock or groundwater is encountered during subsurface testing for the construction of the bioretention area, the bottom sump elevation of the water quality swale design shall be above the lowest bedrock/refusal or groundwater elevation encountered in subsurface testing. Bedrock removal should be limited to unexpected outcroppings and rises not encountered in subsurface testing.

Note that planned removal of bedrock is not desirable and should be utilized only when all other design possibilities have been exhausted. Where a hardship can be show and all other possibilities have been exhausted, a stormwater variance for bedrock removal may be granted on a case-by-case basis.

In cases where the reduced curve number method is to be utilized in stormwater quantity calculations, the bottom sump elevation shall be a minimum of 2 feet above existing bedrock elevations.

7.2 STEEP TERRAIN

In areas of steep terrain, water quality swales can be implemented with contributing slopes of up to 20% gradient, if a multiple cell design is used to dissipate erosive energy prior to filtering. This can be accomplished by terracing a series of water quality swale cells to manage runoff across or down a slope. The drop in elevation between cells should be limited to 1 foot and armored with river stone or a suitable equivalent. A greater emphasis on properly engineered energy dissipaters and/or drop structures is warranted.

7.3 SITE SPECIFIC LIMITATIONS

Some sites may have areas identified as site specific limitations to infiltration of stormwater runoff. Site specific limitations shall be determined by the City engineer and approved through the Stormwater variance process. Sites with brownfield permits are an example of site specific limitations. Site specific limitations cannot be self-imposed or be caused by requirements within the City Ordinance. It should be noted that the site specific limitation may only occupy a portion of the entire proposed use, and that some "clean" areas (such as rooftops) can be diverted away to another infiltration or runoff reduction practice. Development proposals should be carefully reviewed to determine if any future operation, on all or part of the site, will be designated as a potential site specific limitation. Based on this designation, infiltration may be restricted or prohibited.

SECTION 8: CONSTRUCTION

8.1 CONSTRUCTION EROSION PREVENTION AND SEDIMENT CONTROL

Construction Stage EPSC Controls. Water quality swales should be fully protected by silt fence or construction fencing, particularly if they will provide an infiltration function (i.e., have no underdrains). Ideally, water quality swale areas should remain *outside* the limits of disturbance during construction to prevent soil compaction by heavy equipment.

Water quality swale locations may be used for small sediment traps or basins during construction. However, these must be accompanied by notes and graphic details on the EPSC plan specifying that the maximum excavation depth of the sediment trap/basin at the construction stage must (1) be at least 1 foot above the depth of the post-construction water quality swale installation, (2) contain an underdrain, and (3) specify the use of proper procedures for conversion from a temporary practice to a permanent one, including de-watering, cleanout and stabilization.

8.2 CONSTRUCTION SEQUENCE

The following is a typical construction sequence to properly install a water quality swale, although the steps may be modified to adapt to different site conditions.

Step 1. Protection during Site Construction. As noted above, water quality swales should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment. However, this is seldom practical given that swales are a key part of the drainage system at most sites. In these cases, temporary EPSC such as dikes, silt fences and other similar measures should be integrated into the swale design throughout the construction sequence. Specifically, barriers should be installed at key check dam locations, erosion control fabric should be used to protect the channel, and excavation should be no deeper than 2 feet above the proposed invert of the bottom of the planned underdrain. Water quality swales that lack underdrains (and rely on filtration) must be fully protected by silt fence or construction fencing to prevent compaction by heavy equipment during construction.

Step 2. Installation should begin after the entire contributing drainage area has been stabilized by vegetation. The designer should check the boundaries of the contributing drainage area to ensure it conforms to original design.

Additional EPSC may be needed during swale construction, particularly to divert stormwater from the water quality swale until the filter bed and side slopes are fully stabilized. Pretreatment cells should be excavated first to trap sediments before they reach the planned filter beds.

Step 3. Excavators or backhoes should work from the sides to excavate the water quality swale area to the appropriate design depth and dimensions. Excavating equipment should have scoops with adequate reach so they do not have to sit inside the footprint of the water quality swale area.

Step 4. The bottom of the water quality swale should be ripped, roto-tilled or otherwise scarified at a depth of 12 inches to promote greater infiltration.

Step 5. Place the stone needed for storage layer over the filter bed. Perforate the underdrain pipe and check its slope. Add the remaining stone jacket, and then pack #57 stone to 3 inches above the top of the underdrain, and then add 3 inches of choker stone as a filter layer.

Step 6. Add the soil media in 12-inch lifts until the desired top elevation of the water quality swale is achieved. Wait a few days to check for settlement, and add additional media as needed.

Step 7. Install check dams and internal pretreatment features, as specified in the plan.

Step 8. Prepare planting holes for specified trees, shrubs, and grasses install erosion control fabric where needed, and install any temporary irrigation.

Step 9. Plant landscaping materials as shown in the landscaping plan, and water them weekly during the first 2 months. The construction contract should include a care and replacement warranty to ensure that vegetation is properly established and survives during the first growing season following construction.

Step 10. Conduct a final construction inspection and develop a punch list for facility acceptance.

8.3 CONSTRUCTION INSPECTION

Inspections are needed during construction to ensure that the water quality swale is built in accordance with these specifications. Detailed inspection checklists should be used that include sign-offs by qualified individuals at critical stages of construction, to ensure that the contractor's interpretation of the plan is consistent with the designer's intent. Some common pitfalls can be avoided by careful construction supervision that focuses on the following key aspects of water quality swale installation.

- Check the filter media to confirm that it meets specifications and is installed to the correct depth.
- Check elevations such as the invert of the underdrain, inverts for the inflow and outflow points, and the ponding depth provided between the surface of the filter bed and the overflow structure.
- Ensure that caps are placed on the upstream (but not the downstream) ends of the underdrains.
- Inspect check dams and pretreatment structures to make sure they are properly installed and working effectively.
- Check that outfall protection/energy dissipation measures at concentrated inflow and outflow points are stable.

The real test of a water quality swale occurs after its first big storm. The post-storm inspection should focus on whether the desired sheet flow, shallow concentrated flows or fully concentrated flows assumed in the plan actually occur in the field. Also, inspectors should check that the water quality swale drains completely within 24 hour drawdown period. Minor adjustments are normally needed as a result of this post-storm inspection (e.g., spot reseeding, gully repair, added armoring at inlets or outfalls, and check dam realignment.

SECTION 9: AS-BUILT REQUIREMENTS

As-built and certification requirements can be found in **Appendix D**. Please reference the appendix, as required components of the as-built differ from measure to measure.

SECTION 10: MAINTENANCE

10.1 MAINTENANCE DOCUMENT

Each BMP must have a City of Franklin Long Term Maintenance Plan (LTMP) Agreement submitted for approval and maintained and updated by the BMP owner. The LTMP Agreement must be completed and submitted to the City with the grading permit application. The LTMP Agreement is for the use of the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the long term maintenance plan and agreement.

10.2. MAINTENANCE INSPECTIONS

Annual inspections are used to trigger maintenance operations such as sediment removal, spot revegetation and inlet stabilization. The following is a list of several key maintenance inspection points:

- Add reinforcement planting to maintain 95% turf cover or vegetation density. Reseed or replant any dead vegetation.
- Remove any accumulated sand or sediment deposits on the filter bed surface or in pretreatment cells.
- Inspect upstream and downstream of check dams for evidence of undercutting or erosion and remove trash or blockages at weepholes.
- Examine filter beds for evidence of braiding, erosion, excessive ponding or dead grass.
- Check inflow points for clogging and remove any sediment.
- Inspect side slopes and grass filter strips for evidence of any erosion, and repair as needed.
- Look for any bare soil or sediment sources in the contributing drainage area and stabilize immediately.

Ideally, yearly inspections should be conducted in the spring of each year and yearly inspection reports submitted to the City by July 1.

10.3 ROUTINE MAINTENANCE AND OPERATION

Once established, water quality swales have minimal maintenance needs outside of the spring clean-up, regular mowing of pretreatment areas only if needed, and pruning and management of trees and shrubs. The surface of the filter bed can become clogged with fine sediment over time, but this can be alleviated through core aeration or deep tilling of the filter bed. Additional effort may be needed to repair check dams, stabilize inlet points and remove deposited sediment from pretreatment cells.