Stream Crossings, Culvert Crossings and Limited Access Points

Survey, Design and Installation

By John M Cooke

Stream Crossing

A well constructed crossing can serve multiple purposes and still protect the stream from direct access by livestock. This crossing provides access to another boundary, and provides an emergency water source for both boundaries.

Culvert Crossing

Culvert crossings also protect the streams from direct livestock access but do not have the multiple benefits of a stream crossing. They are also more difficult to maintain.

Limited Access

Limited Accesses are essentially ½ of a stream crossing. They are another method of providing water to a boundary. Other sources of water should be investigated before considering a limited access point.

Stream Crossing Design

Stream Crossings

A. Site Selection Considerations
   1. Location of existing crossings in field
      a) The landowner and/or livestock will generally find a good location for a crossing.
   2. Channel bottom
      a) Armor is not required on the stream bottom if it is firm and stable.
   3. Stream bank height
      a) A higher banks equals a longer crossings… which equals more expense.
      b) It also complicates locating the crossing because of the length of the ramps.
   4. Channel slope
      a) Steep channel slopes mean higher flow velocities and will require larger base rock.
      b) Placing a crossing through an area of pooled water could result in possible sediment deposition on the crossing.
   5. Surrounding topography
      a) Will a reasonable catch point be found for the 8:1 slope or can the crossing be angled to achieve a reasonable catch point.
   6. Existing trees
      a) Preserve as many trees as possible to keep the stream banks stable. Also removing trees means disposing of tree and root ball somewhere. All waste material including excavated soil will be disposed of out of the floodplain.

Notice that the side slopes were steepened and armored with gabion stone to allow trees to remain. Removing the trees and rootballs would loosen the soil and create an unstable streambank upstream of the crossing. This crossing is for equipment only so no fence is required.

This stream crossing is also for equipment only. Notice that the surface layer of stone is more course (VDOT #3's)than is typical for livestock crossings. Generally in Virginia the surface layer will be a finer stone such as VDOT #57's or #21A's. Or even rock dust for dairy cattle.

A stream crossing for livestock. The red arrows are to point out the gravel extends to the fence and beyond. The gravel must extend to the fence but it is difficult to get gravel to the fenceline, if the fence is installed before the gravel. This crossing was installed first and then the cross fence. Talk to the landowners about staging the work correctly.

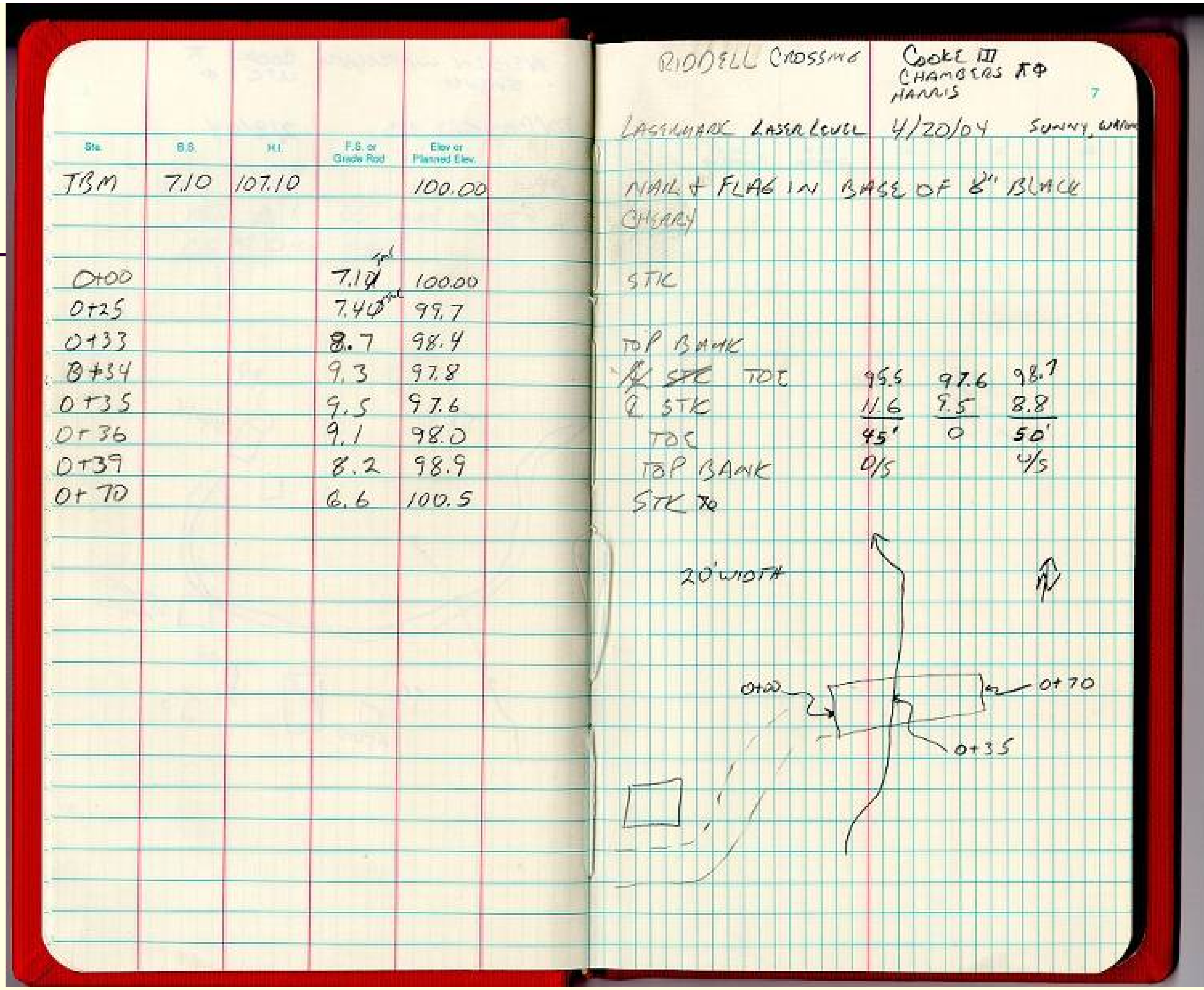
Same crossing as last slide. I would not recommend a board cross fence except for horse owners. They tend to be expensive and are easily damaged during a flood event.

This is an equipment crossing that was installed over an existing crossing. Notice that the left bank is left relatively undisturbed. The right bank was disturbed and then armored. Using an existing crossing will generally reduce the materials costs and equipment costs of the crossing.

Stream Crossings

B. Survey Data (print and use as a check list)

1. Cross Section of stream along centerline of planned crossing.
2. Profile of stream U/S and D/S of centerline.
3. Approximate angle of turns (if any) in crossing.
4. Stake centerline and label stakes with centerline station.
5. Do a site investigation along streambank.
6. Determine the “n” value of the stream or describe the channel in enough detail to determine “n” in office.
7. Take pictures of site to document existing conditions.
8. Draw a sketch in the field book showing:
    - a) Magnetic North.
    - b) TBM location and description.
    - c) Stream flow direction.
    - d) Centerline of crossing and direction of stationing.
    - e) Existing fences or structures. (if any)
    - f) Show angles on centerline (if any) and station of angle point.
    - g) Planned crossing width.
    - h) Location of soil borings or test pits.



My survey notekeeping format for stream crossings. Cross section data on left page. Profile data on right page aligned with the station it was taken on. Sketch on bottom of left page. Centerline station of stream is noted on sketch as well as stations with stakes set. Note that the D/S profile shot was only 45’ down stream instead of the normal 50’. Brush was blocking the view at 50’ so it was taken (and noted) at 45”. Also the profile shots should be taken from riffle to riffle, not in pooled or ponded water.

"n" Values

"n" is the Channel Roughness Coefficient used in Manning's Equation.

"n" varies from reach to reach of the stream. It is a measure of how much resistance the water flow receives from the streambed, stream shape and vegetation. Unfortunately "n" is a judgment call. You will have to try and select the best value for the stream you are working on. The next slides are some examples of guides to estimating "n".

Please contact your Area Engineer for the "n" value list used in your area.

Mannings Roughness Coefficient (n)

TABLE 2.8.2

Manning roughness coefficients, n [1]

	Manning's n range [2]
I. Closed conduits:	
A. Concrete pipe	0.011–0.013
B. Corrugated-metal pipe or pipe-arch:	
1. 2⅔ by ½-in. corrugation (riveted pipe): [3]	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved):	
(1) Flow full depth	0.021–0.018
(2) Flow 0.8 depth	0.021–0.016
(3) Flow 0.6 depth	0.019–0.013
2. 6 by 2-in. corrugation (field bolted)	0.03
C. Vitrified clay pipe	0.012–0.014
D. Cast-iron pipe, uncoated	0.013
E. Steel pipe	0.009–0.011
F. Brick	0.014–0.017
G. Monolithic concrete:	
1. Wood forms, rough	0.015–0.017
2. Wood forms, smooth	0.012–0.014
3. Steel forms	0.012–0.013
H. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017–0.022
2. Natural floor	0.019–0.025
I. Laminated treated wood	0.015–0.017
J. Vitrified clay liner plates	0.015
II. Open channels, lined [4] (straight alinement): [5]	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013–0.017
2. Trowel finish	0.012–0.014
3. Float finish	0.013–0.015
4. Float finish, some gravel on bottom	0.015–0.017
5. Gunite, good section	0.016–0.019
6. Gunite, wavy section	0.018–0.022
B. Concrete, bottom float finished, sides as indicated:	
1. Dressed stone in mortar	0.015–0.017
2. Random stone in mortar	0.017–0.020
3. Cement rubble masonry	0.020–0.025
4. Cement rubble masonry, plastered	0.016–0.020
5. Dry rubble (riprap)	0.020–0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017–0.020
2. Random stone in mortar	0.020–0.023
3. Dry rubble (riprap)	0.023–0.033
D. Brick	0.014–0.017
E. Asphalt:	
1. Smooth	0.013
2. Rough	0.016
F. Wood, planed, clean	0.011–0.013
G. Concrete-lined excavated rock:	
1. Good section	0.017–0.020
2. Irregular section	0.022–0.027
III. Open channels, excavated [4] (straight alinement, [5] natural lining):	
A. Earth, uniform section:	
1. Clean, recently completed	0.016–0.018
2. Clean, after weathering	0.018–0.020
3. With short grass, few weeds	0.022–0.027
4. In gravelly soil, uniform section, clean	0.022–0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022–0.025
2. Grass, some weeds	0.025–0.030
3. Dense weeds or aquatic plants in deep channels	0.030–0.035
4. Sides clean, gravel bottom	0.025–0.030
5. Sides clean, cobble bottom	0.030–0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028–0.033
2. Light brush on banks	0.035–0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035–0.040
b. Jagged and irregular	0.040–0.045
E. Channels not maintained, weeds and brush uncut:	
1. Dense weeds, high as flow depth	0.08–0.12
2. Clean bottom, brush on sides	0.05–0.08
3. Clean bottom, brush on sides, highest stage of flow	0.07–0.11
4. Dense brush, high stage	0.10–0.14
IV. Highway channels and swales with maintained vegetation [6,7] (values shown are for velocities of 2 and 6 f.p.s.):	
A. Depth of flow up to 0.7 foot:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.07–0.045
b. Length 4–6 inches	0.09–0.05
2. Good stand, any grass:	
a. Length about 12 inches	0.18–0.09
b. Length about 24 inches	0.30–0.15
3. Fair stand, any grass:	
a. Length about 12 inches	0.14–0.08
b. Length about 24 inches	0.25–0.13
B. Depth of flow 0.7–1.5 feet:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.05–0.035
b. Length 4 to 6 inches	0.06–0.04
2. Good stand, any grass:	
a. Length about 12 inches	0.12–0.07
b. Length about 24 inches	0.20–0.10
3. Fair stand, any grass:	
a. Length about 12 inches	0.10–0.06
b. Length about 24 inches	0.17–0.09
V. Street and expressway gutters:	
A. Concrete gutter, troweled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accumulate, increase above values of n by	0.002
VI. Natural stream channels: [8]	
A. Minor streams [9] (surface width at flood stage less than 100 ft.):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030–0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035–0.05
c. Some weeds, light brush on banks	0.035–0.05
d. Some weeds, heavy brush on banks	0.05–0.07
e. Some weeds, dense willows on banks	0.06–0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	0.01–0.02
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e about	0.01–0.02
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04–0.05
b. Bottom of cobbles, with large boulders	0.05–0.07
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030–0.035
b. High grass	0.035–0.05
2. Cultivated areas:	
a. No crop	0.03–0.04
b. Mature row crops	0.035–0.045
c. Mature field crops	0.04–0.05
3. Heavy weeds, scattered brush	0.05–0.07
4. Light brush and trees: [10]	
a. Winter	0.05–0.06
b. Summer	0.06–0.08
5. Medium to dense brush: [10]	
a. Winter	0.07–0.11
b. Summer	0.10–0.16
6. Dense willows, summer, not bent over by current	0.15–0.20
7. Cleared land with tree stumps, 100–150 per acre:	
a. No sprouts	0.04–0.05
b. With heavy growth of sprouts	0.06–0.08
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.10–0.12
b. Flood depth reaches branches	0.12–0.16
C. Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follow recommendation in publication cited [8] if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of	0.028–0.033

2-31

VI. Natural stream channels:[4]	
A. Minor streams[9] (surface width at flood stage less than 100 ft.):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030–0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035–0.05
c. Some weeds, light brush on banks	0.035–0.05
d. Some weeds, heavy brush on banks	0.05–0.07
e. Some weeds, dense willows on banks	0.06–0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	*0.01–0.02*
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e about	*0.01–0.02*
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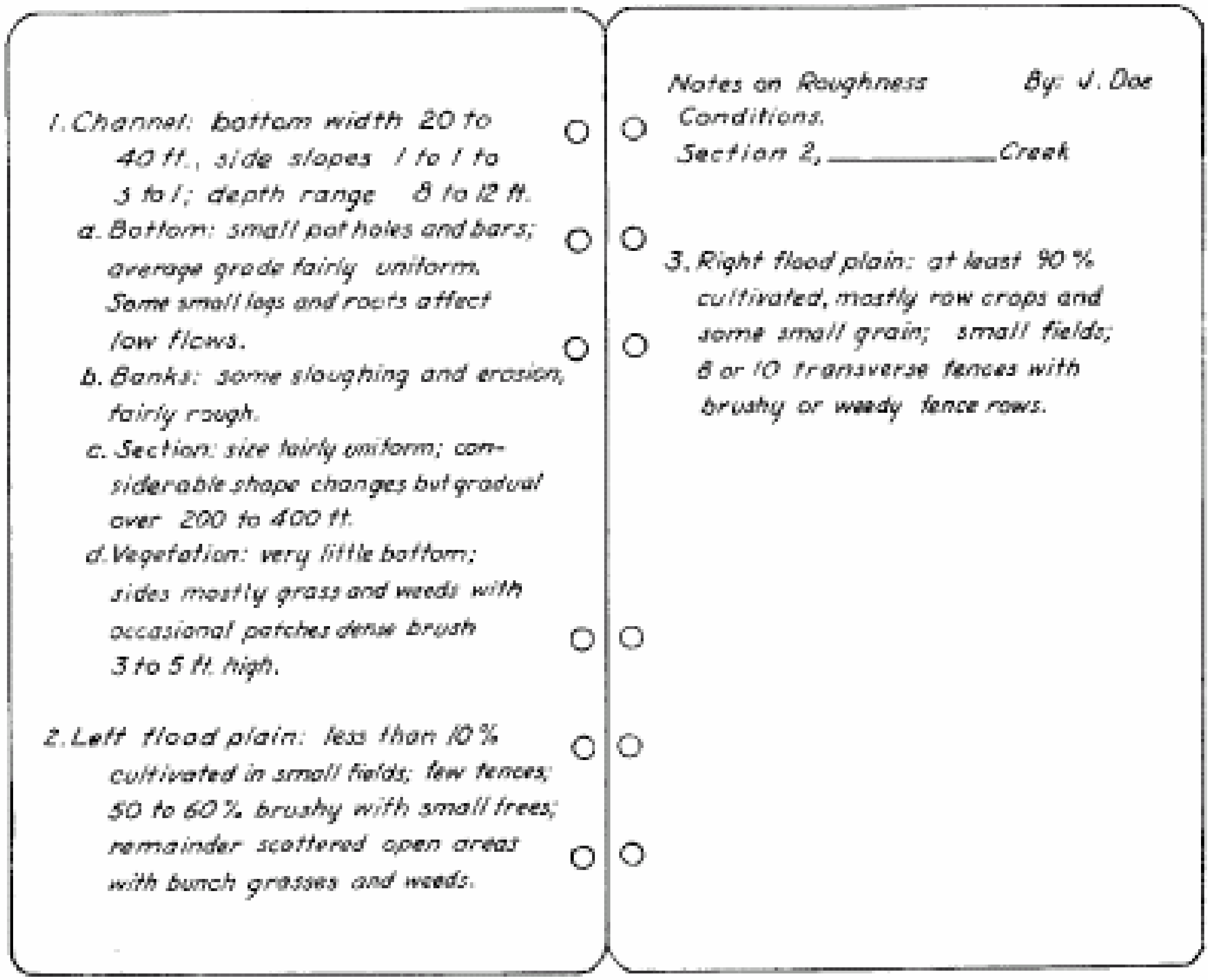
Figure B.2 Sample notes on roughness conditions.



Notes on Roughness Conditions. By: J. Doe

Section 2, ____________ Creek

1. Channel: bottom width 20 to 40 ft., side slopes 1 to 1 to 3 to 1; depth range 8 to 12 ft.
   a. Bottom: small pot holes and bars; average grade fairly uniform. Some small logs and roots affect low flows.
   b. Banks: some sloughing and erosion, fairly rough.
   c. Section: size fairly uniform; considerable shape changes but gradual over 200 to 400 ft.
   d. Vegetation: very little bottom; sides mostly grass and weeds with occasional patches dense brush 3 to 5 ft. high.

2. Left flood plain: less than 10% cultivated in small fields; few fences; 50 to 60% brushy with small trees; remainder scattered open areas with bunch grasses and weeds.

3. Right flood plain: at least 90% cultivated, mostly row crops and some small grain; small fields; 8 or 10 transverse fences with brushy or weedy fence rows.

An example of how to record roughness conditions in the field book for a determination of “n” at another time.

Stream Crossings

C. Design Data (print and use as a checklist)

(Having this design data will get you through the design review part of a spot check)

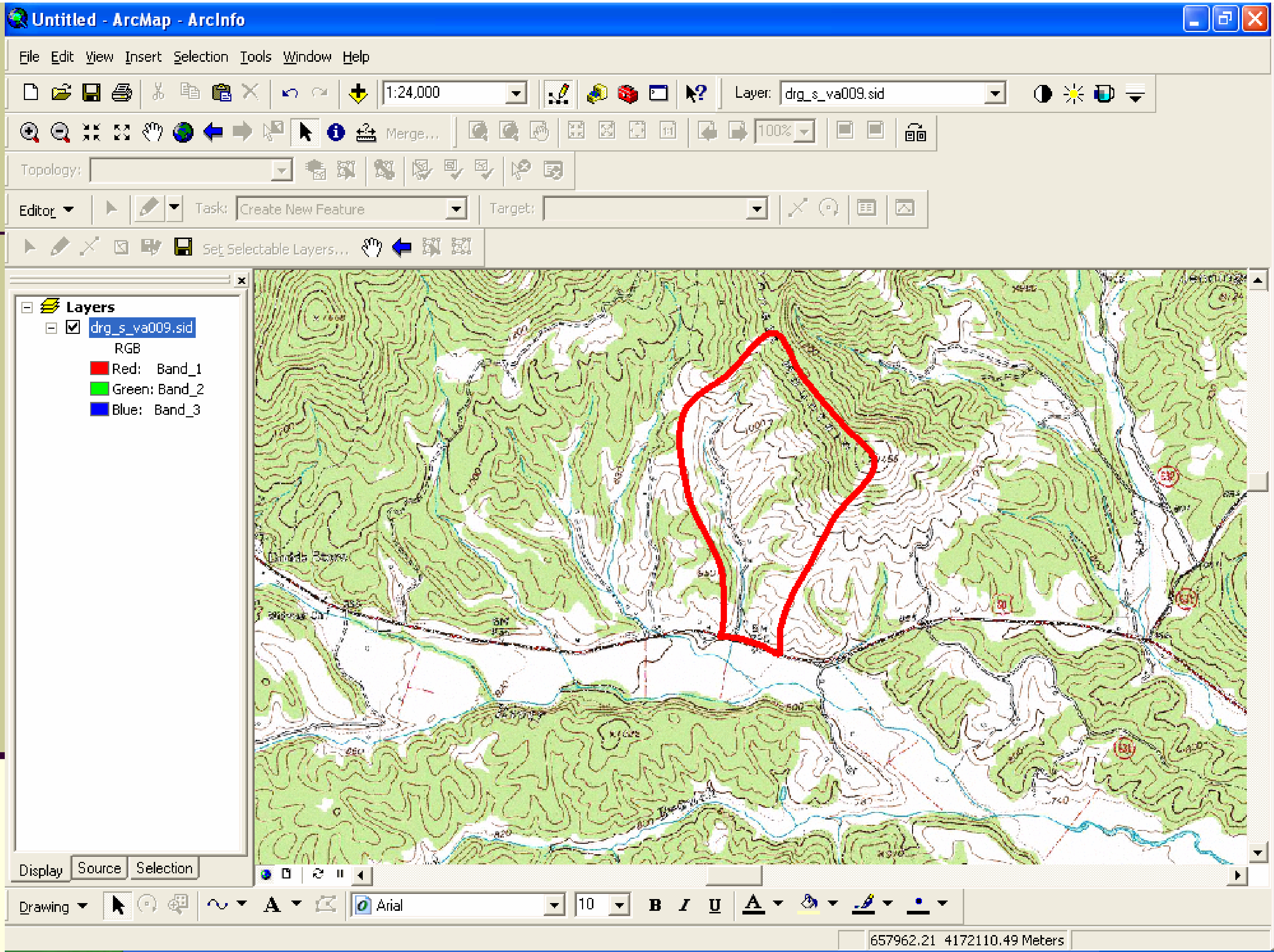
1. Completed EE (Please follow all wetland guidance, as needed.)
2. Drainage area map of stream (If greater than 5 sq mi a permit is required and a copy of the letter of notification to the landowner will document this.)
3. If the stream is a designated trout stream, VGIF needs to be notified by the landowner. (Place copy of letter notification to the landowner in design file to document this.)
4. Copy of field notes. (Attach to design.)
5. Plotted cross section and profile of stream.
   (Virginia's standard design sheets for stream crossings work well.)
6. Cross sectional area and wetted perimeter of channel at full flow.
   (Full flow defined as lowest bank elevation, for these purposes.)
7. Stream velocity calculations at full flow.
8. Copy of design package (see below), including spec's and O&M plan, **with the cover sheet signed by landowner and contractor**. (At the least the signed design with a note attached to the design stating that the spec's and O&M plan were given to the landowner.)

D. Design Package (for landowner and contractor)

1. Completed cover sheet with location map.
2. Completed plan view drawing of site.
3. Completed stream crossing design sheets.
4. Provide landowner two copies of the design, specifications and O&M plan. (One for landowner's records and one for the contractor.)

Drainage area using planimeter

The old fashion way still works. Copy the map and outline the drainage area. Include in design for documentation.



This way is a little more modern. Again, print the drainage area map with drainage area outlined for design documentation.

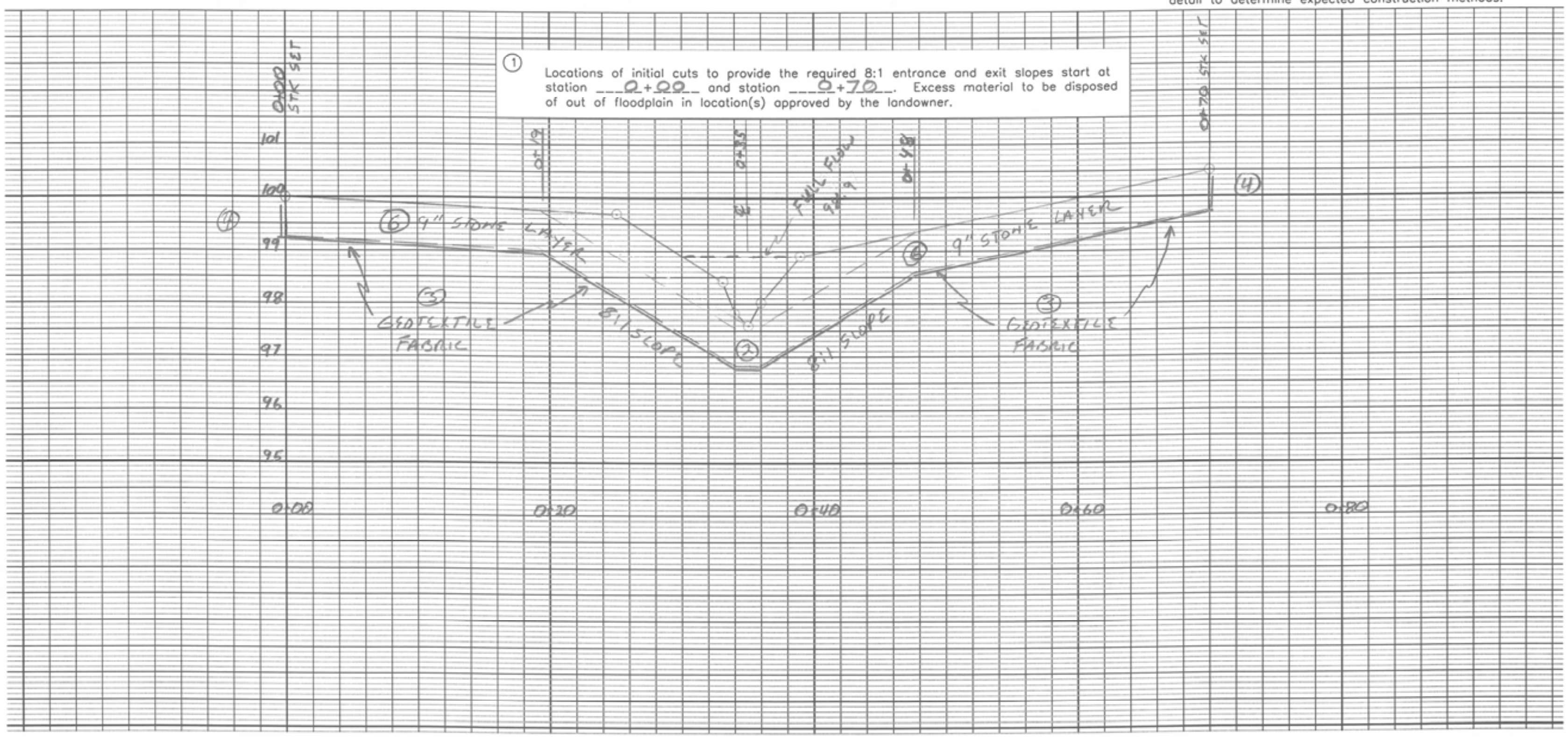
Standard Drawing Sheet 1

Scale: 1" Horizontal = 8 feet
1" Vertical = 4 feet

TBM Description & 100.00 NAIL + FLAGGING ...
TBM Elevation: BASE OF 8" CHERRY

Stream Cross-Section

Numbers in circles correspond to Design Notes listed at the bottom of this sheet. Match number to appropriate detail to determine expected construction methods.



Designed: Jim Cooke 5/04
Drawn: J. Williams 5/04
Checked
Approved

RIDDELL STREAM CROSSING
CHANNEL CROSS SECTION
BEALTON, VIRGINIA

Stream Crossing/Access Design Notes

1) Locations of the initial cuts to provide 8:1 slopes are shown. Ramp slope to be 8:1 or flatter. Grade side slopes to 3:1 if they are to be seeded. Grade to 2:1 if they are to be armored with VDOT #1 stone over geotextile. Excess material to be disposed of out of floodplain in location approved by landowner.

2) If necessary to provide a solid bottom to the crossing, the existing streambed may be excavated six inches (or until a stable foundation is reached) and backfilled with VDOT #1 stone. If no stone is needed to harden the stream bottom, then stone on ramps needs to be placed so the ramps blend naturally into the existing streambed. Do not place stone that will obstruct the natural flow path of the stream. Any stone placed to harden channel bottom must be installed below the existing natural grade of the stream.

3) Geotextile used will have the following minimum specifications (non-woven is recommended):

- 120 pound minimum tensile strength.
- 320 pound minimum bursting strength.
- Elongation at failure greater than 50%.
- 90 pound minimum puncture strength.
- 70% minimum residual tensile strength in 150 hours exposure to Ultraviolet light.

4) Geotextile will be keyed on both ends per manufacturer's specifications and stapled in place.

5) If the livestock will have access to the slopes they shall be armored with stone (See note 1). If the fencing will restrict access then the slopes may be seeded. All seeding will be done according to the Plant Establishment Guide for Virginia.

6) The minimum ramp armor for streams will be 3 inches of VDOT #57 or #357 stone placed over 6 inches of VDOT #1 stone placed over geotextile. Refer to sheet 2 of 2 for drawings of the actual layer details. Additional finer stone may be brought in as a cap to provide a more suitable hoof-contact zone if the crossing will be used on a frequent basis by livestock.

7) Fencing shall be of type, extent, and location as required and approved by local NRCS or Conservation District personnel.

8) Construct fencing across the stream so that it is not directly anchored to the permanent riparian fencing. This will keep the permanent fencing from being torn down along with the fencing across the stream in the event of a flood. The cross-stream fencing may be anchored to separate posts erected next to the riparian fencing. This will allow for easier repair should the cross-stream fencing be torn down. Cross-stream fencing shall be of a type approved by local NRCS or Conservation District personnel.

VIRGINIA ENGINEERING STANDARD DRAWING	
/s/ Mathew Lyons, SCE	Standard Drawings shall NOT be altered without State Conservation Engineer Approval
STANDARD DWG NO: VA-ENG-SO-801	
DATE 2/05	SHEET 1 OF 2

NRCS Natural Resources Conservation Service, United States Department of Agriculture

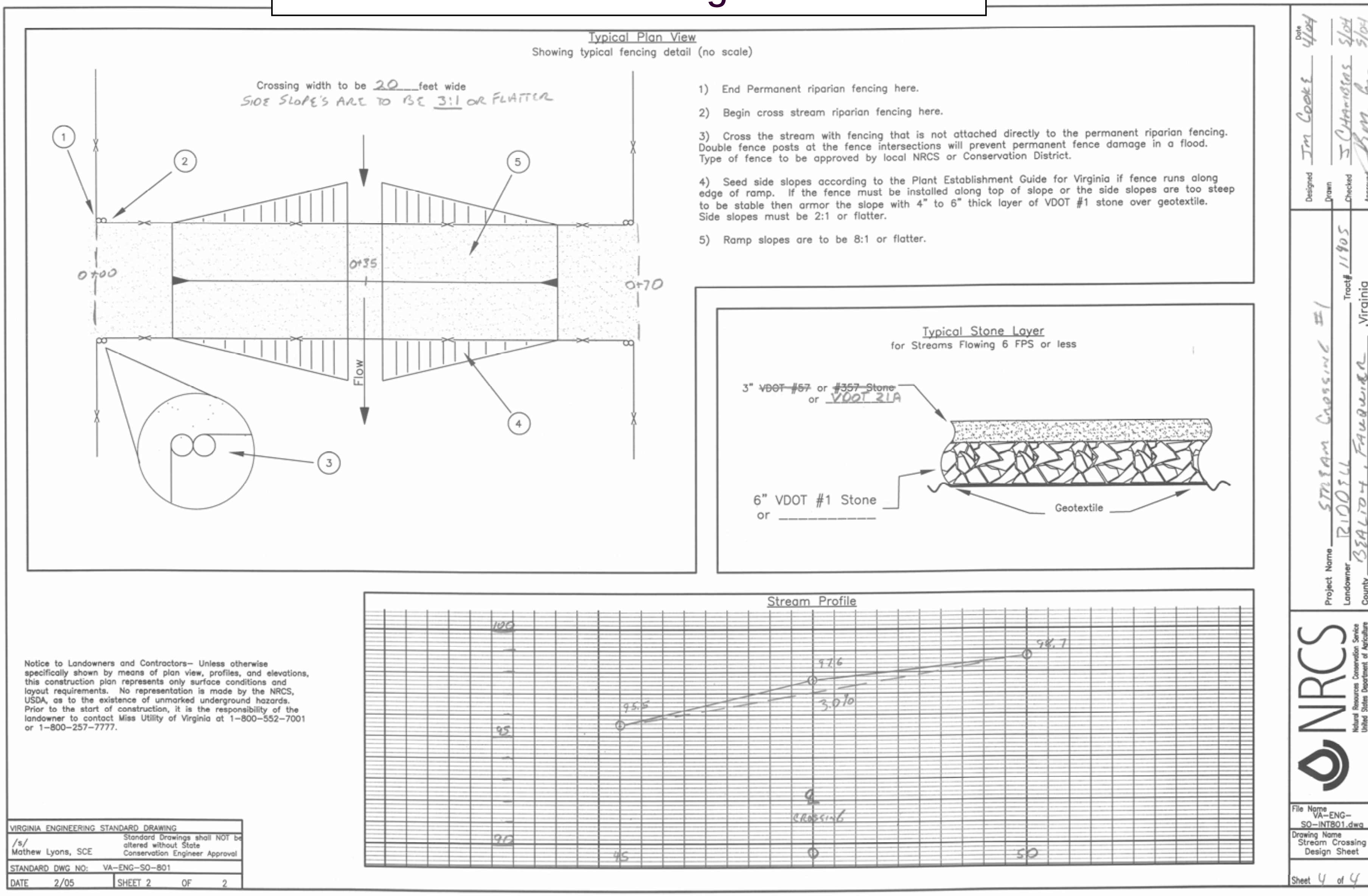
File Name VA-ENG-SO-INT801.dwg

Drawing Name Stream Crossing Design Sheet

Sheet 3 of 4

The stations should be indicated at the end points and all grade changes. Station for the centerline of the stream is also shown. If using a planimeter to determine the drainage area, the scales are very important. Please note that NRCS Profile sheets are four lines to the inch horizontally and twenty lines to the inch vertically.

Standard Drawing Sheet 2



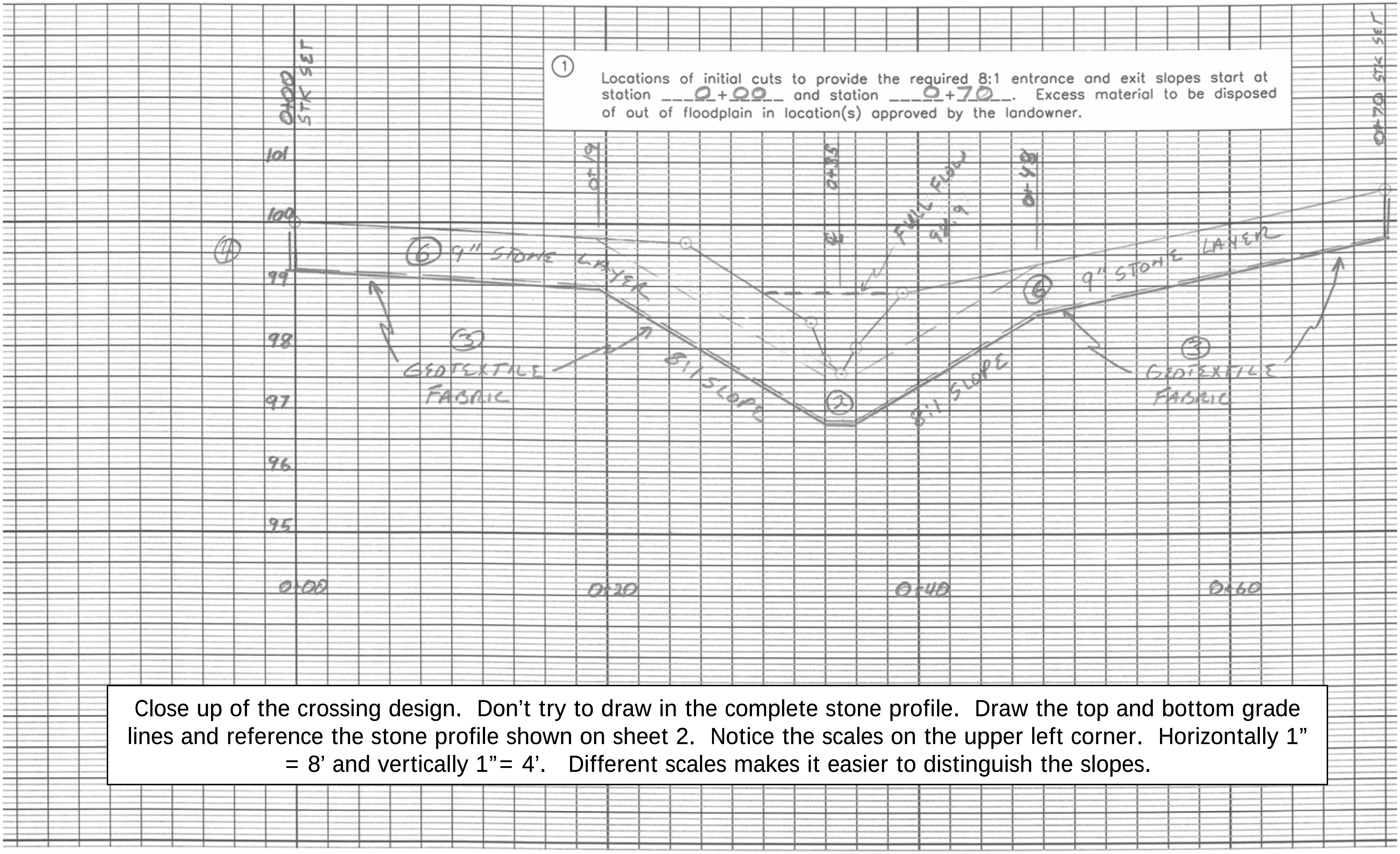
The centerline of crossing should be indicated on profile. The channel slope should be computed and then noted on the profile. Crossing width must be noted as well as the slope of the side slopes. Stationing should also be noted on plan view. The typical stone layer is given but can be modified by filling in different stone sizes.

le: 1" Horizontal = ___8____ feet
1" Vertical = ___4____ feet

TBM Description & 100.00 NAIL + FLAGGING IN
TBM Elevation: BASE OF 8" CHERRY

Stream Cross–Section

Numbers
the bott
detail to



① Locations of initial cuts to provide the required 8:1 entrance and exit slopes start at station ___0+00___ and station ___0+70___. Excess material to be disposed of out of floodplain in location(s) approved by the landowner.

Close up of the crossing design. Don’t try to draw in the complete stone profile. Draw the top and bottom grade lines and reference the stone profile shown on sheet 2. Notice the scales on the upper left corner. Horizontally 1” = 8’ and vertically 1”= 4’. Different scales makes it easier to distinguish the slopes.

m Crossing/Access Design Notes

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s are shown. Ramp slope to be 8:1 or
r. Grade side slopes to 3:1 if they are to

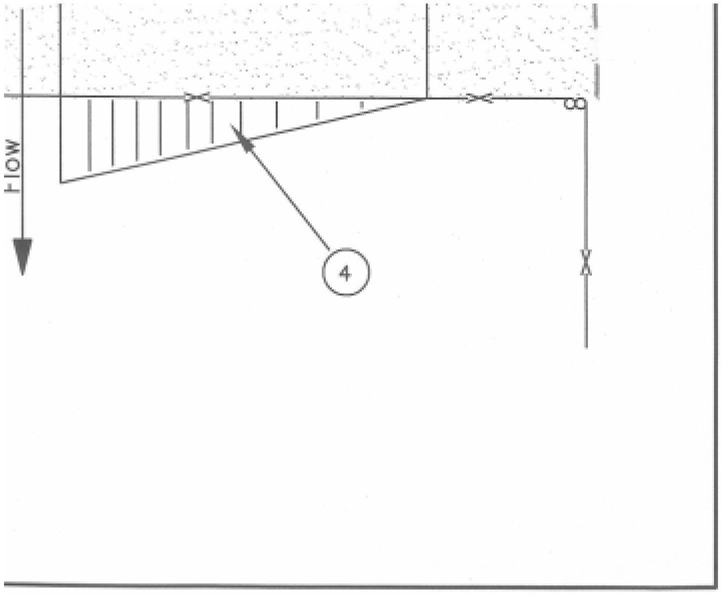
bottom, then stone on ramps needs to be placed so the ramps blend naturally into the existing streambed. Do not place stone that will obstruct the natural flow path of the stream. Any stone placed to harden channel bottom must be installed below the existing natural grade of the stream

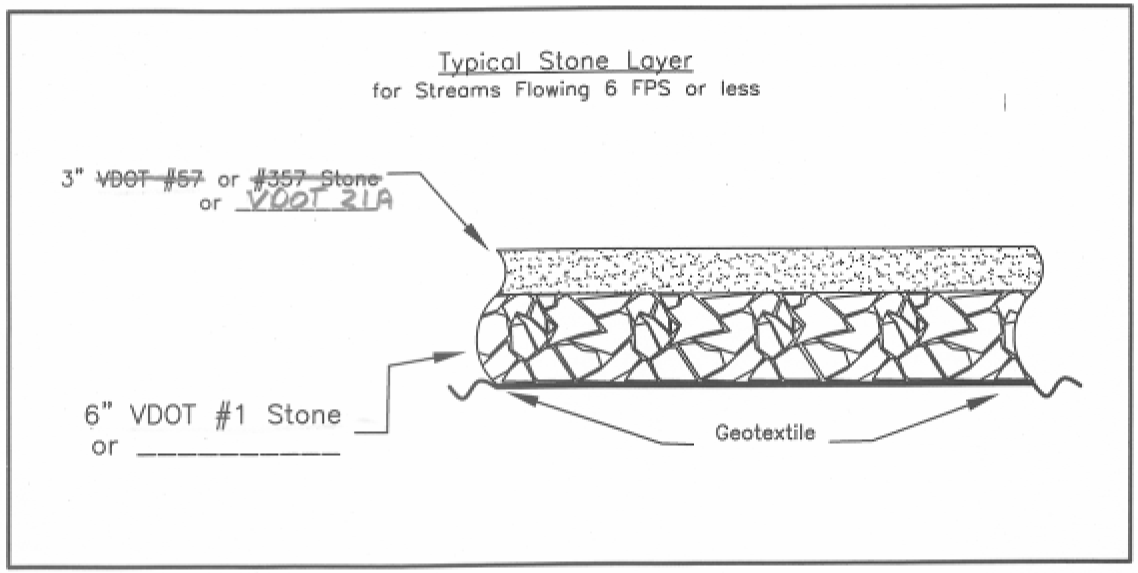
4) Geotextile will be keyed on both ends per manufacturer's specifications and stapled in place.

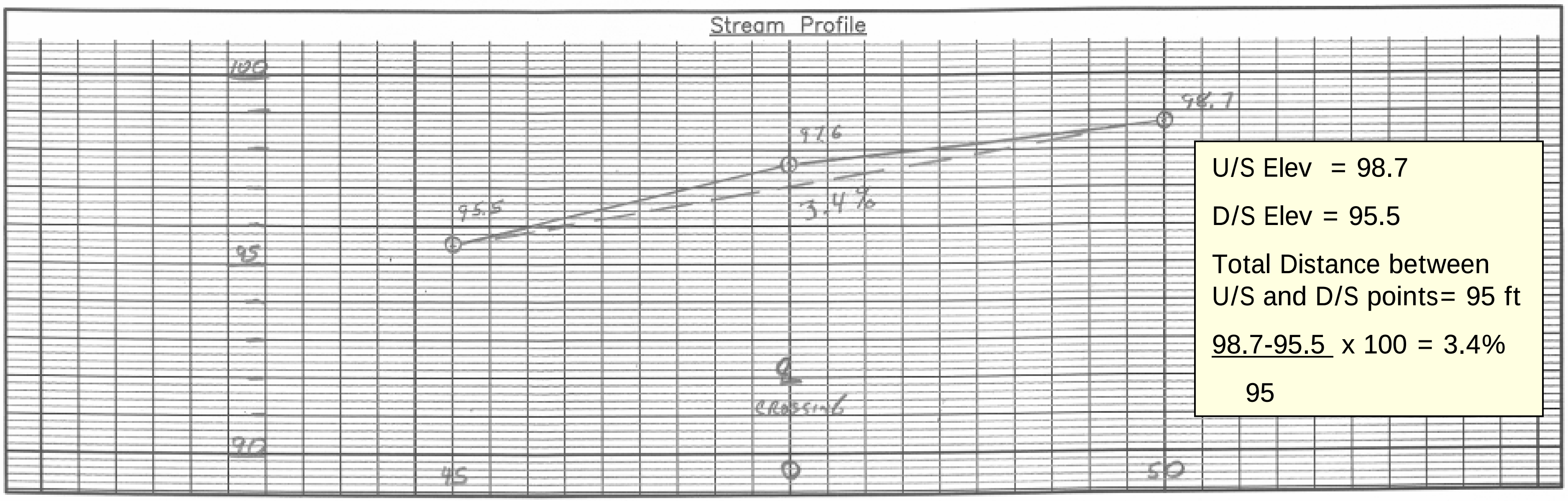
5) If the livestock will have access to the slopes they shall be armored with stone (See note 1). If

7) Fencing shall be as required and app Conservation District

8) Construct fencing







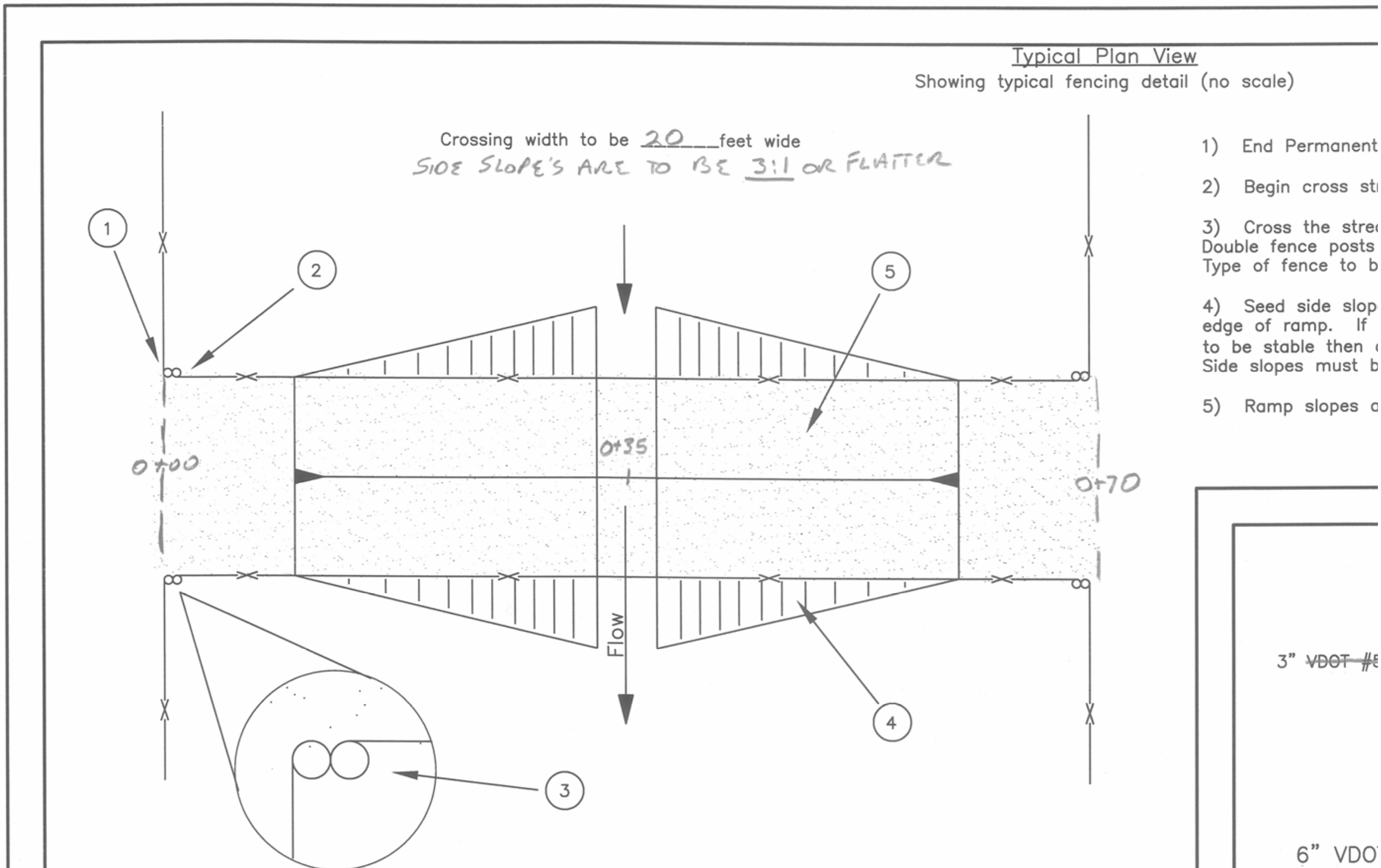
U/S Elev = 98.7

D/S Elev = 95.5

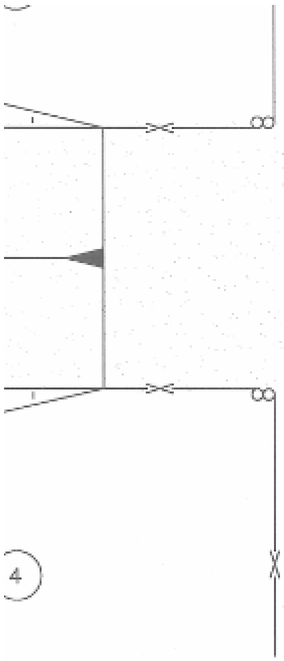
Total Distance between U/S and D/S points= 95 ft

$\frac{98.7-95.5}{95} \times 100 = 3.4\%$

The stream profile is a series of survey points on the bottom of the stream channel. Plot the data here and determine the average bottom grade of the stream. This data is used to determine stream velocity.



The plan view drawing assists the contractor and landowner to understand how the crossing is positioned on the ground. It also gives fencing guidance and locations. To change the direction of the stream flow, "X" out the arrowheads on the flow lines and put one on the other end of the line.

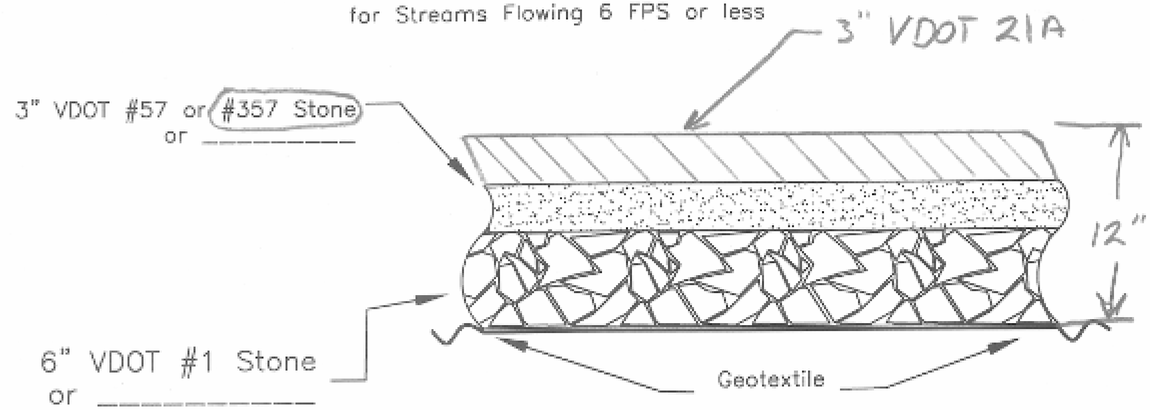


4) Seed side slopes according to the Plant Establishment Guide for Virginia if fence runs along edge of ramp. If the fence must be installed along top of slope or the side slopes are too steep to be stable then armor the slope with 4" to 6" thick layer of VDOT #1 stone over geotextile. Side slopes must be 2:1 or flatter.

5) Ramp slopes are to be 8:1 or flatter.

Typical Stone Layer

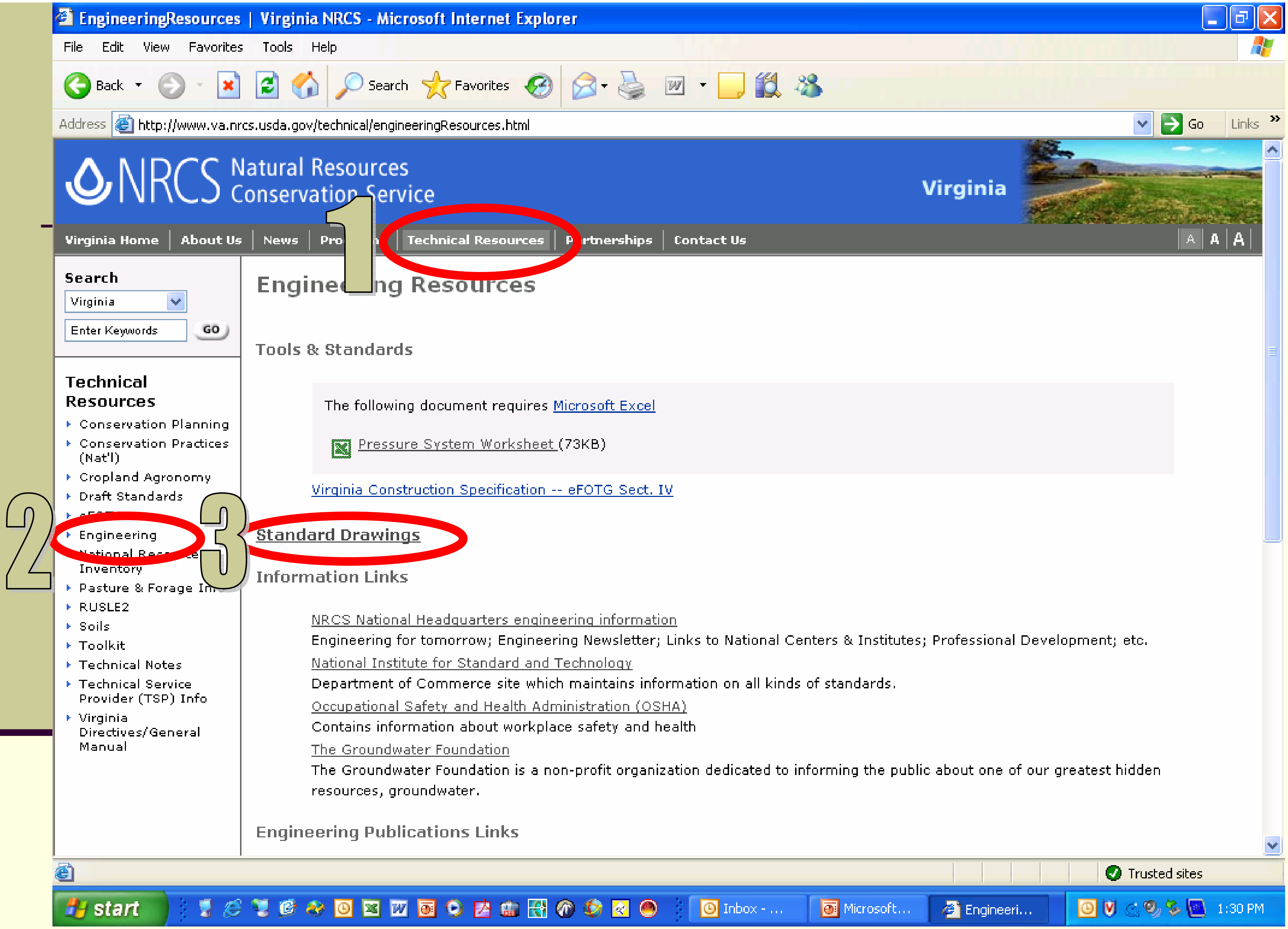
for Streams Flowing 6 FPS or less



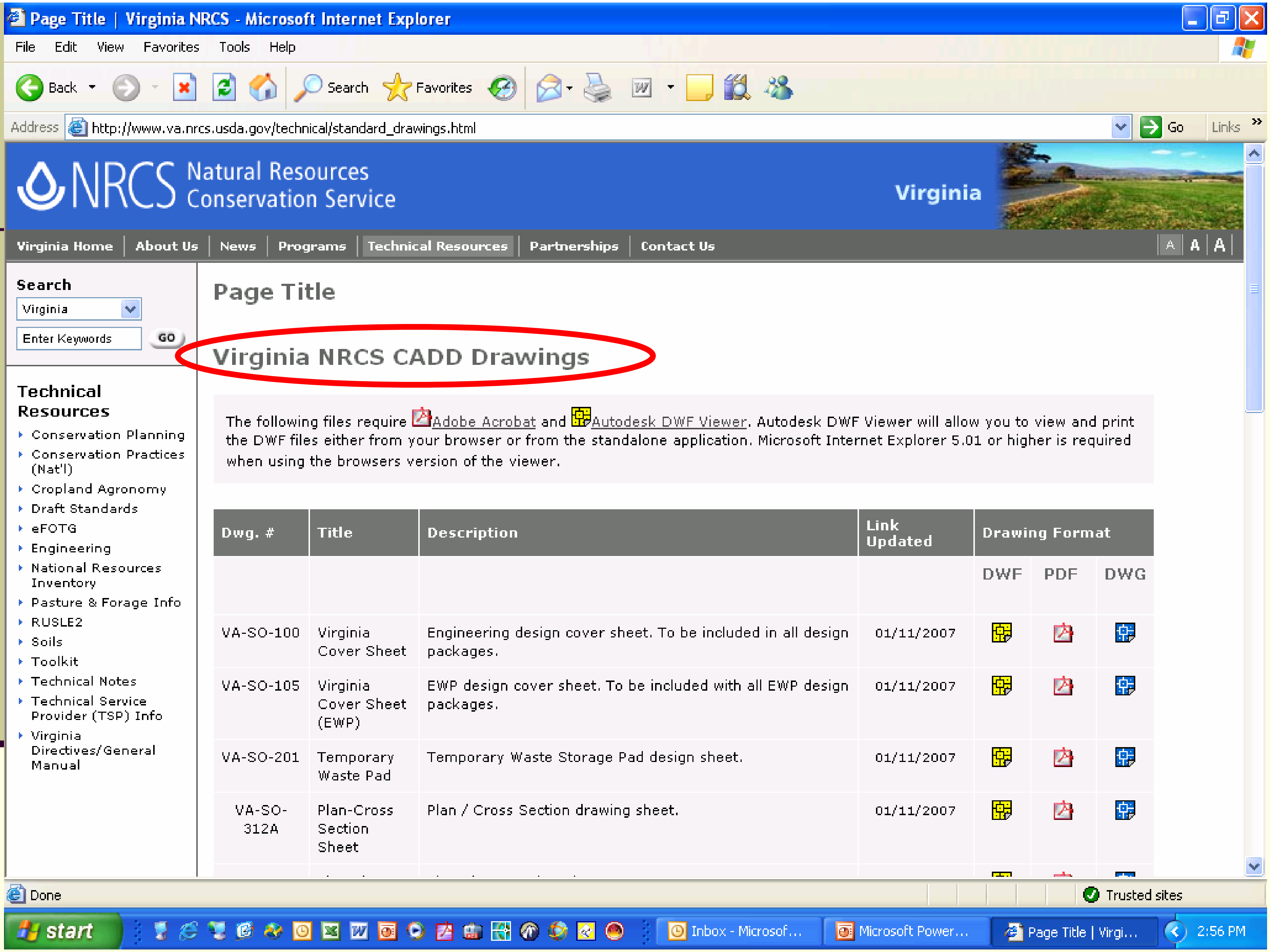
Stream Profile

This an example of how to modify the Typical Stone Layer detail on sheet 2 to show a different stone layer.

Designed
Drawn
Checked
Approved
Project Name
Landowner
County
Tract#
, Virginia
NRCS
Natural Resources Conservation Service
United States Department of Agriculture
File Name



Location of Standard Stream Crossing Drawings on the NRCS Virginia WEB Page. 1)Click on the Technical Resources tab, then 2)Engineering, then 3)Standard Drawings.



When the Standard Drawing page opens…

Virginia Standard Engineering Drawings | Virginia NRCS - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://www.va.nrcs.usda.gov/technical/standard_drawings.html

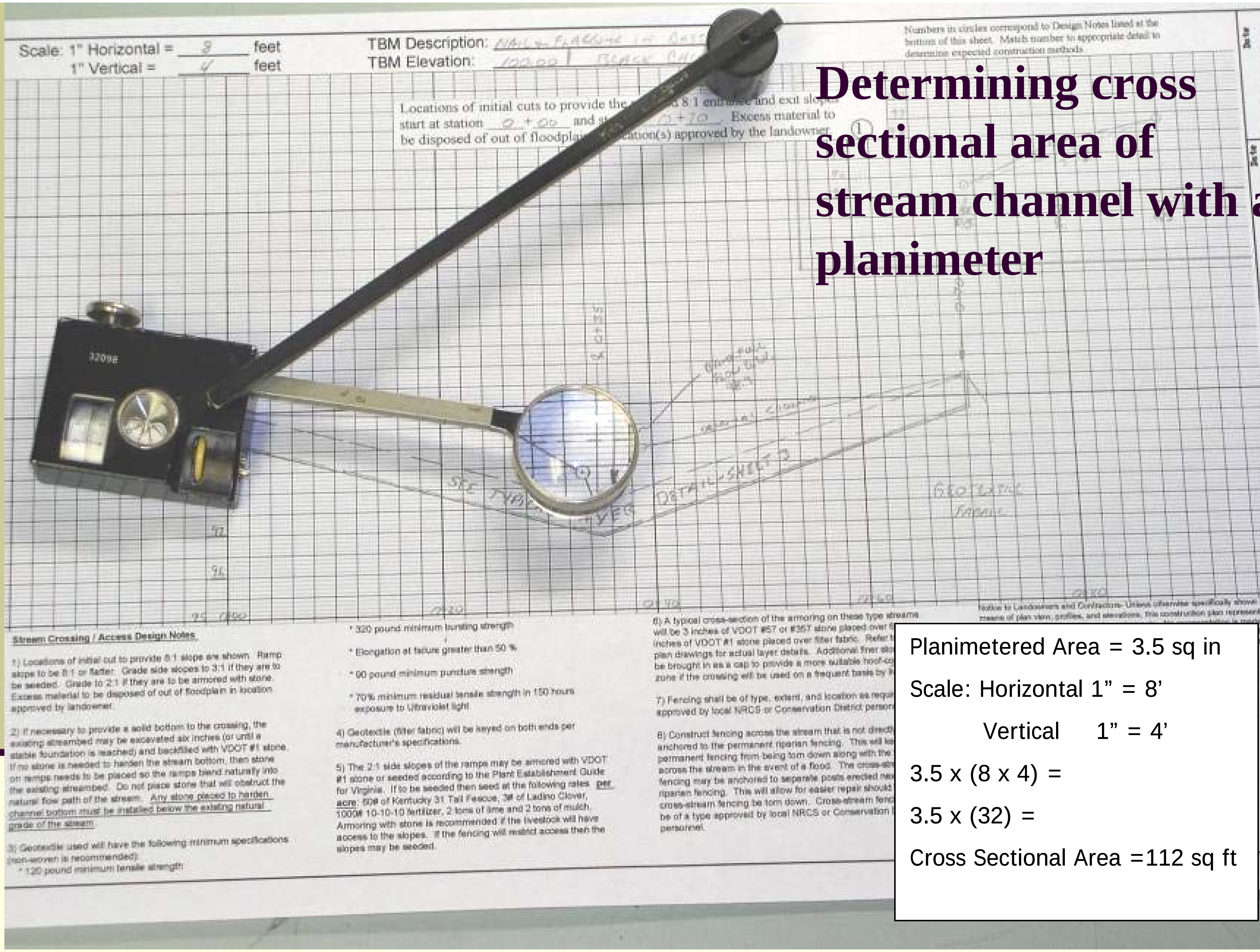
- Technical Service Provider (TSP) Info
- Virginia Directives/General Manual
- Find a Service Center

VA-SO-261	Temporary Waste Pad	Temporary waste storage pad design sheet.	1/11/2007
VA-SO-312A	Plan-Cross Section Sheet	Plan / Cross Section drawing sheet.	1/11/2007
VA-SO-313A	Plan Sheet	Plan View Drawing Sheet	1/11/2007
VA-SO-315A	Cross Section Sheet	Cross Section Drawing Sheet	1/11/2007
VA-SO-316A	Profile Sheet	Profile Drawing Sheet	1/11/2007
VA-SO-317A	Plan Profile Sheet	Plan Profile Drawing Sheet	1/11/2007
VA-SO-502	Livestock Shade Structure	Standard drawing of a Livestock Shade Structure	1/11/2007
VA-SO-600	Waterway	Waterway Design Sheet	1/11/2007
VA-SO-800	Stream Crossing	Stream Crossing Design Sheets 1 and 2	1/11/2007
VA-SO-900	Spring Development	Spring Development Design Sheet	1/11/2007
VA-SO-901	Pipeline	Pipeline Design Sheet	1/11/2007
VA-SO-902	Frost-Free Trough	Frost-free Trough Design Sheet	1/11/2007
VA-SO-903	Concrete Trough	Concrete Trough Design Sheet	1/11/2007
VA-SO-904	HET Trough	Heavy Equipment Tire trough (HETT) design sheet	1/11/2007

Done | Trusted sites

Click on the icon of the format you wish to download. Drawings are in three formats; Adobe PDF, Autodesk DWF, which is a free download like Adobe Reader; and Autodesk DWG.

Determining cross sectional area of stream channel with a planimeter



Planimetered Area = 3.5 sq in

Scale: Horizontal 1" = 8'

Vertical 1" = 4'

3.5 x (8 x 4) =

3.5 x (32) =

Cross Sectional Area =112 sq ft

When determining the cross sectional area of the stream channel with a planimeter the horizontal and vertical become very important. The square inches on the paper now have more square feet of area in them. Use the following formula to compute the channel area. Planimetered sq. inches x (H scale x V scale) = area sq. ft.

Velocity Computations Worksheet

COMPUTATION SHEET
NRCS-ENG-523A Rev. 10-97

U. S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

STATE VA		PROJECT M RIDDELL		
BY GWH	DATE 4/01	CHECKED BY	DATE	JOB NO.
SUBJECT STREAM CROSSING/ACCESS VELOCITY CALCS.				SHEET 1 OF 1

Stream Crossing Calculations Worksheet

Velocity = (1.49/ n) * $R^{2/3}$ * $S^{1/2}$

Where n = Manning's n

R = hydraulic radius = Area/Wetted Perimeter

S = stream slope in feet/feet (decimal form, not percent)

The area is the cross-sectional area of the stream flow. For calculations, compute the area right before the water would leave the defined channel and spill out of the low bank side and into the floodplain. The wetted perimeter is the distance along the edge of one side of the stream bank(b_1) plus the channel width (cw) plus the distance along the edge of the other side of the stream bank (b_2). Start and stop these measurements at the same points you use to define your area (the points where water is just ready to spill into the floodplain).

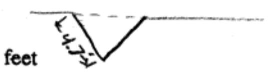
Manning's n for a stream will generally range from 0.035 to 0.05. A stream in an open field will be closer to 0.035 and a stream with heavy woody vegetation along the banks may have an "n" approaching 0.05. Care should be taken when selecting an "n" value. If you have a question contact an engineer.

Calculations:

1. **Selected "n" =** 0.04

2. **Wetted Perimeter = b_1 + cw + b_2 (in feet)**

   W.P. = 4.7 + 0 + 4.7 = 9.4 feet



3. Area = ______ inches squared x ______ ft^2/in^2 (determined by planimetering your stream plot and multiplying by your scale) SEE COMPUTATION SHEET __ OF __

   Area = 5.85 feet ^{2}

4. $R^{2/3}$ = $(A/WP)^{2/3}$ --> $R^{2/3}$ = $(5.85 / 9.4)^{0.667}$ -->

   $R^{2/3}$ = $(0.6223)^{0.667}$ --> $R^{2/3}$ = 0.7289

5. Slope = (feet of fall/ length between shots in feet)$^{1/2}$ (This data comes from your survey)

   Slope, s = (3.2 / 95) --> slope, s= 0.0337 -->

   $s^{0.5}$ = $(0.0337)^{0.5}$ --> $s^{0.5}$ = 0.1836 NOTE: $s^{0.5} = \sqrt{s}$

6. V = (1.49/n) $R^{0.667}$ $S^{0.5}$ --> V = (1.49/ 0.04) (0.7289) (0.1836)

   V = (37.25) (0.7289) (0.1836) --> Velocity = 5.0 feet per second

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Velocity Computation Spreadsheet

Manning's Equation-Stream Crossing Applications

1. Enter selected 'n' value: 0.04

2. Enter Wetted Perimeter, WP: 9.4 feet

3. Enter Area, A: 5.85 square feet

The Hydraulic Radius, R, equals (A / WP) R= 0.62

Determine the slope of the stream:

4. Enter the upstream elevation: 98.7 , the downstream elevation: 95.5 and the distance between the two elevations: 95

The slope equals: 0.034 in decimal form. This is equal to: 3.37 percent

Manning's equation calculates velocity as $V = (1.49 / n) * R^{2/3} * S^{1/2}$

So the velocity for the conditions given above equals: 4.98 feet / second.

Excavation of the foundation of a crossing. Notice the vertical cut on the side. Think of the final excavation as forming a cup to put the base stone in. Place geotextile fabric over the cut and then place the base stone into the fabric. The fabric should extend to the top of the stone layer on the sides.

Completed crossing. All that remains to be completed is the fence installation and seeding.

This crossing is in Northern Virginia. It was constructed using an extra thick base stone layer (12”) because of the very soft bottom. The contractor was experienced in installing crossings with a normal stone layer thickness. But here an error was made. Can you find the error on the next photo.

Do you see the problem?

Look at this point. What will happen when the water gets higher and flows over and around the loose mud here. The ramp was not cut deep enough to allow the ramp surface to tie into the stream bottom before or at the edge of the bank.

This crossing was constructed on a stream with a gravel bottom. The ramps have been excavated and armored but the bottom was left as it was. Why disturb the streambed if it is not necessary? Leave it alone if you can.

This photo is of a crossing just after a flood event. Look at the fence going to the crossing in the upper left. This is actually a three strand barbwire fence. The reason it is so thick is because up stream there was a fresh cut, but not baled, hay field. The wires are covered with hay and grass. Install separate posts on all cross fences.

Culvert Crossing Design

Culvert Crossings

D. Site Selection Considerations

1. Do you really want to “dam” this stream?
2. Drainage area
3. Q and V of watershed
4. Width of stream channel
5. Bank height
6. Emergency spillway site
7. Diameter and length of culvert needed
8. Side slopes of fill… armored or not

This is a nice single culvert crossing. The stone armor is place 1' thick over non-woven geotextile fabric as over topping protection. Notice that the trees were left undisturbed during construction.

Crossing in fox hunting country. Notice the coops for the horses to jump. Also notice the double spillways installed with this culvert crossing.

Same crossing from downstream. Notice that one tube is 6” lower then the other. This is required by our old permit agreement.

Again same culvert crossing. This landowner decided to use the belled double walled PE pipe. It has a “n” factor of 0.012, or VERY SLICK. This is a great product and well worth mentioning to the landowners. As always do not mention brands of pipe only types. The drain tile is to sleeve a pipeline to the trough sight in the distance.

Culvert Crossings

E. Culvert Design Data

1. Drainage area of stream
2. Plot cross section and profile of stream
3. Cross sectional area and wetted perimeter of channel at bank full flow
4. Stream velocity at bank full flow
5. Calculate culvert size based on the $Q_{2yr.}$ Call your friendly Area Engineer for assistance.
6. Complete cover sheet. With signatures!
7. Complete plan view sheet
8. Complete crossing design sheet
9. Provide landowner 2 copies of design and specs

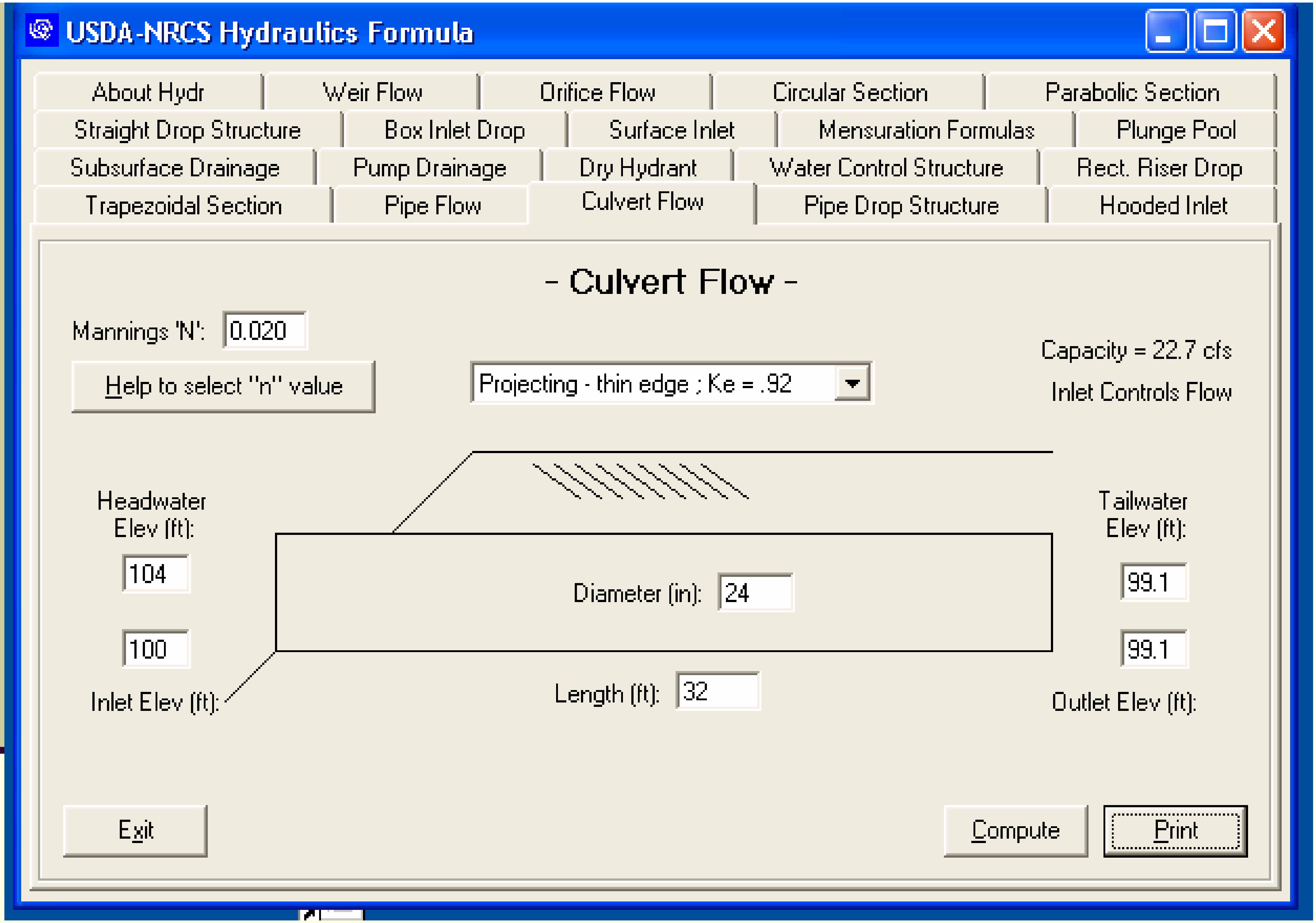
Calculating Culvert Length

Culvert length is determined by:

1. Height of fill above culverts FH (fill height) 1 ft
2. Culvert Diameter CD (culvert dia.) 2 ft
3. U/S and D/S fill slopes SS (side slope) 2:1, 2:1
4. Crossing Top Width TW (top width) 16 ft
5. Per standard.. Culverts must extend 2 ft beyond toe of slopes 4 ft

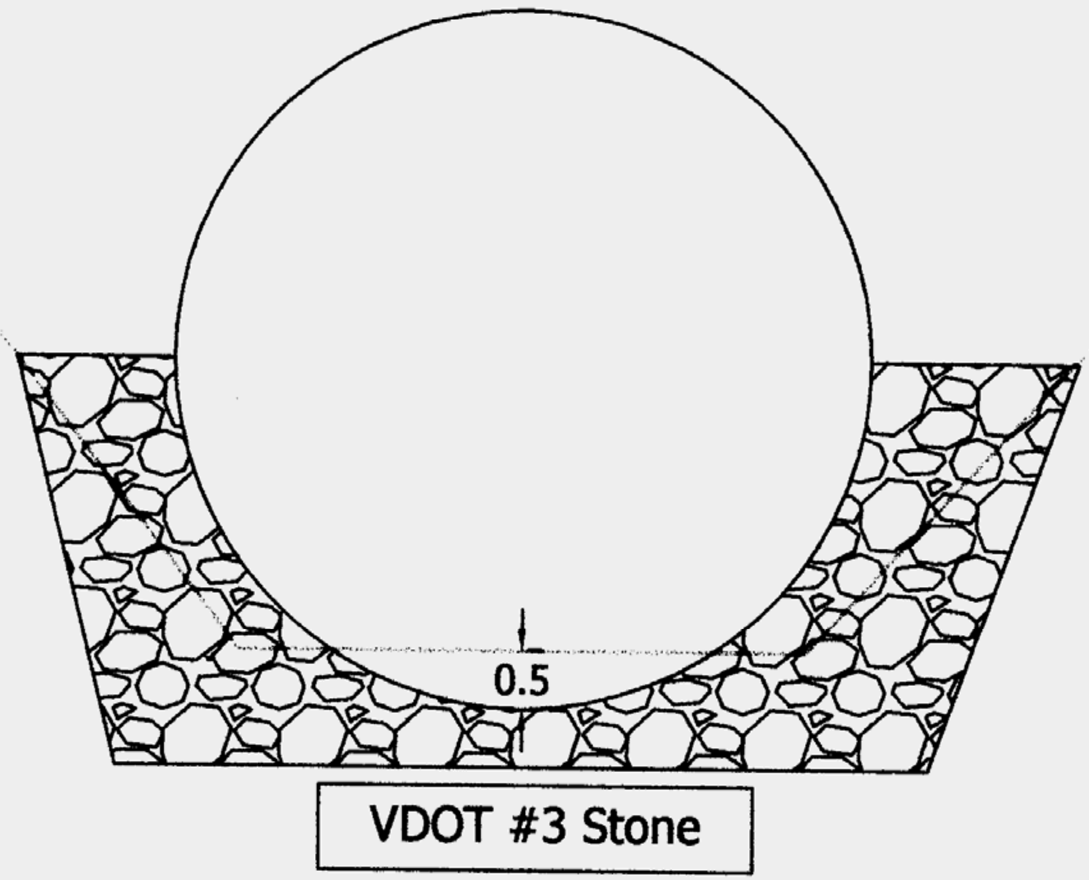
(((FH+CD) *SS)*2)+TW+ 4' = culvert length

(((1+2)*2)*2)+16+4 =32' culvert length



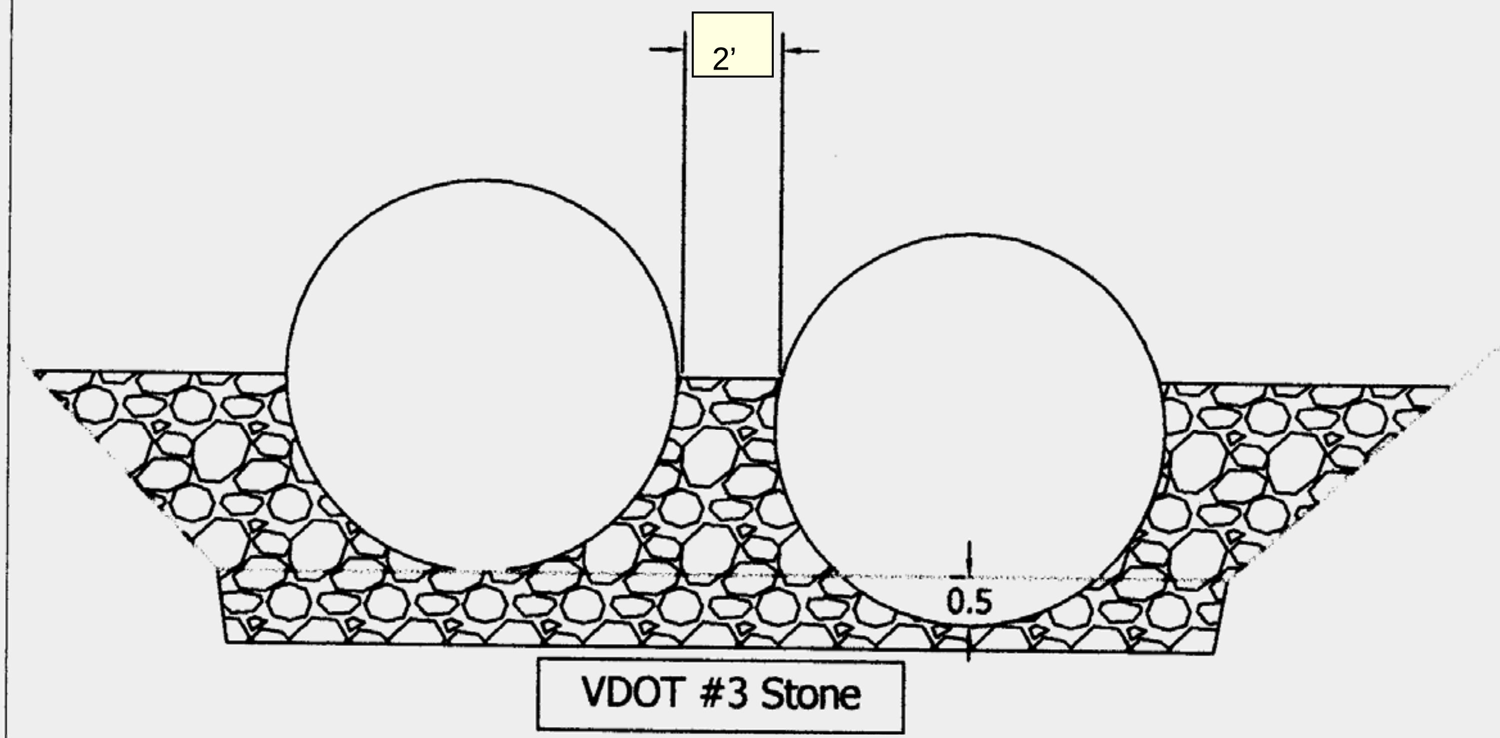
Hydraulics Formula Program.

Single Culvert Crossing



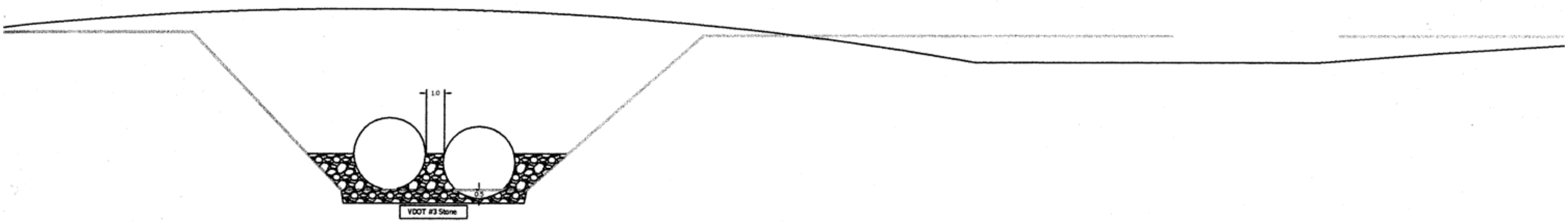
Single culvert backfilling with gravel. Place a geotextile fabric between the subgrade and the stone. I also have geotextile fabric placed over the top of the stone and culvert to prevent the earth backfill from migrating into the stone layer. VDOT # 1 size stone is also acceptable for the stone backfill.

Double Culvert Crossing



Double culverts backfilling with gravel. Place a geotextile fabric as mentioned in the previous slide. A minimum space of 2' is to be left between the culverts. This allows the contractor to consolidate the stone backfill between the culverts. VDOT # 1 size stone is also acceptable for the stone backfill. It is also acceptable to completely backfill with stone.

Single Spillway for routing heavy flows away from culvert



Remember the spillway should function BEFORE the crossing is overtopped. Use the hydraulics formula program to calculate the flow through the spillway.

Limited Access Watering Points

Limited Access Points

1. Are basically ½ a stream crossing
2. Use same design criteria as stream crossings
3. Should be wide...12 to 16 ft min
4. Ponds accesses should extend to a depth of 2 to 3 ft. Stream access depths will be determined by the stream.
5. Stream and pond accesses should have an armored bottom for all areas that have livestock access.

Armor all areas that have concentrated livestock traffic. This access fence is installed in a “V” to limit concentration.

Don't recommend the use of electric fence as the end fence for an access. If the cows crowd and shove one cow into the fence then all the cows in the water are shocked and mass panic ensues. Resulting in…

Livestock within the buffer.

Steel gates or boards work better.

This limited access should be deeper into the pond so that the livestock has access to water during periods of drought. I would recommend 3’ of water depth for most ponds.

Nice pond access! And look at the buffer. Nice high grass.. Soon to be replaced by brush and trees.

Same access. Should be deeper into the pond but landowner said that the pond was spring fed and water level of the pond did not fluctuate.

If you have any questions or need assistance with the survey, design, or installation of one of these practices, please contact the NRCS Area Engineer for your area.

You may also contact John Cooke if you have a question about anything discussed in this training.

804-287-1648 or john.cooke@va.usda.gov

END