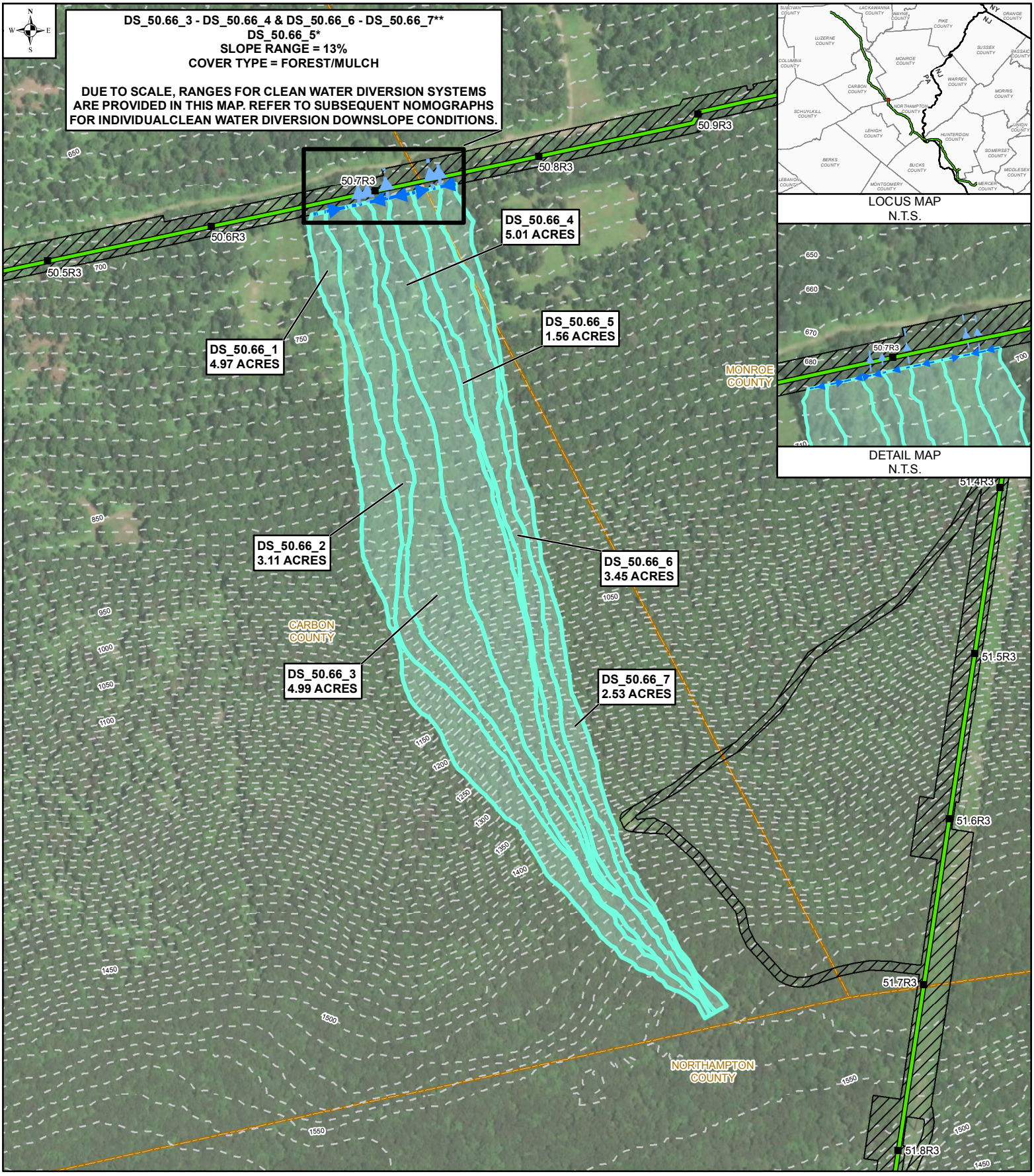
Appendix 2C
Monroe County



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.66

CARBON & MONROE COUNTIES, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 63 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_6
3.45 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON & MONROE COUNTIES
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_6	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_6	2824	FOREST	0.309	1.40	33.66

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
47.27

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON & MONROE COUNTIES
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_6	1	FOREST	0.20	3.45	0.69	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	47.27	1.65	2.04	2.42	1.65	2.04	2.42

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.04	3.45	1.14	1.41	1.67

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON & MONROE COUNTIES

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.45		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.41		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.42		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.57		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.34		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.52 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.52		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.94		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.011		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_7
2.53 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_7	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_7	2826	FOREST	0.309	1.40	33.70

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.61

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_7	1	FOREST	0.20	2.53	0.51	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.61	1.67	2.06	2.44	1.67	2.06	2.44

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.06	2.53	0.84	1.04	1.24

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

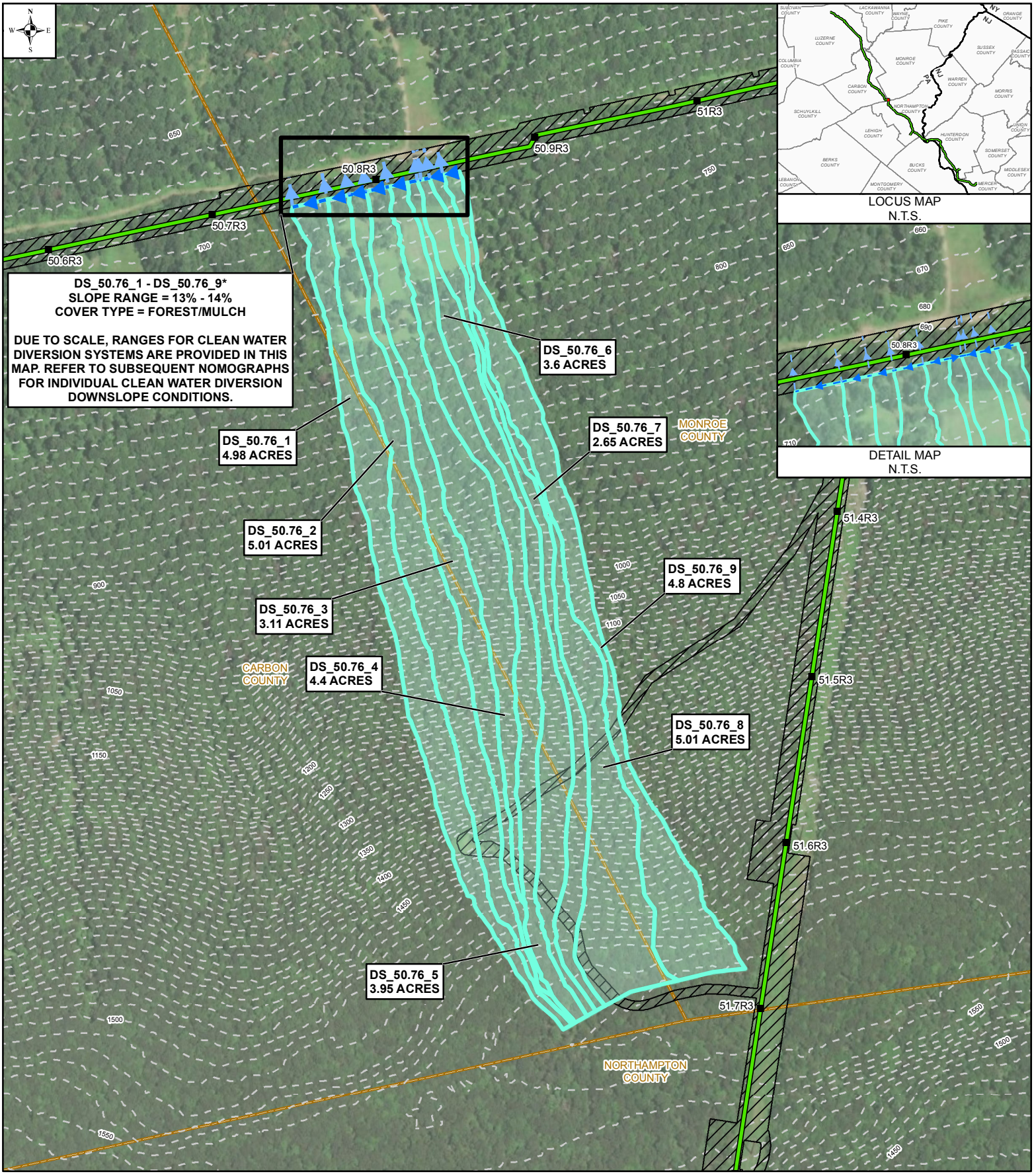
LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.53		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.04		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.97		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.97		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.00		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.00		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.083		
$.7S_c$	(FT/FT)	0.058		
$1.3S_c$	(FT/FT)	0.107		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.76

MONROE COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 64 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_1
4.98 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_1	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_1	2792	FOREST	0.311	1.40	33.17

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.08

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_1	1	FOREST	0.20	4.98	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.08	1.68	2.07	2.46	1.68	2.07	2.46

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.07	4.98	1.67	2.07	2.45

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.98		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.07		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.62		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.01		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.78 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.78		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.89		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.72		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.044		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

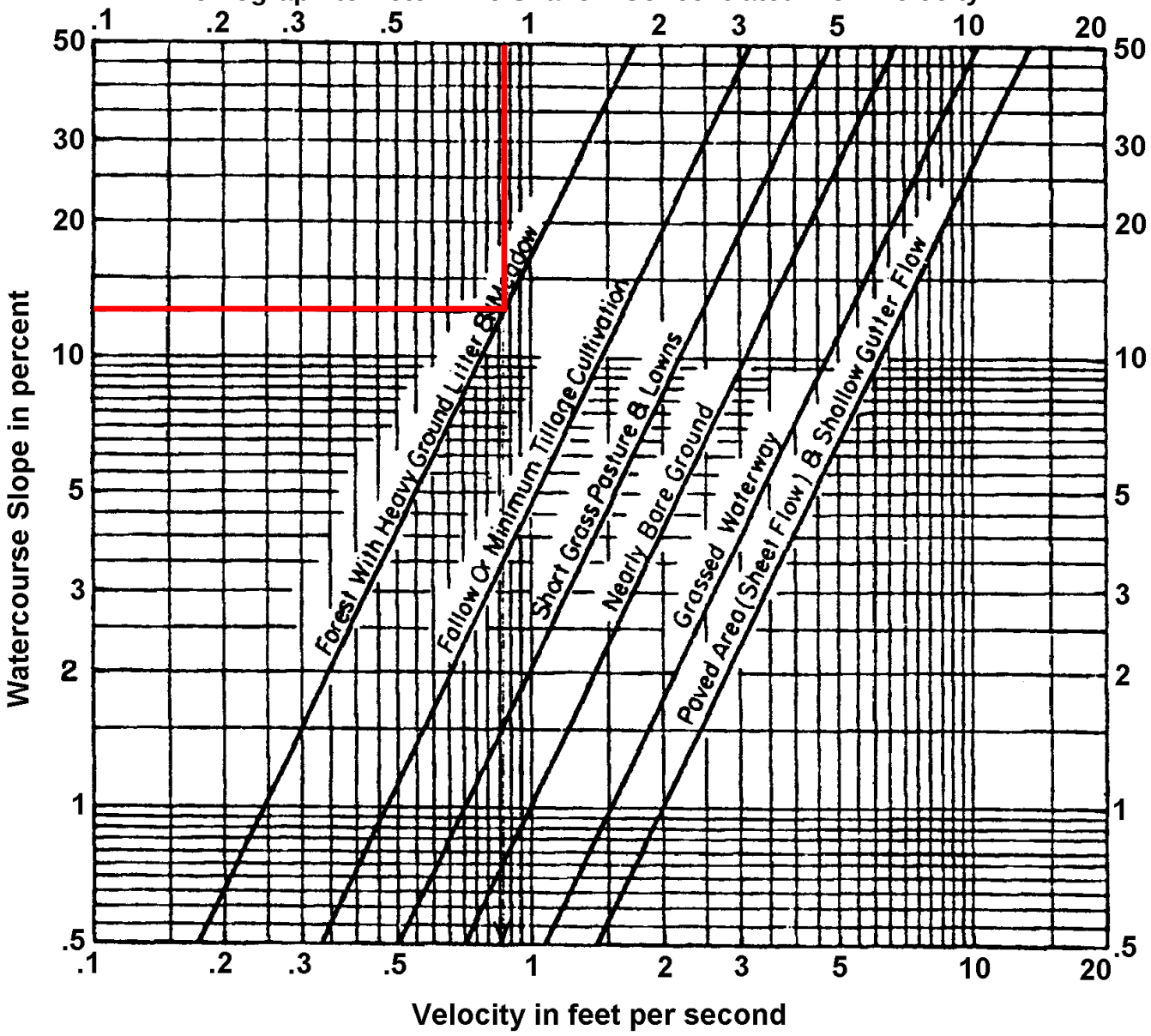
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_2
5.01 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_2	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_2	2765	FOREST	0.314	1.41	32.69

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
45.06

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_2	1	FOREST	0.20	5.01	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	45.06	1.71	2.11	2.50	1.71	2.11	2.50

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.11	5.01	1.71	2.11	2.50

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.01		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.11		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.09		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.19		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.90		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.81 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.81		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.91		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.98		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.029		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

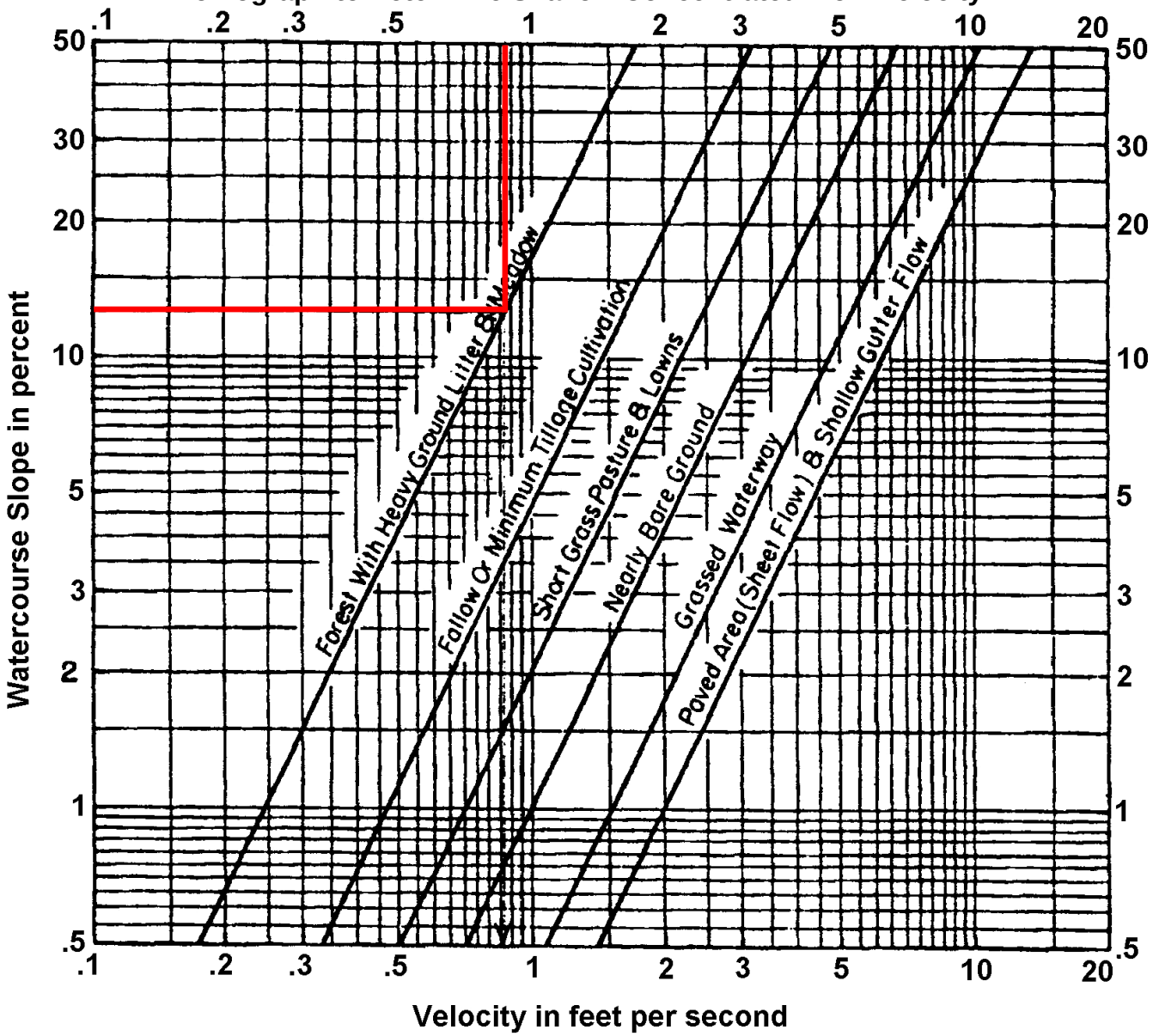
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_3
3.11 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_3	100	0.8	0.080	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_3	2653	FOREST	0.324	1.43	30.87

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
42.44

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_3	1	FOREST	0.20	3.11	0.62	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	42.44	1.78	2.20	2.60	1.78	2.20	2.60

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.20	3.11	1.11	1.37	1.62

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.11		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.37		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.56		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.84		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.12		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.036		
S_C (CRITICAL SLOPE)	(FT/FT)	0.085		
$.7S_c$	(FT/FT)	0.060		
$1.3S_c$	(FT/FT)	0.111		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

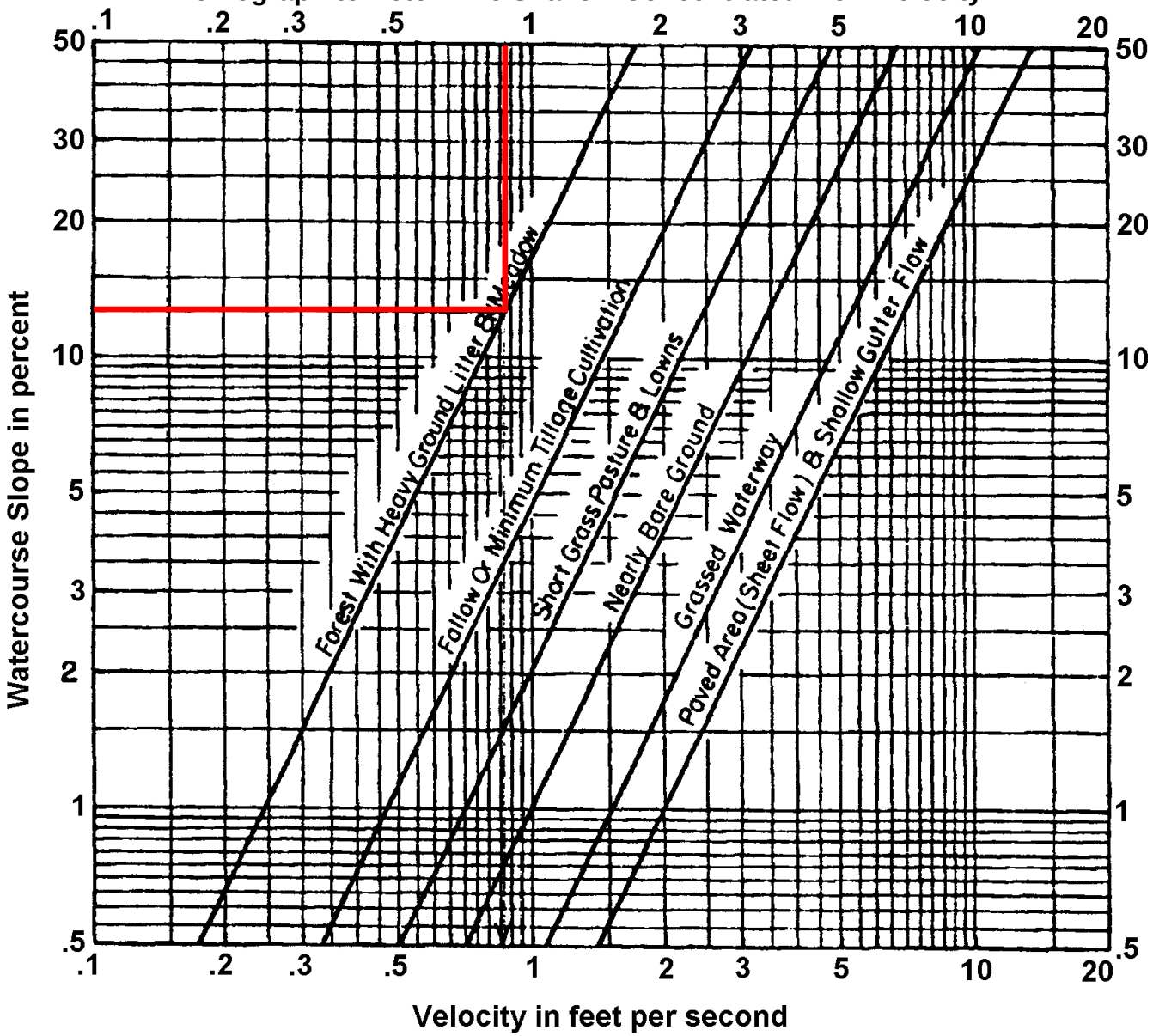
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_4
4.4 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_4	100	0.8	0.400	7.94

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_4	2386	FOREST	0.337	1.46	27.23

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
35.17

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_4	1	FOREST	0.20	4.40	0.88	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	35.17	2.03	2.49	2.92	2.03	2.49	2.92

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.49	4.40	1.79	2.19	2.57

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.4		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.19		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.46		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.42		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.58 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.58		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.29		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.82		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

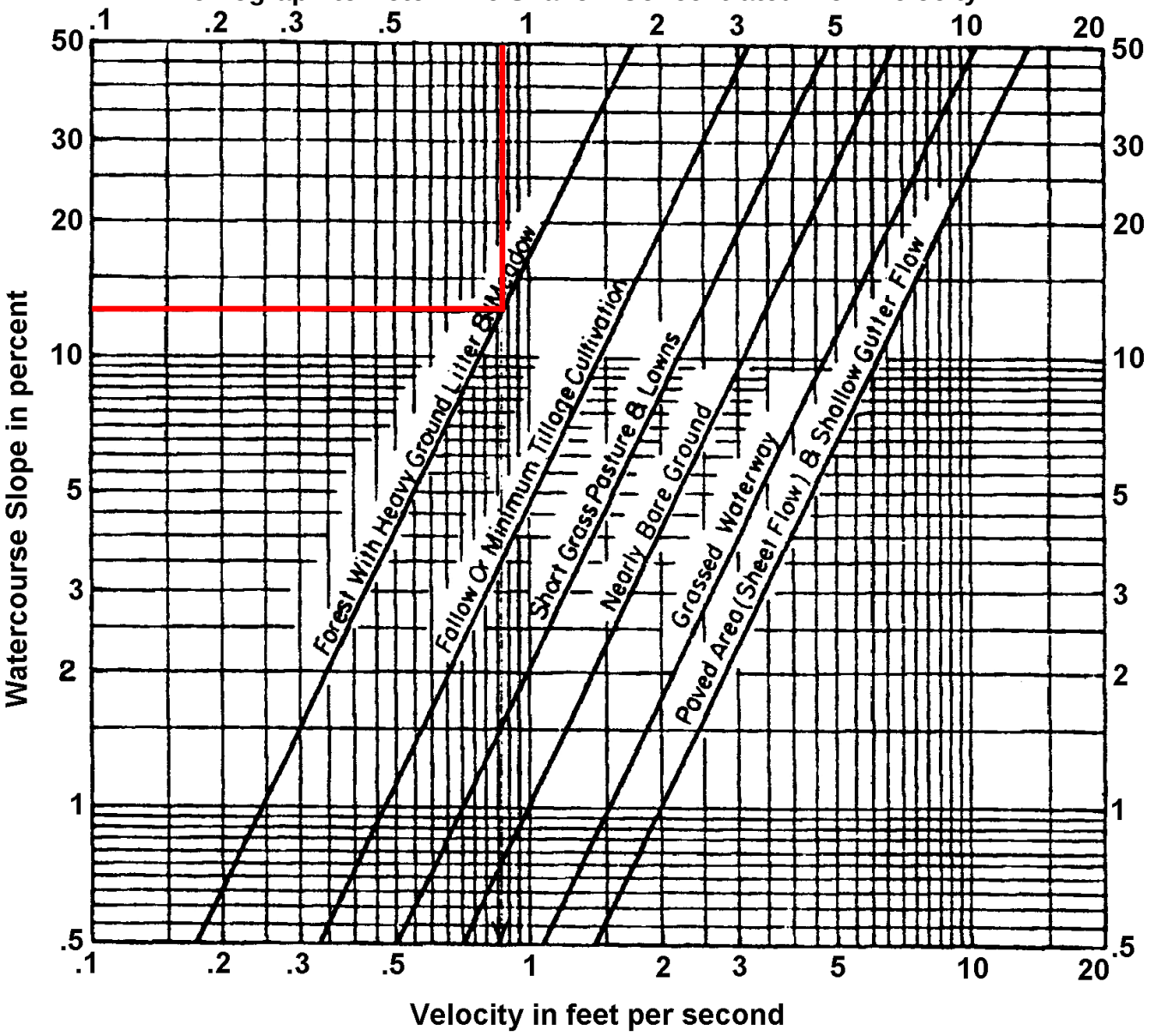
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_5
3.95 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_5	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_5	2761	FOREST	0.313	1.41	32.71

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
45.09

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_5	1	FOREST	0.20	3.95	0.79	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	45.09	1.71	2.11	2.50	1.71	2.11	2.50

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.11	3.95	1.35	1.66	1.97

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.95		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.66		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.02		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.11		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.75 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.75		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.88		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.97		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.016		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

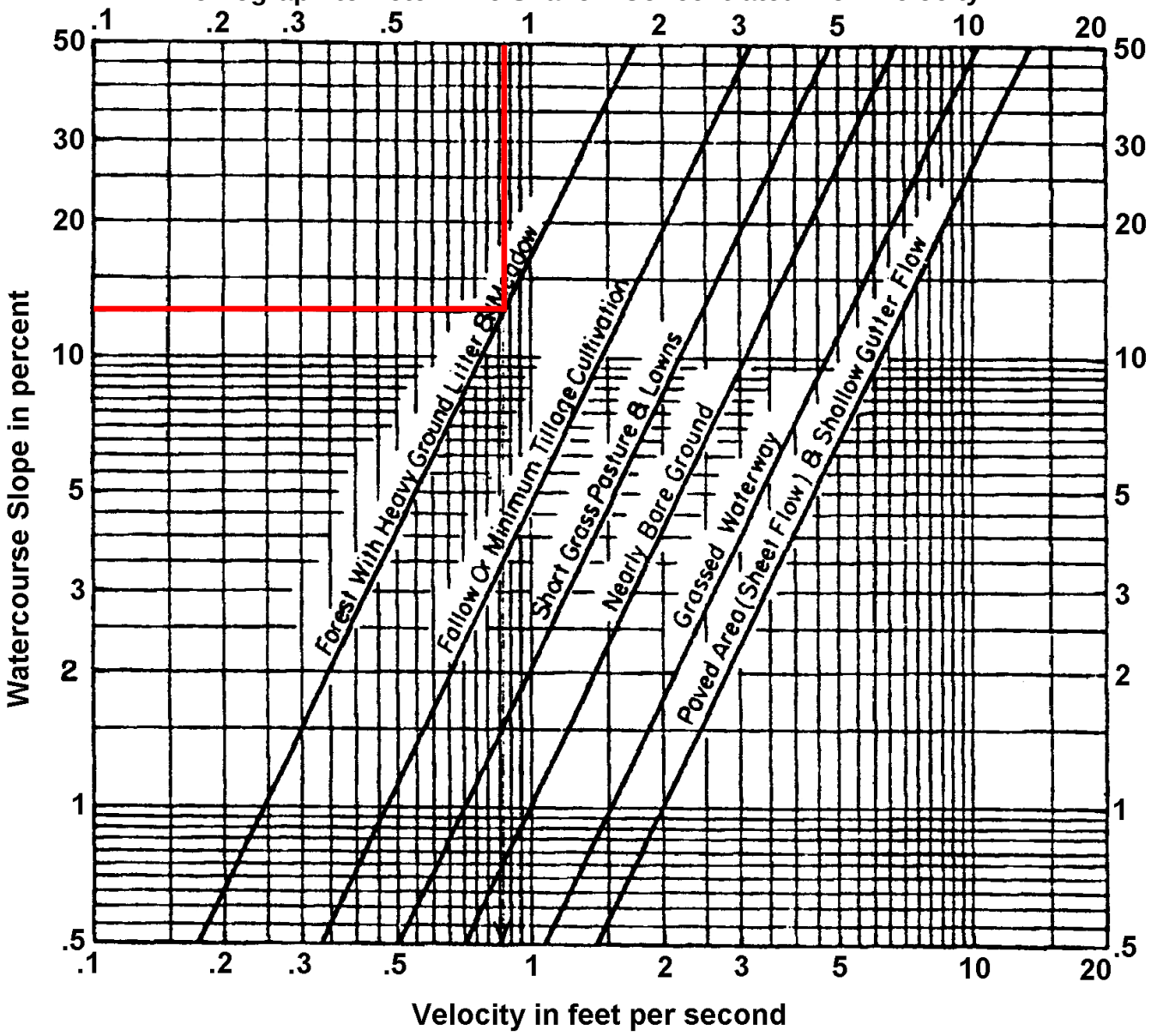
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_6
3.6 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_6	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_6	2750	FOREST	0.314	1.41	32.50

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
44.87

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_6	1	FOREST	0.20	3.60	0.72	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	44.87	1.71	2.11	2.50	1.71	2.11	2.50

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.11	3.60	1.23	1.52	1.80

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.6		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.52		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.56		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.82		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.09		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.85 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.85		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.42		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.86		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.035		
S_C (CRITICAL SLOPE)	(FT/FT)	0.085		
$.7S_c$	(FT/FT)	0.059		
$1.3S_c$	(FT/FT)	0.110		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

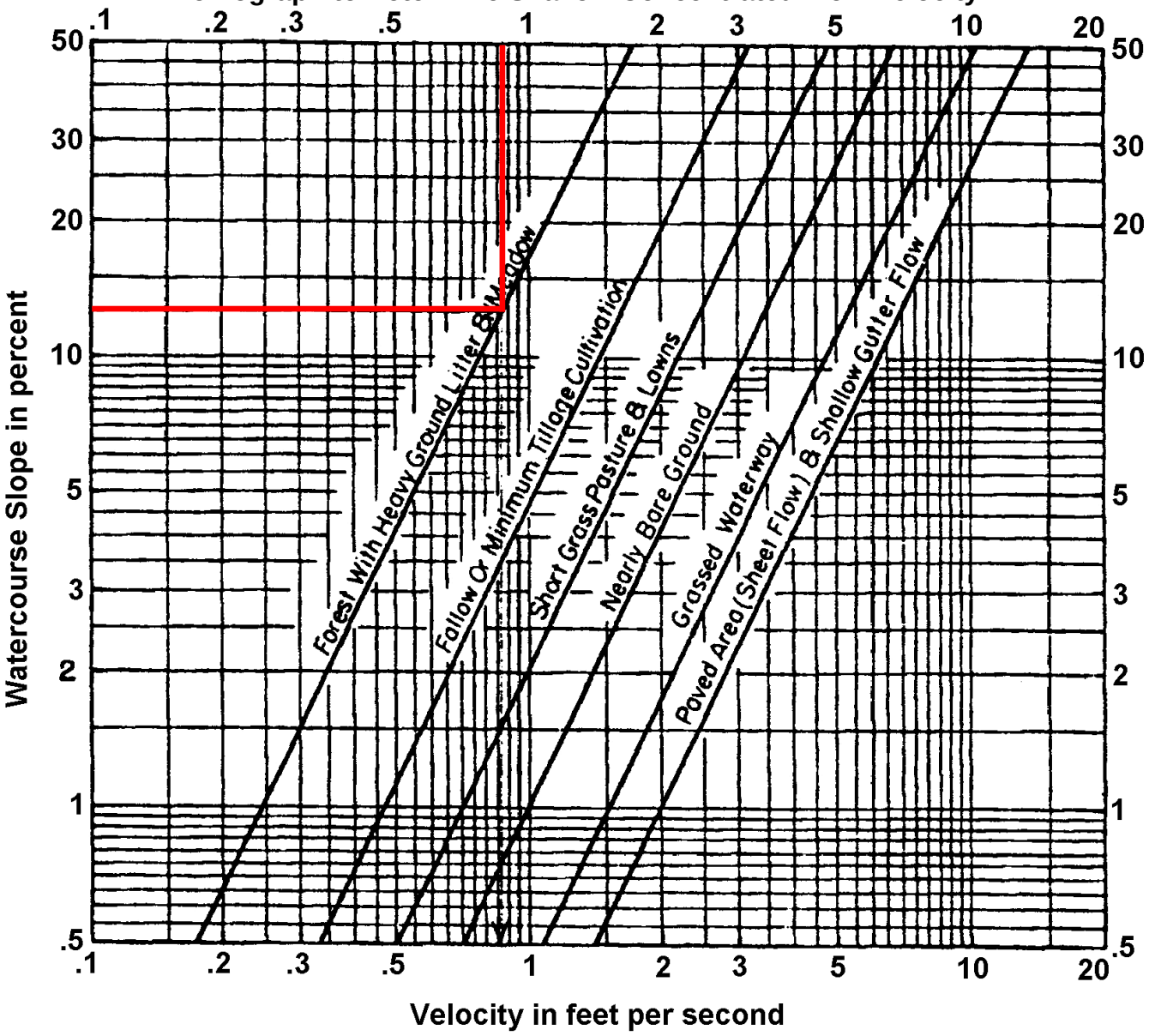
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_7
2.65 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_7	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_7	2743	FOREST	0.315	1.41	32.39

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
44.77

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_7	1	FOREST	0.20	2.65	0.53	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	44.77	1.72	2.12	2.51	1.72	2.12	2.51

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.12	2.65	0.91	1.12	1.33

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.65		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.12		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.29		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.06		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.42		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.3 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.30		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.65		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.91		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.100		
$.7S_c$	(FT/FT)	0.070		
$1.3S_c$	(FT/FT)	0.130		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

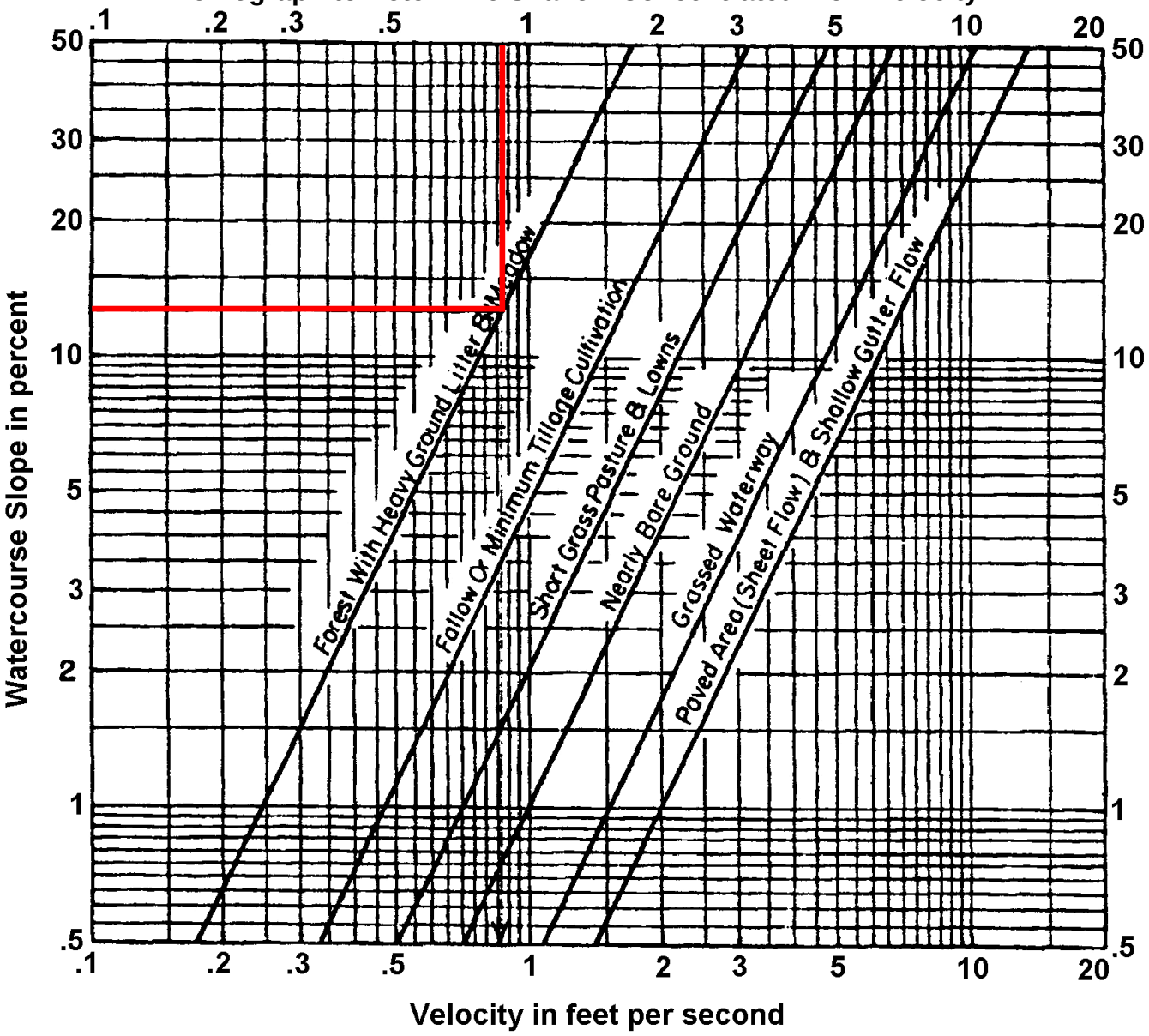
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_8
5.01 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_8	100	0.8	0.130	10.33

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_8	2743	FOREST	0.315	1.41	32.36

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
42.69

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_8	1	FOREST	0.20	5.01	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	42.69	1.78	2.19	2.59	1.78	2.19	2.59

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.19	5.01	1.78	2.19	2.59

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.01		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.19		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.11		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.68		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.023		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

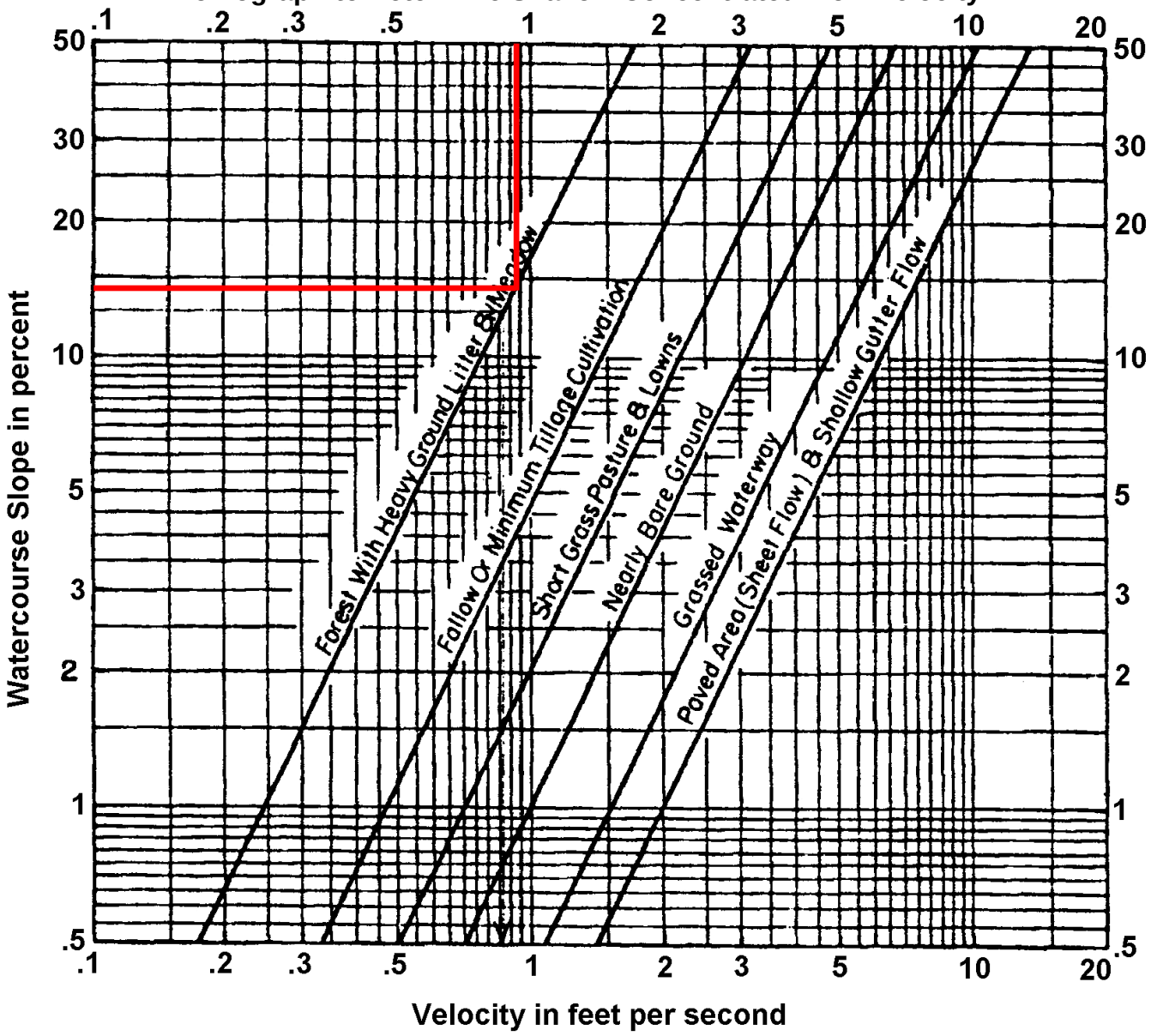
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.76_9
4.8 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.76_9	100	0.8	0.120	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.76_9	2723	FOREST	0.318	1.42	32.00

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
42.53

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.76_9	1	FOREST	0.20	4.80	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	42.53	1.78	2.19	2.59	1.78	2.19	2.59

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.19	4.80	1.71	2.11	2.49

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.76_9		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.8		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.11		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.56		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.32		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.17 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.17		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.09		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.77		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.019		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

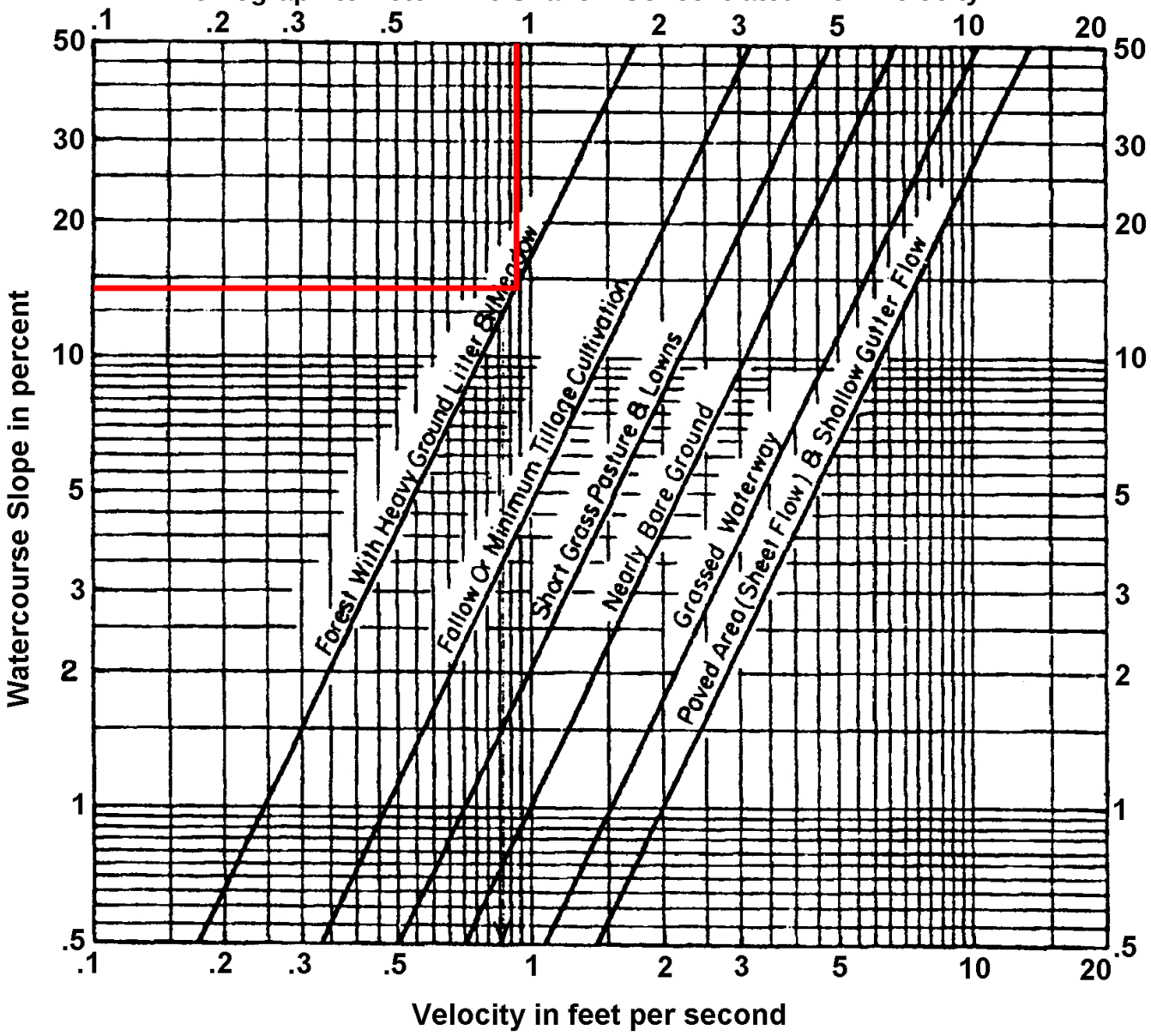
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.76_9

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

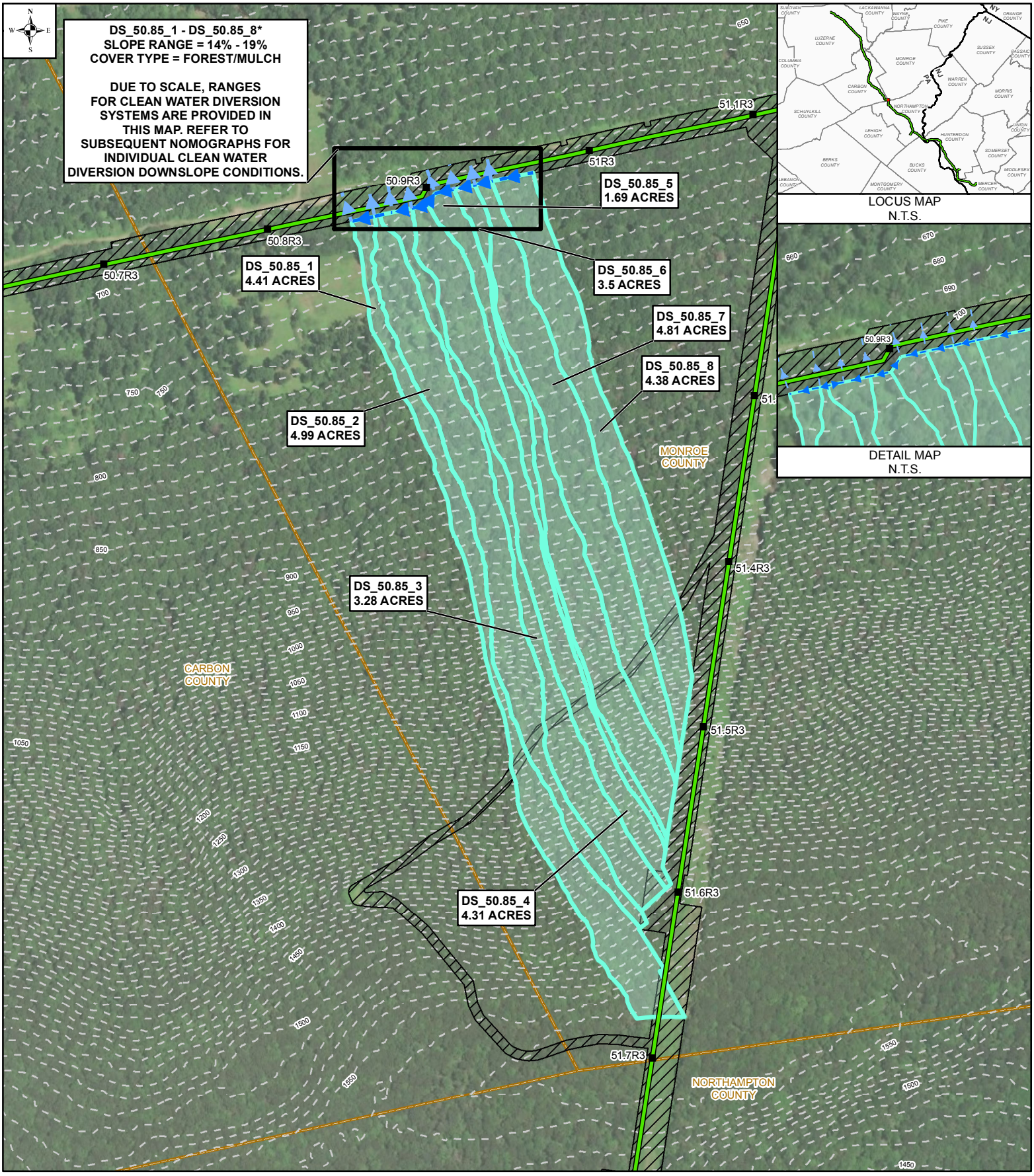


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.85

MONROE COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 65 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_1
4.41 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_1	100	0.8	0.130	10.33

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_1	2623	FOREST	0.320	1.42	30.72

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
41.04

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_1	1	FOREST	0.20	4.41	0.88	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	41.04	1.83	2.25	2.65	1.83	2.25	2.65

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.25	4.41	1.61	1.98	2.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.41		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.98		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.34		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.77		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.41		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.013		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

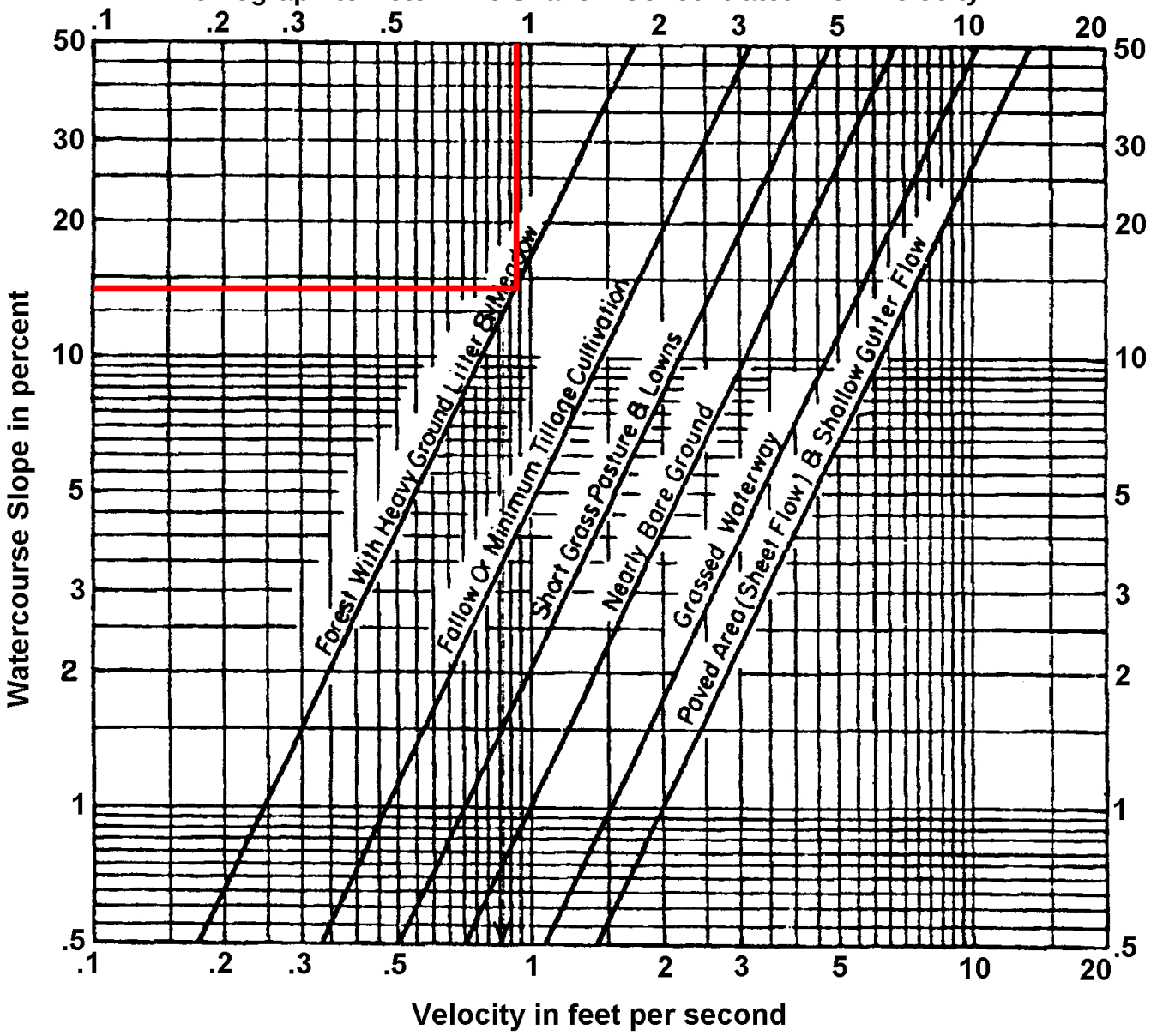
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_2
4.99 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_2	100	0.8	0.380	8.04

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_2	2375	FOREST	0.330	1.45	27.39

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
35.43

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_2	1	FOREST	0.20	4.99	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	35.43	2.02	2.48	2.91	2.02	2.48	2.91

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.48	4.99	2.02	2.48	2.90

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.99		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.73		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.24		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.90		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.93 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.93		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.46		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.12		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.029		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

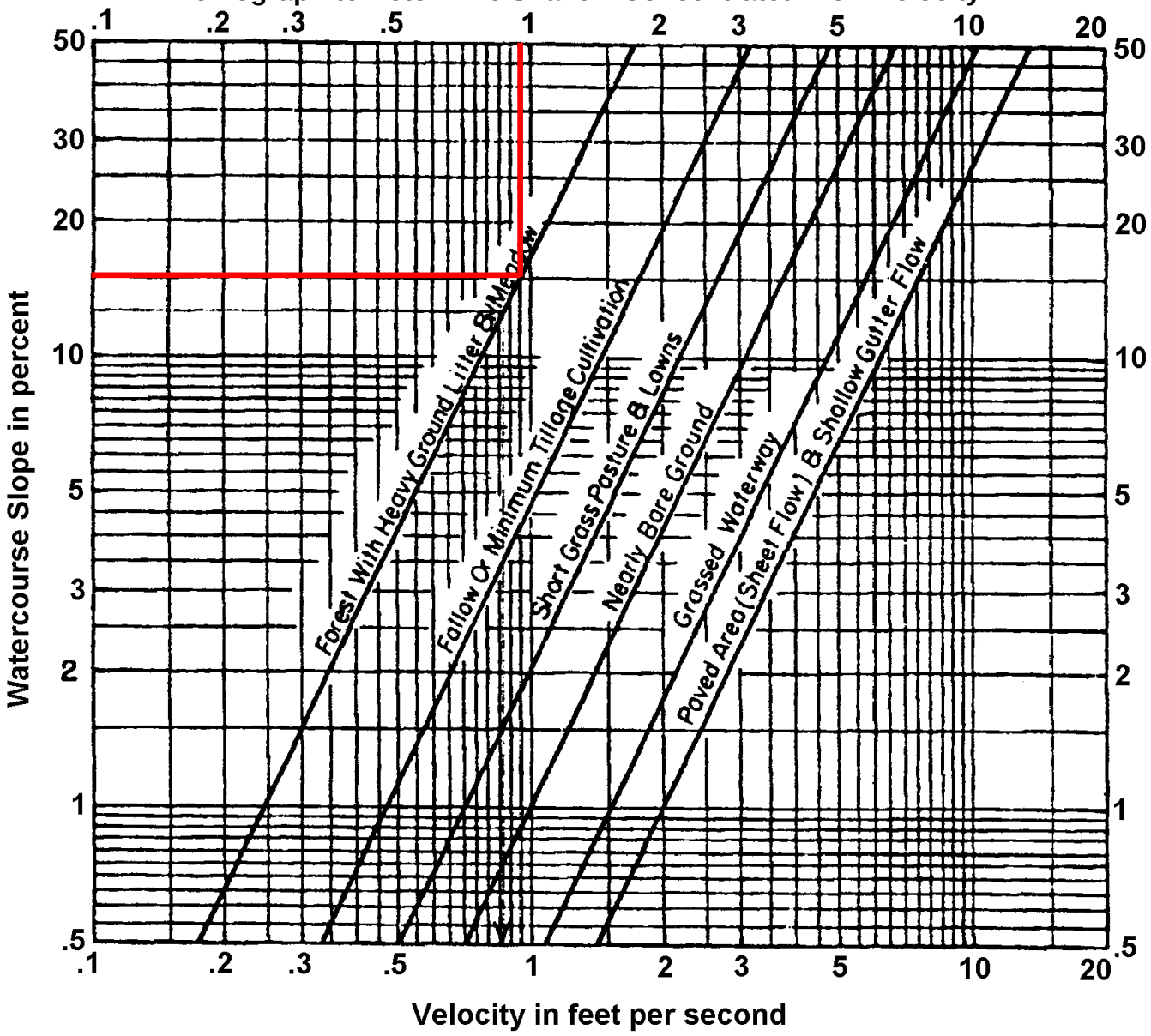
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_3
3.28 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_3	100	0.8	0.360	8.14

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_3	2308	FOREST	0.330	1.45	26.61

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
34.76

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_3	1	FOREST	0.20	3.28	0.66	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	34.76	2.05	2.51	2.94	2.05	2.51	2.94

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.51	3.28	1.34	1.65	1.93

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.28		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.65		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.74		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.42		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.41 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.41		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.21		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.80		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

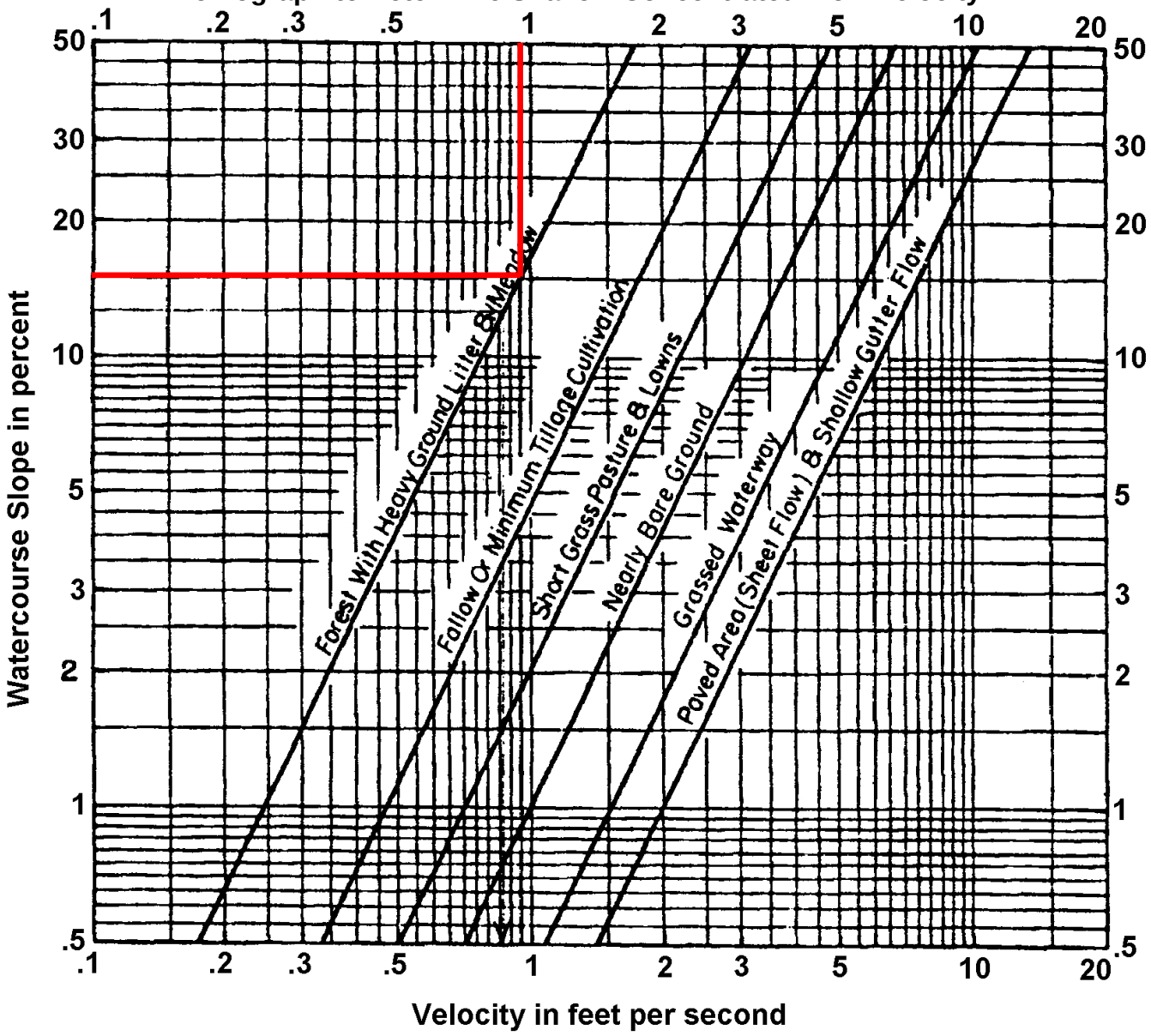
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_4
4.31 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_4	100	0.8	0.400	7.94

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_4	2242	FOREST	0.330	1.45	25.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
33.80

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_4	1	FOREST	0.20	4.31	0.86	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	33.80	2.09	2.56	2.99	2.09	2.56	2.99

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.56	4.31	1.80	2.20	2.58

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.31		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.2		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.44		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.38		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.78 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.78		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.89		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.72		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

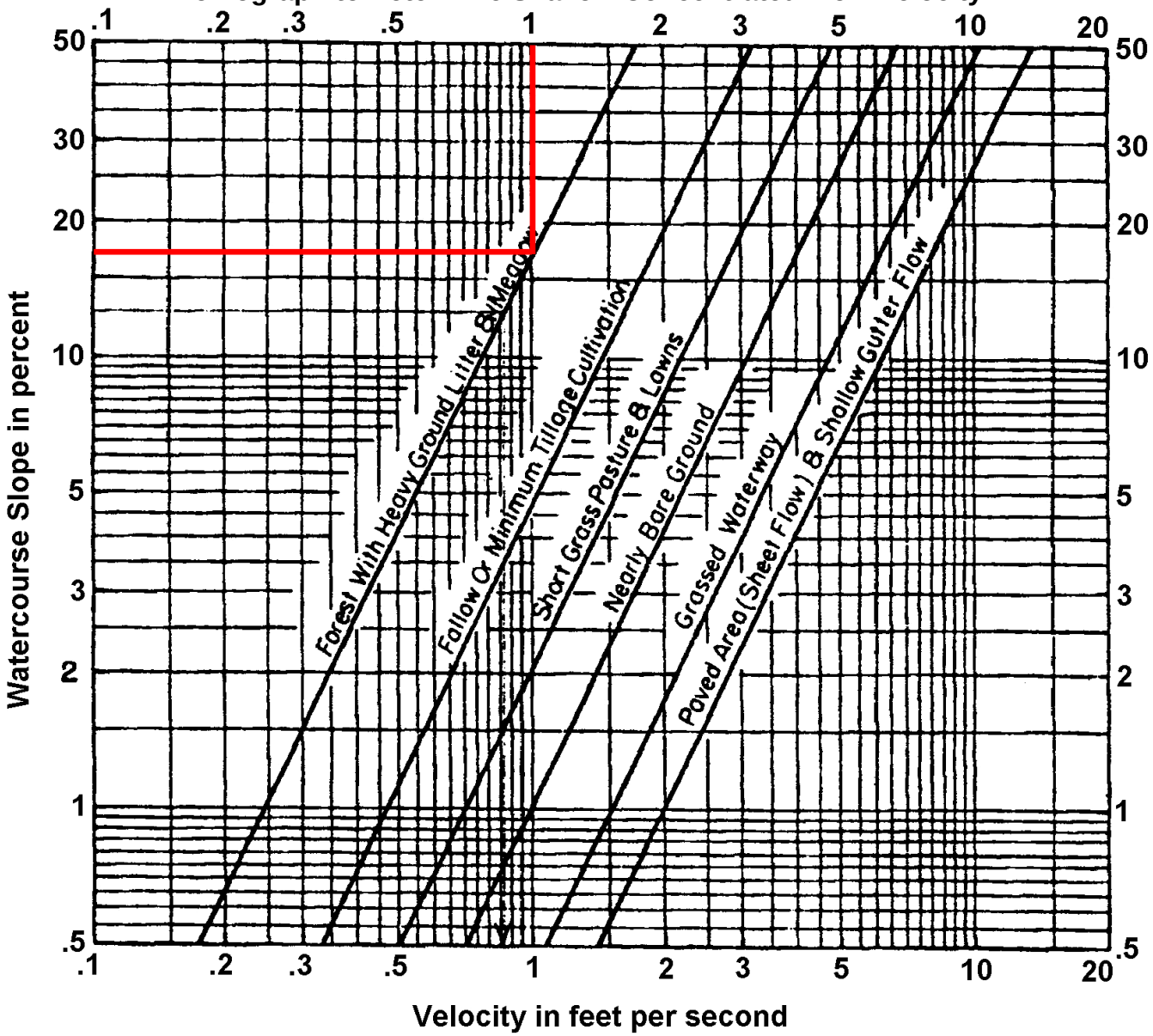
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_5
1.69 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_5	100	0.8	0.510	7.51

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_5	2100	FOREST	0.320	1.42	24.59

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
32.10

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_5	1	FOREST	0.20	1.69	0.34	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	32.10	2.16	2.64	3.09	2.16	2.64	3.09

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.64	1.69	0.73	0.89	1.04

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.69		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.89		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.90		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.034		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.71		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.62 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.62		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.31		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.83		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.09		
S_C (CRITICAL SLOPE)	(FT/FT)	0.033		
$.7S_c$	(FT/FT)	0.023		
$1.3S_c$	(FT/FT)	0.042		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

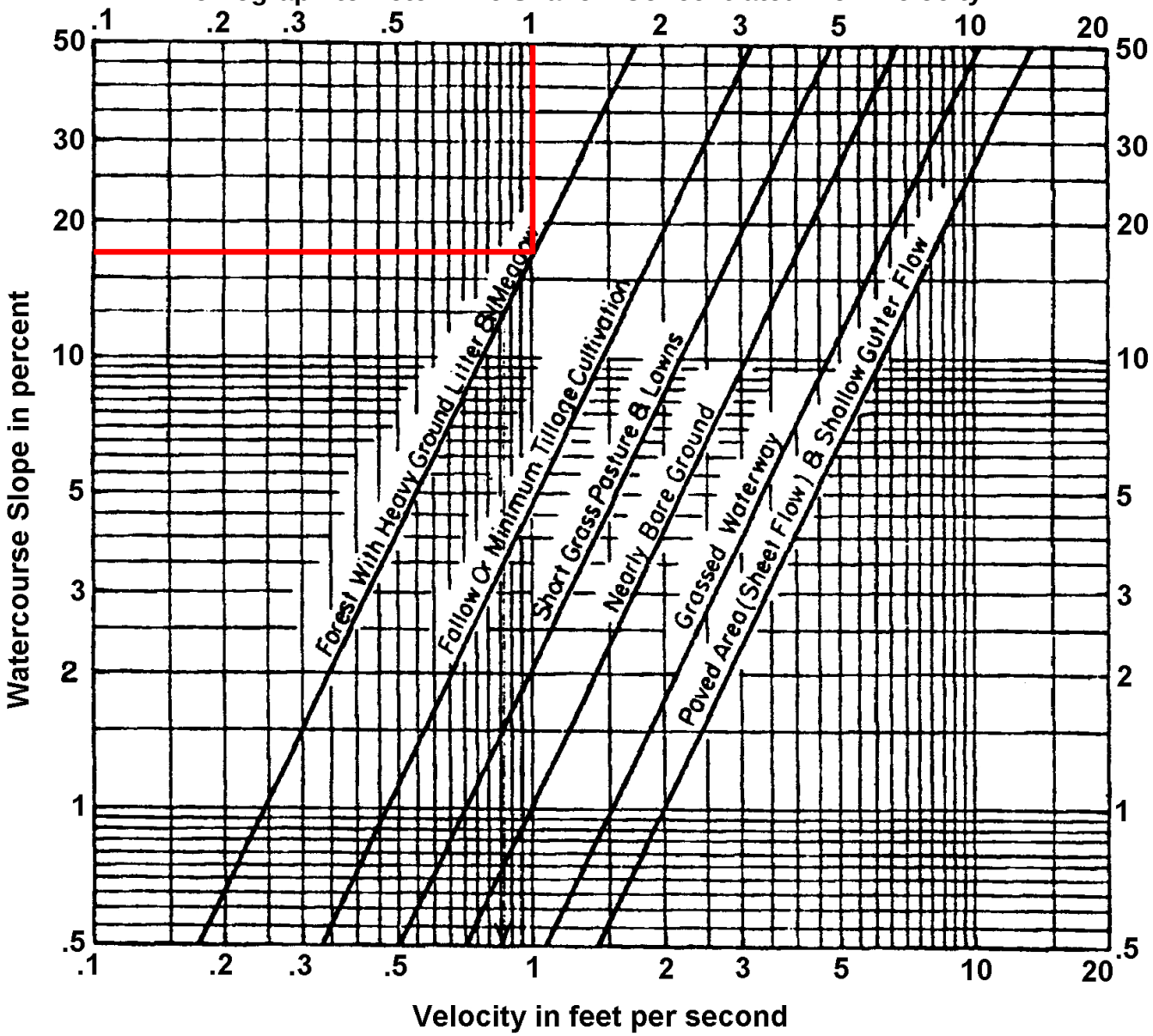
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_6
3.5 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_6	100	0.8	0.520	7.47

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_6	2092	FOREST	0.320	1.42	24.50

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
31.97

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_6	1	FOREST	0.20	3.50	0.70	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	31.97	2.16	2.65	3.09	2.16	2.65	3.09

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.65	3.50	1.52	1.85	2.16

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.5		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.85		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.63		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.99		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.47		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.04 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.04		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.52		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.88		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.015		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

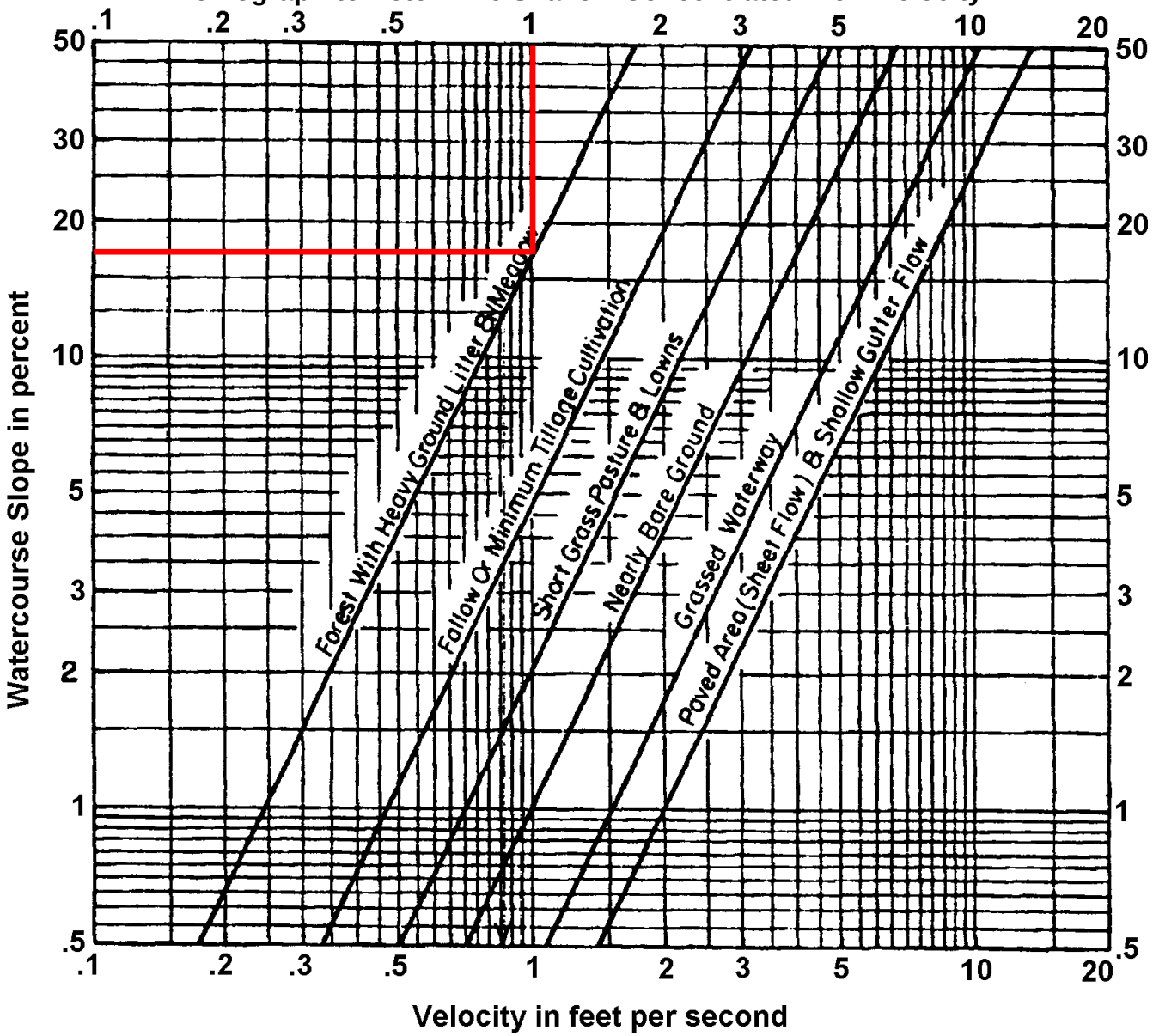
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_7
4.81 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_7	100	0.8	0.560	7.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_7	1922	FOREST	0.320	1.42	22.51

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
29.85

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_7	1	FOREST	0.20	4.81	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	29.85	2.26	2.76	3.22	2.26	2.76	3.22

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.76	4.81	2.18	2.66	3.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.81		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.66		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.92		
PROTECTIVE LINING[2,6]		C125BN		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	6.53		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.35		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.02 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.02		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.01		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.75		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.074		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

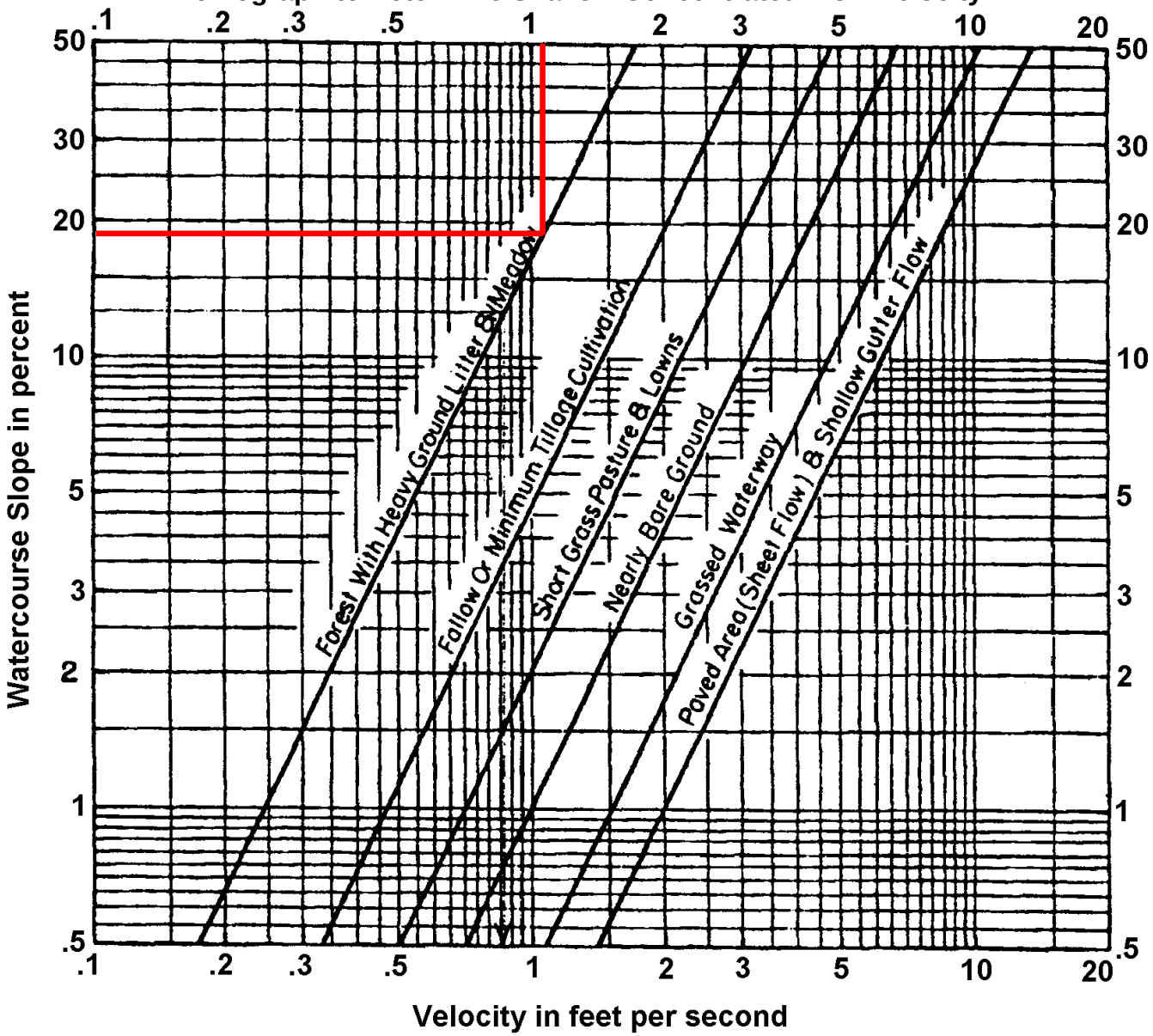
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 19%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.85_8
4.38 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.85_8	100	0.8	0.540	7.41

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.85_8	1825	FOREST	0.320	1.42	21.37

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
28.78

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.85_8	1	FOREST	0.20	4.38	0.88	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.78	2.32	2.83	3.28	2.32	2.83	3.28

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.83	4.38	2.03	2.48	2.88

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.85_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.38		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.18		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.69		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.9 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.90		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.45		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.86		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.023		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

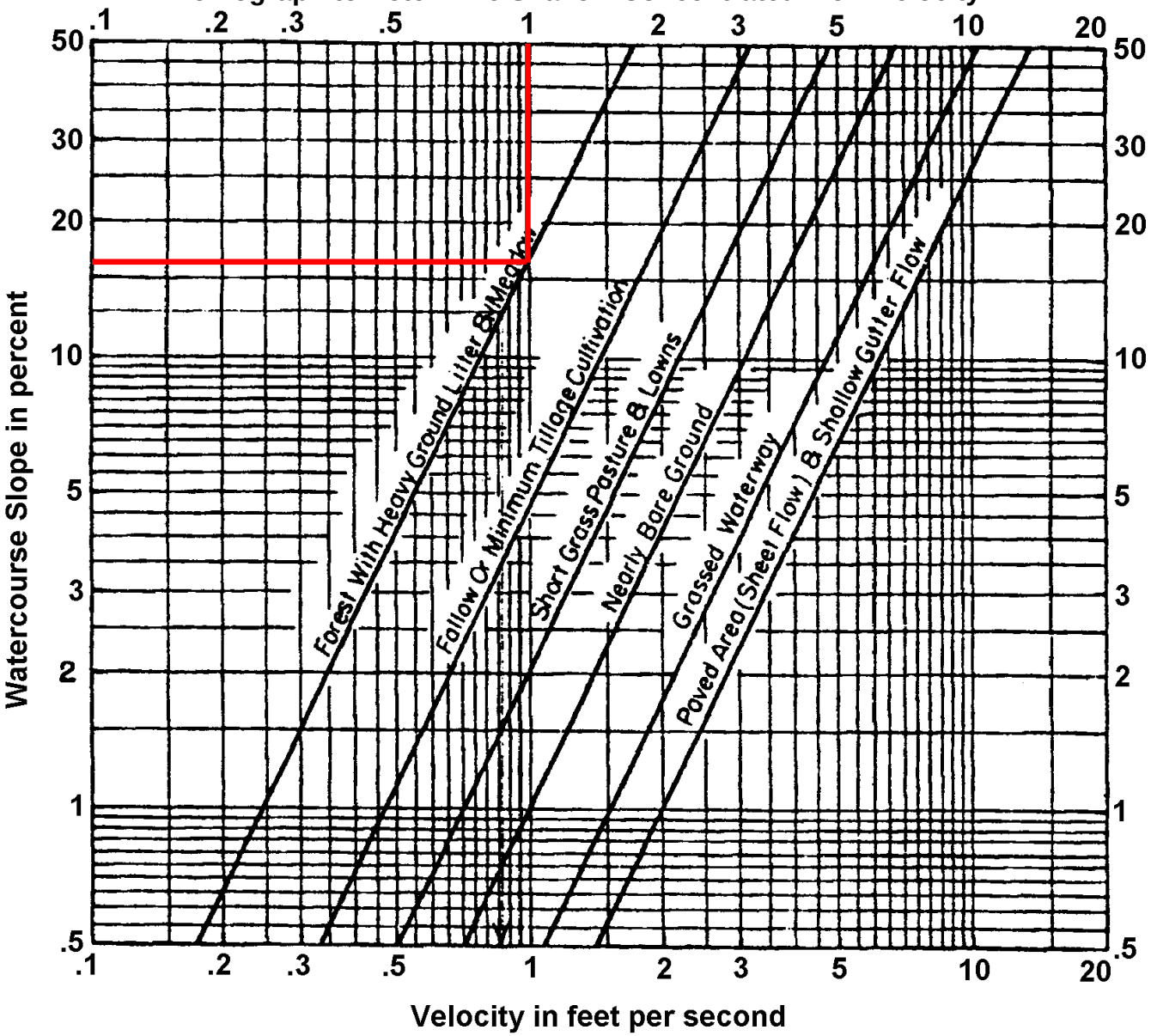
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.85_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

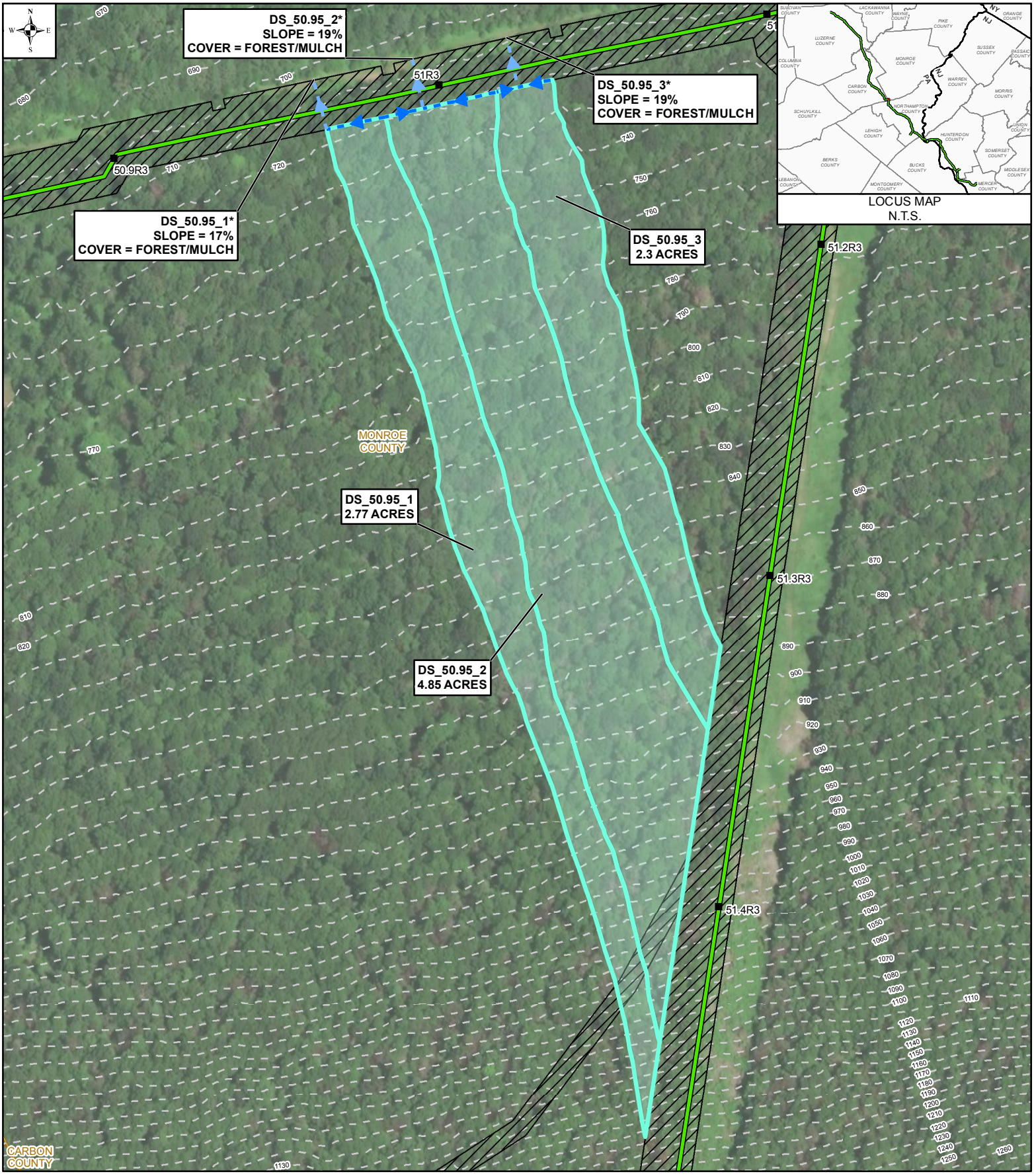


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.95

MONROE COUNTY, PENNSYLVANIA

0 100 200 FEET

PennEast PIPELINE

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 200 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

DWG NO: PAGE 66 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.95_1
2.77 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.95_1	100	0.8	0.590	7.25

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.95_1	1575	FOREST	0.280	1.33	19.72

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
26.97

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.95_1	1	FOREST	0.20	2.77	0.55	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	26.97	2.41	2.94	3.40	2.41	2.94	3.40

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.94	2.77	1.34	1.63	1.88

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.95_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.77		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.63		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.64		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.75		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.00		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.46 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.46		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.73		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.93		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.032		
S_C (CRITICAL SLOPE)	(FT/FT)	0.084		
$.7S_c$	(FT/FT)	0.058		
$1.3S_c$	(FT/FT)	0.109		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

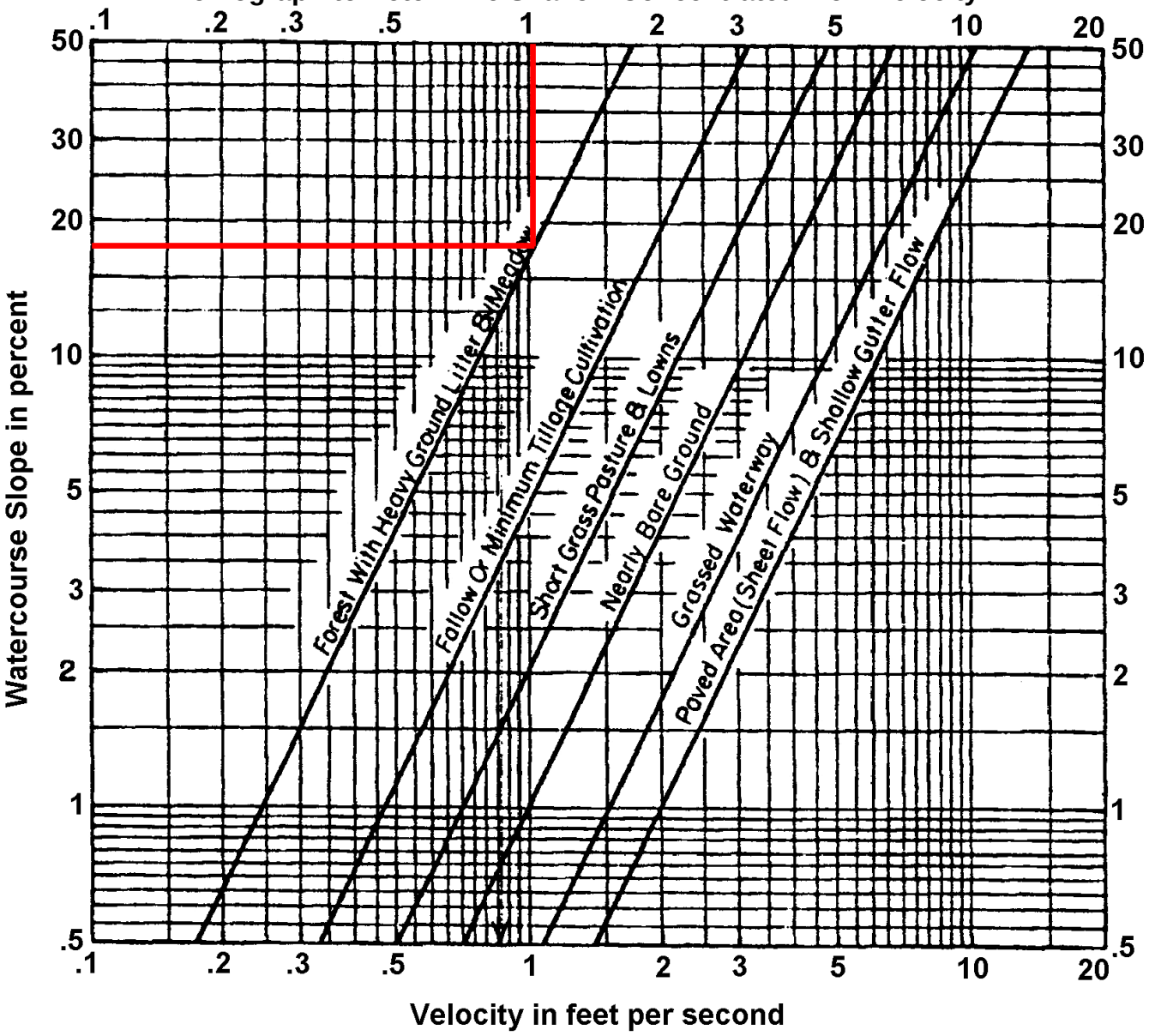
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.95_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.95_2
1.19 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_50.95_1	100	0.8	0.510	7.51

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_50.95_1	1428	FOREST	0.226	1.20	19.90

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
27.40

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_50.95_1	1	FOREST	0.20	4.85	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	27.40	2.39	2.91	3.37	2.39	2.91	3.37

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.91	4.85	2.32	2.82	3.27

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.95_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.19		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.692		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.90		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.06		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.15		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.25 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.25		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.78		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.103		
$.7S_c$	(FT/FT)	0.072		
$1.3S_c$	(FT/FT)	0.134		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

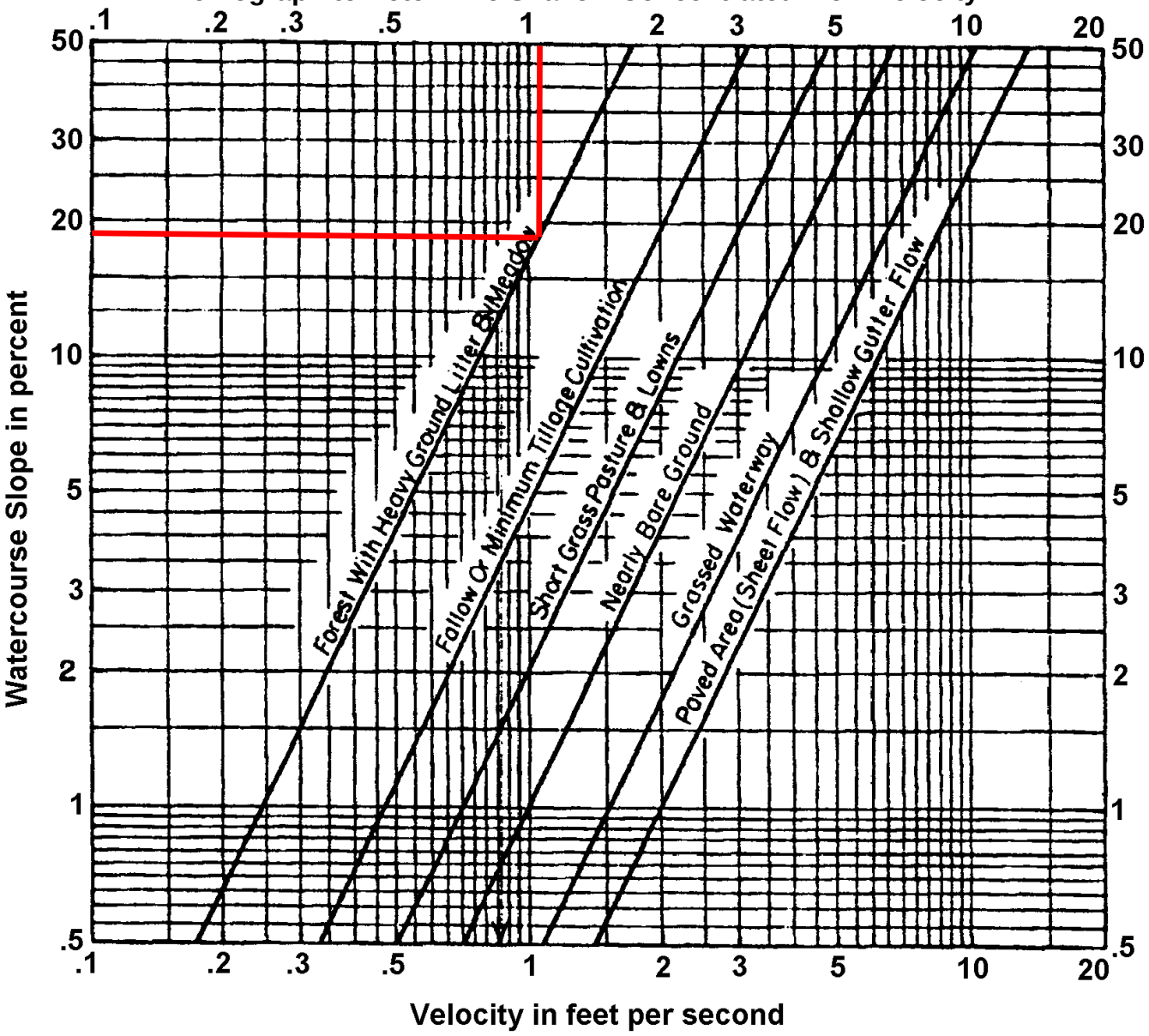
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.95_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 19%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.95_3
2.3 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.95_3	100	0.8	0.220	9.13

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.95_3	971	FOREST	0.190	1.10	14.76

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
23.89

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.95_3	1	FOREST	0.20	2.30	0.46	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	23.89	2.59	3.15	3.63	2.59	3.15	3.63

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.15	2.30	1.19	1.45	1.67

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.95_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.3		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.45		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.92		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.52		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.34		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.1 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.10		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.05		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.76		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.011		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

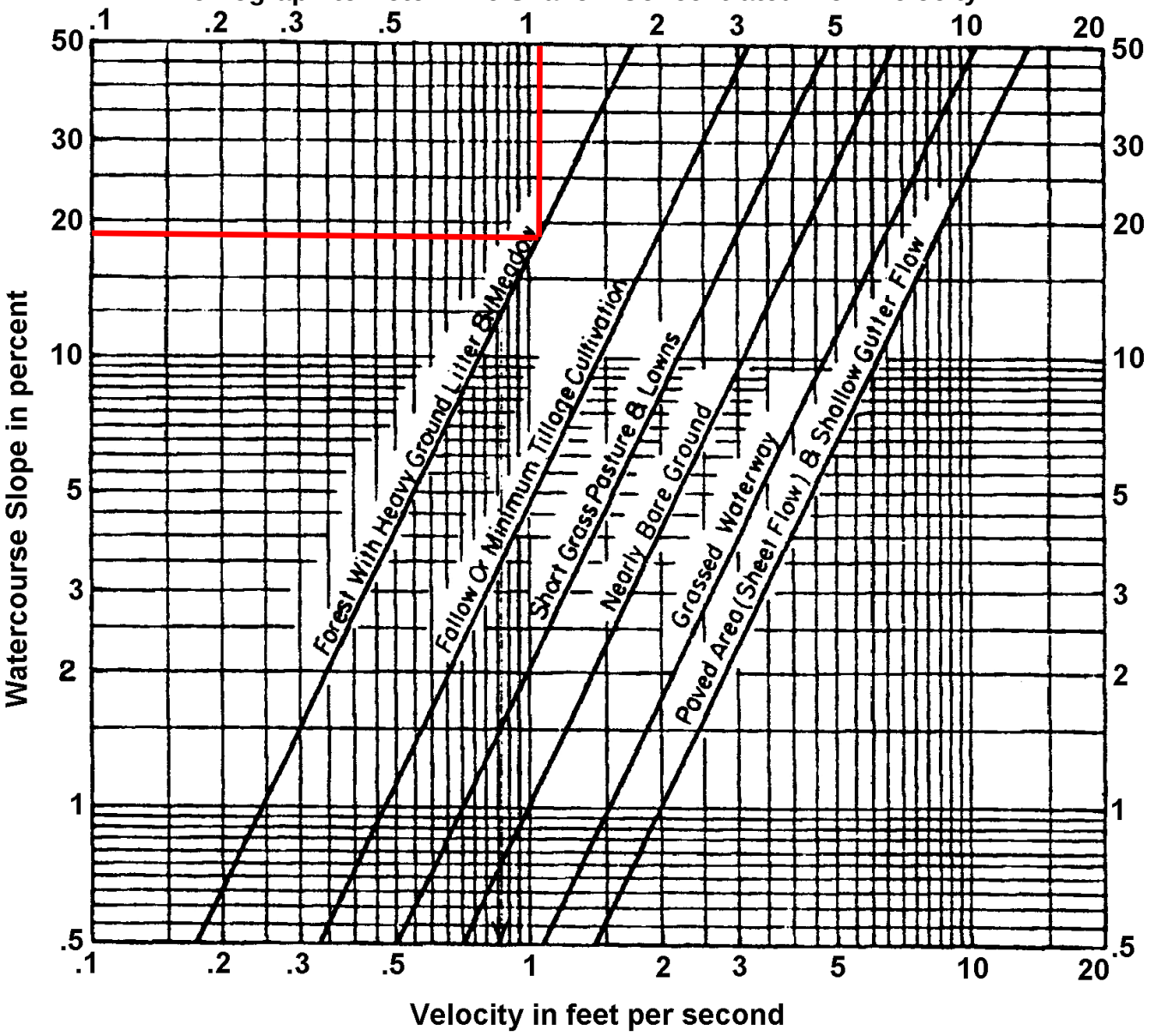
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.95_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

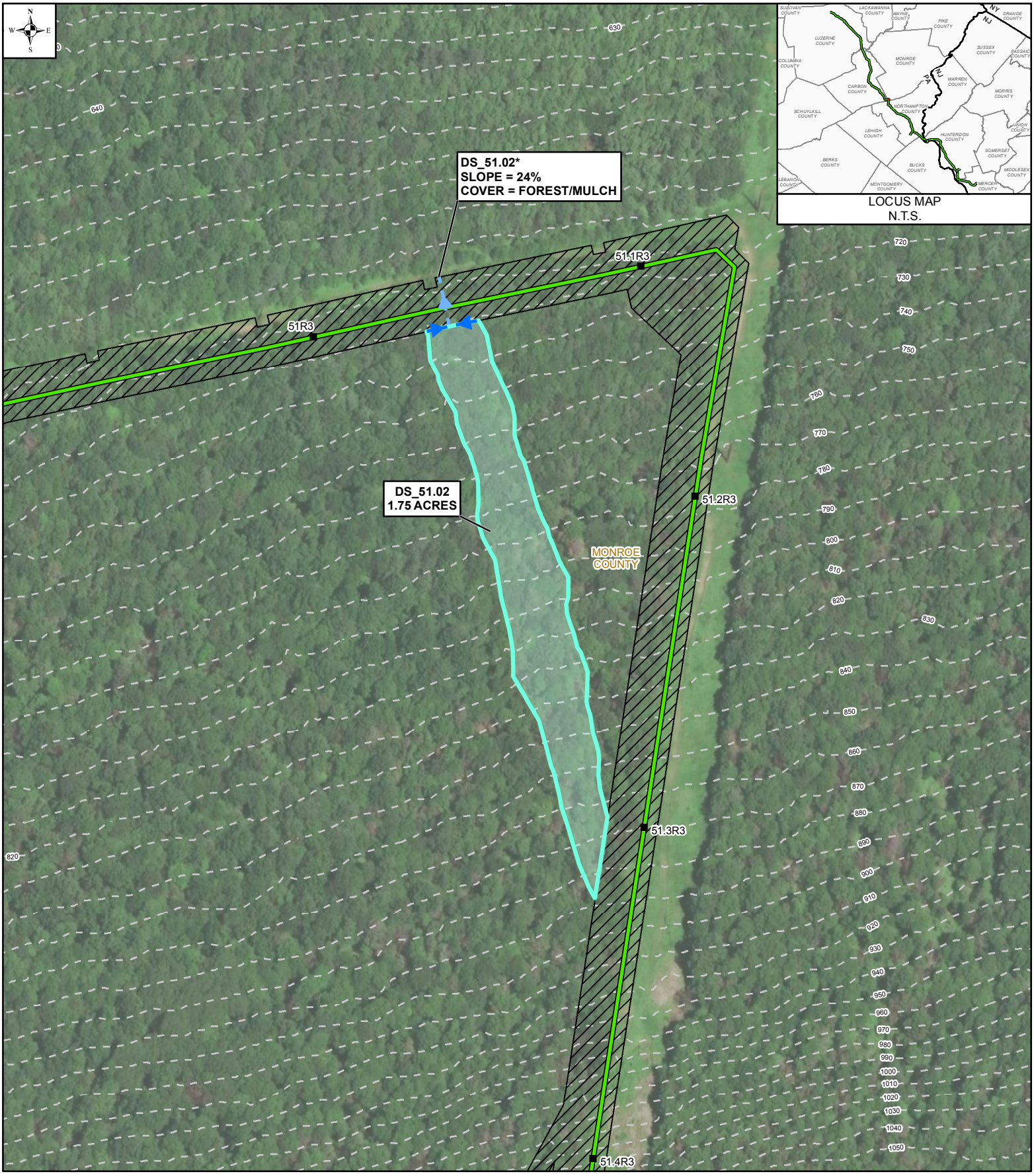


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 19%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_51.02

MONROE COUNTY, PENNSYLVANIA

0 100 200 FEET

PennEast PIPELINE

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 200 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

DWG NO: PAGE 67 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_51.02	100	0.8	0.200	9.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_51.02	844	FOREST	0.170	1.04	13.56

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
22.90

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_51.02	1	FOREST	0.20	1.75	0.35	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	22.90	2.66	3.22	3.70	2.66	3.22	3.70

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.22	1.75	0.93	1.13	1.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_51.02		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.75		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.13		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.32		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.86		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.44		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.49 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.49		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.25		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.81		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.014		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.5		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

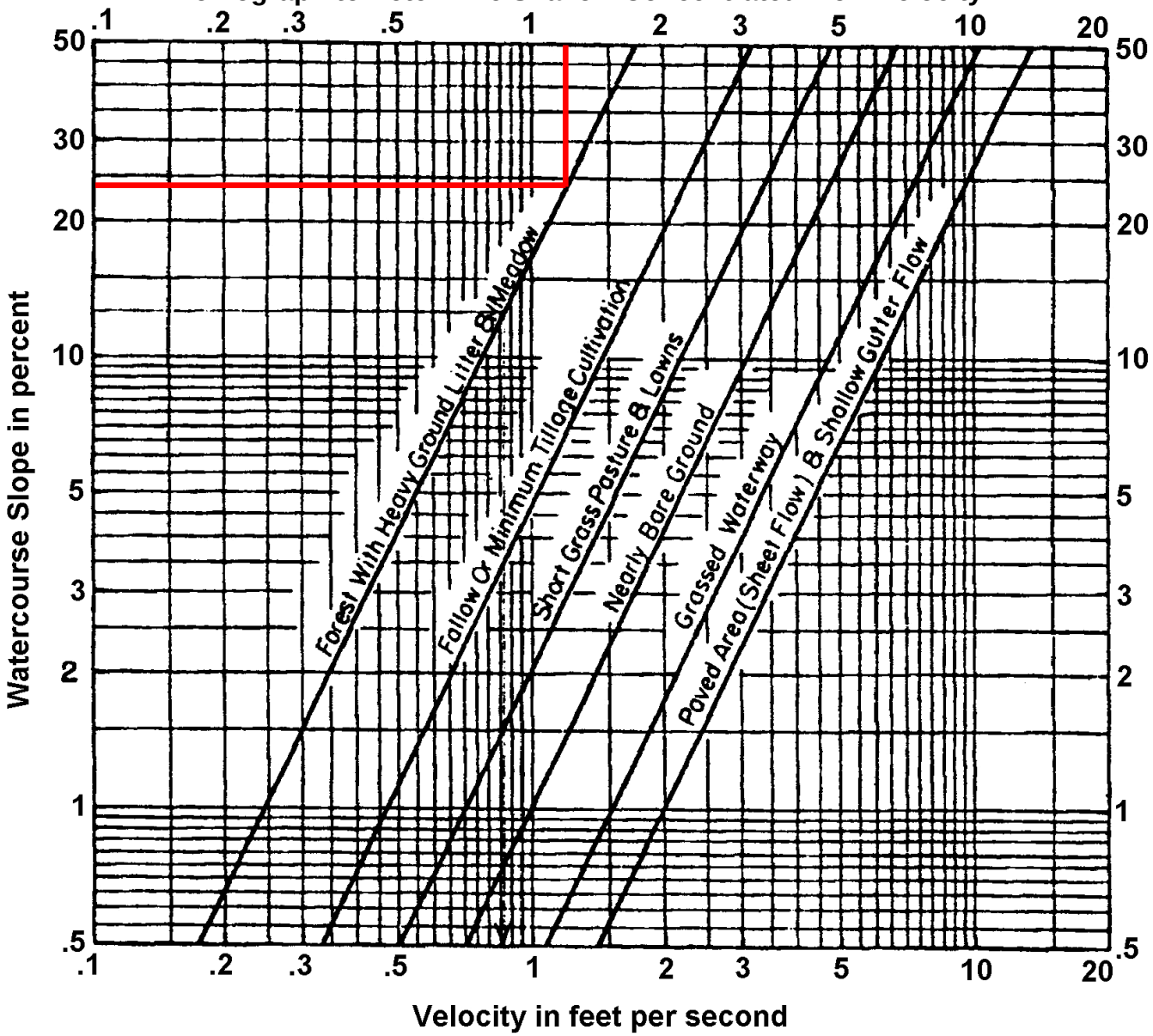
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_51.02

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

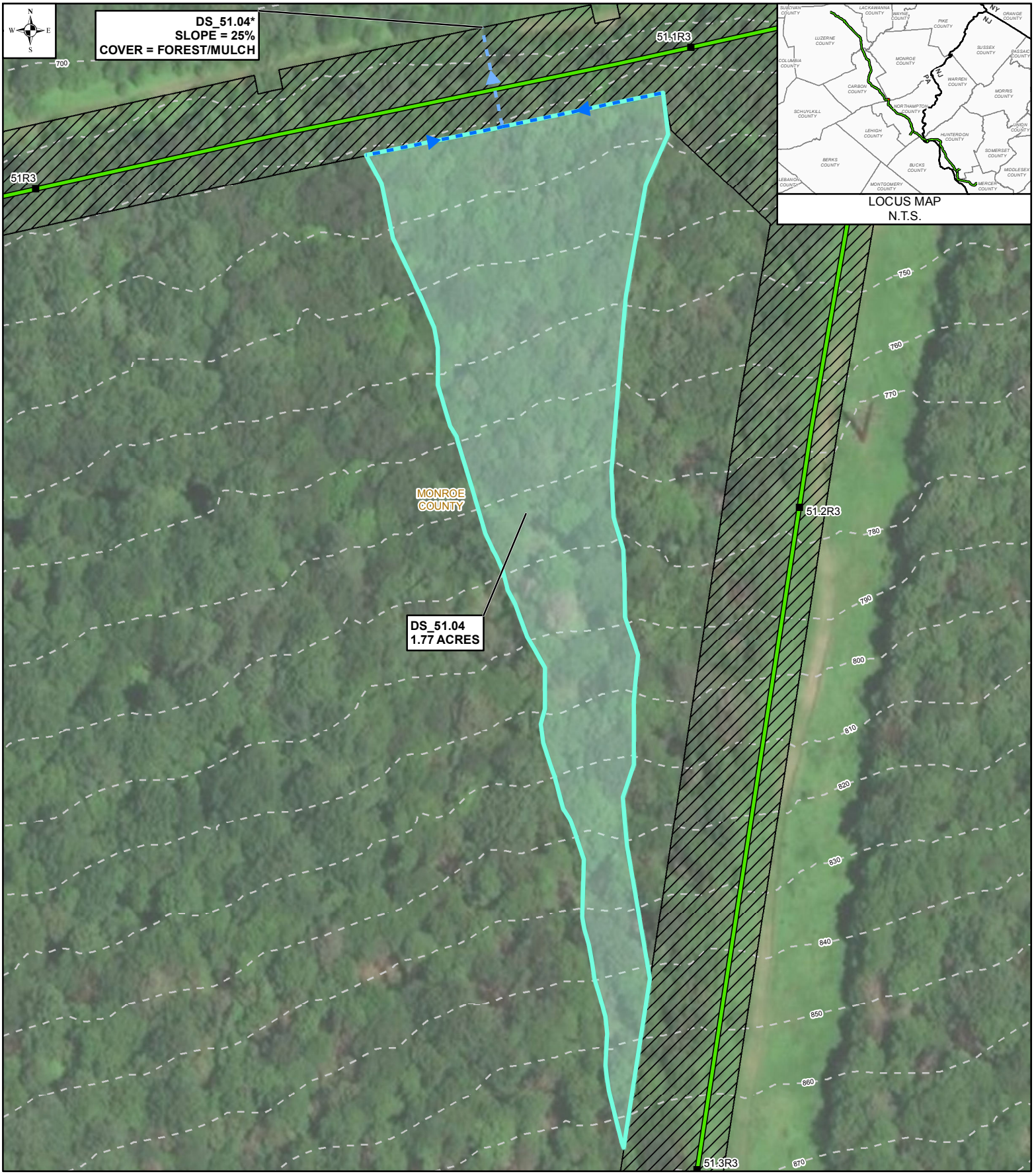


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 24%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.3 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.3 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_51.04

MONROE COUNTY, PENNSYLVANIA

0 50 100 FEET

PennEast PIPELINE

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 100 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

DWG NO: PAGE 68 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 51.04	100	0.8	0.190	9.45

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 51.04	720	FOREST	0.180	1.07	11.24

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
20.69

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: MONROE COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 51.04	1	FOREST	0.20	1.77	0.35	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	20.69	2.81	3.40	3.89	2.81	3.40	3.89

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.40	1.77	1.00	1.20	1.38

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: MONROE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_51.04		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.77		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.2		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.65		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.38		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.56 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.56		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.78		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.69		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

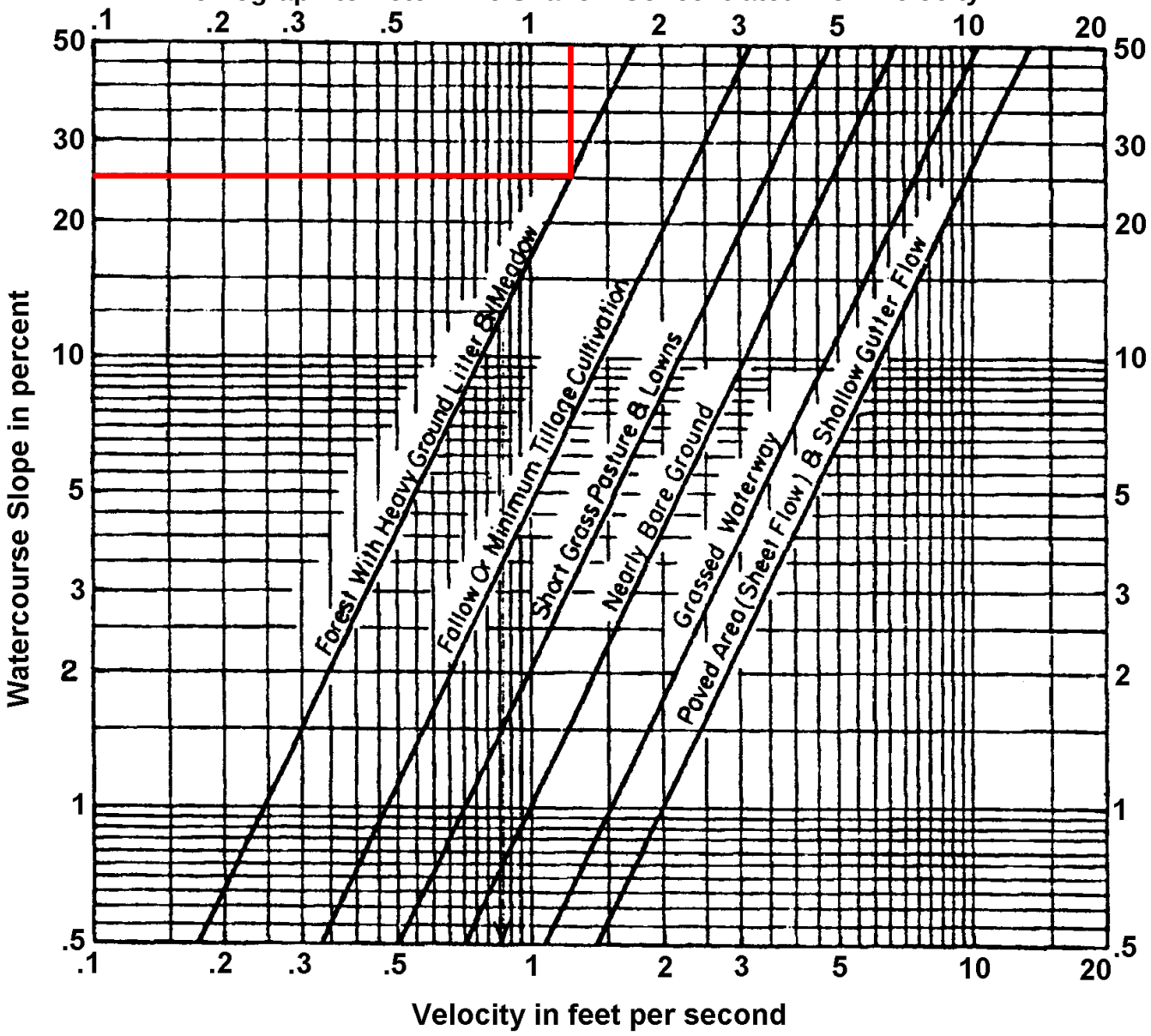
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_51.04

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 25%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.3 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.3 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.