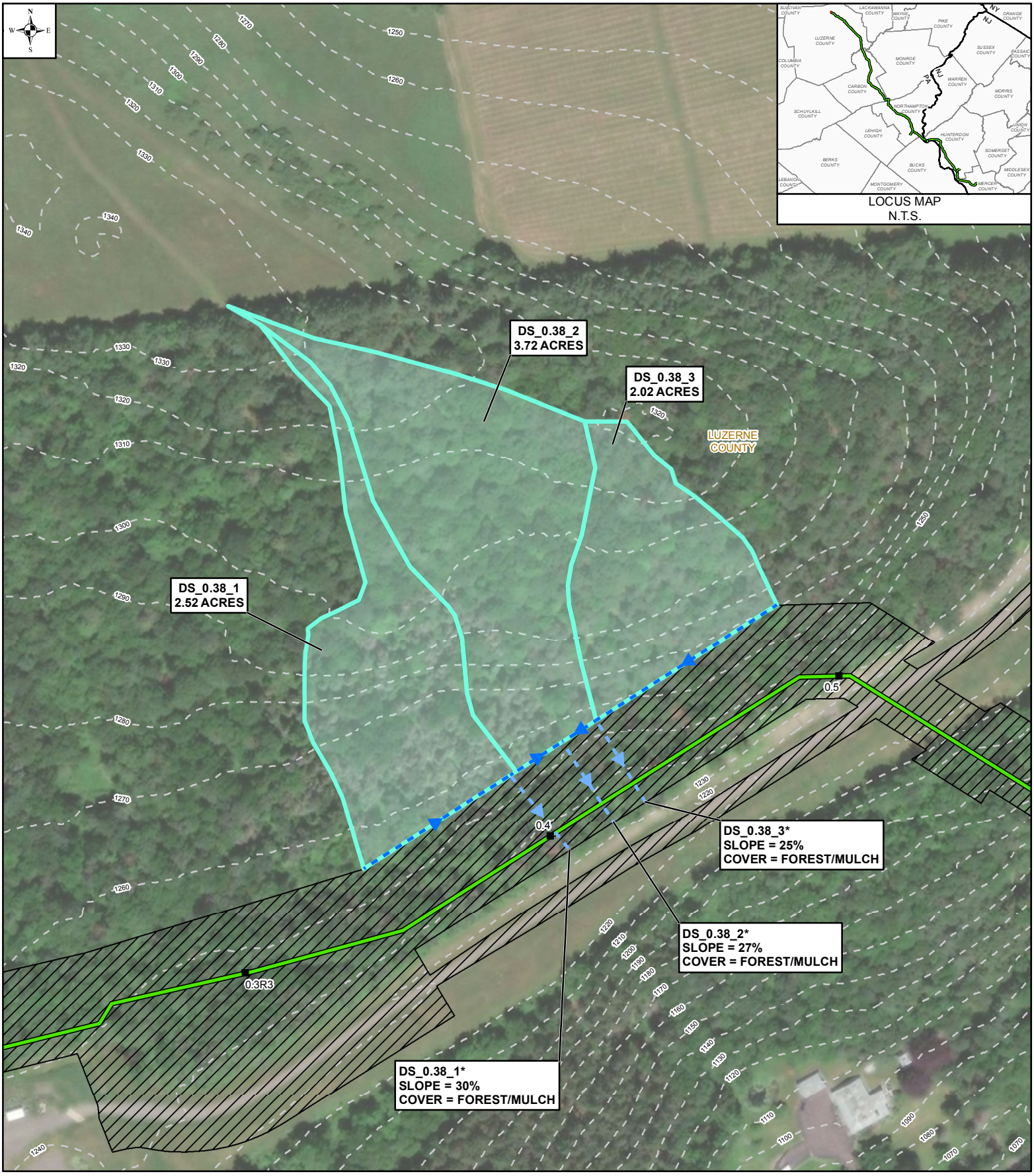
Appendix 2A
Luzerne County



LOCUS MAP
N.T.S.

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_0.38

LUZERNE COUNTY, PENNSYLVANIA

0 100 200 FEET

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

PennEast PIPELINE

DWG NO: PAGE 1 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_1
2.52 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 0.38_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 0.38_1	874	FOREST	0.084	0.73	19.98

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)
32.89

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: LUZERNE 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 0.38_1	1	FOREST	0.2	2.52	0.50	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}
	32.89	2.12	2.60	3.04	2.12	2.60	3.04

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	2.52	1.07	1.31	1.53

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_0.38_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2.52		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.07		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.22		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.043		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.47		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
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)	6.67 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.67		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.33		
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)	0.014		
S_C (CRITICAL SLOPE)	(FT/FT)	0.052		
$.7S_c$	(FT/FT)	0.037		
$1.3S_c$	(FT/FT)	0.068		
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		

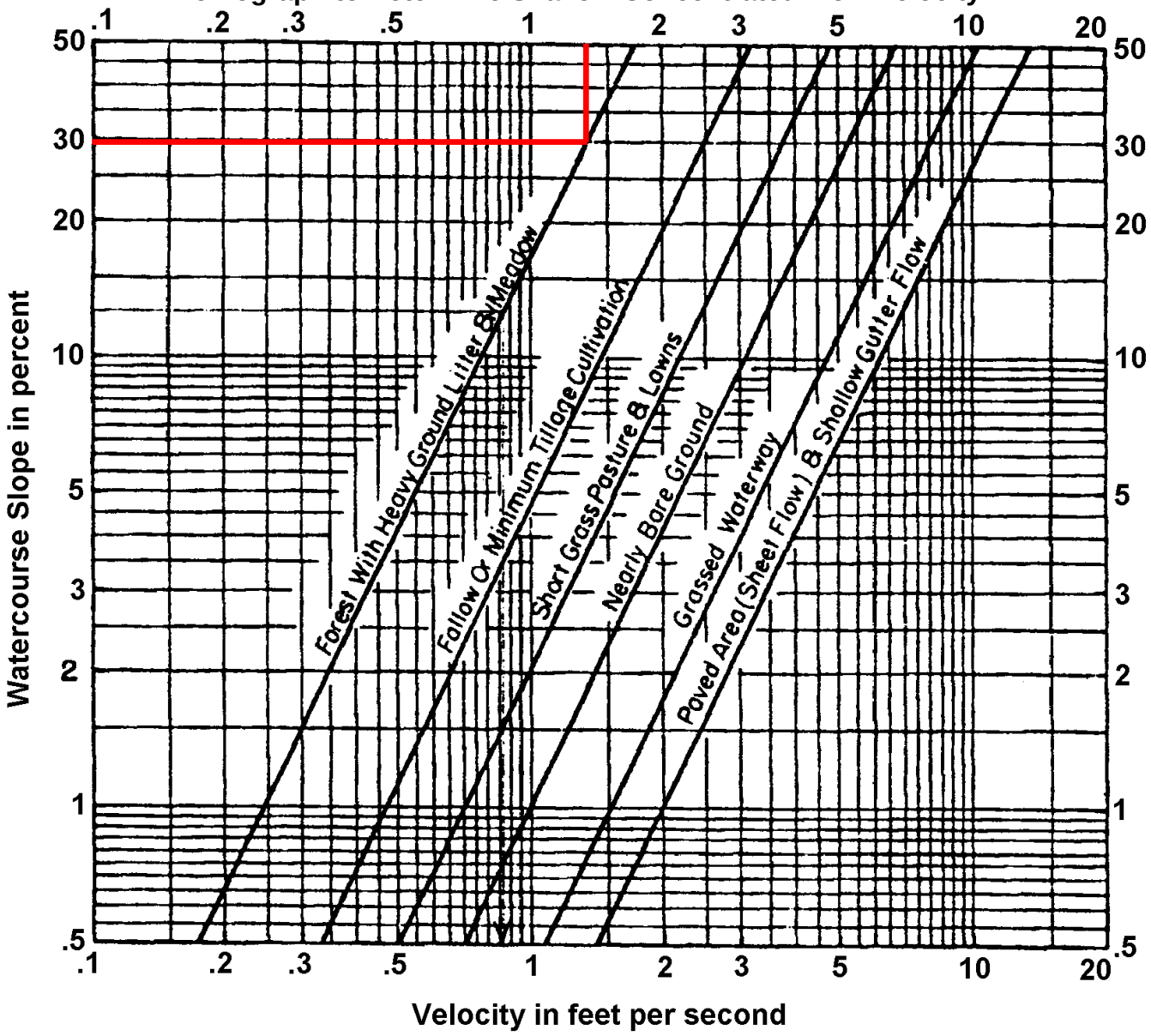
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_0.38_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 = 30%

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.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_2
3.72 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 0.38_2	100	0.8	0.040	13.60

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

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 0.38_2	975	FOREST	0.078	0.70	23.13

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)
36.73

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: LUZERNE 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 0.38_2	1	FOREST	0.2	3.72	0.74	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}
	36.73	1.97	2.42	2.85	1.97	2.42	2.85

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	1.97	3.72	1.47	1.80	2.12

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_0.38_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	3.72		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.47		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.93		
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)	4.44		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.29 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.29		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.65		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.66		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.084		
S_C (CRITICAL SLOPE)	(FT/FT)	0.034		
$.7S_c$	(FT/FT)	0.024		
$1.3S_c$	(FT/FT)	0.045		
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		

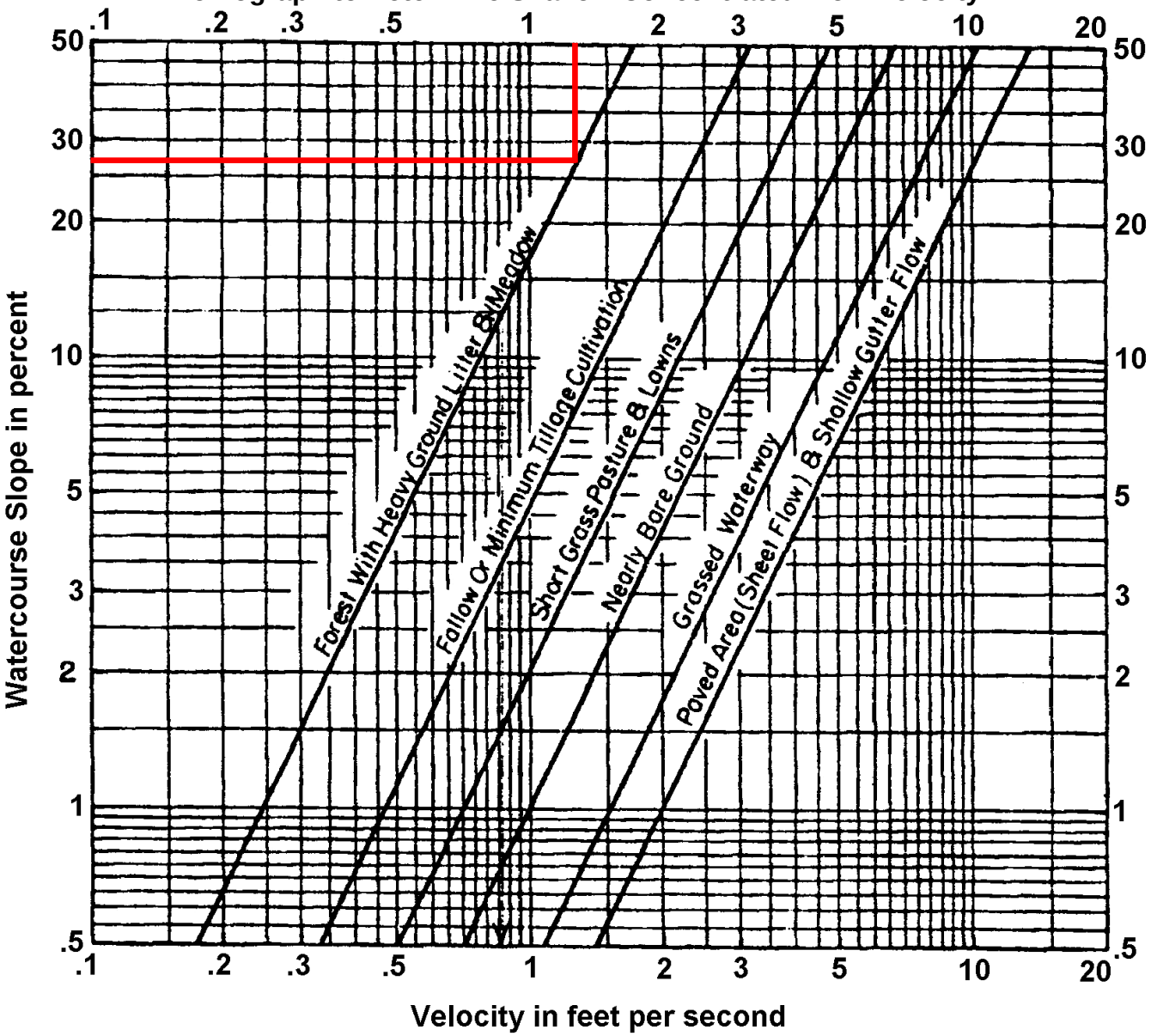
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_0.38_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 = 27%

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.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_3
2.02 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 0.38_3	100	0.8	0.090	11.26

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

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 0.38_3	384	FOREST	0.146	0.96	6.66

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)
17.91

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: LUZERNE 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 0.38_3	1	FOREST	0.2	2.02	0.40	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}
	17.91	3.04	3.66	4.16	3.04	3.66	4.16

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	3.04	2.02	1.23	1.48	1.68

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_0.38_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2.02		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.98		
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)	3.64		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.35 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.35		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.54		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.011		
$1.3S_c$	(FT/FT)	0.020		
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		

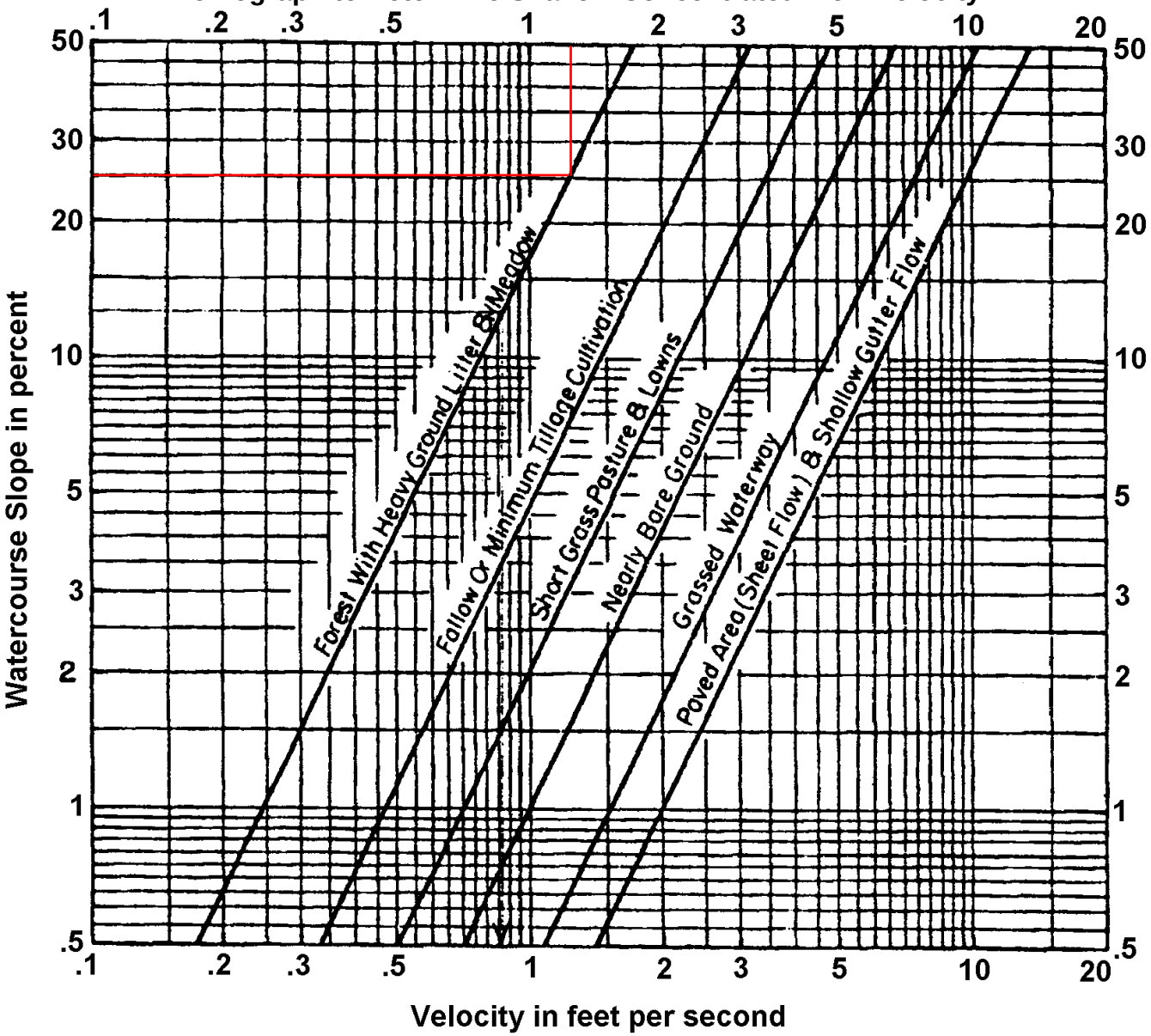
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_0.38_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

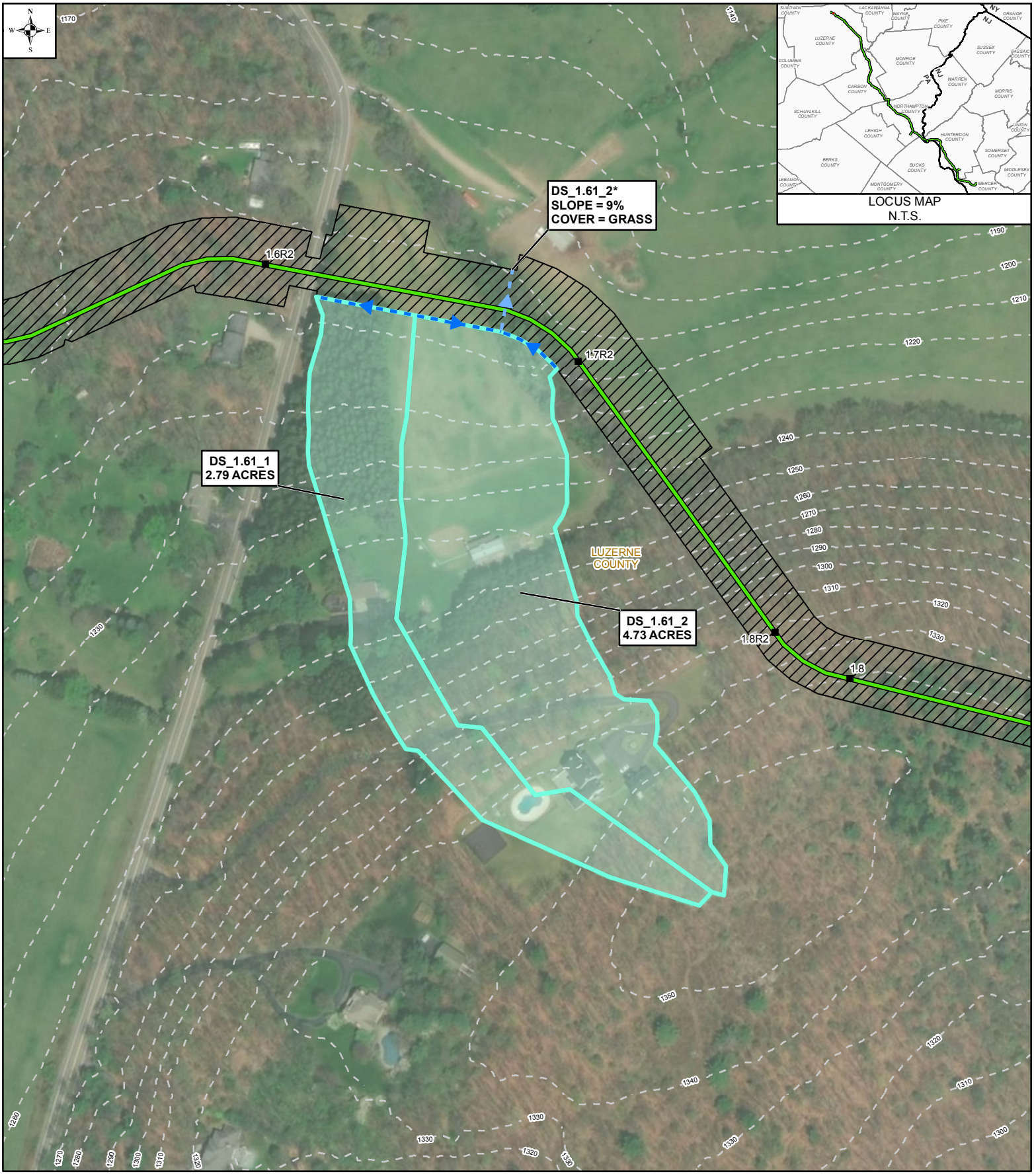


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 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.



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_1.61

LUZERNE COUNTY, PENNSYLVANIA

0 100 200 FEET

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

PennEast PIPELINE

DWG NO: PAGE 2 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_1.61_1
2.79 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 1.61_1	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 1.61_1	100	FOREST	0.107	0.82	2.03
	194	SHORT GRASS	0.062	1.73	1.87
	892	FOREST	0.236	1.22	12.16

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)
28.43

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: LUZERNE 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 1.61_1	1	OPEN SPACE	0.28	0.78	0.22	0.25
	2	INDUSTRIAL	0.69	0.18	0.12	
	3	FOREST	0.20	1.83	0.37	

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}
	28.43	2.33	2.85	3.31	2.33	2.85	3.31

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)
	0.25	2.33	2.79	1.65	2.02	2.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_1.61_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2.79		
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)	2.94		
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)	2.82		
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)	8.33 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.04		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.013		
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_1.61_2
4.7 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 1.61_2	100	0.4	0.138	7.37

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

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 1.61_2	108	FOREST	0.120	0.87	2.07
	62	SHORT GRASS	0.097	2.17	0.48
	108	PAVEMENT	0.046	4.36	0.41
	342	FOREST	0.210	1.15	4.94
	480	SHORT GRASS	0.102	2.22	3.60

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)
18.86

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: LUZERNE 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 1.61_2	1	PASTURE	0.50	2.30	1.15	0.38
	2	INDUSTRIAL	0.69	0.29	0.20	
	3	FOREST	0.20	2.11	0.42	

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}
	18.86	2.96	3.57	4.06	2.96	3.57	4.06

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)
	0.38	2.96	4.70	5.24	6.32	7.20

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_1.61_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	4.7		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	5.24		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	7.21		
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)	4.27		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.87		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	13.51 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	13.51		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.69		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.028		
S_C (CRITICAL SLOPE)	(FT/FT)	0.012		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.016		
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		

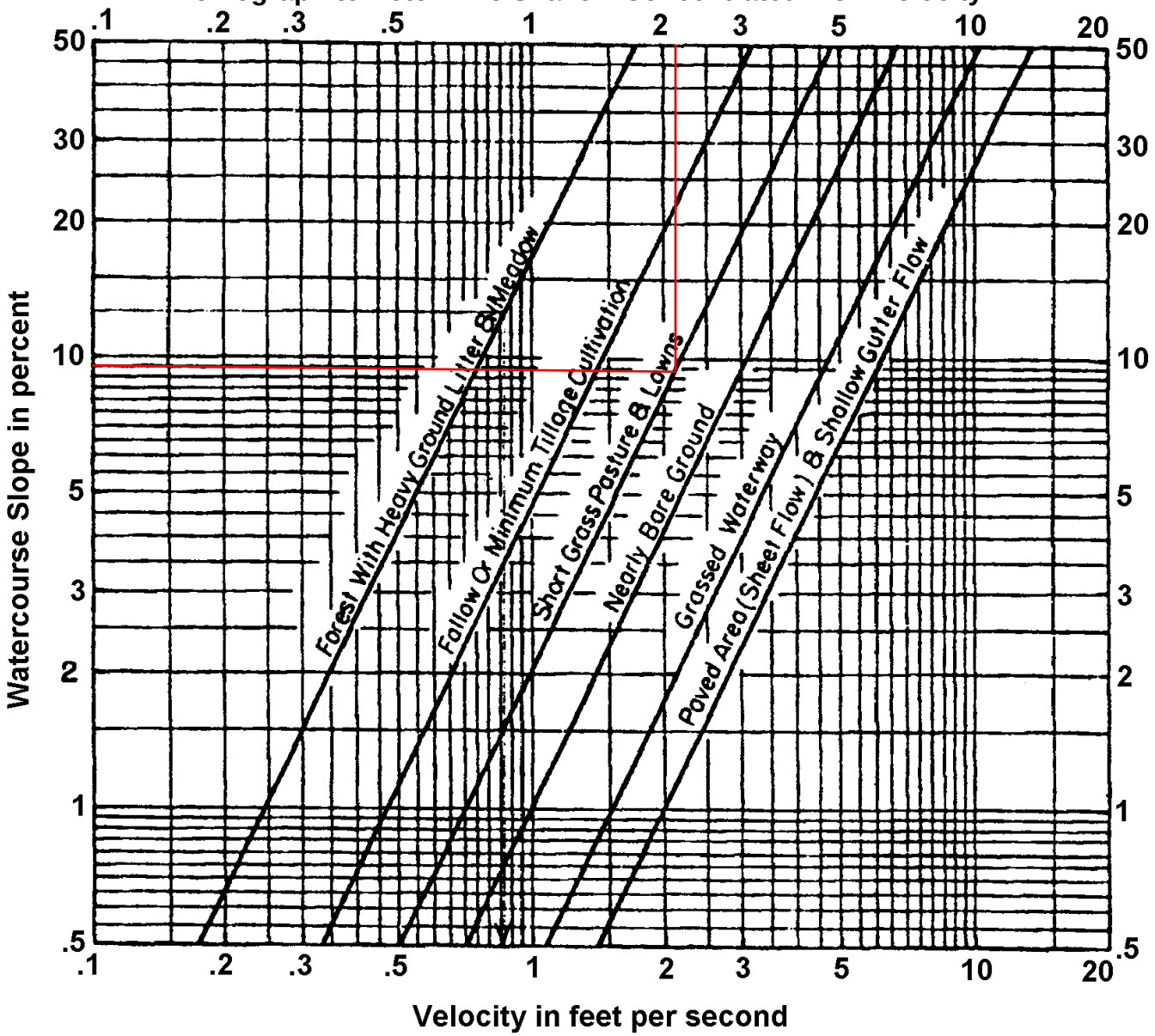
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_1.61_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

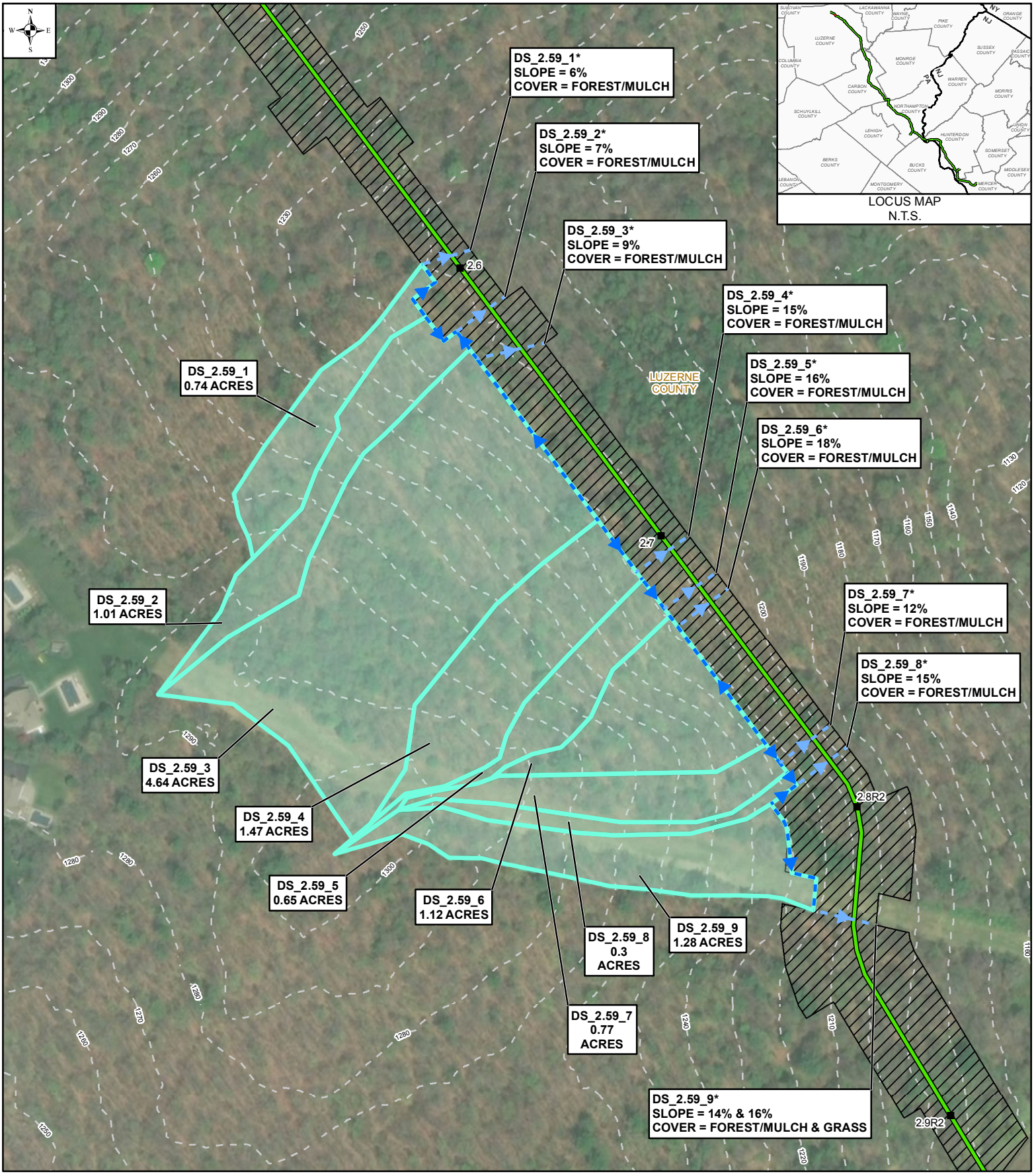


TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 9%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.1 FPS < 4.0 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_2.59

LUZERNE COUNTY, PENNSYLVANIA

0 100 200 FEET

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

PennEast PIPELINE

DWG NO: PAGE 3 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_2.59_1
0.74 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_1	100	0.8	0.160	9.84

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

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 2.59_1	478	FOREST	0.123	0.88	9.03

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)
18.87

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: LUZERNE 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 2.59_1	1	FOREST	0.20	0.74	0.15	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}
	18.87	2.96	3.56	4.06	2.96	3.56	4.06

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	2.96	0.74	0.44	0.53	0.60

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.74		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.437		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.06		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.70		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.2 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	12.20		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.10		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.52		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.165		
$.7S_c$	(FT/FT)	0.115		
$1.3S_c$	(FT/FT)	0.214		
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		

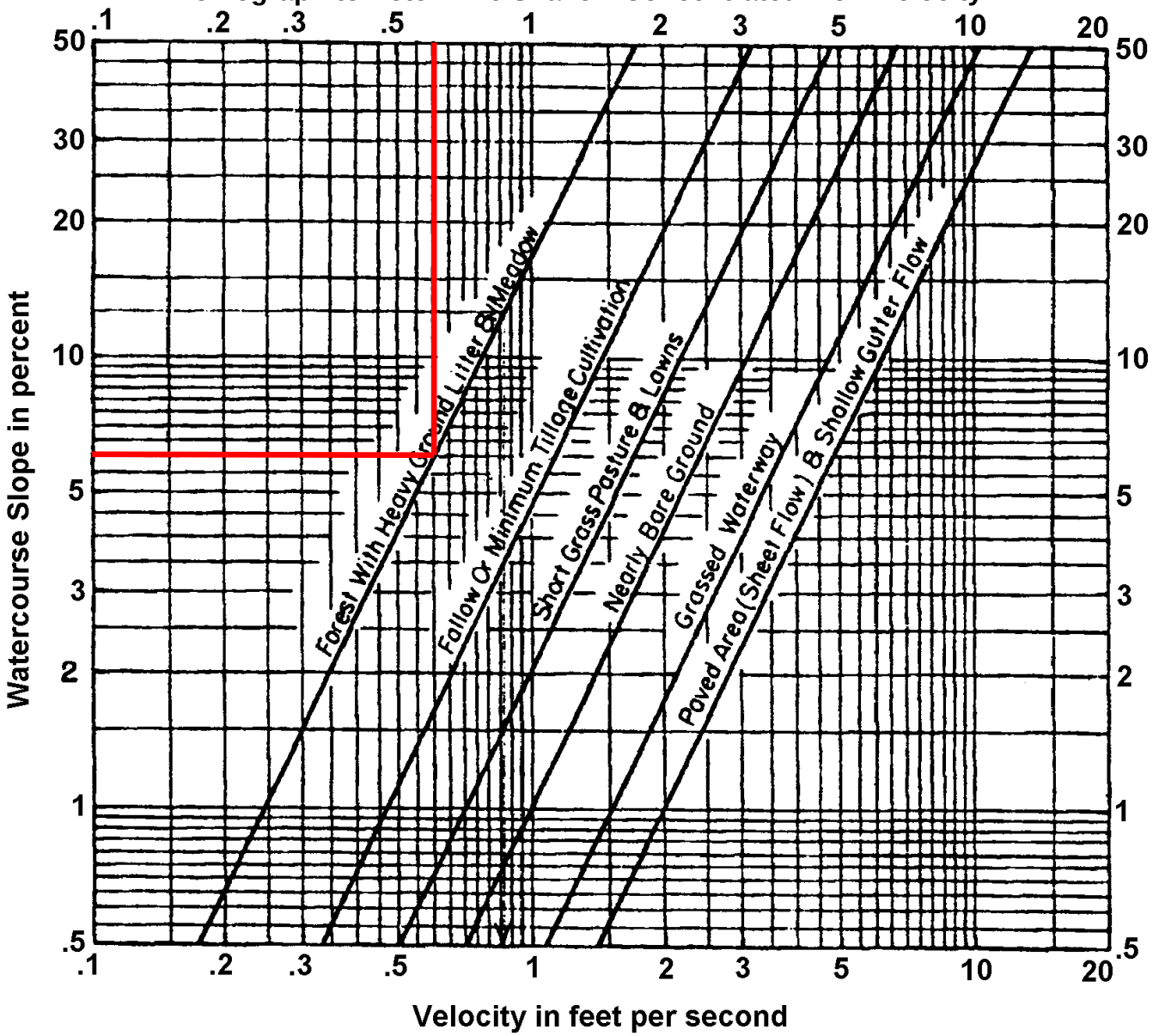
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = 6%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_2.59_2
1.01 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_2	100	0.8	0.030	14.55

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

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 2.59_2	653	FOREST	0.120	0.87	12.49

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)
27.04

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: LUZERNE 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 2.59_2	1	OPEN SPACE	0.21	0.02	0.00	0.20
	2	FOREST	0.20	0.99	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}
	27.04	2.41	2.93	3.40	2.41	2.93	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	2.41	1.01	0.49	0.59	0.69

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.01		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.487		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.71		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.68		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.33 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.04		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.174		
$.7S_c$	(FT/FT)	0.121		
$1.3S_c$	(FT/FT)	0.226		
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		

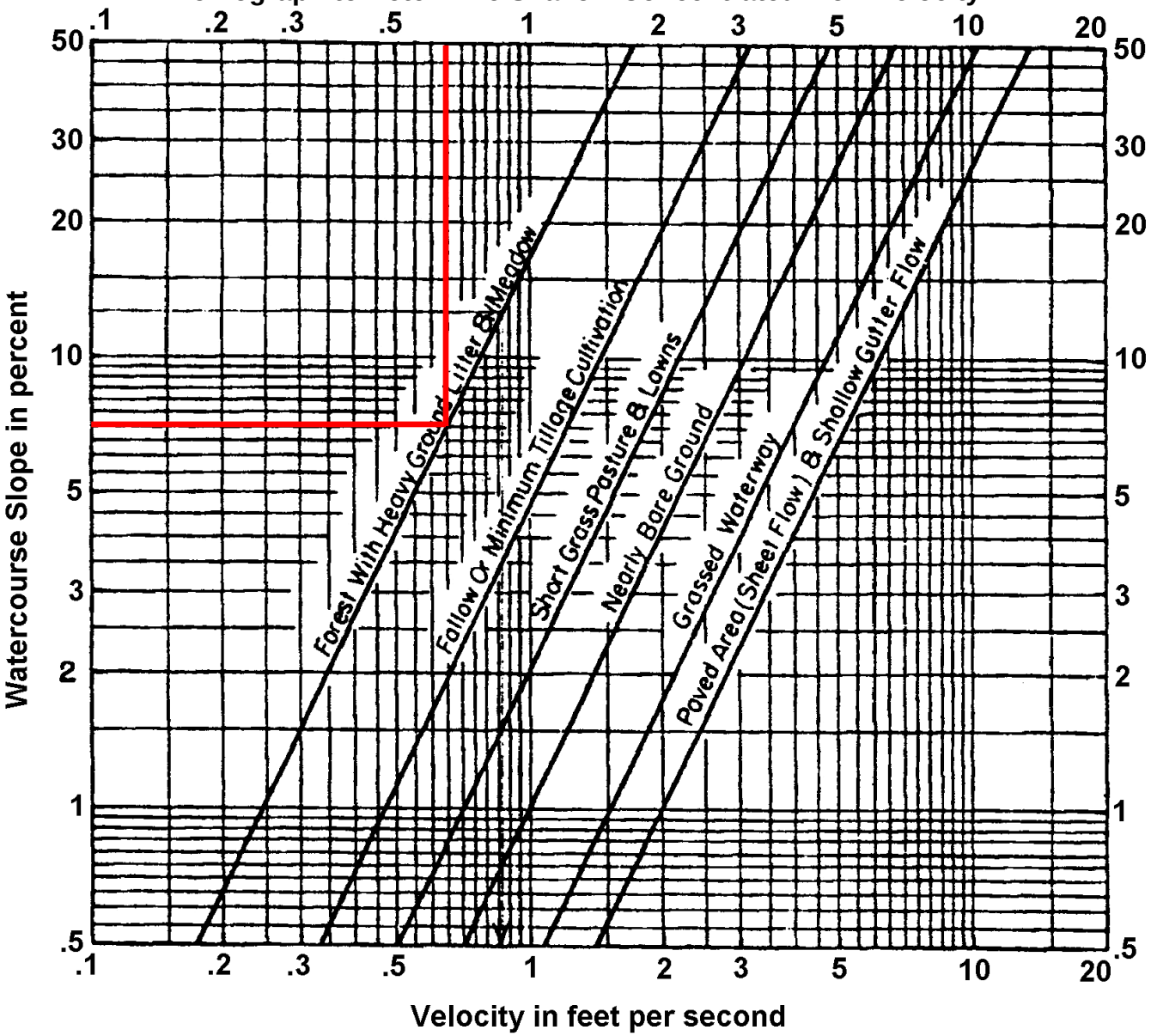
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_2.59_3
4.64 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_3	100	0.8	0.030	14.55

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

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 2.59_3	653	FOREST	0.120	0.87	12.49

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)
27.04

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: LUZERNE 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 2.59_3	1	FOREST	0.20	4.10	0.82	0.20
	2	OPEN SPACE	0.21	0.54	0.11	

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}
	27.04	2.41	2.93	3.40	2.41	2.93	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	2.41	4.64	2.25	2.74	3.17

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	4.64		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.25		
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)	4.14		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.97		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.08 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.08		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.54		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.63		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.031		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
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		

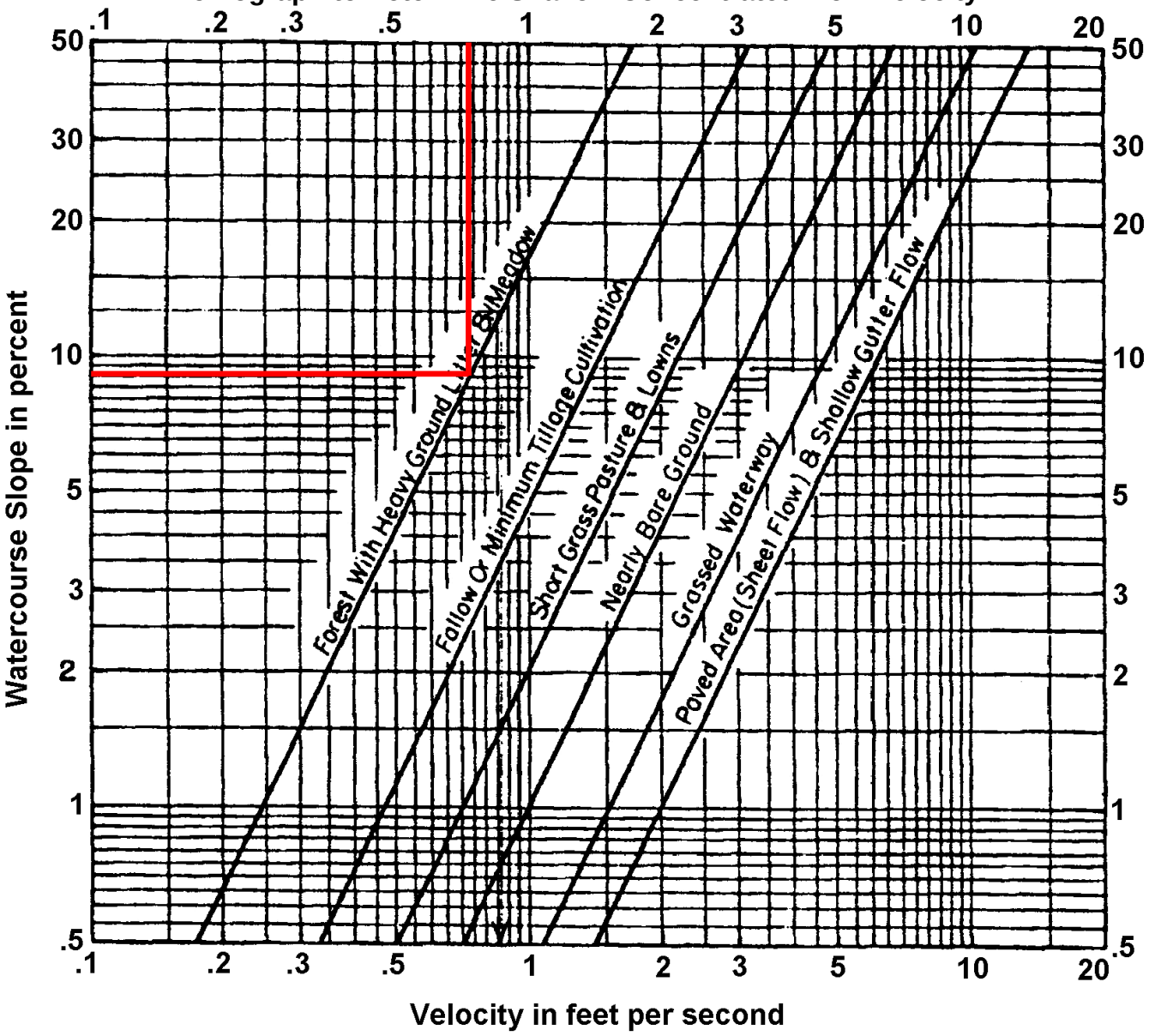
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = 9%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_2.59_4
1.47 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_4	100	0.8	0.040	13.60

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

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 2.59_4	498	FOREST	0.163	1.02	8.17

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)
21.77

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: LUZERNE 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 2.59_4	1	FOREST	0.20	1.39	0.28	0.30
	2	OPEN SPACE	0.21	0.80	0.17	

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}
	21.77	2.73	3.31	3.80	2.73	3.31	3.80

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)
	0.30	2.73	1.47	1.22	1.48	1.69

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.47		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.22		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.60		
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)	4.31		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.06		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.83 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.83		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.42		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.60		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.034		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
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		

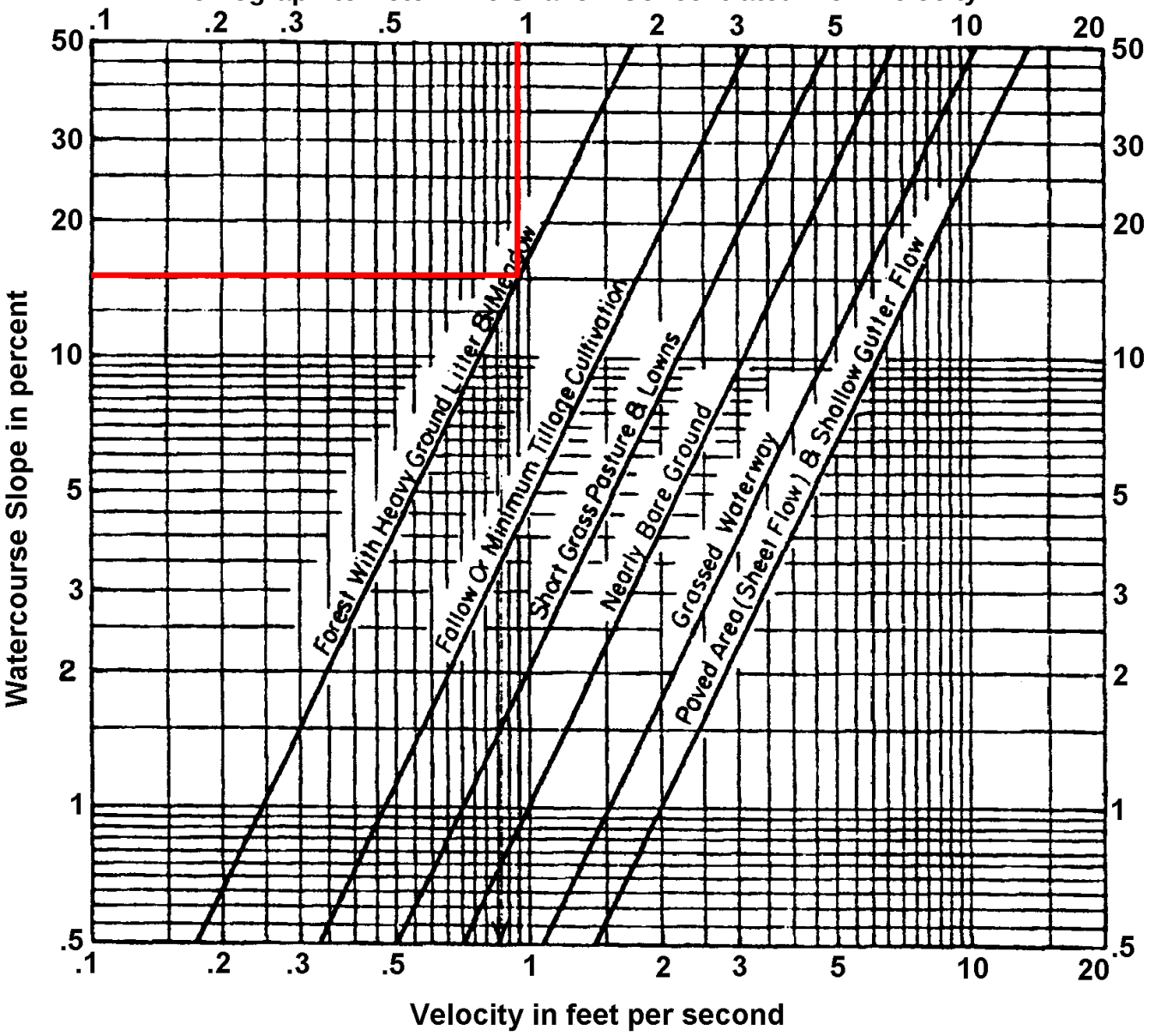
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = 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_2.59_5
0.65 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_5	100	0.8	0.030	14.55

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

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 2.59_5	160	PASTURE	0.056	1.65	1.62
	417	FOREST	0.182	1.07	6.47

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)
22.64

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: LUZERNE 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 2.59_5	1	FOREST	0.20	0.63	0.13	0.21
	2	PASTURE	0.40	0.02	0.01	

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}
	22.64	2.67	3.24	3.72	2.67	3.24	3.72

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)
	0.21	2.67	0.65	0.36	0.43	0.50

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.65		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.36		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.78		
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)	1.22		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.1 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.10		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.55		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.64		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.108		
$.7S_c$	(FT/FT)	0.076		
$1.3S_c$	(FT/FT)	0.140		
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		

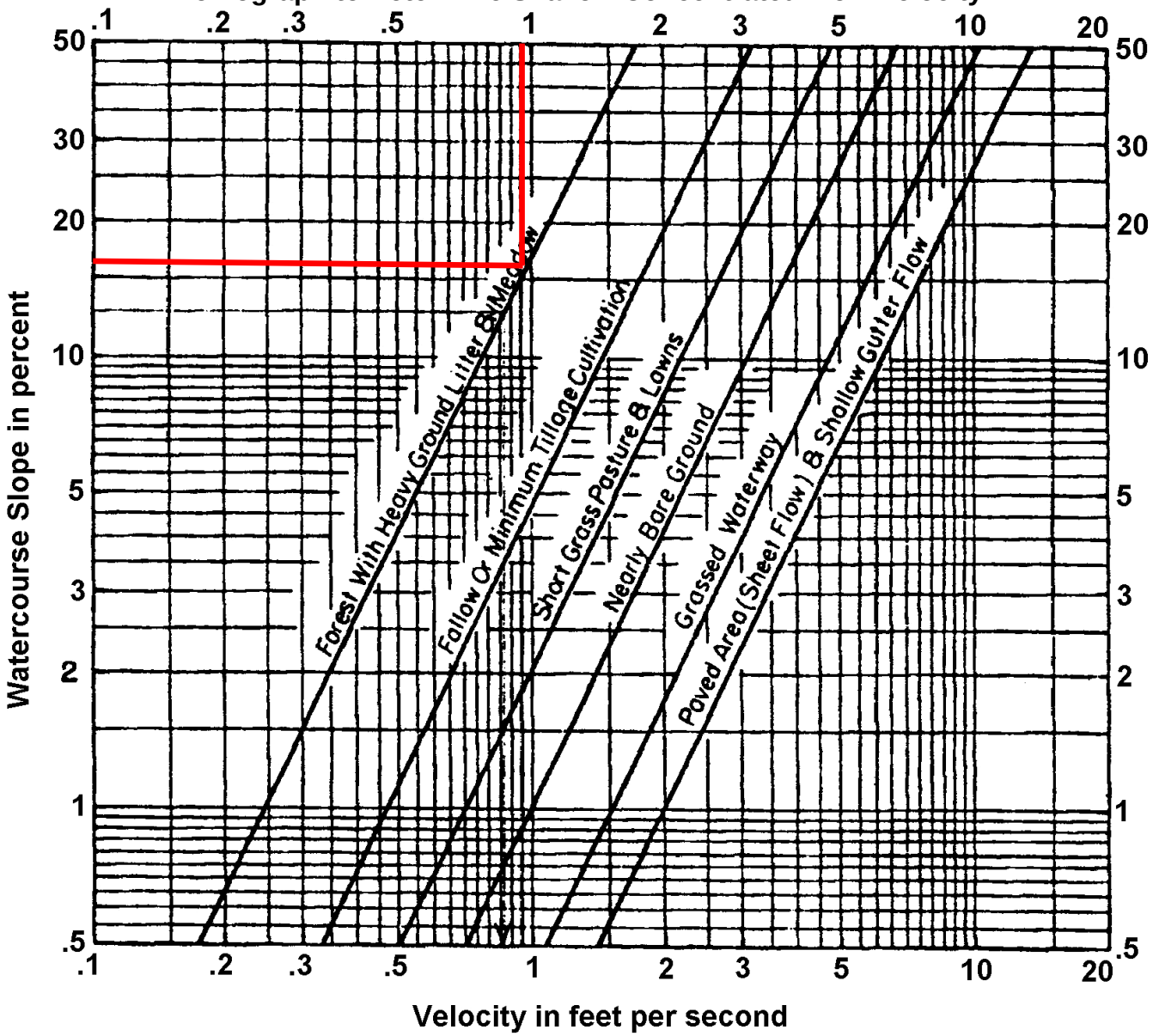
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = 16%

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_2.59_6
1.12 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_6	100	0.8	0.100	10.98

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

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 2.59_6	344	FOREST	0.172	1.04	5.49

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)
16.48

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: LUZERNE 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 2.59_6	1	FOREST	0.20	1.12	0.22	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}
	16.48	3.17	3.81	4.31	3.17	3.81	4.31

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	3.17	1.12	0.71	0.85	0.96

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.12		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.71		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.32		
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)	3.59		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.87		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	2.94 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	2.94		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.47		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.37		
R (HYDRAULIC RADIUS)		0.18		
S (BED SLOPE)[3, 7]	(FT/FT)	0.028		
S_C (CRITICAL SLOPE)	(FT/FT)	0.017		
$.7S_c$	(FT/FT)	0.012		
$1.3S_c$	(FT/FT)	0.023		
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		

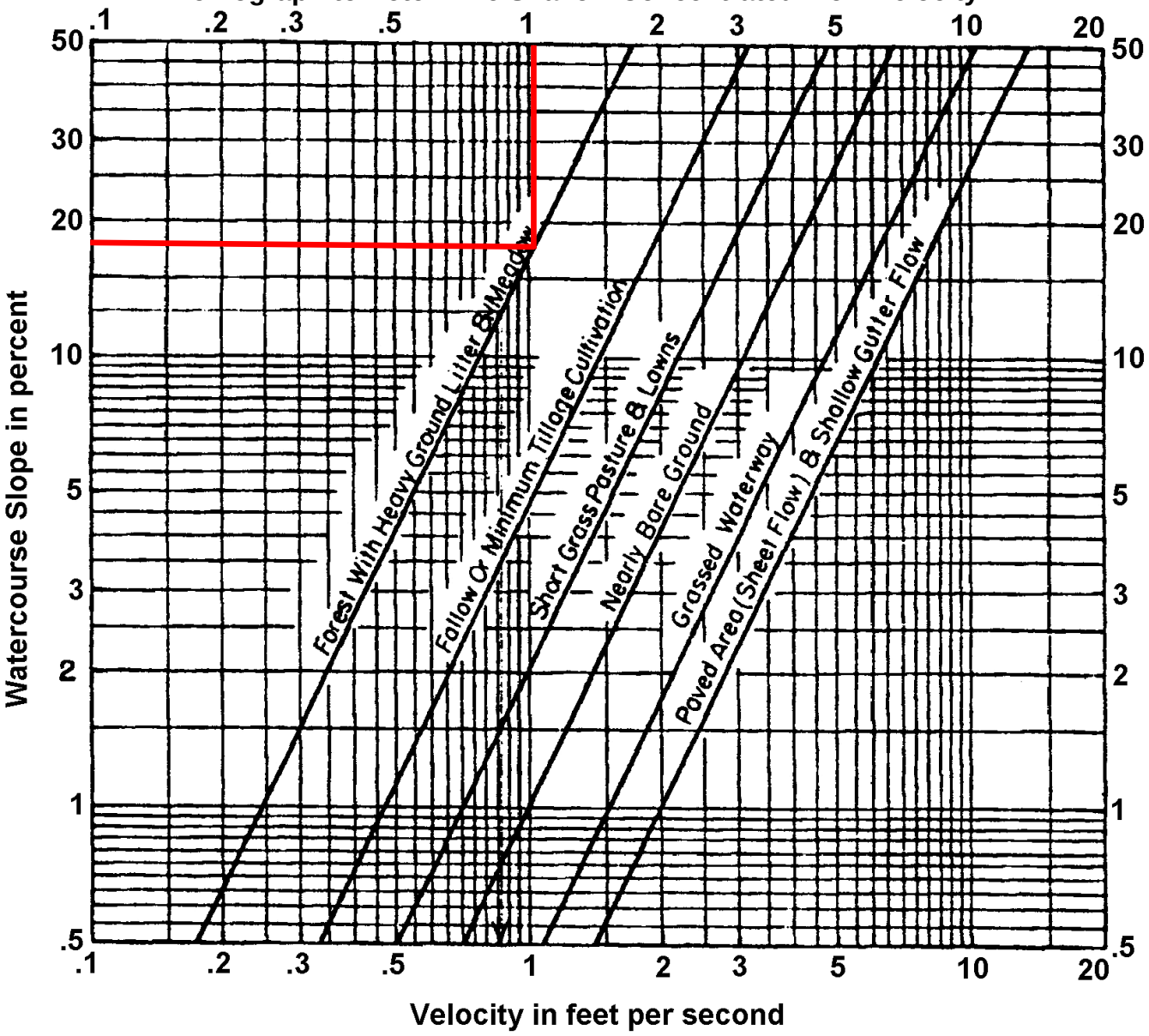
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = 18%

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_2.59_7
0.77 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_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 2.59_7	255	SHORT GRASS	0.106	2.27	1.88
	284	FOREST	0.158	1.00	4.73

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)
19.52

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: LUZERNE 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 2.59_7	1	FOREST	0.20	0.64	0.13	0.21
	2	OPEN SPACE	0.28	0.13	0.04	

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}
	19.52	2.90	3.50	4.00	2.90	3.50	4.00

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)
	0.21	2.90	0.77	0.48	0.58	0.66

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.77		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.50		
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)	1.10		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.64 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.64		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.82		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.45		
R (HYDRAULIC RADIUS)		0.19		
S (BED SLOPE)[3, 7]	(FT/FT)	0.018		
S_C (CRITICAL SLOPE)	(FT/FT)	0.120		
$.7S_c$	(FT/FT)	0.084		
$1.3S_c$	(FT/FT)	0.155		
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		

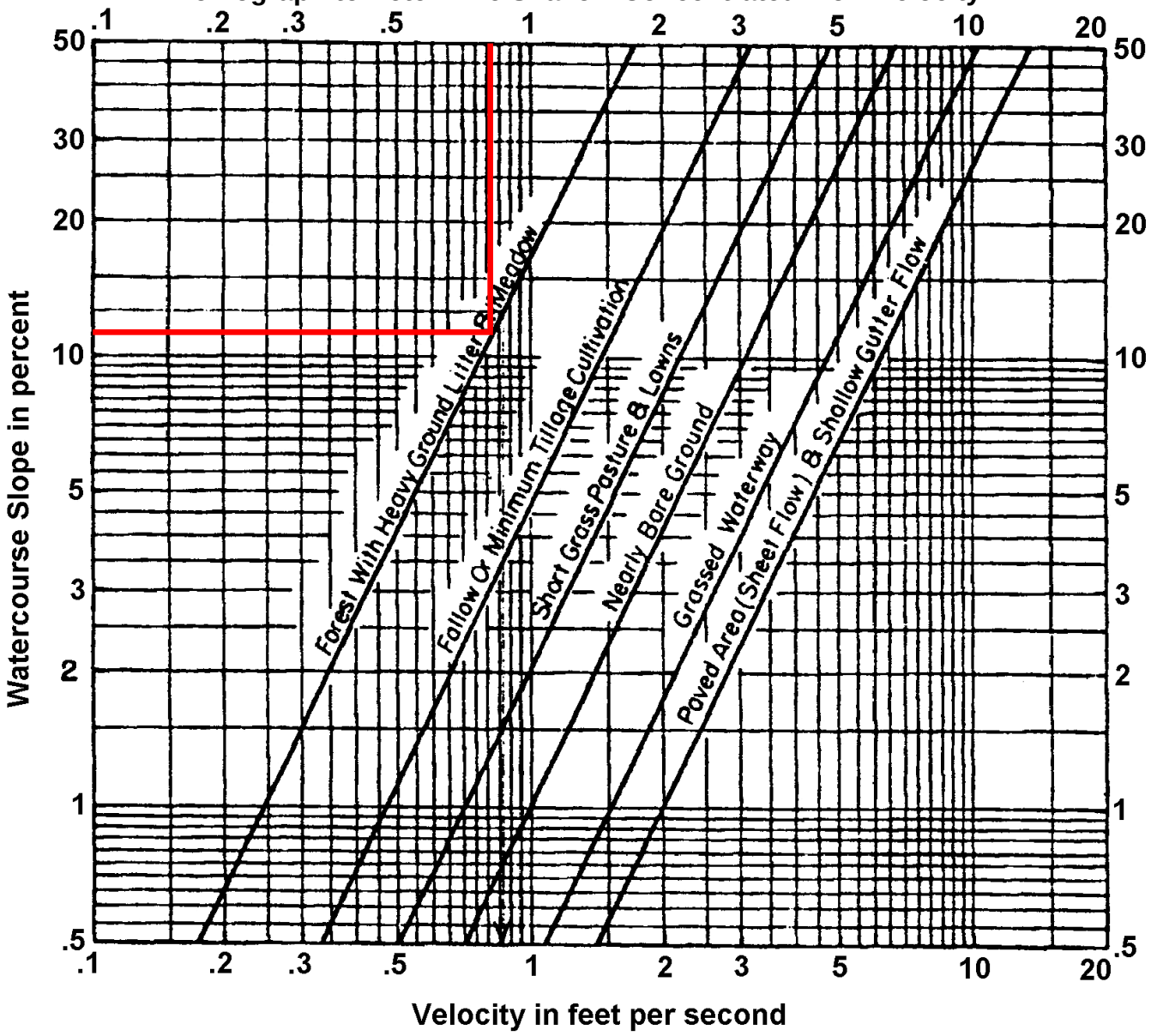
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = 12%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_2.59_8
0.3 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_8	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 2.59_8	287	SHORT GRASS	0.110	2.31	2.07
	254	FOREST	0.158	1.00	4.23

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)
19.22

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: LUZERNE 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 2.59_8	1	FOREST	0.20	0.12	0.02	0.25
	2	OPEN SPACE	0.28	0.18	0.05	

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}
	19.22	2.93	3.53	4.03	2.93	3.53	4.03

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)
	0.25	2.93	0.30	0.22	0.26	0.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		**DS_2.59_8a**	DS_2.59_8b	
TEMPORARY OR PERMANENT?	(T OR P)	**T**	T	
DESIGN STORM	(2, 5, OR 10 YR)	**2**	2	
ACRES	(AC)	**0.3**	0.3	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	**N/A**	N/A	
Q_r (REQUIRED CAPACITY)	(CFS)	**0.22**	0.22	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	**0.22**	0.42	
PROTECTIVE LINING[2,6]		**C125**	SC150BN	
n (MANNING'S COEFFICIENT)[2]		**0.022**	0.05	
V_a (ALLOWABLE VELOCITY)	(FPS)	**N/A**	N/A	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	**3.17**	2.40	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	**2.25**	2.10	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	**0.82**	2.08	
CHANNEL BOTTOM WIDTH	(FT)	**0**	0	
CHANNEL SIDE SLOPES	(H:V)	**5 / 0**	12.5 / 0	
D (TOTAL DEPTH)	(FT)	**0.67**	0.67	
CHANNEL TOP WIDTH @ D	(FT)	**3.33**	8.33	
d (CALCULATED FLOW DEPTH)	(FT)	**0.17**	0.17	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	**0.83**	2.08	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	**0**	0	
d_{50} STONE SIZE	(IN)	**N/A**	N/A	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	**0.07**	0.17	
R (HYDRAULIC RADIUS)		**0.07**	0.08	
S (BED SLOPE)[3]	(FT/FT)	**0.079**	0.20	
S_C (CRITICAL SLOPE)	(FT/FT)	**0.021**	0.093	
$.7S_c$	(FT/FT)	**0.015**	0.065	
$1.3S_c$	(FT/FT)	**0.027**	0.121	
STABLE FLOW?	(Y/N)	**Y**	Y	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	**N/A**	N/A	
FREEBOARD BASED ON STABLE FLOW	(FT)	**0.50**	0.50	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	**0.50**	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		**S**	S	

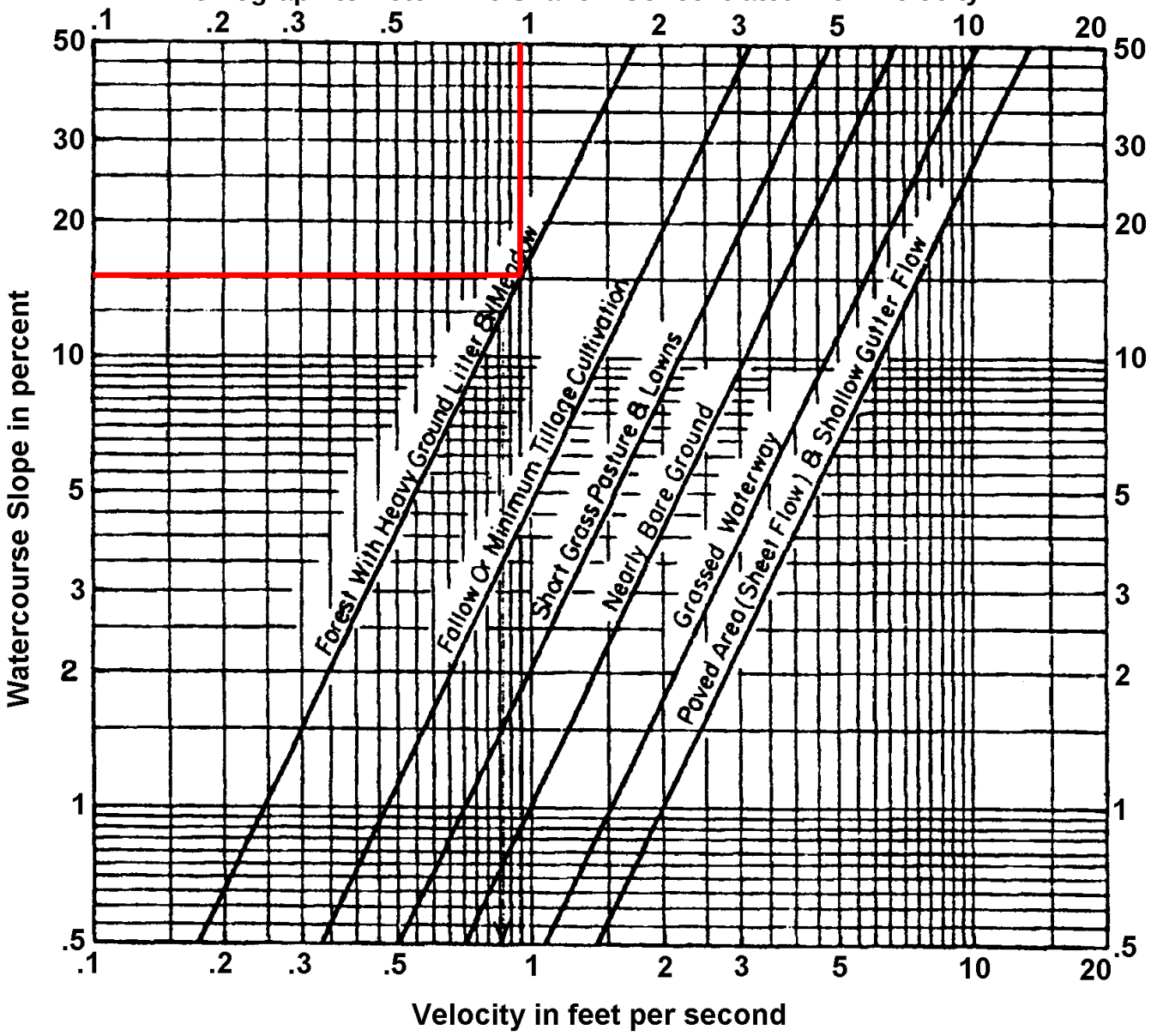
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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 methods 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. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION ID:
DS_2.59_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 = 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_2.59_9
1.28 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.59_9	100	0.8	0.040	13.62

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

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 2.59_9	676	FOREST	0.123	0.88	12.77

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)
26.39

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: LUZERNE 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 2.59_9	1	FOREST	0.20	0.93	0.19	0.22
	2	OPEN SPACE	0.28	0.35	0.10	

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}
	26.39	2.44	2.97	3.44	2.44	2.97	3.44

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)
	0.22	2.44	1.28	0.69	0.84	0.98

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.59_9		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.28		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.69		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.32		
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)	1.77		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.06		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.95 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.95		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.98		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.034		
S_C (CRITICAL SLOPE)	(FT/FT)	0.087		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.114		
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		

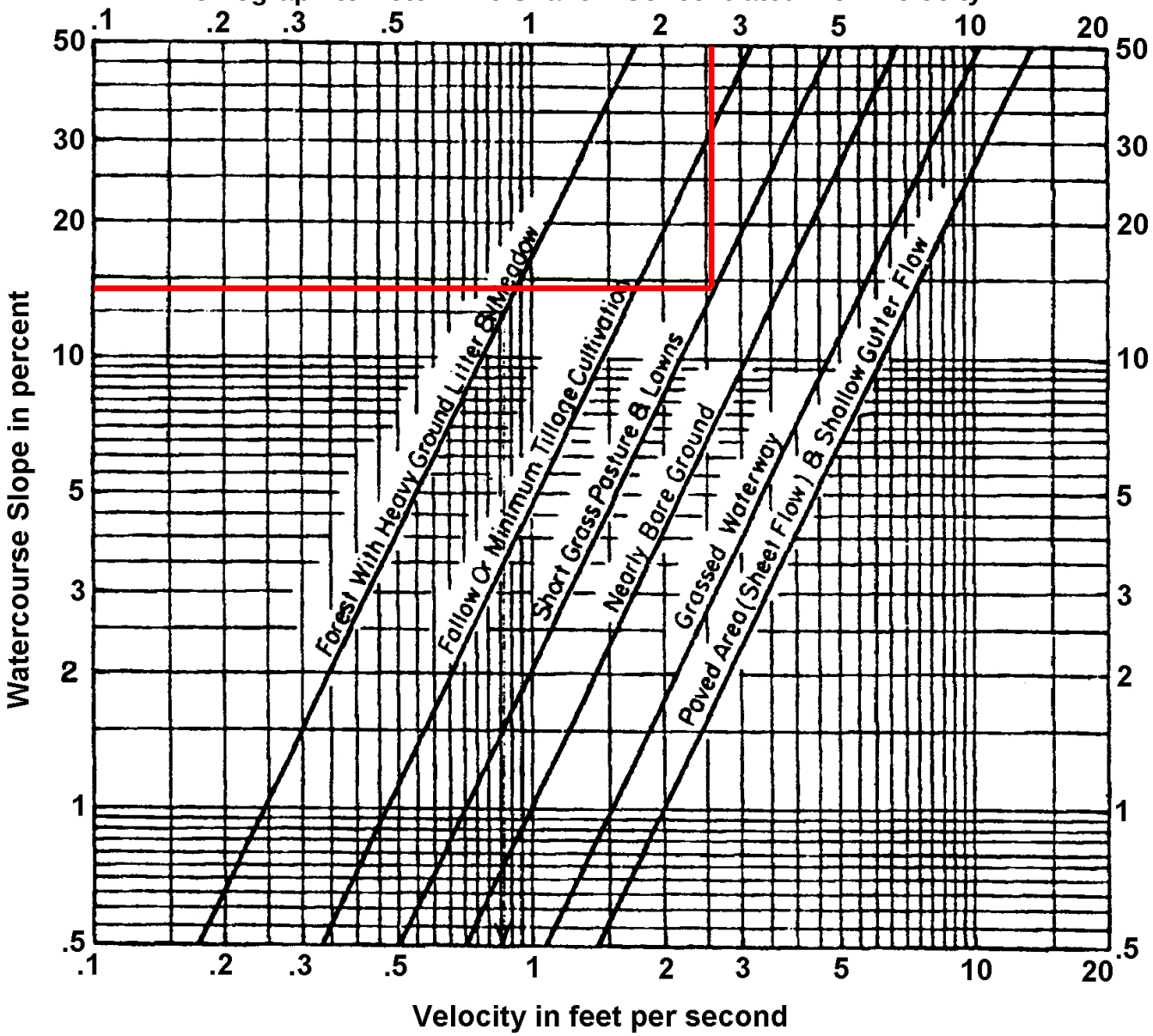
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.59_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 = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.6 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

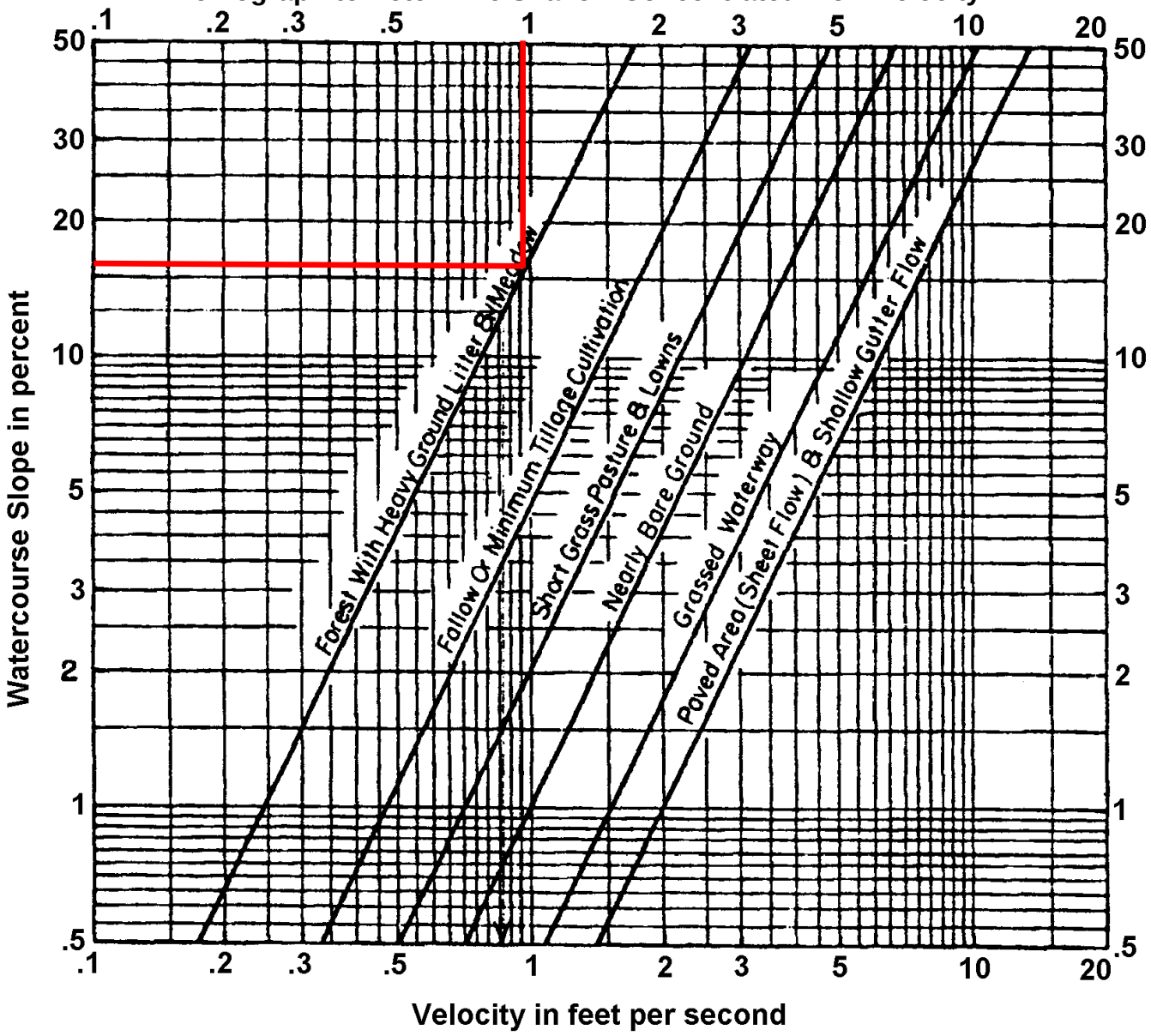
2.6 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION ID:
DS_2.59_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

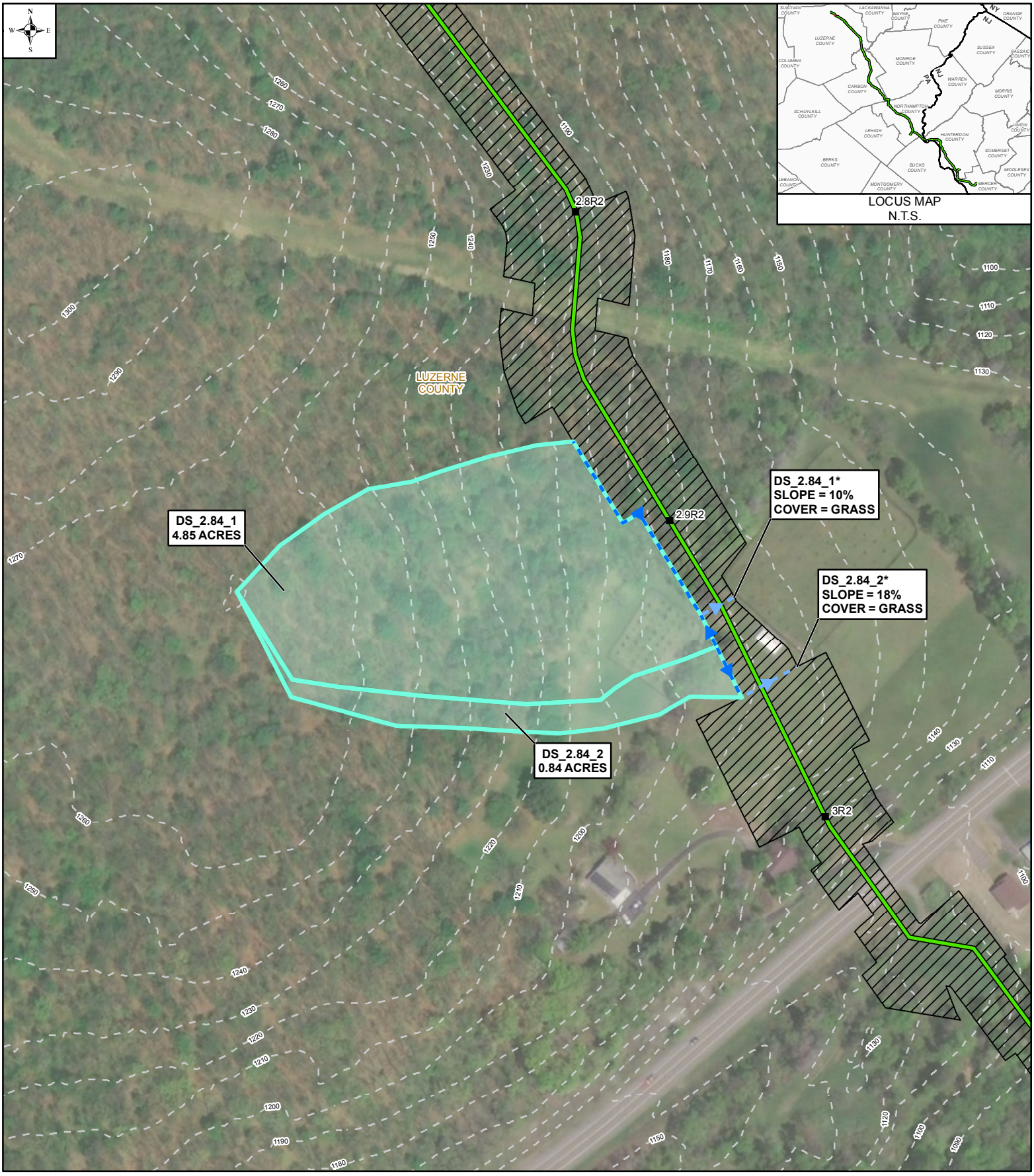


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

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
- 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_2.84

LUZERNE COUNTY, PENNSYLVANIA

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

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 4 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_2.84_1
4.87 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.84_1	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 2.84_1	551	FOREST	0.118	0.86	10.63
	203	SHORT GRASS	0.084	2.02	1.68

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)
25.91

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: LUZERNE 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 2.84_1	1	FOREST	0.20	4.10	0.82	0.21
	2	OPEN SPACE	0.28	0.77	0.22	

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}
	25.91	2.47	3.01	3.48	2.47	3.01	3.48

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)
	0.21	2.47	4.87	2.56	3.11	3.60

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		**DS_2.84_1a**	DS_2.84_1b	
TEMPORARY OR PERMANENT?	(T OR P)	**T**	T	
DESIGN STORM	(2, 5, OR 10 YR)	**2**	2	
ACRES	(AC)	**4.87**	4.87	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	**N/A**	N/A	
Q_r (REQUIRED CAPACITY)	(CFS)	**2.56**	2.56	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	**8.29**	4.17	
PROTECTIVE LINING[2,6]		**C125**	EXISTING GRASS	
n (MANNING'S COEFFICIENT)[2]		**0.022**	0.06	
V_a (ALLOWABLE VELOCITY)	(FPS)	**N/A**	N/A	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	**6.64**	1.70	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	**2.25**	1	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	**2.18**	1.00	
CHANNEL BOTTOM WIDTH	(FT)	**0**	0	
CHANNEL SIDE SLOPES	(H:V)	**10 / 0**	19.61 / 0	
D (TOTAL DEPTH)	(FT)	**1.00**	1.0	
CHANNEL TOP WIDTH @ D	(FT)	**10.00**	19.61	
d (CALCULATED FLOW DEPTH)	(FT)	**0.50**	0.50	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	**5.00**	9.80	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	**0**	0	
d_{50} STONE SIZE	(IN)	**N/A**	N/A	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	**1.25**	2.45	
R (HYDRAULIC RADIUS)		**0.23**	0.24	
S (BED SLOPE)[3]	(FT/FT)	**0.07**	0.032	
S_C (CRITICAL SLOPE)	(FT/FT)	**0.013**	0.089	
$.7S_c$	(FT/FT)	**0.009**	0.062	
$1.3S_c$	(FT/FT)	**0.017**	0.116	
STABLE FLOW?	(Y/N)	**Y**	Y	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	**N/A**	N/A	
FREEBOARD BASED ON STABLE FLOW	(FT)	**0.50**	0.50	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	**0.50**	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		**S**	S	

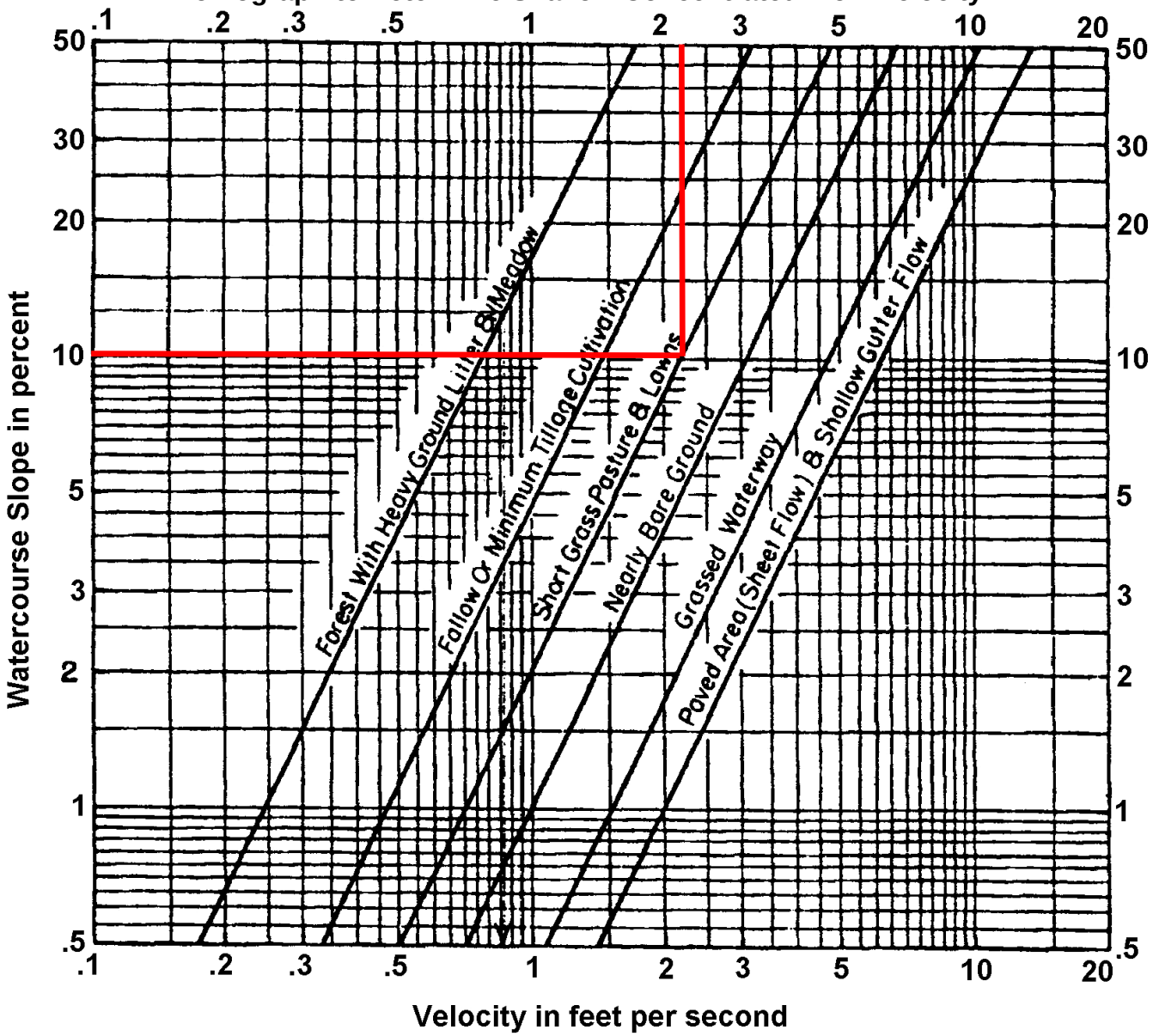
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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 methods 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. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION ID:
DS_2.84_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 = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 10%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.2 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.2 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_2.84_2
0.84 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 2.84_2	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 2.84_2	536	FOREST	0.104	0.81	11.01
	276	SHORT GRASS	0.101	2.21	2.08

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)
26.00

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: LUZERNE 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 2.84_2	1	FOREST	0.20	0.61	0.12	0.22
	2	OPEN SPACE	0.28	0.23	0.06	

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}
	26.00	2.47	3.00	3.47	2.47	3.00	3.47

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)
	0.22	2.47	0.84	0.46	0.56	0.65

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_2.84_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.84		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.46		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.50		
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)	2.25		
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)	16.13 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	10.75		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.69		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.22		
R (HYDRAULIC RADIUS)		0.08		
S (BED SLOPE)[3, 7]	(FT/FT)	0.033		
S_C (CRITICAL SLOPE)	(FT/FT)	0.018		
$.7S_c$	(FT/FT)	0.012		
$1.3S_c$	(FT/FT)	0.023		
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		

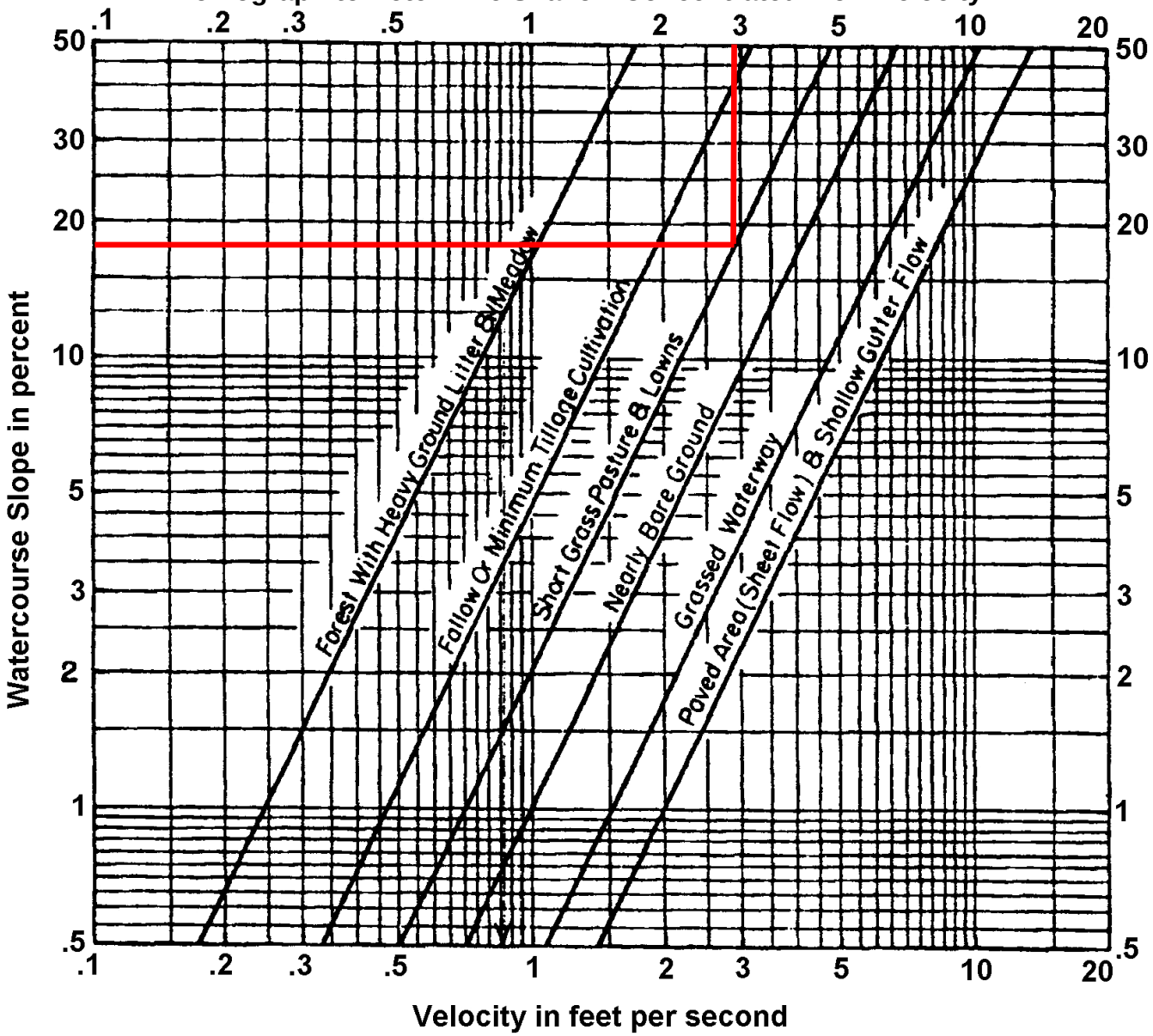
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_2.84_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

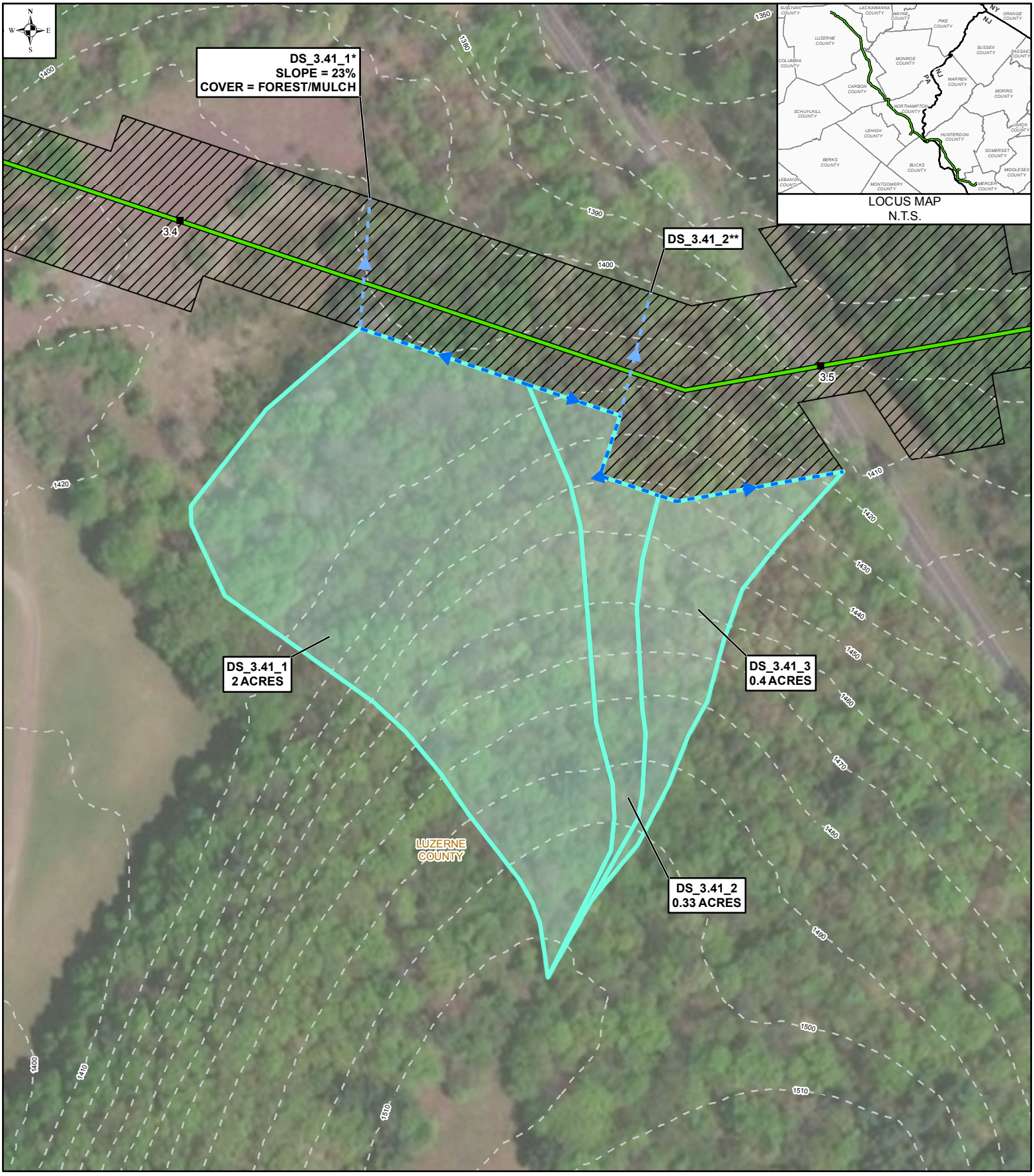


TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 18%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.9 FPS < 4.0 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_3.41

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 5 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_3.41_1
2 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 3.41_1	100	0.4	0.121	7.60

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

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 3.41_1	577	FOREST	0.166	1.03	9.38

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)
16.98

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: LUZERNE 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 3.41_1	1	FOREST	0.20	2.00	0.40	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}
	16.98	3.12	3.75	4.25	3.12	3.75	4.25

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	3.12	2.00	1.25	1.50	1.70

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_3.41_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.25		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.91		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.18		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
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)	6.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.50		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.87		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
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		

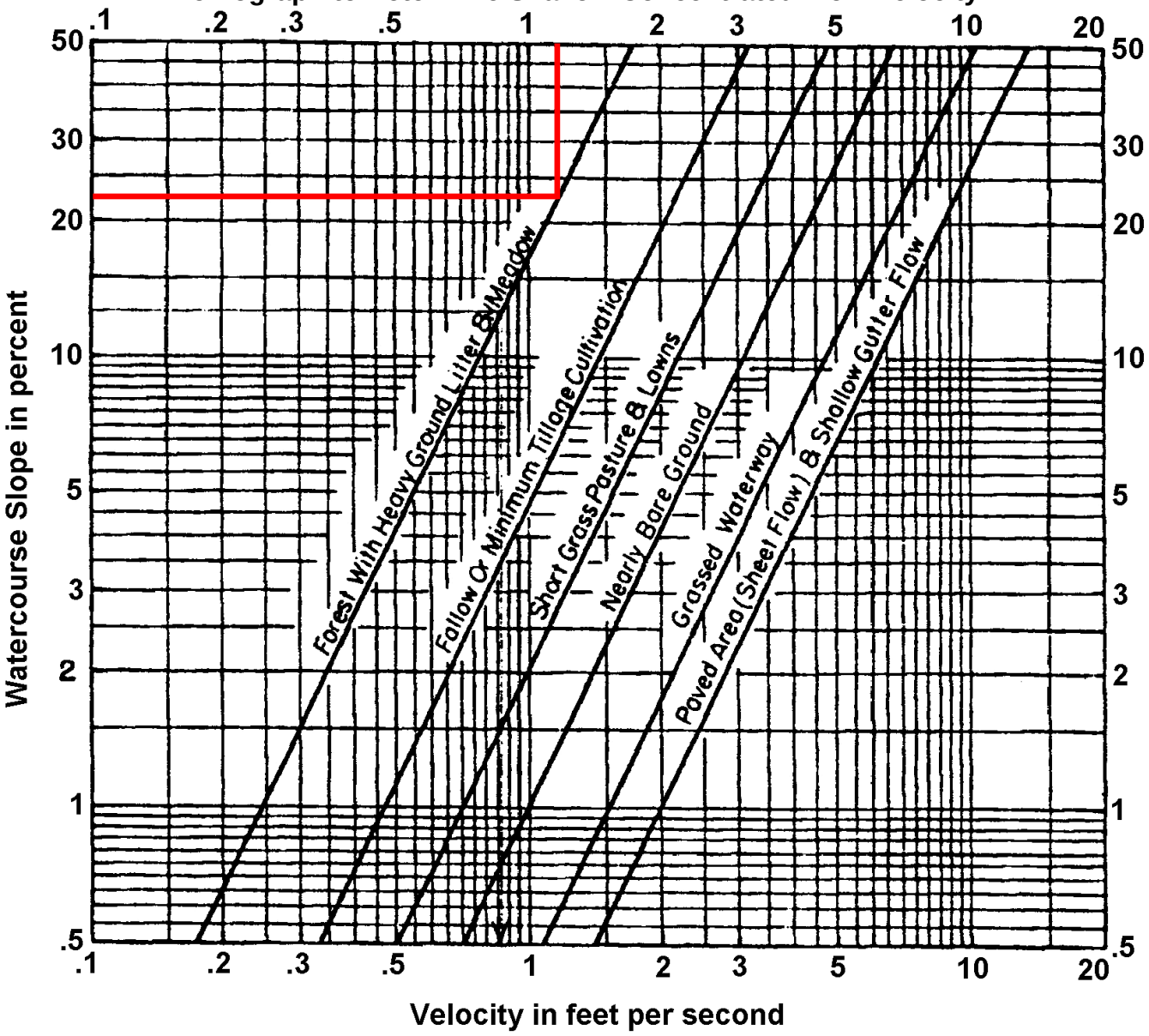
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_3.41_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 = 23%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.2 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_3.41_2
0.33 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 3.41_2	100	0.4	0.070	8.63

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

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 3.41_2	389	FOREST	0.227	1.20	5.41

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)
14.04

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: LUZERNE 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 3.41_2	1	FOREST	0.20	0.33	0.07	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}
	14.04	3.41	4.09	4.59	3.41	4.09	4.59

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	3.41	0.33	0.23	0.27	0.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_3.41_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.33		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.23		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.28		
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)	4.09		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.36		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	3.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	0.83		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.07		
R (HYDRAULIC RADIUS)		0.07		
S (BED SLOPE)[3, 7]	(FT/FT)	0.131		
S_C (CRITICAL SLOPE)	(FT/FT)	0.021		
$.7S_c$	(FT/FT)	0.015		
$1.3S_c$	(FT/FT)	0.027		
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

DRAINAGE AREA
DS_3.41_3
0.4 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 3.41_3	100	0.4	0.129	7.48

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

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 3.41_3	296	FOREST	0.271	1.31	3.77

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)
11.25

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: LUZERNE 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 3.41_3	1	FOREST	0.20	0.40	0.08	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}
	11.25	3.75	4.46	4.96	3.75	4.46	4.96

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	3.75	0.40	0.30	0.36	0.40

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

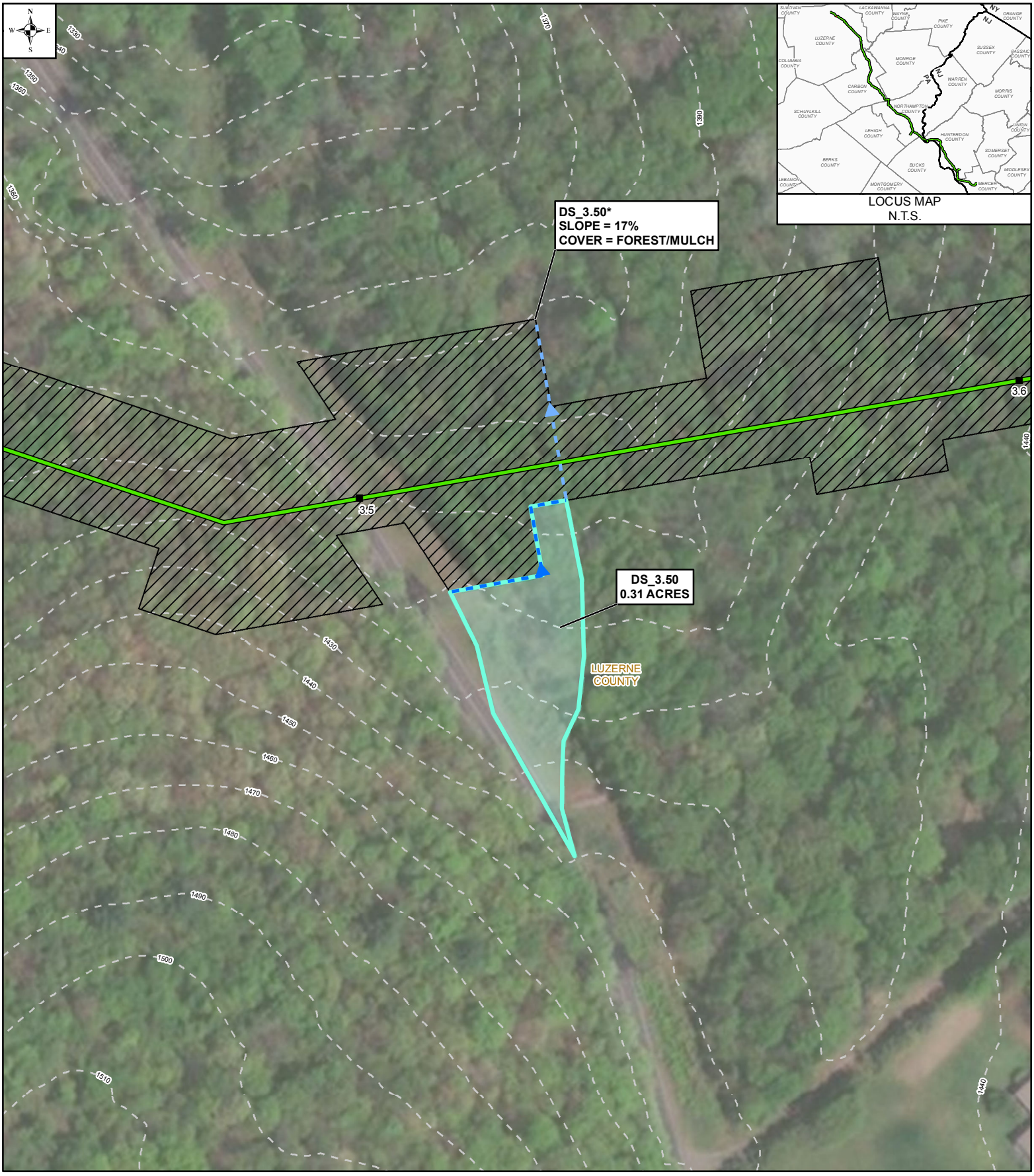
LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_3.41_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.4		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.3		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.33		
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)	4.79		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.87		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	3.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	0.83		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.07		
R (HYDRAULIC RADIUS)		0.07		
S (BED SLOPE)[3, 7]	(FT/FT)	0.18		
S_C (CRITICAL SLOPE)	(FT/FT)	0.021		
$.7S_c$	(FT/FT)	0.015		
$1.3S_c$	(FT/FT)	0.027		
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
- 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_3.50

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 6 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 3.50	49	0.8	0.122	7.51

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

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 3.50	237	FOREST	0.156	0.99	3.97

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)
11.49

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: LUZERNE 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 3.50	1	FOREST	0.20	0.27	0.05	0.26
	2	INDUSTRIAL	0.69	0.04	0.03	

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}
	11.49	3.72	4.43	4.93	3.72	4.43	4.93

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)
	0.26	3.72	0.31	0.30	0.36	0.40

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_3.50		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.31		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.3		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.35		
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)	3.52		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.94		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.14 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	4.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.19		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.10		
R (HYDRAULIC RADIUS)		0.07		
S (BED SLOPE)[3, 7]	(FT/FT)	0.09		
S_C (CRITICAL SLOPE)	(FT/FT)	0.019		
$.7S_c$	(FT/FT)	0.014		
$1.3S_c$	(FT/FT)	0.025		
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		

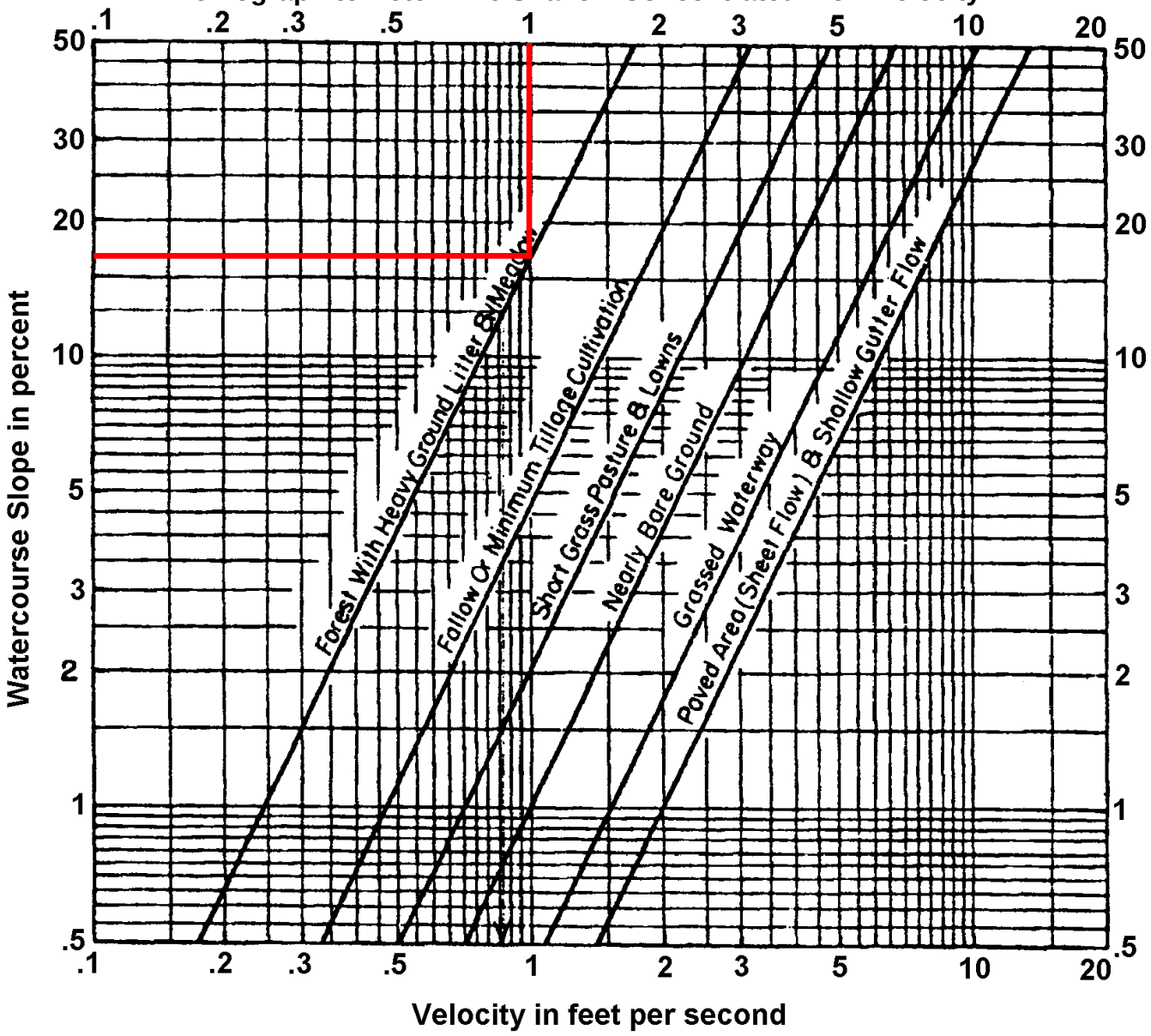
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_3.50

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

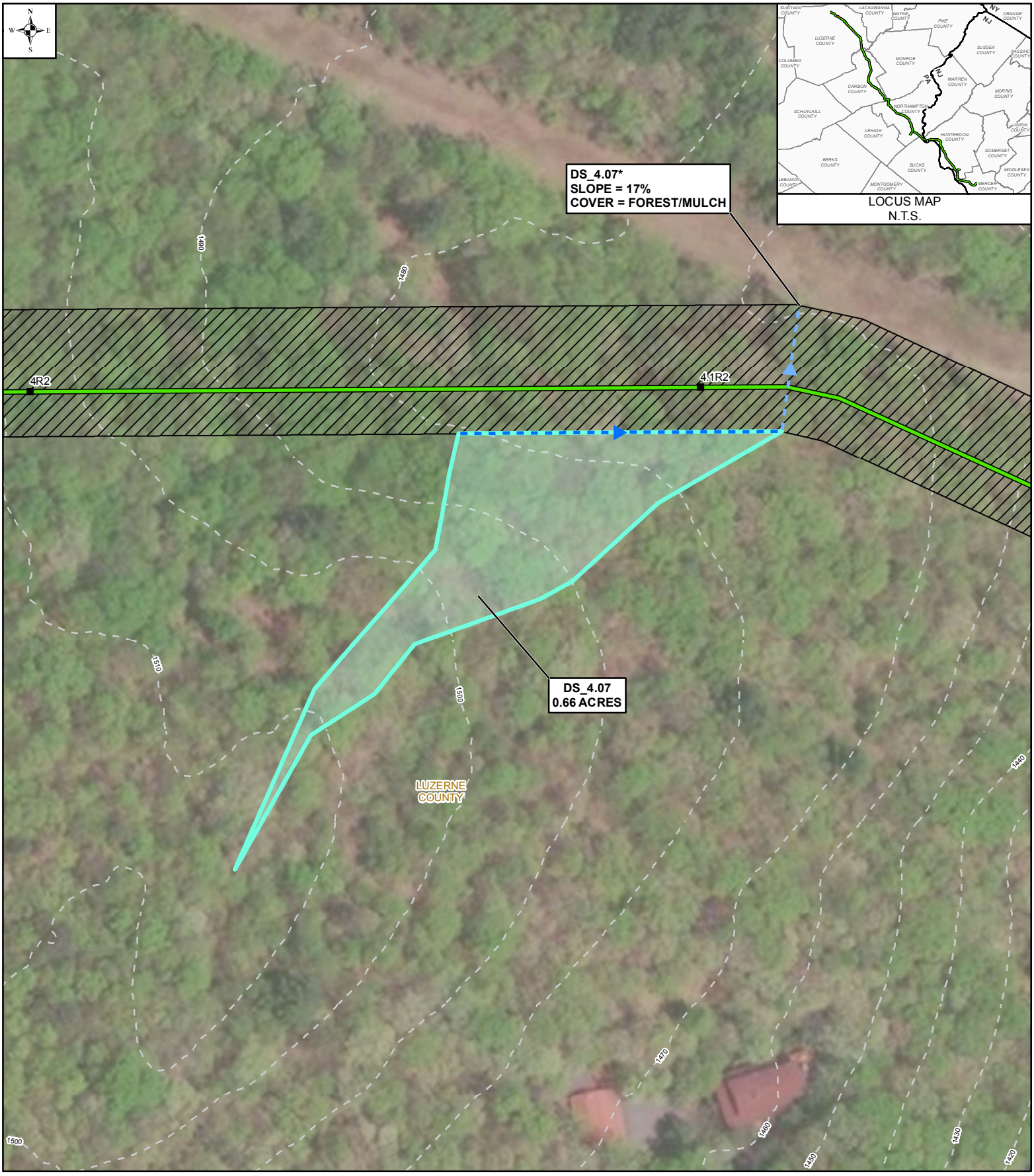


TR-55

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.



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_4.07

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 7 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 4.07	100	0.8	0.040	13.60

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

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 4.07	470	FOREST	0.077	0.70	11.22

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)
24.82

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: LUZERNE 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 4.07	1	FOREST	0.20	0.66	0.13	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}
	24.82	2.53	3.08	3.55	2.53	3.08	3.55

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	2.53	0.66	0.33	0.41	0.47

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_4.07		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.66		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.34		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.62		
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)	1.77		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.21		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	25 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	16.67		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.35		
R (HYDRAULIC RADIUS)		0.08		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.017		
$.7S_c$	(FT/FT)	0.012		
$1.3S_c$	(FT/FT)	0.022		
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		

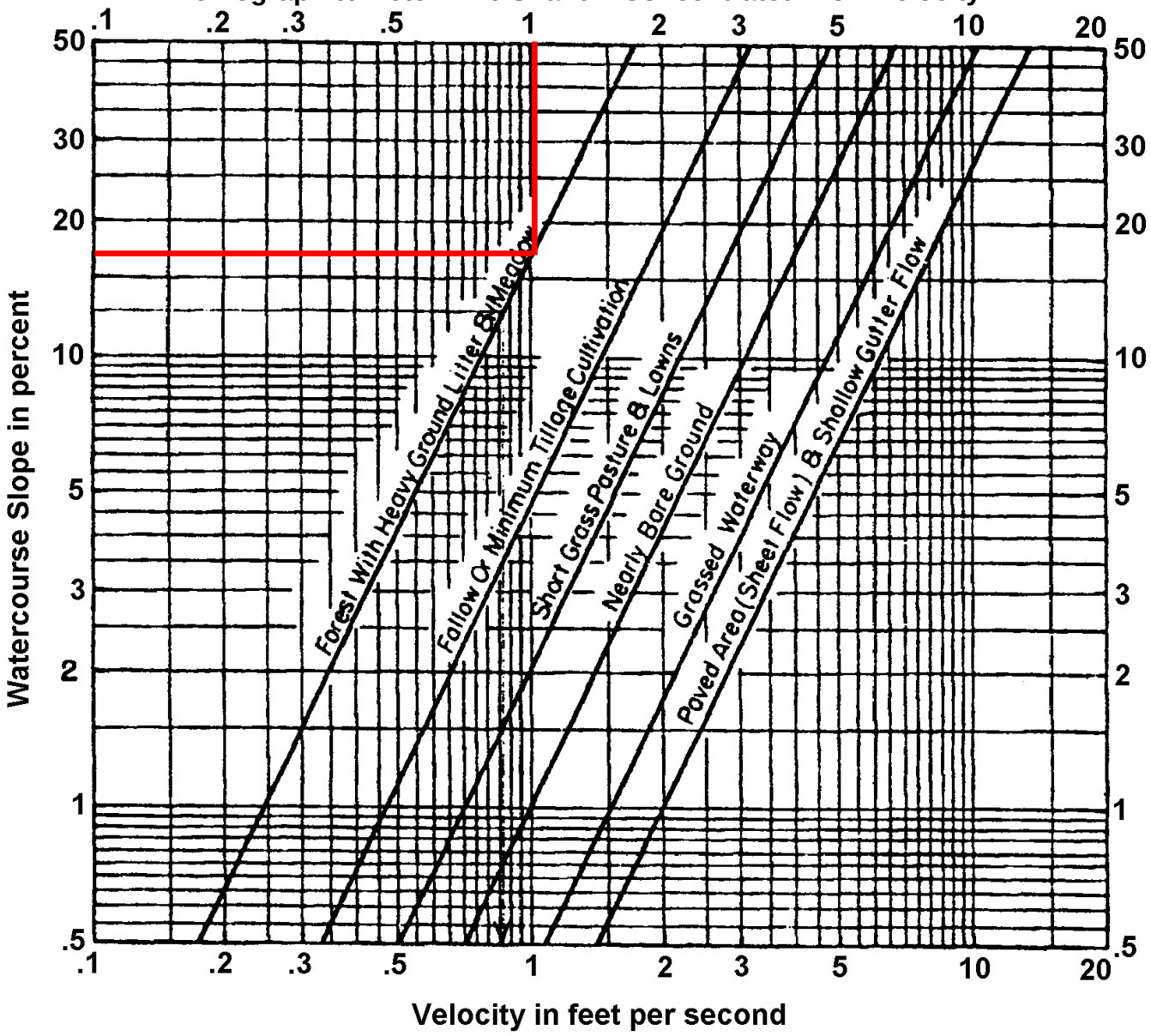
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_4.07

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

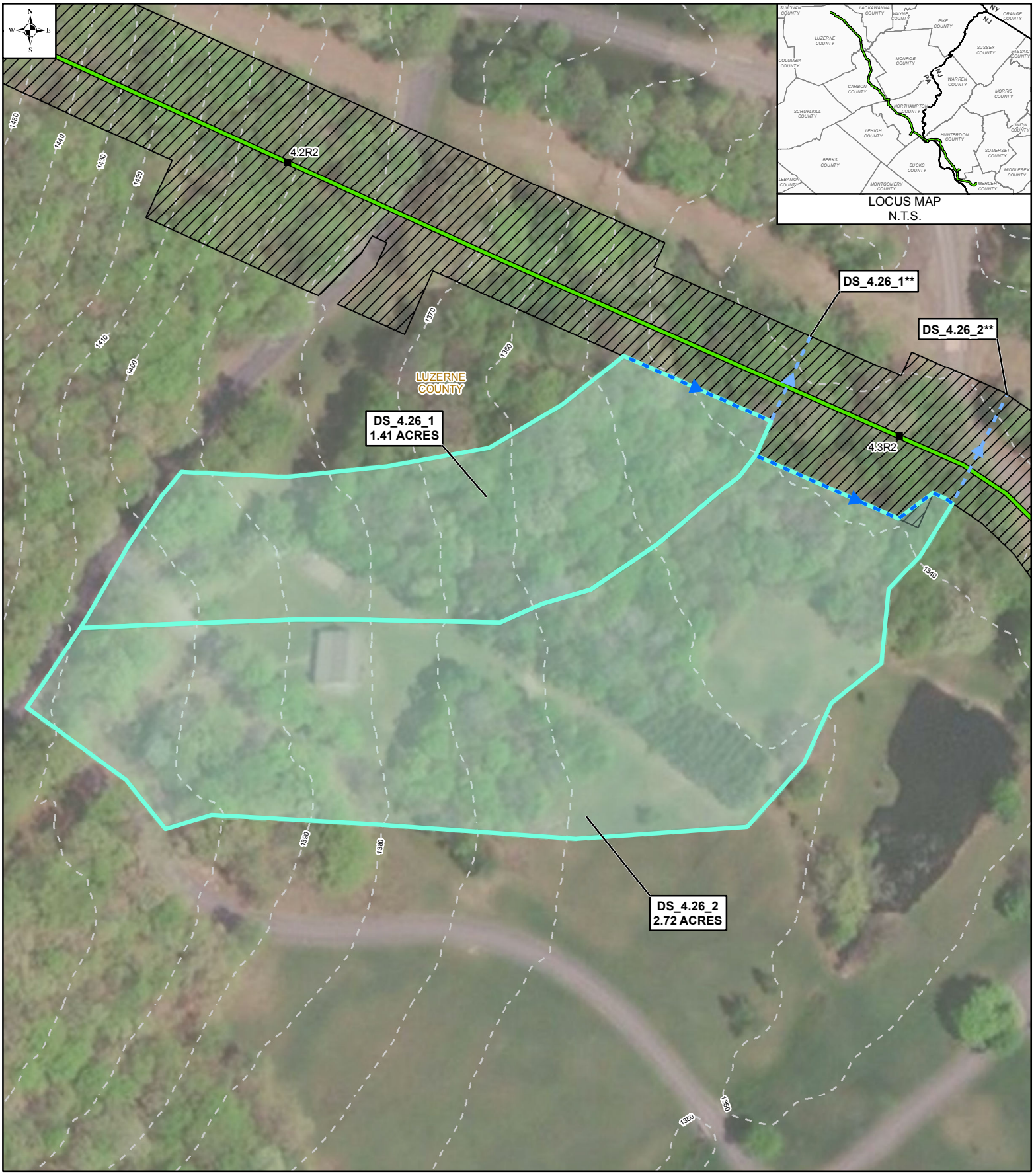


TR-55

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.



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_4.26

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 8 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_4.26_1
1.41 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 4.26_1	83	0.4	0.097	7.33

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

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 4.26_1	20	PAVEMENT	0.150	7.87	0.04
	163	SHORT GRASS	0.160	2.78	0.98
	322	FOREST	0.109	0.83	6.46

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)
14.81

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: LUZERNE 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 4.26_1	1	FOREST	0.20	1.24	0.25	0.22
	2	INDUSTRIAL	0.69	0.05	0.03	
	3	OPEN SPACE	0.28	0.12	0.03	

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}
	14.81	3.33	3.99	4.50	3.33	3.99	4.50

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)
	0.22	3.33	1.41	1.05	1.26	1.42

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_4.26_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.41		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.05		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.99		
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)	4.47		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.14 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.14		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.57		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.89		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.08		
S_C (CRITICAL SLOPE)	(FT/FT)	0.032		
$.7S_c$	(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

DRAINAGE AREA
DS_4.26_2
2.72 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 4.26_2	100	0.4	0.093	8.08

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

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 4.26_2	375	FOREST	0.120	0.87	7.17
	326	SHORT GRASS	0.040	1.39	3.90
	119	FOREST	0.092	0.76	2.60

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)
21.75

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: LUZERNE 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 4.26_2	1	FOREST	0.20	1.64	0.33	0.22
	2	INDUSTRIAL	0.69	0.11	0.08	
	3	OPEN SPACE	0.21	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}
	21.75	2.74	3.31	3.80	2.74	3.31	3.80

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)
	0.22	2.74	2.72	1.66	2.01	2.31

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

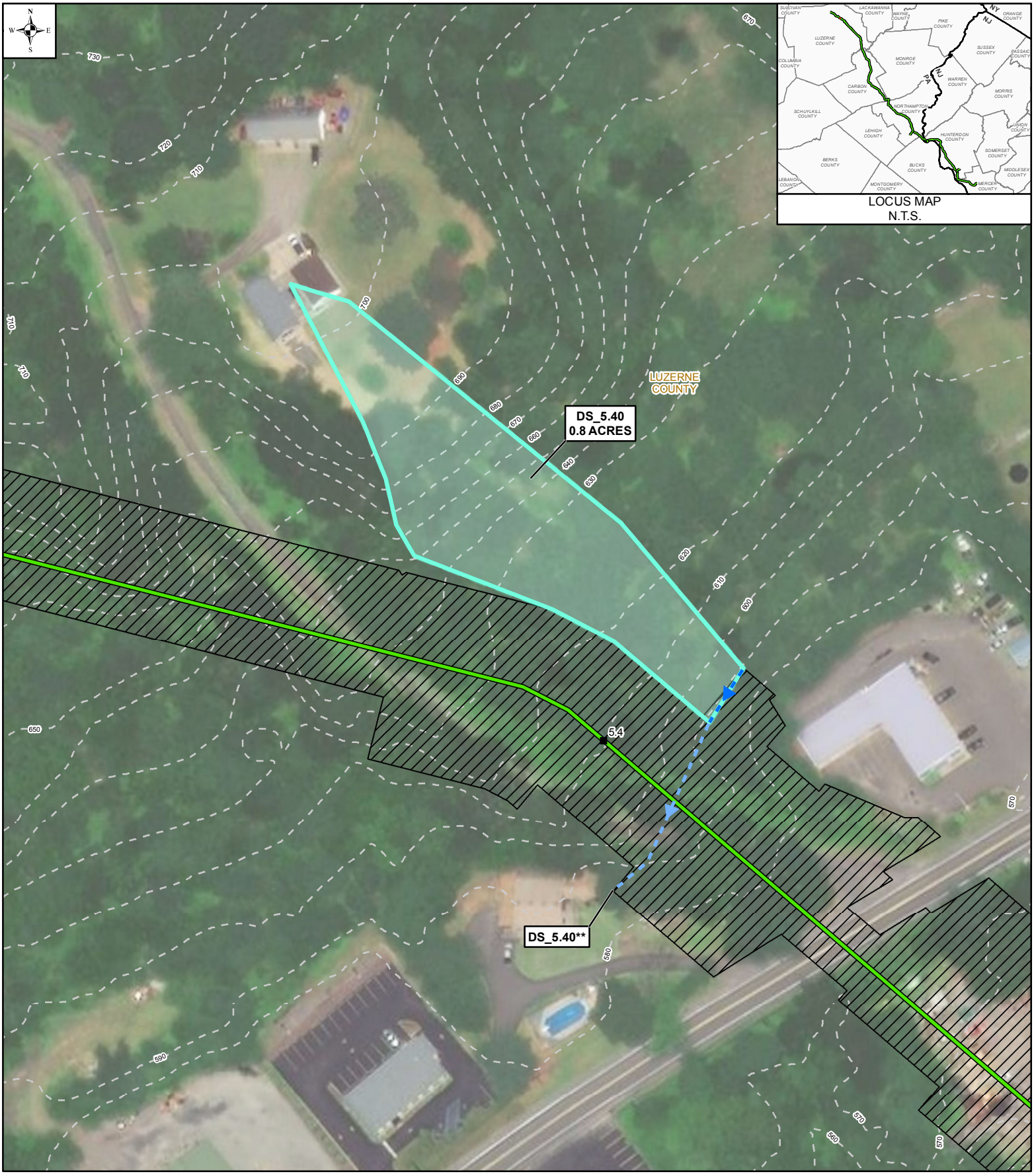
LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_4.26_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2.72		
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)	2.78		
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)	4.67		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.60		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
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
- 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_5.40

LUZERNE COUNTY, PENNSYLVANIA

0 50 100 FEET

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

PennEast PIPELINE

DWG NO: PAGE 9 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 5.40	40	0.02	0.080	1.34

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

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 5.40	133	SHORT GRASS	0.120	2.41	0.92
	301	FOREST	0.320	1.42	3.52

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)
5.79

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: LUZERNE 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 5.40	1	FOREST	0.20	0.69	0.14	0.21
	2	INDUSTRIAL	0.69	0.01	0.01	
	3	OPEN SPACE	0.21	0.10	0.02	

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}
	5.79	4.65	5.45	5.91	4.65	5.45	5.91

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)
	0.21	4.65	0.80	0.77	0.90	0.98

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

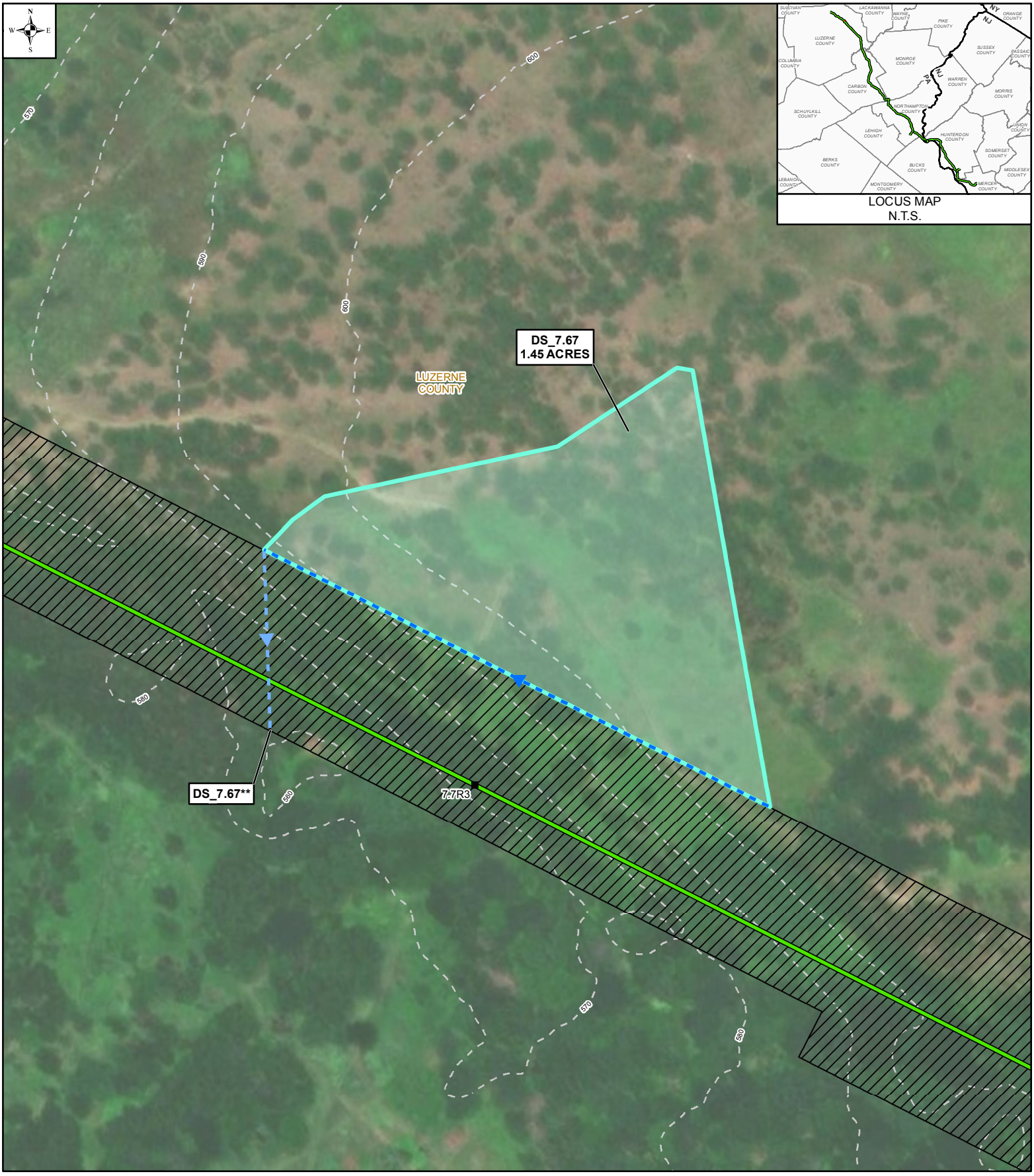
LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_5.40		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.8		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.77		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.08		
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)	3.02		
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)	2.86 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	2.86		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.43		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.36		
R (HYDRAULIC RADIUS)		0.18		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.018		
$.7S_c$	(FT/FT)	0.012		
$1.3S_c$	(FT/FT)	0.023		
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.



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_7.67

LUZERNE COUNTY, PENNSYLVANIA

0 50 100 FEET

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

PennEast PIPELINE

DWG NO: PAGE 10 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 7.67	100	0.4	0.020	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 7.67	184	FOREST	0.016	0.32	9.64
	93	SHORT GRASS	0.150	2.70	0.57

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)
21.78

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: LUZERNE 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 7.67	1	FOREST	0.12	0.70	0.08	0.20
	2	OPEN SPACE	0.28	0.75	0.21	

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}
	21.78	2.73	3.31	3.80	2.73	3.31	3.80

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	2.73	1.45	0.80	0.97	1.12

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

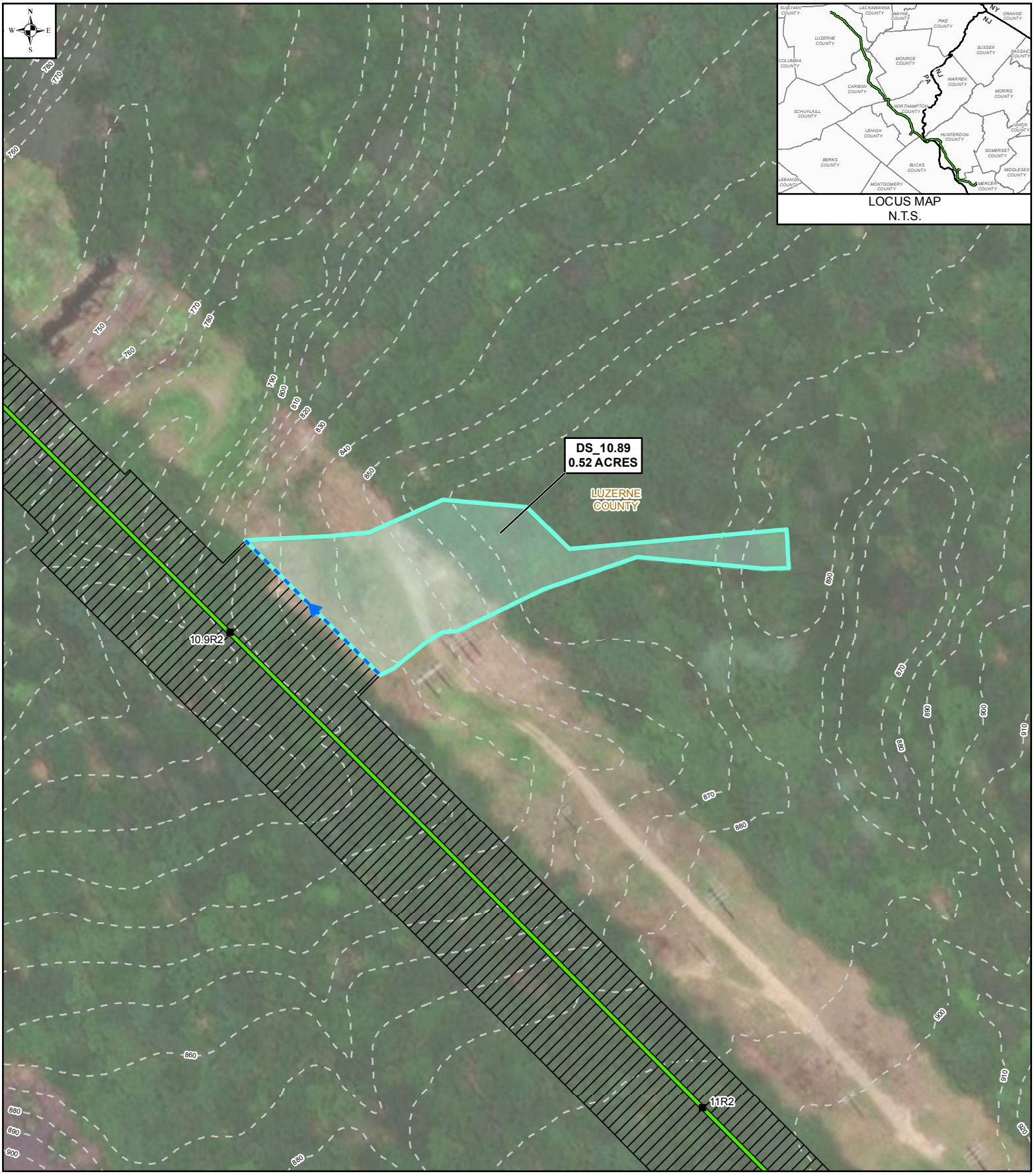
LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_7.67		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.45		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.8		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.05		
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)	1.85		
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)	4.55 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.55		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.27		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.57		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.094		
$.7S_c$	(FT/FT)	0.065		
$1.3S_c$	(FT/FT)	0.122		
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
- 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_10.89

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 11 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 10.89	100	0.8	0.180	9.57

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

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 10.89	185	FOREST	0.043	0.52	5.91
	93	SHORT GRASS	0.300	3.81	0.41

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)
15.89

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: LUZERNE 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 10.89	1	FOREST	0.20	0.20	0.04	0.25
	2	OPEN SPACE	0.28	0.30	0.08	

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}
	15.89	3.22	3.87	4.37	3.22	3.87	4.37

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)
	0.25	3.22	0.50	0.40	0.48	0.54

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

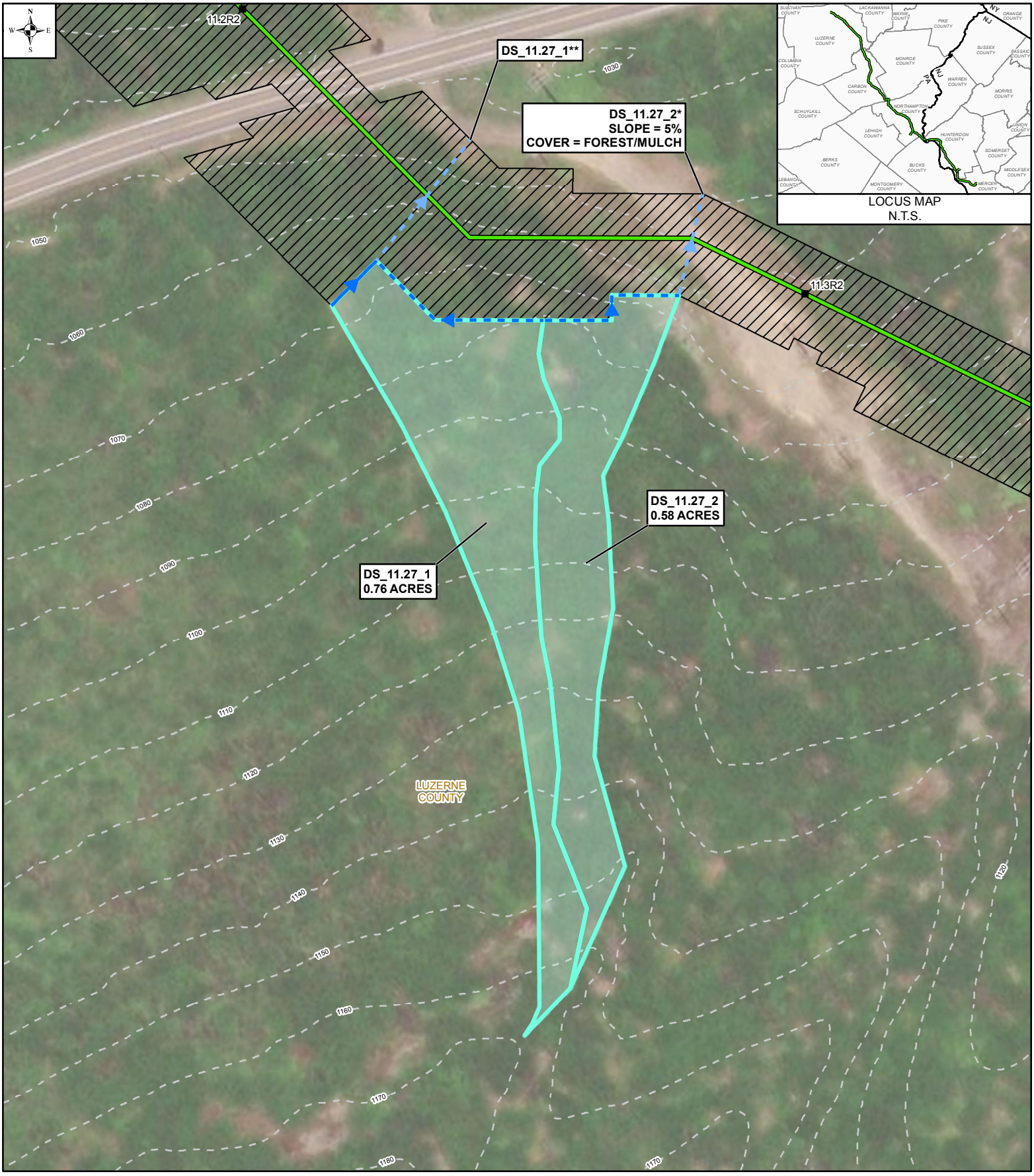
LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		DS_10.89a	**DS_10.89a**	DS_10.89b
TEMPORARY OR PERMANENT?	(T OR P)	T	**T**	T
DESIGN STORM	(2, 5, OR 10 YR)	2	**2**	2
ACRES	(AC)	0.5	**0.5**	0.5
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A	**N/A**	N/A
Q_r (REQUIRED CAPACITY)	(CFS)	0.4	**0.4**	0.4
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.34	**5.34**	1.12
PROTECTIVE LINING[2,6]		P300 (Unvegetated)	**P300 (Vegetated)**	S150
n (MANNING'S COEFFICIENT)[2]		0.034	**0.034**	0.055
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	**N/A**	N/A
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	7.27	**7.27**	2.06
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00	**8.00**	1.75
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	6.86	**6.86**	1.56
CHANNEL BOTTOM WIDTH	(FT)	0	**0**	0
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0	**5.88 / 0**	4.35 / 0
D (TOTAL DEPTH)	(FT)	1.00	**1.00**	1.00
CHANNEL TOP WIDTH @ D	(FT)	5.88	**5.88**	4.35
d (CALCULATED FLOW DEPTH)	(FT)	0.50	**0.50**	0.50
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94	**2.94**	2.17
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0	**0**	0
d_{50} STONE SIZE	(IN)	N/A	**N/A**	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74	**0.74**	0.54
R (HYDRAULIC RADIUS)		0.21	**0.21**	0.20
S (BED SLOPE)[3]	(FT/FT)	0.22	**0.22**	0.05
S_C (CRITICAL SLOPE)	(FT/FT)	0.033	**0.033**	0.095
$.7S_c$	(FT/FT)	0.023	**0.023**	0.066
$1.3S_c$	(FT/FT)	0.044	**0.044**	0.123
STABLE FLOW?	(Y/N)	Y	**Y**	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	**N/A**	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	**0.50**	0.50
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	**0.50**	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	**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 methods 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. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.



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_11.27

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 12 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_11.27_1
0.8 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 11.27_1	100	0.8	0.170	9.70

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

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 11.27_1	513	FOREST	0.180	1.07	8.01

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)
17.71

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: LUZERNE 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 11.27_1	1	FOREST	0.20	0.80	0.16	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}
	17.71	3.05	3.68	4.18	3.05	3.68	4.18

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	3.05	0.80	0.49	0.59	0.67

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_11.27_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.8		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.49		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.74		
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)	4.60		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.90		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.60		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.093		
S_C (CRITICAL SLOPE)	(FT/FT)	0.035		
$.7S_c$	(FT/FT)	0.025		
$1.3S_c$	(FT/FT)	0.046		
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

DRAINAGE AREA
DS_11.27_2
0.5 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 11.27_2	100	0.8	0.120	10.52

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

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 11.27_2	472	FOREST	0.190	1.10	7.17

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)
17.70

CHANNEL DIMENSIONS:

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

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 11.27_2	1	FOREST	0.20	0.50	0.10	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}
	17.70	3.06	3.68	4.18	3.06	3.68	4.18

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	3.06	0.50	0.31	0.37	0.42

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_11.27_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.5		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.31		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.16		
PROTECTIVE LINING[2,6]		P550		
n (MANNING'S COEFFICIENT)[2]		0.041		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.31		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	4.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	3.90		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.00		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.50		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.125		
S_C (CRITICAL SLOPE)	(FT/FT)	0.054		
$.7S_c$	(FT/FT)	0.038		
$1.3S_c$	(FT/FT)	0.070		
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		

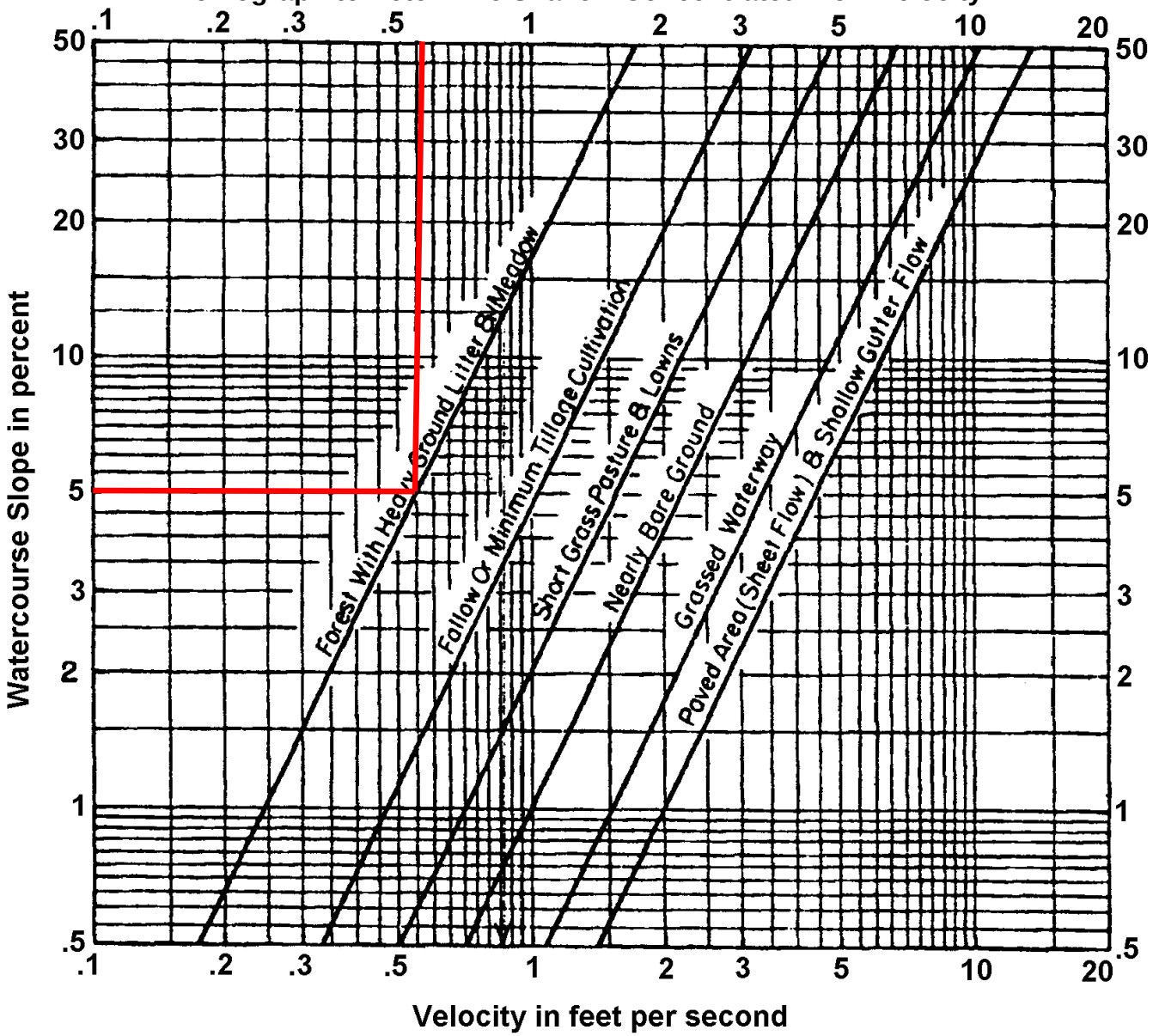
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_11.27_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

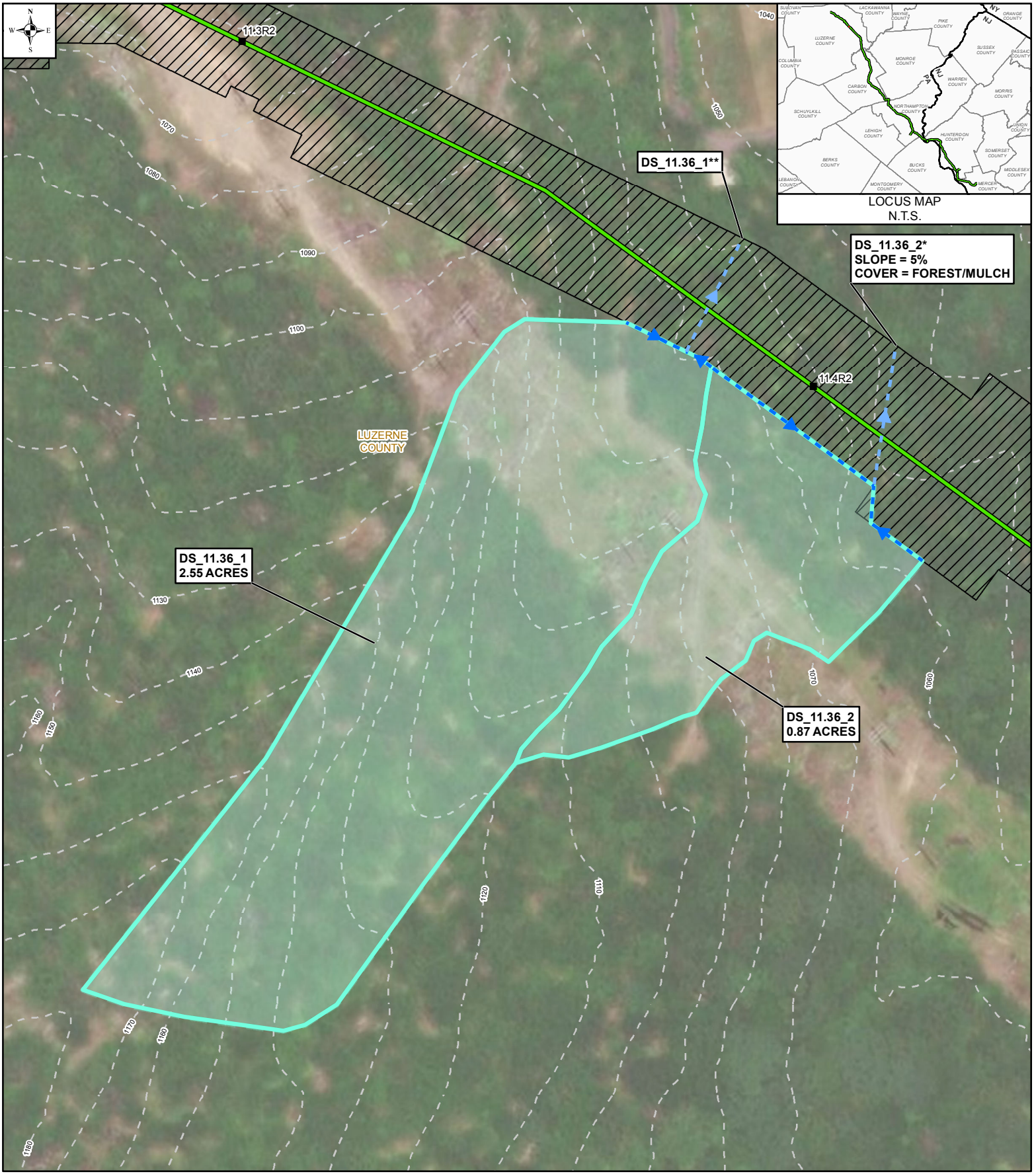


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 5%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 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.

0.6 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_11.36

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 13 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_11.36_1
2.55 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 11.36_1	100	0.8	0.250	8.87

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

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 11.36_1	494	FOREST	0.107	0.82	10.00
	143	SHORT GRASS	0.140	2.60	0.91
	76	FOREST	0.076	0.69	1.83

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)
21.61

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: LUZERNE 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 11.36_1	1	FOREST	0.20	1.98	0.40	0.22
	2	OPEN SPACE	0.28	0.57	0.16	

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}
	21.61	2.75	3.32	3.81	2.75	3.32	3.81

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)
	0.22	2.75	2.55	1.53	1.85	2.12

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_11.36_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2.55		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.53		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.14		
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)	4.94		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.96		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.33 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.04		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.095		
S_C (CRITICAL SLOPE)	(FT/FT)	0.031		
$.7S_c$	(FT/FT)	0.022		
$1.3S_c$	(FT/FT)	0.041		
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

DRAINAGE AREA
DS_11.36_2
0.87 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 11.36_2	100	0.8	0.160	9.84

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

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 11.36_2	49	FOREST	0.143	0.95	0.86
	151	SHORT GRASS	0.112	2.33	1.08
	76	FOREST	0.092	0.76	1.66

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)
13.44

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: LUZERNE 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 11.36_2	1	FOREST	0.20	0.58	0.12	0.23
	2	OPEN SPACE	0.28	0.29	0.08	

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}
	13.44	3.48	4.16	4.67	3.48	4.16	4.67

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)
	0.23	3.48	0.87	0.69	0.82	0.92

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		DS_11.36_2a	DS_11.36_2b	**DS_11.36_2b**
TEMPORARY OR PERMANENT?	(T OR P)	T	T	**T**
DESIGN STORM	(2, 5, OR 10 YR)	2	2	**2**
ACRES	(AC)	0.87	0.87	**0.87**
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A	N/A	**N/A**
Q_r (REQUIRED CAPACITY)	(CFS)	0.69	0.69	**0.69**
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.18	4.10	**4.10**
PROTECTIVE LINING[2,6]		S150	SC250 (Unvegetated)	**SC250 (Vegetated)**
n (MANNING'S COEFFICIENT)[2]		0.055	0.04	**0.04**
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A	**N/A**
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.07	7.21	**7.21**
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75	3.00	**10.00**
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56	9.98	**9.98**
CHANNEL BOTTOM WIDTH	(FT)	0	0	**0**
CHANNEL SIDE SLOPES	(H:V)	4.55 / 0	4.55 / 0	**4.55 / 0**
D (TOTAL DEPTH)	(FT)	1.00	1.00	**1.00**
CHANNEL TOP WIDTH @ D	(FT)	4.55	4.55	**4.55**
d (CALCULATED FLOW DEPTH)	(FT)	0.50	0.50	**0.50**
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.27	2.27	**2.27**
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0	0	**0**
d_{50} STONE SIZE	(IN)	N/A	N/A	**N/A**
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.57	0.57	**0.57**
R (HYDRAULIC RADIUS)		0.20	0.20	**0.20**
S (BED SLOPE)[3]	(FT/FT)	0.05	0.32	**0.32**
S_C (CRITICAL SLOPE)	(FT/FT)	0.094	0.049	**0.049**
$.7S_c$	(FT/FT)	0.065	0.035	**0.035**
$1.3S_c$	(FT/FT)	0.122	0.064	**0.064**
STABLE FLOW?	(Y/N)	Y	Y	**Y**
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A	**N/A**
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.50	**0.50**
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50	**0.50**
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S	**S**

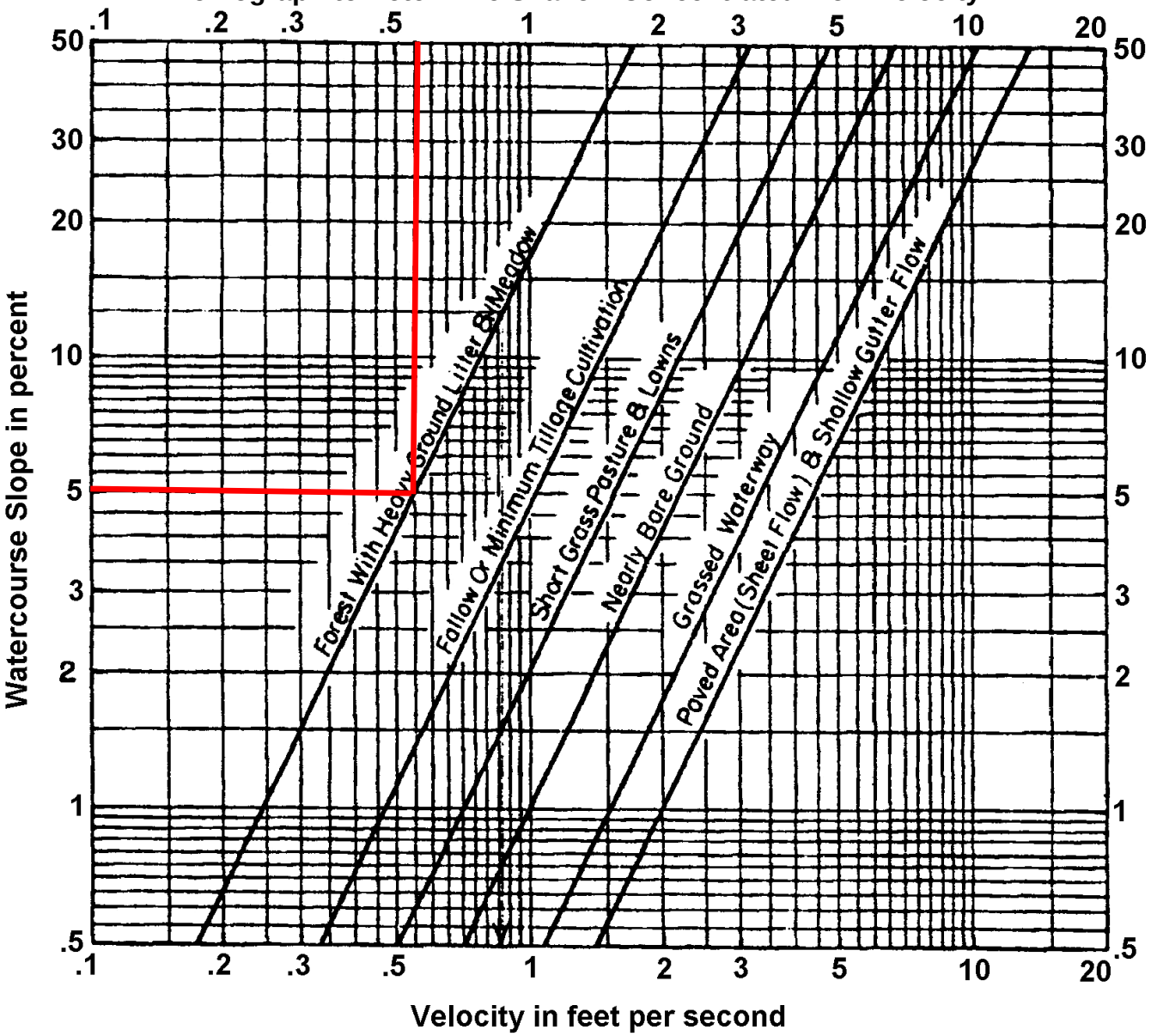
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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 methods 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. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION ID:
DS_11.36_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

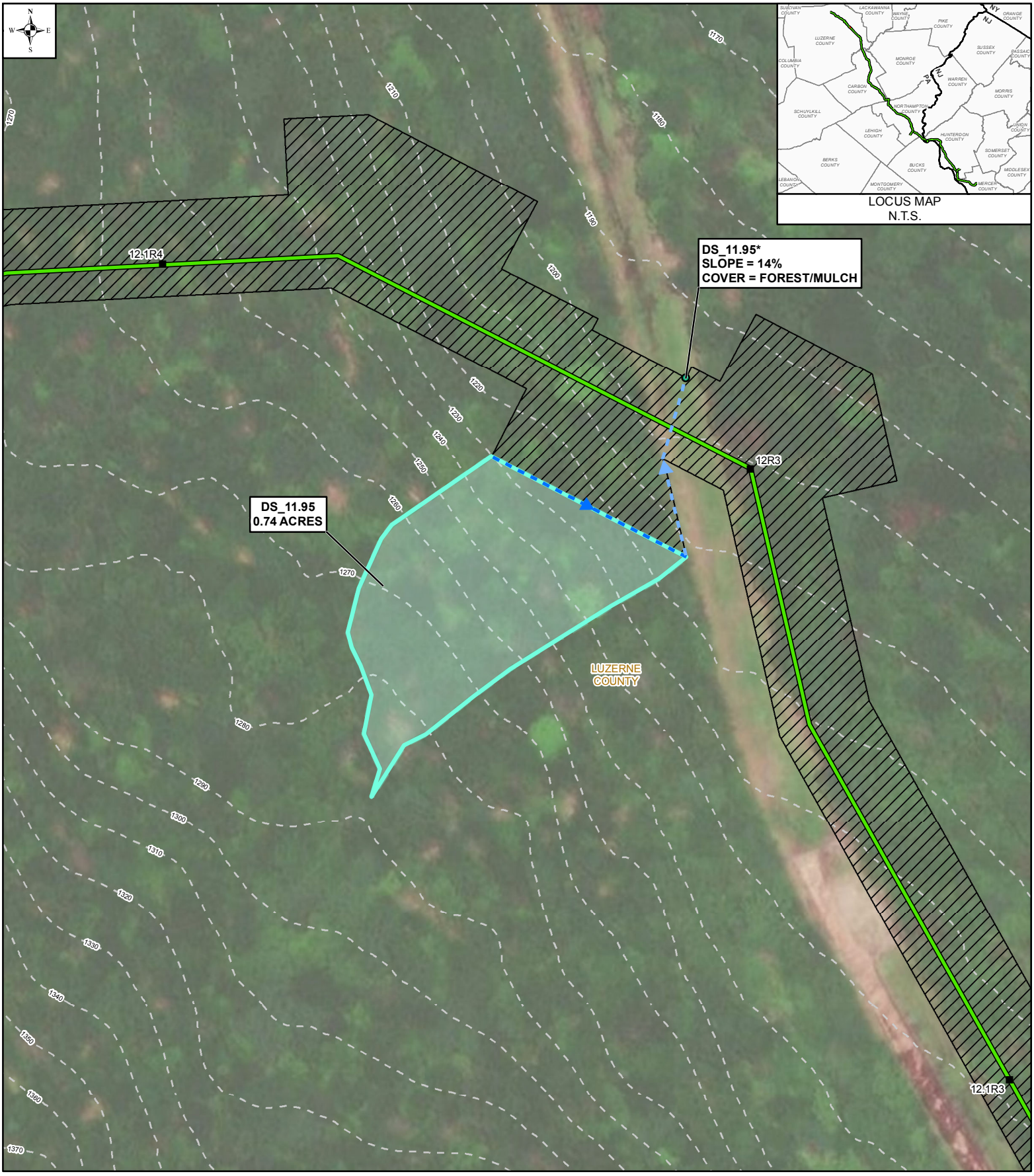


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 5%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 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.

0.6 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_11.95

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 14 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 11.95	100	0.8	0.091	11.23

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

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 11.95	227	FOREST	0.221	1.18	3.20

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)
14.43

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: LUZERNE 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 11.95	1	FOREST	0.20	0.74	0.15	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}
	14.43	3.37	4.04	4.54	3.37	4.04	4.54

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	3.37	0.74	0.50	0.60	0.67

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_11.95		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.74		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.5		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.76		
PROTECTIVE LINING[2,6]		C350		
n (MANNING'S COEFFICIENT)[2]		0.041		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.81		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.20		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	3.12		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.7 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.70		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.85		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.46		
R (HYDRAULIC RADIUS)		0.19		
S (BED SLOPE)[3, 7]	(FT/FT)	0.1		
S_C (CRITICAL SLOPE)	(FT/FT)	0.055		
$.7S_c$	(FT/FT)	0.039		
$1.3S_c$	(FT/FT)	0.072		
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		

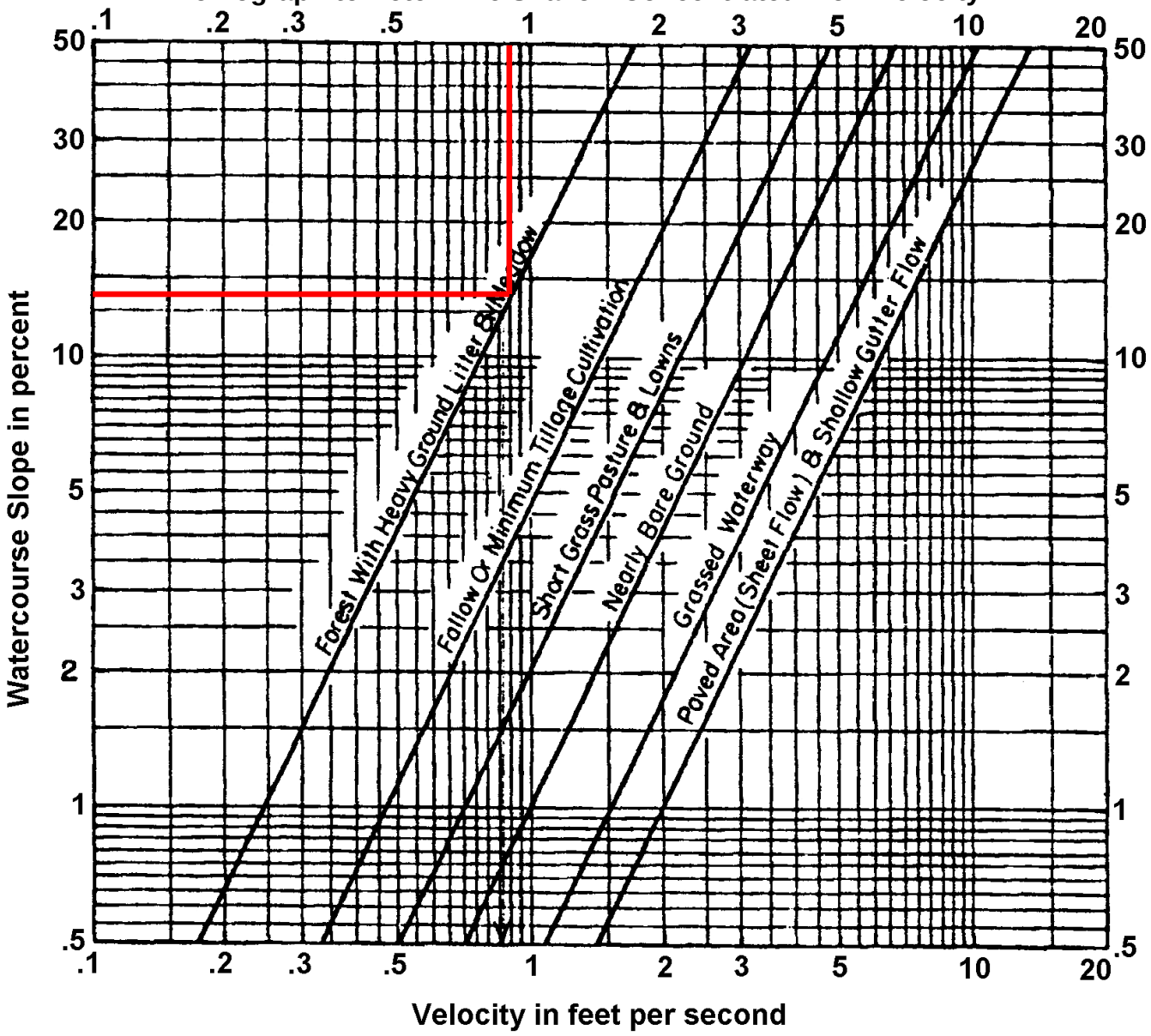
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_11.95

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

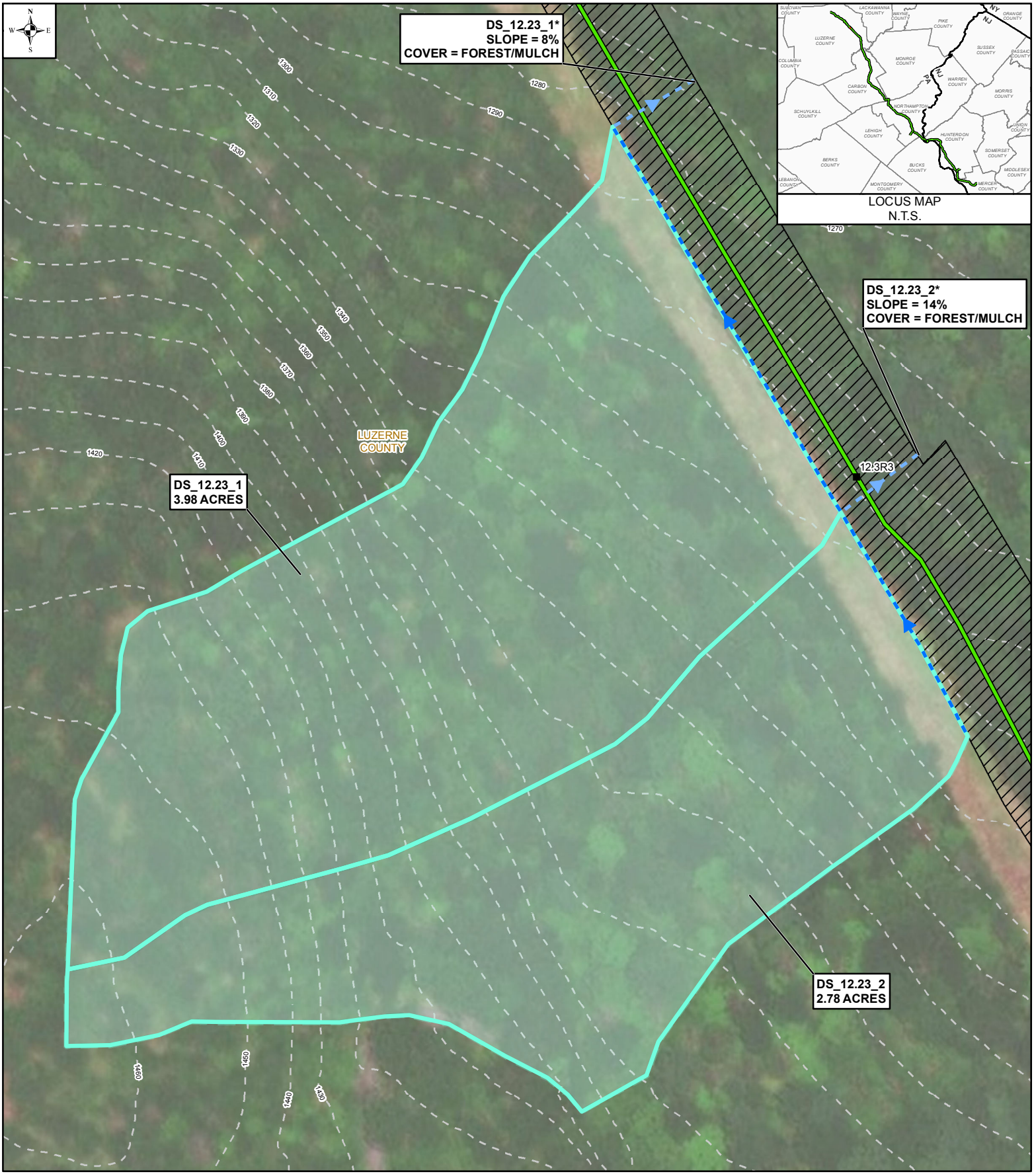


TR-55

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
- 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_12.23

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 15 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_12.23_1
4 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 12.23_1	100	0.8	0.050	12.91

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

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 12.23_1	650	FOREST	0.257	1.28	8.49
	106	SHORT GRASS	0.075	1.91	0.93

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)
22.33

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: LUZERNE 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 12.23_1	1	FOREST	0.20	3.70	0.74	0.21
	2	OPEN SPACE	0.28	0.30	0.08	

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}
	22.33	2.69	3.27	3.75	2.69	3.27	3.75

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)
	0.21	2.69	4.00	2.22	2.69	3.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_12.23_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	4		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.22		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.37		
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)	6.29		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.18		
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)	0.07		
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		

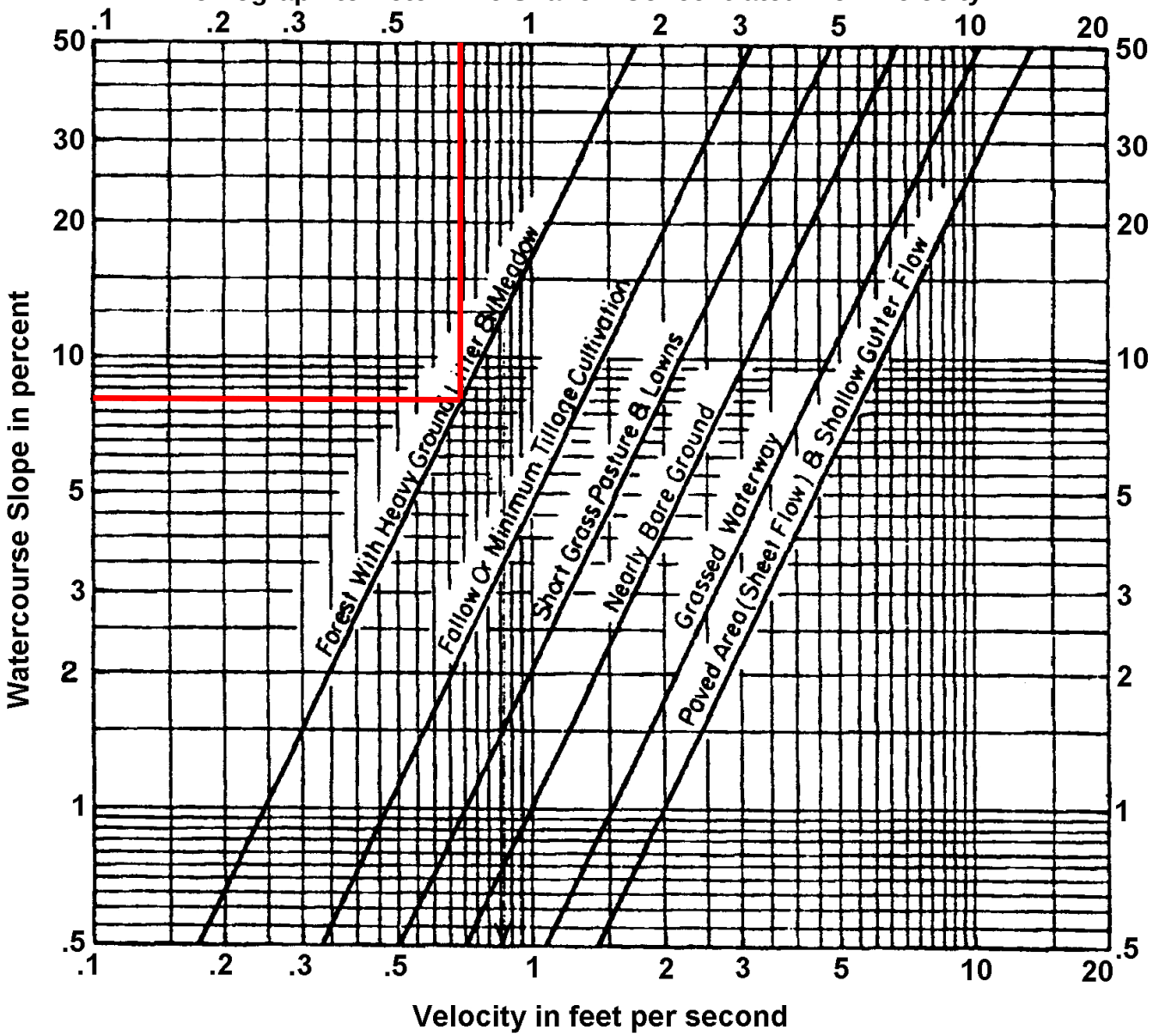
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_12.23_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 = 8%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_12.23_2
2.78 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 12.23_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 12.23_2	726	FOREST	0.191	1.10	11.00
	40	SHORT GRASS	0.125	2.46	0.27

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)
23.65

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: LUZERNE 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 12.23_2	1	FOREST	0.20	2.64	0.53	0.20
	2	OPEN SPACE	0.28	0.14	0.04	

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}
	23.65	2.61	3.17	3.64	2.61	3.17	3.64

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	2.61	2.78	1.48	1.80	2.07

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_12.23_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2.78		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.80		
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)	1.58		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.94		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	9.09 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.09		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.55		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.14		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.03		
S_C (CRITICAL SLOPE)	(FT/FT)	0.096		
$.7S_c$	(FT/FT)	0.067		
$1.3S_c$	(FT/FT)	0.125		
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		

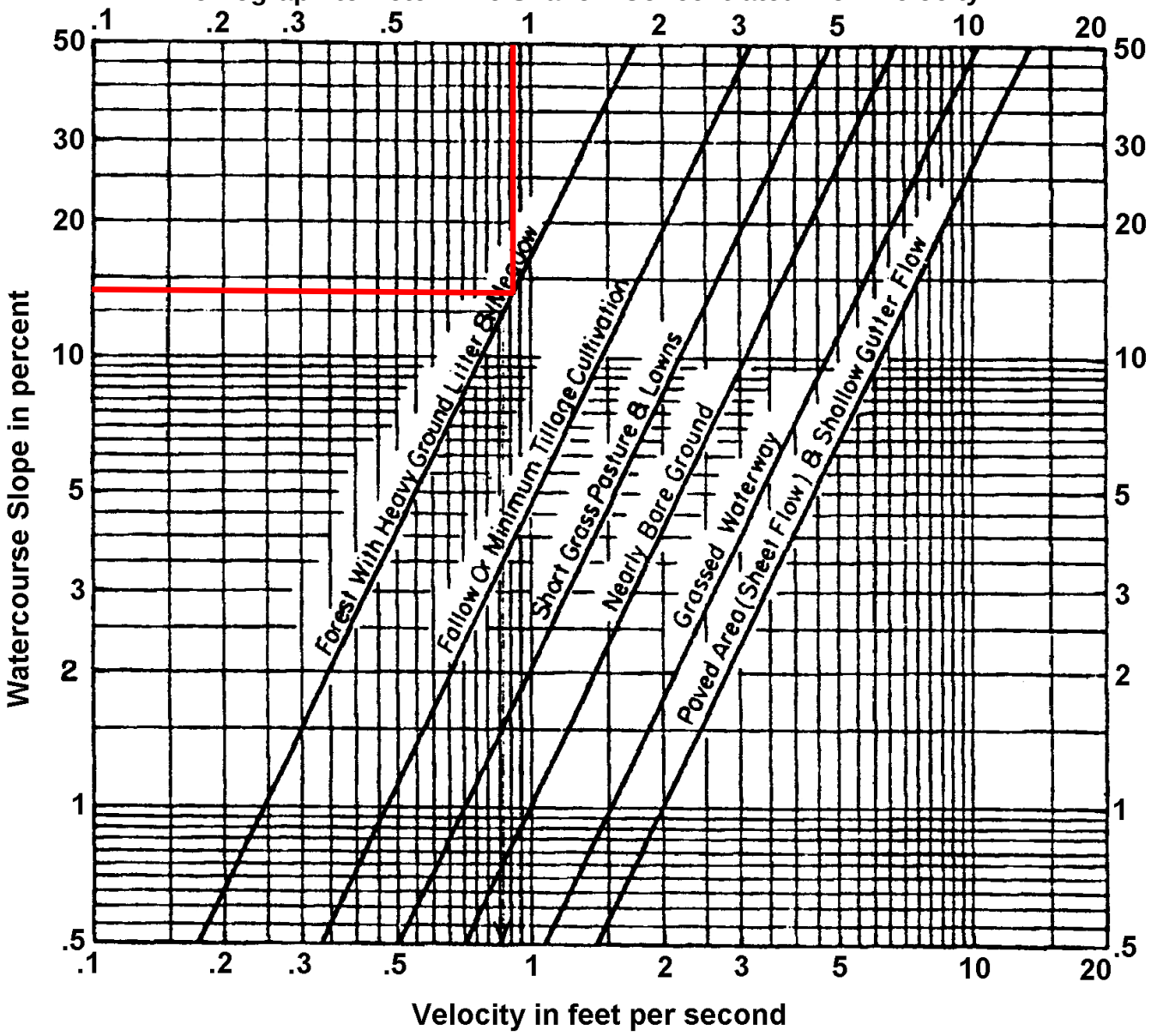
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_12.23_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

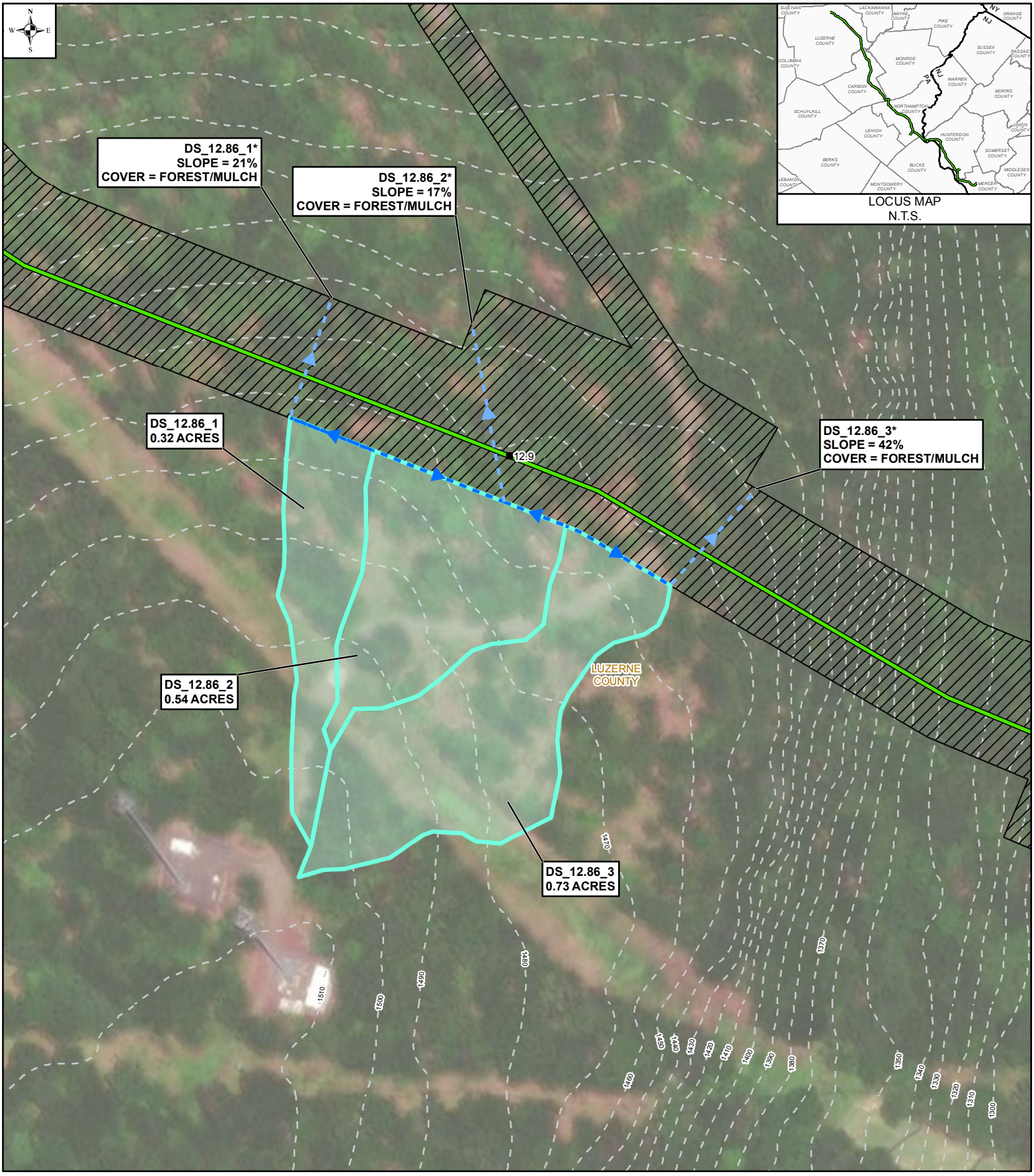


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 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
- 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_12.86

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 16 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_12.86_1
0.33 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 12.86_1	31	0.1	0.065	2.66

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

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 12.86_1	104	FOREST	0.097	0.78	2.21
	92	SHORT GRASS	0.109	2.30	0.67
	119	FOREST	0.168	1.03	1.92

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)
7.46

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: LUZERNE 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 12.86_1	1	FOREST	0.20	0.26	0.05	0.24
	2	OPEN SPACE	0.28	0.05	0.01	
	3	INDUSTRIAL	0.69	0.02	0.01	

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}
	7.46	0.54	0.63	0.69	4.33	5.10	5.58

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)
	0.24	4.33	0.33	0.35	0.41	0.45

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_12.86_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.33		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.35		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.44		
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)	1.96		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.042		
S_C (CRITICAL SLOPE)	(FT/FT)	0.088		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.114		
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		

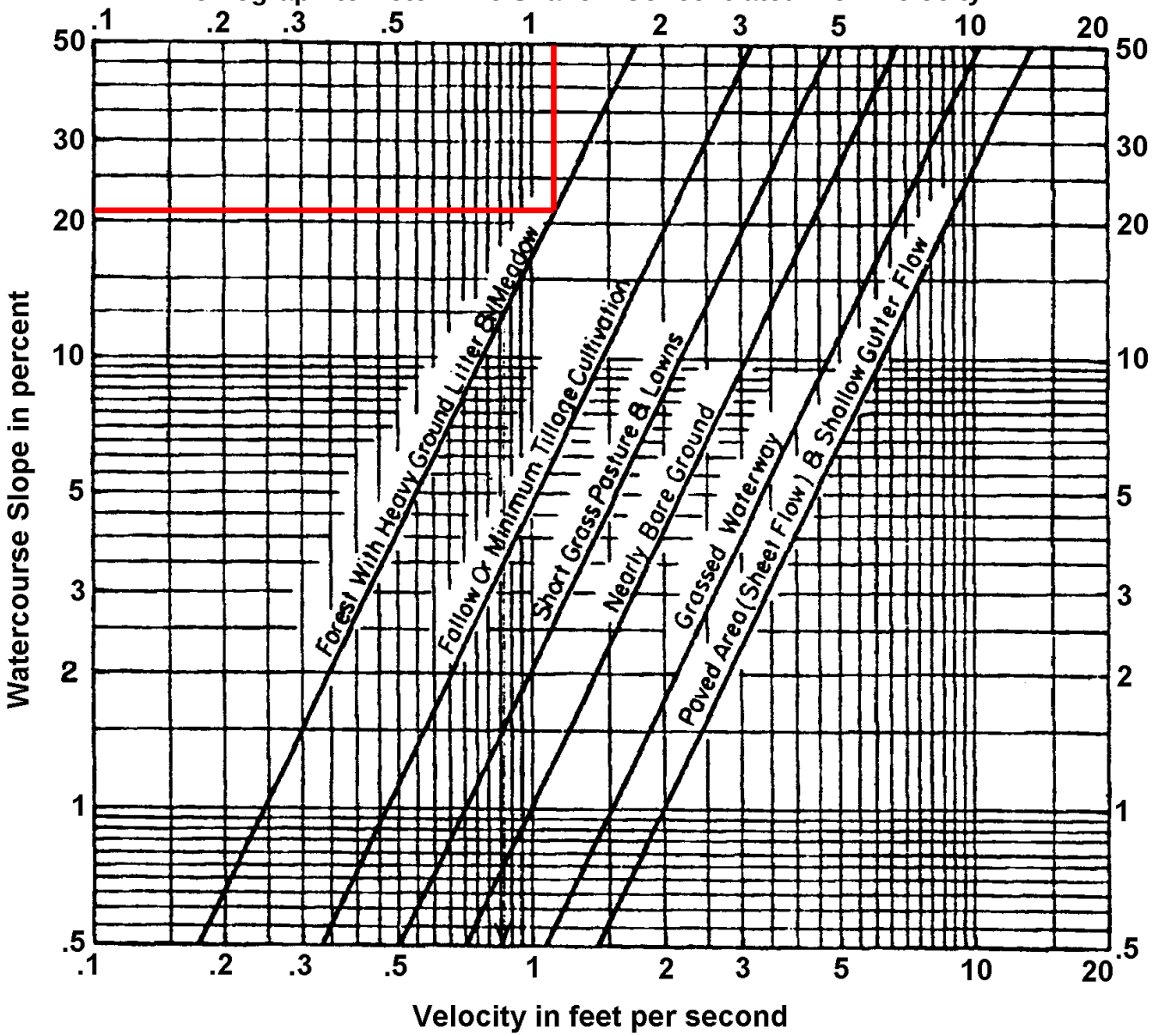
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_12.86_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 = 21%

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_12.86_2
0.54 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 12.86_2	37	0.8	0.108	6.78

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

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 12.86_2	37	SHORT GRASS	0.135	2.56	0.24
	113	FOREST	0.186	3.00	0.63
	29	PAVEMENT	0.103	6.52	0.07
	70	FOREST	0.100	0.80	1.47

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)
9.19

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: LUZERNE 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 12.86_2	1	FOREST	0.20	0.52	0.10	0.21
	2	OPEN SPACE	0.28	0.02	0.01	
	3	INDUSTRIAL	0.70	0.00	0.00	

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}
	9.19	0.62	0.73	0.81	4.05	4.79	5.28

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)
	0.21	4.05	0.54	0.45	0.53	0.59

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		**DS_12.86_2a**	DS_12.86_2b	
TEMPORARY OR PERMANENT?	(T OR P)	**T**	T	
DESIGN STORM	(2, 5, OR 10 YR)	**2**	2	
ACRES	(AC)	**0.54**	0.54	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	**N/A**	N/A	
Q_r (REQUIRED CAPACITY)	(CFS)	**0.45**	0.45	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	**2.02**	2.44	
PROTECTIVE LINING[2,6]		**C350**	S75	
n (MANNING'S COEFFICIENT)[2]		**0.041**	0.055	
V_a (ALLOWABLE VELOCITY)	(FPS)	**N/A**	N/A	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	**3.88**	1.96	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	**3.20**	1.55	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	**3.12**	1.19	
CHANNEL BOTTOM WIDTH	(FT)	**0**	0	
CHANNEL SIDE SLOPES	(H:V)	**4.17 / 0**	10 / 0	
D (TOTAL DEPTH)	(FT)	**1.00**	1.00	
CHANNEL TOP WIDTH @ D	(FT)	**4.17**	10.00	
d (CALCULATED FLOW DEPTH)	(FT)	**0.50**	0.50	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	**2.08**	5.00	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	**0**	0	
d_{50} STONE SIZE	(IN)	**N/A**	N/A	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	**0.52**	1.25	
R (HYDRAULIC RADIUS)		**0.20**	0.23	
S (BED SLOPE)[3]	(FT/FT)	**0.1**	0.038	
S_C (CRITICAL SLOPE)	(FT/FT)	**0.053**	0.080	
$.7S_c$	(FT/FT)	**0.037**	0.056	
$1.3S_c$	(FT/FT)	**0.069**	0.104	
STABLE FLOW?	(Y/N)	**Y**	Y	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	**N/A**	N/A	
FREEBOARD BASED ON STABLE FLOW	(FT)	**0.50**	0.50	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	**0.50**	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		**S**	S	

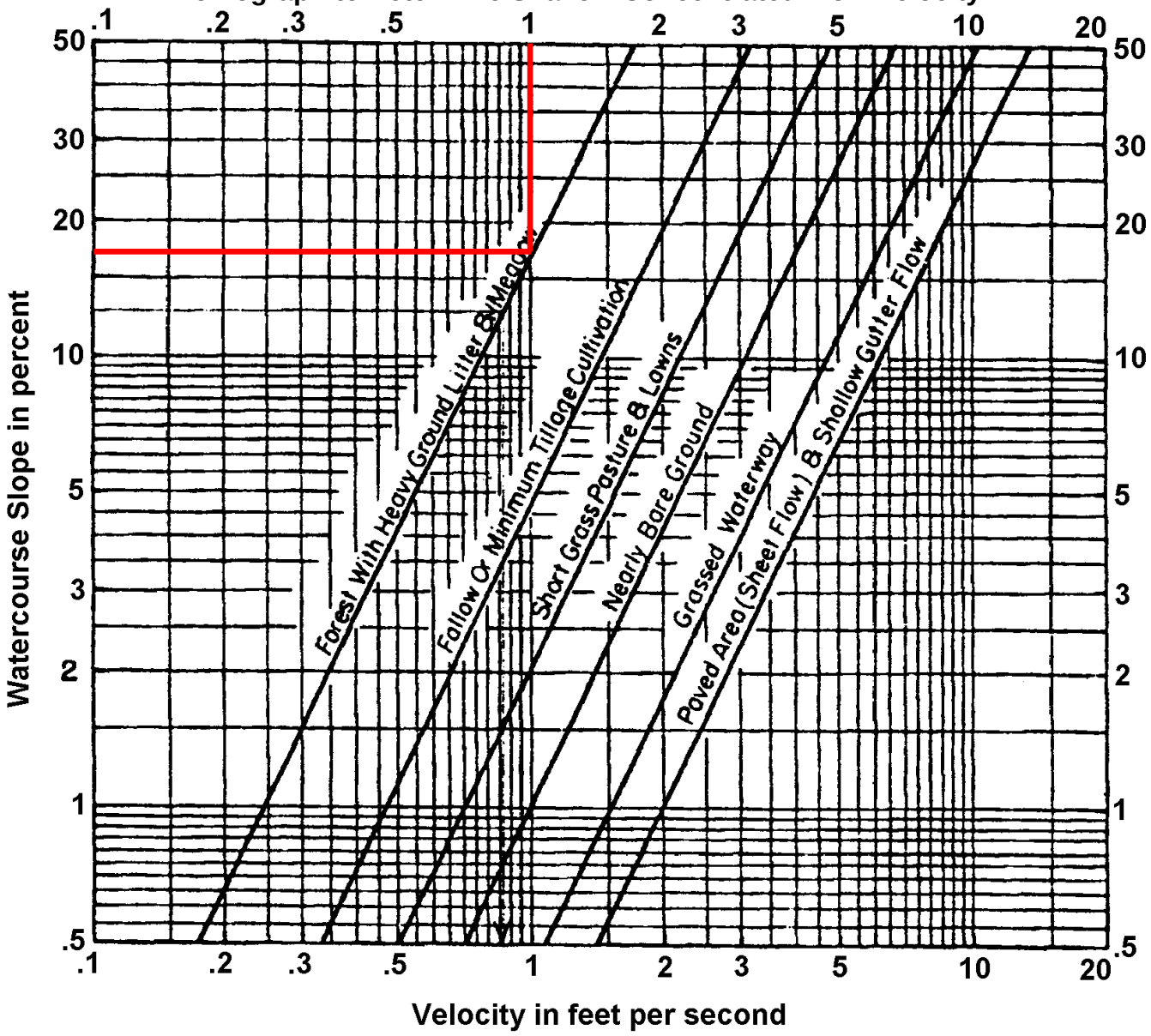
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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 methods 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. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION ID:
DS_12.86_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 = 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_12.86_3
0.73 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 12.86_3	100	0.8	0.133	10.27

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

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 12.86_3	36	FOREST	0.310	1.40	0.43
	57	SHORT GRASS	0.087	2.05	0.46
	245	FOREST	0.102	0.80	5.08

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)
16.25

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: LUZERNE 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 12.86_3	1	FOREST	0.20	0.60	0.12	0.21
	2	OPEN SPACE	0.28	0.13	0.04	

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}
	16.25	0.86	1.04	1.17	3.19	3.83	4.33

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)
	0.21	3.19	0.73	0.50	0.60	0.68

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_12.86_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.73		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.5		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.41		
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)	1.96		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.75 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.75		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.87		
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)	0.042		
S_C (CRITICAL SLOPE)	(FT/FT)	0.088		
$.7S_c$	(FT/FT)	0.062		
$1.3S_c$	(FT/FT)	0.114		
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		

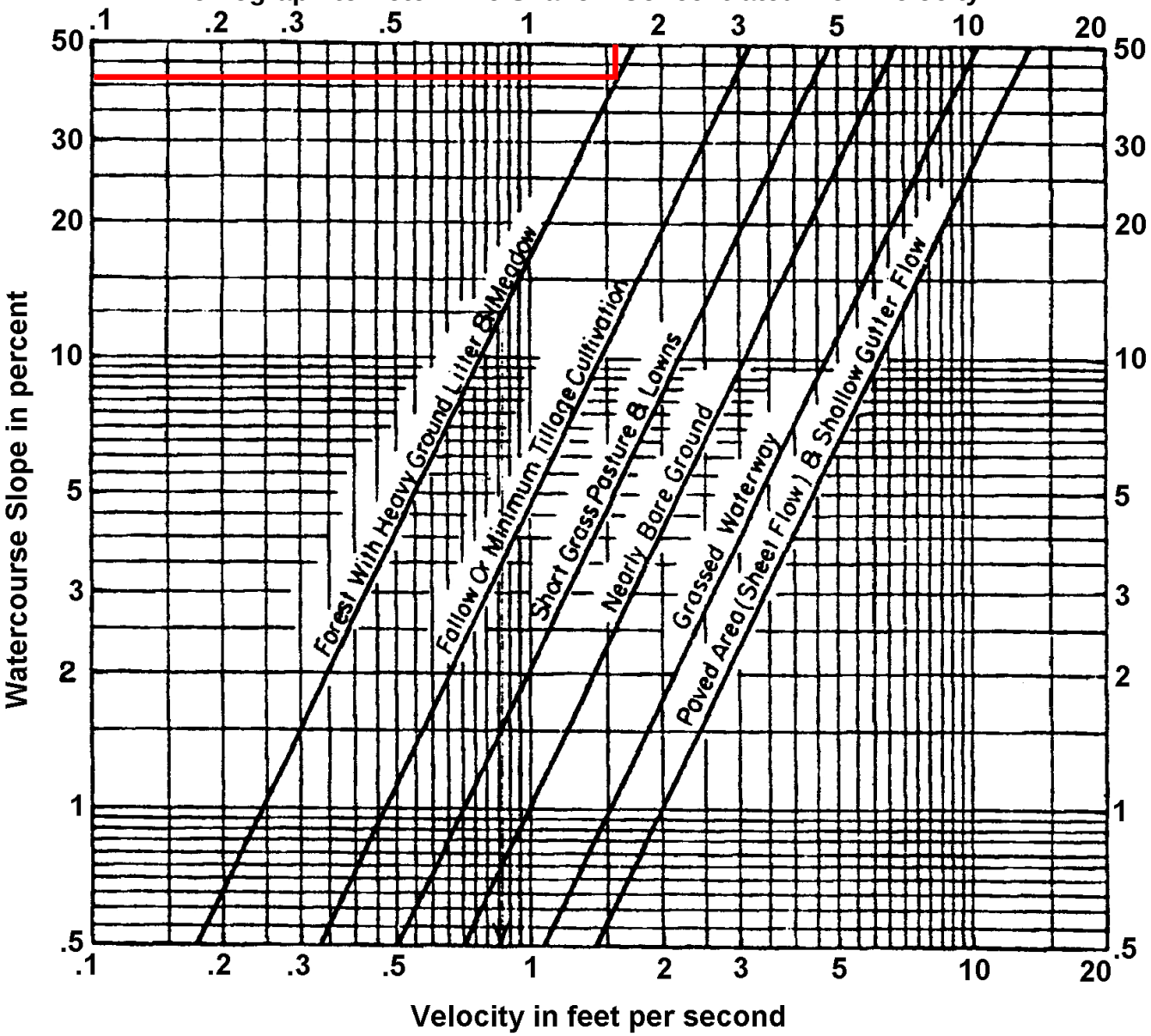
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_12.86_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

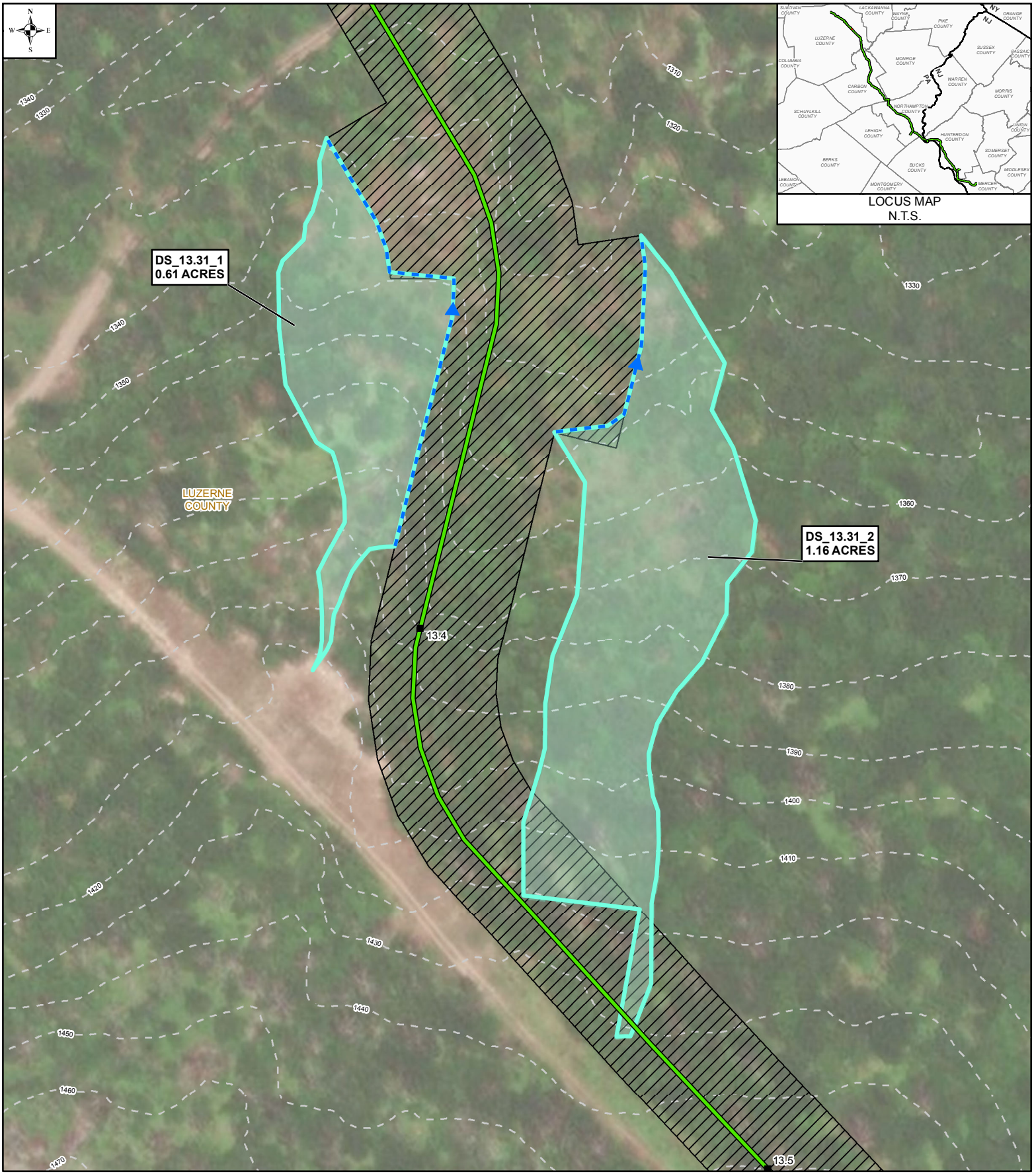


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 42%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.6 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.

1.6 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_13.31

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 17 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_13.31_1
0.61 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 13.31_1	100	0.4	0.210	6.68

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

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 13.31_1	352	FOREST	0.180	1.07	5.50

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)
12.18

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: LUZERNE 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 13.31_1	1	FOREST	0.20	0.61	0.12	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}
	12.18	0.74	0.88	0.98	3.63	4.33	4.83

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	3.63	0.61	0.44	0.53	0.59

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		DS_13.31_1a	**DS_13.31_1a**	DS_13.31_1b
TEMPORARY OR PERMANENT?	(T OR P)	T	**T**	T
DESIGN STORM	(2, 5, OR 10 YR)	2	**2**	2
ACRES	(AC)	0.61	**0.61**	0.61
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A	**N/A**	N/A
Q_r (REQUIRED CAPACITY)	(CFS)	0.44	**0.44**	0.44
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.23	**5.23**	0.67
PROTECTIVE LINING[2,6]		P300 (Unvegetated)	**P300 (Vegetated)**	C125
n (MANNING'S COEFFICIENT)[2]		0.034	**0.034**	0.055
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	**N/A**	N/A
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	6.28	**6.28**	1.29
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00	**8.00**	2.25
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	4.99	**4.99**	0.62
CHANNEL BOTTOM WIDTH	(FT)	0	**0**	0
CHANNEL SIDE SLOPES	(H:V)	6.67 / 0	**6.67 / 0**	4.17 / 0
D (TOTAL DEPTH)	(FT)	1.00	**1.00**	1.00
CHANNEL TOP WIDTH @ D	(FT)	6.67	**6.67**	4.17
d (CALCULATED FLOW DEPTH)	(FT)	0.50	**0.50**	0.50
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.33	**3.33**	2.08
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0	**0**	0
d_{50} STONE SIZE	(IN)	N/A	**N/A**	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.83	**0.83**	0.52
R (HYDRAULIC RADIUS)		0.22	**0.22**	0.20
S (BED SLOPE)[3]	(FT/FT)	0.16	**0.16**	0.02
S_C (CRITICAL SLOPE)	(FT/FT)	0.033	**0.033**	0.096
$.7S_c$	(FT/FT)	0.023	**0.023**	0.067
$1.3S_c$	(FT/FT)	0.042	**0.042**	0.125
STABLE FLOW?	(Y/N)	Y	**Y**	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	**N/A**	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	**0.50**	0.50
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	**0.50**	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	**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 methods 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. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_13.31_2
1.16 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 13.31_2	100	0.8	0.135	10.24

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

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 13.31_2	588	FOREST	0.145	0.96	10.23

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)
20.47

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: LUZERNE 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 13.31_2	1	FOREST	0.20	1.16	0.23	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}
	20.47	2.83	3.42	3.91	2.83	3.42	3.91

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	2.83	1.16	0.66	0.79	0.91

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

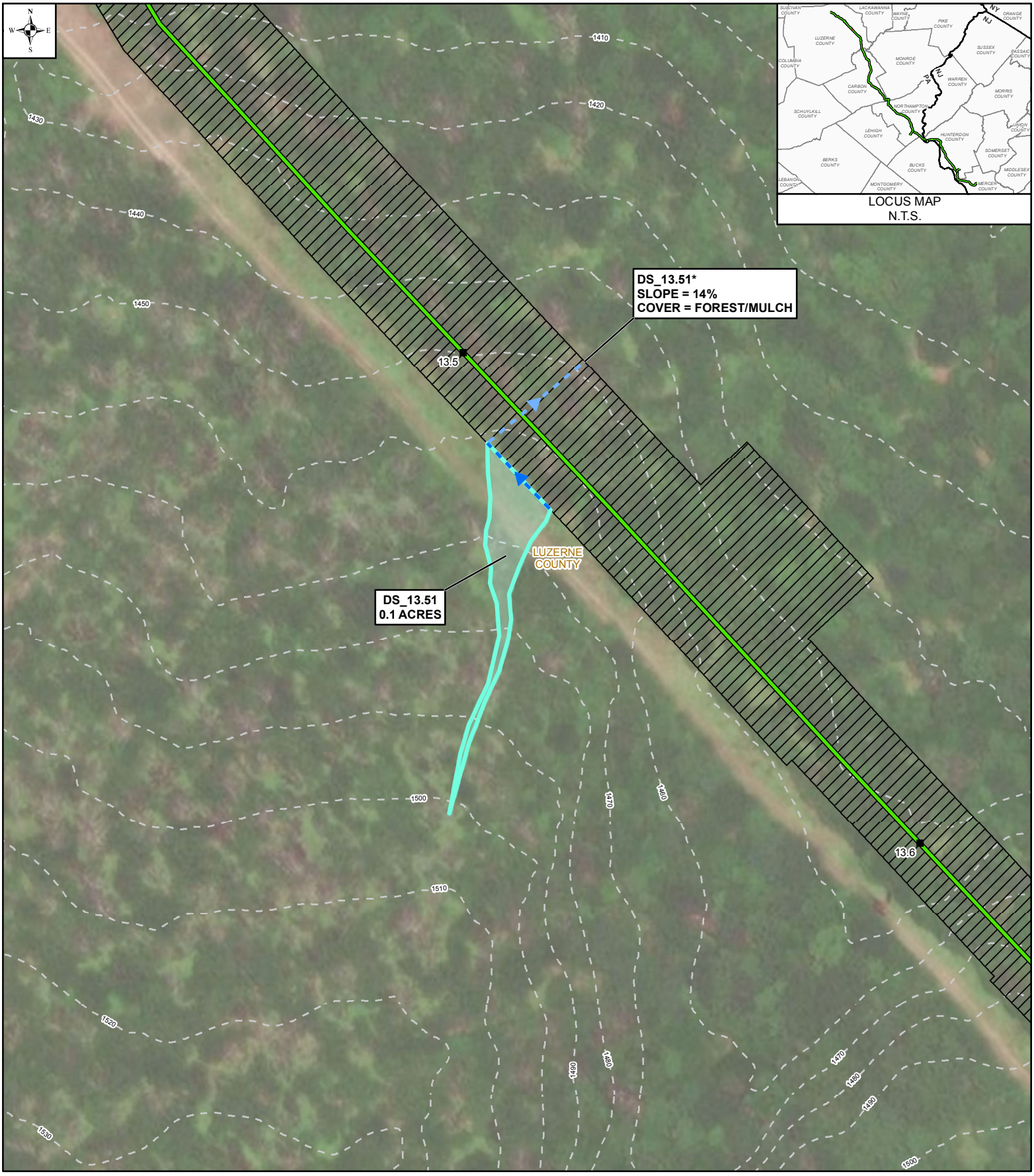
LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		DS_13.31_2a	**DS_13.31_2a**	DS_13.31_2b
TEMPORARY OR PERMANENT?	(T OR P)	T	**T**	T
DESIGN STORM	(2, 5, OR 10 YR)	2	**2**	2
ACRES	(AC)	1.16	**1.16**	1.16
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A	**N/A**	N/A
Q_r (REQUIRED CAPACITY)	(CFS)	0.66	**0.66**	0.66
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.77	**1.77**	1.32
PROTECTIVE LINING[2,6]		P300 (Unvegetated)	**P300 (Vegetated)**	C125
n (MANNING'S COEFFICIENT)[2]		0.034	**0.034**	0.022
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	**N/A**	N/A
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.67	**5.67**	3.69
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00	**8.00**	2.25
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	5.62	**5.62**	0.94
CHANNEL BOTTOM WIDTH	(FT)	0	**0**	0
CHANNEL SIDE SLOPES	(H:V)	2.5 / 0	**2.5 / 0**	2.86 / 0
D (TOTAL DEPTH)	(FT)	1.00	**1.00**	1.00
CHANNEL TOP WIDTH @ D	(FT)	2.50	**2.50**	2.86
d (CALCULATED FLOW DEPTH)	(FT)	0.50	**0.50**	0.50
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.25	**1.25**	1.43
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0	**0**	0
d_{50} STONE SIZE	(IN)	N/A	**N/A**	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.31	**0.31**	0.36
R (HYDRAULIC RADIUS)		0.17	**0.17**	0.18
S (BED SLOPE)[3]	(FT/FT)	0.18	**0.18**	0.03
S_C (CRITICAL SLOPE)	(FT/FT)	0.045	**0.045**	0.018
$.7S_c$	(FT/FT)	0.031	**0.031**	0.012
$1.3S_c$	(FT/FT)	0.058	**0.058**	0.023
STABLE FLOW?	(Y/N)	Y	**Y**	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	**N/A**	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	**0.50**	0.50
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	**0.50**	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	**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 methods 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. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.



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_13.51

LUZERNE COUNTY, PENNSYLVANIA

0 50 100 FEET

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

PennEast PIPELINE

DWG NO: PAGE 18 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 13.51	100	0.8	0.130	10.33

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

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 13.51	140	FOREST	0.150	0.97	2.39
	60	SHORT GRASS	0.100	2.20	0.45

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)
13.18

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: LUZERNE 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 13.51	1	FOREST	0.20	0.05	0.01	0.24
	2	OPEN SPACE	0.28	0.05	0.01	

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}
	13.18	3.51	4.20	4.70	3.51	4.20	4.70

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)
	0.24	3.51	0.10	0.08	0.10	0.11

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_13.51		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.1		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.08		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.25		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.05		
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)	0.73		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.5 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	8.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.08		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.17		
R (HYDRAULIC RADIUS)		0.08		
S (BED SLOPE)[3, 7]	(FT/FT)	0.07		
S_C (CRITICAL SLOPE)	(FT/FT)	0.093		
$.7S_c$	(FT/FT)	0.065		
$1.3S_c$	(FT/FT)	0.121		
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		

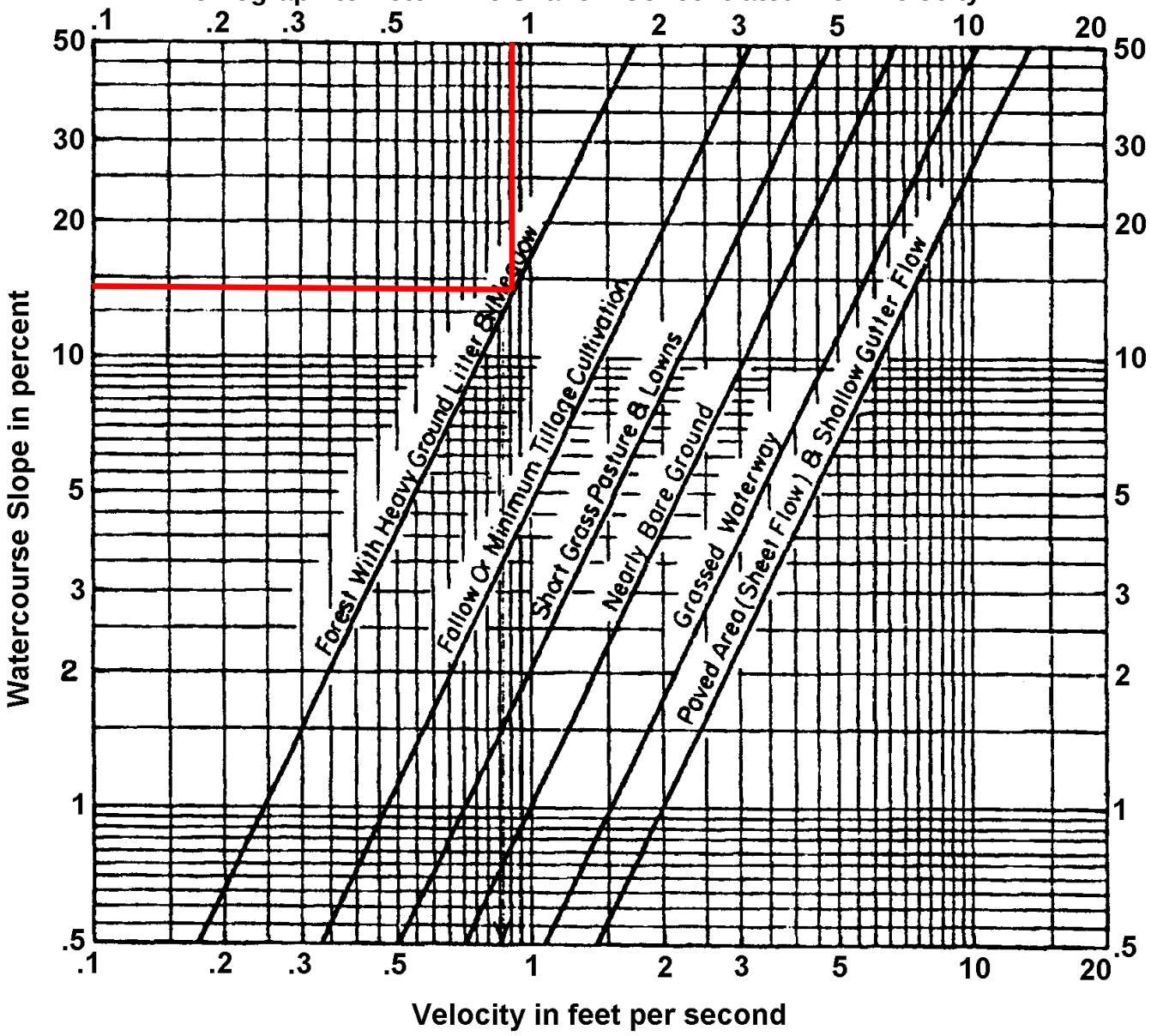
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_13.51

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

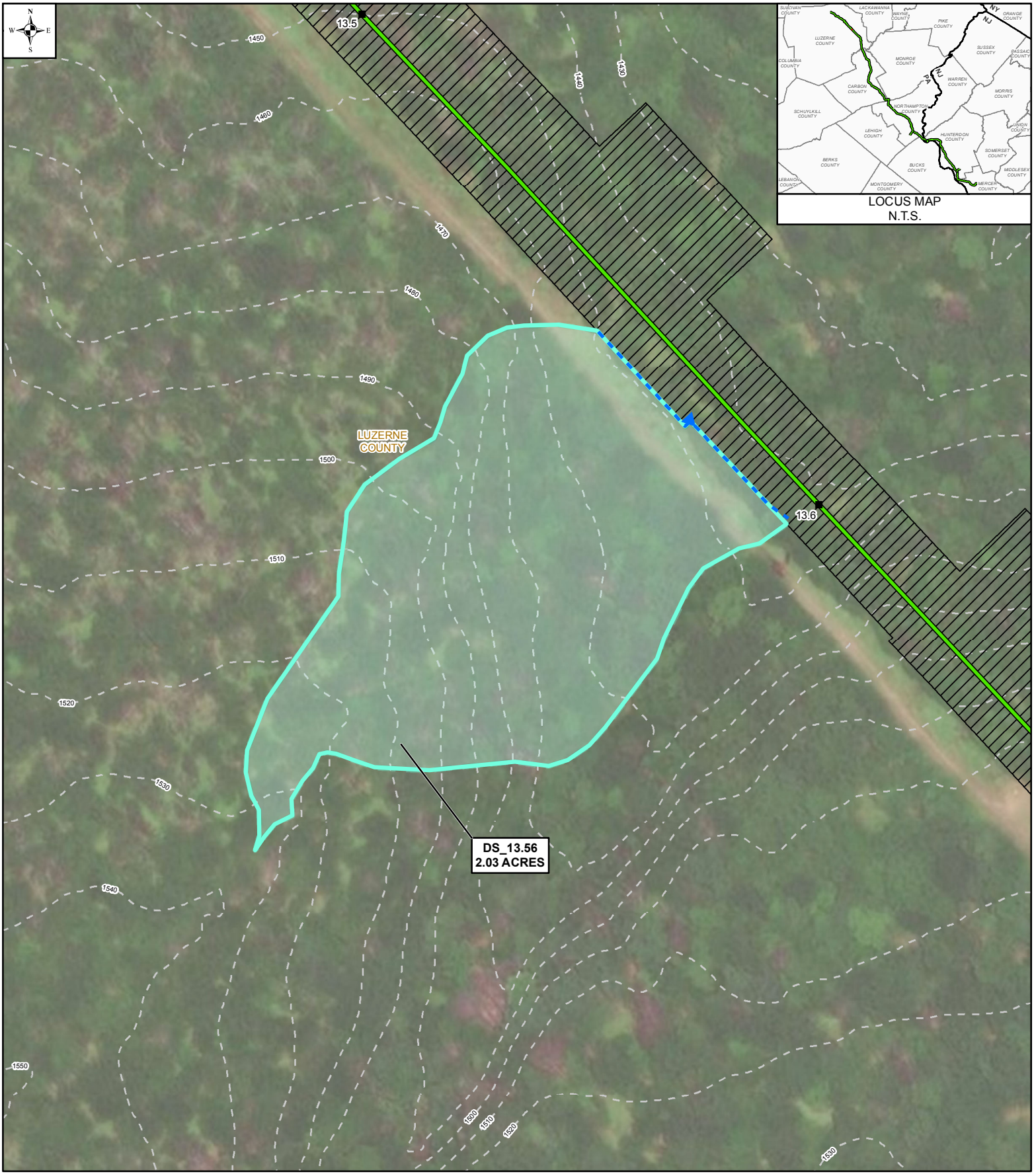


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.9 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.

1.9 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
- 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_13.56

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 19 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 13.56	100	0.8	0.124	10.44

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

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 13.56	435	FOREST	0.186	1.09	6.68
	26	SHORT GRASS	0.115	2.36	0.18

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)
17.31

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: LUZERNE 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 13.56	1	FOREST	0.20	1.87	0.37	0.21
	2	OPEN SPACE	0.28	0.16	0.04	

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}
	17.31	3.09	3.72	4.22	3.09	3.72	4.22

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)
	0.21	3.09	2.03	1.29	1.56	1.77

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

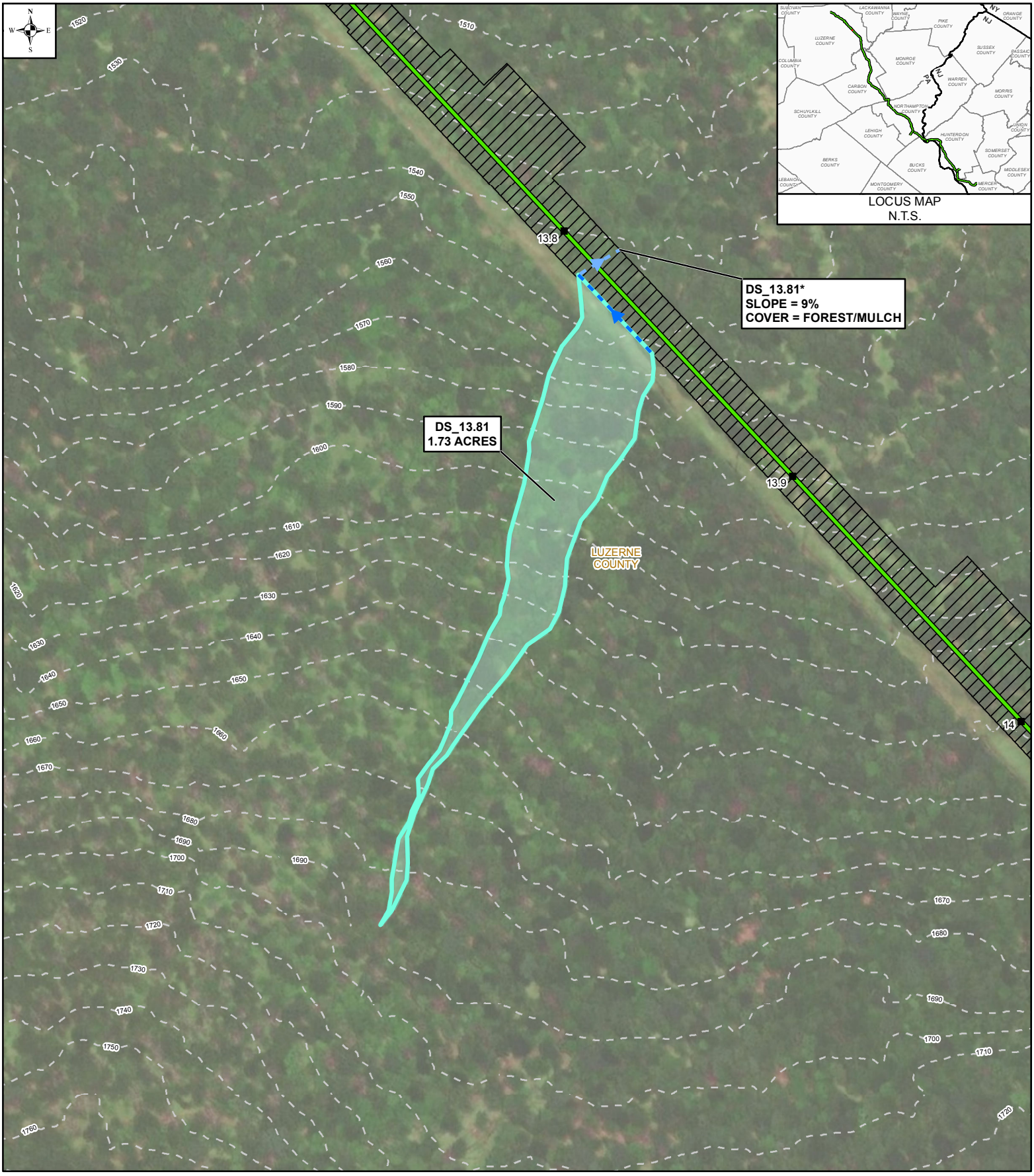
LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_13.56		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	2.03		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.29		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.50		
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)	1.50		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
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)	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)	0.023		
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
- 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_13.81

LUZERNE 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 20 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 13.81	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 13.81	929	FOREST	0.141	0.94	16.39
	67	SHORT GRASS	0.044	1.46	0.76

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)
28.72

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: LUZERNE 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 13.81	1	FOREST	0.20	1.58	0.32	0.20
	2	OPEN SPACE	0.21	0.15	0.03	

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}
	28.72	2.32	2.83	3.29	2.32	2.83	3.29

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	2.32	1.73	0.81	0.98	1.14

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_13.81		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.73		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.81		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.95		
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)	3.06		
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)	22.22 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	14.81		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.70		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.31		
R (HYDRAULIC RADIUS)		0.08		
S (BED SLOPE)[3, 7]	(FT/FT)	0.06		
S_C (CRITICAL SLOPE)	(FT/FT)	0.017		
$.7S_c$	(FT/FT)	0.012		
$1.3S_c$	(FT/FT)	0.022		
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		

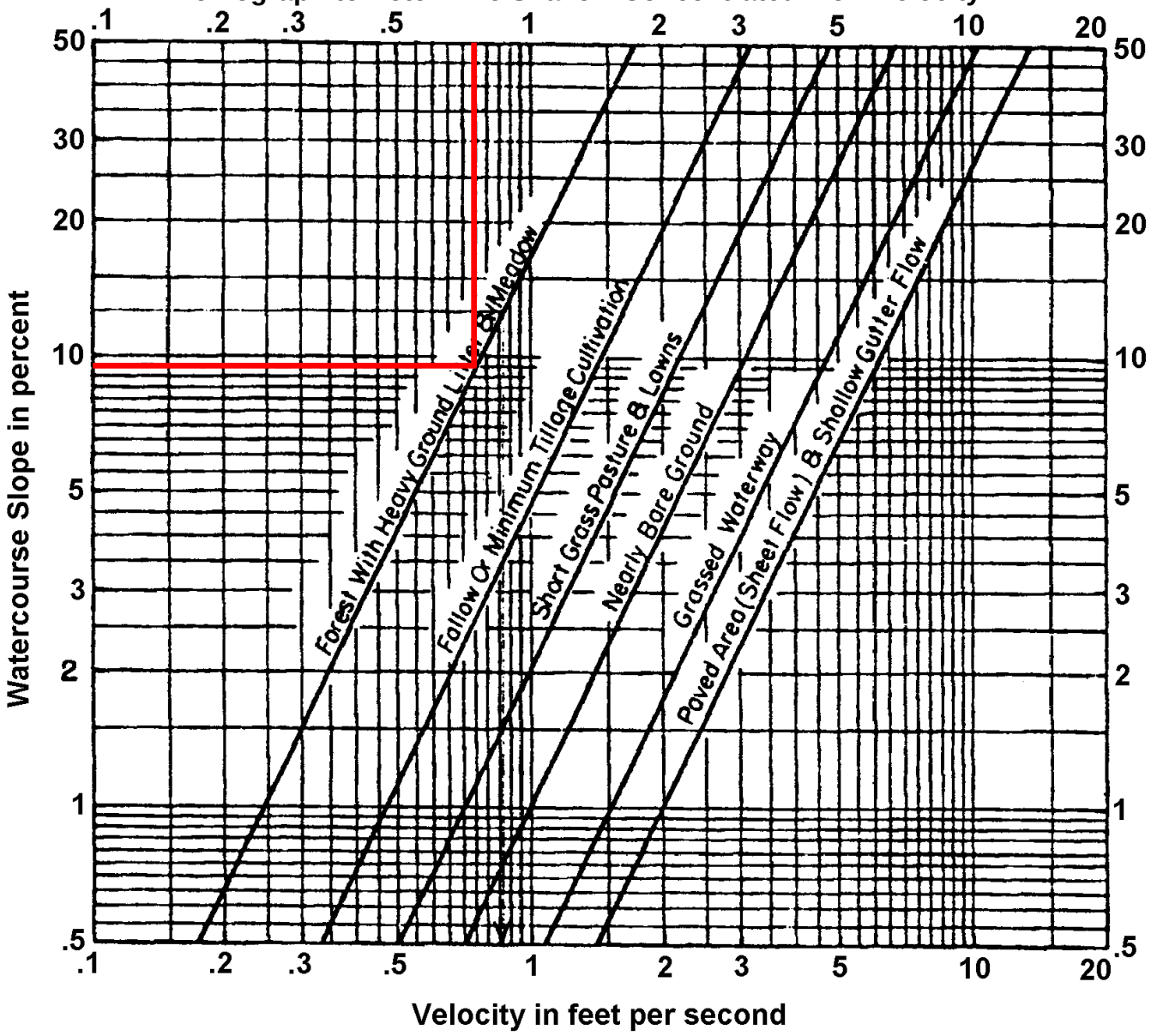
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_13.81

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

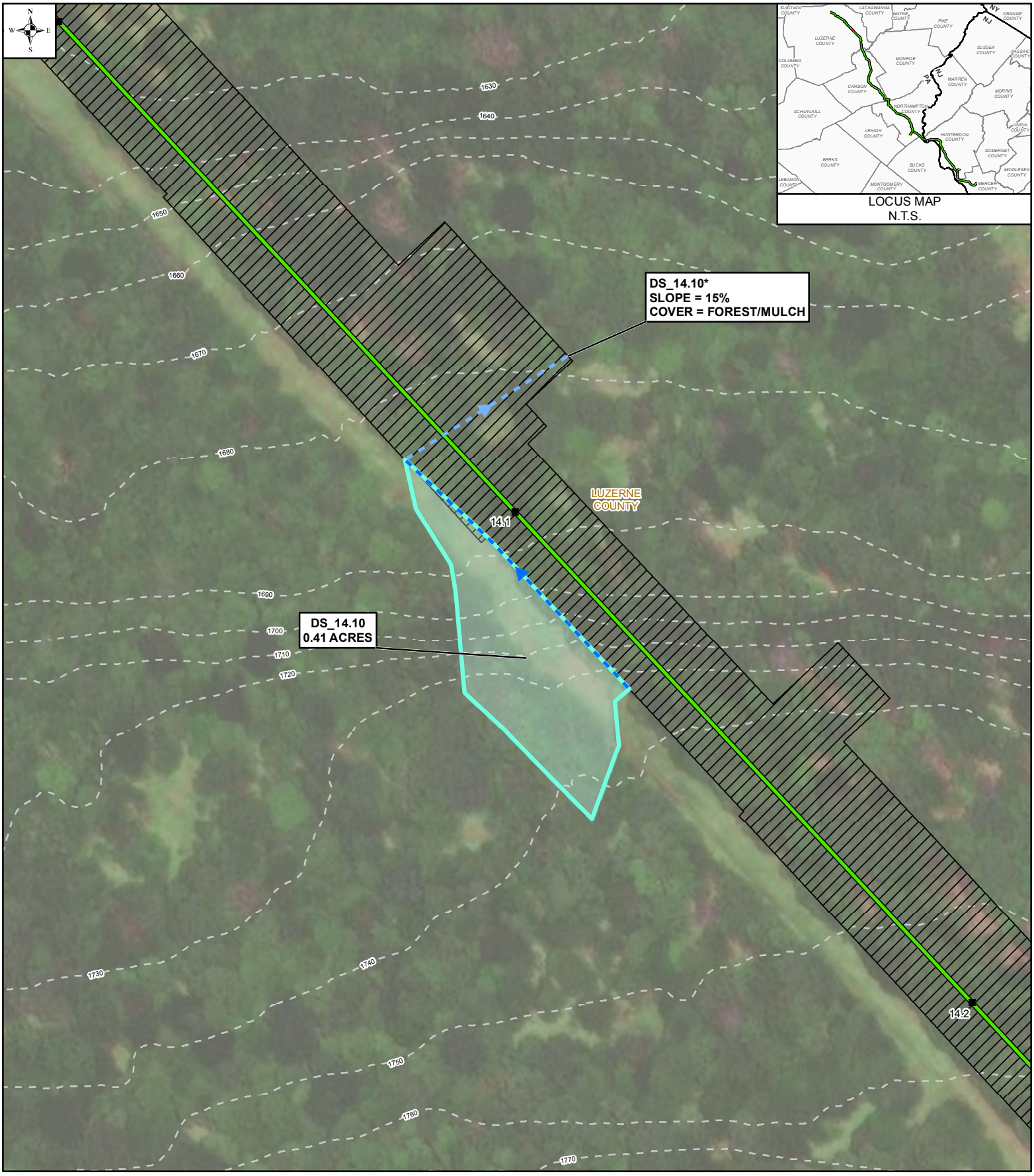


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 9%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 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.

0.8 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_14.10

LUZERNE COUNTY, PENNSYLVANIA

0 50 100 FEET

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

PennEast PIPELINE

DWG NO: PAGE 21 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 14.10	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 14.10	173	FOREST	0.283	1.34	2.15
	62	SHORT GRASS	0.048	1.53	0.68

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)
15.74

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: LUZERNE 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 14.10	1	FOREST	0.20	0.27	0.05	0.20
	2	OPEN SPACE	0.21	0.14	0.03	

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}
	15.74	3.24	3.89	4.39	3.24	3.89	4.39

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	3.24	0.41	0.27	0.32	0.37

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_14.10		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.41		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.27		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.28		
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)	1.58		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.08		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.8 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	8.54		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.18		
R (HYDRAULIC RADIUS)		0.08		
S (BED SLOPE)[3, 7]	(FT/FT)	0.1043		
S_C (CRITICAL SLOPE)	(FT/FT)	0.112		
$.7S_c$	(FT/FT)	0.078		
$1.3S_c$	(FT/FT)	0.145		
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		

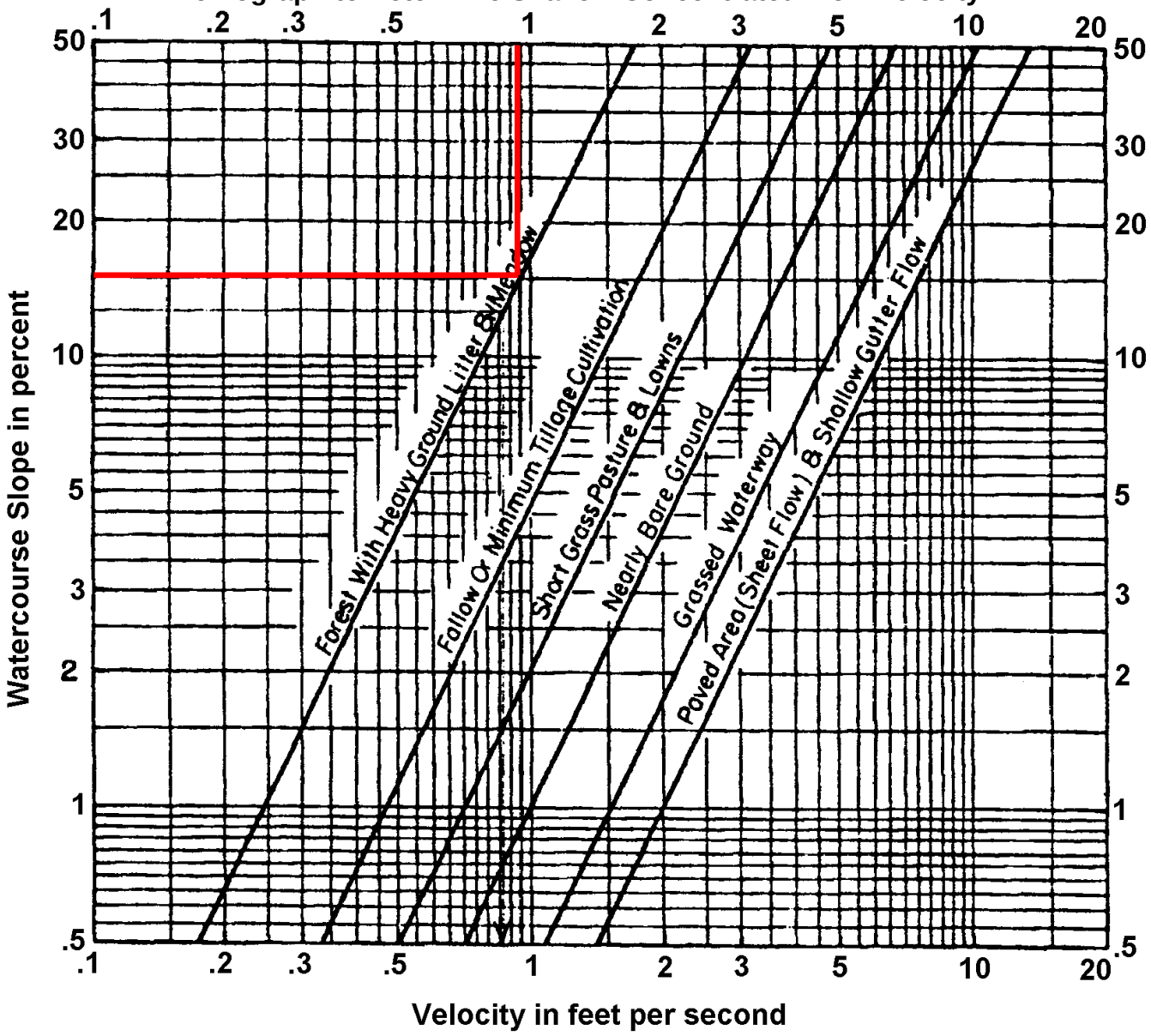
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_14.10

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

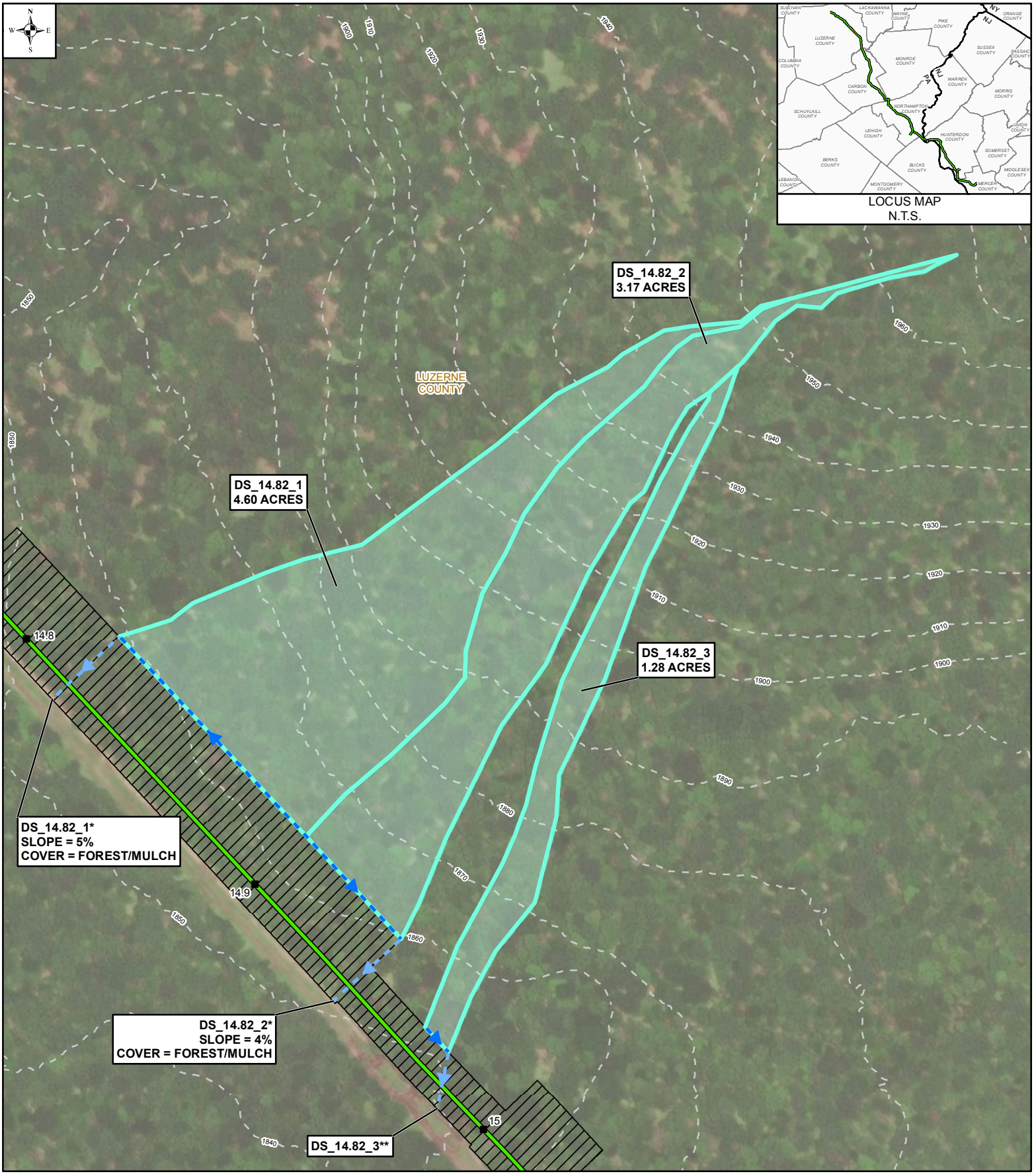


TR-55

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.



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_14.82

LUZERNE COUNTY, PENNSYLVANIA

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

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 22 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_14.82_1
4.6 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 14.82_1	100	0.8	0.040	13.60

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

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 14.82_1	1106	FOREST	0.080	0.71	25.90

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)
39.51

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: LUZERNE 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 14.82_1	1	FOREST	0.20	4.60	0.92	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}
	39.51	1.88	2.31	2.72	1.88	2.31	2.72

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	1.88	4.60	1.73	2.12	2.50

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_14.82_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	4.6		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.73		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.42		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.78		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.36		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	35.09 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	35.09		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	17.54		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	4.39		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.0116		
S_C (CRITICAL SLOPE)	(FT/FT)	0.154		
$.7S_c$	(FT/FT)	0.108		
$1.3S_c$	(FT/FT)	0.200		
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		

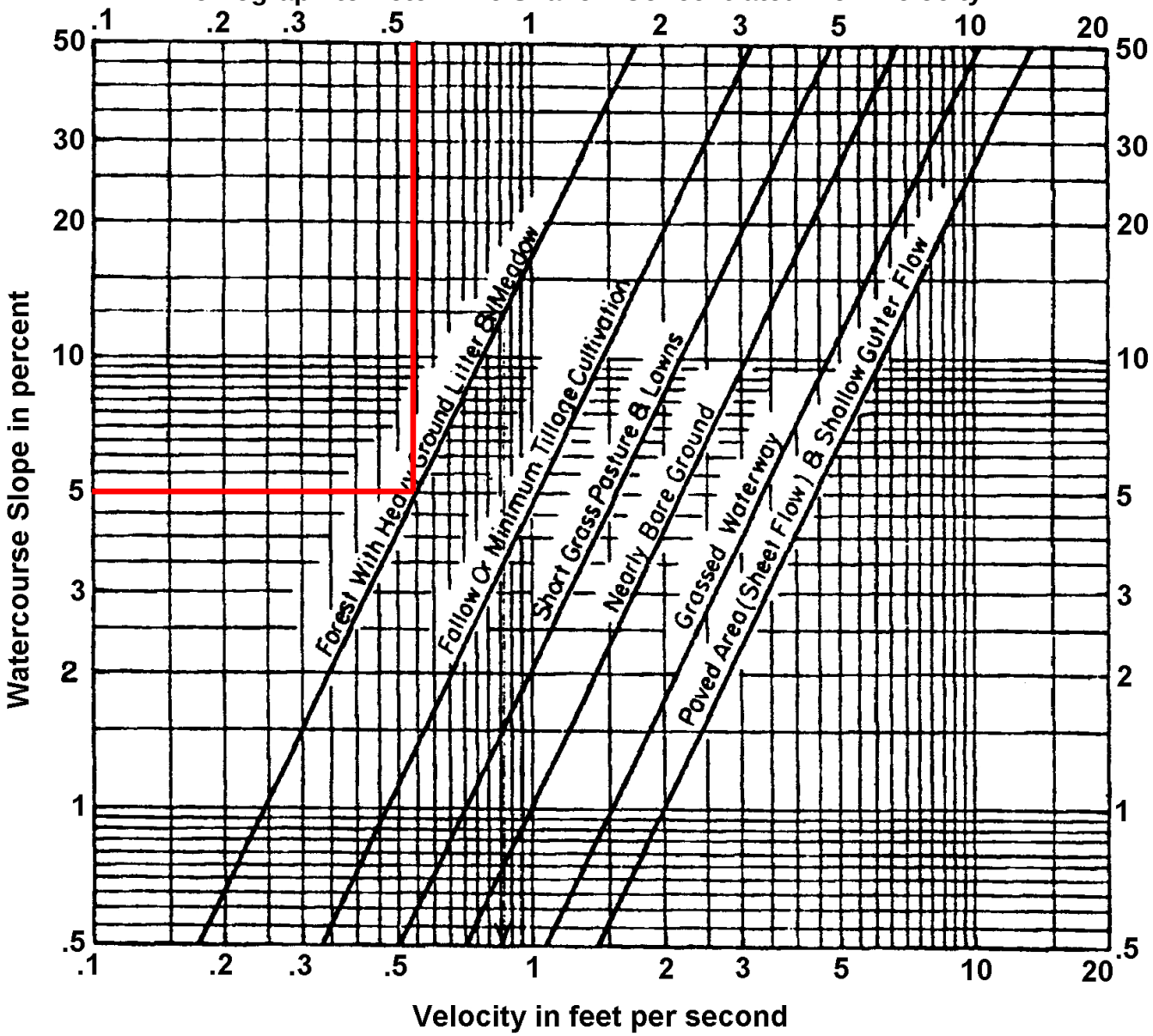
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_14.82_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 = 5%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_14.82_2
3.17 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 14.82_2	100	0.8	0.050	12.91

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

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 14.82_2	1360	FOREST	0.071	0.67	33.81

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)
46.72

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: LUZERNE 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 14.82_2	1	FOREST	0.20	3.17	0.63	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}
	46.72	1.66	2.05	2.44	1.66	2.05	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	1.66	3.17	1.05	1.30	1.55

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_14.82_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	3.17		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.06		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.93		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.08		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	14.29 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	14.29		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.14		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.79		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.0181		
S_C (CRITICAL SLOPE)	(FT/FT)	0.124		
$.7S_c$	(FT/FT)	0.087		
$1.3S_c$	(FT/FT)	0.162		
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		

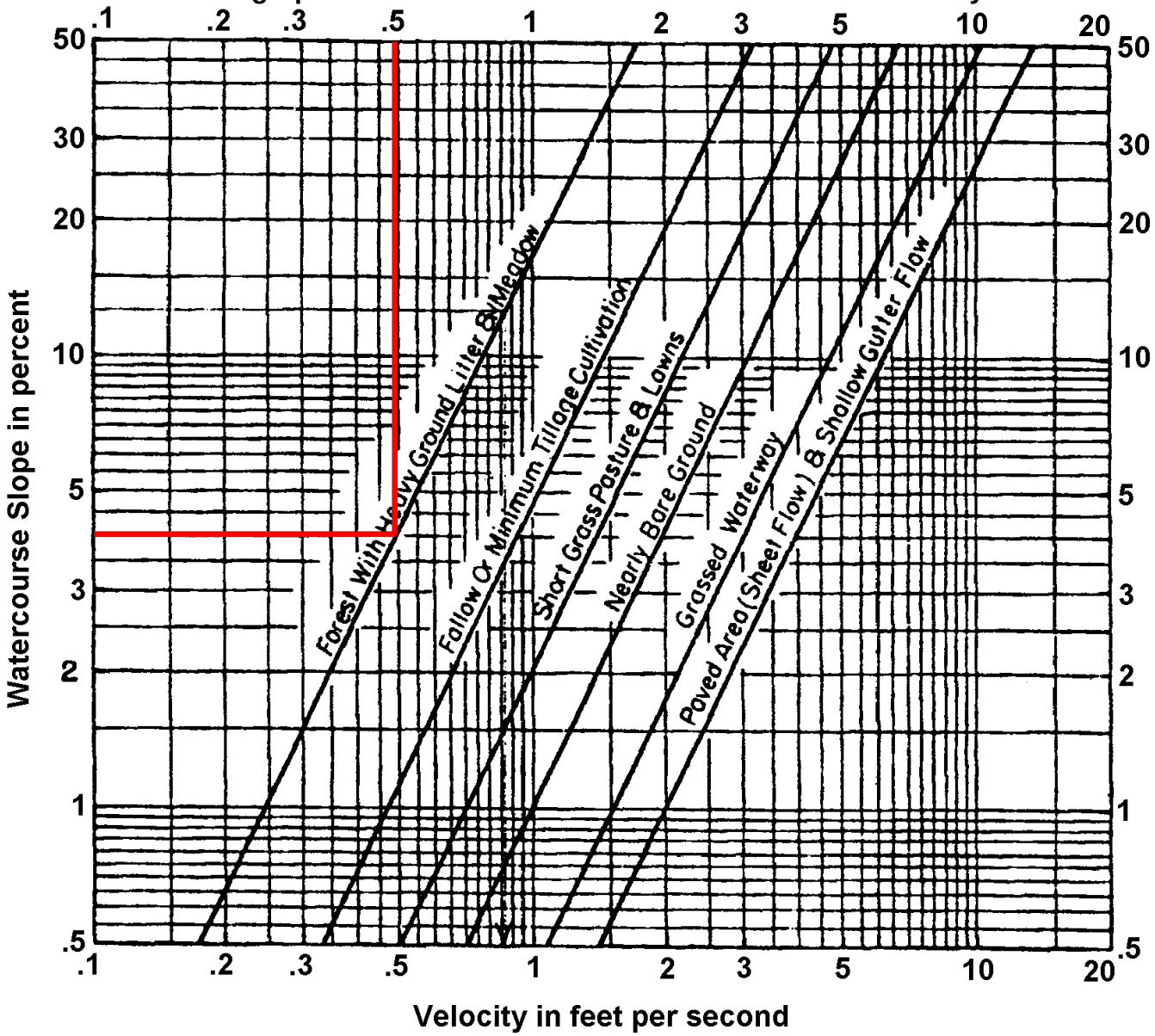
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_14.82_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 = 4%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.5 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_14.82_3
1.28 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 14.82_3	100	0.8	0.070	11.94

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

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 14.82_3	1083	FOREST	0.082	0.72	25.05

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)
36.99

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: LUZERNE 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 14.82_3	1	FOREST	0.20	1.28	0.26	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}
	36.99	1.96	2.41	2.83	1.96	2.41	2.83

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	1.96	1.28	0.50	0.62	0.73

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_14.82_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	1.28		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.5		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.07		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.11		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	14.93 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	14.93		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.46		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.87		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.019		
S_C (CRITICAL SLOPE)	(FT/FT)	0.124		
$.7S_c$	(FT/FT)	0.087		
$1.3S_c$	(FT/FT)	0.161		
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.

LOCUS MAP
N.T.S.

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_17.54

LUZERNE 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 23 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 17.54	100	0.8	0.030	14.55

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

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 17.54	331	FOREST	0.033	0.46	12.07
	46	PAVEMENT	0.043	4.22	0.18
	225	SHORT GRASS	0.058	1.68	2.24

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)
29.04

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: LUZERNE 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 17.54	1	FOREST	0.20	1.16	0.23	0.23
	2	OPEN SPACE	0.21	1.13	0.24	
	3	INDUSTRIAL	0.69	0.11	0.08	

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}
	29.04	2.30	2.81	3.27	2.30	2.81	3.27

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)
	0.23	2.81	2.40	1.26	1.53	1.78

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_17.54		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.4		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.53		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.80		
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)	1.95		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.15		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	11.49 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	11.49		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.75		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.44		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.037		
S_C (CRITICAL SLOPE)	(FT/FT)	0.079		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.102		
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		

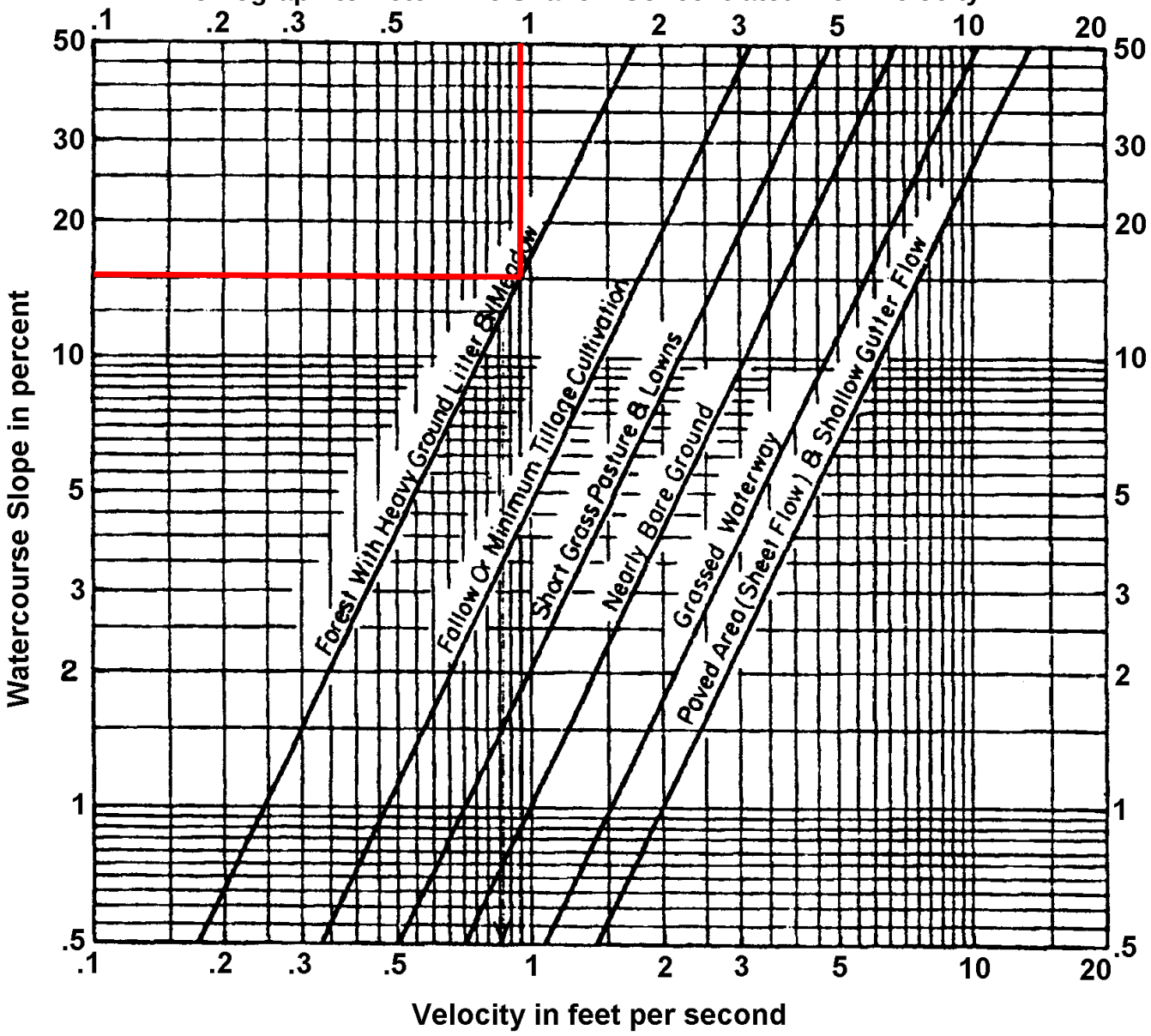
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_17.54

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

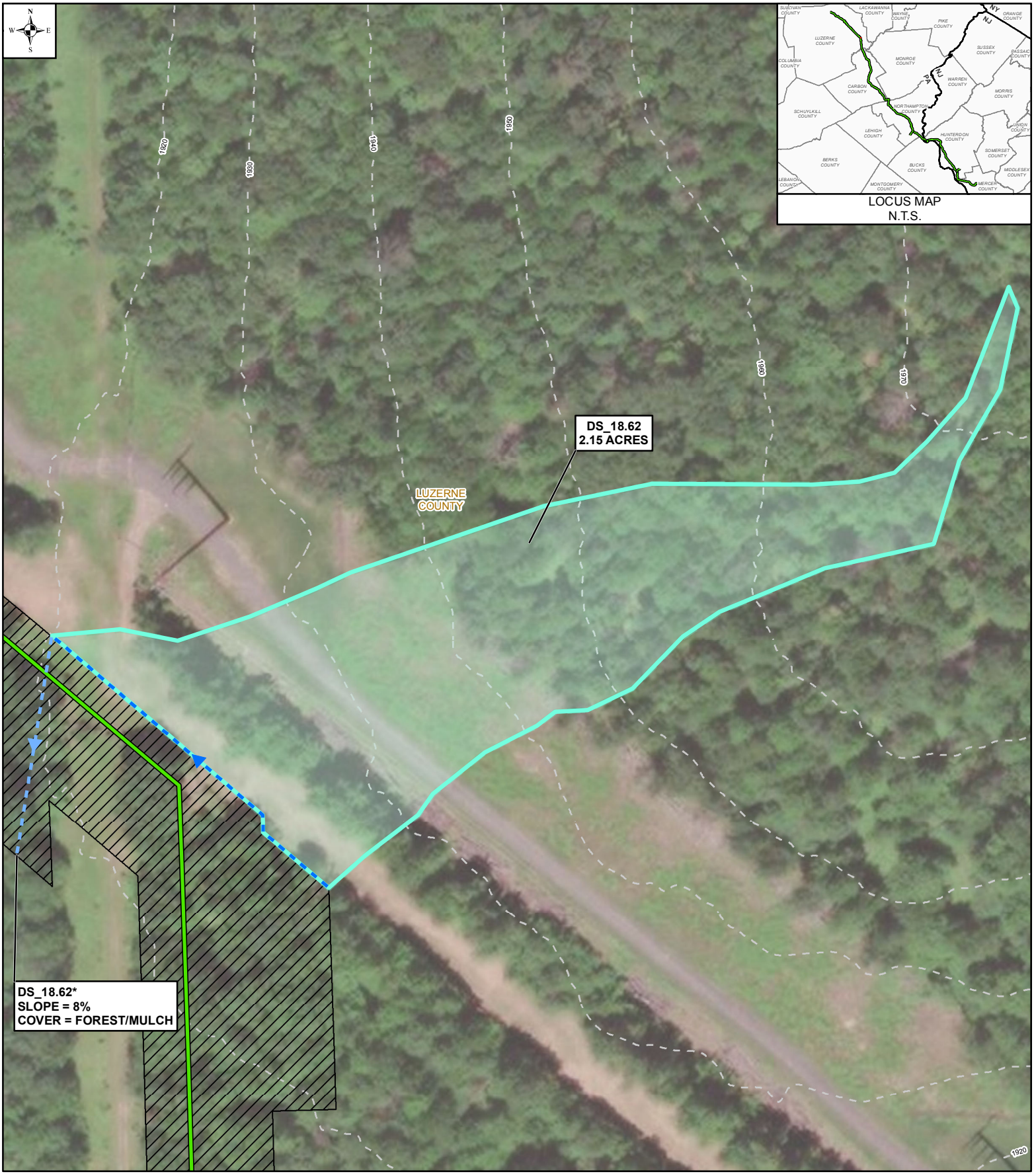


TR-55

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.



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_18.62

LUZERNE COUNTY, PENNSYLVANIA

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

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 24 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 18.62	100	0.8	0.020	16.00

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

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 18.62	472	FOREST	0.070	0.67	11.82
	110	SHORT GRASS	0.100	6.43	0.29
	27	PAVEMENT	0.037	3.91	0.12
	152	SHORT GRASS	0.046	1.49	1.70

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)
29.91

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: LUZERNE 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 18.62	1	FOREST	0.20	1.16	0.23	0.22
	2	OPEN SPACE	0.21	0.87	0.18	
	3	INDUSTRIAL	0.69	0.07	0.05	

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}
	29.91	2.26	2.76	3.21	2.26	2.76	3.21

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)
	0.22	2.76	2.10	1.05	1.28	1.49

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_18.62		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.15		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.28		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.60		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.06		
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)	19.61 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	19.61		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	9.80		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.45		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.121		
$.7S_c$	(FT/FT)	0.085		
$1.3S_c$	(FT/FT)	0.158		
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		

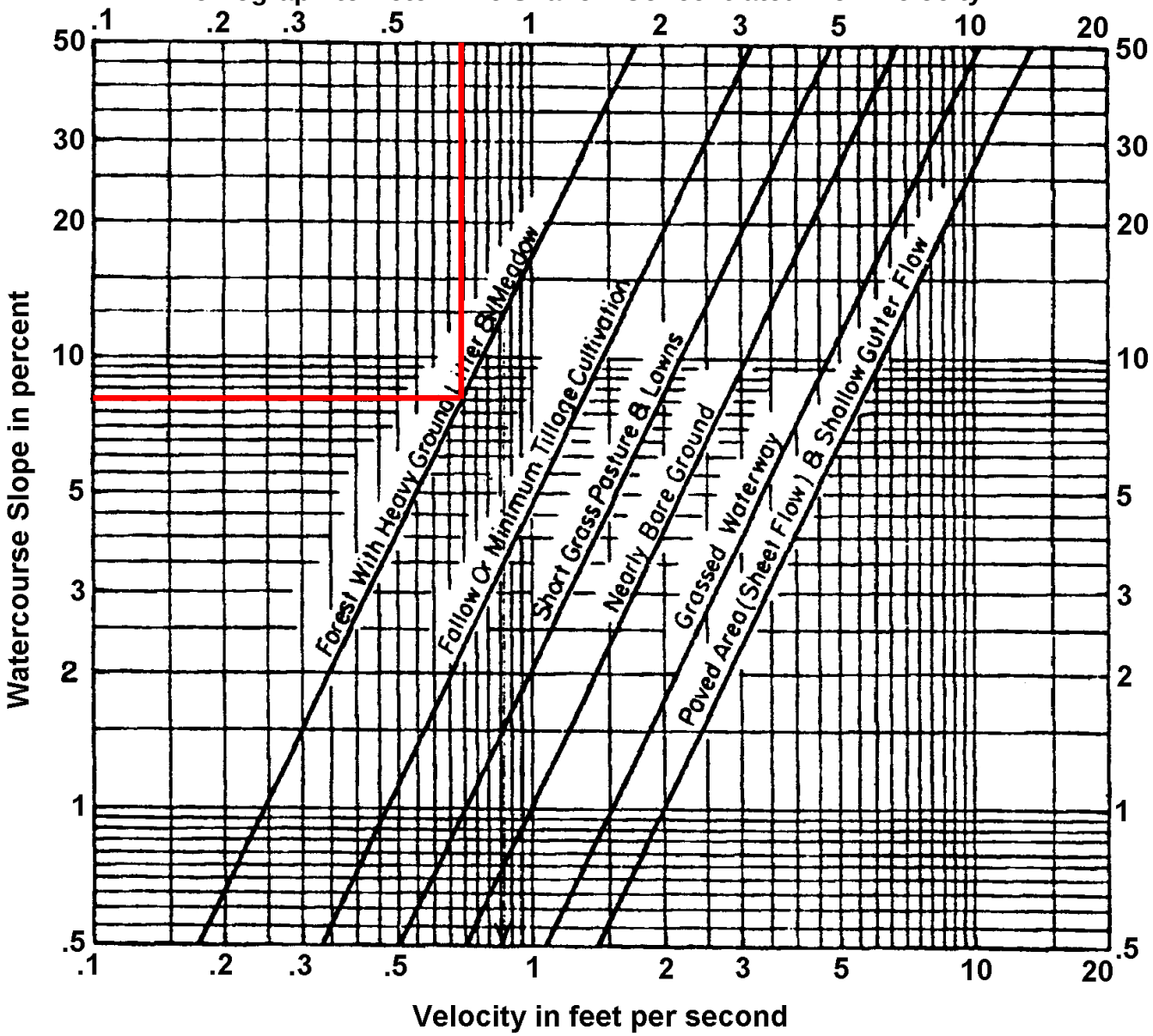
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_18.62

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

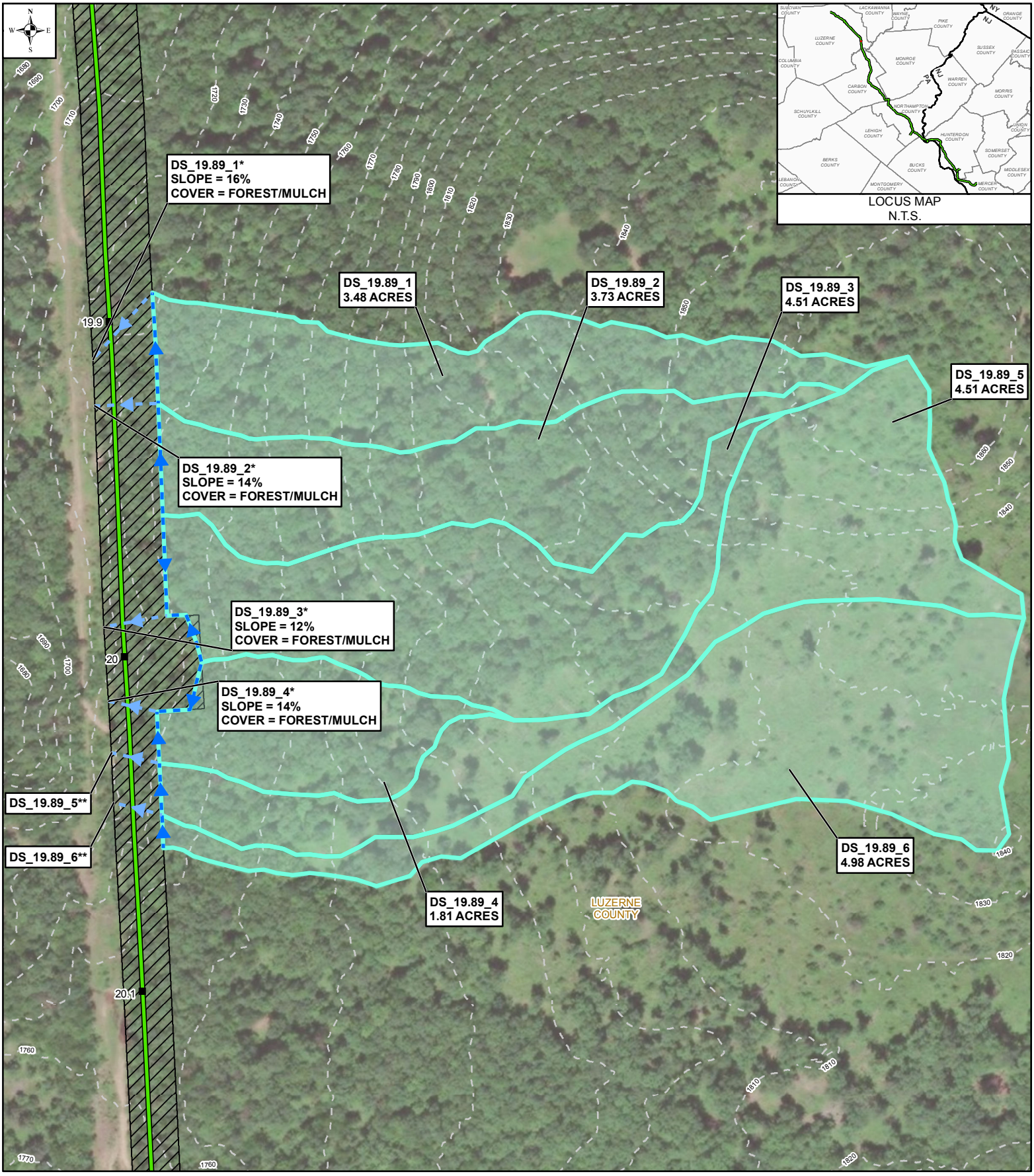


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 8%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 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.

0.7 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_19.89

LUZERNE COUNTY, PENNSYLVANIA

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

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 25 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_19.89_1
3.48 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 19.89_1	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 19.89_1	1153	FOREST	0.118	0.86	22.23

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)
35.84

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: LUZERNE 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 19.89_1	1	FOREST	0.20	3.48	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}
	35.84	2.01	2.46	2.89	2.01	2.46	2.89

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	2.46	3.48	1.40	1.71	2.01

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_19.89_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.48		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.71		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	6.68		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.35		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	22.73 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	22.73		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	11.36		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.84		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.051		
S_C (CRITICAL SLOPE)	(FT/FT)	0.074		
$.7S_c$	(FT/FT)	0.052		
$1.3S_c$	(FT/FT)	0.096		
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		

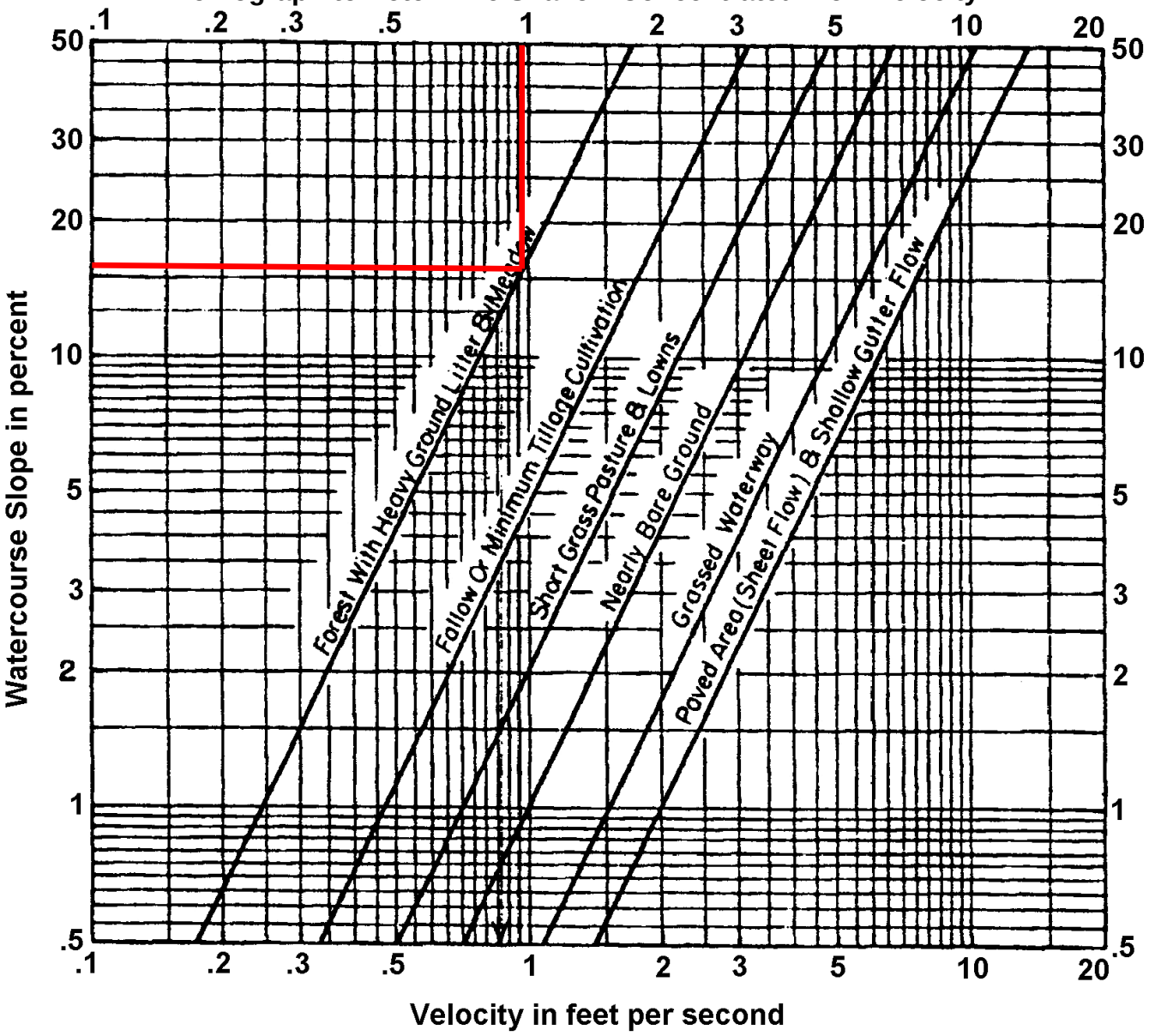
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_19.89_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 = 16%

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_19.89_2
3.73 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 19.89_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 19.89_2	1182	FOREST	0.096	0.78	25.27

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)
37.64

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: LUZERNE 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 19.89_2	1	FOREST	0.20	3.73	0.75	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}
	37.64	1.94	2.38	2.80	1.94	2.38	2.80

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	2.38	3.73	1.45	1.78	2.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_19.89_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.73		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.78		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.32		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.22		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	15.15 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	15.15		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.58		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.89		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.023		
S_C (CRITICAL SLOPE)	(FT/FT)	0.124		
$.7S_c$	(FT/FT)	0.087		
$1.3S_c$	(FT/FT)	0.161		
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		

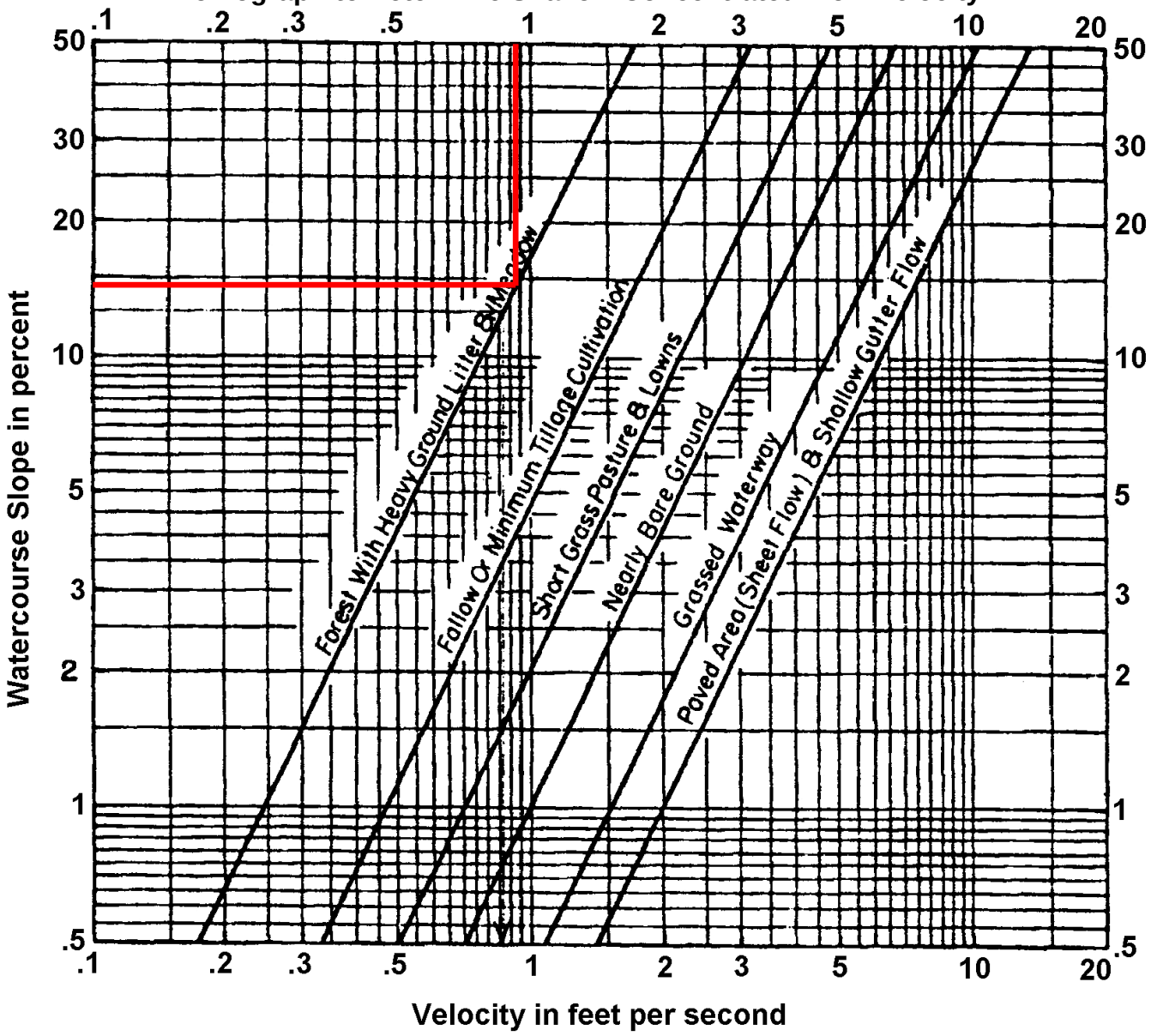
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_19.89_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 = 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_19.89_3
4.51 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 19.89_3	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 19.89_3	1139	FOREST	0.095	0.78	24.48

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)
37.39

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: LUZERNE 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 19.89_3	1	FOREST	0.20	4.51	0.90	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}
	37.39	1.95	2.39	2.81	1.95	2.39	2.81

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	2.39	4.51	1.76	2.16	2.54

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_19.89_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.51		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.16		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.84		
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)	3.79		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.99		
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)	0.025		
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		

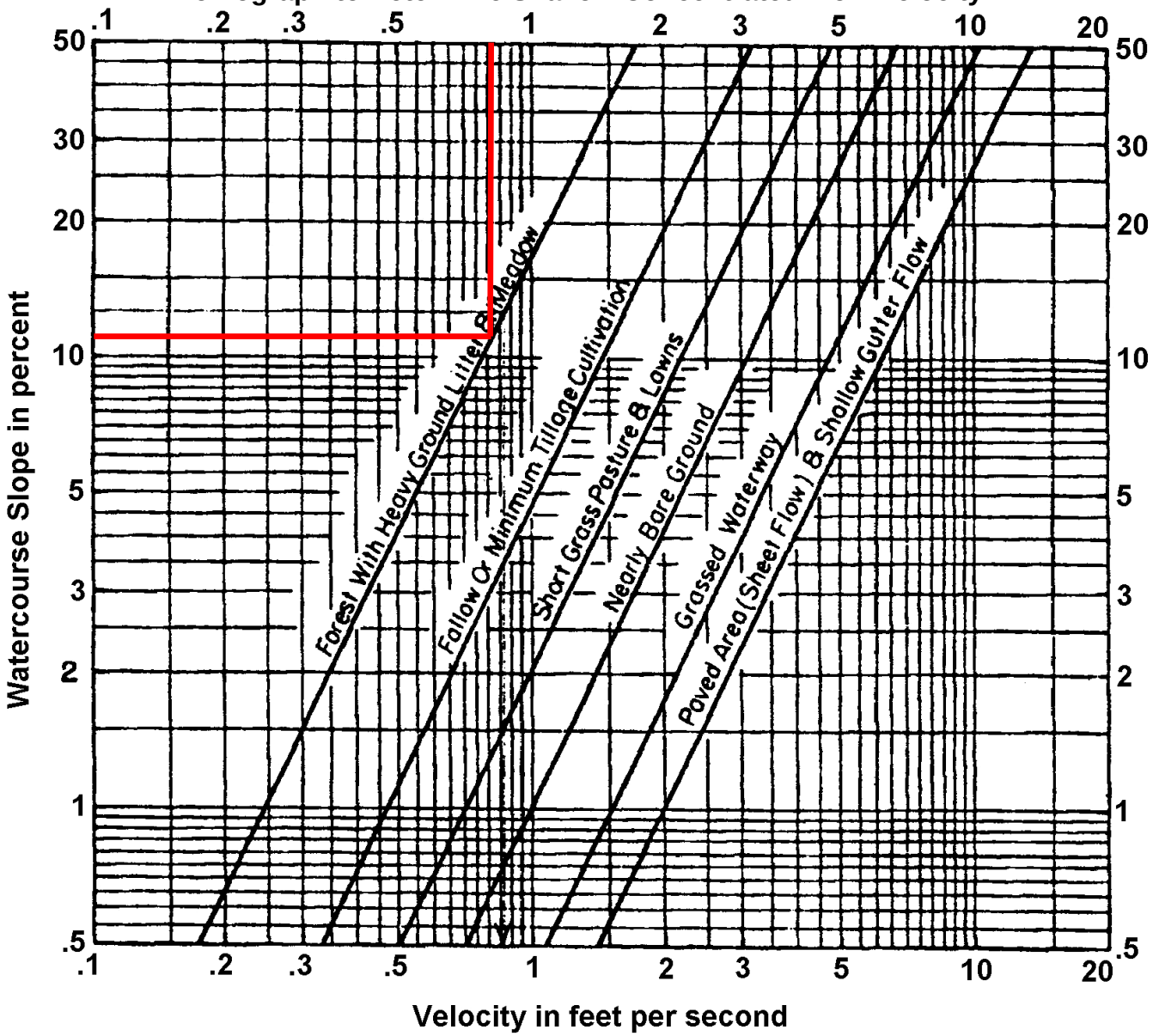
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_19.89_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 = 12%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_19.89_4
1.81 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 19.89_4	100	0.8	0.075	11.75

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

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 19.89_4	538	FOREST	0.106	0.82	10.95

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)
22.69

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: LUZERNE 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 19.89_4	1	FOREST	0.20	1.81	0.36	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}
	22.69	2.67	3.24	3.72	2.67	3.24	3.72

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	3.24	1.81	0.97	1.17	1.35

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_19.89_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.81		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.17		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.11		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.20		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
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)	7.69 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.69		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.85		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.96		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.083		
$.7S_c$	(FT/FT)	0.058		
$1.3S_c$	(FT/FT)	0.108		
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		

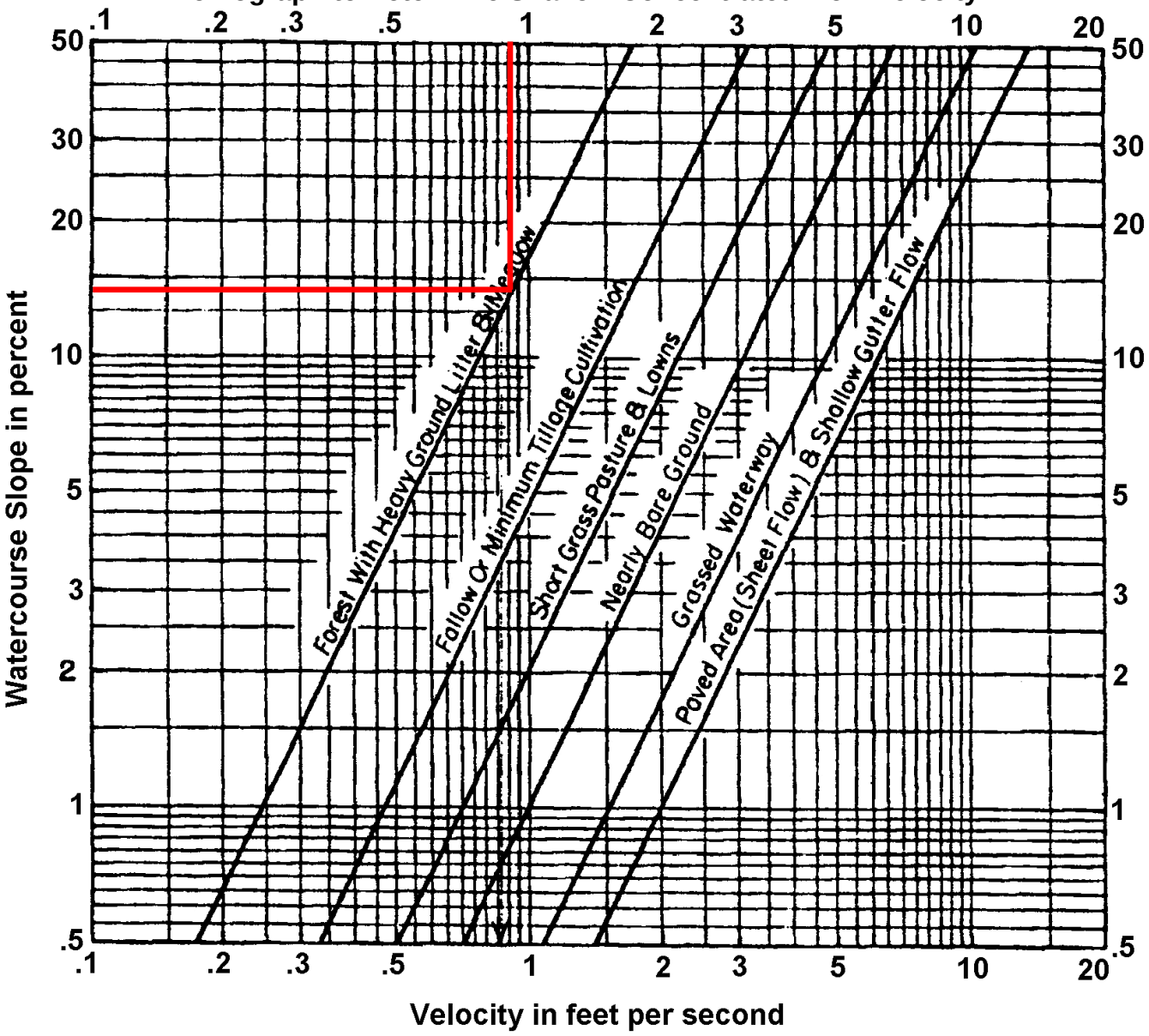
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_19.89_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 = 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_19.89_5
4.51 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 19.89_5	100	0.8	0.030	14.55

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

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 19.89_5	1477	FOREST	0.085	0.73	33.56

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)
48.11

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: LUZERNE 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 19.89_5	1	FOREST	0.20	4.51	0.90	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}
	48.11	1.63	2.01	2.39	1.63	2.01	2.39

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	2.01	4.51	1.47	1.81	2.16

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_19.89_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.51		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.82		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.93		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.051		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.70		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
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)	9.09 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.09		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.55		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.14		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.070		
$.7S_c$	(FT/FT)	0.049		
$1.3S_c$	(FT/FT)	0.090		
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

DRAINAGE AREA
DS_19.89_6
4.98 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 19.89_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 19.89_6	1400	FOREST	0.065	0.64	36.38

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)
48.75

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: LUZERNE 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 19.89_6	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}
	48.75	1.61	1.99	2.37	1.61	1.99	2.37

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	1.99	4.98	1.61	1.98	2.36

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_19.89_6		
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)	1.98		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.44		
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)	1.96		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.19		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	10 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	10.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.00		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.25		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.038		
S_C (CRITICAL SLOPE)	(FT/FT)	0.080		
$.7S_c$	(FT/FT)	0.056		
$1.3S_c$	(FT/FT)	0.104		
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.

LOCUS MAP
N.T.S.

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_20.09

LUZERNE 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 26 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 20.09	100	0.8	0.099	11.01

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

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 20.09	598	FOREST	0.045	0.53	18.67

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)
29.68

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: LUZERNE 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 20.09	1	FOREST	0.20	0.68	0.14	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}
	29.68	2.27	2.77	3.23	2.27	2.77	3.23

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	2.77	0.68	0.31	0.38	0.44

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_20.09		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.68		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.38		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.56		
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)	1.68		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.19		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	23.81 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	15.87		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.97		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.33		
R (HYDRAULIC RADIUS)		0.08		
S (BED SLOPE)[3, 7]	(FT/FT)	0.018		
S_C (CRITICAL SLOPE)	(FT/FT)	0.017		
$.7S_c$	(FT/FT)	0.012		
$1.3S_c$	(FT/FT)	0.022		
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		

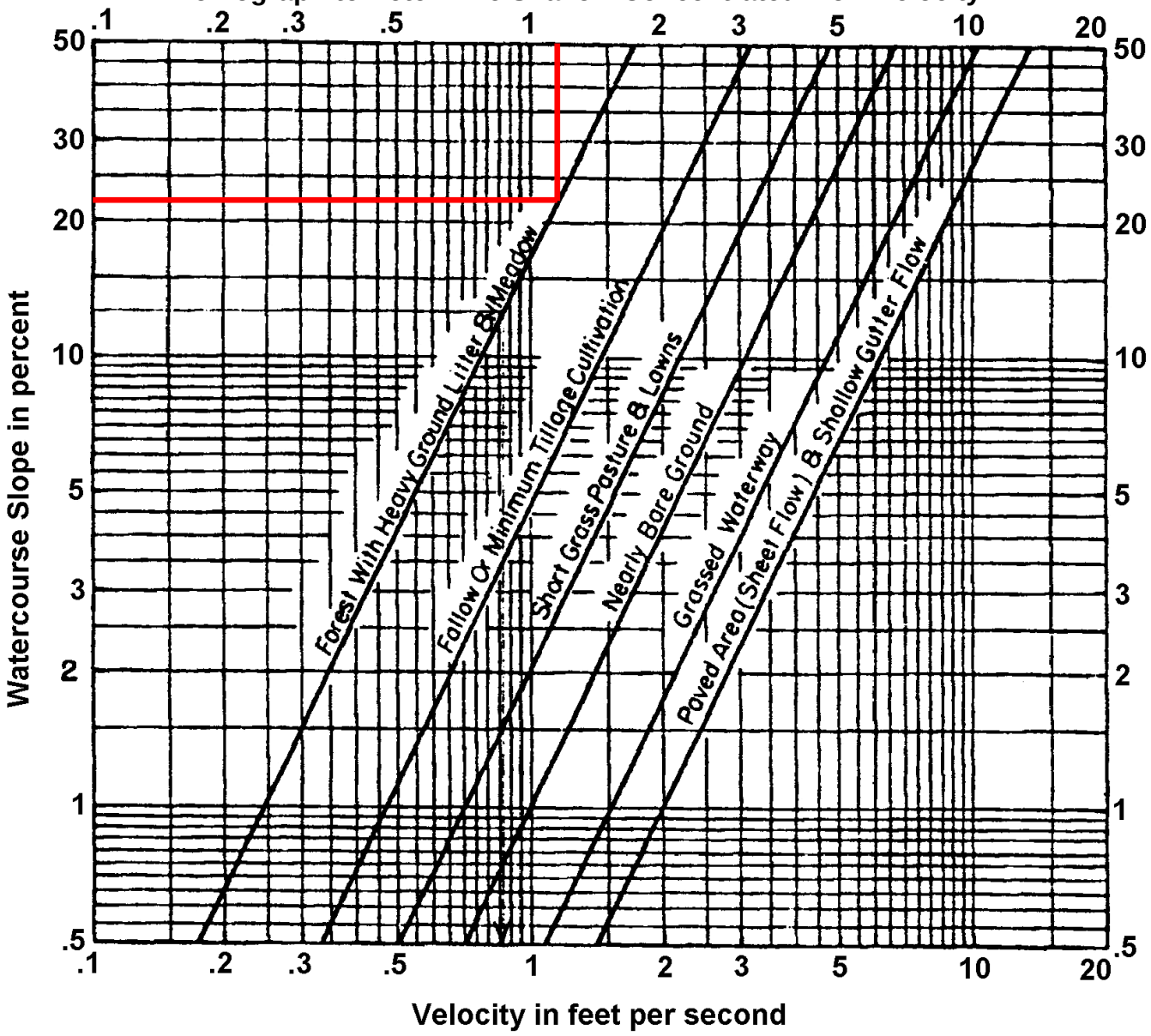
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_20.09

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

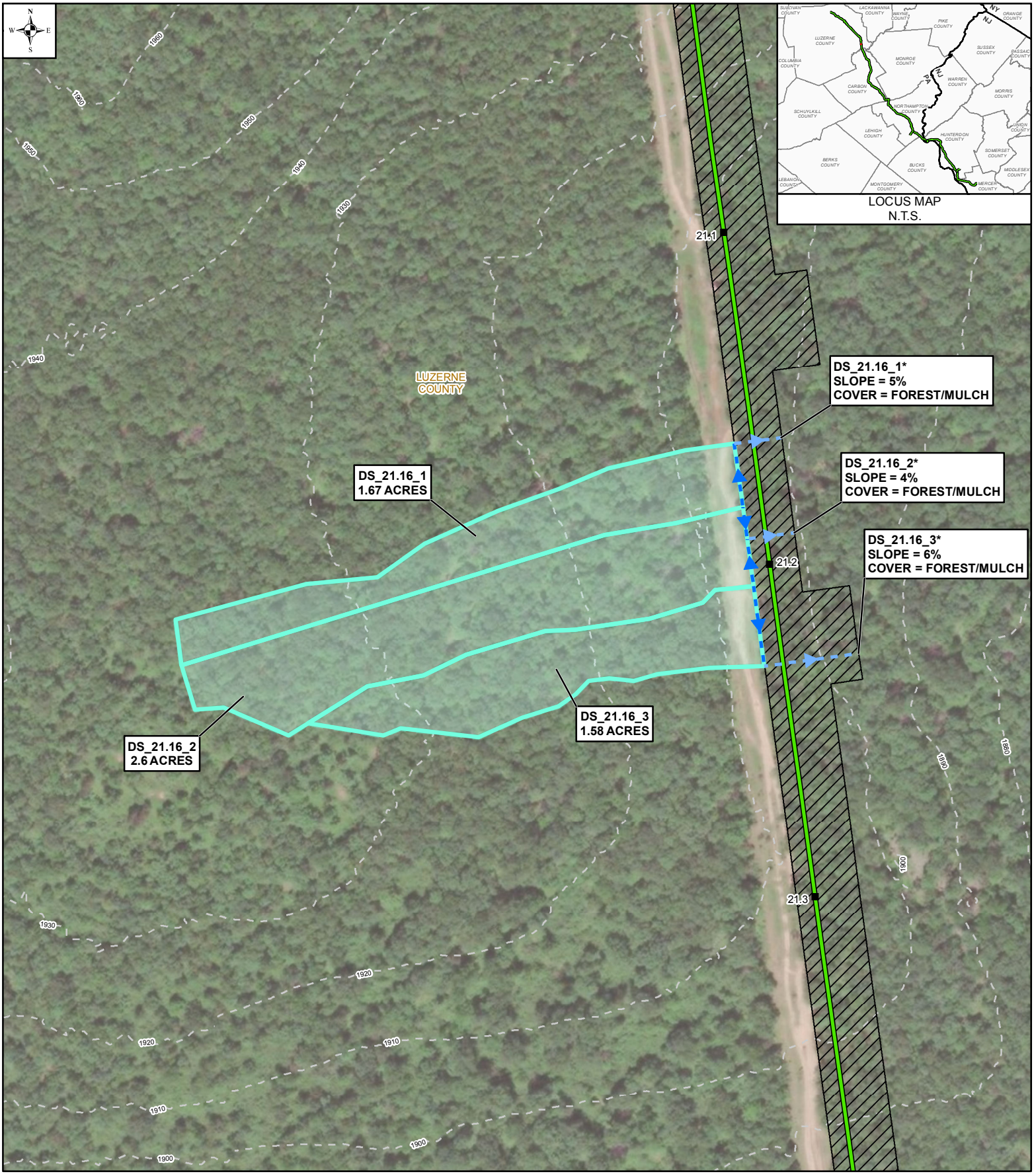


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 22%

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_21.16

LUZERNE COUNTY, PENNSYLVANIA

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

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 27 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_21.16_1
1.68 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 21.16_1	100	0.8	0.010	18.81

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

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 21.16_1	833	FOREST	0.031	0.44	31.34

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)
50.15

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: LUZERNE 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 21.16_1	1	FOREST	0.20	1.57	0.31	0.20
	2	OPEN SPACE	0.21	0.11	0.02	

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}
	50.15	1.58	1.95	2.32	1.58	1.95	2.32

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	1.95	1.68	0.53	0.66	0.78

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_21.16_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.68		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.66		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.56		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.71		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	17.54 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	17.54		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	8.77		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.19		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.160		
$.7S_c$	(FT/FT)	0.112		
$1.3S_c$	(FT/FT)	0.207		
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		

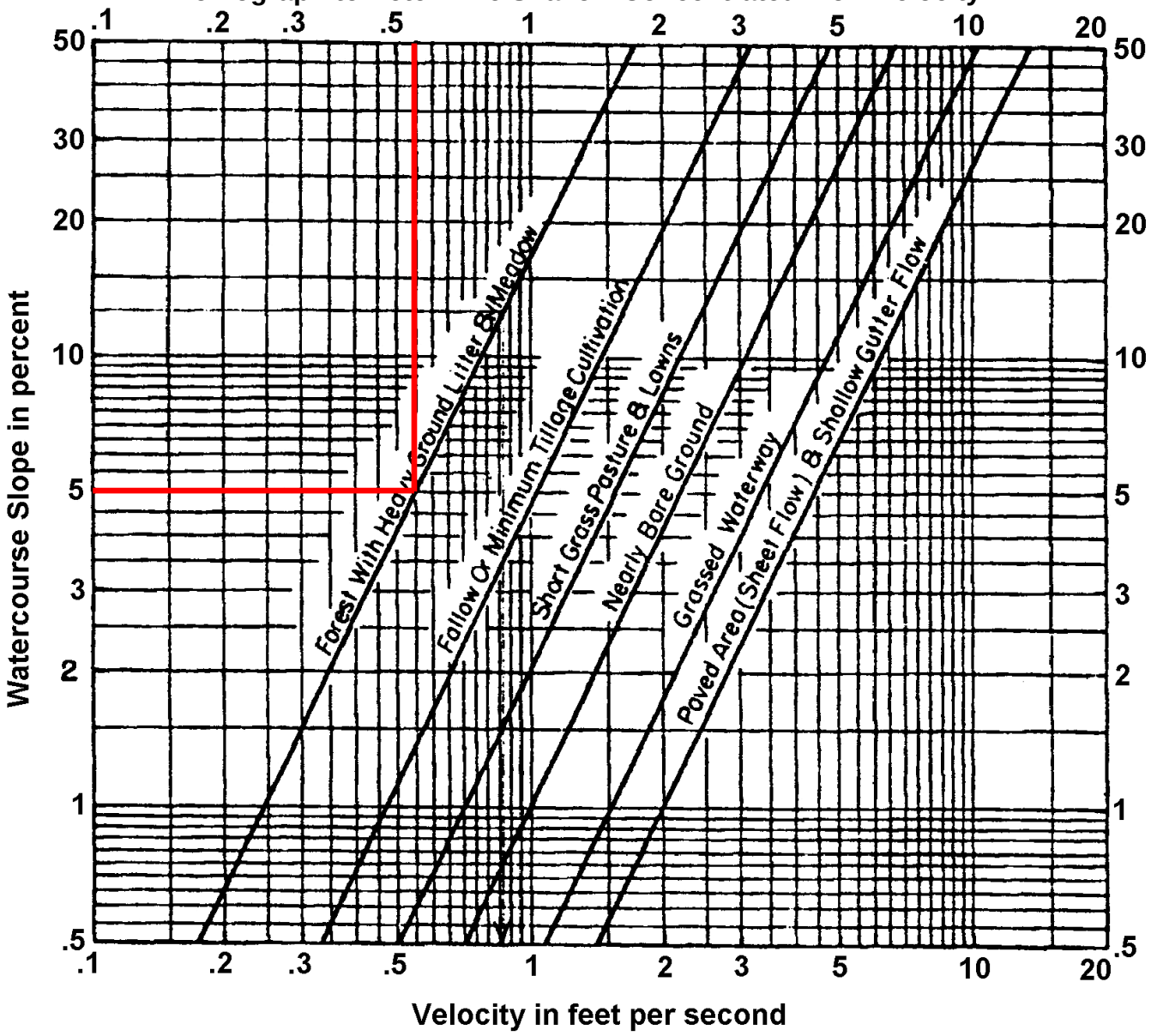
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_21.16_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 = 5%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_21.16_2
2.60 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 21.16_2	100	0.8	0.010	18.81

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

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 21.16_2	799	FOREST	0.031	0.44	30.06
	41	SHORT GRASS	0.050	1.56	0.44

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)
49.31

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: LUZERNE 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 21.16_2	1	FOREST	0.20	2.47	0.49	0.20
	2	OPEN SPACE	0.21	0.13	0.03	

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}
	49.31	1.60	1.98	2.35	1.60	1.98	2.35

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	1.98	2.60	0.83	1.03	1.23

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_21.16_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.6		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.03		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.49		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.82		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.41		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	24.39 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	24.39		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	12.20		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	3.05		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.013		
S_C (CRITICAL SLOPE)	(FT/FT)	0.156		
$.7S_c$	(FT/FT)	0.109		
$1.3S_c$	(FT/FT)	0.203		
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		

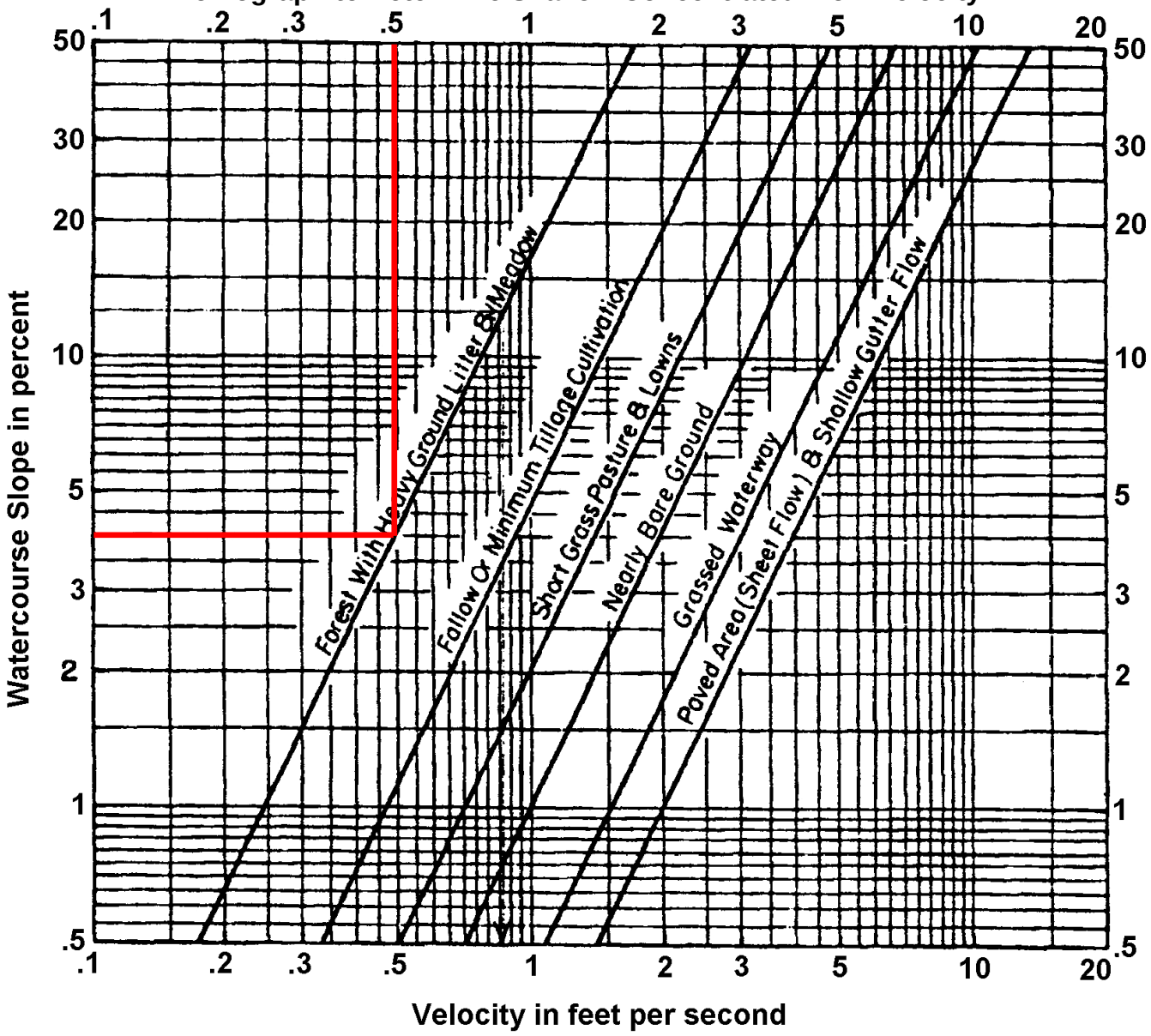
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_21.16_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 = 4%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.5 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.

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

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_21.16_3
1.58 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: LUZERNE 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 21.16_3	100	0.8	0.010	18.81

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

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 21.16_3	610	FOREST	0.041	0.51	19.96
	37	SHORT GRASS	0.050	1.56	0.40

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)
39.16

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: LUZERNE 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 21.16_3	1	FOREST	0.20	1.47	0.29	0.20
	2	OPEN SPACE	0.21	0.11	0.02	

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}
	39.16	1.89	2.32	2.73	1.89	2.32	2.73

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	2.32	1.58	0.60	0.74	0.87

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: LUZERNE COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_21.16_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.58		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.74		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.30		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.70		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	14.71 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	14.71		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.35		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.84		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.162		
$.7S_c$	(FT/FT)	0.113		
$1.3S_c$	(FT/FT)	0.211		
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		

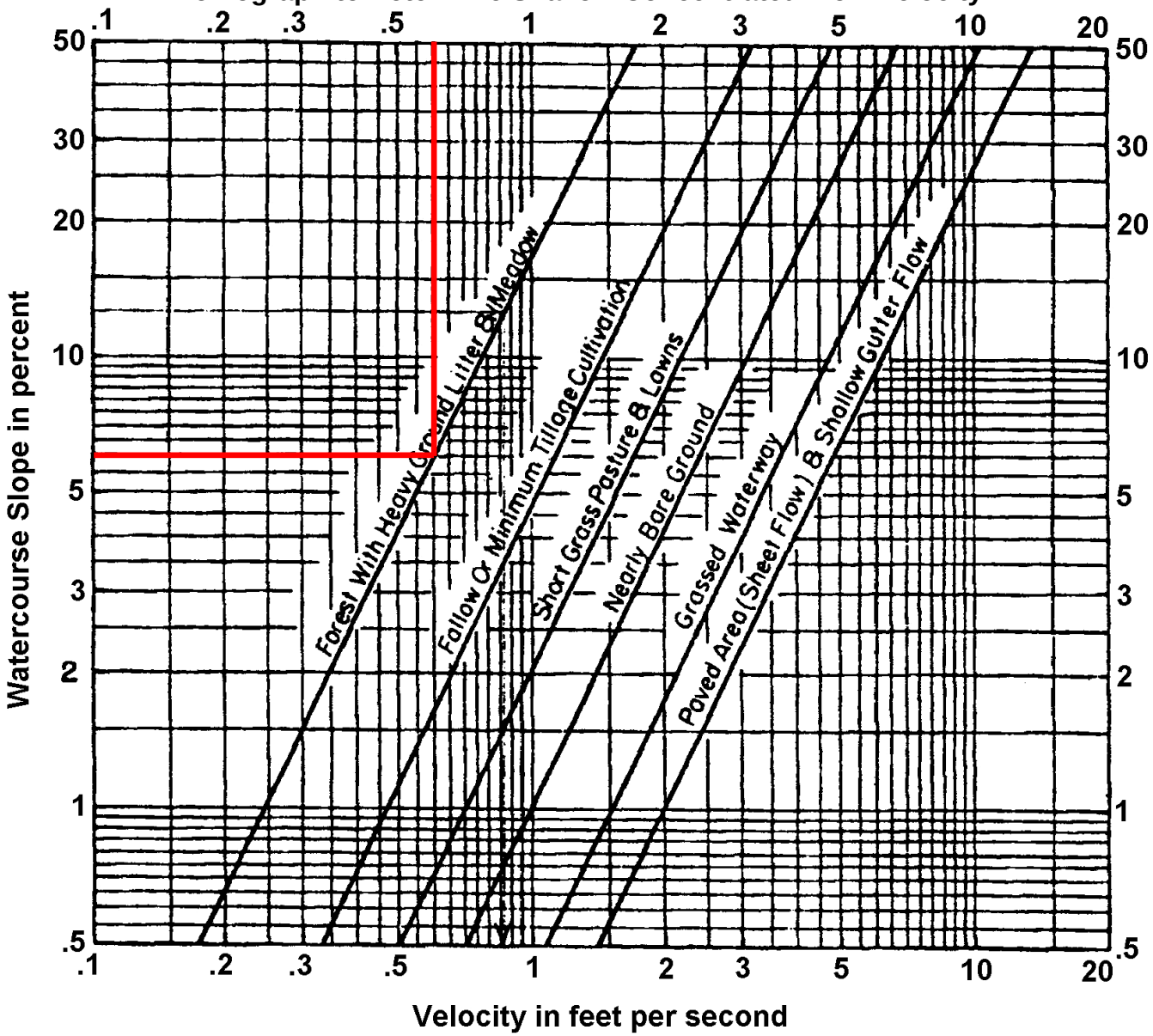
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel 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_21.16_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 = 6%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 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.

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