Appendix IX:

Wisconsin Department of Transportation (WisDOT) Erosion Control Matrices; Wisconsin Department of Natural Resources (WDNR) Conservation Practice Standards (NRCS Best Management Practices)

CHANNEL EROSION CONTROL MATRIX
(Concentrated Flow Application)

TYPE OF EROSION CONTROL DEVICE	PERMISSIBLE SHEAR LB/S.F.	DITCH GRADE															REMARKS
		< 2%			2% - 4%			4% - 6%			6% - 9%*			9% - 12%*			
		Max. Length (ft.)			Max. Length (ft.)			Max. Length (ft.)			Max. Length (ft.)			Max. Length (ft.)			
		300	600	1200	300	600	1200	300	600	1200	300	600	1200	300	600	1200	
Seed with properly anchored mulch	0.6	▬	▬														Anchor mulch per specifications.
Sod ditch checks with seed and mulch	N/A	▬	▬	▬	▬	C											Install one ditch check for every 1 foot of drop. Sod stakes required.
Temporary ditch checks (hay bales or approved manufactured alternatives lisited in the WisDOT PAL)	N/A	▬	▬	▬	▬	▬	▬										Install one ditch check for every 2 feet of drop. Maximum 200' spacing. Not recommended for slopes less than 1%.
Sod ditch liner	1.0	▬	▬	▬													Upstream end must be buried. Additional sod stakes required.
Double netted light duty (WisDOT Class I Type B) erosion mat	1.5	▬	▬	▬	▬	▬	▬	▬									Only mat type products allowed.
Sod reinforced with a double netted jute (WisDOT Class II Type A) erosion mat	1.5	▬	▬	▬	▬	▬											Upstream end must be buried. Additional sod stakes required. Two bid items needed.
Stone or rock ditch checks, or Rock-Filled Filter Bags	N/A	▪ ▪	▪ ▪	▪ ▪	▬	▬	▬	▬	▬	▬							Use No. 2 coarse aggregate, railroad ballast, or breaker run. Install one ditch check for every 2 feet of drop. Use in conjunction with a channel lining.
Medium duty coconut erosion mat (WisDOT Class II Type B or C)	2.0	▪ ▪	▪ ▪	▪ ▪	▬	▬	▬	▬	▬	⊗	▬						
Heavy duty synthetic (WisDOT Class III Type A) erosion mat or turf reinforcement mat (WisDOT Class III Type B)	2.0	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▬	▬	▬	▬						Germination may be a problem with Class III Type A mats. An ECRM is required for initial erosion protection for Class III Type B mats.
Heavy duty synthetic turf reinforcement (WisDOT Class III Type C) mat	3.5	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▬	▬	▬	▬			An ECRM is required for initial erosion protection. Contact manufacturer if higher shears are needed.
Riprap ditch checks	N/A	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▬	▬	▬	▬	▬		Place top of downstream ditch check level with bottom of upstream ditch check. Use in conjunction with a channel lining.
Heavy duty synthetic turf reinforcement (Class III Type D) mat	5	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	An ECRM is required for initial erosion protection. Contact manufacturer if higher shears are needed.
Light riprap	4	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▬	▬	▬	▬		Outfalling, overtopping and scour need to be addressed. Use 2' minimum ditch depth.
Medium riprap	5	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▬	
Heavy riprap	8	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	▪ ▪	

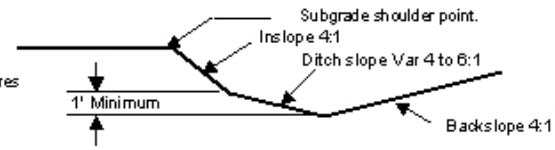
Riprap measures apply to all ditch types. Use of these measure requires engineering judgement and design.

CHANNEL EROSION CONTROL MATRIX
(Concentrated Flow Application)

TYPE OF EROSION CONTROL DEVICE	PERMISSIBLE SHEAR LB/S.F.	DITCH GRADE < 2% Max. Length (ft.) 300	600	1200	2%- 4% Max. Length (ft.) 300	600	1200	4%- 6% Max. Length (ft.) 300	600	1200	6%- 9%* Max. Length (ft.) 300	600	1200	9%- 12%* Max. Length (ft.) 300	600	1200	REMARKS
Grouted rip rap	N/A	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	Address outfalling, overtopping and scour. Line with Grotextile fabric Type "HR", (see Chap. 10, Const. Detail and special provision). Use 2' minimum ditch depth.
Articulated Concrete Block Type A	5	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■							ACBs apply to all ditch types. Use of these measures requires engineering judgement and design.
Articulated Concrete Block Type B	10	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■			
Articulated Concrete Block Type C	15	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	
Articulated Concrete Block Type D	20	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	
Articulated Concrete Block Type E	30	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	■ ■ ■	

Standard Ditch Section

Erosion control for ditches not conforming to the typical at right, that complies with FDM procedures 11-15-1 Figures 6 & 7, should be designed according to FDM Chapter 13.



KEY

Effective range of device for Sandy or Clayey Soil: ■■■■■■■■

Device applicable, may not be cost effective: ■ ■ ■ ■ ■ ■ ■ ■

" C " effective for clayey soil only

Not applicable. Use in conjunction with other BMPs: ⊗

ECRM - Erosion control revegetation mat. All Class I and II mats are ECRMs.
TRM - Turf reinforcement mat.
FDM - WisDOT Facilities Development Manual
BMP - Best Management Practice
PAL - See Note 6

* For ditch grades over 9% special design considerations may be required.
** Soils that are not sandy should be treated as clay soils.

NOTES

1) Ditch flow rates used to develop bar chart are based on a 60 ft. right of way from pavement centerline and a 2-Yr. rainfall event for temporary liners or a 25-Yr. rainfall event for permanent (Class III mat or riprap) liners. If the drainage area extends outside the 60 foot right of way or unusual flows are expected, use the shear stress column values to determine the suitablity of a liner. See FDM procedures in Chapter 10 and in Section 13-30-10.
2) Erosion mats shall extend upslope 1.0 ft. min. vertically from the ditch bottom or 6" higher than the design flow depth. There shall be no joints within 18" of the low point.
3) Cost shall be a consideration in the selection of these devices.
4) Add sediment traps at the bottom of channel slopes.
5) Refer to FDM Chapter 10 for any channels exceeding the limits shown.
6) Approved materials for erosion products are referenced from the Wisconsin Department of Transportation Erosion Control Product Acceptability Lists (PAL), found at the web site: http://www.dot.wisconsin.gov/business/engrserv/pal.htm
7) On long or steep channels that require a higher class mat, use the appropriate lower class mat for the first 300 ft to 600 ft of the channel.
8) Effective erosion control involves minimizing the amount of time soil is exposed and the selection of a combination of practices, and not reliance on just one practice.

SLOPE EROSION CONTROL MATRIX

TYPE OF EROSION CONTROL	SLOPE																		REMARKS
	6:1 or flatter (7)			4:1			3:1			2.5:1			2:1			1:1			
	SLOPE LENGTH			SLOPE LENGTH			SLOPE LENGTH			SLOPE LENGTH			SLOPE LENGTH			SLOPE LENGTH			
	0 - 30'	30 - 60'	60 - 120'	0 - 30'	30 - 60'	60 - 120'	0 - 30'	30 - 60'	60 - 120'	0 - 30'	30 - 60'	60 - 120'	0 - 30'	30 - 60'	60 - 120'	0 - 30'	30 - 60'	60 - 120'	
Seed with properly anchored mulch	▬	▬	▬	▬	▬	▬	▬	▬											
Single netted light duty (WisDOT Class I Type A) erosion mat	▪	▪	▪	▪	▪	▪	▬	▬	▬	▬	▬								
Light duty single netted 100% biodegradeable (WisDOT Urban Type A) erosion mat	▬	▬	▬	▬	▬	▬													Use only 100% biodegradeable anchors for urban mats.
Light duty double netted 100% biodegradeable (WisDOT Urban Type B) erosion mat	▪	▪	▪	▬	▬	▬	▬	▬	▬	▬									Use only 100% biodegradeable anchors for urban mats.
Bonded Mulch (WisDOT Type A Soil Stabilizer)	▪	▪	▪	▬	▬	▬	▬	▬											May be applied over Class III Type B, C, or D mats in place of erosion control revegetation mats.
Polymer (WisDOT Type B Soil Stabilizer)	Used in conjunction with other BMPs effective up to a 2:1 slope. Not effective in sand. When used alone effective up to a 3:1 slope. Stand alone use appropriate for earthen stock piles, temporary, and late season applications																		
Double netted light duty (WisDOT Class I Type B) erosion mat	▪	▪	▪	▪	▪	▪	▬	▬	▬	▬	▬	⊗	▬						
Sod	▪	▪	▪	▪	▪	▪	▬	▬	▬	▬	▬	⊗	▬						
Medium duty coconut erosion mat (WisDOT Class II Type B or C)	▪	▪	▪	▪	▪	▪	▪	▪	▬	▬	▬	▬	▬	▬					
Sod reinforced with a double netted jute (WisDOT Class II Type A) erosion mat	▪	▪	▪	▪	▪	▪	▪	▪	▬	▬	▬	⊗	▬	▬					Sod stakes required. Two bid items needed.
Heavy duty synthetic erosion control revegetation mat (WisDOT Class III Type A)	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▬	▬	▬				Germination may be a problem with Class III Type A mats
Riprap	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▬	▬	▬				Angle of repose must be considered, see FDM Chapter 13.
Heavy duty synthetic turf reinforcement (WisDOT Class III Type B or C) mat	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▬	▬	▬	▬			A soil stabilizer or ECRM will be required for initial erosion protection.
Heavy duty synthetic turf reinforcement (WisDOT Class III Type D) mat	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▬	▬	▬	▬	▬	▬	A soil stabilizer or ECRM will be required for initial erosion protection.
Slope paving or grouted riprap	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	Consider clear zone requirements. Only use in limited circumstances such as overflow areas near bridges.

SLOPE EROSION CONTROL MATRIX

Benches	Consider benches when cuts exceed 20', bench at approximately 15' vertical intervals to collect and drain water. Treat benches as channels (ditches). Adjust elevations to provide drainage. Consider flumes at transitions.
Intercepting embankments	Used to intercept runoff from abutting lands. Flumes may be necessary to direct runoff.
Silt fence	Used at toe of slopes to intercept and detain small amounts of sediment. Use only WisDOT approved silt fence as listed in the PAL.
Temporary ditch checks or Erosion bales	Used at toe of slopes to intercept and detain small amounts of sediment.
Slope drains/flumes	May be necessary on slopes (see channel matrix for design guidance).
Sediment traps	Used to trap sediment laden runoff. Could be used at the inlet or outlet end of slope drain.

KEY:

Not applicable. Use in conjunction with other BMPs: ⊗

Effective range of device for Sandy or Clayey Soil: ▬▬▬▬▬▬

Device applicable, may not be cost effective: ▪ ▪ ▪ ▪ ▪ ▪ ▪

* Soils that are not sandy should be treated as clay soils.

ECRM - Erosion control revegetation mat. All Class I and II mats are ECRMs.
TRM - Turf reinforcement mat.
FDM - WisDOT Facilities Development Manual
PAL - See Note 5

NOTES

1) Cost shall be a consideration in the selection of these devices.
2) Designers should review FDM Chapter 10 prior to selection of erosion mats.
3) Install intercepting ditches to limit slope lengths to 15' vertical intervals. (See FDM Chapter 10)
4) Refer to FDM Chapter 10 for any slopes exceeding the limits shown.
5) Approved materials for erosion products are referenced from the Wisconsin Department of Transportation Erosion Control Product Acceptability Lists (PAL), found at the web site: http://www.dot.wisconsin.gov/business/engrserv/pal.htm
6) On steeper slopes that require a higher class mat, use the appropriate lower class mat or seed and mulch for the first 30 ft to 60 ft of the slope.
7) Unless project conditions require otherwise, seed and mulch all slopes that are flatter than a 5% grade, regardless of length. If practicable, bench the slopes.
8) Effective erosion control involves minimizing the amount of time soil is exposed and the selection of a combination of practices, and not reliance on just one practice.

Wet Detention Pond
(1001)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A permanent pool of water with designed dimensions, inlets, outlets and storage capacity, constructed to collect, detain, treat and release stormwater runoff.

II. Purposes

The primary purposes of this practice are to improve water quality and reduce peak flow.

III. Conditions Where Practice Applies

This practice applies to urban sites where stormwater runoff pollution due to particulate solids loading and attached pollutants is a concern. It also applies where increased runoff from urbanization or land use change is a concern. Site conditions must allow for runoff to be directed into the pond and a permanent pool of water to be maintained.

This standard establishes criteria for ponds to detain stormwater runoff, although some infiltration may occur. In some instances, detention ponds may present groundwater contamination risks, and this standard sets criteria for determining when liners may be necessary to address risks to groundwater. Where the detention pond will be discharging to an infiltration practice, see WDNR Conservation Practice Standards 1002-1004.

Application of this standard is not intended to address flood control. Modifications to the peak flow criteria or additional analysis of potential flooding issues may be needed or required by local authorities. For ponds used during the construction period, see WDNR Conservation Practice Standard 1064, Sediment Basin.

This practice provides a method to demonstrate that a wet detention pond achieves the total suspended solids (TSS) reduction and peak flow control required by NR 151.12, Wis. Adm. Code, for post-construction sites. Pollutant loading models such as SLAMM, P8, DETPOND or equivalent methodology may also be used to evaluate the efficiency of the design in reducing TSS.

IV. Federal, State and Local Laws

The design, construction and maintenance of wet detention ponds shall comply with all federal, state and local laws, rules or regulations. The owner/operator is responsible for securing required permits. This standard does not contain the text of any federal, state or local laws governing wet detention ponds.

The location and use of wet detention ponds may be limited by regulations relating to stormwater management, navigable waters (Ch. 30, Wis. Stats.), floodplains, wetlands, buildings, wells and other structures, or by land uses such as waste disposal sites and airports. The pond embankment may be regulated as a dam under Ch. 31, Wis. Stats., and further restricted under NR 333, Wis. Adm. Code, which includes regulations for embankment heights and storage capacities.

V. Criteria

The following minimum criteria apply to all wet detention pond designs used for the purposes stated in Section II of this standard. Use more restrictive criteria as needed to fit the conditions found in the site assessment.

A. Site Assessment – Conduct and document a site assessment to determine the site characteristics that will affect the placement, design, construction and maintenance of the pond. Document the pond design. Items to assess include:

1. At the pond site, on a site map:

    a. Identify buildings and other structures, parking lots, property lines, wells, wetlands, 100-year floodplains, surface

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

drains, navigable streams, known drain tile, roads, and utilities (both overhead and buried) showing elevation contours and other features specified by the applicable regulatory authority.

b. Show location of soil borings and test pits on site map, characterize the soils, *seasonally high groundwater level*[1], and *bedrock* conditions to a minimum depth of 5 feet below the proposed bottom of the pond or to bedrock, whichever is less. Conduct one test pit or boring per every 2 acres of permanent pool footprint, with a minimum of two per pond. Include information on the soil texture, color, structure, moisture and groundwater indicators, and bedrock type and condition, and identify all by elevation. Characterize soils using both the USDA and USCS classification systems.

Note: USCS characterization is used for soil stability assessment while USDA soil characterization identifies the soil's potential permeability rate.

c. Investigate the potential for *karst features* nearby.

2. In the watershed, on a watershed map:

a. Identify predominant soils, the drainage ways, navigable streams and floodways, wetlands, available contour maps, land cover types and known karst features. Identify the receiving surface waters, or whether the drainage basin drains directly to groundwater.

b. Show channels and overland flow before and after development, contours, and property lines.

c. Refer to the Tc (time of concentration) flow paths and subwatershed boundaries used in runoff calculations.

B. Pond Design – Properly designed wet detention ponds are effective at trapping smaller particles, and controlling peak flows (see App. C, Figures 1-3).

1. Water Quality – Pollutant reduction (TSS and phosphorus) is a function of the permanent pool area and depth, the outlet structure and the active storage volume. The following criteria apply:

a. Permanent Pool – The elevation below which runoff volume is not discharged and particles are stored.

i. Design ponds to include a permanent pool of water. The surface area of the permanent pool is measured at the invert of the lowest outlet. The minimum surface area of the permanent pool must address the total drainage area to the pond.

Note: Use App. A for the initial estimate of the permanent pool area based on drainage area. Prorate values for mixed land uses.Use Equation 1 to solve for q_o and iterate as needed.

ii. The permanent pool surface area is sized based on the particle size and the peak outflow during the 1-yr., 24-hour design storm using Equation 1:

$$\mathbf{S_a = 1.2 * (q_o / v_s)} \text{ [Equation 1(a)]}$$

or

$$\mathbf{q_o = (v_s * S_a) / 1.2} \text{ [Equation 1(b)]}$$

Where:

$\mathbf{S_a}$ = Permanent pool surface area measured at the invert of the lowest outlet of the wet detention pond (square feet)

$\mathbf{q_o}$ = Post-construction peak outflow (cubic feet/second) during the 1-yr., 24-hour design storm for the principal outlet

$\boldsymbol{v_s}$ = Particle settling velocity (feet/second)

1.2 = EPA recommended safety factor

iii. Particle settling velocities (v_s) shall be based on representative particle sizes for the desired percent TSS reduction.

- 80% (3 micron): $v_s = 1.91 \times 10^{-5}$ ft./sec.
- 60% (6 micron): $v_s = 7.37 \times 10^{-5}$ ft./sec.
- 40% (12 micron): $v_s = 2.95 \times 10^{-4}$ ft./sec.

Note: Particle settling velocities were calculated assuming a specific gravity of 2.5, a water temperature of 50 degrees Fahrenheit (10 degrees C) and a kinematic viscosity of 0.01308 $cm.^2/sec.$ (Pitt, 2002). The calculations also assume discrete and quiescent settling conditions per Stoke's Law.

b. Active Storage Volume – Volume above the permanent pool that is released slowly to settle particles. Calculate the volume with the following method:

Use a hydrograph-producing method, such as the one outlined in Natural Resources Conservation Service, Technical Release 55 (TR-55), to determine the storage volume for detention ponds. This can be accomplished by using App. B where:

$\mathbf{q_o}$ = Peak outflow during the 1-yr., 24-hour design storm for the principal outlet calculated using Equation 1 (see V.B.1.a.ii).

$\mathbf{q_i}$ = Calculated post-construction peak inflow or runoff rate during the 1-yr., 24-hour design storm.

$\mathbf{V_R}$ = Calculated volume of runoff from the 1-year, 24-hour design storm for the entire contributory area.

$\mathbf{V_S}$ **=** The required active storage volume determined using App. B.

Note: This method may require iterative calculations.

c. Safety – Include a safety shelf (or aquatic shelf) that extends a minimum of 8 ft. from the edge of the permanent pool waterward with a slope of 10:1 (horizontal:vertical) or flatter. The maximum depth of the permanent pool of water over the shelf shall be 1.5 ft.

d. Depth – The average water depth of the permanent pool shall be a minimum of 3 ft., excluding the safety shelf area and sediment storage depth.

e. Length to Width – Maximize the length to width ratio of the flow path to prevent short-circuiting and dead zones (areas of stagnant water). See Section VII, Considerations D and N for options to prevent short circuiting.

f. Sediment Storage – After all construction has ceased and the contributory watershed has been stabilized, one of the following applies:

i. A minimum of 2 ft. shall be available for sediment storage (for a total of 5 ft. average depth, excluding the safety shelf area). For ponds greater than 20,000 sq. ft., 50% of the total surface area of the permanent pool shall be a minimum of 5 ft. deep. For ponds less than 20,000 sq. ft., maximize the area of 5 ft. depth.

ii. Modeling shows that for 20 years of sediment accumulation, less than 2 ft. sediment storage is needed (not to be less than 0.5 feet).

iii. A minimum of 4 ft. shall be available for sediment storage if the contributory area includes cropland not stabilized by any other practice, such as strip cropping, terraces and conservation tillage.

For information on sediment storage in forebays, see Section VII, Consideration C.

Note: Municipalities that use sand in the winter may consider increasing the sediment storage depth.

g. Side Slopes Below Safety Shelf – All side slopes below the safety shelf shall be 2:1 (horizontal:vertical) or flatter as required to maintain soil stability, or as required by the applicable regulatory authority.

h. Outlets – Wet detention ponds shall have both a principal outlet and an emergency spillway.

i. Prevent Damage – Incorporate into outlet design trash accumulation preventive features, and measures for preventing ice damage and scour at the outfall. Direct outlets to channels, pipes, or similar

conveyances designed to handle prolonged flows.

ii. Principal Water Quality Outlet – Design the outlet to control the proposed 2-yr., 24-hour discharge from the pond within the primary principal outlet without use of the emergency spillway or other outlet structures. If a pipe discharge is used as the primary principal outlet, then the minimum diameter shall be 4 inches. Where an orifice is used, features to prevent clogging must be added.

iii. Backward Flow – Any storm up to the 10-yr., 24-hour design storm shall not flow backward through the principal water quality outlet or principal outlet. Flap gates or other devices may be necessary to prevent backward flow.

iv. Emergency Spillway – All ponds shall have an emergency spillway. Design the spillway to safely pass peak flows produced by a 100-yr., 24-hour design storm routed through the pond without damage to the structure. The flow routing calculations start at the permanent pool elevation.

v. Peak Flow Control – Design the peak flow control to maintain stable downstream conveyance systems and comply with local ordinances or conform with regional stormwater plans where they are more restrictive than this standard. At a minimum:

a) The post-development outflow shall not exceed pre-development peak flows for the 2-yr., 24-hour design storm.

b) Use a hydrograph-producing method such as TR-55 for all runoff and flow calculations.

c) When pre-development land cover is cropland, use the runoff curve numbers in Table 1, unless local ordinances are more restrictive.

d) For all other pre-development land covers, use runoff curve numbers from TR-55 assuming "good hydrologic conditions."

e) For post-development calculations, use runoff curve numbers based on proposed plans.

Note: Local ordinances may require control of larger storm events than the 2-yr., 24-hour storm. In these cases, additional or compound outlets may be required.

Table 1 - Maximum Pre-Development Runoff Curve Numbers for Cropland Areas

Hydrologic Soil Group	A	B	C	D
Runoff Curve Number	55	69	78	83

2. Other Pond Criteria

a. Inflow Points – Design all inlets to prevent scour during peak flows produced by the 10-yr., 24-hr. design storm, such as using half-submerged inlets, stilling basins and rip-rap. Where infiltration may initially occur in the pond, the scour prevention device shall extend to the basin bottom.

b. Side Slopes – All interior side slopes above the safety shelf shall be 3:1 (horizontal:vertical), or flatter if required by the applicable regulatory authority.

c. Ponds in Series – To determine the overall TSS removal efficiency of ponds in series, the design shall use an *approved model* such as DETPOND or P8, that can track particle size distribution from one pond to the next.

d. Earthen Embankments – Earthen embankments (see App. C, Figure 3) shall be designed to address potential risk and structural integrity issues such as seepage and saturation. All constructed earthen embankments shall meet the following criteria.

i. Vegetation – Remove a minimum of 6 in. of the parent material (including all vegetation, stumps, etc.) beneath the proposed base of the embankment.

ii. Core Trench or Key-way – For embankments where the permanent pool is ponded 3 ft. or more against the embankment, include a core trench or key-way along the centerline of the embankment up to the permanent pool elevation to prevent seepage at the joint between the existing soil and the fill material. The core trench or key-way shall be a minimum of 2 ft. below the existing grade and 8 ft. wide with a side slope of 1:1 (horizontal:vertical) or flatter. Follow the construction and compaction requirements detailed in V.B.2.d.iii below for compaction and fill material.

iii. Materials – Construct all embankments with non-organic soils and compact to 90% standard proctor according to the procedures outlined in ASTM D-698 or by using compaction requirements of USDA Natural Resources Conservation Service, Wisconsin Construction Specification 3. Do not bury tree stumps, or other organic material in the embankment. Increase the constructed embankment height by a minimum of 5% to account for settling.

iv. Freeboard – Ensure that the top of embankment, after settling, is a minimum of 1 vertical foot above the flow depth for the 100-yr., 24-hr. storm.

v. Pipe Installation, Bedding and Backfill – If pipes are installed after construction of the embankment, the pipe trench shall have side slopes of 1:1 or flatter. Bed and backfill any pipes extending through the embankment with embankment or equivalent soils. Compact the bedding and backfill in lifts and to the same standard as the original embankment.

vi. Seepage – Take measures to minimize seepage along any conduit buried in the embankment. Measures such as anti-seep collars, sand diaphragms or use of bentonite are acceptable.

vii. Exterior side slopes shall be 2:1 (horizontal:vertical) or flatter, with a minimum top width of the embankment of 4 ft., or 10 ft. if access for maintenance is needed. The embankment must be designed for slope stability.

e. Topsoil and Seeding – Spread topsoil on all disturbed areas above the safety shelf, as areas are completed, to a minimum depth of 4 inches. Stabilize according to the permanent seeding criteria in WDNR Conservation Practice Standard 1059, Seeding for Construction Site Erosion Control.

f. Liners – Use the Liner Flowchart in App. D to determine when a liner is needed. For types of liners, see the Liner Flowchart and specifications in App. D. If a liner is used, provide a narrative that sets forth the liner design and construction methods.

Note: Some municipalities have wellhead protection areas and all municipalities have source water protection areas delineated by WDNR. Consult with the local community about when a liner will be needed if located within one of these areas.

g. Depth to Bedrock – The separation distance from the proposed bottom of a wet detention pond to bedrock will determine which of the following apply:

i. If the separation distance is a minimum of 5 ft. and the soil beneath the pond to bedrock is 10% fines or more, refer to the Liner Flowchart to determine if a liner may be needed for reasons other than proximity to bedrock;

ii. If the separation distance is a minimum of 3 ft. and the soil beneath the pond to bedrock is 20% fines or more, refer to the Liner Flowchart to determine if a liner may be needed for reasons other than proximity to bedrock;

iii. If conditions in (i) or (ii) are not met, then a Type B liner is required at a minimum. Refer to the Liner

Flowchart to determine if a Type A liner may be needed for reasons other than proximity to bedrock (see liner specifications in App. D);

iv. If blasting in bedrock is performed to construct a wet detention pond in bedrock, then a Type A liner is required (see liner specifications in App. D) and an engineering design must be conducted.

h. Separation from Wells – Wet detention ponds shall be constructed 400 feet from community wells (NR 811, Wis. Adm. Code) and 25 feet from non-community and private wells (NR 812, Wis. Adm. Code).

Note: The 25 foot setback from non-community and private wells is a final construction distance. This may not be sufficient to prevent running over the well with heavy equipment during construction of the pond.

i. Wetlands – For wet detention ponds that discharge to wetlands, use level spreaders or rip-rap to prevent channelization, erosion and reduce sedimentation in the wetlands.

j. Off-site runoff – Address off-site runoff in the design of a wet detention pond.

k. Aerators/Fountains – If an aerator or fountain is desired for visual and other aesthetic effects (aerators designed to mix the contents of the pond are prohibited) they must meet one of the first two items (i – ii), and items (iii) and (iv) below.

i. Increase the surface area of the wet detention pond beyond the area needed to achieve compliance with a stormwater construction site permit. The increase in surface area is equal to or greater than the *area of influence* of the aerator/fountain. Use an aerator/fountain that does not have a *depth of influence* that extends into the sediment storage depth (see App. E, Figure 4).

ii. For wet detention ponds where the surface area is no more than required to meet the stormwater construction site permit conditions, the depth of influence of the device cannot extend below the sediment storage elevation. Include in the design an automatic shut-off of the aerator/fountain as the pond starts to rise during a storm event. The aerator/fountain must remain off while the pond depth returns to the permanent pool elevation and, further, shall remain off until such time as required for the design micron particle size to settle to below the draw depth of the pump. (See V.B.1.a.iii for the design micron particle sizes that correlate with a TSS reduction.)

iii. Aerator/fountains are not allowed in wet detention ponds with less than a 5 ft. permanent pool designed depth.

iv. Configure the pump intake to draw water primarily from a horizontal plane so as to minimize the creation of a circulatory pattern from bottom to top throughout the pond.

VI. Operation and Maintenance

Develop an operation and maintenance plan that is consistent with the purposes of this practice, the wet detention pond's intended life, safety requirements and the criteria for its design. The operation and maintenance plan will:

A. Identify the responsible party for operation, maintenance and documentation of the plan.

B. Require sediment removal once the average depth of the permanent pool is 3.5 ft. At a minimum, include details in the plan on inspecting sediment depths, frequency of accumulated sediment removal, and disposal locations for accumulated sediment (NR 500, Wis. Adm. Code).

C. Include inlet and outlet maintenance, keeping embankments clear of woody vegetation, and providing access to perform the operation and maintenance activities.

D. Identify how to reach any forebay, safety shelf, inlet and outlet structures.

E. Address weed or algae growth and removal, insect and wildlife control and any landscaping practices.

F. If a liner is used, show how the liner will be protected from damage during sediment removal or when the liner is undergoing repair.

G. Prohibit excavation below the original design depth unless geotechnical analysis is completed in accordance with V.A.1.b & c.

VII. Considerations

Consider the following items for all applications of this standard:

A. Additional conservation practices should be considered if the receiving water body is sensitive to temperature fluctuations, oxygen depletion, excess toxins or nutrients.

B. To prevent nuisance from geese, consider not mowing around the pond perimeter. To maximize safety and pollutant removal, consider spreading topsoil along the safety shelf to promote plant growth.

C. For ease of maintenance, a sediment forebay should be located at each inlet (unless inlet is < 10% of total inflow or an equivalent upstream pretreatment device exists) to trap large particles such as road sand. The storage volume of the sediment forebay should be consistent with the maintenance plan, with a goal of 5%-15% of the permanent pool surface area. The sediment forebay should be a minimum depth of 3 ft. plus the depth for sediment storage.

D. The length to width ratio of the flow path should be maximized with a goal of 3:1 or greater. The flow path is considered the general direction of water flow within the pond, including the permanent pool and forebay.

E. Consider providing additional length to the safety shelf, above or below the wet pool elevation, to enhance safety.

F. To prevent damage or failure due to ice, all risers extending above the pond surface should be incorporated into the pond embankment.

G. The use of underwater outlets should be considered to minimize ice damage, accumulation of floating trash or vortex control.

H. Watershed size and land cover should be considered to ensure adequate runoff volumes to maintain a permanent pool.

I. Aesthetics of the pond should be considered in designing the shape and specifying landscape practices. Generally, square ponds are aesthetically unappealing.

J. If downstream flood management or bank erosion is a concern, consider conducting a watershed study to determine the most appropriate location and design of stormwater management structures, including consideration of potential downstream impacts on farming practices and other land uses.

K. For wet detention ponds with surface area more than 2 acres or where the fetch is greater than 500 feet, consider reinforcing banks, extending the safety shelf, vegetating the safety shelf or other measures to prevent erosion of embankment due to wave action.

L. To prevent failure, consider reinforcing earthen emergency spillways constructed over fill material to protect against erosion.

M. All flow channels draining to the pond should be stable to minimize sediment delivery to the pond.

N. Baffles may be used to artificially lengthen the flow path in the pond. In some designs, a circular flow path is set up in a pond even when the inlet and outlet are next to each other and no baffles are used. Then the flow path can be calculated using the circular path.

O. Consider using low fertilizer inputs on the embankments and collecting the clippings.

P. Consider providing a method to facilitate dewatering during accumulated sediment removal.

Q. Consider using backflow preventers to minimize fish entrapment.

R. Consider providing a terrestrial buffer of 10-15 feet around the pond if it has low or no embankments.

S. Consider a hard surface for the bottom of the forebay to ease sediment removal.

T. Use of algaecides, herbicides or polymers to control nuisance growths or to enhance sedimentation must receive a permit under NR 107, Wis. Adm. Code. Contact the appropriate DNR specialist.

U. Consider additional safety features beyond the safety shelf where conditions warrant them.

V. Consider vegetative buffer strips along drainage ways leading to the detention pond to help filter pollutants.

W. After the site assessment is complete, review and discuss it with the local administering agency at a pre-design conference to determine and agree on appropriate pond design for the site.

X. Design so that the 10-yr., 24-hour design storm does not flow through the emergency spillway. The 10-yr. design criteria protects the embankment from premature failure due to frequent or long-duration flows through the emergency spillway.

Y. Where practical, construct the emergency spillway on original grade.

Z. Conduct a groundwater boring to 15 feet below the pond and consider the historic "mottling marks" in assessing groundwater levels.

AA. For partially or fully submerged inlet pipes, consider using pipe ties or some other method to keep pipes from dislodging during frost movement.

BB. Consider employing a geotechnical engineer if stability of the embankment is a concern and to justify slopes steeper than 2.5:1.

CC. Assess potential environmental hazards at the site from previous land uses. The assessment should use historical information about the site to determine if the potential for environmental hazard exists, e.g., contaminated soils, contaminated groundwater, abandoned dumps or landfills. Contaminated areas can be located by reviewing the Bureau of Remediation and Redevelopment Tracking System (BRRTS), the DNR Registry of Waste Disposal Sites in Wisconsin and the Solid and Hazardous Waste Information System (SHWIMS) available through the WDNR website.

DD. Consider direct and indirect impacts to area wetland hydrology and wetland hydroperiod due to area hydrologic modifications that result from routing wetland source waters through a wet detention pond or releasing the discharge from a wet detention pond directly into a wetland.

EE. Consider conducting more than one test pit or boring per every 2 acres of permanent pool footprint, with a minimum of two per pond, if more are needed to determine the variability of the soil boundary or to identify perched water tables due to clay lenses. For the soils analysis, consider providing information on soil thickness, groundwater indicators—such as soil mottle or redoximorphic features—and occurrence of saturated soil, groundwater or disturbed soil.

FF. Where the soils are fine, consider groundwater monitoring if the groundwater table is less than 10 feet below the bottom of the wet pond because the water table may fluctuate seasonally. Other impacts on the groundwater table elevation may be from seasonal pumping of irrigation wells or the influence of other nearby wells. Monitoring or modeling may be necessary in these situations to identify the groundwater elevation.

GG. For additional guidance on seepage control for embankments, consult sections V.B.1.c and V.B.1.e(2) of NRCS Conservation Practice Standard 378, Pond, particularly if a wet detention pond's embankment is considered to be a dam.

VIII. Plans and Specifications

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use. Plans shall specify the materials, construction processes, location, size and elevations of all components of the practice to allow for certification of construction upon completion.

IX. References

Center for Watershed Protection, *Stormwater BMP Design for Cold Climates*, December 1997.

R. Pitt and J. Voorhees, *The Design and Use of Detention Facilities for Stormwater Management Using DETPOND*, 2000.

United States Department of Agriculture, Natural Resources Conservation Service, Conservation Practice Standard 378, *Pond*, July 2001.

United States Department of Agriculture, Natural Resources Conservation Service, *Engineering Field Handbook.*

United States Department of Agriculture, Natural Resources Conservation Service, *Ponds – Planning, Design, Construction*, Agriculture Handbook 590, revised September 1997.

United States Department of Agriculture, Natural Resources Conservation Service, Technical Release 55, *Urban Hydrology for Small Watersheds*.

United States Department of Agriculture, Natural Resources Conservation Service, *Wisconsin Field Office Technical Guide*, *Section IV*.

United States Department of Commerce, Weather Bureau, *Rainfall Frequency Atlas of the United States, Technical Paper 40*.

University of Wisconsin – Extension, *The Wisconsin Storm Water Manual, Part Four: Wet Detention Basins,* Publication No. G3691-P.

Wisconsin State Legislature, Revisor of Statutes Bureau, *Wisconsin Administrative Code*; for information on the codes of state agencies, including WDNR, see http://www.legis.state.wi.us/rsb/code.htm.

X. Definitions

Approved Model (V.B.2.c) – A computer model that is used to predict pollutant loads from urban lands and has been approved by the applicable regulatory authorities. SLAMM and P8 are examples of models that may be used to verify that a detention pond design meets the desired total suspended solids reduction.

Area of Influence (V.B.2.k.i) – The area of influence of an aerator/fountain is a function of the circular area of impact of the return water and the mixing area of the pump, whichever is greater.

Bedrock (V.A.1.b) – Consolidated rock material and weathered in-place material with > 50%, by volume, larger than 2 mm in size.

Depth of Influence (V.B.2.k.i) – The depth of influence of an aerator/fountain is a function of the impact depth of the return water and the draw depth of the pump, whichever is greater.

Karst Feature (V.A.1.c) – An area or surficial geologic feature subject to bedrock dissolution so that it is likely to provide a conduit to groundwater. May include caves, enlarged fractures, mine features, exposed bedrock surfaces, sinkholes, springs, seeps, swallets, fracture trace (linear feature, including stream segment, vegetative trend and soil tonal alignment), Karst pond (closed depression in a karst area containing standing water) or Karst fen (marsh formed by plants overgrowing a karst lake or seepage area).

Seasonally high groundwater level (V.A.1.b) – The higher of either the elevation to which the soil is saturated as observed as a free water surface in an unlined hole, or the elevation to which the soil has been seasonally or periodically saturated as indicated by soil color patterns throughout the soil profile.

Appendix A—Calculation of Preliminary Permanent Pool Surface Area for TSS Reduction [1]

		80%	60%
Land Use/Description/Management[2]	Total Impervious (%)[3]	Minimum Surface Area of the Permanent Pool (% of Watershed Area)	Minimum Surface Area of the Permanent Pool (% of Watershed Area)
Residential • < 2.0 units/acre (>1/2 acre lots) (low density • 2.0 - 6.0 units/acre (medium density) • > 6.0 units/acre (high density)	8 - 28 >28 -41 >41 - 68	0.7 0.8 1.0	0.3
Commercial/Office Park/Institutional/Warehouse/Industrial/Manufacturing/Storage[4] (Non-retail related business, multi-storied buildings, large heavily used outdoor parking areas, material storage, or manufacturing operations	<60 60-80 80-90 >90	1.8 2.1 2.4 2.8	0.6
Parks/Open Space/Woodland/Cemeteries	0-12	0.6	0.2
Highways/Freeways (Includes right-of-way area) • Typically grass banks/conveyance • Mixture of grass and curb/gutter • Typically curb/gutter conveyance	<60 60-90 >90	1.4 2.1 2.8	1.0

[1] Multiply the value listed by the watershed area within the category to determine the minimum pond surface area. Prorate for drainage areas with multiple categories due to different land use, management, percent impervious, soil texture, or erosion rates. For example, to achieve an 80% TSS reduction, a 50 acre (residential, 50% imperviousness) x 0.01 (1% of watershed from table) = 0.5 acre + 50 acres (office park, 85% imperviousness) x 0.024 (2.4% of watershed) = 1.2 acre. Therefore 0.5 acre + 1.2 acre = 1.7 acres for the minimum surface area of the permanent pool.

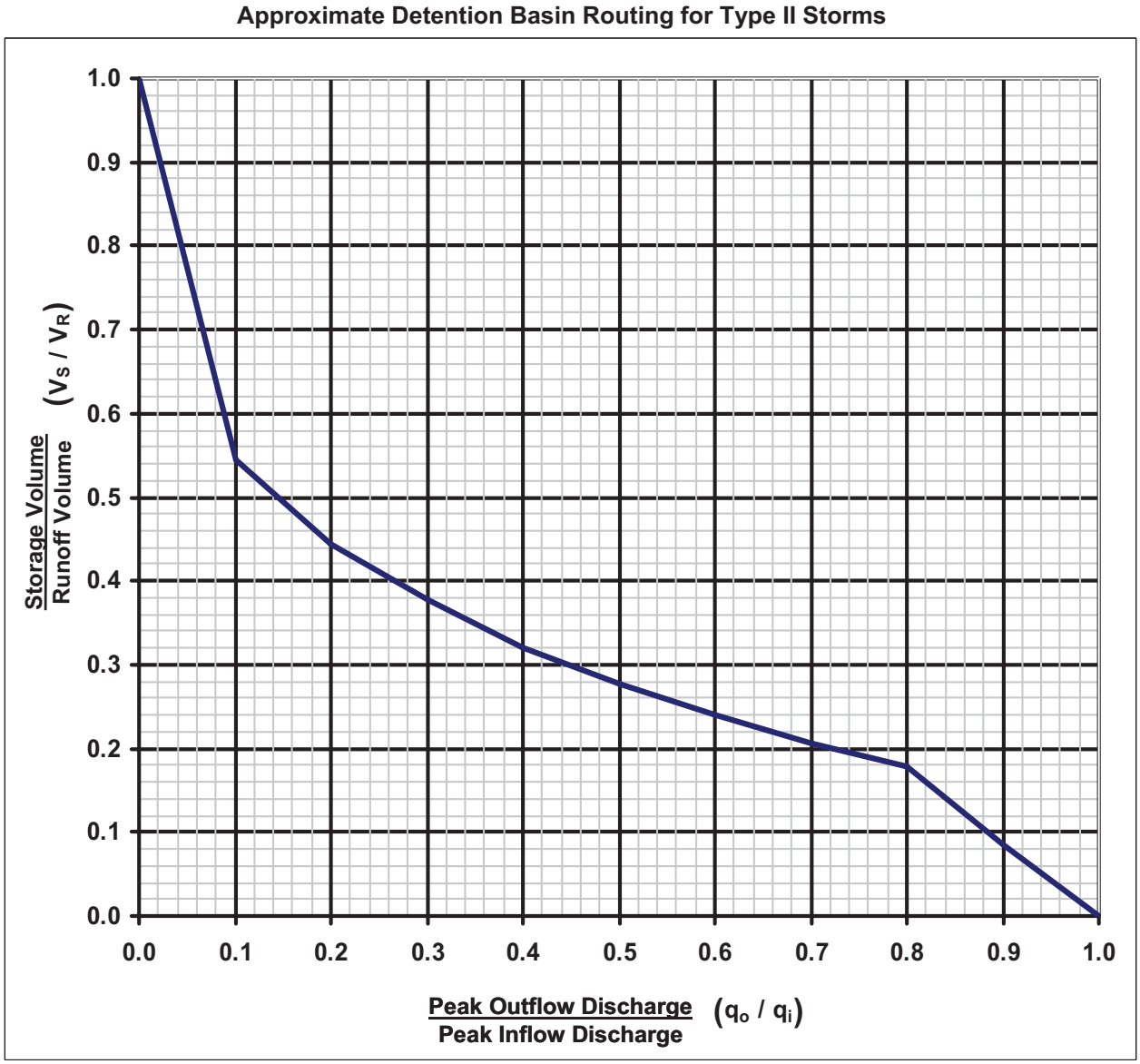
[2] For offsite areas draining to the proposed land use, refer to local municipalities for planned land use and possible institutional arrangements as a regional stormwater plan.

[3] Impervious surfaces include rooftops, parking lots, roads, and similar hard surfaces, including gravel driveways/parking areas.

[4] Category includes insurance offices, government buildings, company headquarters, schools, hospitals, churches, shopping centers, strip malls, power plants, steel mills, cement plants, lumber yards, auto salvage yards, grain elevators, oil tank farms, coal and salt storage areas, slaughter houses, and other outdoor storage or parking areas.

Source: This table was modified from information in "The Design and Use of Detention Facilities for Stormwater Management Using DETPOND" by R. Pitt and J. Voorhees (2000).

Appendix B



Source: Technical Release 55, United States Department of Agriculture, Natural Resources Conservation Service, Washington, D.C. 1986. NRCS Bulletin No. WI-210-8-16 (Sept. 12, 1988) amended the TR-55 routing graph for Type II storms to include flows outside the original range.

Appendix B (cont'd.)

Rainfall Quantities:

Table 2 provides a summary of the 1-year, 24-hour rainfall totals using NRCS mandated TP-40, which has not been updated since 1961. Table 3 provides a summary of more current data from the Rainfall Frequency Atlas of the Midwest published in 1992. Local requirements may dictate the use of one dataset over the other.

Table 2 – Rainfall for Wisconsin Counties for a 1-year, 24-hour Rainfall[1]	
Inches of Rainfall	County
2.1 in.	Door, Florence, Forest, Kewaunee, Marinette, Oconto, Vilas
2.2 in.	Ashland, Bayfield, Brown, Calumet, Douglas, Iron, Langlade, Lincoln, Manitowoc, Menominee, Oneida, Outagamie, Price, Shawano, Sheboygan
2.3 in.	Barron, Burnett, Dodge, Fond du Lac, Green Lake, Marathon, Milwaukee, Ozaukee, Portage, Racine, Rusk, Sawyer, Taylor, Washburn, Washington, Waukesha, Waupaca, Waushara, Winnebago, Wood
2.4 in.	Adams, Chippewa, Clark, Columbia, Dane, Dunn, Eau Claire, Jackson, Jefferson, Juneau, Kenosha, Marquette, Pepin, Pierce, Polk, Rock, St. Croix, Walworth
2.5 in.	Buffalo, Green, Iowa, La Crosse, Monroe, Richland, Sauk, Trempealeau, Vernon
2.6 in.	Crawford, Grant, Lafayette
[1]TP – 40: Rainfall Frequency Atlas of the United States, U.S. Department of Commerce Weather Bureau.	

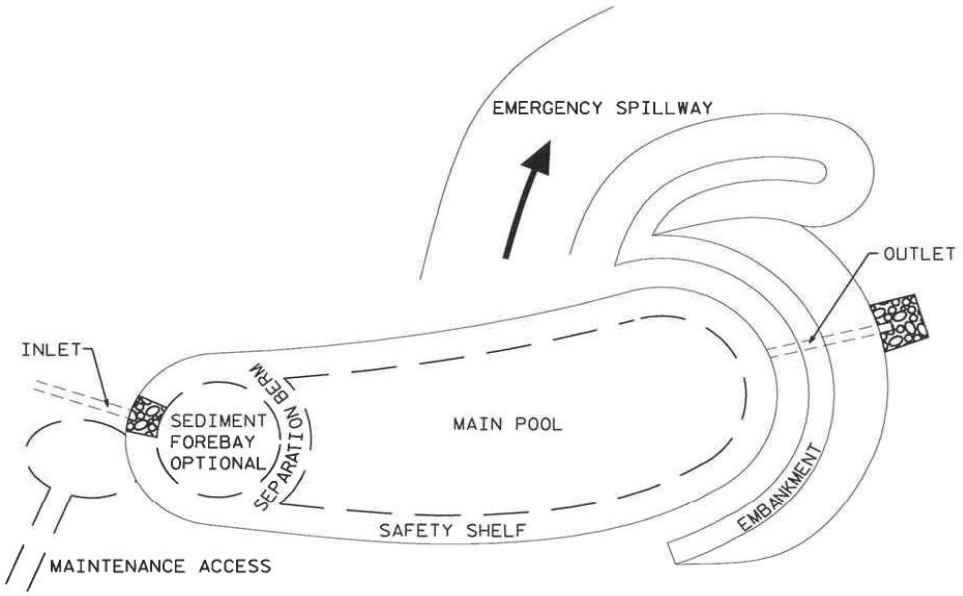
Table 3 - Rainfall for Wisconsin Counties for a 1-year, 24-hour Rainfall[2]		
Zone	Inches of Rainfall	County
1	2.22	Douglas, Bayfield, Burnett, Washburn, Sawyer, Polk, Barron, Rusk, Chippewa, Eau Claire
2	2.21	Ashland, Iron, Vilas, Price, Oneida, Taylor, Lincoln, Clark, Marathon
3	1.90	Florence, Forest, Marinette, Langlade, Menominee, Oconto, Door, Shawano
4	2.23	St. Croix, Dunn, Pierce, Pepin, Buffalo, Trempealeau, Jackson, La Crosse, Monroe
5	2.15	Wood, Portage, Waupaca, Juneau, Adams, Waushara, Marquette, Green Lake
6	1.96	Outagamie, Brown, Kewaunee, Winnebago, Calumet, Manitowoc, Fond du Lac, Sheboygan
7	2.25	Vernon, Crawford, Richland, Sauk, Grant, Iowa, Lafayette
8	2.25	Columbia, Dodge, Dane, Jefferson, Green, Rock
9	2.18	Ozaukee, Washington, Waukesha, Milwaukee, Walworth, Racine, Kenosha
[2]Bulletin 71: Rainfall Frequency Atlas of the Midwest, Midwest Climate Center and Illinois State Water Survey, 1992.		

Appendix B (cont'd.)

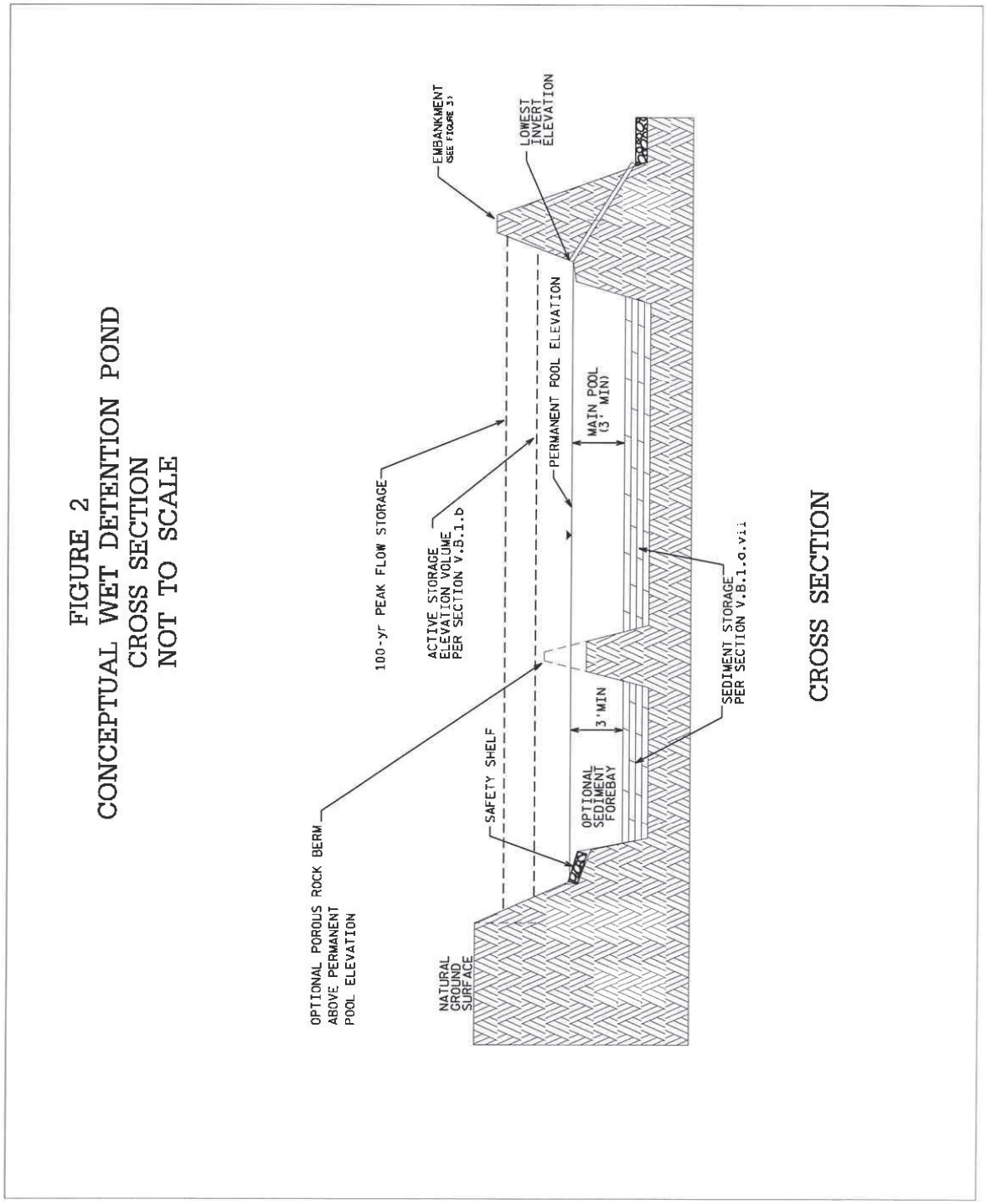
Table 4 – Runoff for Selected Curve Numbers and Rainfall Amounts[1]											
	Runoff Depth in Inches for Curve Number of:										
Rainfall (inches)	50	55	60	65	70	75	80	85	90	95	98
1.9	0.00	0.01	0.04	0.11	0.20	0.33	0.50	0.72	1.01	1.39	1.68
1.96	0.00	0.01	0.05	0.12	0.23	0.36	0.54	0.77	1.06	1.44	1.73
2.1	0.00	0.02	0.08	0.16	0.28	0.43	0.62	0.87	1.18	1.58	1.87
2.15	0.00	0.03	0.09	0.18	0.30	0.46	0.66	0.91	1.22	1.63	1.92
2.18	0.00	0.03	0.10	0.19	0.31	0.47	0.68	0.93	1.25	1.65	1.95
2.2	0.00	0.04	0.10	0.19	0.32	0.48	0.69	0.94	1.27	1.67	1.97
2.21	0.00	0.04	0.10	0.20	0.32	0.49	0.69	0.95	1.28	1.68	1.98
2.22	0.00	0.04	0.10	0.20	0.33	0.49	0.70	0.96	1.28	1.69	1.99
2.23	0.01	0.04	0.11	0.20	0.33	0.50	0.71	0.97	1.29	1.70	2.00
2.25	0.01	0.04	0.11	0.21	0.34	0.51	0.72	0.98	1.31	1.72	2.02
2.3	0.01	0.05	0.12	0.23	0.36	0.54	0.75	1.02	1.35	1.77	2.07
2.4	0.02	0.07	0.15	0.26	0.41	0.59	0.82	1.10	1.44	1.87	2.17
2.5	0.02	0.08	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
2.6	0.03	0.10	0.20	0.34	0.50	0.71	0.96	1.26	1.62	2.06	2.37
[1]NRCS TR-55, Equations 2-1 to 2-4 used to determine runoff depths.											

Appendix C—Pond Geometry

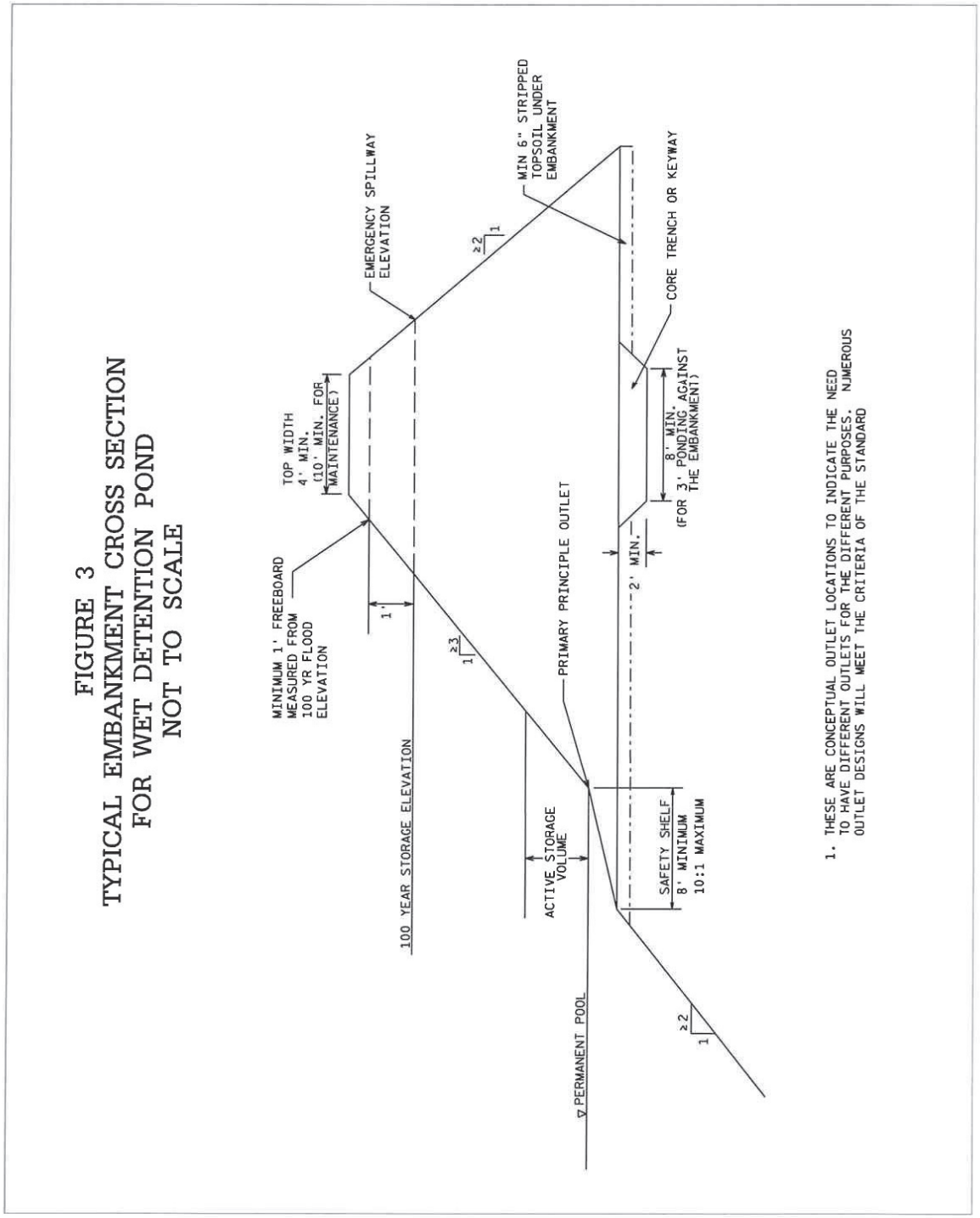
FIGURE 1
CONCEPTUAL WET DETENTION POND
PLAN VIEW
NOT TO SCALE



Appendix C—Pond Geometry (cont'd.)



Appendix C—Pond Geometry (cont'd.)



Appendix D—Pond Liner Design, Decision Flowchart

Pond Liner Design Specifications for Three Levels of Liners

A. Type A Liners—for sites with the highest potential for groundwater pollution. They include:
   - Clay (natural soil, not bentonite)
   - High Density Polyethylene (HDPE)
   - Geosynthetic Clay Liners (GCL)

   1. Clay liner criteria (essentially the same as the clay below landfills but not as thick):
      a. 50% fines (200 sieve) or more.
      b. An in-place hydraulic conductivity of 1×10^{-7} cm./sec. or less.
      c. Average liquid limit of 25 or greater, with no value less than 20.
      d. Average PI of 12 or more, with no values less than 10.
      e, Clay installed wet of optimum if using standard Proctor, and 2% wet of optimum if using modified Proctor.
      f. Clay compaction and documentation as specified in NRCS Wisconsin Construction Specification 300, Clay Liners.
      g. Minimum thickness of two feet.
      h. Specify method for keeping the pool full or use of composite soils below liner.
   2. HDPE liner criteria:
      a. Minimum thickness shall be 60 mils.
      b. Design according to the criteria in Table 3 of the NRCS 313, Waste Storage Facility technical standard.
      c. Install according to NRCS Wisconsin Construction Specification 202, Polyethylene Geomembrane Lining.
   3. GCL liner criteria:
      a. Design according to the criteria in Table 4 of NRCS 313, Waste Storage Facility technical standard.
      b. Install according to NRCS Wisconsin Construction Specification 203, Geosynthetic Clay Liner.

B. Type B Liners—for sites with medium potential for groundwater pollution or where need for a full pool level is high. They include:
   - All liners meeting Type A criteria
   - Clay
   - HDPE
   - Polyethylene Pond Liner (PPL)

   1. Clay liner criteria:
      a. 50% fines (200 sieve) or more.
      b. An in-place hydraulic conductivity of 1×10^{-6} cm./sec. or less.
      c. Average liquid limit value of 16 or greater, with no value less than 14.
      d. Average PI of 7 or more with no values less than 5.
      e. Clay compaction and documentation as specified in NRCS Wisconsin Construction Specification 204, Earthfill for Waste Storage Facilities.
      f. Minimum thickness of two feet.
      g. Specify method for keeping the pool full or use of composite soils below liner.
   2. HDPE liner criteria:
      a. Minimum thickness shall be 40 mils.
      b. All other criteria same as for Type A HDPE liner.
   3. PPL liner criteria:
      a. Minimum thickness shall be 30 mils.
      b. All other criteria same as for Type A HDPE liner.

C. Type C Liners—for sites with little potential for groundwater pollution or where the need for a full pool is less important. They include:
   - All liners meeting Type A or B criteria
   - Silts and clays
   - HDPE (<40 mil)
   - PPL (20-24 mil)
   - PVC (30-40 mil)
   - EPDM (45 mil)

   1. Silt/Clay liner criteria:
      a. 50% fines (200 sieve), or 20% fines and a PI of 7.
      b. Soil compaction and documentation as specified in NRCS Wisconsin Construction Specification 204, Earthfill for Waste Storage Facilities.
      c. Minimum thickness of two feet.
      d. Specify method for keeping the pool full or use of composite soils below liner.

D. Liner Elevation—All liners must extend above the permanent pool up to the elevation reached by the 2-yr., 24-hour storm event.

E. For synthetic liners, follow the manufacturers' recommendations for installation.

Appendix E—Aerators/Fountains

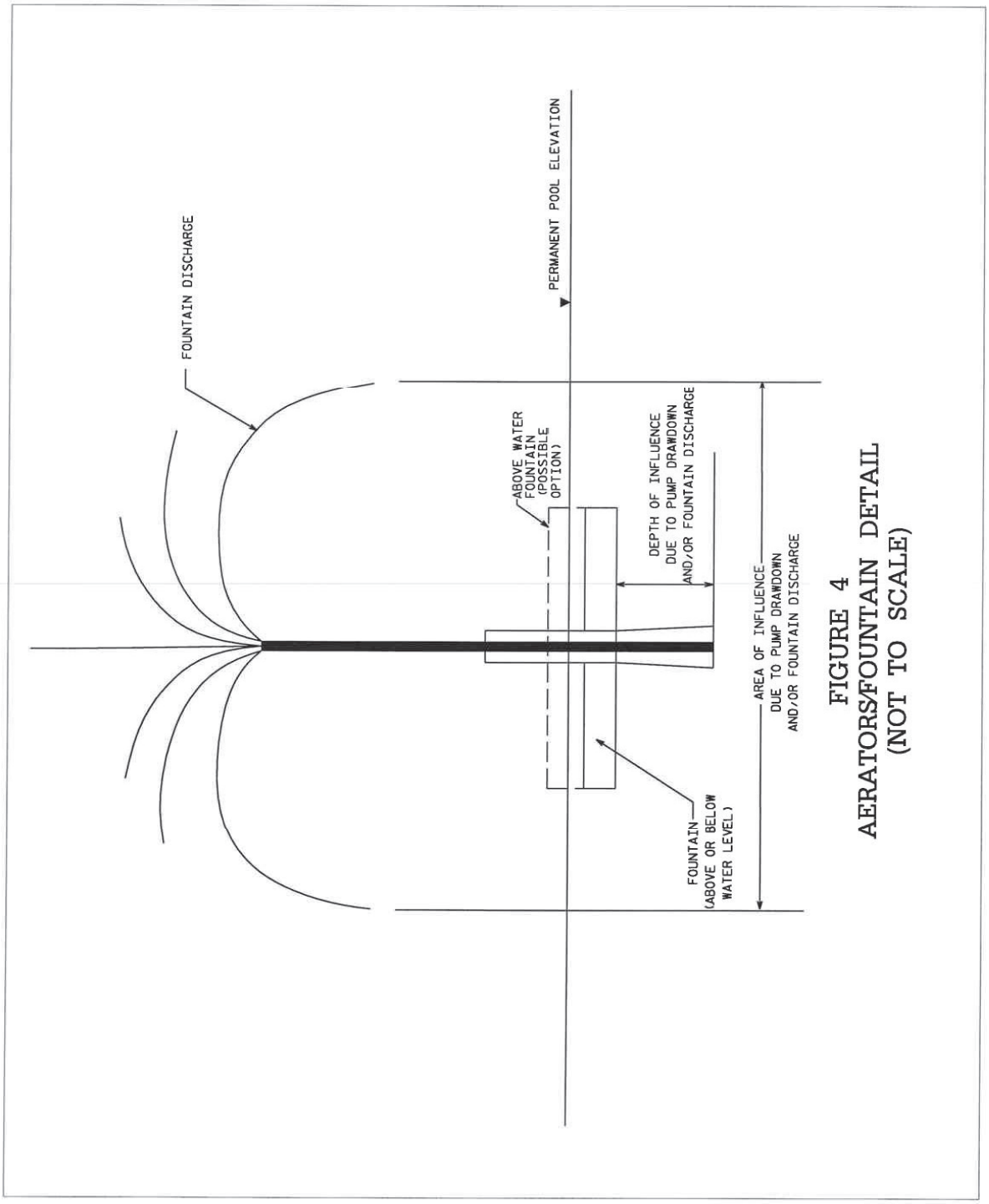


FIGURE 4
AERATORS/FOUNTAIN DETAIL
(NOT TO SCALE)

Site Evaluation for Stormwater Infiltration
(1002)

Wisconsin Department of Natural Resources
Conservation Practice Standards

I. Definition

This standard defines site evaluation procedures to:

1. Perform an initial screening of a *development site*[1] to determine its suitability for infiltration.

2. Evaluate each area within a development site that is selected for infiltration.

3. Prepare a site evaluation report.

II. Purpose

1. Establish methodologies to characterize the site and screen for exclusions and exemptions under Chapter NR 151 Wis. Adm. code.

2. Establish requirements for siting an *infiltration device* and the selection of design infiltration rates.

3. Define requirements for a site evaluation report that insures appropriate areas are selected for infiltration and an appropriate *design infiltration rate* is used.

III. Conditions where Practice Applies

This standard is intended for development sites being considered for stormwater infiltration devices. Additional site location requirements may be imposed by other stormwater infiltration device technical standards.

IV. Federal, State and Local Laws

Users of this standard shall be aware of applicable federal, state and local laws, rules, regulations or permit requirements governing infiltration devices. This standard does not contain the text of federal, state or local laws.

V. Criteria

The site evaluation consists of four steps for locating the optimal areas for infiltration, and properly sizing infiltration devices.

- Step A. Initial Screening.
- Step B. Field Verification of information collected in Step A.
- Step C. Evaluation of Specific *Infiltration Areas*.
- Step D. Soil and Site Evaluation Reporting.

The steps shall coincide, as much as possible, for when the information is needed to determine the following: 1) the potential for infiltration on the site, 2) the optimal locations for infiltration devices, and 3) the design of the infiltration device(s). Steps A and B shall be completed as soon as possible in the approval process. See Consideration VI.M for an example.

Step A. Initial Screening

The initial screening identifies potential locations for infiltration devices. The purpose of the initial screening is to determine if installation is limited by ss. NR 151.12(5)(c)5. or NR 151.12(5)(c)6., and to determine where field work is needed for Step B. Optimal locations for infiltration are verified in Step B.

Information collected in Step A will be used to explore the potential for multiple infiltration areas versus relying on a regional infiltration device. Smaller infiltration devices dispersed around a development are usually more sustainable than a single *regional device* that is more likely to have maintenance and groundwater mounding problems.

The initial screening shall determine the following: Note: Useful references for the existing resource maps and information are listed in Considerations VI.I and J.

1. Site topography and slopes greater than 20%.
2. Site soil infiltration capacity characteristics as defined in NRCS County soil surveys.
3. *Soil parent material.*
4. Regional or local depth to groundwater and bedrock. Use seasonally *high groundwater* information where available.

[1] Words in the standard that are shown in italics are described in VIII. Definitions. The words are italicized the first time they are used in the text.

5. Distance to sites listed on the GIS Registry of Closed Remediation sites within 500 feet from the perimeter of the development site.
6. Distance to sites listed on the Bureau of Remediation and *Redevelopment* Tracking System within 500 feet from the perimeter of the development site.
7. Presence of endangered species habitat.
8. Presence of flood plains and flood fringes.
9. Location of hydric soils based on the USDA County Soil Survey and wetlands from the WDNR Wisconsin Wetland Inventory map.
10. Sites where the installation of stormwater infiltration devices is excluded, due to the potential for groundwater contamination, by chapter NR 151 Wis. Adm. Code.
11. Sites exempted by chapter NR 151 Wis. Adm. Code from the requirement to install infiltration devices.
12. Potential impact to adjacent property.

Step B. Field Verification of the Initial Screening

A. Field verification is required for areas of the development site considered suitable for infiltration. This includes verification of Step A.1, 2, 3, 4, 9, 10 and 11.

B. Sites shall be tested for depth to groundwater, depth to bedrock and *percent fines* information to verify any exemption and exclusion found in Step A.10 and 11. The following is a description of the percent fines expected for each type of soil textural classification.

   1. Several textural classes are assumed to meet the percent fines limitations of Ch. NR 151.12(5)(c)5.i. for both 3 and 5 foot soil layers. These classifications include the sandy loams, loams, silt loams and all the clay textural classifications. *Coarse sand* is the only soil texture that by definition will not meet NR 151.12(5)(c)5.i. limitations for a 3 foot soil layer consisting of 20% fines. Other sand textures and loamy sands may need the percent fines level verified with a laboratory analysis.

   2. Borings and pits shall be dug to verify soil infiltration capacity characteristics and to determine depth to groundwater and bedrock.

C. The following information shall be recorded for Step B:

   1. The date or dates the data was collected.

   2. A legible site plan/map that is presented on paper that is no less than 8 ½ X 11 inches in size and:

      a. Is drawn to scale or fully dimensional.
      b. Illustrates the entire development site.
      c. Shows all areas of planned filling and/or cutting.
      d. Includes a permanent vertical and horizontal reference point.
      e. Shows the percent and direction of land slope for the site or contour lines. Highlight areas with slopes over 20%.
      f. Shows all flood plain information that is pertinent to the site.
      g. Shows the location of all pits/borings included in the report.
      h. Location of wetlands as field delineated and surveyed.
      i. Location of karst features, private wells within 100 feet of the development site, and public wells within 400 feet of the development site.

   3. Soil profile descriptions must be written in accordance with the descriptive procedures, terminology and interpretations found in the Field Book for Describing and Sampling Soils, USDA, NRCS, 1998. Frozen soil material must be thawed prior to conducting evaluations for soil color, texture, structure and consistency. In addition to the data determined in Step B, soil profiles must include the following information for each soil horizon or layer:

      a. Thickness, in inches or decimal feet.
      b. Munsell soil color notation.
      c. Soil mottle or redoximorphic feature color, abundance, size and contrast.
      d. USDA soil textural class with rock fragment modifiers.
      e. Soil structure, grade size and shape.
      f. Soil consistence, root abundance and size.
      g. Soil boundary.
      h. Occurrence of saturated soil, groundwater, bedrock or disturbed soil.

Step C. Evaluation of Specific Infiltration Areas

This step is to determine if locations identified for infiltration devices are suitable for infiltration, and to provide the required information to design the device.

A minimum number of borings or pits shall be constructed for each infiltration device (Table 1). The following information shall be recorded for Step C:

1. All the information under Step B.C.3.

2. A legible site plan/map that is presented on paper no less than 8 1/2 X 11 inches in size and:

   a. Is drawn to scale or fully dimensional.
   b. Illustrates the location of the infiltration devices.
   c. Shows the location of all pits and borings.
   d. Shows distance from device to wetlands.

3. An analysis of groundwater mounding potential is required as per Table 1. The altered groundwater level, based on mounding calculations, must be considered in determining the vertical separation distance from the infiltration surface to the *highest anticipated groundwater elevation* as specified in NR 151. References include but are not limited to Finnemore 1993 and 1995, and Hantush 1967.

4. One of the following methods shall be used to determine the design infiltration rate:

   a. Infiltration Rate Not Measured - Table 2 shall be used if the infiltration rate is not measured. Select the design infiltration rate from Table 2 based on the least permeable soil horizon five feet below the bottom elevation of the infiltration system.

   b. Measured Infiltration Rate - The tests shall be conducted at the proposed bottom elevation of the infiltration device. If the infiltration rate is measured with a *Double-Ring Infiltrometer* the requirements of ASTM D3385 shall be used for the field test.

      The measured infiltration rate shall be divided by a correction factor selected from Table 3. The correction factor adjusts the measured infiltration rates for the occurrence of less permeable soil horizons below the surface and the potential variability in the subsurface soil horizons throughout the infiltration site.

      A less permeable soil horizon below the location of the measurement increases the level of uncertainty in the measured value. Also, the uncertainty in a measurement is increased by the variability in the subsurface soil horizons throughout the proposed infiltration site.

      To select the correction factor from Table 3, the ratio of design infiltration rates must be determined for each place an infiltration measurement is taken. The design infiltration rates from Table 2 are used to calculate the ratio. To determine the ratio, the design infiltration rate for the surface textural classification is divided by the design infiltration rate for the least permeable soil horizon. For example, a device with a loamy sand at the surface and a least permeable layer of loam will have a design infiltration rate ratio of about 6.8 and a correction factor of 4.5. The depth of the least permeable soil horizon should be within five feet of the proposed bottom of the device or to the depth of a limiting layer.

5. To determine if infiltration is not required under NR 151.12(5)(c)6.a., a scientifically credible field test method is required unless the least permeable soil horizon five feet below the bottom of infiltration system is one of the following: sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, or clay. The infiltration rate used to claim the exemption shall be the actual field measurement and shall be used without the correction factors found in Table 3.

Step D. Soil and Site Evaluation Report Contents

The site's legal description and all information required in Steps B and C shall be included in the Soil and Site Evaluation Report. These reports shall be completed prior to the *construction plan* submittal.

Table 1: Evaluation Requirements Specific to Proposed Infiltration Devices

Infiltration Device	Tests Required[1]	Minimum Number of Borings/Pits Required	Minimum Drill/Test Depth Required Below the Bottom of the Infiltration System
Irrigation Systems[2]	Pits or borings	NA[2]	5 feet or depth to *limiting layer*, whichever is less.
Rain Garden[2]	Pits or Borings	NA[2]	5 feet or depth to limiting layer, whichever is less.
Infiltration Trenches (≤ 2000 sq feet impervious drainage area)	Pits or borings	1 test/100 linear feet of trench with a minimum of 2, and sufficient to determine variability	5 feet or depth to limiting layer, whichever is less.
Infiltration Trenches (> 2000 sq ft of impervious drainage area)	• Pits or borings • Mounding potential	1 pit required and an additional 1 pit or boring/100 linear feet of trench, and sufficient to determine variability	Pits to 5 feet or depth to limiting layer Borings to 15 feet or depth to limiting layer
Bioretention Systems	• Pits or borings • Mounding potential	1 test/50 linear feet of device with a minimum of 2, and sufficient to determine variability	5 feet or depth to limiting layer
Infiltration Grassed Swales	Pits or borings	1 test/1000 linear feet of swale with a minimum of 2, and sufficient to determine variability	5 feet or depth to limiting layer
Surface *Infiltration Basins*	• Pits or borings • Mounding potential	2 pits required per infiltration area with an additional 1 pit or boring for every 10,000 square feet of infiltration area, and sufficient to determine variability	Pits to 10 feet or depth to limiting layer Borings to 20 feet or depth to limiting layer
Subsurface Dispersal Systems greater than 15 feet in width.	• Pits or borings • Mounding potential	2 pits required per infiltration area with an additional 1 pit or boring for every 10,000 square feet of infiltration area, and sufficient to determine variability	Pits to 10 feet or depth to limiting layer Borings to 20 feet or depth to limiting layer

[1]Continuous soil borings shall be taken using a bucket auger, probe, split-spoon sampler, or shelby tube. Samples shall have a minimum 2-inch diameter. Soil pits must be of adequate size, depth and construction to allow a person to enter and exit the pit and complete a morphological soil profile description.

[2]Information from Step B is adequate to design rain gardens and irrigation systems.

Table 2: Design Infiltration Rates for Soil Textures Receiving Stormwater

Soil Texture[1]	Design Infiltration Rate Without Measurement inches/hour[2]
Coarse sand or coarser	3.60
Loamy coarse sand	3.60
Sand	3.60
Loamy sand	1.63
Sandy loam	0.50
Loam	0.24
Silt loam	0.13
Sandy clay loam	0.11
Clay loam	0.03
Silty Clay loam	0.04[3]
Sandy clay	0.04
Silty clay	0.07
Clay	0.07

[1]Use sandy loam design infiltration rates for fine sand, loamy fine sand, very fine sand, and loamy fine sand soil textures.

[2] Infiltration rates represent the lowest value for each textural class presented in Table 2 of Rawls, 1998.

[3] Infiltration rate is an average based on Rawls, 1982 and Clapp & Hornberger, 1978.

Table 3: Total Correction Factors Divided into Measured Infiltration Rates

Ratio of Design Infiltration Rates[1]	Correction Factor
1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

[1]Ratio is determined by dividing the design infiltration rate (Table 2) for the textural classification at the bottom of the infiltration device by the design infiltration rate (Table 2) for the textural classification of the least permeable soil horizon. The least permeable soil horizon used for the ratio should be within five feet of the bottom of the device or to the depth of the limiting layer.

Required Qualifications

A. Site Evaluations - Individuals completing site evaluations shall be a licensed professional acceptable to the authority having jurisdiction and have experience in soil investigation, interpretation and classification.

B. Soil Evaluations - Individuals completing the soils evaluation shall be a Soil Scientist licensed by the Department of Regulation and Licensing or other licensed professional acceptable to the authority having jurisdiction.

VI. Considerations

Additional recommendations relating to design that may enhance the use of, or avoid problems with this practice but are not required to insure its function are as follows:

A. Groundwater monitoring wells, constructed as per chapter NR 141, Wis. Adm. Code, can be used to determine the seasonal *high groundwater level*. Large sites considered for infiltration basins may need to be evaluated for the direction of groundwater flow.

B. Karst Inventory Forms on file with the Wisconsin Geological and Natural History Survey should be filled out if a karst feature is located within the site.

C. Cation Exchange Capacity (CEC) of the soil can indicate the number of available adsorption sites. Sandy soils have limited adsorption capacity and a CEC ranging from 1-10 meq/100g. Clay and organic soils have a CEC greater than 20 and have a high adsorption rate.

D. Soil organic matter and pH can be used to determine adsorption of stormwater contaminants. A pH of 6.5 or greater is optimal. A soil organic content greater than 1 percent will enhance adsorption.

E. NR 151 provides for a maximum area to be dedicated for infiltration depending upon land use. This cap can be voluntarily exceeded.

F. One or more areas within a development site may be selected for infiltration. A development site with many areas suitable for infiltration is a good candidate for a dispersed approach to infiltration. It may be beneficial to contrast regional devices with onsite devices that receive runoff from one lot or a single source area within a lot, such as rooftop or parking lot.

G. Stormwater infiltration devices may fail prematurely if there is:

1. An inaccurate estimation of the Design Infiltration Rate;
2. An inaccurate estimation of the seasonal high water table;
3. Excessive compacting or sediment loading during construction;
4. No pretreatment for post-development and lack of maintenance.

H. No construction erosion should enter the infiltration device. This includes erosion from site grading as well as home building and construction. If possible, rope off areas selected for infiltration during grading and construction. This will preserve the infiltration rate and extend the life of the device.

I. Resources available for completing Step A. Initial screening:

1. Sites listed on the GIS Registry of Closed Remediation sites. http://gomapout.dnr.state.wi.us/org/at/et/geo/gwur/index.htm
2. Sites listed in the Bureau of Remediation and Redevelopment Tracking System. http://dnr.wi.gov/org/aw/rr/brrts/index.htm
3. Flood plain areas as regulated under s. 87.30, Wis. Stats. and NR 116, NR 30 and NR 31, Wis. Adm. Code.
4. Wetlands as defined in Ch. NR 103, Wis. Adm. Code.
5. Endangered species habitat as shown on National Heritage Inventory County maps
6. Access points and road setbacks as determined by county or municipal zoning plans.
7. Existing reports concerning the groundwater and bedrock. Examples include: Publications from USGS, NRCS, Regional Planning Commissions, DNR, DATCP, DOT, UW system or WGNHS.
8. The Drinking Water and Groundwater pages of the DNR http://dnr.wi.gov/org/water/dwg/
9. The Wisconsin Grain Size Database http:\\www.geology.wisc.edu/~qlab/

J. The development site should be checked to determine the potential for archeological sites. This search may be conducted by state staff for projects required or funded by the state.

K. Slopes 20% or greater are inappropriate for some infiltration devices.

L. Expect to complete the preliminary design work (Criteria Step A through Step C) before the approval process (platting). Once required information is compiled, the initial design work for an infiltration device can begin.

M. The approval process requirements for development sites vary across the state and may also vary within a municipality depending on the number of lots being developed. The timing of Steps A, B, and C might have to be adjusted for the type of approval process. The following is an example of when the steps might be completed for a typical development site requiring a plat. The sequence in the example would comply with the criteria for timing of Steps A, B, and C.

Step A should be completed before the preliminary plat and Step B should be completed before the final plat, or CSM is approved. For regional infiltration devices, and for devices constructed on public right-of-ways, public land or jointly owned land, Step C should be completed before the final plat or final CSM approval.

It can be difficult to select the final location and drainage area for an infiltration device before the use of the lot is known. Sometimes it is more desirable to design an infiltration device for an individual lot after the lot is purchased. For this situation Step C would be completed after the final plat is approved. The information for Step C would be collected when the lot is purchased. To give future devices credit towards achieving the infiltration performance standard, the final plat would contain approximate sizing information for each device. Information from Step A and B would be used to determine the approximate sizing information.

N. The inner ring of the Double-Ring Infiltrometer should be at least 12 inches in diameter.

O. Section NR 151.12(5)(c)5., is included in the administrative code as a means to discourage infiltration of runoff from or into the listed areas, due to potential concerns of groundwater contamination. Although it is not illegal to infiltrate storm water in areas with the listed limitations, DNR will not give credit for this infiltration towards meeting the infiltration requirements of ss. NR 151.12(5)(c)1. or NR 151.12(5)(c)2. Runoff that is infiltrated must be in compliance with s. NR 151.12(5)(c)8., which requires minimizing infiltration of pollutants so that groundwater quality standards are maintained.

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VIII. Definitions

Bioretention systems (Table 1): Bioretention is an infiltration device consisting of an excavated area that is back-filled with an engineered soil, covered with a mulch layer and planted with a diversity of woody and herbaceous vegetation. Storm water directed to the device percolates through the mulch and engineered soil, where it is treated by a variety of physical, chemical and biological processes before infiltrating into the native soil.

Construction Plan (V.Step D): A map and/or plan describing the built-out features of an individual lot.

Coarse sand (V.Step B.B.1): Soil material that contains 25% or more very coarse and coarse sand, and <50% any other one grade of sand.

Design infiltration rate (II.3): A velocity, based on soil structure and texture, at which precipitation or runoff enters and moves into or through soil. The design rate is used to size an infiltration device or system. Rates are selected to be minimal rates for the different types of soils. Selection of minimal rates will provide a robust design and maximize the longevity of the device.

Development site (I.1): The entire area planned for development, irrespective of how much of the site is disturbed at any one time or intended land use. It can be one lot or multiple lots.

Double-ring infiltrometer (V.Step C.4.b): A device that directly measures infiltration rates into a soil surface. The double-ring infiltrometer requires a fairly large pit excavated to depth of the proposed infiltration device and preparation of a soil surface representative of the bottom of the infiltration area.

High groundwater level (V.Step A.4): The higher of either the elevation to which the soil is saturated as observed as a free water surface in an unlined hole, or the elevation to which the soil has been seasonally or periodically saturated as indicated by soil color patterns throughout the soil profile.

Highest anticipated groundwater elevation (V.Step C.3): The sum of the calculated mounding effects of the discharge and the seasonal high groundwater level.

Infiltration areas (V): Areas within a development site that are suitable for installation of an infiltration device.

Infiltration basin (Table 1): An open impoundment created either by excavation or embankment with a flat densely vegetated floor. It is situated on permeable soils and temporarily stores and allows a designed runoff volume to infiltrate the soil.

Infiltration device (II.2): A structure or mechanism engineered to facilitate the entry and movement of precipitation or runoff into or through the soil. Examples of infiltration devices include irrigation systems, rain gardens, infiltration trenches, bioretention systems, infiltration grassed swales, infiltration basins, subsurface dispersal systems and infiltration trenches.

Infiltration trench (Table 1): An excavated trench that is usually filled with coarse, granular material in which stormwater runoff is collected for temporary storage and infiltration. Other materials such as metal pipes and plastic domes are used to maintain the integrity of the trench.

Irrigation system (Table 1): A system designed to disperse stored stormwater to lawns or other pervious areas.

Limiting layer (Table 1): A limiting layer can be bedrock, an aquatard, aquaclude or the seasonal high groundwater table.

Percent fines (V. Step B.B): the percentage of a given sample of soil, which passes through a # 200 sieve.

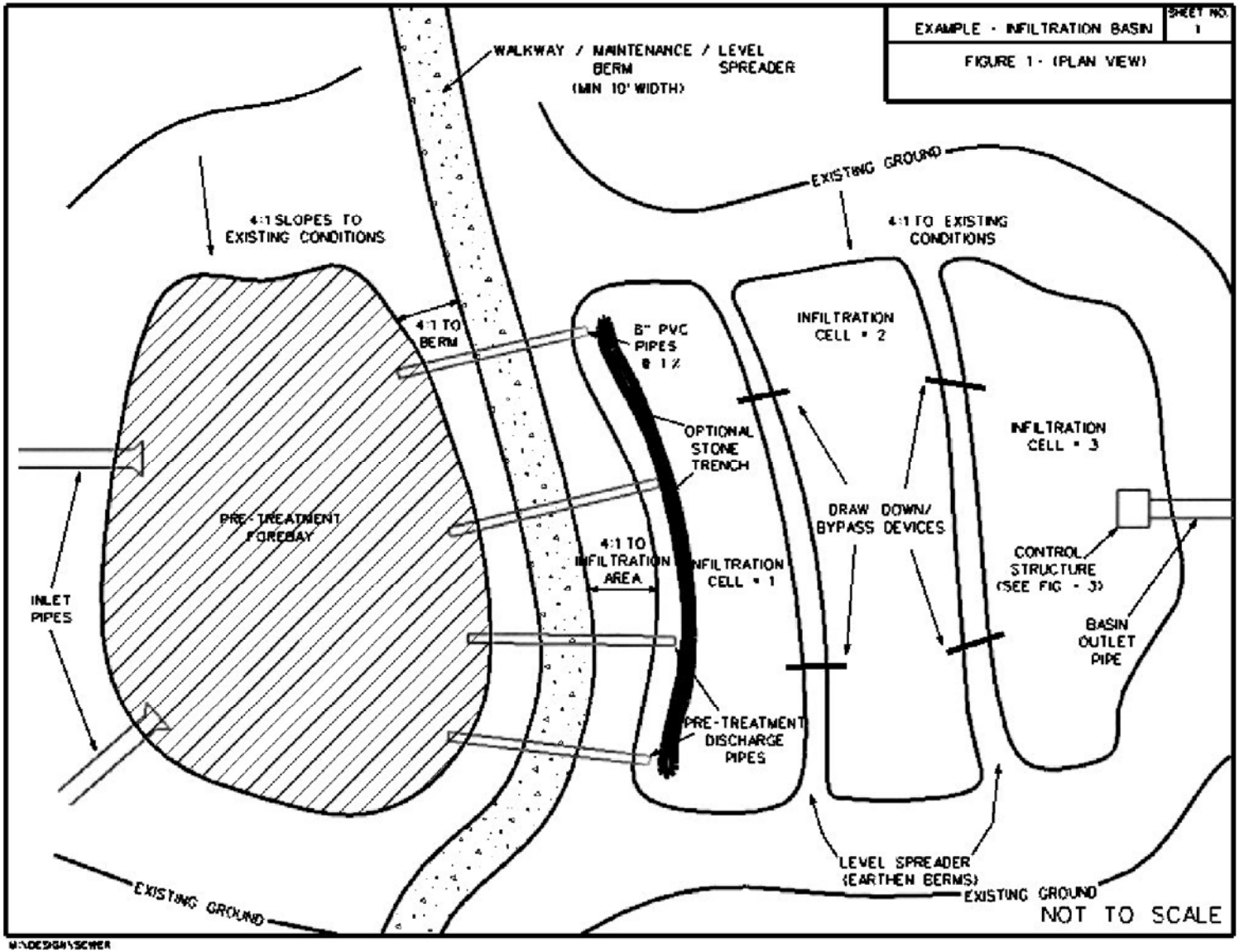
Rain garden (Table 1): A shallow, vegetated depression that captures stormwater runoff and allows it to infiltrate.

Regional device (V.Step A): An infiltration system that receives and stores stormwater runoff from a large area. Infiltration basins are the most commonly used regional infiltration devices.

Redevelopment (V.Step A.6): Areas where new development is replacing older development.

Soil parent material (V.Step A.3): The unconsolidated material, mineral or organic, from which the solum develops.

Subsurface dispersal systems (Table 1): An exfiltration system that is designed to discharge stormwater through piping below the ground surface, but above the seasonal high groundwater table.



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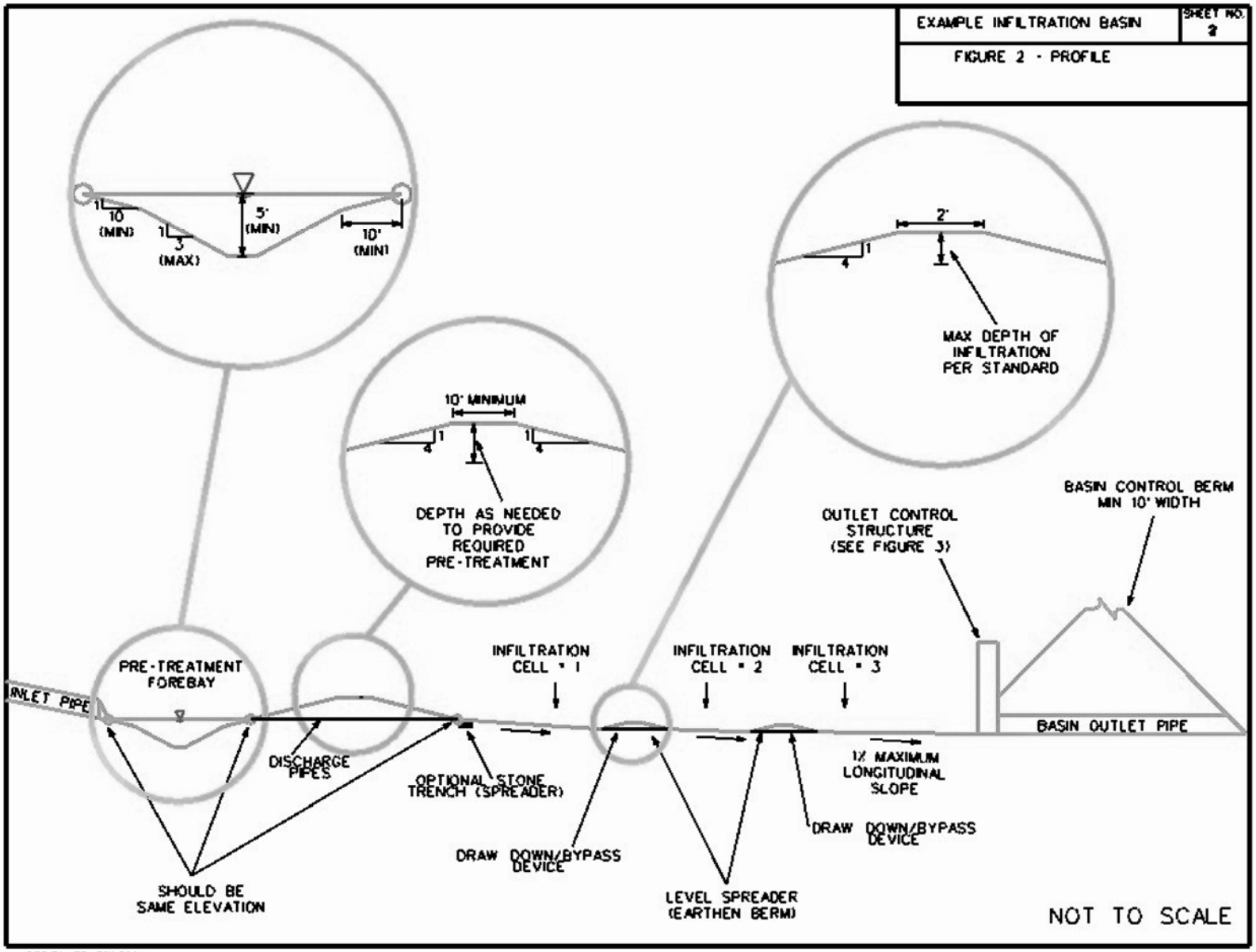

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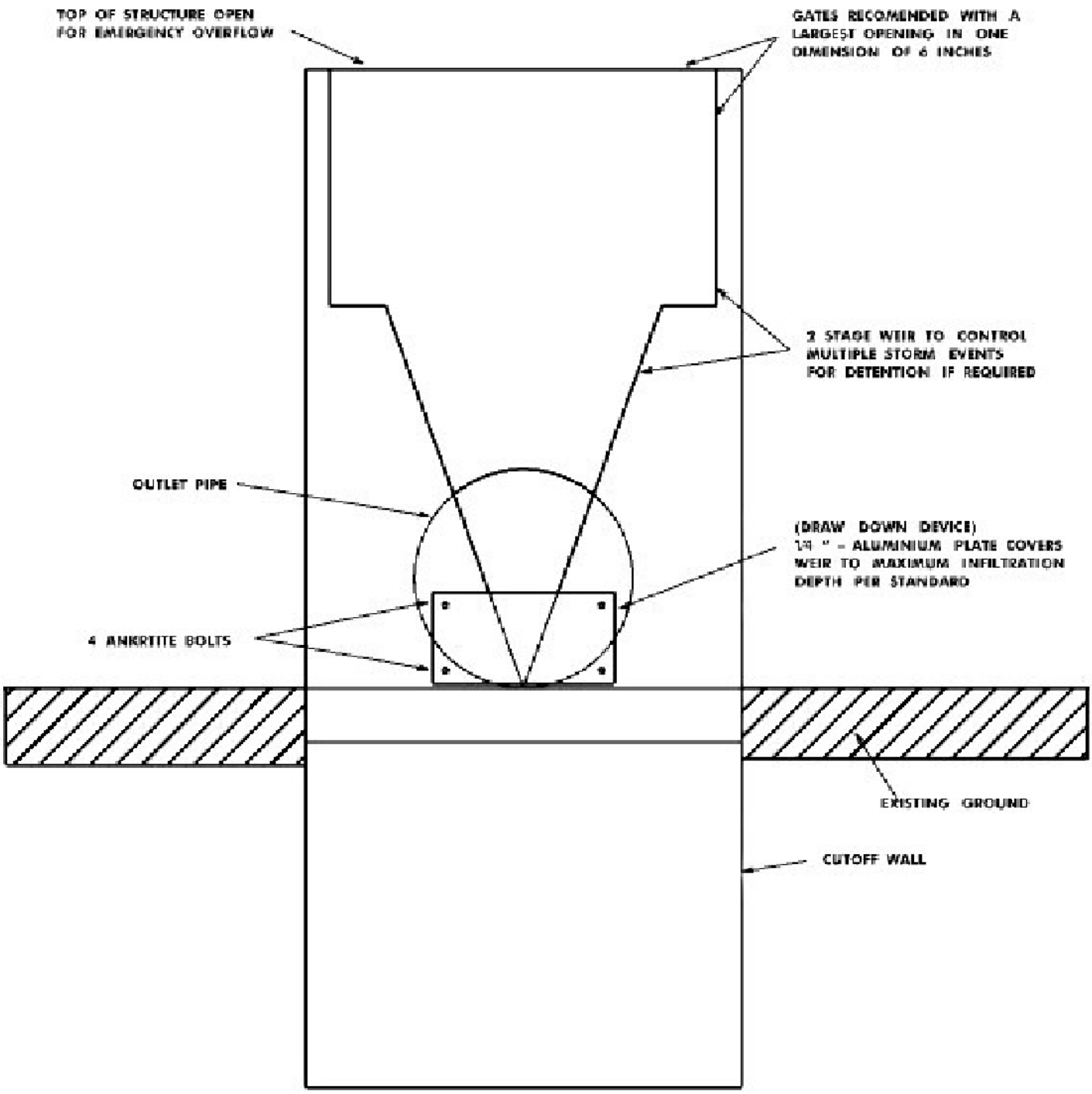
EXAMPLE INFILTRATION BASIN OUTLET STRUCTURE	SHEET NO 3
FIGURE 3 - FRONT VEIW	



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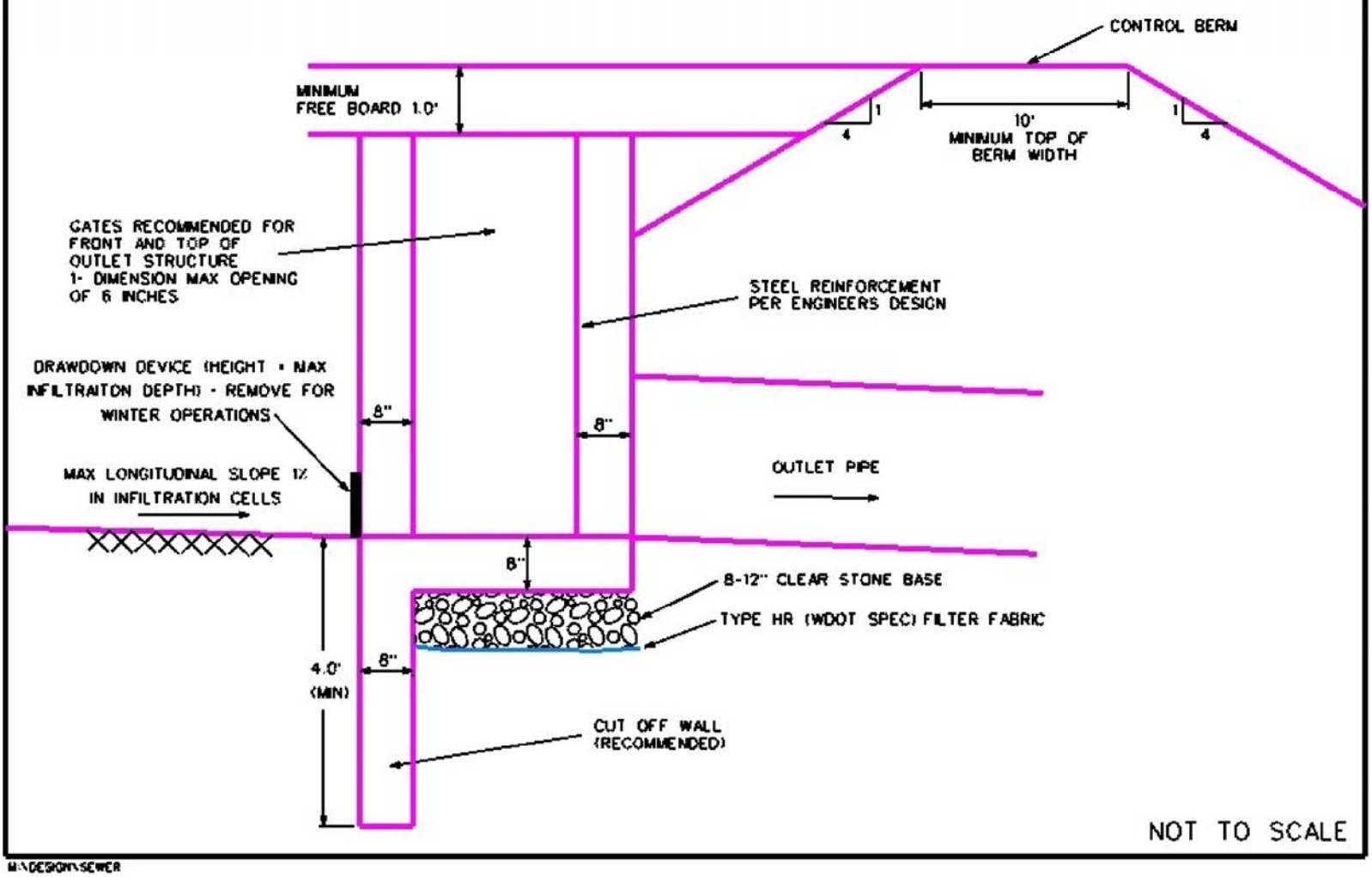
EXAMPLE - INFILTRATION BASIN CONTROL STRUCTURE	SHEET NO. 6
FIGURE 4 - SIDE VIEW	



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Infiltration Basin

(Acre-Feet)
(1003)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

An infiltration basin is defined as an open impoundment (greater than 15 feet wide in its minimum dimension) created either by excavation or embankment with a flat, densely vegetated floor dedicated to the infiltration of runoff through the ground surface.

II. Purpose

The practice may be applied as part of a structural stormwater management practice system to support one or more of the following purposes:

- Reduce stormwater pollutants
- Increase discharge to groundwater
- Decrease runoff peak flow rates and volumes
- Preserve base flow in streams
- Reduce temperature impacts of runoff.

III. Conditions Where Practice Applies

The infiltration basin practice applies to urban areas where increased pollutant loadings, thermal impacts, or increased runoff volumes are a concern and the area is suitable for infiltration. (See NR 151.12(5) (c) 5 and 6 and WDNR Conservation Practice Standard Site Evaluation for Stormwater Infiltration (1002).)

IV. Federal, State and Local Laws

Users of this standard shall be aware of applicable federal, state and local laws, rules, regulations or permit requirements governing infiltration basins. This standard does not contain the text of federal, state or local laws.

V. Criteria

A. Screening criteria located in the WDNR Conservation Practice Standard Site Evaluation for Stormwater Infiltration (1002) shall be followed. In addition, the following site location criteria shall be met.

1. Building location – The basin shall not be *hydraulically connected*[1] to foundations or pavements, or cause negative impacts to structures. These negative impacts could include: water in basements and foundation instability.

2. 20% Slopes - Infiltration shall not cause seepage, contribute to hill slope failure or increase erosion on down gradient slopes. A minimum horizontal setback distance of 200 feet shall be maintained from down gradient slopes greater than 20% unless slope stability calculations demonstrate that the slope is stable under saturated conditions at a shorter distance from the practice. Note: Berms constructed as part of the practice are not included in this separation distance.

B. Design

1. Bypass/Dewatering – The basin shall be designed with a maintenance draw down capability. An example of this device is shown on Figure #3.

   When infiltration cells are used, a *draw down device* shall be provided for each cell.

2. Pretreatment Practices – Space must be allotted for pretreatment prior to infiltration to remove the following percentage of total suspended solids, on an average annual basis, based on the following land uses.

   a. 60% for residential (and associated roads)

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

b. 80% for commercial, industrial, institutional (and associated roads)

3. Infiltration Rates - See WDNR Conservation Practice Standard Site Evaluation for Stormwater Infiltration (1002) for design infiltration rates.

4. Dimensions

   a. Depth – Depth is a function of the maximum draw down time of 24 hours (for the infiltration portion of the practice only), using the design infiltration rate, with a not to exceed depth of 24 inches.

      The maximum depth of 24 inches applies to all infiltration cells within the practice.

   b. *Target Stay-on Depth* – The target stay-on depth shall meet the requirements of NR 151. (See Consideration L.)

   c. Effective Infiltration Area – The maximum depth along with the storage volume of water to be infiltrated can be used to determine the preliminary *effective infiltration area* necessary for the infiltration basin. (See Consideration L.)

   d. Slopes

      1. Longitudinal Slope – If used, the longitudinal slope shall not exceed 1% (0% longitudinal slope is recommended). If any longitudinal slope is specified, "infiltration cells" as described in V.B.4.f. shall be required.

      2. Lateral Slopes in the effective infiltration area shall be 0%.

Example: (This example is a continuation of the 20 acre mixed land use example presented in "Technical Note for Sizing Infiltration Basins and Bioretention Devices to Meet State of Wisconsin Stormwater Infiltration Performance Standards." See Consideration L. for reference.)

This example assumed an average pre-development curve number of 75 for the pre-development soil condition in the drainage basin, sandy loam soils at the infiltration site and a post-development curve number of 70 for the pervious areas in the drainage basin. From that example, the preliminary effective infiltration area is 8,930 square feet or 0.2 acres. Therefore, the storage volume (SV) at a one-foot maximum depth (MD) is 0.2 acre-ft or 8,930 cu. ft.

Calculate the dimensions of the basin. Assume a rectangular basin with a length to width ratio of 3:1
SV=MD * L * W substitute L=3W
SV=MD * $3W^2$.
Solve for W:
8,930 cu. ft. = 1 X $3W^2$ 2,977 = W^2
W = 55 ft
L= 3W so L = 164 ft

If using a longitudinal slope, it is still required that the maximum depth, at any point in the basin, not exceed 24 inches (or in this case 12 inches due to the soil type). This slope results in a 3D triangle of infiltration volume versus the cubic volume created by a basin with a flat floor.

To correct for this and to provide the required infiltration volume, the preliminary effective infiltration area originally calculated must be divided by 0.5. This will correct for the triangle of lost volume created by the sloped floor of the basin, the maximum depth and the water surface.

8,930 sq. ft. / 0.5 = 17,860 sq. ft.
The new W and L are now W = 77ft. and L = 3W = 231ft.

Note: The surface area calculated is the minimum effective infiltration area and does not include slopes or setbacks. Additional site area will be needed to account for berms and slopes.

e. Side Slopes – All side slopes for interior and exterior berms shall have a 4:1 slope (horizontal: vertical) or flatter.

f. Infiltration Cells – To maximize the effective infiltration area utilized and to prevent channelized flow, the effective infiltration area shall be subdivided into multiple smaller "cells" using *level spreaders* (example shown in Figure 1 & 2). These "cells" shall be used if a longitudinal slope is specified or if the length of the flow path exceeds 300 linear feet.

   The effective infiltration area shall be divided such that as a downstream cell reaches the depth of its level spreader, the elevation of the water in that cell does not exceed the downstream toe of slope from the next upstream level spreader. The height of any level spreader shall not exceed the maximum ponding depth.

Example (continued)

Given: MD = 12 inches, SA = 17, 860 sq. ft., longitudinal slope = 1%. W = 77 ft. L = 231 ft.

With a length of 231 feet and a slope of 1% we know the basin rises 2.3 feet along its length from the outlet to the toe of the pre-treatment area. Given a 12-inch maximum depth of water in the practice for infiltration, the basin needs to be divided into multiple cells with each cell a maximum 300 feet length or a maximum of 12 inches of depth in each cell.

As this example has a longitudinal slope of 1% the maximum cell is 100 feet in length (100 * 1% = 1 feet which is the maximum depth). Had this basin had no longitudinal slope on the floor, a cell up to 300 feet long could have been utilized.

The first level spreader should be located 100 feet upstream from the outlet structure. This leaves us with 131 feet to the pretreatment area. At 1% slope, the height of the level spreader should be 1.3 feet, which is greater than allowed. So the second level spreader should be 1 foot in height, with the third being 100 more feet upstream with a height of 0.43 feet.

Note: To improve the aesthetics of the basin, the second and third cells may be evened out to two cells of 66 feet each and level spreader heights of 0.66 feet.

5. Basin Inlets and Cell Dividers / Level Spreader – The design shall evenly spread the outflow from the pretreatment device or between cells across the width of the basin. The pretreatment discharge pipes and stone trench shown in Figures 1 & 2 (plan and profile view) provide an example of level spreaders.

6. Basin Outlets – The infiltration basin outlet shall safely convey stormwater

from the basin through all of the following mechanisms. An example of outlet pipes is shown in Figures 3 & 4 (front and side view)

a. Draw Down Device – A means shall be provided to quickly remove standing water from the basins for maintenance and winter diversion.

b. Emergency Spillway – A means shall be provided to release discharge in excess of the infiltration volume safely into the downstream stormwater conveyance system. The spillway shall be designed for a 100 year 24-hour storm event.

c. Freeboard – One foot of freeboard above the flow depth in the spillway shall be provided.

7. Maintenance Access – Provide a 12 foot wide access route, with a 6:1 slope, to the floor of the basin for sediment and debris removal.

8. Embankment Construction – Embankments shall conform with WDNR Conservation Practice Standard Wet Detention Basin (1001). A basin embankment may be regulated as a dam under ch. 31 Stats., and further restricted under ch. NR 333, Wis. Adm. Code, which includes regulations for embankment heights and storage capacities.

C. Construction

1. Construction shall be suspended during periods of rainfall or snowmelt. Construction shall remain suspended if ponded water is present or if residual soil moisture contributes significantly to the potential for soil smearing, clumping or other forms of compaction.

2. An assessment of the active erosion in the drainage area to the infiltration basin shall be performed to determine when to bring the infiltration basin on-line. The basin shall be brought on-line when the area draining to the basin has achieved 90% build out of all lots in any of the first 3 years or 75% build out in any subsequent year. By 5 years from the start of construction in the drainage area, all infiltration basins shall be brought on-line. Build out means that the lot has been fully developed and stabilized from erosion. If the infiltration basin area is to also provide peak flow control for the fully built out 5-year, 24-hour event or greater, then a bypass device to divert those flows into the practice will be allowed until the infiltration basin is brought fully on-line. Erosion and sediment control practices shall be implemented for the remaining 10-25% of the undeveloped lots with the goal of preventing any sediment from reaching the infiltration basin.

3. During construction one of the following methods shall be used:

a. No disturbance – The infiltration area shall be fenced off to prevent heavy equipment access during development.

b. Compaction Mitigation – If the active infiltration area is graded the effects of compaction shall be mitigated using the following methods:

(1) Incorporate soil additives consisting of two inches of compost mixed into two inches of topsoil.

(2) The soil mix (V.C.3.b.1) shall be incorporated into the existing soil using a chisel plow or rotary device with the capability of reaching to 12 inches below the existing surface.

(3) The compost component shall meet the following WDNR Specification S100 Compost.

4. The basin shall be constructed to the grades, elevations, and specifications in the plan. After grading and top soiling, the elevation of the basin shall be surveyed for conformance to design specifications.

D. Vegetation Cover

1. Establishment – Cover crops need to be applied in conjunction with the initial seeding of permanent vegetation. When establishing turf type grass, use the criteria contained in the DNR Conservation Practice Standard Seeding for Construction Site Erosion Control (1059). Sod shall not be used.

   If turf grass is utilized, the basin cannot be used for recreational purposes due to compaction concerns.

2. Native Seeding – Native vegetation shall be established in conformance with recommendations from a qualified native nursery in the area. If trees are to be used, species shall be selected that will not interfere with the function of the basin, or cause maintenance problems. Section IX References, lists sources that provide suggested seed mixtures.

   Native (prairie) seeding shall be completed in the fall (as dormant seeding prior to first snowfall) or in the spring (between May 1 and June 20), or plugs shall be used.

3. Fertilizer – Soil testing shall be used to determine proper applications for nutrients and liming. Fertilizer application shall conform to the criteria located in NRCS Conservation Practice Technical Standard, Critical Area Planting (342) or WDNR Conservation Practice Standard Seeding for Construction Site Erosion Control (1059).

4. Mulch – Mulch shall conform to the criteria located in WDNR Conservation Practice Standard Mulching for Construction Sites (1058).

VI. Considerations

A. Pretreatment Options - See WDNR Conservation Practice Technical Standards Wet Detention Basin (1001), Ditch Check (1062), and Vegetated Infiltration Swale (1005) for guidance. Estimates of pollutant reduction by proprietary devices should be based on monitoring using the EPA Environmental Testing Verification protocol.

B. Well Locations - If well locations in relation to the basin are a concern, the site should be evaluated for the direction of ground water flow.

C. Multiple Uses - Basins can be used for both infiltration and peak shaving as shown on Figure 1 and 2. However, another option is to include a *flow splitter* or diversion prior to pretreatment. By limiting the inflow into a BMP, a flow splitter can enhance the longevity of the BMP by reducing the volumetric rate of treatment, erosion or scour, and vegetation damage. Flow splitters need to be designed to address site conditions and flows.

D. Drainage Area Size – The drainage area should be between 5 and 50 acres. If the drainage area is more than 50 acres, multiple basins should be provided.

E. Regulatory Caps - Ch. NR 151 provides for a maximum area to be dedicated for infiltration depending upon land use. This cap can be voluntarily exceeded.

F. Native Vegetation - The use of prairie grass or other deep-rooted plants is encouraged because these plants can increase the infiltration capacity of the basin. Dense vegetation will also reduce soil erosion on the basin floor.

G. Level Spreader - Since it is often difficult to construct a level spreader, a combination of a berm and stone trench is recommended. Other methods to disperse flows include irrigation practices such as ridge and furrow irrigation systems. Refer to American Society of Agricultural Engineering Standards for guidelines on construction of irrigation dispersal systems.

H. Tracked vehicles should be used during construction to lessen compaction.

I. The final grading should be conducted by the landscape contractor so that the drainage area can be stabilized first.

J. Snow should not be placed in the effective infiltration area. It may be placed on the

pretreatment area or areas draining into the pretreatment area.

K. Internally Drained Watersheds – There are unique considerations for watersheds that are closed basins which are internally drained. Infiltration basins constructed in internally drained watersheds shall meet the requirements of NR 151 and this standard. Storms with a recurrence interval greater than a 2-year 24-hour storm must also be considered in the design and engineering judgment may determine that criteria such as draw down time and maximum depth may be exceeded for these larger storms. Infiltration basins in internally drained watershed may have different needs for plants, pretreatment, safety, maintenance or other characteristic that must be considered during design and construction.

L. The DNR has created a technical note that may be used to size infiltration basins. The "Technical Note for Sizing Infiltration Basins and Bioretention Devices To Meet State Of Wisconsin Stormwater Infiltration Performance Standards" contains an approved method to determine the target stay-on depth and 12 design charts that can be used to size these basins for a variety of conditions. In addition, the technical note contains a reference to an approved infiltration model (RECARGA) that can also be used to determine effective infiltration area requirements. Other models may be used if approved. The Technical Note can be accessed at: http://dnr.wi.gov/org/water/wm/nps/stormwater/techstds.htm#Post

VII. Plans and Specifications

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use. Plans shall specify the materials, construction processes, location, size and elevations of all components of the practice to allow for certification of construction upon completion.

VIII. Operations and Maintenance

An operation and maintenance plan shall be developed that is consistent with the purposes of this practice, intended life of the components, safety requirements, and the criteria for the design. There may be state and local laws that require adequate O&M of public and private facilities and the identification of responsible parties. At a minimum, the plan shall include:

A. Inspection Intervals – At minimum, quarterly inspections shall occur. Inspection shall include spreader and overflow spillway for indication of failure. Note the condition of vegetation as part of inspection. If standing water is observed over 50% of the basin floor 3 days after rainfall, the basin is clogged and measures should be undertaken to unclog it. (See section VIII.C).

B. Native Vegetation - Maintenance of Native Vegetation – Mowing (cutting) or burning shall be used to maintain the vegetation.

1. Establishment - The first mowing of newly planted seed shall occur once it reaches a height of 10 to 12 inches.
2. Mowing
   a. Mowing shall reduce the height of plants to 5 to 6 inches.
   b. After establishment, if burning cannot be accommodated, mowing shall occur once in the fall (after November 1). The area shall be mowed to a height of 5 to 6 inches.
3. Burning
   a. Routine Maintenance - Beginning the second year, burning shall occur in the early spring (prior to May 1st) or in the late fall (after November 1st)
   b. Burning shall be done two consecutive years and then up to three years can pass before the next burning.
   c. Under no circumstances shall burning occur every other year.

C. Restoration Procedures – these include removing the top 2 to 3 inches, chisel plowing and adding topsoil and compost. If deep tilling is used, the basin shall be drained and the soils dried to a depth of 8 inches. If the basin was planted in turf grass and clogging again occurs after these restoration procedures have been used, the owner /operator shall replant with prairie

style vegetation using the soil preparation method recommended by the native nursery in the area.

D. Trash shall be removed as quickly as possible once observed.

E. Pretreatment – If wet detention is used, see WDNR Conservation Practice Technical Standard Wet Detention Basin (1001) for operations and maintenance requirements.

F. Winter Maintenance – All draw down devices in the pond shall be opened during winter months to discourage infiltration of runoff water containing high levels of chlorides. If this practice is an enclosed basin, the use of chloride deicers shall be limited in the area draining to the basin to reduce the chance of exceeding the limits in ch. NR 140.

IX. References

Metropolitan Council, 2003. Urban Small Sites Best Management Practice Manual, Chapter 3, Vegetative Methods 3-85 – 3-91. Minneapolis.

United States Department of Agriculture – Natural Resources Conservation Service. Engineering Field Handbook, Chapters 16 and 18.

UWEX Publication A3434 Lawn and Establishment & Renovation.

WisDOT, 2003. State of Wisconsin Standard Specifications for Highway and Structure Construction. Section 630, Seeding.

X. Definitions

Draw down device (V.B.1): A draw down device can consist of any device that allows for the dewatering of the infiltration basin or the infiltration cells down to the ground elevation. Examples include removable weir plates (shown in Figure 3), pipes with valves, weirs with removable stop logs.

Effective infiltration area (V.B.4.c.): An effective infiltration area means the area of the infiltration system that is used to infiltrate runoff and does not include the area used for site access, berms or pretreatment.

Flow Splitter (VI.C): A flow splitter is a device used to direct a fraction of runoff into the BMP facility while bypassing excess flows from larger storm events.

Hydraulically connected (V.A.1.): Two entities are said to be hydraulically connected if a surface or subsurface conduit exists between the two such that water is transmitted from one entity to the other.

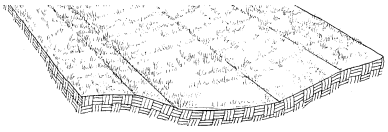
Level spreader (V.B.4.f): A level spreader is a device used to disperse concentrated flows back over a wide area, dissipating the energy of the runoff and promoting sheet flow. Common types of level spreaders include vegetated, earthen or stone berms, weirs and stone trenches.

Target Stay-on Depth (IV.B.4.b.): The amount of infiltration required on an average annual basis. It is the portion of the annual rainfall (inches) on the development site that must be infiltrated on an annual basis to meet the infiltration goal.

Vegetated Infiltration Swale
(1005)
Interim Technical Standard
Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

Vegetated infiltration swales are stormwater conveyance systems designed to enhance the infiltration runoff. A vegetated infiltration swale can be a natural elongated depression or a constructed channel. A vegetated infiltration swale differs from a conventional drainage channel or ditch in that it is constructed specifically to promote infiltration.



II. Purposes

The primary purpose of this practice is to infiltrate storm water, while limiting groundwater contamination by providing filtering of pollutants. Vegetated swales can also help attenuate peak flows through reducing runoff velocities and volumes.

III. Conditions where Practice Applies

Vegetated infiltration swales are best suited for
- *low- to medium-density residential land uses*[1], and
- Non-residential areas where infiltration of runoff is allowable under Chapter NR 151.

Swales are often placed along roads and in drainage easements in side/back lot lines. Swales are intended to treat relatively flat and small drainage areas with contributory areas less than 5 acres. Swales are not suitable in areas of steep topography or areas with erodible soils without implementation of additional measures to reduce flow velocities and protect against erosion.

This standard does not apply to swales installed to meet the swale treatment option set forth in ss. NR 151.24(10) and Trans 401.106(10).

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable Federal, State, and local laws, rules, regulations, or permit requirements governing vegetated infiltration swales. This standard does not contain the text of Federal, State, or local laws.

V. Criteria

Vegetated infiltration swales shall be designed to infiltrate runoff and can be a component of a system intended to meet the runoff infiltration requirements of Chapter NR 151. The swale may also be a component of the stormwater conveyance/storage system.

A. **Site Assessment** - A site assessment shall be conducted and documented meeting the requirements of the WDNR Conservation Practice Standard "Site Evaluation for Stormwater Infiltration" (1002). In addition, the site assessment shall evaluate the alignment of the infiltration swale in relation to ground slopes; drainage patterns; and proximity to buildings.

B. **Determination of *Effective Infiltration Area*** – In order to take credit towards the infiltration requirements in NR 151.12(5)(c), the swale must meet the criteria outlined in this standard.

The effective infiltration area is the area that can be counted toward the requirements in NR 151.12(5)(c) and is calculated based on wetted perimeter of the vegetated infiltration swale at a flow depth of 1-inch multiplied by the length of vegetated infiltration swale.

*Effective Infiltration Area (ft^2) = ½ * Wetted Perimeter (ft) at 1-inch depth of flow * Length of Vegetated Infiltration Swale (ft)*

Details on the calculation methodology can be found in Attachment 1.

Vegetated infiltration swales receiving runoff from source areas outlined under NR 151.12 (5)(c)(4) cannot be counted toward the effective infiltration area unless the water is effectively pre-treated prior to entering the swale. The area of the

[1] Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used in the text.

pre-treatment device shall not be counted toward the effective infiltration area.

C. **Pre-treatment -** As with other infiltration devices, vegetated infiltration swales require pretreatment of stormwater to remove sediment from source areas listed in NR 151.12 (5)(c)(4). Pretreatment can be accomplished through the use of practices such as grassed swales, detention basins, and vegetated filter strips.

If a pre-treatment swale is used, the length of pre-treatment shall be calculated based on the following equation with a minimum length of 200 feet:

$$\mathbf{L = v * HRT *} 60\text{s/m}$$

Where:
L = Swale length in feet
v = Peak flow velocity in fps for 2-year, 24-hour design storm
HRT = Hydraulic residence time in minutes shall be either:

- 5-minutes for infiltration rate greater than or equal to 0.5 inches per hour (sandy loam).
- 8-minutes for infiltration rate less than 0.5 inches per hour (sandy loam).

Infiltration rates shall be determined in accordance with WDNR Conservation Practice Standard Code 1002, "Site Evaluation for Stormwater Infiltration."

If a pre-treatment swale is used, the area of the pre-treatment swale shall not be counted toward the effective infiltration area

D. **Design Infiltration Rate** - The *design infiltration rate* for swale ($\mathbf{K}_{swale}$) shall be ½ the infiltration rate ($\mathbf{K}_{static}$) determined in accordance with WDNR Conservation Practice Standard Code 1002, "Site Evaluation for Stormwater Infiltration." This is to account for the dynamic nature of a swale in which water is moving through the system rather than the static nature of the infiltration tests where the water is allowed to pond.

$$\mathbf{K}_{swale}\ (\text{inches/hr.}) = ½\ \mathbf{K}_{static}$$

E. **Infiltration Volume Credit -** The volume of water infiltrated and the resulting pollutant reduction must be quantified through the use of an *approved model*.

F. **Velocity and Depth Criteria** – A maximum velocity is based on providing adequate residence time for infiltration, allowing for a stable swale design, and preventing re-suspension and scour of sediment.

1. Peak flow velocity for the 2-year, 24-hour design storm shall not exceed 1.5 feet per second and have a maximum flow depth of 12-inches. For larger design storms greater than the 2-year, 24-hour, velocities shall be non-erosive.

2. Manning's roughness coefficients, "*n*", shall be selected consistent with the type of vegetation, mowing height, and depth of flow. Attachment 2 provides guidance on selection of Manning's *n* values for shallow depth of flows.

   When calculating the infiltration volume, if the approved model does not vary Manning's n with the depth of flow, a default value of 0.30 can be used for the Manning's n provided the flow depth does not submerge the vegetation.

3. Ditch checks, if allowed by the regulatory authority, shall be installed as necessary to reduce velocities, extend detention time, or retain a design volume. Refer to Technical Standard 1062 Ditch Checks for design requirements.

   If utilizing ditch checks, ensure that the design allows for no standing water within 24 hours after a rainfall / runoff event.

G. **Swale Geometry Criteria**[a] -

1. Swales shall have side slopes no steeper than three horizontal to one vertical (3:1) for trapezoidal channels and 4:1 for triangular shaped swales. Flatter side slopes are recommended to reduce erosion potential and increase infiltration area.

2. The bottom width of the swale is shape dependent but shall be a maximum of 6-feet. If widths greater than 6-feet are needed then length-wise dividers shall be

[a] *This standard does not set forth criteria for the analysis of site hydrology, system hydraulic analysis for large flows, or channel stability See Reference Section X.*

employed such that the maximum width of any given cell is 6-feet.

3. The longitudinal slope of the swale shall between 1% and 4%.

H. **Vegetation** - Swales shall be planted with native vegetation or seeded with turf grass. A specific planting guide shall be prepared for each project. A companion (cover) crop may be necessary for establishing native vegetation. Depending on location of the swale, vegetation shall be selected that is tolerant of road salt and wetness. A planting medium that can support the selected vegetation shall be installed.

To maintain vegetation, infiltration swales shall be designed to have no standing water within 24 hours after a rainfall / runoff event.

Sod shall not be used. Sod does not establish roots as well as seed and often has muck soils not conducive to infiltration.

I. **Site Layout** - The site layout shall consider features such as location of infiltration swales relative to buildings, water supply wells, lot boundaries, and existing or proposed public rights-of-way.

1. Where a swale accepts runoff from more than one property, it shall be located in a legally established drainage easement granting access for maintenance, or in a public right-of-way.

2. Swales shall not be *hydraulically connected* to foundations or cause negative impacts to structures.

3. Swales shall not be located such that overflow from the swale could cause flooding of existing or proposed buildings during storms with recurrence intervals commensurate with the degree of hazard.

J. **Construction Criteria** - Following excavation, exclude vehicles and heavy equipment from entering the infiltration swale area to prevent compaction. To minimize or mitigate the effects of compaction during construction and to control soil erosion associated with construction:

1. Compaction Mitigation – The effects of compaction shall be mitigated using the following methods:

a. Incorporate soil additives consisting of two inches of *compost* and two inches of topsoil.

b. The compost shall be incorporated into the existing soil using a chisel plow or rotary device with the capability of reaching to 12 inches below the existing surface.

c. The compost component shall meet Wisconsin Department of Natural Resources Specifications S100 Compost.

2. A construction erosion control plan shall be prepared. Prior to compaction mitigation and final grading of the infiltration swale, the drainage area to the swale shall have proper erosion controls in place to prevent sediment from entering the swale, and the lot(s) adjacent to the swale shall be stabilized. Any sediment entering the swale during construction shall be removed after the tributary area is stabilized. The infiltration swale itself shall also be stabilized following compaction mitigation and final grading. Stabilize swale prior to receiving runoff. For stabilization design criteria for tributary areas and the swale itself, refer to WDNR Conservation Practice Standards Channel Erosion Mat (1053), Mulching for Construction Sites (1054) and Seeding for Construction Site Erosion Control (1059).

VI. Considerations

These additional factors are set forth to enhance the use of this practice, or to address special cases that may arise in the implementation of the practice.

A. Swales should be designed to have hydraulic capacities that meet applicable local government or state agency requirements for conveying runoff from large storms, and they should also be designed as part of a *major stormwater management system* as defined in this standard.

B. The number and length of swales is dictated by the topography and amounts of runoff from the contributing area. For a given depth of flow, the width of a swale depends on the rate and velocity of flow through the swale. Minimum length and width requirements to achieve infiltration and water quality improvements may limit the use of a swale at some sites.

C. The establishment of deep-rooted vegetation will enhance infiltration.

D. Swale geometry should attempt to maximize the infiltrative surface but avoid convergence of flows that may result in erosion or gullies.

E. Excavation hoes, light equipment with turf-type tires, marsh equipment, or wide-track loaders should be used to construct swales.

F. Public education is recommended to inform local residents of the swale's purpose and to discourage dumping of leaves or parking on the edge of the swale.

G. This infiltration device is not suitable for treating chlorides. Chloride use on source areas tributary to a swale can be reduced or eliminated by minimizing the amount of compound used, using alternative de-icers or using clean sand.

VII. Plans and Specifications

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use. Plans shall specify the materials, construction processes, locations, size and elevations of all components of the practice to allow for certification of construction upon completion.

VIII. Operation and Maintenance

A. An operation and maintenance plan for the specific swales shall be prepared. The responsible party shall be identified.

B. Consider prevention of off-street parking or other activities that may cause rutting or soil compaction in the swale.

C. Pesticides and fertilizer shall be used in moderation, and only if needed to establish or maintain dense vegetation.

D. Vegetation shall be mowed or cut such that the proper design height is maintained. To take credit for potential phosphorus removal by the swale, mowed/cut vegetation must be removed as part of routine maintenance.

E. Sediment shall be removed when infiltration rates are impeded or sediment reaches a height of 2-inches. Minimize serious disturbance of the vegetation and avoid compaction of the soil in the swale during the sediment removal process. After sediment removal, repair any damaged or eroded areas. Fill any eroded areas with topsoil and reseed.

F. If during construction or maintenance erosion becomes severe enough to prevent establishment of vegetation, additional erosion control measures shall be taken. Refer to WDNR Conservation Practice Standards 1053, 1054, and 1059 for further guidance.

G. When maintenance is required the infiltration capacity of the swale shall be restored. Vegetation shall be reestablished following compaction mitigation.

H. Annual inspections shall be made to detect and remedy nuisance conditions such as mosquitoes, weeds, woody growth and trash dumping.

IX. Definitions

Approved Model (V.E.): A computer model with an infiltration component that adequately accounts for the hydraulic nature of swales and that has been approved by the applicable regulatory authority. Examples include SLAMM, P-8, and RECARGA.

Compost (J.1.): A mixture that consists largely of aerobically decayed organic waste.

Design Infiltration Rate (V.D.): A velocity, based on soil structure and texture, at which precipitation or runoff enters and moves into or through soil. The design rate is used to size an infiltration device or system. Rates are selected to be minimal rates for the different types of soils. Selection of minimal rates will provide a robust design and maximize the longevity of the device.

Effective Infiltration Area (V.B.): The area of the infiltration system that is used to infiltrate runoff. Does not include the area used for pretreatment.

Hydraulically Connected (I.): Two entities are considered to be hydraulically connected if a surface or subsurface link exists between the two exist such that water is transmitted from one entity to the other.

Low -density Residential Land Use (III): Single-family houses on lots with areas of 19,000 square feet or greater.

Major Stormwater Management System (VI.A): The stormwater management facilities that are intended to convey and/or store runoff in excess of the capacity of the minor system. The minor system is designed to

function frequently to prevent nuisance flooding and is sized for a smaller storm than the major system, generally a 10-year storm. The major system is primarily designed to function infrequently to prevent flooding of buildings and ponding of runoff in locations where it could promote harmful infiltration and inflow to sanitary sewers. The major system is generally designed for a 100-year storm. It consists of the components of the minor system, such as overland flow, swales, curbs and gutters, storm sewers, and detention/retention basins, and also includes the entire roadway cross section and associated swales or overland flow paths ultimately discharging to receiving streams.

Medium-density Residential Land Use (III)*:* Single-family houses on lots with areas ranging from 10,900 to 18,999 square feet.

X. References[b]

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USDA-Natural Resources Conservation Service, *Grassed Waterway Conservation Practice Standard*, Code 412, June 1993.

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[b] Methods for hydraulic analysis and channel stability are well documented and are; therefore; not included in this standard.. For more background, see open channel hydraulics texts such as Open Channel Hydraulics, Chow, 1988; Open Channel Flow, Henderson, 1966; and Open-Channel Hydraulics, French, 1985.

Attachment 1:
Calculation of Effective Infiltration Area
Vegetated Infiltration Swales (1005)

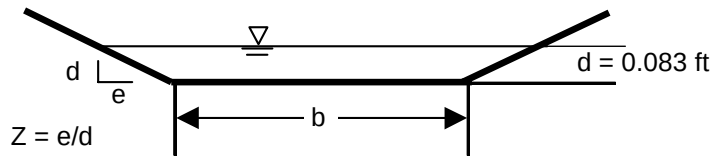
The effective infiltration area as outlined in NR 151 is defined as the area of the infiltration system that is used to infiltrate runoff and does not include the area used for site access, berms, or pretreatment. The area of infiltration is calculated for a swale based on the wetted perimeter of the swale. However, the swale is rarely flowing at capacity under the numerous smaller rainfall events that dominate an average year, so the wetted perimeter at the design capacity of the swale (typically a 2-year or 10-year storm) is not appropriate. The effective infiltration area is determined as follows:

Effective Infiltration Area (ft^2) = ½ * Wetted Perimeter (ft) * Length of Vegetated Infiltration Swale (ft)

For the purpose of NR 151, the wetted perimeter will be calculated at a 1-inch (0.083 feet) depth of flow. The 1-inch depth of flow is intended to simulate the water quality volume. The multiplication by ½ is to account for the reduced infiltration rate in swales compared to other practices such as infiltration basins were water is allowed to pond. Wetted perimeter can be calculated as outlined below.

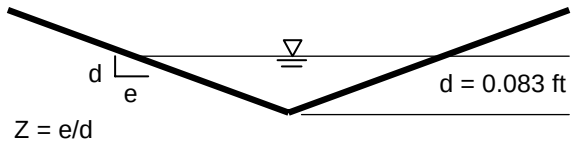
Trapezoidal Channel Cross section:

Wetted Perimeter, p
$p = b + 2d (Z^2 + 1)^{1/2}$



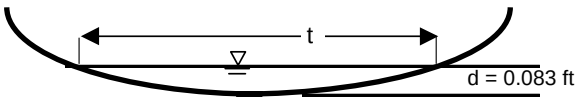
Triangular Channel Cross section:

Wetted Perimeter, p
$p = 2d (Z^2 + 1)^{1/2}$



Parabolic Channel Cross section

Wetted Perimeter, p	Top Width of flow, t	Cross-sectional Area of flow, a
$p = t + (8 d^2) / (3 t)$	$t = a / (0.67 d)$	$a = 2/3 (t d)$

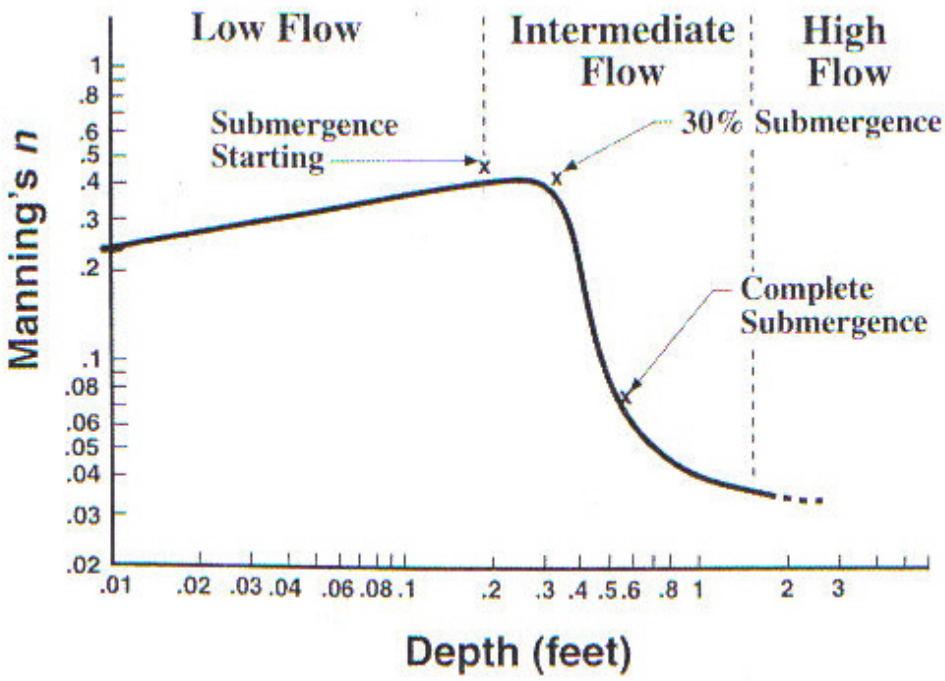


[1] Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used in the text.

Attachment 2:
Calculation of Manning's n Values
Vegetated Infiltration Swales (1005)

Manning's n, the roughness coefficient, varies with the type and height of vegetation and the depth of flow. Typically, vegetation creates a significant flow resistance at lower flows when the grass remains erect and the water surface is below the top of the vegetation. Vegetated infiltration swales are designed to convey runoff from smaller more frequent storm events and thus at lower flow depths than typically encountered using the typical design-storm methodology (i.e. 2-year or 10-year storm). Figure 1 shows a variation of Manning's n with flow depth. Figure 1 assumes dense turf type vegetation mowed to a height of 4-inches. This is consistent with published values that show a Manning's n value of 0.030 for short turf grass under higher flow conditions (Chow, 1959) in which the vegetation is submerged.

Figure 1: Manning's n Under Different Flow Depths



Source: Minton 2005

Research has shown that Manning's n can be related to the product of the flow velocity and the hydraulic radius. This relationship is further dependent again on the type and height of vegetation. Currently, data does not exist for native prairie vegetation.

[1] Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used in the text.

Non-Channel Erosion Mat

(1052)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A protective soil cover made of straw, wood, coconut fiber or other suitable plant residue, or plastic fibers formed into a mat, usually with a plastic or biodegradable mesh on one or both sides. Erosion mats are rolled products available in many varieties and combinations of material and with varying life spans.

II. Purpose

The purpose of this practice is to protect the soil surface from the erosive effect of rainfall and prevent *sheet erosion* [1] during the establishment of grass or other vegetation, and to reduce soil moisture loss due to evaporation. This practice applies to both *Erosion Control Revegetative Mats (ECRM*) and *Turf-Reinforcement Mats* (*TRM*).

III. Conditions Where Practice Applies

This standard applies to erosion mat selection for use on erodible slopes.

This standard is not for channel erosion; for channel applications reference WDNR Conservation Practice Standard (1053) Channel Erosion Mat.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of erosion mat. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum allowable standards for design, installation and performance requirements. Only Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List (PAL) approved mats will be accepted for use in this standard.

Slope and slope length shall be taken into consideration. This information can be found in the Slope Erosion Control Matrix located in the PAL.

To differentiate applications Erosion mats are organized into three Classes of mats, which are further broken down into various Types.

A. **Class I**: A short-term duration (minimum of 6 months), light duty, organic mat with photodegradable plastic or biodegradable netting.

   1. **Type A** – Use on erodible slopes 2.5:1 or flatter.

   2. **Type B** – Double netted product for use on erodible slopes 2:1 or flatter.

B. **Class I, Urban**: A short-term duration (minimum of 6 months), light duty, organic erosion control mat for areas where mowing may be accomplished within two weeks after installation.

   1. **Urban, Type A** – Use on erodible soils with slopes 4:1 or flatter.

   2. **Urban, Type B** – A double netted product for use on slopes 2.5:1 or flatter.

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

C. **Class II**: A long-term duration (three years or greater), organic erosion control revegetative mat.

1. **Type A** – Jute fiber only for use on slopes 2:1 or flatter for sod reinforcement.

2. **Type B –** For use on slopes 2:1 or greater made with plastic or biodegradable net.

3. **Type C** – A woven mat of 100% organic fibers for use on slopes 2:1 or flatter and in environmentally and biologically sensitive areas where plastic netting is inappropriate.

D. **Class III**: A permanent 100% synthetic ECRM or TRM. Either a soil stabilizer Type A or Class I, Type A or B erosion mat must be placed over the soil filled TRM.

1. **Type A** – An ECRM for use on slopes 2:1 or flatter.

2. **Type B or C** – A TRM for use on slopes 2:1 or flatter.

3. **Type D** – A TRM for use on slopes 1:1 or flatter.

E. **Material Selection**

1. For mats that utilize netting, the netting shall be bonded to the parent material to prevent separation of the net for the life of the product.

2. For urban class mats the following material requirements shall be adhered to:

a. Only 100% organic biodegradable netted products are allowed, including parent material, stitching, and netting.

b. The netting shall be stitched with biodegradable thread/yarn to prevent separation of the net from parent material.

c. All materials and additive components used to manufacture the anchoring devices shall be completely biodegradable as determined by ASTM D 5338.

d. Mats with photodegradable netting shall not be installed after September 1st.

F. **Installation**

1. ECRMs shall be installed after all topsoiling, fertilizing, liming and seeding is complete.

2. The mat shall be in firm and intimate contact with the soil. It shall be installed and anchored per the manufacturer's recommendation.

3. TRM shall be installed in conjunction with the topsoiling operation and shall be followed by ECRM installation.

4. At time of installation, document the manufacturer and mat type by retention of material labels and manufacturer's installation instructions. Retain this documentation until the site has been stabilized.

VI. Considerations

A. Urban mats may be used in lieu of sod.

B. Documentation of materials used, monitoring logs, project diary and weekly inspection forms, including erosion and stormwater management plans, should be turned over to the authority charged with long term maintenance of the site.

VII. Plans and Specifications

A. Plans and specifications for installing erosion mat shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of erosion mat

2. Installation Sequence

3. Material specification conforming to standard

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Erosion mat shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24-hour period.

B. If there are signs of rilling under the mat, install more staples or more frequent anchoring trenches. If rilling becomes severe enough to prevent establishment of vegetation, remove the section of mat where the damage has occurred. Fill the eroded area with topsoil, compact, reseed and replace the section of mat, trenching and overlapping ends per manufacturer's recommendations. Additional staking is recommended near where rilling was filled.

C. If the reinforcing plastic netting has separated from the mat, remove the plastic and if necessary replace the mat.

D. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

WisDOT "Erosion Control Product Acceptability List" is available online at http://www.dot.wisconsin.gov/business/engrserv/pal.htm Printed copies are no longer distributed.

Field Code Changed

X. Definitions

Sheet and Rill Erosion (II): Sheet and rill erosion is the removal of soil by the action of rainfall and shallow overland runoff. It is the first stage in water erosion. As flow becomes more concentrated rills occur. As soil detachment continues or flow increases, rills will become wider and deeper forming gullies.

Erosion Control Revegetative Mats (ECRM) (II): erosion control revegetative mats designed to be placed on the soil surface.

Turf-Reinforcement Mats (TRM) (II): turf-reinforcement mats are permanent devices constructed from various types of synthetic materials and buried below the surface to help stabilize the soil. TRMs must be used in conjunction with an ECRM or an approved Type A soil stabilizer.

Channel Erosion Mat

(1053)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A protective soil cover of straw, wood, coconut fiber or other suitable plant residue, or plastic fibers formed into a mat, usually with a plastic or biodegradable mesh on one or both sides. Erosion mats are rolled products available in many varieties and combination of materials and with varying life spans.

II. Purpose

The purpose of this practice is to protect the channel from erosion or act as turf reinforcement during and after the establishment of grass or other vegetation in a channel. This practice applies to both *Erosion Control Revegative Mats* (*ECRM*[1]) and *Turf-Reinforcement Mats* (*TRM*).

III. Conditions Where Practice Applies

This standard applies where runoff channelizes in intermittent flow and vegetation is to be established. Some products may have limited applicability in projects adjacent to navigable waters.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of erosion mat. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements. To complete the shear calculations, a 2 year, 24 hour storm event shall be used to calculate depth of flows for an ECRM. For sizing a TRM, use the depth of flow corresponding to the maximum design capacity of the channel.

Only mats listed in the Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List (PAL) will be accepted for use in this standard.

To differentiate applications WisDOT organizes erosion mats into three classes of mats, which are further broken down into various Types.

A. **Class I**: A short-term duration (minimum of 6 months), light duty, organic ECRM with plastic or biodegradable netting.

   1. **Type A** – Only suitable for slope applications, not channel applications.

   2. **Type B** – Double netted product for use in channels where the calculated (design) shear stress is 1.5 lbs/ft^2 or less.

B. **Class II**: A long-term duration (three years or greater), organic ECRM.

   1. **Type A** – Jute fiber only for use in channels to reinforce sod.

   2. **Type B** – For use in channels where the calculated (design) shear stress is 2.0 lbs/ft^2 or less. Made with plastic or biodegradable mat.

   3. **Type C** – A woven mat of 100% organic material for use in channels where the calculated (design) shear stress is 2.0 lbs/ft^2 or less. Applicable

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

for use in environmentally sensitive areas where plastic netting is inappropriate.

C. **Class III**: A permanent 100% synthetic ECRM or TRM. Class I, Type B erosion mat or Class II, Type B or C erosion mat must be placed over a soil filled TRM.

1. **Type A** – An ECRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft^2 or less.

2. **Type B** – A TRM for use in channels where the calculated (design) shear stress of 2.0 lbs/ft^2 or less.

3. **Type C** – A TRM for use in channels where the calculated (design) shear stress of 3.5 lbs/ft^2 or less.

4. **Type D** – A TRM for use in channels where the calculated (design) shear stress of 5.0 lbs/ft^2 or less.

D. **Installation**

1. ECRM shall be installed after all topsoiling, fertilizing, liming, and seeding is complete.

2. Erosion mats shall extend for whichever is greater: upslope one-foot minimum vertically from the ditch bottom or 6 inches higher than the design flow depth.

3. The mat shall be in firm and continuous contact with the soil. It shall be anchored, overlapped, staked and entrenched per the manufacturer's recommendations.

4. TRM shall be installed in conjunction with the topsoiling operation and shall be followed by ECRM installation.

5. At time of installation, document the manufacturer and mat type by saving material labels and manufacturer's installation instructions. Retain this documentation until the site is stabilized.

VI. Considerations

A. Erosion mats shall be selected so that they last long enough for the grass or other vegetation to become densely established.

B. Consider using Class II, Type C mats adjacent to waterways where trapping small animals is to be avoided.

C. Class III TRM may be appropriate as a replacement for riprap as a channel liner. Check the shear stress criteria for the channel to determine mat applicability.

D. Once a gully has formed in a channel, it is difficult to stabilize due to loss of soil structure. Even when the gully is filled with topsoil and reseeded, the soil has a tendency to dislodge in the same pattern. If gully formation continues to be a problem the design should be reevaluated, including other mat classes or riprap.

E. It may be difficult to establish permanent vegetation and adequate erosion protection in a channel with continuous flow. Consider riprap or planting wetland species with an ECRM.

F. Documentation of materials used, monitoring logs, project diary, and weekly inspection forms including erosion and stormwater management plans, should be provided to the authority charged with long term maintenance of the site.

G. Channel cross sections may be parabolic, v-shaped or trapezoidal. The use of "V" channels is generally discouraged due to erosion problems experienced.

H. To help determine the appropriate channel liner, designers can refer to the design matrix in the back of the WisDOT PAL. However, for channels not conforming to the typical section shown in the channel matrix or having a depth of flow greater than 6 inches (150 mm), the designer will need to design

for an appropriate channel liner. One way to do this is to use the "tractive force" method presented in FHWA's Hydraulic Engineering Circular (HEC) No. 15. This method requires that the calculated maximum shear stress of a channel is not to exceed the permissible shear stress of the channel liner. To use this method, permissible shear stress values are stated next to each device listed in the channel matrix.

VII. Plans and Specifications

A. Plans and specifications for installing erosion mat shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of erosion mat
2. Installation sequence
3. Material specification conforming to standard

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Erosion mats shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24-hour period.

B. If there are signs of rilling under the mat, install more staples or more frequent anchoring trenches. If rilling becomes severe enough to prevent establishment of vegetation, remove the section of mat where the damage has occurred. Fill the eroded area with topsoil, compact, reseed and replace the section of mat, trenching and overlapping ends per manufacturer's recommendations. Additional staking is recommended near where rilling was filled.

C. If the reinforcing plastic netting has separated from the mat, remove the plastic and if necessary replace the mat.

D. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

WisDOT "Erosion Control Product Acceptability List" is available online at http://www.dot.wisconsin.gov/business/engrserv/pal.htm.

X. Definitions

Channel Erosion: The deepening and widening of a channel due to soil loss caused by flowing water. As rills become larger and flows begin to concentrate, soil detachment occurs primarily as a result of shear.

Erosion Control Revegative Mats (*ECRM)* (II): Erosion control revegetative mats are designed to be placed on top of soil.

Turf-Reinforcement Mats (*TRM)* (II): Turf-reinforcement mats are permanent devices constructed from various types of synthetic materials and buried below the surface to help stabilize the soil. TRMs must be used in conjunction with an ECRM or an approved soil stabilizer Type A (as classified in the WisDOT PAL)

Sediment Bale Barrier
(Non-Channel)
(1055)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales, hay bales or equivalent material used to intercept sediment-laden sheet flow from small drainage areas of disturbed soil.

II. Purpose

The purpose of this practice is to reduce slope length of the disturbed area and to intercept and retain transported sediment from disturbed areas.

III. Conditions Where Practice Applies

A. This standard applies to the following applications where:

1. Erosion occurs in the form of *sheet and rill erosion*[1]. There is no concentration of water flowing to the barrier (*channel erosion*).

2. Where adjacent areas need protection from sediment-laden runoff.

3. Effectiveness is required for less than 3 months.

4. Conditions allow for the bales to be properly entrenched and staked as outlined in the Criteria Section V.

B. Under no circumstance shall sediment bale barriers be used in the following applications:

1. Below the ordinary high watermark or placed perpendicular to flow in streams, swales, ditches or any place where flow is concentrated.

2. Where the maximum gradient upslope of the sediment bale barriers is greater than 50% (2:1).

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of the sediment bale barrier. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Placement

1. At a minimum, sediment bale barriers shall be placed in a single row, lengthwise on the contour, with the ends of adjacent sediment bale barriers tightly abutting one another. The holes between bales shall be chinked (filled by wedging) with straw, hay or equivalent material to prevent water from escaping between the bales.

2. The maximum allowable slope lengths contributing runoff to a sediment bale barrier are specified in Table 1.

[1] Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used in the text.

Table 1.	
Slope	**Barrier Row Spacing**
< 2%	100 feet
2 to 5%	75 feet
5 to 10%	50 feet
10 to 33%	25 feet
33 to 50%	20 feet
> 50%	Not Permitted

3. Sediment bale barriers shall not be placed perpendicular to the contour.

4. The end of the sediment bale barrier shall be extended upslope to prevent water from flowing around the barrier ends.

B. Height – Installed sediment bale barrier shall be a minimum of 10 inches high and shall not exceed a maximum height of 20 inches from ground level.

C. Anchoring and Support

1. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a sediment bale barrier and the length of the proposed barrier to a minimum depth of 4 inches. After bales are staked and chinked, the excavated soil shall be backfilled and compacted against the barrier. Backfill to ground level on the down slope side. On the upslope side of the sediment bale barrier backfill to 4 inches above ground level.

2. At least two wood stakes, “T" or "U" steel posts, or ½ inch rebar driven through at equidistance along the centerline of the barrier shall securely anchor each bale. The minimum cross sectional area for wood stakes shall be 2.0 by 2.0 inches nominal. The first stake in each bale shall be driven toward the previously laid bale to force the bales together. Stakes shall be driven a minimum 12-inches into the ground to securely anchor the sediment bale barriers.

3. Bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings.

VI. Considerations

A. Improper placement as well as improper installation and maintenance of sediment bale barriers will significantly decrease the effectiveness of this practice.

B. Sediment bale barriers should not be used upslope of the disturbed area.

C. A double row of sediment bale barriers may be installed in areas where additional protection is needed.

D. For safety, place all anchoring flush with the sediment bale barrier or cap any exposed anchoring device.

VII. Plans and Specifications

A. Plans and specifications for installing sediment bale barriers shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of sediment bale barrier

2. Contributory drainage area

3. Schedules

4. Standard drawings and installation details

5. Restoration after removal

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Sediment bale barriers shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24-hour period.

B. Damaged or decomposed sediment bale barriers, any undercutting, or flow channels

around the end of the sediment bale barriers shall be repaired.

C. Sediment shall be properly disposed of once the deposits reach 1/2 the height of the sediment bale barrier.

D. Sediment bale barriers and anchoring devices shall be removed and properly disposed of when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

E. Any sediment deposits remaining in place after the sediment bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.

IX. Definitions

Channel Erosion (III.A.1): The deepening and widening of a channel due to soil loss caused by flowing water. As rills become larger and flows begin to concentrate soil detachment occurs primarily as a result of shear. The transport capacity of the flow in a channel is based on the availability of sediment and is a monatomic function of velocity.

Sheet and Rill Erosion (III.A.1): Sheet and rill erosion is the removal of soil by the action of rainfall and shallow overland runoff. It is the first stage in water erosion. As flow becomes more concentrated rills occur. As soil detachment continues or flow increases, rills will become wider and deeper forming gullies.

Silt Fence
(1056)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

Silt fence is a temporary sediment barrier of entrenched permeable geotextile fabric designed to intercept and slow the flow of sediment-laden sheet flow runoff from small areas of disturbed soil.

II. Purpose

The purpose of this practice is to reduce slope length of the disturbed area and to intercept and retain transported sediment from disturbed areas.

III. Conditions Where Practice Applies

A. This standard applies to the following applications:

1. Erosion occurs in the form of *sheet and rill erosion*[1]. There is no concentration of water flowing to the barrier (*channel erosion*).

2. Where adjacent areas need protection from sediment-laden runoff.

3. Where effectiveness is required for one year or less.

4. Where conditions allow for silt fence to be properly entrenched and staked as outlined in the Criteria Section V.

B. Under no circumstance shall silt fence be used in the following applications:

1. Below the ordinary high watermark or placed perpendicular to flow in streams, swales, ditches or any place where flow is concentrated.

2. Where the maximum gradient upslope of the fence is greater than 50% (2:1).

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of silt fence. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Placement

1. When installed as a stand-alone practice on a slope, silt fence shall be placed on the contour. The parallel spacing shall not exceed the maximum slope lengths for the appropriate slope as specified in Table 1.

Table 1.

Slope	Fence Spacing
< 2%	100 feet
2 to 5%	75 feet
5 to 10%	50 feet
10 to 33%	25 feet
> 33%	20 feet

2. Silt fences shall not be placed perpendicular to the contour.

3. The ends of the fence shall be extended upslope to prevent water from flowing around the ends of the fence.

B. Height – Installed silt fences shall be a minimum 14 inches high and shall not exceed 28 inches in height measured from the installed ground elevation.

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

C. Support – Silt fences shall be supported by either steel or wood supports as specified below:

1. Wood supports

   a. The full height of the silt fence shall be supported by 1 1/8 inches by 1 1/8 inches air or kiln dried posts of hickory or oak.

   b. The silt fence fabric shall be stapled, using at least 0.5-inch staples, to the upslope side of the posts in at least 3 places.

   c. The posts shall be a minimum of 3 feet long for 24-inch silt fence and a minimum of 4 feet for 36-inch silt fence fabric.

2. Steel supports

   a. The full height of the silt fence shall be supported by steel posts at least 5 feet long with a strength of 1.33 pounds per foot and have projections for the attachment of fasteners.

   b. The silt fence fabric shall be attached in at least three places on the upslope side with 50 pound plastic tie straps or wire fasteners. To prevent damage to the fabric from fastener, the protruding ends shall be pointed away from the fabric.

3. The maximum spacing of posts for non-woven silt fence shall be 3 feet and for woven fabric 8 feet.

4. Silt fence shall have a support cord.

5. Where joints are necessary, each end of the fabric shall be securely fastened to a post. The posts shall then be wrapped around each other to produce a stable, secure joint or shall be overlapped the distance between two posts.

6. A minimum of 20 inches of the post shall extend into the ground after installation.

D. Anchoring – Silt fence shall be anchored by spreading at least 8 inches of the fabric in a 4 inch wide by 6 inch deep trench, or 6 inch deep V-trench on the upslope side of the fence. The trench shall be backfilled and compacted. Trenches shall not be excavated wider and deeper than necessary for proper installation.

On the terminal ends of silt fence the fabric shall be wrapped around the post such that the staples are not visible.

E. Geotextile Fabric Specifications – The geotextile fabric consists of either woven or non-woven polyester, polypropylene, stabilized nylon, polyethylene, or polyvinylidene chloride. Non-woven fabric may be needle punched, heat bonded, resin bonded, or combinations thereof. All fabric shall meet the following requirements as specified in Table 2.

Table 2.

Test Requirement	Method	Value[1]
Minimum grab tensile strength in the machine direction	ASTM D 4632	120 lbs. (550 N)
Minimum grab tensile strength in the cross machine direction	ASTM D 4632	100 lbs. (450 N)
Maximum apparent opening size equivalent standard sieve	ASTM D 4751	No. 30 (600 μm)
Minimum permittivity	ASTM D 4491	0.05 scc^{-1}
Minimum ultraviolet stability percent of strength retained after 500 hours of exposure	ASTM D 4355	70%

(WisDOT Standard Specifications for Road and Bridge Construction, 2001)

[1] All numerical values represent minimum / maximum average roll values. (For example, the average minimum test results on any roll in a lot should meet or exceed the minimum specified values.)

Silt fence shall have a maximum flow rate of 10-gallons/minute/square foot at 50mm constant head as determined by multiplying permittivity in 1/second as determined by ASTM D-4491 by a conversion factor of 74.

F. Removal – Silt fences shall be removed once the disturbed area is permanently stabilized and no longer susceptible to erosion.

VI. Considerations

A. Improper placement as well as improper installation and maintenance of silt fences will significantly decrease the effectiveness of this practice.

Silt fences should be considered for trapping sediment where sheet and rill erosion may be expected to occur in small drainage areas. Silt fences should not be placed in areas of concentrated flow.

B. Silt fences should be installed prior to disturbing the upslope area.

C. Silt fences should not be used to define the boundaries of the entire project. Silt fence should be placed only in areas where it is applicable due to its cost and the fact that it is not biodegradable. For example, silt fence should not be placed in locations where the natural overland flow is from an undisturbed area into disturbed areas of the project. It should also not be used as a diversion.

D. Silt fence should not be used in areas where the silt fence is at a higher elevation than the disturbed area.

E. When placing silt fence near trees, care should be taken to minimize damage to the root system. Avoid compaction and root cutting within 1.5 feet multiplied by the inch diameter of the tree (for example: for 10-inch trees keep out a 15-foot radius from the trunk). Refer to UWEX publication Preserving Trees During Construction for more information.

F. To protect silt fence from damage in areas of active construction or heavy traffic, silt fence should be flagged, marked, or highlighted to improve visibility.

G. Silt fence effectiveness is generally increased when used in conjunction with other upslope erosion control practices. To further strengthen the silt fence, straw / hay bales can be placed on the down slope side.

H. To help ensure effectiveness, silt fence should be inspected and repaired as necessary prior to forecasted rain events.

I. Where installation with wood posts is difficult, such as when hard or frozen ground is encountered, the use of steel post is recommended.

J. Silt fence can be mechanically installed with a plow type device provided that the silt fence is trenched in a manner such that equivalent performance is achieved to that specified in Section V.D.

VII. Plans and Specifications

A. Plans and specifications for installing silt fence shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of silt fence
2. Contributory drainage area
3. Schedules
4. Material specification conforming to standard
5. Standard drawings and installation details
6. Restoration after removal

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Silt fences shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24 hour period.

B. Damaged or decomposed fences, undercutting, or flow channels around the end of barriers shall be repaired or corrected.

C. Sediment shall be properly disposed of once the deposits reach ½ the height of the fence.

IX. References

UWEX Publication A0327 “Preserving Trees During Construction”

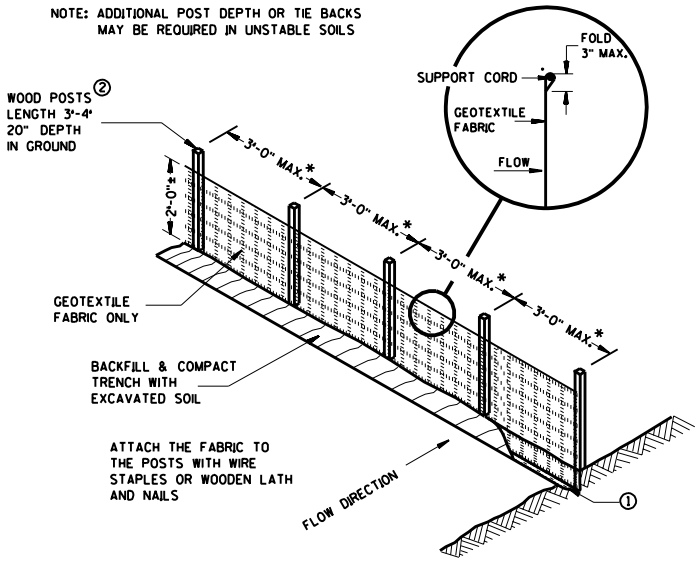
X. Definitions

Channel Erosion (III.A.1): The deepening and widening of a channel due to soil loss caused by flowing water. As rills become larger and flows begin to concentrate, soil detachment occurs primarily as a result of shear.

Sheet and Rill Erosion (III.A.1): Sheet and rill erosion is the removal of soil by the action of rainfall and shallow overland runoff. It is the first stage in water erosion. As flow becomes more concentrated rills occur. As soil detachment continues or flow increases, rills will become wider and deeper forming gullies.

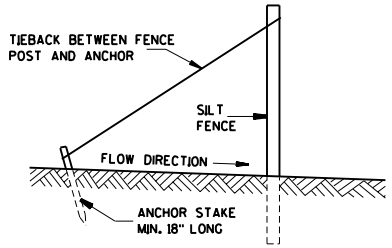
GENERAL NOTES

1. TRENCH SHALL BE A MINIMUM OF 4" WIDE & 6" DEEP TO BURY AND ANCHOR THE GEOTEXTILE FABRIC. FOLD MATERIAL TO FIT TRENCH AND BACKFILL & COMPACT TRENCH WITH EXCAVATED SOIL.
2. WOOD POSTS SHALL BE A MINIMUM SIZE OF 1 1/8" X 1 1/8" OF OAK OR HICKORY.
3. CONSTRUCT SILT FENCE FROM A CONTINUOUS ROLL IF POSSIBLE BY CUTTING LENGTHS TO AVOID JOINTS. IF A JOINT IS NECESSARY USE ONE OF THE FOLLOWING TWO METHODS: A) TWIST METHOD -- OVERLAP THE END POSTS AND TWIST, OR ROTATE, AT LEAST 180 DEGREES. B) HOOK METHOD -- HOOK THE END OF EACH SILT FENCE LENGTH.

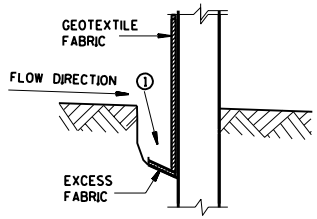


*NOTE: 8'-0" POST SPACING ALLOWED IF A WOVEN GEOTEXTILE FABRIC IS USED.

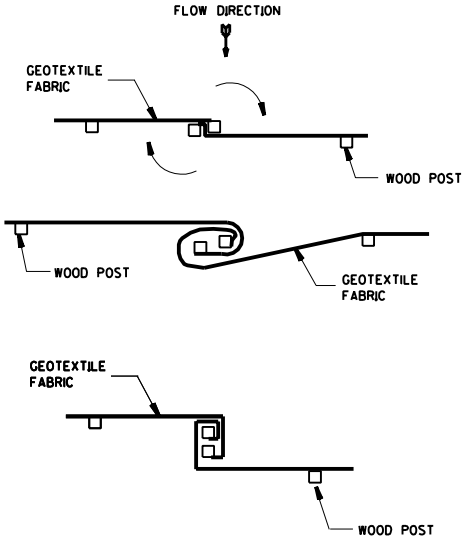
SILT FENCE



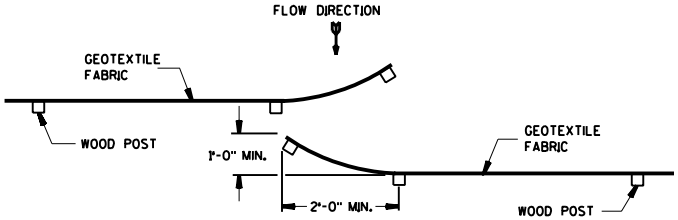
SILT FENCE TIE BACK
(WHEN ADDITIONAL SUPPORT REQUIRED)



TRENCH DETAIL



TWIST METHOD



HOOK METHOD

JOINING TWO LENGTHS OF SILT FENCE ④

This drawing based on Wisconsin Department of Transportation Standard Detail Drawing 8 E 9-6.

SILT FENCE

Stone Tracking Pad and Tire Washing
(1057)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A stabilized pad of stone aggregate or tire washing station located at any point where traffic will egress a construction site.

II. Purpose

The purpose of this standard is to reduce off-site sedimentation by eliminating the tracking of sediment from construction sites.

III. Conditions Where Practice Applies

Either a stone tracking pad or tire washing station shall be used at all points of construction egress. This standard applies where construction traffic is likely to transport sediment off site.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of this practice. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Tracking Pad:

1. The tracking pad shall be installed prior to any traffic leaving the site

2. The aggregate for tracking pads shall be 3 to 6 inch clear or washed stone. All material to be retained on a 3-inch sieve.

3. The aggregate shall be placed in a layer at least 12 inches thick. On sites with a high water table, or where saturated conditions are expected during the life of the practice, stone tracking pads shall be underlain with a WisDOT Type R geotextile fabric to prevent migration of underlying soil into the stone.

4. The tracking pad shall be the full width of the egress point. The tracking pad shall be at a minimum 50 feet long.

5. Surface water must be prevented from passing through the tracking pad. Flows shall be diverted away from tracking pads or conveyed under and around them by using a variety of practices, such as culverts, *water bars*[1], or other similar practices.

B. Tire washing: If conditions on the site are such that the sediment is not removed from vehicle tires by the tracking pad, then tires shall be washed utilizing pressurized water before entering a public road.

1. The washing station shall be located on-site in an area that is stabilized and drains into suitable sediment trapping or settling device.

2. The wash rack shall consist of a heavy grating over a lowered area. The rack shall be strong enough to support the vehicles that will cross it.

C. Rocks lodged between the tires of dual wheel vehicles shall be removed prior to leaving the construction site.

[1] Words in the standard that are shown in italics are described in IX. Definitions. The words are italicized the first time they are used in the text.

VI. Considerations

A. Vehicles traveling across the tracking pad should maintain a slow constant speed.

B. The best approach to preventing off-site tracking is to restrict vehicles to stabilized areas.

C. It is always preferable to prevent sediment from being deposited upon the road than cleaning the road later. Sediment on a road can create a safety hazard as well as a pollution problem.

D. Any sediment tracked onto a public or private road should be removed by street cleaning, not flushing, before the end of each working day.

VII. Plans and Specifications

A. Plans and specifications for installing tracking pads shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of all points of egress with tracking pad locations shown
2. Material specifications conforming to standard
3. Schedule for installation and removal
4. Standard drawings and installation details
5. Stabilization after removal

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Tracking pads and tire washing stations shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24-hour period.

B. The tracking pad performance shall be maintained by scraping or top-dressing with additional aggregate.

C. A minimum 12-inch thick pad shall be maintained.

IX. Definitions

Water bar (V.A.5): A shallow trench or diversion dam that diverts surface water runoff into a dispersion area.

Mulching For Construction Sites
(1058)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

Mulching is the application of organic material to the soil surface to protect it from raindrop impact and overland flow. Mulch covers the soil and absorbs the erosive impact of rainfall and reduces the flow velocity of runoff.

II. Purpose

This practice may be used to:

- Reduce soil erosion
- Aid in seed germination and establishment of plant cover
- Conserve soil moisture

III. Conditions Where Practice Applies

This practice may be applied on exposed soils as a temporary control where soil grading or landscaping has taken place or in conjunction with temporary or permanent seeding. Mulching is generally not appropriate in areas of concentrated flow.

IV. Federal, State, and Local Laws

Users of this standard shall comply with applicable federal, state and local laws, rules, regulations or permit requirements governing mulching. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Site Preparation:

Soil surface shall be prepared prior to the application of mulch in order to achieve the desired purpose and to ensure optimum contact between soil and mulch. All areas to be mulched shall be reasonably free of rills and gullies.

B. Materials:

Mulch shall consist of natural biodegradable material such as plant residue (including but not limited to straw, hay, wood chips, bark and wood cellulose fiber), or other equivalent materials of sufficient dimension (depth or thickness) and durability to achieve the intended effect for the required time period.

Mulch shall be environmentally harmless to wildlife and plants. Materials such as gravel, plastic, fabric, sawdust, municipal solid waste, *solid waste byproducts*[1], shredded paper, and non-biodegradable products shall not be used.

Mulch shall be free of diseased plant residue (i.e. oak wilt), *noxious weed* seeds, harmful chemical residues, heavy metals, hydrocarbons and other known environmental toxicants.

Marsh hay shall not be used as mulch in lowland areas but may be used on upland sites to prevent the spread of invasive, non-native species (i.e. reed canary grass) commonly found in marsh hay.

Straw and hay mulch that will be crimped shall have a minimum fiber length of 6 inches.

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

Wood chips or wood bark shall only be used for sites that are not seeded.

C. Application Rate:

1. Mulch shall cover a minimum of 80% of the soil surface for unseeded areas. For seeded areas, mulch shall be placed loose and open enough to allow some sunlight to penetrate and air to circulate but still cover a minimum of 70% of the soil surface.

2. Mulch shall be applied at a uniform rate of 1½ to 2 tons per acre for sites that are seeded, and 2 to 3 tons per acre for sites that are not seeded. This application results in a layer of ½ to 1½ inches thick for seeded sites, and 1½ to 3 inches thick for sites not seeded.

3. Wood chips or wood bark shall be applied at a rate of 6 to 9 tons per acre to achieve a minimum of 80% ground cover. This application should result in a layer of wood chips or wood bark ½ to 1½ inches thick.

D. Mulch Anchoring Methods

Anchoring of mulch shall be based on the type of mulch applied, site conditions, and accomplished by one of the following techniques:

1. Crimping

   Immediately after spreading, the mulch shall be anchored by a mulch crimper or equivalent device consisting of a series of dull flat discs with notched edges spaced approximately 8 inches apart. The mulch shall be impressed in the soil to a depth of 1 to 3 inches.

2. Polypropylene Plastic, or Biodegradable Netting

   Apply plastic netting over mulch application and staple according to manufacturer's recommendations.

3. Tackifier

   Tackifier shall be sprayed in conjunction with mulch or immediately after the mulch has been placed. Tackifiers must be selected from those that meet the WisDOT Erosion Control Product Acceptability List (PAL). Asphalt based products shall not be applied.

   The tackifiers shall be applied at the following minimum application rates per acre:

   a. Latex-Base: mix 15 gallons of adhesive (or the manufacturer's recommended rate which ever is greater) and a minimum of 250 pounds of recycled newsprint (pulp) as a tracer with 375 gallons of water.

   b. Guar Gum: mix 50 pounds of dry adhesive (or the manufacturer's recommended rate which ever is greater) and a minimum of 250 pounds of recycled newsprint (pulp) as tracer with 1,300 gallons of water.

   ~~c.~~ Other Tackifiers: (Hydrophilic Polymers) mix 100 pounds of dry adhesive (or the manufacturer's recommended rate which ever is greater) and a minimum of 250 pounds of recycled newsprint (pulp) as a tracer with 1,300 gallons of water.

VI. Considerations

A. Wood products typically absorb available soil nitrogen as they degrade, thus making it unavailable for seed.

B. The use of mulch behind curb and gutter may not be desirable unless anchored by netting, because air turbulence from nearby traffic can displace the mulch. Consider the use of erosion mat or sod as an alternative.

C. In areas where lawn type turf will be established, the use of tackifiers is the preferred anchoring method. Crimping will tend to leave an uneven surface and plastic netting can become displaced and entangled in mowing equipment.

D. A heavier application of mulch may be desired to prevent seedlings from being damaged by frost.

E. It may be beneficial to apply polyacrylimide in addition to mulch. Refer to WDNR Conservation Practice Standard (1050) Erosion Control Land Application of Anionic Polyacrylamide for information about the advantages and proper use of polymers.

F. Concentrated flows above the site where mulch is applied should be diverted.

G. Mulch should be placed within 24 hours of seeding.

H. Mulching operations should not be performed during periods of excessively high winds that would preclude the proper placement of mulch.

I. Materials such as gravel may be effective for erosion control but are not considered mulches.

VII. Plans and Specifications

A. Plans and specifications for mulching shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

   1. Type of mulch used

   2. Application rate

   3. Timing of application

   4. Method of anchoring

B. All plans, standard detail drawings, or specifications shall include schedules for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

Mulch shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24 hour period.

Mulch that is displaced shall be reapplied and properly anchored. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

WisDOT's Erosion Control Product Acceptability List (PAL) can be found on the WisDOT web site: http://www.dot.wisconsin.gov/business/engrserv/pal.htm Printed copies are no longer being distributed.

X. Definitions

Noxious weed (V.B): Any weed a governing body declares to be noxious within its respective boundaries. The State of Wisconsin list of noxious weeds can be found in Statute 66.0407.

Solid Waste Byproducts (V.B): Includes industrial, commercial, residential, and agricultural wastes that have been processed, incinerated, or composted and still contain inorganic wastes such as glass and metals and organic wastes including plastics, textiles, rubber, leather, and other miscellaneous organic wastes which may be toxic or hazardous in nature.

Seeding For Construction Site Erosion Control

(1059)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

Planting seed to establish temporary or permanent vegetation for erosion control.

II. Purpose

The purpose of *temporary seeding*[1] is to reduce runoff and erosion until permanent vegetation or other erosion control practices can be established. The purpose of *permanent seeding* is to permanently stabilize areas of exposed soil.

III. Conditions Where Practice Applies

This practice applies to areas of exposed soil where the establishment of vegetation is desired. Temporary seeding applies to disturbed areas that will not be brought to final grade or on which land-disturbing activities will not be performed for a period greater than 30 days, and requires vegetative cover for less than one year. Permanent seeding applies to areas where perennial vegetative cover is needed.

IV. Federal, State and Local Laws

Users of this standard shall be aware of all applicable federal, state and local laws, rules, regulations or permit requirements governing seeding. This standard does not contain the text of federal, state or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Site and Seedbed Preparation

Site preparation activities shall include:

1. Temporary Seeding

   a. Temporary seeding requires a seedbed of loose soil to a minimum depth of 2 inches.

   b. Fertilizer application is not generally required for temporary seeding. However, any application of fertilizer or lime shall be based on soil testing results.

   c. The soil shall have a pH range of 5.5 to 8.0.

2. Permanent Seeding

   a. *Topsoil* installation shall be completed prior to permanent seeding.

   b. Permanent seeding requires a seedbed of loose topsoil to a minimum depth of 4 inches with the ability to support a *dense* vegetative cover.

   c. Application rates of fertilizer or lime shall be based on soil testing results.

   d. Prepare a tilled, fine, but firm seedbed. Remove rocks, twigs foreign material and clods over two inches that cannot be broken down.

   e. The soil shall have a pH range of 5.5 to 8.0.

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

B. Seeding

1. Seed Selection

   a. Seed mixtures that will produce dense vegetation shall be selected based on soil and site conditions and intended final use. Section IX References, lists sources containing suggested seed mixtures.

   b. All seed shall conform to the requirements of the Wisconsin Statutes and of the Administrative Code Chapter ATCP 20.01 regarding noxious weed seed content and labeling.

   c. Seed mixtures that contain potentially invasive species or species that may be harmful to native plant communities shall be avoided.

   d. Seed shall not be used later than one year after the test date that appears on the label.

   e. Seed shall be tested for purity, germination and noxious weed seed content and shall meet the minimum purity and germination requirements as prescribed in the current edition of Rules for Testing Seed, published by the Association of Official Seed Analysts.

2. Seed Rates

   a. Temporary Seeding (Cover Crop)

      Areas needing protection during periods when permanent seeding is not applied shall be seeded with annual species for temporary protection. See Table 1 for seeding rates of commonly used species. The residue from this crop may either be incorporated into the soil during seedbed preparation at the next permanent seeding period or left on the soil surface and the planting made as a no-till seeding.

Table 1 Temporary Seeding Species and Rates

Species	Lbs/Acre	Percent Purity
Oats	131[1]	98
Cereal Rye	131[2]	97
Winter wheat	131[2]	95
Annual Ryegrass	80[2]	97

[1] Spring and summer seeding
[2] Fall seeding

   b. Permanent Seeding

      Rates shall be based on pounds or ounces of Pure Live Seed (PLS) per acre. Section IX contains some possible reference documents that provide seeding rates. Permanent seeding rates may be increased above the minimum rates shown in the reference documents to address land use and environmental conditions.

      If a *nurse crop* is used in conjunction with permanent seeding, the nurse crop shall not hinder establishment of the permanent vegetation.

      A nurse crop shall be applied at 50% its temporary seeding rate when applied with permanent seed.

3. Inoculation

   Legume seed shall be inoculated in accordance with the manufacturer's recommendations. Inoculants shall not be mixed with liquid fertilizer.

4. Sowing

   Seed grasses and legumes no more than ¼ inch deep. Distribute seed uniformly. Mixtures with low seeding rates require special care in sowing to achieve proper seed distribution.

   Seed may be broadcast, drilled, or hydroseeded as appropriate for the site.

   Seed when soil temperatures remain consistently above 53° F. *Dormant seed* when the soil temperature is consistently below 53° F (typically

Nov. 1st until snow cover). Seed shall not be applied on top of snow.

VI. Considerations

A. Consider seeding at a lower rate and making two passes to ensure adequate coverage.

B. Compacted soil areas may need special site preparation prior to seeding to mitigate compaction. This may be accomplished by chisel plowing to a depth of 12 inches along the contour after heavy equipment has left the site.

C. Sod may be considered where adequate watering is available.

D. When working in riparian areas refer to the NRCS Engineering Field Handbook, Chapter 16, Streambank and Shoreline Protection and Chapter 18, *Soil Bioengineering* for Upland Slope Protection and Erosion Reduction.

E. A site assessment should be conducted to evaluate soil characteristics, topography, exposure to sunlight, proximity to natural plant communities, proximity to nuisance, noxious and/or invasive species, site history, moisture regime, climatic patterns, soil fertility, and previous herbicide applications.

F. Use *introduced species* only in places where they will not spread into existing natural areas.

G. Lightly roll or compact the area using suitable equipment when the seedbed is judged to be too loose, or if the seedbed contains clods that might reduce seed germination.

H. See Section IX. References for suggested seed mixes (NRCS, WisDOT, UWEX) or use their equivalent.

I. Turf seedlings should not be mowed until the stand is at least 6 inches tall. Do not mow closer than 3 inches during the first year of establishment.

J. Seeding should not be done when the soil is too wet.

K. Consider watering to help establish the seed. Water application rates shall be controlled to prevent runoff and erosion.

L. Prairie plants may not effectively provide erosion control during their establishment period without a nurse crop.

M. Topsoil originating from agricultural fields may contain residual chemicals. The seedbed should be free of residual herbicide or other contaminants that will prevent establishment and maintenance of vegetation. Testing for soil contaminants may be appropriate if there is doubt concerning the soil's quality.

N. Consider using mulch or a nurse crop if selected species are not intended for quick germination. When mulching refer to WDNR Conservation Practice Standard Mulching for Construction Sites (1058).

VII. Plans and Specifications

Plans and specifications for seeding shall be in keeping with this standard and shall describe the requirements for applying this practice.

All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. During construction areas that have been seeded shall at a minimum be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24-hour period. Inspect weekly during the growing season until vegetation is densely established or permit expires. Repair and reseed areas that have erosion damage as necessary.

B. Limit vehicle traffic and other forms of compaction in areas that are seeded.

C. A fertilizer program should begin with a soil test. Soil tests provide specific fertilizer recommendations for the site and can help to avoid over-application of fertilizers.

IX. References

A. Seed Selection References

United States Department of Agriculture – Natural Resource Conservation Service Field Office Technical Guide Section IV, Standard 342, Critical Area Planting.

UWEX Publication A3434 Lawn and Establishment & Renovation.

WisDOT, 2003. State of Wisconsin Standard Specifications For Highway and Structure Construction. Section 630, Seeding.

B. General References

Association of Official Seed Analysts, 2003. Rules for Testing Seed. http://www.aosaseed.com.

Metropolitan Council, 2003. Urban Small Sites Best Management Practice Manual, Chapter 3, Vegetative Methods 3-85 – 3-91. Minneapolis.

The State of Wisconsin list of noxious weeds can be found in Statute 66.0407.

United States Department of Agriculture – Natural Resources Conservation Service. Engineering Field Handbook, Chapters 16 and 18.

UWEX Publication GWQ002 Lawn & Garden Fertilizers.

X. Definitions

Dense (V.A.2.b) A stand of 3-inch high grassy vegetation that uniformly covers at least 70% of a representative 1 square yard plot.

Dormant seed (V.B.4): Seed is applied after climatic conditions prevent germination until the following spring.

Introduced Species (VI.F) Plant species that historically would not have been found in North America until they were brought here by travelers from other parts of the world. This would include smooth bromegrass and alfalfa. Some of these species may have a wide distribution such as Kentucky bluegrass.

Nurse Crop (V.B.2.b): Also known as a companion crop; is the application of temporary (annual) seed with permanent seed.

Permanent seeding (II) Seeding designed to minimize erosion for an indefinite period after land disturbing construction activities have ceased on the site.
Soil Bioengineering (VI.D) Practice of combining mechanical, biological and ecological concepts to arrest and prevent shallow slope failures and erosion.

Temporary Seeding (II) Seeding designed to control erosion for a time period of one year or less that is generally removed in order to perform further construction activities or to permanently stabilize a construction site.

Topsoil (V.A.2.a) Consists of loam, sandy loam, silt loam, silty clay or clay loam humus-bearing soils adapted to sustain plant life with a pH range of 5.5 – 8.0. Manufactured topsoil shall through the addition of sand or organic humus material, peat, manure or compost meet the above criteria.

Ditch Check
(Channel)
(1062)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A temporary dam constructed across a swale or drainage ditch to reduce the velocity of water flowing in the channel. *Ditch checks*[1] can be constructed out of stone, a double row of straw bales or from engineered products found on the Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List (PAL).

II. Purpose

The purpose of this practice is to reduce flow velocity and to pond water, thereby reducing active channel erosion and promoting settling of suspended solids behind the ditch check.

III. Conditions Where Practice Applies

This Standard applies where grading activity occurs in areas of channelized flows and a temporary measure is needed to control erosion of the channel until permanent stabilization practices can be applied.

Under no circumstance shall ditch checks be placed in intermittent or perennial stream without permission from WDNR. This Practice may not be substituted for major perimeter trapping measures.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of ditch checks. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements.

A. Height

1. Installed, the minimum height of ditch checks shall be 10 inches and shall not exceed a maximum height of 16 inches for manufactured or biodegradable materials and 36 inches for stone (or other inorganic materials).

2. Ditch checks must be installed with the center lower than the sides forming a weir. If this is not done stormwater flows are forced to the edge of the ditch check thus promoting scour, or out of the channel causing excessive erosion

3. Stone ditch checks shall have a minimum top width of 2-feet measured in the direction of flow with maximum slopes of 2:1 (2 horizontal to 1 vertical) on the upslope side and 2:1 on the down slope side.

B. Placement

1. At a minimum install one ditch check for every two feet of drop in the channel.

2. Ditch checks shall be placed such that the resultant ponding will not cause inconvenience or damage to adjacent areas.

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

C. Material Specifications

1. Stone ditch checks shall be constructed of a well-graded angular stone, a D_{50} of 3 inch or greater, sometimes referred to as breaker run or shot rock.

2. Ditch checks may be constructed of other approved materials but must be capable of withstanding the flow velocities in the channel. Manufactured products listed in WisDOT's PAL are also acceptable for temporary ditch checks.

   Note: Silt fence and single rows of straw bales are ineffective as ditch checks and are not permitted.

D. Construction - Refer to Figure 1 & 2

1. Ditch checks shall be utilized during rough grading and shall be removed once the final grading and channel stabilization is applied, unless intended to be part of a permanent stormwater management plan.

2. Channel erosion mat or other non-erodible materials shall be placed at the base of a ditch check, and extended a minimum of 6 feet, to prevent scour and washing out the toe of the ditch check. DNR Conservation Practice Channel Erosion Mat (1053) contains criteria for the placement of erosion mat in this location.

3. Chink or seal stone and rock ditch checks to minimize the flow through the ditch check.

VI. Considerations

A. For added stability, the base of a stone or rock ditch check should be keyed into the soil to a depth of 6-inches.

B. Stone ditch checks may be underlain by a nonwoven geotextile fabric to ease installation and removal. If the geotextile fabric is extended, it can serve purpose specified in section V.D.2

C. Ditch checks installed in grass lined channels may kill the vegetation if water is ponded for extended periods or excessive siltation occurs. Proper maintenance is required to keep areas above and below the ditch check stabilized.

D. The best way to prevent sediment from entering the storm sewer system is to stabilize the disturbed area of the site as quickly as possible, preventing erosion and stopping sediment transport at its source.

E. When placing ditch checks in swales adjacent to roadways consider designating a 'clear zone' free of obstacles posing a threat to out of control vehicles.

F. Mowing operations may throw stones from ditch checks causing a potential safety hazard.

VII. Plans and Specifications

A. Plans and specifications for installing ditch checks shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. The plans and specifications shall address the following:

   1. Location and spacing of ditch check

   2. Schedules and sequence of installation and removal

   3. Standard drawings and installation details

   4. Rock gradation

B. All plans, standard detail drawings, or specifications shall include schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Ditch checks shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24 hour period.

B. Unless incorporated into a permanent stormwater management system, ditch

checks shall be removed once the final grading and channel stabilization is applied.

C. Sediment deposits shall be removed when deposits reach 0.5 the height of the barrier. Removal of sediment may require replacement of stone. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

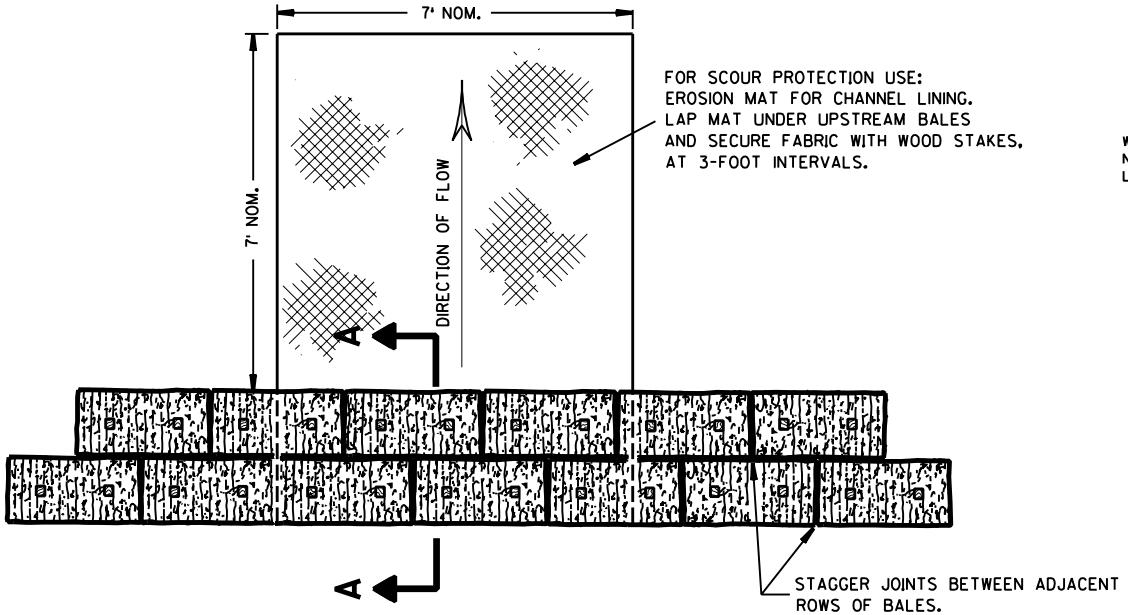
WisDOT "Erosion Control Product Acceptability List" is available online at: http://www.dot.wisconsin.gov/business/engrserv/pal.htm Printed copies are no longer distributed.

X. Definitions

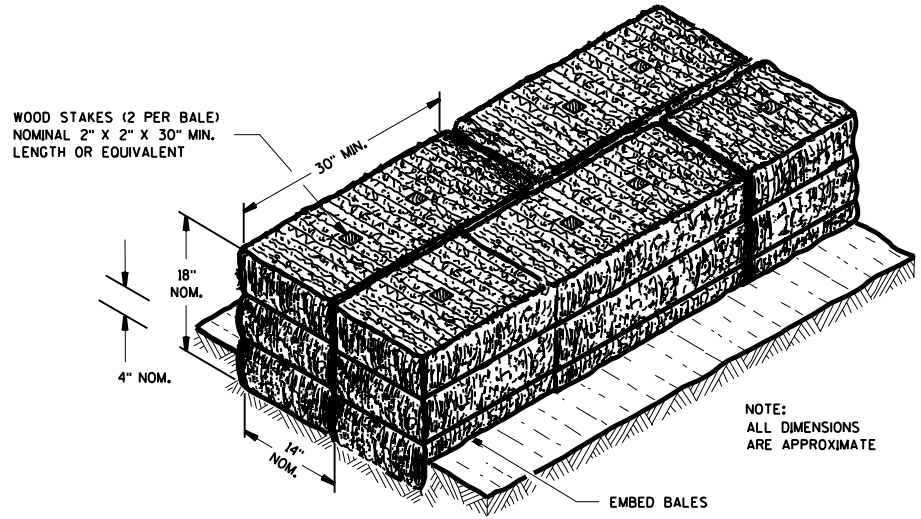
D_{50} (V.C.1): The particle size for which 50% of the material by weight is smaller than that size.

Ditch Checks (I) Are commonly referred to as temporary check dams. Stone ditch checks refer to those made out of either stone or rock.

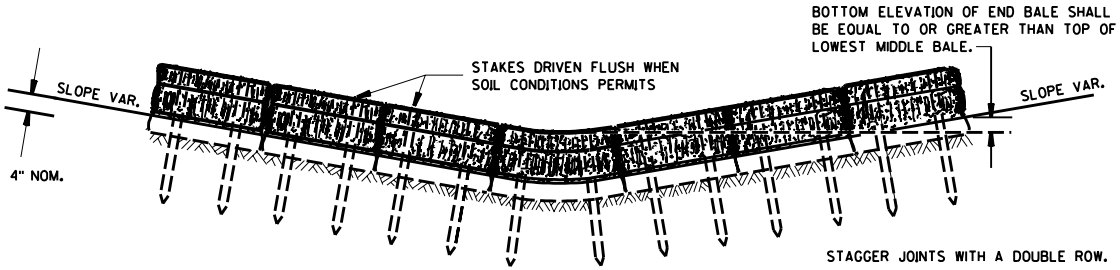
Figure 1



PLAN VIEW



SECTION A-A



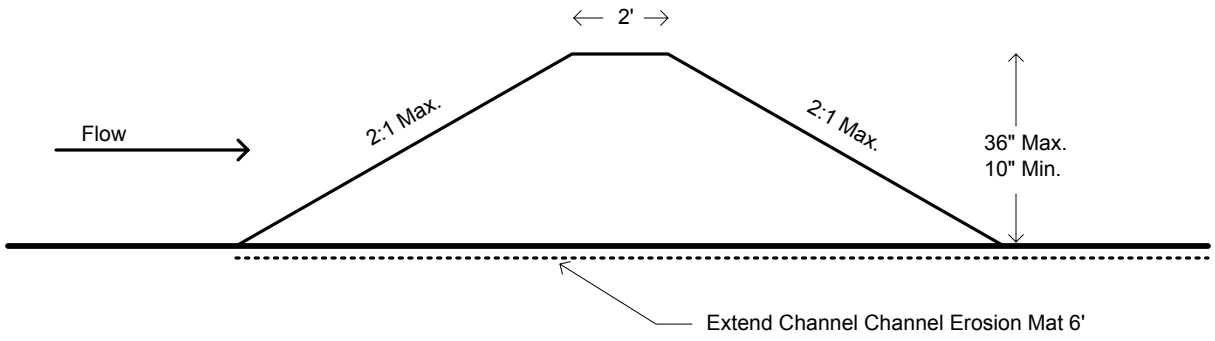
FRONT ELEVATION

TEMPORARY DITCH CHECK USING EROSION BALES ①

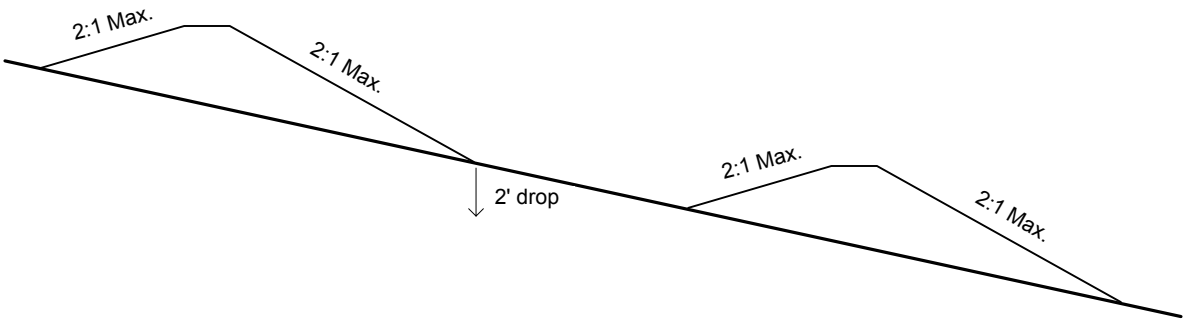
This drawing based on Wisconsin Deptartment of Transportation Standard Detail Drawing 8 E 8-3.

TYPICAL INSTALLATIONS OF EROSION BALES / TEMPORARY DITCH CHECKS

Figure 2. Stone Ditch Check



Side View



Side View

Not to Scale

WDNR