APPENDIX B
PERFORMANCE EVALUATION FOR TEMPORARY EROSION AND SEDIMENT CONTROL PRACTICES

Background

Standard details and drawings for temporary erosion and sediment control practices have been used since the early 1970's. Many of these details were developed by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS), now known as the Natural Resources Conservation Service (NRCS). These details were incorporated into many state design manuals. These practices included the following:

- Earth Dike
- Temporary Swale
- Perimeter Dike/Swale
- Level Spreader
- Pipe Slope Drain
- Straw Bale Dike
- Silt Fence

What made the use of these details attractive was that they were sized based upon the drainage area, and no extensive engineering calculations were needed for design. For example, if we needed to design a temporary swale to control the runoff from 8 acres above a disturbed construction area by sloping the swale at 3 percent, we would look at page 7A.3 and select Swale B, with a channel treatment of seed and straw mulch. The Swale B cross section is a 6-foot bottom width, 1-foot design depth, and 2:1 side slopes.

This selection process is independent of location in New York State as well as the design rainfall amount. As a result, individuals have often wondered what level of protection is actually being provided.

Site specific practice design depends on a number of variables. These include drainage area, hydrologic soil group, cover, topography, rainfall amount, and intensity or distribution. The following evaluation procedure can be used to incorporate these variables into the practice design. The procedure can also be used to design temporary practices for site specific storm events.

Conveyance Evaluation Procedure

This method of evaluating the performance of a practice is applicable to most of the temporary practices. The first example evaluates the effectiveness of the temporary swale.

CASE 1—Swale A, Average Conditions

Given:

Drainage Area = 4.9 acres

Hydrologic Soil Group = C

Runoff Curve Number = 91
(C soil disturbed for construction)

Slope of Swale = 3%

Rainfall (P) = 2.5 inches
(This represents NY state's average 1-year, 24-hour storm)

Runoff (Q) = 1.6 inches

Time of Concentration for Runoff (T_c) = 6 minutes
(assumed 0.1 hour, the shortest allowed with TR-55)

From Section 4, TR-55 Graphical Method, where:

I_a = Initial Abstraction = 0.198"
Q_{in} = Runoff in inches
q_u = Unit peak discharge in cubic feet per second per square mile
A_m = Drainage area in square miles
F_p = Pond and swamp factor

Drainage Area = 4.9/640 = 0.00766 sq. mi.

if P = 2.5 inches, then I_a/P = 0.00, use 0.1

$Q_{in} = 1.6$

Then, from Figure 4.15 (Type 2), q_u = 1,000 csmlin

from Equation 4.8 $q_p = (q_u)(A_m)(Q)(F_p)$

Therefore, $q_p = (1{,}000)(.00766)(1.6)$

q_p = 12.2 cfs

For Swale A, the design cross-section shows a bottom width of 4 feet., design depth of 1 foot, and 2:1 side slopes.

Therefore, swale area = 6 ft^2 for design depth

Compute velocity, $V = \frac{1.486}{n} \left(\frac{A}{Wp}\right)^{2/3} S^{1/2}$

Where

n = .040 for vegetated channels

$A = 6$ sq. ft.
$W_p = 8.2$ ft. (wetted perimeter)
$S = .03$ ft/ft (slope)

$$\text{Therefore, } V = \frac{1.486}{.04}\left(\frac{6}{8.2}\right)^{2/3}(.03)^{1/2}$$

$$= 5 \text{ feet per second}$$

Since $Q = AV$, the swale capacity is

$Q = (6\ \text{ft}^2)(5\ \text{ft/sec}) = 30$ cfs or more than twice required

CASE 2—Swale B, Average Conditions

Given:

Drainage Area = 10 acres
Hydrologic Soil Group = C
Runoff Curve Number = 91, therefore $I_a = 0.198"$
Slope of Swale = 3%
Rainfall (P) = 2.5 inches
Runoff (Q) = 1.6 inches
Time of Concentration for Runoff (T_c) = 0.1

Similarly to Case 1, $q_u = 1{,}000$ CSM

$A_m = 10/640 = 0.01563$

$q_p = (1{,}000)(.01563)(1.6) = 25$ cfs

For Swale B, the design cross-section has a 6-foot bottom width, 1-foot depth, and 2:1 side slopes.

Therefore, the area = 8 ft^2

Computing velocity for a swale slope of 3%,

$$V = \frac{1.486}{.04}\left(\frac{8}{10.47}\right)^{2/3}(.03)^{1/2}$$

$$V = (37.15)(.836)(.173) = 5.37 \text{ ft/sec}$$

Since $Q = AV$, the swale capacity is

$$Q = (8\ \text{ft}^2)(5.37\ \text{ft/sec}) = 43 \text{ cfs}$$

CASE 3—This site is adjacent to a significant water body in Westchester County. We want to protect the site for the 2-year, 24-hour storm.

Given:

Drainage Area = 10 acres
Hydrologic Soil Group = D soils
Runoff Curve Number = 94, ("D" under construction)
Slope of Swale = 3%
Rainfall (P) = 3.5 inches; Ia = 0.128"
Runoff (Q) = 2.8 inches; Type 3 rainfall
Assume Time of Concentration for Runoff (T_c) = 0.1 hour (most conservative value)

$A_m = 10/640 = 0.01563$ sq. mi.

$I_a/P = 0.128/3.5 = 0.04$, therefore use 0.1

From Figure 4.16 (Type 3), $q_u = 655$ CSM

Therefore, $qp = (655)(0.01563)(2.8)$

$= 28.7$ cfs

From CASE 2, Swale B, we know that the maximum capacity is 43 cfs with a velocity of 5.37 feet per second.

Our conclusions would indicate that Swale B is adequate for capacity. The velocity is higher and thus a mulch lining should be used to protect the swale from erosion.

Storage Evaluation Procedure

Practices such as silt fence, straw bale dikes, and earthen berms are often used on slopes or near the toes of fill slopes to capture sediment laden runoff. These have failed many times in the field due to poor siting, improper installation, lack of maintenance, and little consideration of the proper use of the practice.

As an example of how careful we need to be in using these practices, look at the use of silt fence in the following typical situations.

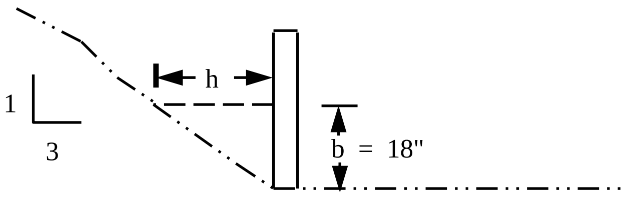
CASE 1—At the toe of a 3:1 earthfill

Given: 30' high earthfill
Hydrologic Soil Group—C
Therefore, Runoff Curve Number = 91

Typically, the installed height of the silt fence is 30-36". The maximum design sediment depth behind the silt fence is 50% of its height, or 18" maximum.

For this case, the design sediment area is equal to:

A = 1/2bh



A = 1/2 (1.5')(4-5') = 3.375 sq. ft. per linear foot

This equals 337.5 cubic feet per 100 feet of fence.

The actual slope surface is approximately 95 feet. For a rainfall of 1 inch on this site, the runoff equals 0.4 inches. The total volume of runoff would equal

$$\frac{0.4 \text{ inches}}{12 \text{ inches/ft}} \quad \times \quad 9500 \text{ sq. ft.} \quad = \quad 317 \text{ cu. ft.}$$

This example shows that the volume required for a 1-inch storm is barely provided, but the location of the fence provides no buffer for material that rolls down the slope nor room for maintenance. The fence should be located at least 10 feet from the toe of the slope.

CASE 2—Determine level of protection for CASE 1 when fence is moved 10 feet from the toe of slope.

When the silt fence is moved 10' away from the 3:1 slope, the design area of storage equals,

337.5 sq. ft. + 1,500 sq. ft. = 1,837.5 cu.ft. per 100 feet of fence

Since this is the maximum runoff volume that can be controlled, the runoff depth is,

$$\frac{1{,}837.5 \text{ ft}^3}{9{,}500 \text{ ft}^2} = 0.193 \text{ feet} = 2.3 \text{ inches}$$

From Section 4, Figure 4.1 for a Q = 2.3 inches, and a Curve Number at 91, P is interpreted at 3.2 inches.

Thus, this design configuration can manage to store the runoff from a 3.2 inch rainfall event.

This method can be used to evaluate the positioning of these sediment control practices on the contour to hold sediment close to its source. It allows a designer to evaluate an existing condition, or to select a specific level of protection higher than that which may be provided by the standard details.