Highway Occupancy Permit Application
1525 Wood Avenue – Drainage Report
Wilson Borough/Palmer Township/Easton City, Northampton County

RISE TO THE
CHALLENGE

Prepared by:
KCI Technologies, Inc.
5001 Louise Drive | Suite 201
Mechanicsburg, PA 17055

Prepared for:
Easton Wood Avenue PropCo, LLC
December 2024
KCI Project No. 222209756
PennDOT EPS Application No.

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PROJECT LOCATION MAP

SR 2017/SR 2024
WILSON BOROUGH/PALMER TOWNSHIP/EASTON CITY, NORTHAMPTON COUNTY

Project Narrative

PennDOT EPS Application No. 320663 covers improvements to Hackett Avenue (SR 2017) and Wood Avenue (SR 2017/SR 2024) including two driveway reconstructions and widening with turn lanes being added.

The proposed improvements on Hackett Avenue include a low-volume full-movement driveway, 200' right turn lane on the westbound approach, replacing the existing culvert carrying the tributary to Bushkill Creek, and constructing a 150' right turn lane and median island on the stop-controlled approach to the intersection with Wood Avenue. Signing and pavement markings will be updated accordingly.

The proposed improvements on Wood Avenue include a low-volume full-movement driveway, 200' right turn lane on the westbound approach, 200' left turn lane on the eastbound approach, 175' right turn lane approaching the intersection with Hackett Avenue, and extension of the left turn lane to the US 22 East Ramps. Signing and pavement markings will be updated accordingly.

The project site is depicted on the ***Project Location Map.***

Pre-Construction Condition

The existing area is an urban community arterial, with the site previously occupied by an industrial pigment plant. The existing site currently drains all stormwater to the existing tributary to Bushkill Creek. Hackett Avenue sheet flows stormwater from both the eastbound and westbound lanes to the existing tributary to Bushkill Creek. Wood Avenue sheet flows the westbound lane to the existing site, while the eastbound lane collects to a sump at the intersection with Hackett Avenue, with an outfall to the existing tributary to Bushkill Creek.

Post-Construction Condition

Proposed development will include widening and addition of left/right auxiliary lanes as described in the Project Narrative. Both driveways will undergo full reconstruction, grade adjustment, full depth pavement, curb, and inlets at the curbed approaches. Proposed inlets at the driveways will capture runoff from the driveways and auxiliary lanes. Inlets will be added/replaced at the sump along the Wood Avenue intersection. A new vegetated swale will be added outside the westbound lanes on Wood Avenue, draining to the tributary to Bushkill Creek. All new facilities will drain to the existing tributary to Bushkill Creek. Because the site development plans incorporate stormwater management facilities such as infiltration basins, the post development condition shows no significant change in discharge entering the drainage system from the pre-construction condition.

SR 2017 / Wood Avenue
Easton, Northampton County

DRAINAGE DESIGN REPORT

DRAINAGE DESIGN CRITERIA

The drainage design for this project was conducted in accordance with PennDOT Design Manual #2 – Chapter 10 and in accordance with PennDOT Publication 584 – PennDOT Drainage Manual.

1. Use the Rational Method Q=CIA (DM-2 page 10-12).
2. Use a 10 year design storm. (DM2 page 10-13). Pipe capacity calculations for the 25-year design storm are included.
3. Use Time of Concentration = 5 min (pipes < 30" diameter) (DM2 page 10-13).
4. Determine rainfall intensity for a 10 year storm from Pub 584 page 7A-1 to 7A-24.
5. The following runoff coefficients will be utilized (Pub 584 page 7-31).
   a. Pavement C = 0.75 to 0.90
   b. Grass C = 0.20 to 0.35
6. Inlet capacities and efficiencies were taken from PENNDOT's Design Manual 2 page 10-19 thru 28.
7. A minimum cover of 6" will be provided between the top of the pipe and the bottom of the pavement subgrade.

APPENDIX A
SPREAD CALCULATIONS

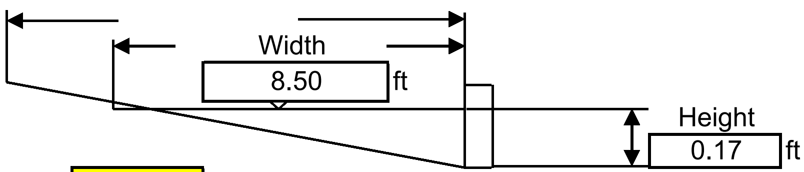
INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA H1 INLET IH-1

Allowable Flow

Allowable Width 8.50 ft



S_x: 2%

Half Lane + Shoulder = 8.50 ft

Roughness (n) = 0.015 (Pub 584 Table 7.5)

$Slope_{Long.}$ = 5.58%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\ L_{ong}^{1/2})$ = 3.91 cfs

Actual Gutter spread = 4.43 ft

Inlet Flow:

Inlet no: IH-1 Station: 0+96.22 RT

A_p	=	0.062 acre	A_g	=	0.163 acre	A_T	=	0.225 acre
C_p	=	0.90	C_g	=	0.30	C_T	=	0.47
I_{10}	=	6.50 in/hr						

Q_{actual} = CIA = 0.68 cfs < $Q_{all.}$ = 3.91 cfs OK

Efficiency: = 97% Q = 0.66 cfs (DM-2 Figure: 10.3.2 $Slope_{Long.}$ = 5.58% **$Slope_x$ = 2%)

Bypass = 0.02 cfs

* For 10 year storm

**For Cross Slope at Inlet

INLET CALCULATION

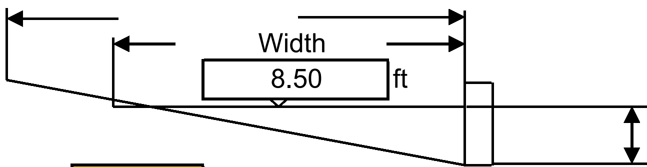
Project name:	Wood Avenue HOP	Designed by:		Date:	
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA H2 INLET IH-2

Allowable Flow

Allowable Width 8.50 ft

Width 8.50 ft



Height 0.17 ft

S_x: 2%

Half Lane + Shoulder = 8.50 ft

Roughness (n) = 0.015 (Pub 584 Table 7.5)

$\text{Slope}_{\text{Long.}}$ = 5.58%

$Q_{\text{allowed}} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 3.91 cfs

Actual Gutter spread = 3.50 ft

Inlet Flow:

Inlet no: IH-2 Station: 0+96.22 LT

A_p	=	0.062	acre	A_g	=	0.000	acre	A_T	=	0.062 acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.90
I_{10}	=	6.50	in/hr							

Q_{actual} = CIA = 0.36 cfs < $Q_{\text{all.}}$ = 3.91 cfs OK

Efficiency: = 100% Q = 0.36 cfs (DM-2 Figure: 10.3.2 $\text{Slope}_{\text{Long.}}$ = 5.58% **Slope_x = 2%)

Bypass = 0.00 cfs

* For 10 year storm

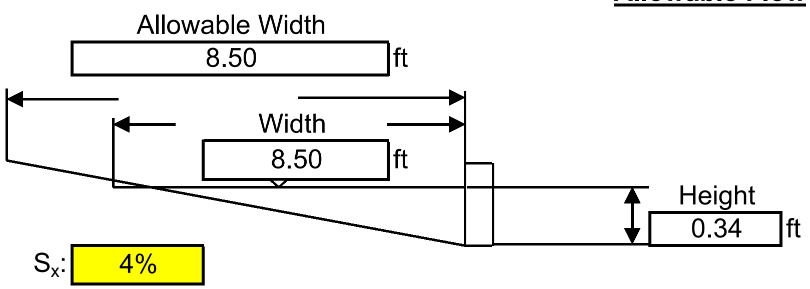
**For Cross Slope at Inlet

INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:	Hackett - 204+56.65 LT				

DRAINAGE AREA H3 INLET IH-3

Allowable Flow



Half Lane + Shoulder = 8.50 ft
Roughness (n) = 0.015 (Pub 584 Table 7.5)
Slope $_{Long.}$ = 5.50%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 12.33 cfs

Actual Gutter spread = 4.72 ft

Inlet Flow:

Inlet no: IH-3 Station: 204+56.83 LT

A_p	=	0.125 acre	A_g	=	0.936 acre	A_T	=	1.061 acre
C_p	=	0.90	C_g	=	0.30	C_T	=	0.37
I_{10}	=	6.50 in/hr						

Q_{actual} = CIA = 2.56 cfs < $Q_{all.}$ = 12.33 cfs OK

Efficiency: = 90% Q = 2.30 cfs (DM-2 Figure: 10.3.3 Slope $_{Long.}$ = 5.50% **Slope $_x$ = 4%)

Bypass = 0.26 cfs

* For 10 year storm

**For Cross Slope at Inlet

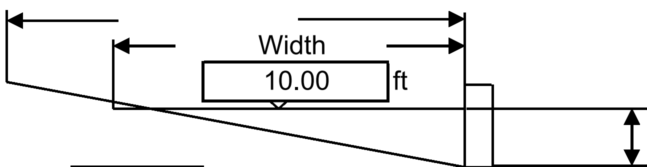
INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA H4 INLET IH-4

Allowable Flow

Allowable Width 10.00 ft



Width 10.00 ft

Height 0.40 ft

S_x: 4%

Half Lane + Shoulder = 10.00 ft

Roughness (n) = 0.015 (Pub 584 Table 7.5)

$Slope_{Long.}$ = 3.16%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 14.41 cfs

Actual Gutter spread = 4.18 ft

Inlet Flow:

Inlet no: IH-4 Station: 205+93.00 LT

A_p	=	0.157	acre	A_g	=	0.105	acre	A_T	=	0.262	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.66	
I_{10}	=	6.50	in/hr					Bypass	=	0.28	cfs

Q_{actual} = CIA = 1.40 cfs < $Q_{all.}$ = 14.41 cfs OK

Efficiency: = 98% Q = 1.38 cfs (DM-2 Figure: 10.3.3 $Slope_{Long.}$ = 3.16% **$Slope_x$ = 4%)

Bypass = 0.03 cfs

* For 10 year storm

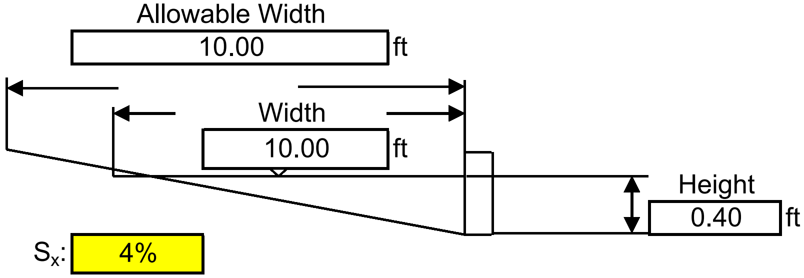
**For Cross Slope at Inlet

INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA H5 INLET IH-5

Allowable Flow



Half Lane + Shoulder = 10.00 ft

Roughness (n) = 0.015 (Pub 584 Table 7.5)

$\text{Slope}_{\text{Long.}}$ = 2.82%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = **13.61** cfs

Actual Gutter spread = 3.96 ft

Inlet Flow:

Inlet no: IH-5 Station: 207+88.00 LT

A_p	=	0.121	acre	A_g	=	0.207	acre	A_T	=	0.328	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.52	
I_{10}	=	6.50	in/hr					Bypass	=	0.03	cfs

Q_{actual} = CIA = 1.14 cfs < $Q_{all.}$ = 13.61 cfs OK

Efficiency: = 100% Q = 1.14 cfs (DM-2 Figure: 10.3.2 $\text{Slope}_{\text{Long.}}$ = 2.82% **Slope $_x$ = 4%)

Bypass = 0.00 cfs

* For 10 year storm

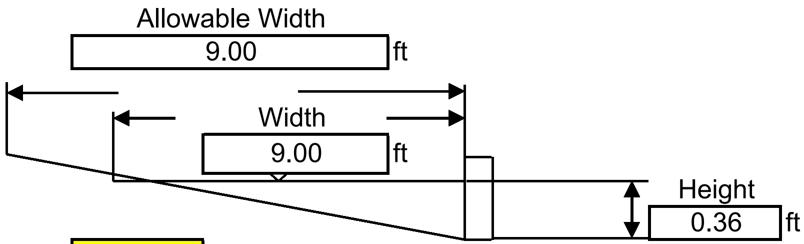
**For Cross Slope at Inlet

INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA H6 INLET IH-6

Allowable Flow



S_x: 4%

Half Lane + Shoulder = 9.00 ft
Roughness (n) = 0.015 (Pub 584 Table 7.5)
$\text{Slope}_{\text{Long.}}$ = 2.82%

$Q_{\text{allowed}} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 10.28 cfs

Actual Gutter spread = 3.31 ft

Inlet Flow:

Inlet no: IH-6 Station: 209+34.78 LT

A_p =	0.071	acre	A_g =	0.152	acre	A_T =	0.223	acre
C_p =	0.90		C_g =	0.30		C_T =	0.49	
I_{10} =	6.50	in/hr						

Q_{actual} = CIA = 0.71 cfs < $Q_{\text{all.}}$ = 10.28 cfs OK

Efficiency: = 100% Q = 0.71 cfs (DM-2 Figure: 10.3.2 $\text{Slope}_{\text{Long.}}$ = 2.82% **Slope $_x$ = 4%)

Bypass = 0.00 cfs

* For 10 year storm

**For Cross Slope at Inlet

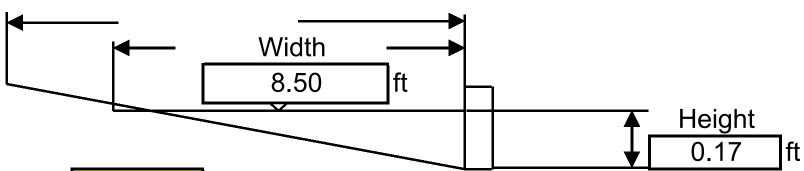
INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA W1 INLET IW-1

Allowable Flow

Allowable Width 8.50 ft



S_x: 2%

Half Lane + Shoulder =	8.50	ft	
Roughness (n) =	0.015	(Pub 584 Table 7.5)	
Slope $_{Long.}$ =	6.38%		

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\ L_{ong}^{1/2})$ = 4.18 cfs

Actual Gutter spread = 3.41 ft

Inlet Flow:

Inlet no: IW-1 Station: 0+94.47 LT

A_p	=	0.062	acre	A_g	=	0.000	acre	A_T	=	0.062	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.90	
I_{10}	=	6.50	in/hr								

Q_{actual} = CIA = 0.36 cfs < $Q_{all.}$ = 4.18 cfs OK

Efficiency: = 97% Q = 0.35 cfs (DM-2 Figure: 10.3.3 Slope $_{Long.}$ = 6.38% **Slope $_x$ = 2%)

Bypass = 0.01 cfs

* For 10 year storm

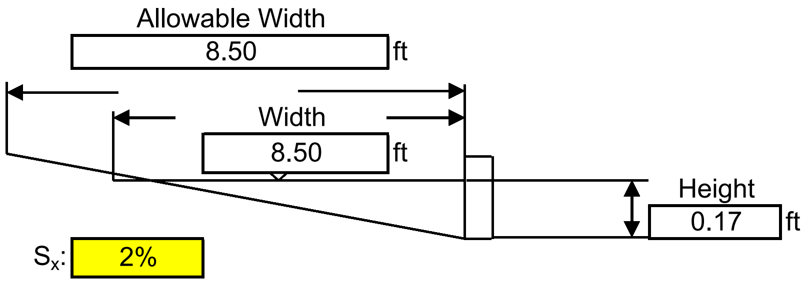
** For Cross Slope at Inlet

INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA W2 INLET IW-2

Allowable Flow



Half Lane + Shoulder = 8.50 ft
Roughness (n) = 0.015 (Pub 584 Table 7.5)
Slope $_{Long.}$ = 6.38%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\ L_{ong}^{1/2})$ = **4.18** cfs

Actual Gutter spread = 3.41 ft

Inlet Flow:

Inlet no: IW-2 Station: 0+94.47 RT

A_p	=	0.062	acre	A_g	=	0.000	acre	A_T	=	0.062	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.90	
I_{10}	=	6.50	in/hr								

Q_{actual} = CIA = 0.36 cfs < $Q_{all.}$ = 4.18 cfs OK

Efficiency: = 97% Q = **0.35** cfs (DM-2 Figure: 10.3.3 Slope $_{Long.}$ = 6.38% **Slope $_x$ = 2%)

Bypass = 0.01 cfs

* For 10 year storm

**For Cross Slope at Inlet

INLET CALCULATION

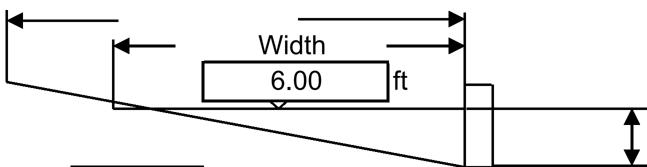
Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA W3 INLET IW-3

Allowable Flow

Allowable Width: 6.00 ft

Width: 6.00 ft



Height: 0.60 ft

S_x: 10%

Half Lane + Shoulder = 6.00 ft

Roughness (n) = 0.015 (Pub 584 Table 7.5)

$\text{Slope}_{\text{Long.}}$ = 4.33%

*SUMP CONDITION

$Q_{\text{allowed}} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}{}^{1/2})$ = 19.90 cfs

Actual Gutter spread = 3.57 ft

Inlet Flow:

Inlet no: IW-3 Station: 102+67.24 RT

A_p	= 0.496	acre	A_g	= 1.060	acre	A_T	= 1.556	acre
C_p	= 0.90		C_g	= 0.30		C_T	= 0.49	
I_{10}	= 6.50	in/hr						

Q_{actual} = CIA = 4.97 cfs < $Q_{\text{all.}}$ = 19.90 cfs OK

Efficiency: = 100% Q = 4.97 cfs (DM-2 Table: 10.3.2 $\text{Slope}_{\text{Long.}}$ = 4.33% **Slope $_x$ = 10%)

Bypass = 0.00 cfs (Inlet Capacity = 5.00 CFS)

* For 10 year storm

**For Cross Slope at Inlet

INLET CALCULATION

Project name: Wood Avenue HOP
Project no.: 222290756
Stations:

Designed by: ZMK Date: 12/4/24
Checked by: Date:

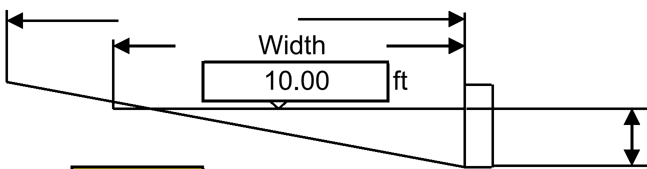
DRAINAGE AREA W4 INLET IW-4

Allowable Flow

Allowable Width: 10.00 ft

Width: 10.00 ft

Height: 0.40 ft



S_x: 4%

Half Lane + Shoulder = 10.00 ft
Roughness (n) = 0.015 (Pub 584 Table 7.5)
Slope $_{Long.}$ = 4.33%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 16.87 cfs

Actual Gutter spread = 4.10 ft

Inlet Flow:

Inlet no: IW-4 Station: 102+59.45 LT

A_p	=	0.266 acre	A_g	=	0.000 acre	A_T	=	0.266 acre
C_p	=	0.90	C_g	=	0.30	C_T	=	0.90
I_{10}	=	6.50 in/hr						

Q_{actual} = CIA = 1.56 cfs < $Q_{all.}$ = 16.87 cfs OK

Efficiency: = 97% Q = 1.51 cfs (DM-2 Figure: 10.3.3 Slope $_{Long.}$ = 4.33% **Slope $_x$ = 4%)

Bypass = 0.05 cfs

* For 10 year storm

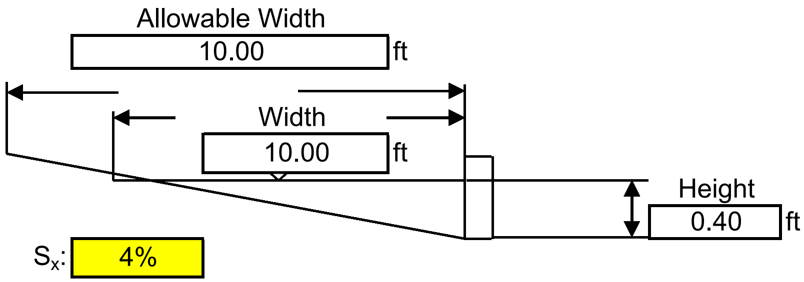
**For Cross Slope at Inlet

INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

DRAINAGE AREA W5 SPREAD CHECK BEFORE SWALE

Allowable Flow



Half Lane + Shoulder = 10.00 ft
Roughness (n) = 0.015 (Pub 584 Table 7.5)
Slope $_{Long.}$ = 4.25%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 16.71 cfs

Actual Gutter spread = 3.96 ft

Inlet Flow:

Station: 101+12.52 LT

A_p	=	0.240	acre	A_g	=	0.000	acre	A_T	=	0.240	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.90	
I_{10}	=	6.50	in/hr								

Q_{actual} = CIA = 1.40 cfs < $Q_{all.}$ = 16.71 cfs OK

Efficiency: = 0% Q = 0.00 cfs
Bypass = 1.40 cfs

* For 10 year storm
**For Cross Slope at Inlet

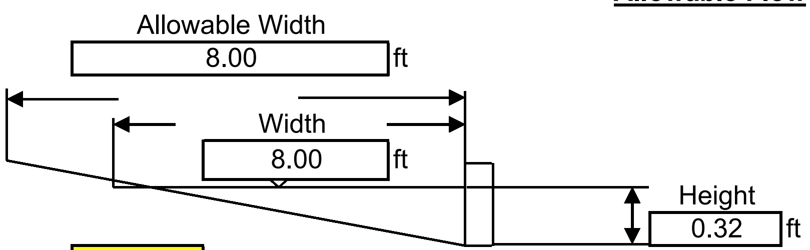
INLET CALCULATION

Project name: Wood Avenue HOP
Project no.: 222290756
Stations:

Designed by: ZMK Date: 12/4/24
Checked by: Date:

DRAINAGE AREA W6 INLET IW-6

Allowable Flow



S_x: 4%

Half Lane + Shoulder = 8.00 ft
Roughness (n) = 0.015 (Pub 584 Table 7.5)
Slope $_{Long.}$ = 2.36%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S L_{ong}^{1/2})$ = 6.87 cfs

Actual Gutter spread = 6.72 ft

Inlet Flow:

Inlet no: IW-6 Station: 98+11.49 RT

A_p	=	0.458 acre	A_g	=	0.828 acre	A_T	=	1.286 acre
C_p	=	0.90	C_g	=	0.30	C_T	=	0.51
I_{10}	=	6.50 in/hr						

Q_{actual} = CIA = 4.29 cfs < $Q_{all.}$ = 6.87 cfs OK

Efficiency: = 82% Q = 3.52 cfs (DM-2 Figure: 10.3.3 Slope $_{Long.}$ = 2.36% **Slope $_x$ = 4%)

Bypass = 0.77 cfs

* For 10 year storm

**For Cross Slope at Inlet

INLET CALCULATION

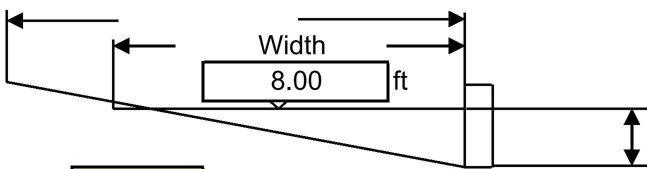
Project name: Wood Avenue HOP
Project no.: 222290756
Stations:

Designed by: ZMK Date: 12/4/24
Checked by: Date:

DRAINAGE AREA W7 INLET IW-7

Allowable Flow

Allowable Width 8.00 ft



S_x: 4%

Half Lane + Shoulder = 8.00 ft
Roughness (n) = 0.015 (Pub 584 Table 7.5)
Slope $_{Long.}$ = 2.36%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 6.87 cfs

Actual Gutter spread = 3.34 ft

Inlet Flow:

Inlet no: IW-7 Station: 97+56.44 RT

A_p	=	0.071 acre	A_g	=	0.128 acre	A_T	=	0.199 acre
C_p	=	0.90	C_g	=	0.30	C_T	=	0.51
I_{10}	=	6.50 in/hr						

Q_{actual} = CIA = 0.66 cfs < $Q_{all.}$ = 6.87 cfs OK

Efficiency: = 100% Q = 0.66 cfs (DM-2 Figure: 10.3.3 Slope $_{Long.}$ = 2.36% **Slope $_x$ = 4%)
Bypass = 0.00 cfs

* For 10 year storm
**For Cross Slope at Inlet

INLET CALCULATION

Project name:	Wood Avenue HOP	Designed by:	ZMK	Date:	12/4/24
Project no.:	222290756	Checked by:		Date:	
Stations:					

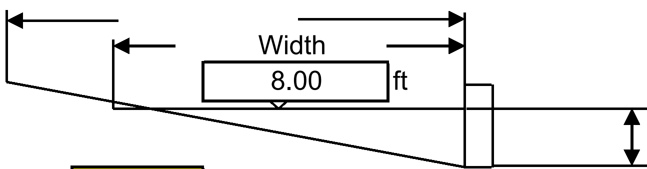
DRAINAGE AREA W8 INLET IW-8

Allowable Flow

Allowable Width 8.00 ft

Width 8.00 ft

Height 0.32 ft



S_x: 4%

Half Lane + Shoulder = 8.00 ft

Roughness (n) = 0.015 (Pub 584 Table 7.5)

Slope $_{Long.}$ = 2.36%

*SUMP CONDITION

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 6.87 cfs

Actual Gutter spread = 4.29 ft

Inlet Flow:

Inlet no: IW-8 Station: 97+83.21 RT

A_p	=	0.062	acre	A_g	=	0.075	acre	A_T	=	0.137	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.57	
I_{10}	=	6.50	in/hr					Bypass	=	0.79	CFS

Q_{actual} = CIA = 1.30 cfs < $Q_{all.}$ = 6.87 cfs OK

Efficiency: = 100% Q = 1.30 cfs (DM-2 Table: 10.3.1 Slope $_{Long.}$ = 2.36% **Slope $_x$ = 4%)

Bypass = 0.00 cfs (Inlet Capacity = 3.50 CFS)

* For 10 year storm

**For Cross Slope at Inlet

INLET CALCULATION

Project name: Wood Avenue HOP
Project no.: 222290756
Stations:

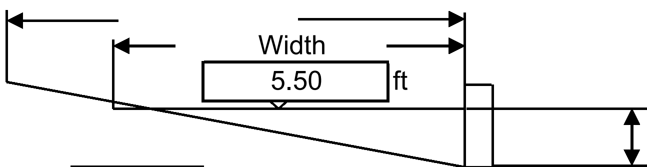
Designed by: ZMK   Date: 12/4/24
Checked by: Date:

DRAINAGE AREA R1   INLET   IR-1

Allowable Flow

Allowable Width: 5.50 ft

Width: 5.50 ft



Height: 0.33 ft

S_x: 6%

Half Lane + Shoulder =	5.50	ft
Roughness (n) =	0.015	(Pub 584 Table 7.5)
Slope $_{Long.}$ =	4.14%	

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\,L_{ong}^{1/2})$ = 6.58 cfs

Actual Gutter spread = 3.34 ft

Inlet Flow:

Inlet no: IR-1   Station: 113+51.94 RT

A_p	=	0.186	acre	A_g	=	0.332	acre	A_T	=	0.518	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.52	
I_{10}	=	6.50	in/hr								

Q_{actual} = CIA = 1.74 cfs < $Q_{all.}$ = 6.58 cfs OK

Efficiency: = 100%   Q = 1.74 cfs   (DM-2 Table: 10.3.1   Slope $_{Long.}$ = 4.14%   **Slope $_x$ = 6%)

Bypass = 0.00 cfs   (Inlet Capacity = 2.60 CFS)

* For 10 year storm

**For Cross Slope at Inlet

INLET CALCULATION

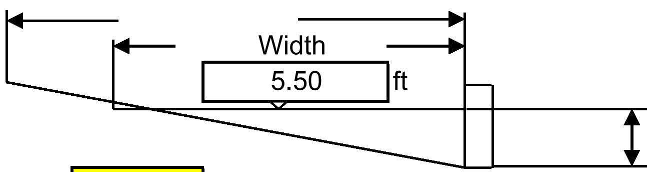
Project name:	Wood Avenue HOP	Designed by: ZMK	Date: 12/4/24
Project no.:	222290756	Checked by:	Date:
Stations:			

DRAINAGE AREA R2 INLET IR-2

Allowable Flow

Allowable Width 5.50 ft

Width 5.50 ft



Height 0.33 ft

S_x: 6%

Half Lane + Shoulder = 5.50 ft

Roughness (n) = 0.015 (Pub 584 Table 7.5)

$Slope_{Long.}$ = 3.65%

$Q_{allowed} = (0.56/n)(Sx^{5/3})(T^{8/3})(S\ L_{ong}^{1/2})$ = 6.18 cfs

Actual Gutter spread = 1.83 ft

Inlet Flow:

Inlet no: IR-2 Station: 114+59.51 RT

A_p	=	0.037	acre	A_g	=	0.057	acre	A_T	=	0.094	acre
C_p	=	0.90		C_g	=	0.30		C_T	=	0.54	
I_{10}	=	6.50	in/hr								

Q_{actual} = CIA = 0.33 cfs < $Q_{all.}$ = 6.18 cfs OK

Efficiency: = 100% Q = 0.33 cfs (DM-2 Table: 10.3.1 $Slope_{Long.}$ = 3.65% **$Slope_x$ = 6%)

Bypass = 0.00 cfs (Inlet Capacity = 2.60 CFS)

* For 10 year storm

**For Cross Slope at Inlet

APPENDIX B

STORM SEWER DESIGN

DRAINAGE CALCULATION

Project name: Wood HOP
Project no.: 222290756

Designed by: ZMK Date: 12/16/24
Checked by: Date:

		Drainage Area								I	Q																		
Inlet Number	Station	ΔA	C	ΔAC_0	AC_B (Bypass from Previous Inlet)	AC_B (Bypass from Previous Inlet)	$\Delta AC_0 + \Delta AC_B$ (Total Flow Available to Inlet)	ΔAC_i (Flow Accepted by Inlet)	$\Sigma\Delta AC_i$ (Cumulative Flow in System)	Rainfall Intensity	Discharge	Downstream Inlet Number	Top of Grate Elev	Pavment Depth	Pipe Cover	Length of Pipe	Invert Out (inlet) Invert In (Pipe)	Invert Out (Pipe) Invert In (Downstream Inlet)	Slope of Pipe	Type of Pipe	Manning's "n" Value	Partial Q to Full Q	Partial V to Full V	Size of Pipe	Mean Velocity	Full Flow Velocity	Pipe Capacity Flowing Full	Pipe Size Design	Remarks
-	-	acres	-	-	-			-	-	in/h	cfs	-	ft	ft	ft	ft	ft	ft	%	-	-	-	-	in	ft/s	ft/s	cfs	-	-
IH-1	-	0.225	0.47	0.105	0.00	0.000	0.105	0.101	0.101	6.50	0.66	IH-2	245.89	1.25	0.43	30.00	242.50	242.30	0.67%	TP	0.012	0.07	0.58	18	3.04	5.24	9.28	OK	
IH-2	-	0.062	0.90	0.056	0.00	0.000	0.056	0.056	0.157	6.50	1.02	IH-3	245.89	1.25	0.80	62.80	242.13	241.80	0.53%	TP	0.012	0.12	0.67	18	3.13	4.68	8.28	OK	
IH-3	-	1.061	0.37	0.394	0.00	0.000	0.394	0.354	0.512	6.50	3.33	IH-4	246.15	1.25	1.39	133.10	241.63	236.00	4.23%	TP	0.012	0.14	0.71	18	9.38	13.20	23.37	OK	
IH-4	-	0.262	0.66	0.173	0.28	0.043	0.216	0.211	0.723	6.50	4.70	IH-5	240.73	1.25	1.94	191.30	235.83	230.00	3.05%	TP	0.012	0.24	0.82	18	9.19	11.21	19.84	OK	
IH-5	-	0.328	0.52	0.171	0.03	0.005	0.176	0.176	0.899	6.50	5.84	IH-6	234.16	1.25	1.20	146.20	229.83	227.75	1.42%	TP	0.012	0.43	0.96	18	7.36	7.66	13.56	OK	
IH-6	-	0.223	0.49	0.109	0.00	0.000	0.109	0.109	1.008	6.50	6.55	Outlet	231.75	0.00	2.29	107.00	227.58	226.00	1.48%	TP	0.012	0.47	0.97	18	7.57	7.81	13.82	OK	
HW-1	-	0.549	0.54	0.296	0.00	0.000	0.296	0.296	0.296	6.50	1.93	Outlet	-	0.00	-	83.00	231.38	230.50	1.06%	CMP	0.024	0.02	0.37	48	2.36	6.38	80.08	OK	
IW-1	-	0.062	0.90	0.056	0.00	0.000	0.056	0.054	0.054	6.50	0.35	IW-2	262.29	1.25	0.33	30.00	259.00	258.80	0.67%	TP	0.012	0.04	0.47	18	2.46	5.24	9.28	OK	
IW-2	-	0.062	0.90	0.056	0.00	0.000	0.056	0.056	0.110	6.50	0.71	IW-4	262.29	1.25	0.70	76.50	258.63	258.00	0.83%	TP	0.012	0.07	0.58	18	3.39	5.84	10.34	OK	
IW-3	-	1.557	0.49	0.764	0.00	0.000	0.764	0.764	0.764	6.50	4.97	IW-4	263.50	1.25	2.54	53.83	260.00	258.00	3.72%	TP	0.012	0.23	0.82	18	10.15	12.37	21.90	OK	
IW-4	-	0.266	0.90	0.239	0.00	0.000	0.239	0.232	1.107	6.50	7.19	Outlet	261.94	1.25	1.15	136.00	257.83	256.00	1.35%	TP	0.012	0.55	1.20	18	8.94	7.45	13.19	OK	
IW-6	-	1.285	0.51	0.660	0.00	0.000	0.660	0.542	0.542	6.50	3.52	IW-8	241.20	1.25	0.25	22.90	238.20	238.00	0.87%	TP	0.012	0.33	0.89	18	5.34	6.00	10.62	OK	
IW-7	-	0.199	0.51	0.102	0.00	0.000	0.102	0.102	0.102	6.50	0.66	IW-8	241.35	1.25	0.40	21.10	238.20	238.00	0.95%	TP	0.012	0.06	0.59	18	3.69	6.25	11.06	OK	
IW-8	-	0.137	0.57	0.078	0.79	0.122	0.200	0.200	0.843	6.50	5.48	Outlet	240.93	1.25	0.18	109.00	237.83	237.00	0.76%	TP	0.012	0.55	1.20	18	6.73	5.61	9.93	OK	

APPENDIX C
SWALE DESIGN

North American Green
5401 St. Wendel-Cynthiana Rd.
Poseyville, Indiana 47633
Tel. 800.772.2040
>Fax 812.867.0247
www.nagreen.com
ECMDS v7.0

CHANNEL ANALYSIS

> > > PR Swale 1

Name	PR Swale 1
Discharge	12
Channel Slope	0.05
Channel Bottom Width	0
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Good 65-79%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	12 cfs	4.65 ft/s	0.93 ft	0.041	4 lbs/ft2	2.89 lbs/ft2	1.38	STABLE	--
Underlying Substrate	Straight	12 cfs	4.65 ft/s	0.93 ft	0.041	1.87 lbs/ft2	1.37 lbs/ft2	1.36	STABLE	--

North American Green
5401 St. Wendel-Cynthiana Rd.
Poseyville, Indiana 47633
Tel. 800.772.2040
>Fax 812.867.0247
www.nagreen.com
ECMDS v7.0

CHANNEL ANALYSIS

> > > PR SWALE 2

Name	PR SWALE 2
Discharge	18
Channel Slope	0.03
Channel Bottom Width	0
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Good 65-79%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	18 cfs	3.97 ft/s	1.23 ft	0.045	4 lbs/ft2	2.3 lbs/ft2	1.74	STABLE	--
Underlying Substrate	Straight	18 cfs	3.97 ft/s	1.23 ft	0.045	2.24 lbs/ft2	1.09 lbs/ft2	2.05	STABLE	--

Job No.	222209756	Designer	ZMK	Date	12/18/2024
		Checker		Date	
Offset LT	STA 97+50 To 101+35	Revised		Date	
		Checker		Date	

DEP WORKSHEET #11
Channel Design Data
WOOD HOP CHANNEL CONDITIONS

CHANNEL OR CHANNEL SECTION	PR SWALE 1	PR SWALE 2				
PROTECTIVE LINING	Unreinforced Vegitation	Unreinforced Vegitation				
T_D (CHANNEL TOP WIDTH, ft @ D)	8.6	10.4				
T_d (CHANNEL TOP WIDTH, ft @ d)	5.6	7.4				
CHANNEL LEFT SIDE SLOPE (H:V)	3	3				
CHANNEL RIGHT SIDE SLOPE (H:V)	3	3				
b (CHANNEL BOTTOM WIDTH, ft)	0	0				
d (FLOW DEPTH IN ft)	0.93	1.23				
BOTTOM WIDTH:DEPTH RATIO (12:1 max)	0	0				
A (AREA IN sq ft)	2.59	4.54				
P (WETTED PERIMETER)	5.88	7.78				
R (HYDRAULIC RADUIS)	0.4	0.6				
S (BED SLOPE, ft/ft)*	0.0500	0.0300				
VEGETATIVE LINING RETARDANCE	C	C				
n (MANNING'S CAPACITY)**	0.041	0.045				
V (AT FLOW DEPTH d, fps)	4.7	4.0				
Q (AT FLOW DEPTH d, cfs)	12.00	18.00				
Q_r (REQUIRED CAPACITY, cfs)	12.00	18.00				
S_C (CRITICAL SLOPE, ft/ft)	0.034	0.037				
$0.7S_C$	0.024	0.026				
$1.3S_C$	0.044	0.048				
STABLE FLOW? (YES/NO)	YES	NO				
FREEBOARD BASED ON UNSTABLE FLOW (ft)	N/A	0.4				
FREEBOARD BASED ON STABLE FLOW (ft)	0.2	N/A				
MINIMUM REQUIRED FREEBOARD (ft)	0.5	0.5				
D (TOTAL DEPTH, ft) Required	1.4	1.7				
D (TOTAL DEPTH, ft) Provided	1.5	2.5				
d_{50} (STONE SIZE, in)	N/A	N/A				
DESIGN METHOD FOR PROTECTIVE LINING **** PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)	S	S				
V_a (ALLOWABLE VELOCITY, fps)	N/A	N/A				
τ_d(SHEAR STRESS AT FLOW DEPTH (d), lb/ft^2)	2.90	2.30				
τ_a(MAXIMUM ALLOWABLE SHEAR STRESS, lb/ft^2)	4.00	4.00				

* Slopes may not be averaged.

** For vegetated channels, provide data for temporary linings and vegetated conditions in separate columns.

*** Minimum Freeboard is 0.5 ft.

**** Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is recommended for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

APPENDIX D
DRAINAGE AREA PLANS

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
5-0	NORTHAMPTON	2017		1 OF 3

REV NO	REVISIONS	DATE	BY	APPD

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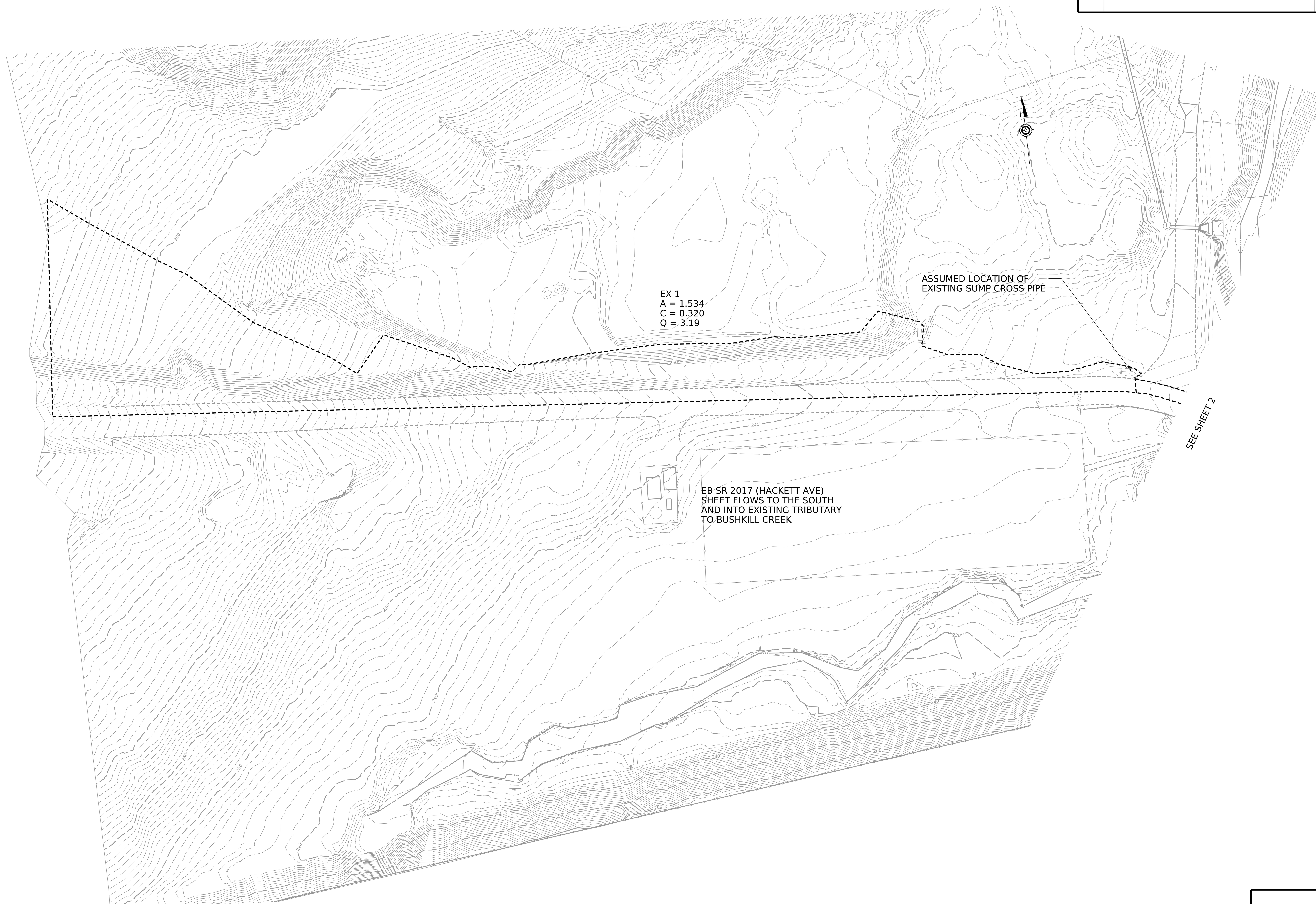


SCALE

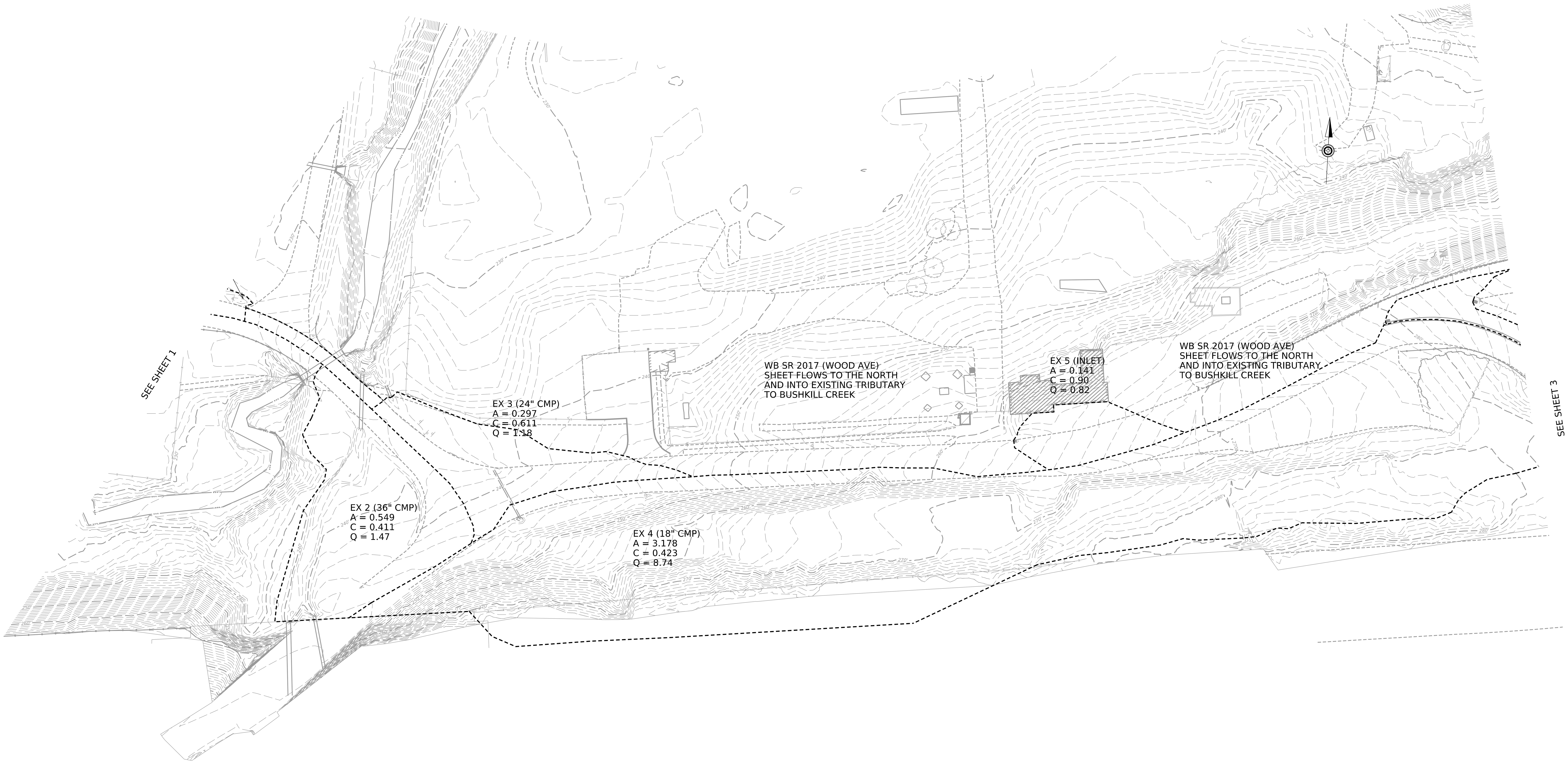
HORIZONTAL 0 25 50 FEET

PRE DEVELOPMENT DRAINAGE AREAS

OPERATOR: Zachary.Kaczmarek
FILE NAME: pw://kci-pw.bentley.com:kci-pw-05/Documents/Projects/2022/222209756/Design/ORD/WorkSets/dgn/Base/EX_Drainage Areas

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
5-0	NORTHAMPTON	2017		2 OF 3

REV NO	REVISIONS	DATE	BY	APPD



SCALE

HORIZONTAL 0 25 50 FEET

PRE DEVELOPMENT DRAINAGE AREAS

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
5-0	NORTHAMPTON	2017		3 OF 3

REV NO	REVISIONS	DATE	BY	APPD

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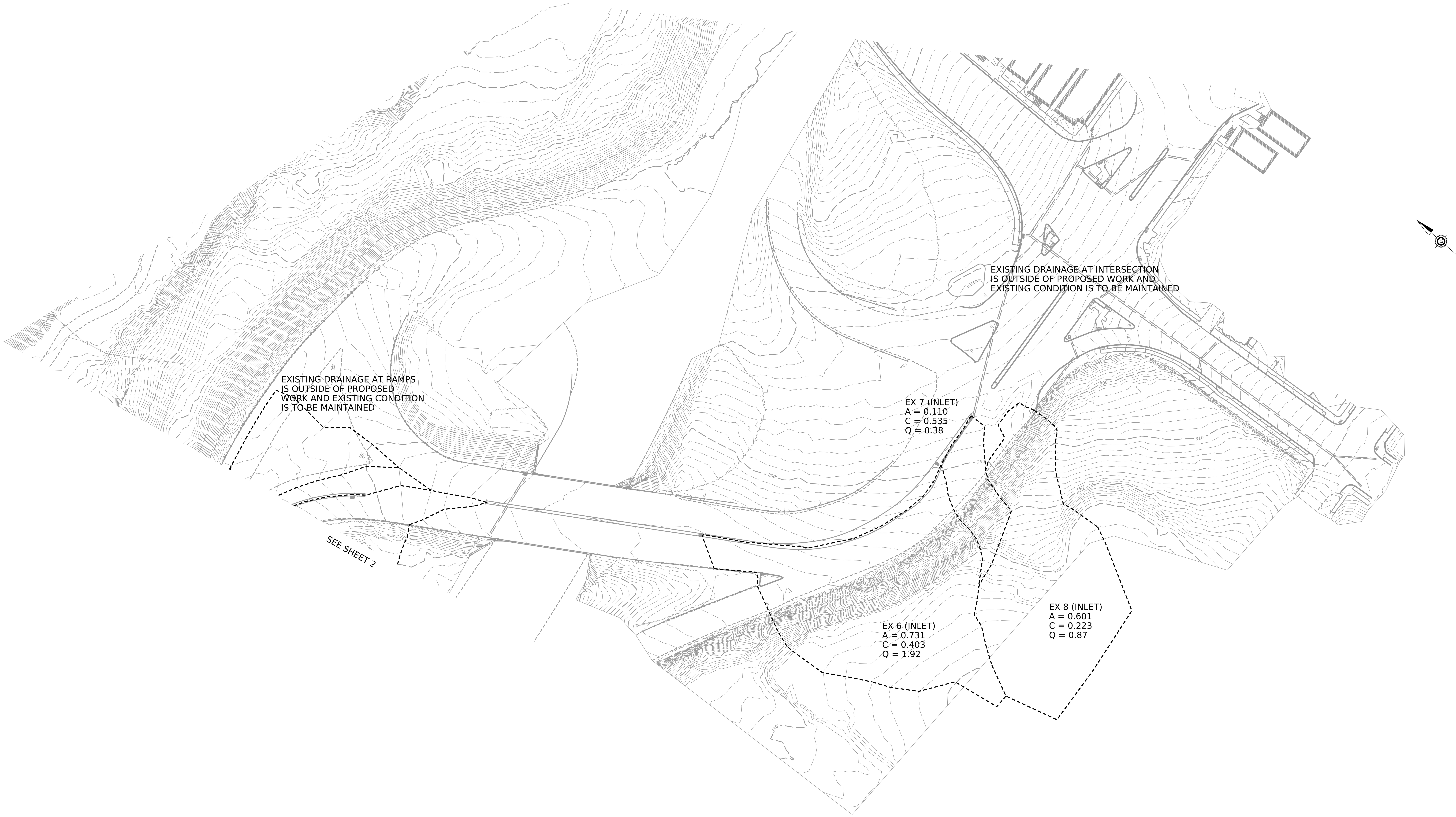


SCALE

HORIZONTAL 0 25 50 FEET

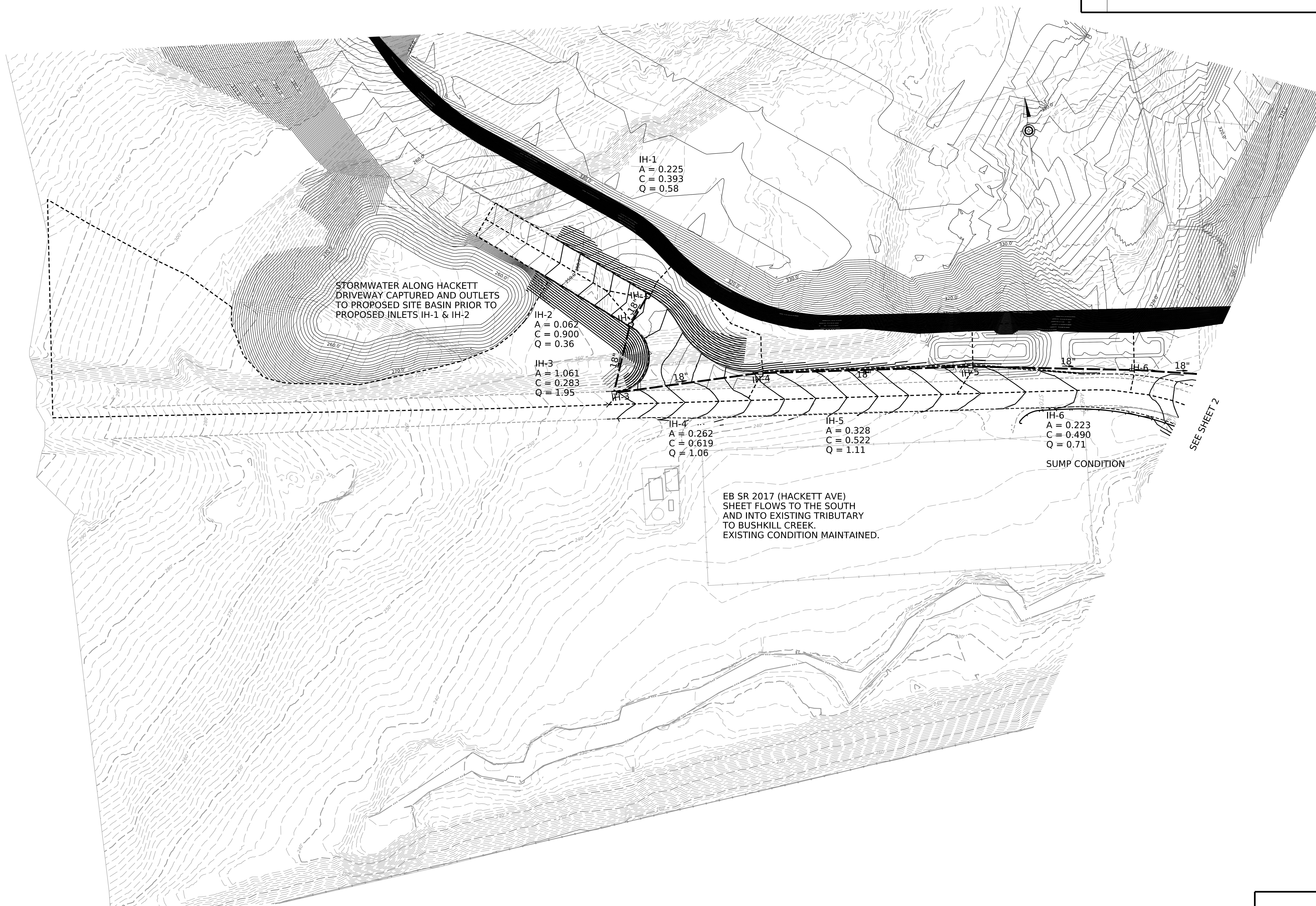
PRE DEVELOPMENT DRAINAGE AREAS

OPERATOR: Zachary.Kaczmarek
FILE NAME: pw://kci-pw.bentley.com:kci-pw-05/Documents/Projects/2022/222209756/Design/ORD/WorkSets/dgn/Base/EX_Drainage Areas

PLOTTED: 19-DEC-2024 10:39

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
5-0	NORTHAMPTON	2017		1 OF 3

REV NO	REVISIONS	DATE	BY	APPD



SCALE

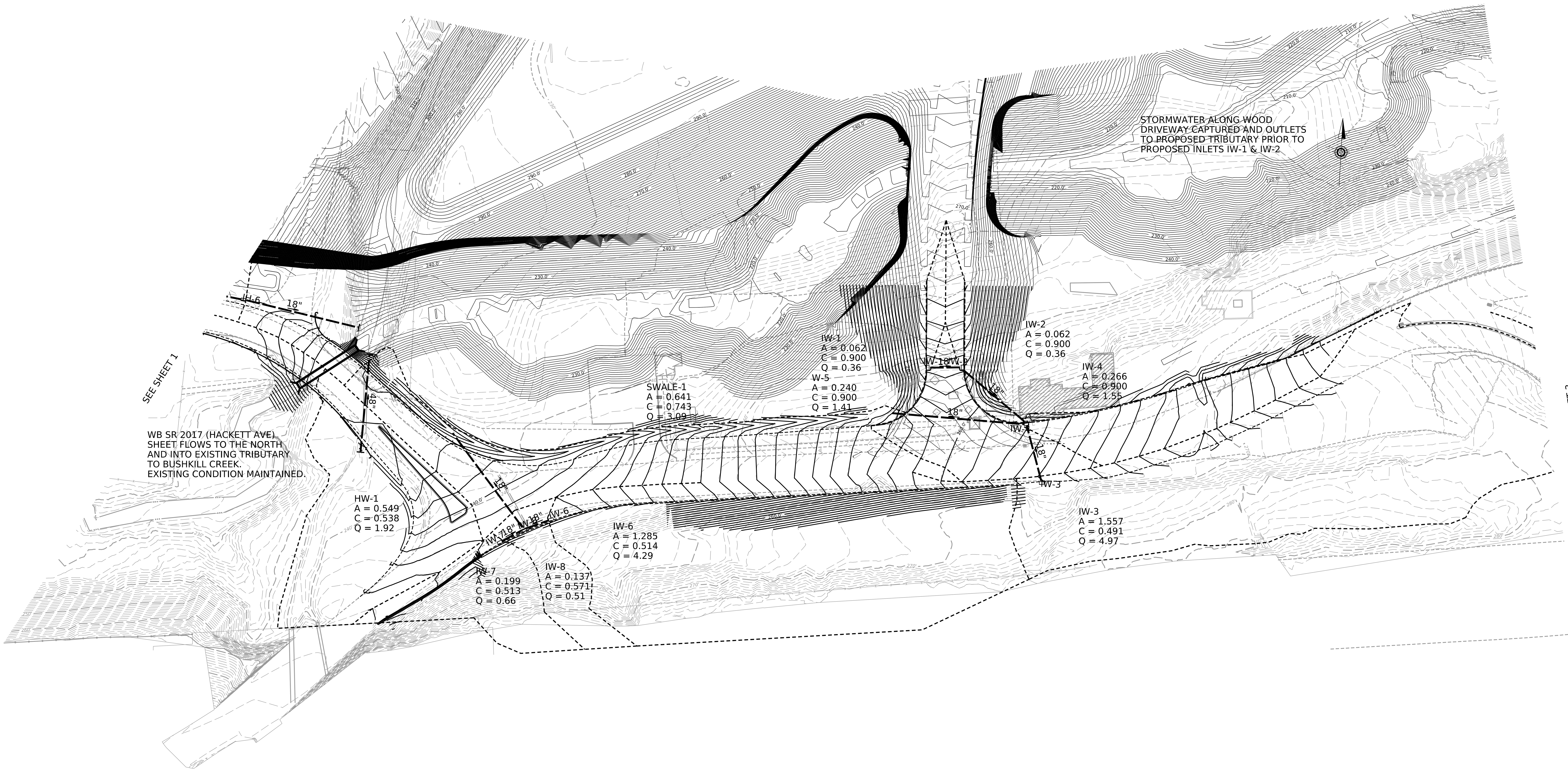
HORIZONTAL 0 25 50 FEET

POST DEVELOPMENT DRAINAGE AREAS

OPERATOR: Zachary.Kaczmarek
FILE NAME: pw://kci-pw.bentley.com:kci-pw-05/Documents/Projects/2022/222209756/Design/ORD/WorkSets/dgn/Working/ZMK/pr_Drainage Areas.dgn

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
5-0	NORTHAMPTON	2017		2 OF 3

REV NO	REVISIONS	DATE	BY	APPD



SCALE

HORIZONTAL 0 25 50 FEET

POST DEVELOPMENT DRAINAGE AREAS

PLOTTED: 19-DEC-2024 10:45
OPERATOR: Zachary.Kaczmarek
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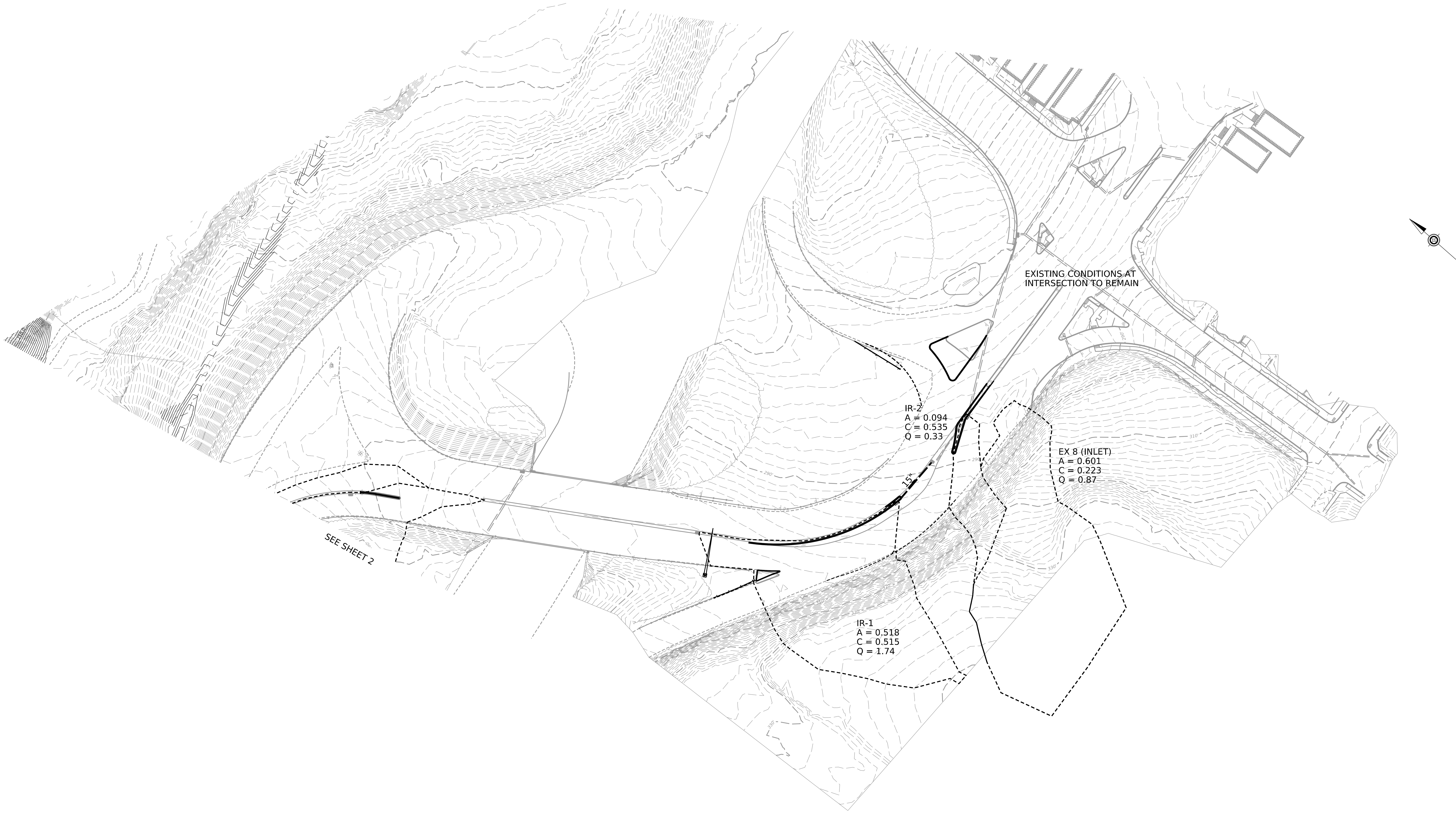
DISTRICT	COUNTY	ROUTE	SECTION	SHEET
5-0	NORTHAMPTON	2017		3 OF 3

REV NO	REVISIONS	DATE	BY	APPD



SCALE

HORIZONTAL 0 25 50 FEET

POST DEVELOPMENT DRAINAGE AREAS

PLOTTED: 19-DEC-2024 10:52

OPERATOR: Zachary.Kaczmarek
FILE NAME: pw://kci-pw.bentley.com:kci-pw-05/Documents/Projects/2022/222209756/Design/ORD/WorkSets/dgn/Working/ZMK/pr_Drainage Areas.dgn

APPENDIX E

DESIGN FIGURES AND CHARTS

systematic assignment of a runoff coefficient "component" is made. Using Equation 7.10, the four assigned components are then added together to form an overall runoff coefficient for the specific watershed segment.

(Equation 7.10)

$$C = C_r + C_i + C_v + C_s$$

Runoff coefficients, listed in Table 7.7 and Table 7.7(a), and others are applicable for storms of 2-year, 5-year, and 10-year return periods. Higher frequency storms will require modifying the runoff coefficient because infiltration and other abstractions have a proportionally smaller effect on runoff. The designer should adjust the runoff coefficient by the factor C_f as indicated in Table 7.8. Generally, the product of C and C_f should not exceed 1.0.

Table 7.7 Runoff Factors for the Rational Equation

TYPE OF DRAINAGE AREA OR SURFACE	RUNOFF FACTOR "C"	
	MINIMUM	MAXIMUM
Pavement, concrete or bituminous concrete	0.75	0.95
Pavement, bituminous macadam or surface-treated gravel	0.65	0.80
Pavement, gravel, macadam, etc.	0.25	0.60
Sandy soil, cultivated or light growth	0.15	0.30
Sandy soil, woods or heavy brush	0.15	0.30
Gravel, bare or light growth	0.20	0.40
Gravel, woods or heavy brush	0.15	0.35
Clay soil, bare or light growth	0.35	0.75
Clay soil, woods or heavy growth	0.25	0.60
City business sections	0.60	0.80
Dense residential sections	0.50	0.70
Suburban, normal residential areas	0.35	0.60
Rural areas, parks, golf courses	0.15	0.30

NOTES

1. Higher values are applicable to denser soils and steep slopes.
2. Consideration should be given to future land use changes in the drainage area in selecting the "C" factor.
3. For drainage area containing several different types of ground cover, a weighted value of "C" factor shall be used.
4. In special situations where sinkholes, stripped abandoned mines, etc. exist, careful evaluation shall be given to the selection of a suitable runoff factor with consideration given to possible reclamation of the land in the future.

CHAPTER 7, APPENDIX A

FIELD MANUAL FOR PENNSYLVANIA DESIGN RAINFALL INTENSITY CHARTS FROM NOAA ATLAS 14 VERSION 3 DATA

7A.0 INTRODUCTION

Previously used procedures to estimate design rainfall intensities, usually obtained from the *U.S. Weather Bureau Technical Paper No. 40* (Hershfield, 1961) or the *1986 Field Manual of PennDOT Storm-Intensity-Duration-Frequency Charts PDT-IDF* (Aron et al., 1986), have been updated in this appendix. The regional rainfall design curves in this Pennsylvania field manual were developed from frequency analyses based on hourly records from 278 daily and 139 hourly rainfall gages in Pennsylvania plus gages in surrounding states for a period of record from April 1, 1863 through December 31, 2000. The analysis leading to the design curves is fully described in this Appendix.

In performing the PDT-IDF analysis, it was found that there were regional differences in rainfall patterns between storm durations. For example, the lowest intensities and amounts for the five (5) minute storms are located in north central PA, whereas the lowest intensities and amounts for the twenty-four (24) hour storm are located in western PA. It was determined that one rainfall region map would not adequately represent the rainfall patterns. Therefore, the maps were developed based upon storm duration and frequency as shown in Table 7A.1.

7A.1 PROCEDURE FOR FINDING DESIGN INTENSITY VALUES

A. Objective. To obtain the design rainfall or return periods from 1 to 100-years and durations from 5 minutes to 24 hours and to obtain the 500-year, 24-hour precipitation.

Step 1 Determine the rainfall duration of the storm that will need to be analyzed. For the rational method, the required storm duration will be equal to the time-of-concentration.

Step 2 From Table 7A.1, determine what Rainfall Region Map should be utilized for the design storm duration of interest.

Table 7A.1 Appropriate Rainfall Region Map for each Storm Duration and Frequency

	Frequency							
Duration	**1 year**	**2 year**	**5 year**	**10 year**	**25 year**	**50 year**	**100 year**	**500 year**
5 min	C	C	C	C	B	B	B	-
10 min	C	C	C	C	C	C	C	-
15 min	A	A	A	A	C	C	C	-
30 min	A	A	A	A	A	C	C	-
60 min	A	A	A	A	A	C	C	-
2 hr	E	E	E	E	E	E	E	-
3 hr	E	E	E	E	E	E	E	-
6 hr	D	D	D	D	D	D	D	-
12 hr	F	F	F	F	F	F	F	-
24 hr	F	F	F	F	F	F	F	F

Step 3 Locate the area of interest on the Pennsylvania map for the Map determined in Step 2 (Figures 7A.1 through 7A.6) and note the region into which this area falls.

Figure 7A.3 Map C. 5- and 10-minute durations for storms occurring with an ARI of 1-, 2-, 5-, and 10-years, 10- and 15-minute durations for storms occurring with an ARI of 25-years and 10-, 15-, 30-, 60-minute durations for storms occurring with an ARI of 50- and 100-years.

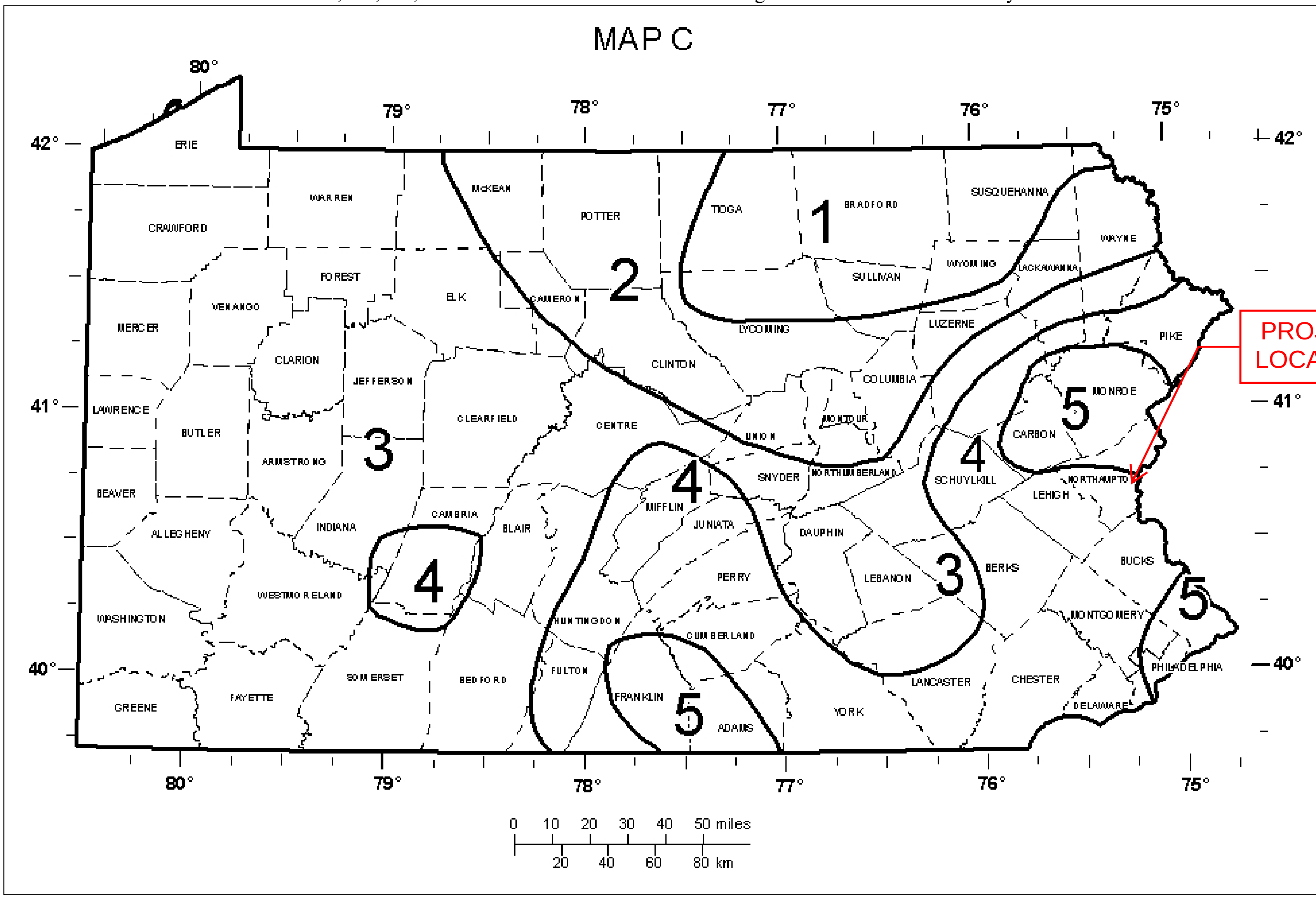


Table 7.5 Roughness Coefficients n-values for Manning's Equation (Pipes and Pavements)

Description	**Manning's n-value**
Polyvinyl Chloride (PVC) with smooth Inner Walls	0.010
Corrugated High-Density Polyethylene (HDPE) with Smooth Inner Walls	0.012
Corrugated High-Density Polyethylene (HDPE) with Corrugated Inner Walls	0.015
Concrete Pipe	0.012
Smooth-lined Corrugated Metal Pipe	0.012
Corrugated Plastic Pipe	0.024
Annular Corrugated Steel And Aluminum Alloy Pipe (Plain or polymer coated)	
68 mm × 13 mm (2 2/3 in × 1/2 in) Corrugations	0.024
75 mm × 25 mm (3 in × 1 in) Corrugations	0.027
125 mm × 25 mm (5 in × 1 in) Corrugations	0.025
150 mm × 50 mm (6 in × 2 in) Corrugations	0.033
Helically Corrugated Steel And Aluminum Alloy Pipe (Plain or polymer coated) 75 mm × 25 mm (3 in × 1 in), 125 mm × 25 mm (5 in × 1 in), or 150 mm × 50 mm (6 in × 2 in) Corrugations	0.024
Helically Corrugated Steel And Aluminum Alloy Pipe (Plain or polymer coated) 68 mm × 13 mm (2 2/3 in × 1/2 in) Corrugations	
a. Lower Coefficients*	
450 mm (18 in) Diameter	0.014
600 mm (24 in) Diameter	0.016
900 mm (36 in) Diameter	0.019
1200 mm (48 in) Diameter	0.020
1500 mm (60 in) Diameter or larger	0.021
b. Higher Coefficients**	0.024
Annular or Helically Corrugated Steel or Aluminum Alloy Pipe Arches or Other Non-Circular Metal Conduit (Plain or Polymer coated)	0.024
Vitrified Clay Pipe	0.012
Ductile Iron Pipe	0.013
Asphalt Pavement	0.015
Concrete Pavement	0.014
Grass Medians	0.050
Grass – Residential	0.030
Earth	0.020
Gravel	0.030
Rock	0.035
Cultivated Areas	0.030 - 0.050
Dense Brush	0.070 - 0.140
Heavy Timber (Little undergrowth)	0.100 - 0.150
Heavy Timber (with underbrush)	0.40
Streams:	
a. Some Grass And Weeds (Little or no brush)	0.030 - 0.035
b. Dense Growth of Weeds	0.035 - 0.050
c. Some Weeds (Heavy brush on banks)	0.050 - 0.070

Notes:

* Use the lower coefficient if any one of the following conditions apply:

- **a.** A storm pipe longer than 20 diameters, which directly or indirectly connects to an inlet or manhole, located in swales adjacent to shoulders in cut areas, shoulders in cut areas or depressed medians.
- **b.** A storm pipe which is specially designed to perform under pressure.

** Use the higher coefficient if any one of the following conditions apply:

- **a.** A storm pipe which directly or indirectly connects to an inlet or manhole located in highway pavement sections or adjacent to curb or concrete median barrier.
- **b.** A storm pipe which is shorter than 20 diameters long.
- **c.** A storm pipe which is partly lined helically corrugated metal pipe.

Figure 7A.14(a) Rainfall Intensity for 1- through 100-year Storms for Region 4 (U.S. Customary).

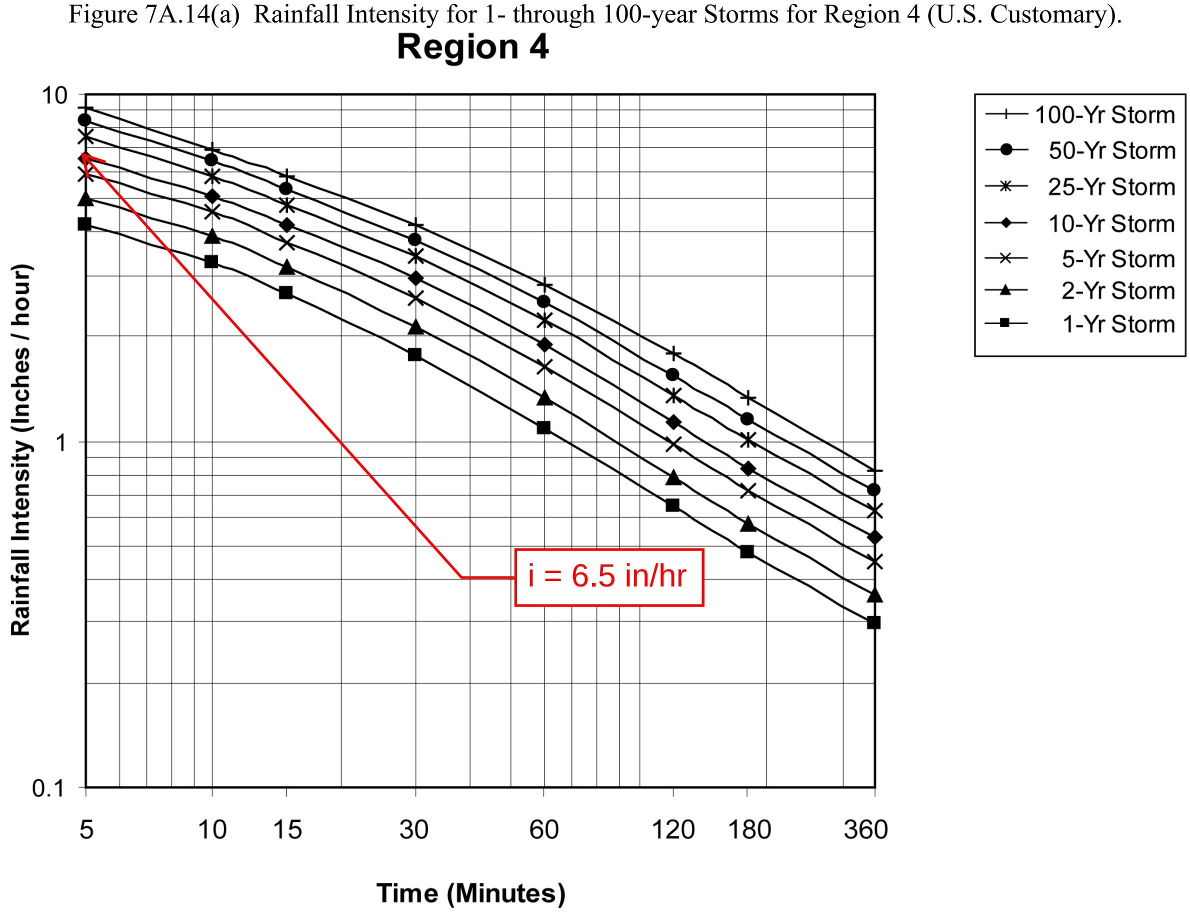


Figure 7A.14(b) Rainfall Amount for 1- through 100-year Storms for Region 4 (U.S. Customary).

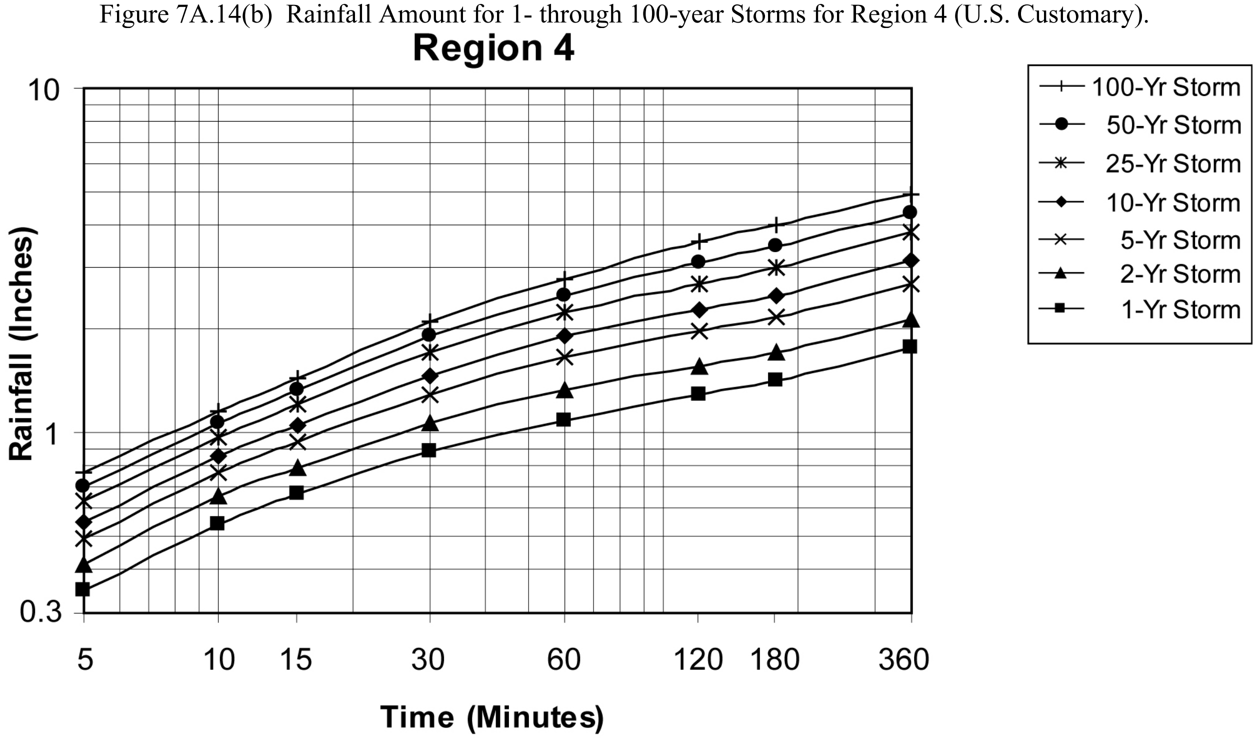


Figure 20

RELATIVE VELOCITY AND FLOW IN CIRCULAR PIPE FOR ANY DEPTH OF FLOW

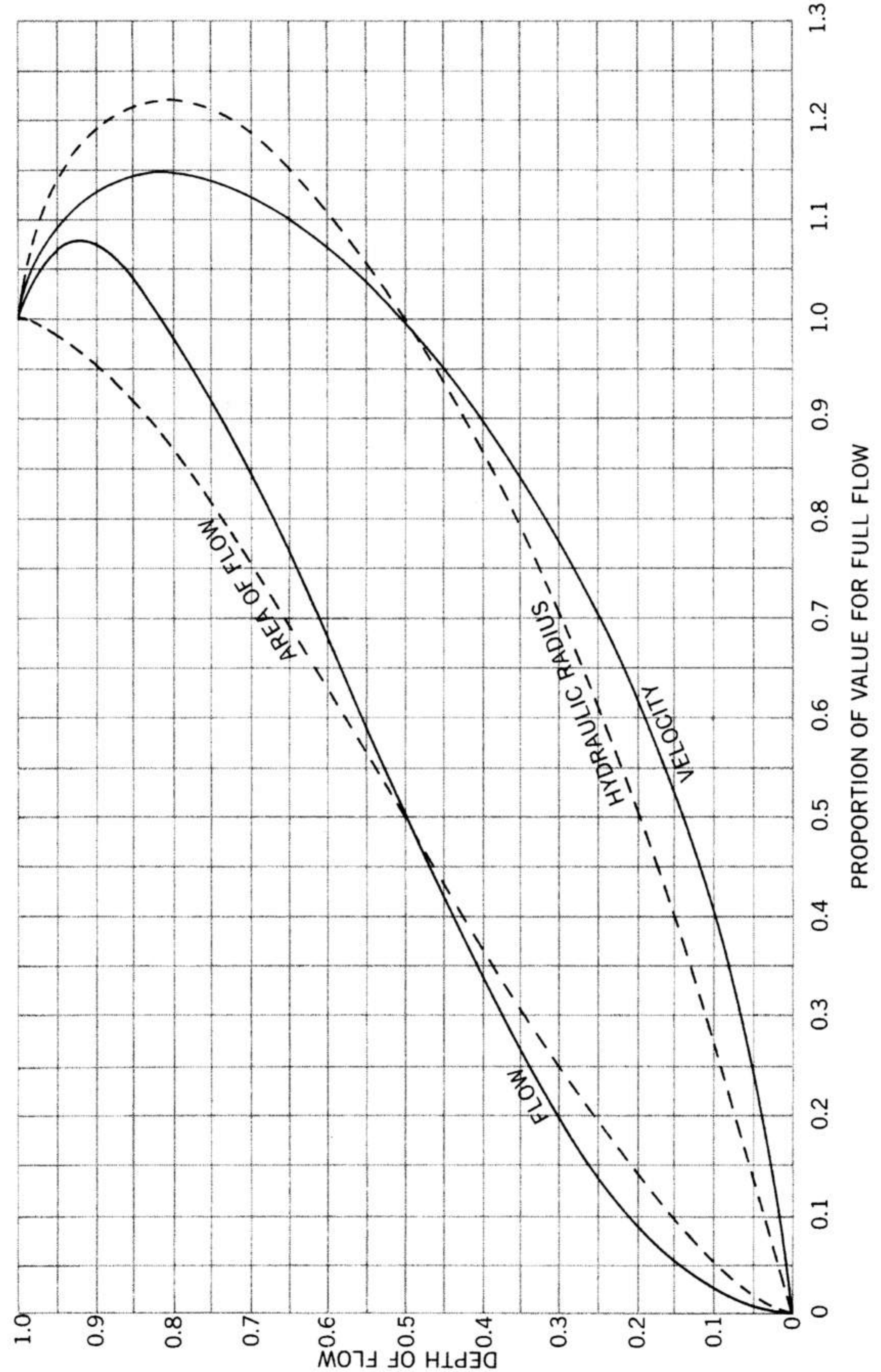


Table 8.11 Allowable Shear Stresses for Various Linings

Lining Category	Lining Type	Allowable Unit Shear Stress	
		Pa	**lb/ft²**
Unlined – Easily Eroded Soils [1]	Silts, Fine-Medium Sands	1.4	0.03
	Coarse Sands	1.9	0.04
	Very Coarse Sands	2.4	0.05
	Fine Gravel	4.8	0.10
Unlined – Erosion Resistant Soils [2]	Clay Loam	12.0	0.25
	Silty Clay Loam	8.6	0.18
	Sandy Clay Loam	4.8	0.10
	Loam	3.4	0.07
	Silt Loam	5.7	0.12
	Sandy Loam	1.0	0.02
	Gravely, Stony, Channery Loam	2.4	0.05
	Stony or Channery Silt Loam	3.4	0.07
Non-Reinforced Vegetation	Class A	177.2	3.70
	Class B	100.6	2.10
	Class C	47.9	1.00
	Class D	28.7	0.60
	Class E	16.8	0.35
Temporary RECPs [3]	Mulch Control Netting [5]	See Table 8.15	
	Netless Rolled Erosion Control Blanket [5]		
	Open Weave Textile		
	Single-net Erosion Control Blanket		
	Double-net Erosion Control Blanket		
Permanent RECPs [3,4]	Turf Reinforcement Mat – Type 5.A	288	6.0
	Turf Reinforcement Mat – Type 5.B	384	8.0
	Turf Reinforcement Mat – Type 5.C	480	10.0
Riprap Lining	R-3	48	1.0
	R-4	96	2.0
	R-5	144	3.0
	R-6	192	4.0
	R-7	240	5.0
	R-8	384	8.0
	Gabion – 305 mm (12 in)	225	4.7
	Gabion – 457 mm (18 in)	249	5.2
	Gabion – 914 mm (36 in)	397	8.3
	Reno Mattress – 152 mm (6 in)	206	4.3
	Reno Mattress – 229 mm (9 in)	220	4.6

[1] Soils having an erodibility K factor greater than 0.37.
[2] Soils having an erodibility K factor less than or equal to 0.37.
[3] Categories are based on FHWA classification system for RECPs.
[4] The difference between the three types of TRMs is the minimum tensile strength.
[5] Few, if any, of these are approved for PennDOT use.

Table 8.12 Permissible Velocities for Various Linings

Lining Category	Lining Type / Soil Material	Permissible Velocity	
		m/s	ft/sec
Unlined [13]	Fine sand, noncolloidal	0.4	1.5
	Sandy loam, noncolloidal	0.5	1.7
	Silt loam, noncolloidal	0.6	2.0
	Alluvial silts, noncolloidal	0.6	2.0
	Ordinary firm loam	0.7	2.5
	Stiff clay, very colloidal	1.1	3.7
	Alluvial silts, colloidal	1.1	3.7
	Fine gravel	0.7	2.5
	Graded, loam to cobbles, noncolloidal	1.1	3.7
	Graded, silt to cobbles, colloidal	1.2	4.0
	Coarse gravel, noncolloidal	1.2	4.0
	Cobbles and shingles	1.5	5.0
	Shales and hardpans	1.8	6.0
Vegetated – Easily Eroded Soils [1, 5-12] Non-Reinforced	[3] Seed Mix. 0-5% Slope	1.2	4.0
	[3] Seed Mix. 5-10% Slope	0.9	3.0
	[4] Sod 0-5% Slope	1.5	5.0
	[4] Sod 5-10% Slope	1.2	4.0
	[4] Sod > 10% Slope	0.9	3.0
Vegetated – Erosion Resistant Soils [2, 5-12] Non-Reinforced	[3] Seed Mix. 0-5% Slope	1.5	5.0
	[3] Seed Mix. 5-10% Slope	1.2	4.0
	[4] Sod 0-5% Slope	2.1	7.0
	[4] Sod 5-10% Slope	1.8	6.0
	[4] Sod > 10% Slope	1.2	4.0
Riprap Lining	R-3	2.0	6.5
	R-4	2.7	9.0
	R-5	3.4	11.5
	R-6	3.9	13.0
	R-7	4.3	14.5
	Gabion - 305 mm (12 in)	4.6	15.0
	Gabion - 457 mm (18 in)	5.5	18.0
	Gabion - 914 mm (36 in)	6.7	22.0
	Reno Mattress - 152 mm (6 in)	1.8	6.0
	Reno Mattress - 229 mm (9 in)	3.6	12.0

[1] Soils having an erodibility K factor greater than 0.37.
[2] Soils having an erodibility K factor less than or equal to 0.37.
[3] Grass Mixture Formulas, as specified in Publication 408, *Specifications*, Section 804.2.
[4] Cultivated SOD, as specified in Publication 408, *Specifications*, Section 809.2 (suggested for intermittent flow only).
[5] Use a maximum 0.9 m/s (3.0 ft/s) if only sparse cover can be established or maintained.
[6] Use 0.9 - 1.2 m/s (3.0 - 4.0 ft/s) under normal conditions if the vegetation is to be established by seeding.
[7] Use 1.2 - 1.5 m/s (4.0 - 5.0 ft/s) if a dense, vigorous sod is obtained quickly or if water can be diverted out the waterway while vegetation is being established.
[8] Use 1.5 - 1.8 m/s (5.0 - 6.0 ft/s) on well-established, good quality sod.
[9] Use 1.8 m/s (6.0 ft/s) to 2.1 m/s (7.0 ft/s) may be used only on established, excellent quality sod.
[10] If erosion resistant materials supplement the vegetative lining, increase by 0.6 m/s (2.0 ft/s).
[11] A rock lined low flow channel should be incorporated when base flow exists.
[12] Use sod only where there is sufficient soil cover to allow proper stapling of the sod.
[13] Based on clear water discharges. Reference: FHWA, HDS No. 3, Design Charts for Open Channel Flow.