
E&SC SUPPORTING CALCULATIONS



E&SC SUPPORTING CALCULATIONS

Slope Drain Engineered Design Scenarios

Project: R230851.01	By: HWT	Date: 5/27/2025
Location: CWD-14-1B	Checked: LEK	Date: 5/28/2025

Check:	☐ Present	☐ Under Development	☒ Developed
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Sheet Flow

Segment ID	A1	
Surface Description.....	Woods	
Manning's Roughness Coefficient, n	0.4	(TR-55, Table 3-1)
Flow Length, L.....	100	ft
Two-year 24-hour Rainfall, P ₂	3.39	in
Land Slope, s.....	0.040	ft/ft
Travel Time, T _t = (0.007*(n*L) ^{0.8}) / (P ₂ ^{0.5} *s ^{0.4}).....	0.2635	hrs

Shallow Concentrated Flow

Segment ID	B1	
Surface Description (Paved / Unpaved).....	Unpaved	
Surface Description Coefficient, C.....	16.13	
Flow Length, L.....	1206	ft
Watercourse Slope, s.....	0.085	ft/ft
Average Velocity, V = C*s ^{0.5}	4.70	ft/sec
Travel Time, T _t = (L) / (3600*V).....	0.071	hrs

Channel Flow

Open Channel Flow

No Open Channel Flow

Pipe Flow

No Pipe Flow

Time of Concentration

Sheet Flow T _t	0.2635	hrs
Shallow Concentrated Flow T _t	0.0713	hrs
Channel Flow T _t	0.0000	hrs
Time of Concentration, T _c	0.3348	hrs
	20.1	mins

Project: R230851.01	By: HWT	Date: 5/23/2025
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Sheet Flow

Segment ID	A1	
Surface Description.....	Woods	
Manning's Roughness Coefficient, n	0.4	(TR-55, Table 3-1)
Flow Length, L.....	100	ft
Two-year 24-hour Rainfall, P ₂	3.39	in
Land Slope, s.....	0.151	ft/ft
Travel Time, T _t = (0.007*(n*L) ^{0.8}) / (P ₂ ^{0.5} *s ^{0.4}).....	0.1551	hrs

Shallow Concentrated Flow

Segment ID	B1	
Surface Description (Paved / Unpaved).....	Unpaved	
Surface Description Coefficient, C.....	16.13	
Flow Length, L.....	1246	ft
Watercourse Slope, s.....	0.222	ft/ft
Average Velocity, V = C*s ^{0.5}	7.60	ft/sec
Travel Time, T _t = (L) / (3600*V).....	0.046	hrs

Channel Flow

Open Channel Flow

No Open Channel Flow

Pipe Flow

No Pipe Flow

Time of Concentration

Sheet Flow T _t	0.1551	hrs
Shallow Concentrated Flow T _t	0.0456	hrs
Channel Flow T _t	0.0000	hrs
Time of Concentration, T _c	0.2006	hrs
	12.0	mins

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Sheet Flow

Segment ID	A1	
Surface Description.....	Grass	
Manning's Roughness Coefficient, n	0.24	(TR-55, Table 3-1)
Flow Length, L.....	100	ft
Two-year 24-hour Rainfall, P ₂	3.39	in
Land Slope, s.....	0.030	ft/ft
Travel Time, T _t = (0.007*(n*L) ^{0.8}) / (P ₂ ^{0.5} *s ^{0.4}).....	0.1952	hrs

Shallow Concentrated Flow

Segment ID	B1	
Surface Description (Paved / Unpaved).....	Unpaved	
Surface Description Coefficient, C.....	16.13	
Flow Length, L.....	1017	ft
Watercourse Slope, s.....	0.044	ft/ft
Average Velocity, V = C*s ^{0.5}	3.38	ft/sec
Travel Time, T _t = (L) / (3600*V).....	0.083	hrs

Channel Flow

Open Channel Flow

No Open Channel Flow

Pipe Flow

No Pipe Flow

Time of Concentration

Sheet Flow T _t	0.1952	hrs
Shallow Concentrated Flow T _t	0.0835	hrs
Channel Flow T _t	0.0000	hrs
Time of Concentration, T _c	0.2787	hrs
	16.7	mins

Project: R230851.01	By: HWT	Date: 5/23/2025
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Check:	☐ Present	☐ Under Development	☒ Developed
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Sheet Flow

Segment ID	A1	
Surface Description.....	Grass	
Manning's Roughness Coefficient, n	0.24	(TR-55, Table 3-1)
Flow Length, L.....	100	ft
Two-year 24-hour Rainfall, P ₂	3.39	in
Land Slope, s.....	0.031	ft/ft
Travel Time, T _t = (0.007*(n*L) ^{0.8}) / (P ₂ ^{0.5} *s ^{0.4}).....	0.1944	hrs

Shallow Concentrated Flow

Segment ID	B1	
Surface Description (Paved / Unpaved).....	Unpaved	
Surface Description Coefficient, C.....	16.13	
Flow Length, L.....	1017	ft
Watercourse Slope, s.....	0.049	ft/ft
Average Velocity, V = C*s ^{0.5}	3.56	ft/sec
Travel Time, T _t = (L) / (3600*V).....	0.079	hrs

Channel Flow

Open Channel Flow

No Open Channel Flow

Pipe Flow

No Pipe Flow

Time of Concentration

Sheet Flow T _t	0.1944	hrs
Shallow Concentrated Flow T _t	0.0794	hrs
Channel Flow T _t	0.0000	hrs
Time of Concentration, T _c	0.2739	hrs
	16.4	mins

Project: R230851.01	By: HWT	Date: 5/27/2025
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Sheet Flow

Segment ID	A1	
Surface Description.....	Woods	
Manning's Roughness Coefficient, n	0.4	(TR-55, Table 3-1)
Flow Length, L.....	100	ft
Two-year 24-hour Rainfall, P ₂	3.39	in
Land Slope, s.....	0.058	ft/ft
Travel Time, T _t = (0.007*(n*L) ^{0.8}) / (P ₂ ^{0.5} *s ^{0.4}).....	0.2265	hrs

Shallow Concentrated Flow

Segment ID	B1	
Surface Description (Paved / Unpaved).....	Unpaved	
Surface Description Coefficient, C.....	16.13	
Flow Length, L.....	1344	ft
Watercourse Slope, s.....	0.069	ft/ft
Average Velocity, V = C*s ^{0.5}	4.24	ft/sec
Travel Time, T _t = (L) / (3600*V).....	0.088	hrs

Channel Flow

Open Channel Flow

No Open Channel Flow

Pipe Flow

No Pipe Flow

Time of Concentration

Sheet Flow T _t	0.2265	hrs
Shallow Concentrated Flow T _t	0.0881	hrs
Channel Flow T _t	0.0000	hrs
Time of Concentration, T _c	0.3146	hrs
	18.9	mins

Project: R230851.01	By: HWT	Date: 4/10/2025
Location: CWD-14-1B	Checked: LEK	Date: 5/28/2025

Check:	☐ Present	☐ Under Development	☒ Developed
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Sheet Flow

Segment ID	A1	
Surface Description.....	Grass	
Manning's Roughness Coefficient, n	0.24	(TR-55, Table 3-1)
Flow Length, L.....	100	ft
Two-year 24-hour Rainfall, P ₂	3.39	in
Land Slope, s.....	0.053	ft/ft
Travel Time, T _t = (0.007*(n*L) ^{0.8}) / (P ₂ ^{0.5} *s ^{0.4}).....	0.1562	hrs

Shallow Concentrated Flow

Segment ID	B1	
Surface Description (Paved / Unpaved).....	Unpaved	
Surface Description Coefficient, C.....	16.13	
Flow Length, L.....	468	ft
Watercourse Slope, s.....	0.115	ft/ft
Average Velocity, V = C*s ^{0.5}	5.47	ft/sec
Travel Time, T _t = (L) / (3600*V).....	0.024	hrs

Channel Flow

Open Channel Flow

No Open Channel Flow

Pipe Flow

No Pipe Flow

Time of Concentration

Sheet Flow T _t	0.1562	hrs
Shallow Concentrated Flow T _t	0.0238	hrs
Channel Flow T _t	0.0000	hrs
Time of Concentration, T _c	0.1800	hrs
	10.8	mins

Project: R230851.01	By: HWT	Date: 4/10/2025
Location: CWD-14-1B	Checked: LEK	Date: 5/28/2025

Check:	☐ Present	☐ Under Development	☒ Developed
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Sheet Flow

Segment ID	A1	
Surface Description.....	Grass	
Manning's Roughness Coefficient, n	0.24	(TR-55, Table 3-1)
Flow Length, L.....	100	ft
Two-year 24-hour Rainfall, P ₂	3.39	in
Land Slope, s.....	0.015	ft/ft
Travel Time, T _t = (0.007*(n*L) ^{0.8}) / (P ₂ ^{0.5} *s ^{0.4}).....	0.2559	hrs

Shallow Concentrated Flow

Segment ID	B1	
Surface Description (Paved / Unpaved).....	Unpaved	
Surface Description Coefficient, C.....	16.13	
Flow Length, L.....	1295	ft
Watercourse Slope, s.....	0.052	ft/ft
Average Velocity, V = C*s ^{0.5}	3.68	ft/sec
Travel Time, T _t = (L) / (3600*V).....	0.098	hrs

Channel Flow

Open Channel Flow

No Open Channel Flow

Pipe Flow

No Pipe Flow

Time of Concentration

Sheet Flow T _t	0.2559	hrs
Shallow Concentrated Flow T _t	0.0977	hrs
Channel Flow T _t	0.0000	hrs
Time of Concentration, T _c	0.3536	hrs
	21.2	mins

PROJECT NAME: WILLIAMS SSE
LOCATION: VIRGINIA
PREPARED BY: TRUAXHW DATE: 5/27/2025
CHECKED BY: KRASILE DATE: 5/28/2025

CWD-08-01 Rainfall Intensity Calculation					
Time of Concentration =	20.1 min				
Factor B =	57.03				
Factor D =	10.78				
Factor E =	0.77				
Rainfall Intensity =	4.06 in/hr				
<i>Notes:</i> 1. Reference VDOT Drainage Manual Appendix BC-2 for B, D, & E Factors. 2. Factors for <u>Chatham Station</u> were used in this calculation.					
CWD-08-01 Rational Method Calculation					
CWD-08-01					
Cf =	1.0		Woods	Meadow	Impervious
c =	0.32	c =	0.30	0.45	0.90
i =	4.06	A =	5.25	0.68	0.00
A =	5.93	c*A =	1.58	0.31	0.00
Q =	7.65 cfs	Weighted 'C' =			0.32

CWD-08-04 Rainfall Intensity Calculation					
Time of Concentration =	12 min				
Factor B =	57.03				
Factor D =	10.78				
Factor E =	0.77				
Rainfall Intensity =	5.14 in/hr				
<i>Notes:</i> 1. Reference VDOT Drainage Manual Appendix BC-2 for B, D, & E Factors. 2. Factors for <u>Chatham Station</u> were used in this calculation.					
CWD-08-04 Rational Method Calculation					
CWD-08-04					
Cf =	1.0		Woods	Meadow	Impervious
c =	0.31	c =	0.30	0.45	0.90
i =	5.14	A =	6.02	0.42	0.00
A =	6.44	c*A =	1.81	0.19	0.00
Q =	10.25 cfs	Weighted 'C' =			0.31

PROJECT NAME: WILLIAMS SSE
LOCATION: VIRGINIA
PREPARED BY: TRUAXHW DATE: 5/23/2025
CHECKED BY: KRASILE DATE: 5/28/2025

CWD-14-1A Rainfall Intensity Calculation					
Time of Concentration =	16.7 min				
Factor B =	57.03				
Factor D =	10.78				
Factor E =	0.77				
Rainfall Intensity =	4.45 in/hr				
<i>Notes:</i> 1. Reference VDOT Drainage Manual Appendix BC-2 for B, D, & E Factors. 2. Factors for <u>Chatham Station</u> were used in this calculation.					
CWD-14-1A Rational Method Calculation					
CWD-14-1A					
Cf =	1.0		Woods	Meadow	Impervious
c =	0.43	c =	0.30	0.45	0.90
i =	4.45	A =	4.33	4.01	1.00
A =	9.34	c*A =	1.30	1.80	0.90
Q =	17.80	cfs	Weighted 'C' =		0.43

CWD-14-1B Rainfall Intensity Calculation					
Time of Concentration =	16.4 min				
Factor B =	57.03				
Factor D =	10.78				
Factor E =	0.77				
Rainfall Intensity =	4.48 in/hr				
<i>Notes:</i> 1. Reference VDOT Drainage Manual Appendix BC-2 for B, D, & E Factors. 2. Factors for <u>Chatham Station</u> were used in this calculation.					
CWD-14-1A Rational Method Calculation					
CWD-14-1A					
Cf =	1.0		Woods	Meadow	Impervious
c =	0.40	c =	0.30	0.45	0.90
i =	4.48	A =	5.16	6.79	0.38
A =	12.33	c*A =	1.55	3.06	0.34
Q =	22.18	cfs	Weighted 'C' =		0.40

PROJECT NAME: WILLIAMS SSE
LOCATION: VIRGINIA
PREPARED BY: TRUAXHW DATE: 5/23/2025
CHECKED BY: KRASILE DATE: 5/28/2025

CWD-33-01 Rainfall Intensity Calculation					
Time of Concentration =	18.9 min				
Factor B =	57.03				
Factor D =	10.78				
Factor E =	0.77				
Rainfall Intensity =	4.19 in/hr				
<i>Notes:</i> 1. Reference VDOT Drainage Manual Appendix BC-2 for B, D, & E Factors. 2. Factors for <u>Chatham Station</u> were used in this calculation.					
CWD-33-01 Rational Method Calculation					
CWD-33-01					
Cf =	1.0		Woods	Meadow	Impervious
c =	0.33	c =	0.30	0.45	0.90
i =	4.19	A =	7.42	1.70	0.00
A =	9.12	c*A =	2.23	0.76	0.00
Q =	12.53	cfs	Weighted 'C' =		0.33

CWD-39-04 Rainfall Intensity Calculation					
Time of Concentration =	10.8 min				
Factor B =	57.03				
Factor D =	10.78				
Factor E =	0.77				
Rainfall Intensity =	5.36 in/hr				
<i>Notes:</i> 1. Reference VDOT Drainage Manual Appendix BC-2 for B, D, & E Factors. 2. Factors for <u>Chatham Station</u> were used in this calculation.					
CWD-39-04 Rational Method Calculation					
CWD-39-04					
Cf =	1.0		Woods	Meadow	Impervious
c =	0.39	c =	0.30	0.45	0.90
i =	5.36	A =	2.00	3.13	0.00
A =	5.13	c*A =	0.60	1.41	0.00
Q =	10.76	cfs	Weighted 'C' =		0.39

PROJECT NAME: WILLIAMS SSE
 LOCATION: VIRGINIA
 PREPARED BY: TRUAXHW DATE: 5/23/2025
 CHECKED BY: KRASILE DATE: 5/28/2025

CWD-39-06 Rainfall Intensity Calculation																																									
Time of Concentration =	21.2 min																																								
Factor B =	57.03																																								
Factor D =	10.78																																								
Factor E =	0.77																																								
Rainfall Intensity =	3.96 in/hr																																								
$i = \frac{B}{(t_c + D)^E}$																																									
Notes: 1. Reference VDOT Drainage Manual Appendix BC-2 for B, D, & E Factors. 2. Factors for <u>Chatham Station</u> were used in this calculation.																																									
CWD-39-06 Rational Method Calculation																																									
<table border="1" style="width: 100%; border-collapse: collapse; margin: 5px;"> <thead> <tr> <th colspan="6" style="text-align: center; padding: 2px;">CWD-39-06</th> </tr> <tr> <th style="width: 10%; padding: 2px;">Cf =</th> <th style="width: 15%; padding: 2px;">1.0</th> <th style="width: 15%; padding: 2px;"></th> <th style="width: 15%; padding: 2px;">Woods</th> <th style="width: 15%; padding: 2px;">Meadow</th> <th style="width: 15%; padding: 2px;">Impervious</th> </tr> </thead> <tbody> <tr> <td style="padding: 2px;">c =</td> <td style="padding: 2px;">0.47</td> <td style="padding: 2px;">c =</td> <td style="padding: 2px;">0.30</td> <td style="padding: 2px;">0.45</td> <td style="padding: 2px;">0.90</td> </tr> <tr> <td style="padding: 2px;">i =</td> <td style="padding: 2px;">3.96</td> <td style="padding: 2px;">A =</td> <td style="padding: 2px;">0.85</td> <td style="padding: 2px;">10.91</td> <td style="padding: 2px;">0.89</td> </tr> <tr> <td style="padding: 2px;">A =</td> <td style="padding: 2px;">12.65</td> <td style="padding: 2px;">c*A =</td> <td style="padding: 2px;">0.26</td> <td style="padding: 2px;">4.91</td> <td style="padding: 2px;">0.80</td> </tr> <tr> <td style="padding: 2px;">Q =</td> <td style="padding: 2px;">23.61</td> <td style="padding: 2px;">cfs</td> <td colspan="2" style="padding: 2px;">Weighted 'C' =</td> <td style="padding: 2px;">0.47</td> </tr> </tbody> </table>						CWD-39-06						Cf =	1.0		Woods	Meadow	Impervious	c =	0.47	c =	0.30	0.45	0.90	i =	3.96	A =	0.85	10.91	0.89	A =	12.65	c*A =	0.26	4.91	0.80	Q =	23.61	cfs	Weighted 'C' =		0.47
CWD-39-06																																									
Cf =	1.0		Woods	Meadow	Impervious																																				
c =	0.47	c =	0.30	0.45	0.90																																				
i =	3.96	A =	0.85	10.91	0.89																																				
A =	12.65	c*A =	0.26	4.91	0.80																																				
Q =	23.61	cfs	Weighted 'C' =		0.47																																				

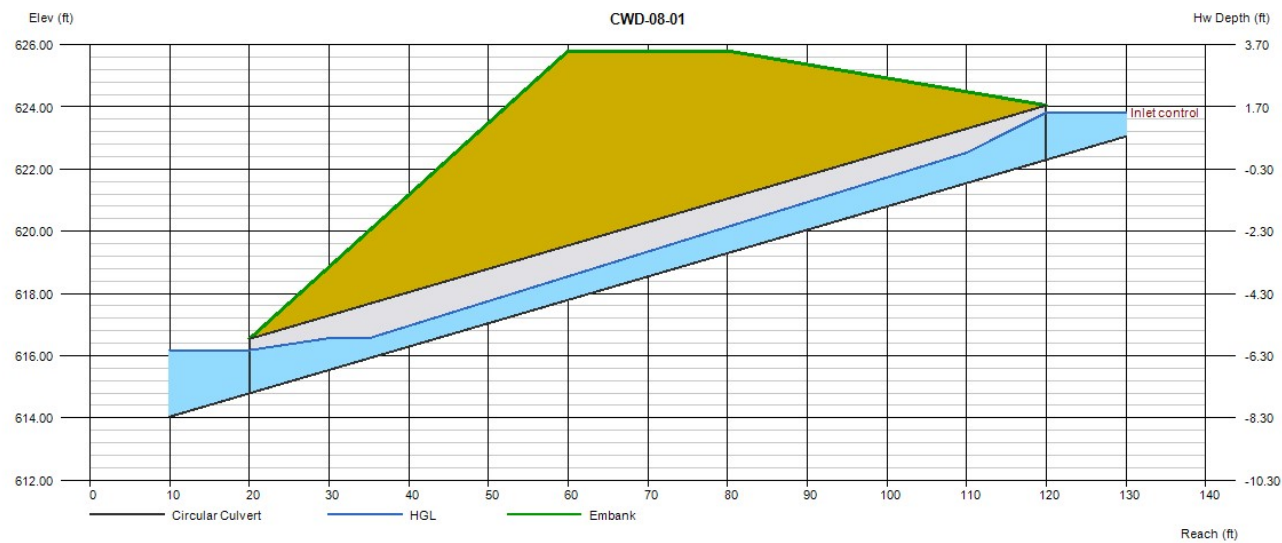
Culvert Report

CWD-08-01

Invert Elev Dn (ft)	= 614.79
Pipe Length (ft)	= 100.00
Slope (%)	= 7.51
Invert Elev Up (ft)	= 622.30
Rise (in)	= 21.0
Shape	= Circular
Span (in)	= 21.0
No. Barrels	= 1
n-Value	= 0.012
Culvert Type	= Circular Culvert
Culvert Entrance	= Smooth tapered inlet throat
Coeff. K,M,c,Y,k	= 0.534, 0.555, 0.0196, 0.9, 0.2

Embankment	
Top Elevation (ft)	= 625.80
Top Width (ft)	= 20.00
Crest Width (ft)	= 20.00

Calculations	
Qmin (cfs)	= 7.65
Qmax (cfs)	= 7.65
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 7.65
Qpipe (cfs)	= 7.65
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 3.74
Veloc Up (ft/s)	= 5.23
HGL Dn (ft)	= 616.18
HGL Up (ft)	= 623.32
Hw Elev (ft)	= 623.82
Hw/D (ft)	= 0.87
Flow Regime	= Inlet Control



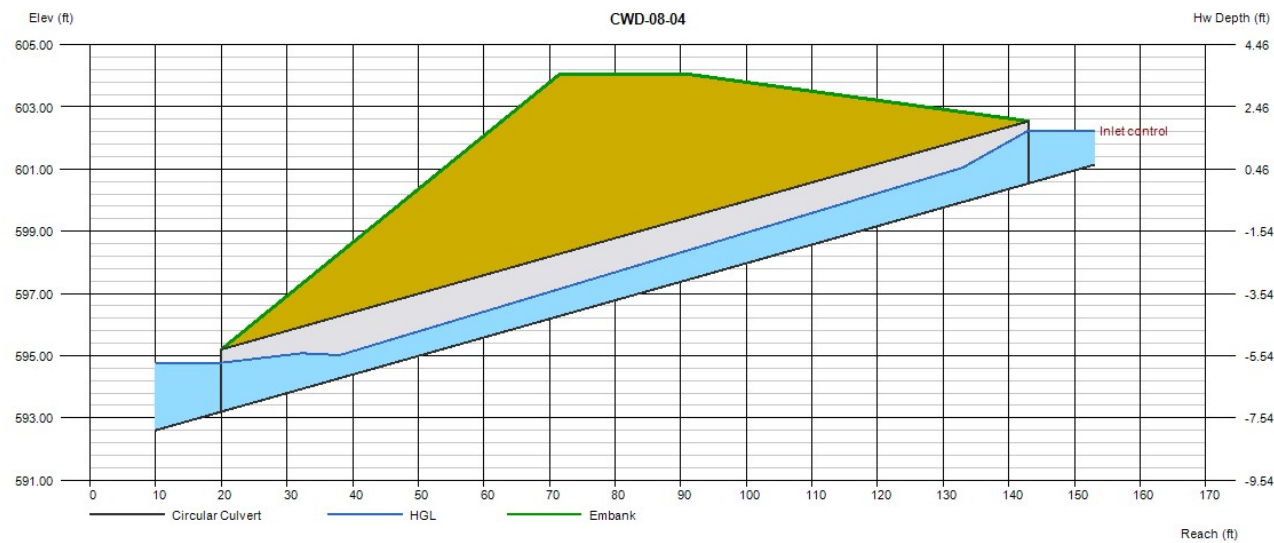
Culvert Report

CWD-08-04

Invert Elev Dn (ft)	= 593.20
Pipe Length (ft)	= 123.00
Slope (%)	= 5.97
Invert Elev Up (ft)	= 600.54
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.012
Culvert Type	= Circular Culvert
Culvert Entrance	= Smooth tapered inlet throat
Coeff. K,M,c,Y,k	= 0.534, 0.555, 0.0196, 0.9, 0.2

Embankment	
Top Elevation (ft)	= 604.04
Top Width (ft)	= 20.00
Crest Width (ft)	= 20.00

Calculations	
Qmin (cfs)	= 10.25
Qmax (cfs)	= 10.25
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 10.25
Qpipe (cfs)	= 10.25
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 3.87
Veloc Up (ft/s)	= 5.51
HGL Dn (ft)	= 594.77
HGL Up (ft)	= 601.69
Hw Elev (ft)	= 602.24
Hw/D (ft)	= 0.85
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc.

Wednesday, May 28 2025

CWD-14-1A

Invert Elev Dn (ft)	= 729.62
Pipe Length (ft)	= 72.00
Slope (%)	= 0.97
Invert Elev Up (ft)	= 730.32
Rise (in)	= 30.0
Shape	= Circular
Span (in)	= 30.0
No. Barrels	= 1
n-Value	= 0.012
Culvert Type	= Circular Culvert
Culvert Entrance	= Smooth tapered inlet throat
Coeff. K,M,c,Y,k	= 0.534, 0.555, 0.0196, 0.9, 0.2

Embankment

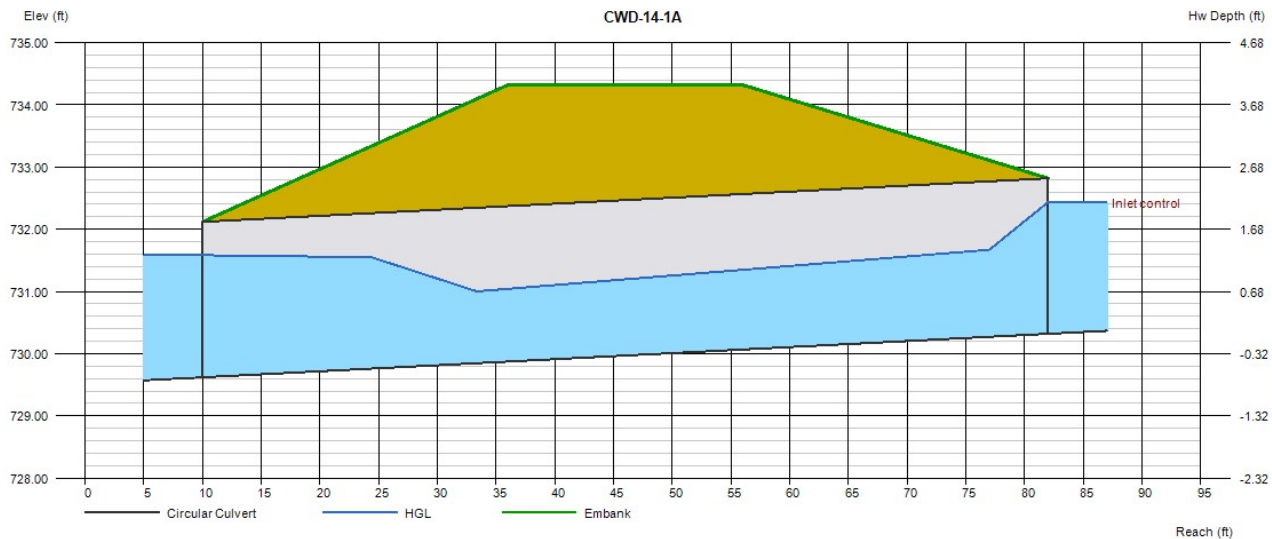
Top Elevation (ft)	= 734.32
Top Width (ft)	= 20.00
Crest Width (ft)	= 20.00

Calculations

Qmin (cfs)	= 17.80
Qmax (cfs)	= 17.80
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 17.80
Qpipe (cfs)	= 17.80
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 4.30
Veloc Up (ft/s)	= 6.15
HGL Dn (ft)	= 731.58
HGL Up (ft)	= 731.75
Hw Elev (ft)	= 732.44
Hw/D (ft)	= 0.85
Flow Regime	= Inlet Control



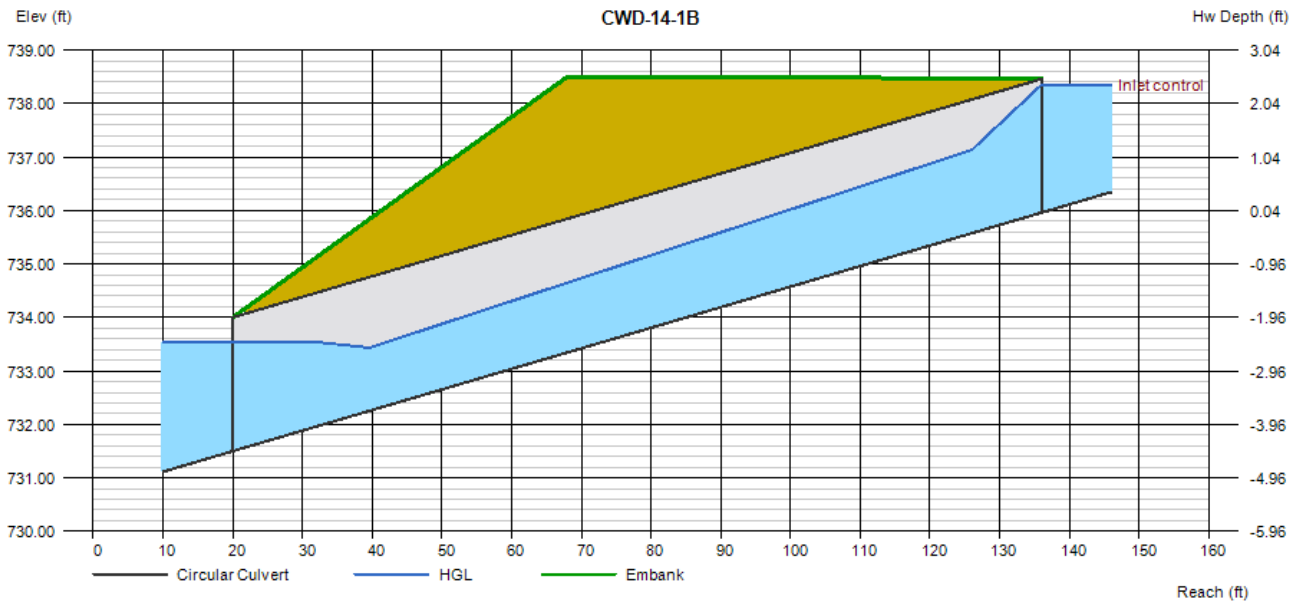
Culvert Report

CWD-14-1B

Invert Elev Dn (ft)	=	731.50
Pipe Length (ft)	=	116.00
Slope (%)	=	3.84
Invert Elev Up (ft)	=	735.96
Rise (in)	=	30.0
Shape	=	Circular
Span (in)	=	30.0
No. Barrels	=	1
n-Value	=	0.012
Culvert Type	=	Circular Culvert
Culvert Entrance	=	Smooth tapered inlet throat
Coeff. K,M,c,Y,k	=	0.534, 0.555, 0.0196, 0.9, 0.2

Embankment	
Top Elevation (ft)	= 738.50
Top Width (ft)	= 20.00
Crest Width (ft)	= 20.00

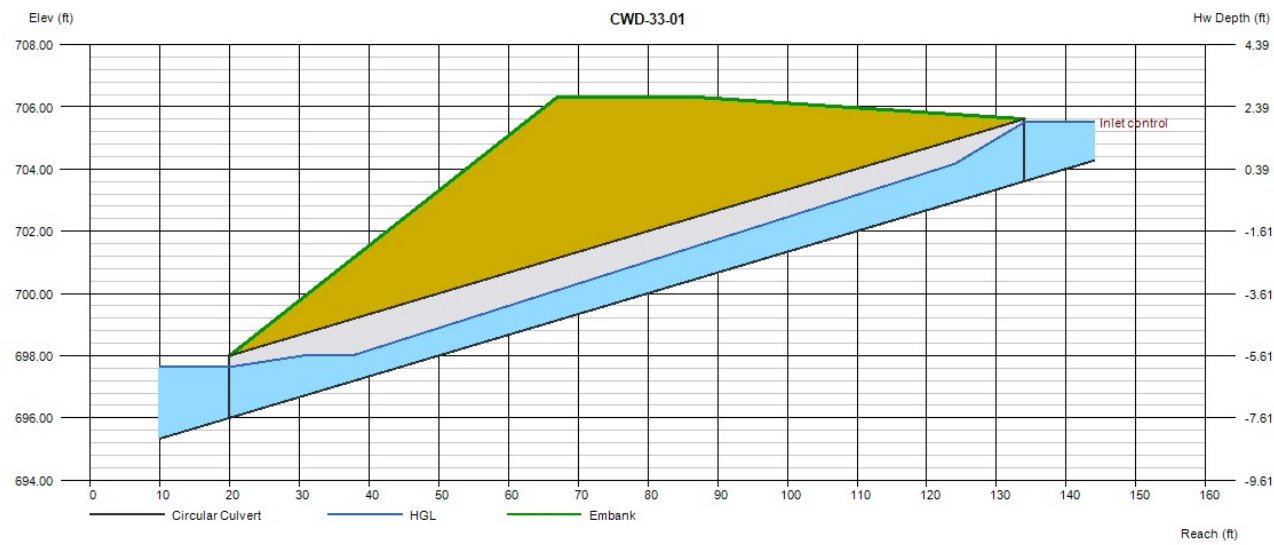
Calculations	
Qmin (cfs)	= 22.18
Qmax (cfs)	= 22.18
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 22.18
Qpipe (cfs)	= 22.18
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.15
Veloc Up (ft/s)	= 6.68
HGL Dn (ft)	= 733.55
HGL Up (ft)	= 737.56
Hw Elev (ft)	= 738.35
Hw/D (ft)	= 0.96
Flow Regime	= Inlet Control



Culvert Report

CWD-33-01

Invert Elev Dn (ft)	= 696.00	Calculations	
Pipe Length (ft)	= 114.00	Qmin (cfs)	= 12.53
Slope (%)	= 6.68	Qmax (cfs)	= 12.53
Invert Elev Up (ft)	= 703.61	Tailwater Elev (ft)	= (dc+D)/2
Rise (in)	= 24.0		
Shape	= Circular	Highlighted	
Span (in)	= 24.0	Qtotal (cfs)	= 12.53
No. Barrels	= 1	Qpipe (cfs)	= 12.53
n-Value	= 0.012	Qovertop (cfs)	= 0.00
Culvert Type	= Circular Culvert	Veloc Dn (ft/s)	= 4.56
Culvert Entrance	= Smooth tapered inlet throat	Veloc Up (ft/s)	= 5.95
Coeff. K,M,c,Y,k	= 0.534, 0.555, 0.0196, 0.9, 0.2	HGL Dn (ft)	= 697.64
		HGL Up (ft)	= 704.88
		Hw Elev (ft)	= 705.51
		Hw/D (ft)	= 0.95
		Flow Regime	= Inlet Control
Embankment			
Top Elevation (ft)	= 706.31		
Top Width (ft)	= 20.00		
Crest Width (ft)	= 20.00		



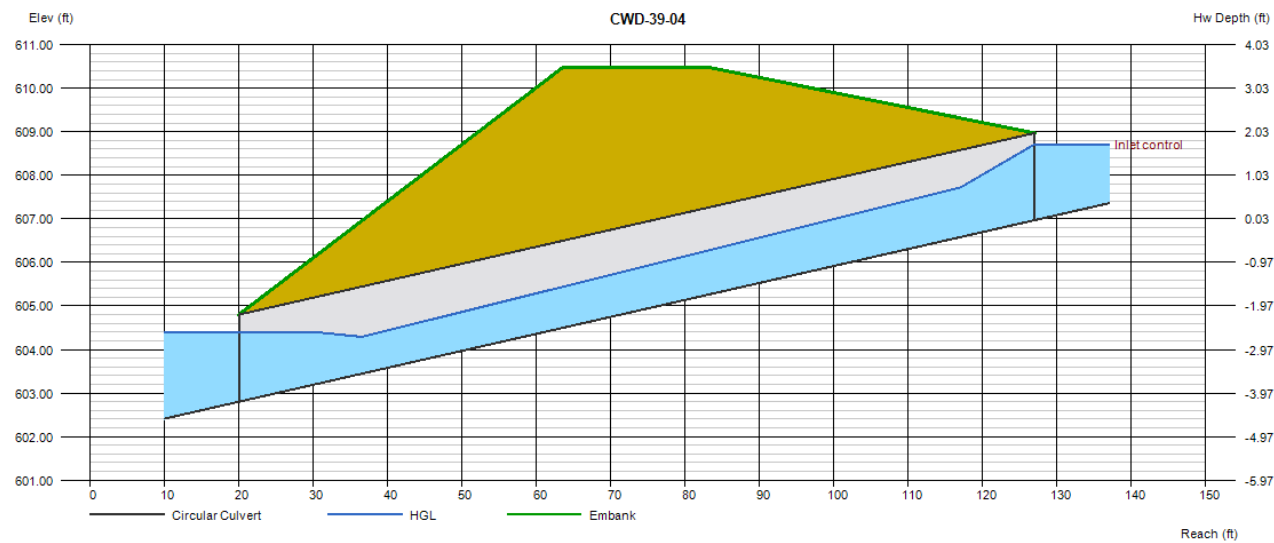
Culvert Report

CWD-39-04

Invert Elev Dn (ft)	= 602.80
Pipe Length (ft)	= 107.00
Slope (%)	= 3.90
Invert Elev Up (ft)	= 606.97
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.012
Culvert Type	= Circular Culvert
Culvert Entrance	= Smooth tapered inlet throat
Coeff. K,M,c,Y,k	= 0.534, 0.555, 0.0196, 0.9, 0.2

Embankment	
Top Elevation (ft)	= 610.47
Top Width (ft)	= 20.00
Crest Width (ft)	= 20.00

Calculations	
Qmin (cfs)	= 10.76
Qmax (cfs)	= 10.76
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 10.76
Qpipe (cfs)	= 10.76
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 4.02
Veloc Up (ft/s)	= 5.61
HGL Dn (ft)	= 604.39
HGL Up (ft)	= 608.14
Hw Elev (ft)	= 608.71
Hw/D (ft)	= 0.87
Flow Regime	= Inlet Control



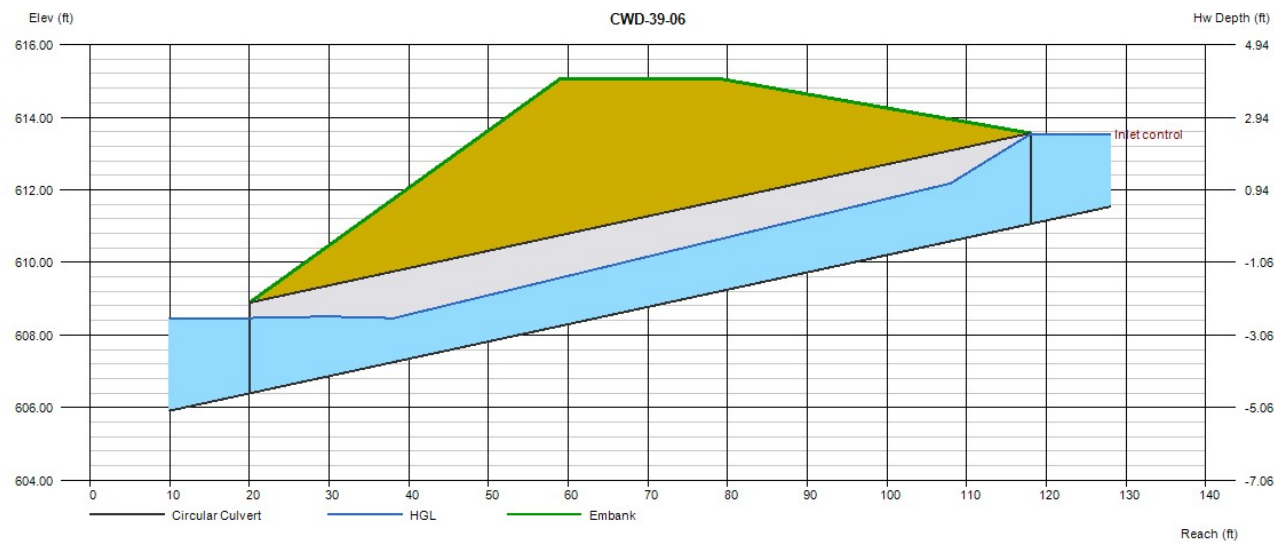
Culvert Report

CWD-39-06

Invert Elev Dn (ft)	= 606.39
Pipe Length (ft)	= 98.00
Slope (%)	= 4.77
Invert Elev Up (ft)	= 611.06
Rise (in)	= 30.0
Shape	= Circular
Span (in)	= 30.0
No. Barrels	= 1
n-Value	= 0.012
Culvert Type	= Circular Culvert
Culvert Entrance	= Smooth tapered inlet throat
Coeff. K,M,c,Y,k	= 0.534, 0.555, 0.0196, 0.9, 0.2

Embankment	
Top Elevation (ft)	= 615.06
Top Width (ft)	= 20.00
Crest Width (ft)	= 20.00

Calculations	
Qmin (cfs)	= 23.61
Qmax (cfs)	= 23.61
Tailwater Elev (ft)	= (dc+D)/2
Highlighted	
Qtotal (cfs)	= 23.61
Qpipe (cfs)	= 23.61
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.42
Veloc Up (ft/s)	= 6.86
HGL Dn (ft)	= 608.47
HGL Up (ft)	= 612.71
Hw Elev (ft)	= 613.54
Hw/D (ft)	= 0.99
Flow Regime	= Inlet Control



E&SC SUPPORTING CALCULATIONS

Outlet Protection – Tee Diffuser Sizing

SLOPE DRAIN TEE DIFFUSER SIZING CHART

Increments	Drainage Area (Acres)	Peak Flow (cfs)*	Tee Diffuser Length (ft)**
1	0.25	0.34	5
2	0.50	0.69	10
3	1.00	1.38	20
4	1.50	2.07	31
5	2.00	2.76	41
6	2.50	3.45	51
7	3.00	4.13	61
8	3.50	4.82	72
9	4.00	5.51	82
10	4.50	6.20	92
11	5.00	6.89	102
12	5.50	7.58	112
13	6.00	8.27	123
14	6.50	8.96	133
15	7.00	9.65	143
16	7.50	10.34	153
17	8.00	11.02	164
18	8.50	11.71	174
19	9.00	12.40	184
20	9.50	13.09	194
21	10.00	13.78	204
22	10.50	14.47	215
23	11.00	15.16	225
24	11.50	15.85	235
25	12.00	16.54	245
26	12.50	17.23	256
27	13.00	17.91	266
28	13.50	18.60	276
29	14.00	19.29	286
30	14.50	19.98	296
31	15.00	20.67	307

Typical Manufactured Product to determine Perforation Size and Spacing:

AASHTO Class II Perforation

The following terminology for perforations is derived from the applicable AASHTO specification. Differences between the specifications are covered in the table below. Class II perforations shall be located in the outside valleys of the corrugations, be circular and/or slotted and evenly spaced around the circumference and length of the pipe. The perforations shall be located in the outside valleys of the corrugations. The water inlet area shall be no less than 0.945 in²/ft (20 cm²/m) for pipe diameters 4- through 10-inch (100 - 250mm), 1.42 in²/ft (3 cm²/m) for pipe diameters 12- through 18-inch (300 - 450 mm) and 1.89 in²/ft (40 cm²/m) for pipe diameters larger than and equal to 24 inches (600 mm). Table 1 below represents ADS standard perforation patterns for AASHTO Class II

Nominal I.D.	Perforation Type	Maximum Slot Length or Diameter	Maximum Slot Width	Minimum Inlet Area
4" (100 mm)	Slot	0.875" (22 mm)	0.125" (3 mm)	1.0 in ² /ft (21 cm ² /m)
6" (150 mm)	Slot	0.875" (22 mm)	0.125" (3 mm)	1.0 in ² /ft (21 cm ² /m)
8" (200 mm)	Slot	1.18" (30 mm)	0.125" (3 mm)	1.0 in ² /ft (21 cm ² /m)
10" (250 mm)	Slot	1.18" (30 mm)	0.125" (3 mm)	1.0 in ² /ft (21 cm ² /m)
12" (300 mm)	Circular	0.313" (8 mm)	-	1.5 in ² /ft (32 cm ² /m)
15" (375 mm)	Circular	0.313" (8 mm)	-	1.5 in ² /ft (32 cm ² /m)
18" (450 mm)	Circular	0.313" (8 mm)	-	1.5 in ² /ft (32 cm ² /m)
24" (600 mm)	Circular	0.313" (8 mm)	-	2.0 in ² /ft (42 cm ² /m)
30" (750 mm)	Circular	0.375" (9.5 mm)	-	2.0 in ² /ft (42 cm ² /m)
36" (900 mm)	Circular	0.375" (9.5 mm)	-	2.0 in ² /ft (42 cm ² /m)
42" (1050 mm)	Circular	0.375" (9.5 mm)	-	2.0 in ² /ft (42 cm ² /m)
48" (1200 mm)	Circular	0.375" (9.5 mm)	-	2.0 in ² /ft (42 cm ² /m)
54" (1350 mm)	Circular	0.375" (9.5 mm)	-	2.0 in ² /ft (42 cm ² /m)
60" (1500 mm)	Circular	0.375" (9.5 mm)	-	2.0 in ² /ft (42 cm ² /m)

* Utilizing Flow Equation $Q=CiA$

,where

C is 0.2 for woods/forests (taken from VaDOT),

i is 6.89 inches/hour for the 10 year/24 hour storm event (with minimum Tc) in project area from NOAA,

and A is from measured drainage area.

** using 24" pipe

Formula: $Q=C*A*\sqrt{2*g*H}$

Given: C=discharge coefficient (0.60)

A=area of orifice (2 in²/ft, or .014ft²/ft)

g= acceleration due to gravity (32.2 ft/s)

H=head (assume 1 ft)

Results:

Q= 0.067409673 cfs / linear foot of pipe

Drainage Area	Length
0 - 1	20
1 - 2	40
2 - 3	60
3 - 4	80
4 - 5	100

Erosive Velocity Check:

A= 0.014 ft²

orifice area per linear foot

V= 4.814976635

ft/s

<5.0 ft/s discharge to vegetated areas

E&SC SUPPORTING CALCULATIONS

Outlet Protection

C-ECM-15-6 Plunge Pool Sizing

C-ECM-15-6 Plunge Pool Sizing and Methodology

1. Select type of plunge pool (larger stone required for Type 1):

Type I: Plunge pool is depressed half the size of the culvert rise.

Type II: Plunge pool is depressed the full height of the culvert rise.

Type II plunge pool is being selected to avoid using larger size stone.

2. Determine the riprap (d₅₀) stone size for the plunge pool type and design storm flow.

Type II: $d_{50} = (0.0082d^2/T_w) \times (Q/d^{2.5})^{4/3}$

As a conservative approach, min. d₅₀ = 6" stone is to be used.

3. Determine plunge pool dimensions.

$$C = (3 \times d) + (6 \times F)$$

$$B = (2 \times d) + (6 \times F)$$

where:

d₅₀ = the median stone size (feet)

d = the culvert diameter or span (feet)

T_w = the tailwater depth (feet)

Q = the design flow for the culvert, minimum 10-year, 24-hour storm (cfs)

B = the plunge pool width (feet)

C = the plunge pool length (feet)

D = 2 x d₅₀ = riprap thickness (feet)

E = the culvert diameter or span (feet) equal to d

3E = the plunge pool bottom length in feet

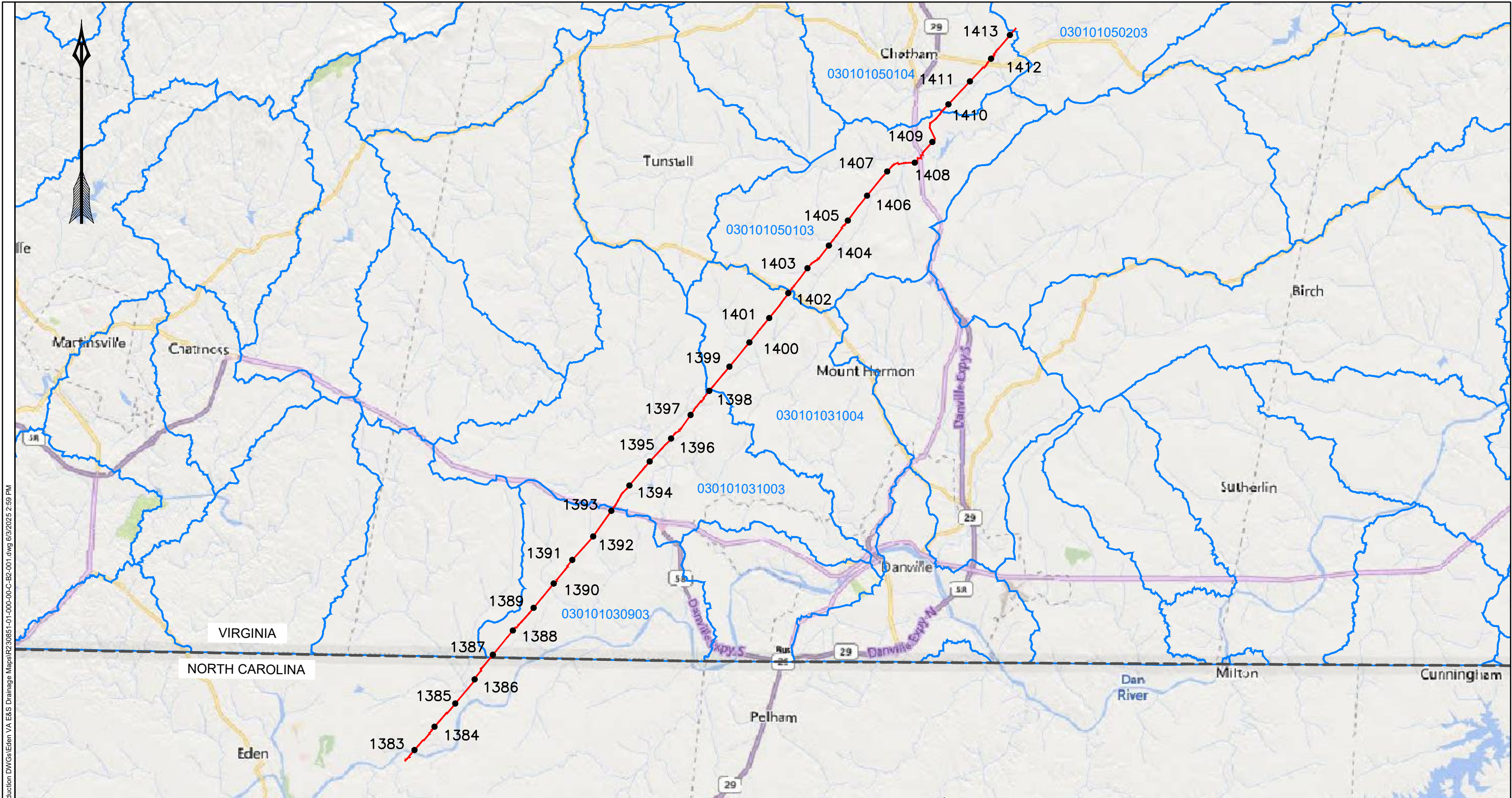
2E = the plunge pool bottom width (feet)

F = plunge pool depth (feet) = d (for Type II) or 0.5 d (for Type I)

Plunge Pool Dimensions		
Pipe Size (in.)	C (feet)	B (feet)
12	9	8
18	13.5	12
21	15.75	14
24	18	16
30	22.5	20

E&SC SUPPORTING CALCULATIONS

Drainage Area Maps

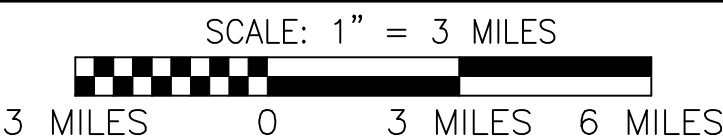


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LEGEND

- PROPOSED PIPELINE
- HUC-12 BOUNDARY
- MILE MARKER

LEGEND

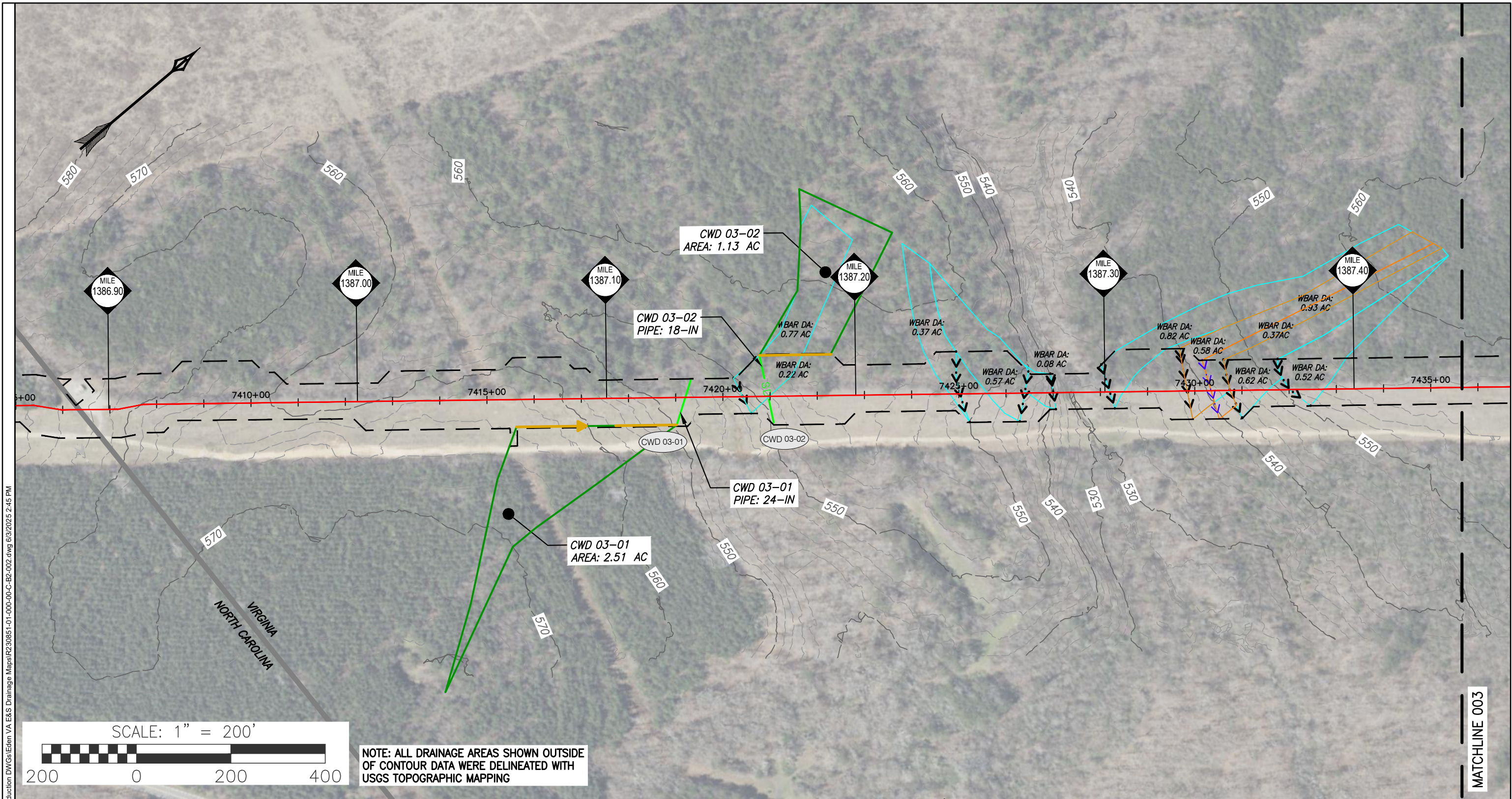


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SOUTHEAST SUPPLY ENHANCEMENT PROJECT
E&SC DRAINAGE AREA MAPS
PITTSYLVANIA COUNTY, VIRGINIA



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- LIMIT OF DISTURBANCE
- PROPOSED PIPELINE
- · · · · EXISTING WATERBAR
- · · · · PROPOSED TEMPORARY WATERBAR
- · · · · PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

LEGEND

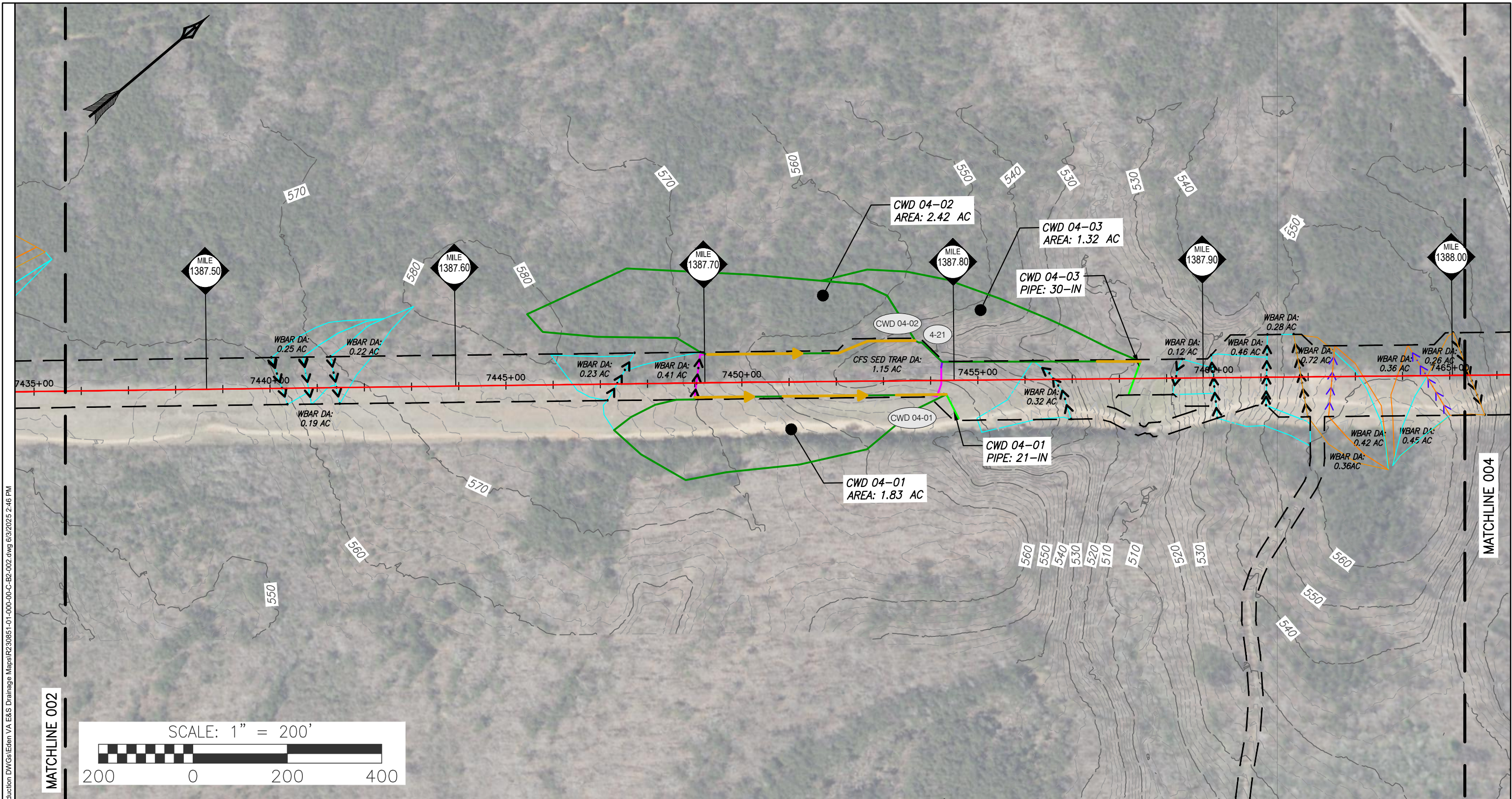
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- PROPOSED CLEAN WATER DIVERSION DIKE/FENCE
- SD SD SD PROPOSED CLEAN WATER DIVERSION SLOPE DRAIN
- CLEAN WATER DIVERSION DRAINAGE AREA
- CFS PROPOSED COMPOST FILTER SOCK TRAP
- COMPOST FILTER SOCK TRAP DRAINAGE AREA

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William's

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- LIMIT OF DISTURBANCE
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- · · · · PROPOSED TEMPORARY WATERBAR
- · · · · PROPOSED PERMANENT WATERBAR
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LEGEND

- WATERBAR DRAINAGE AREA PERMANENT CONDITION
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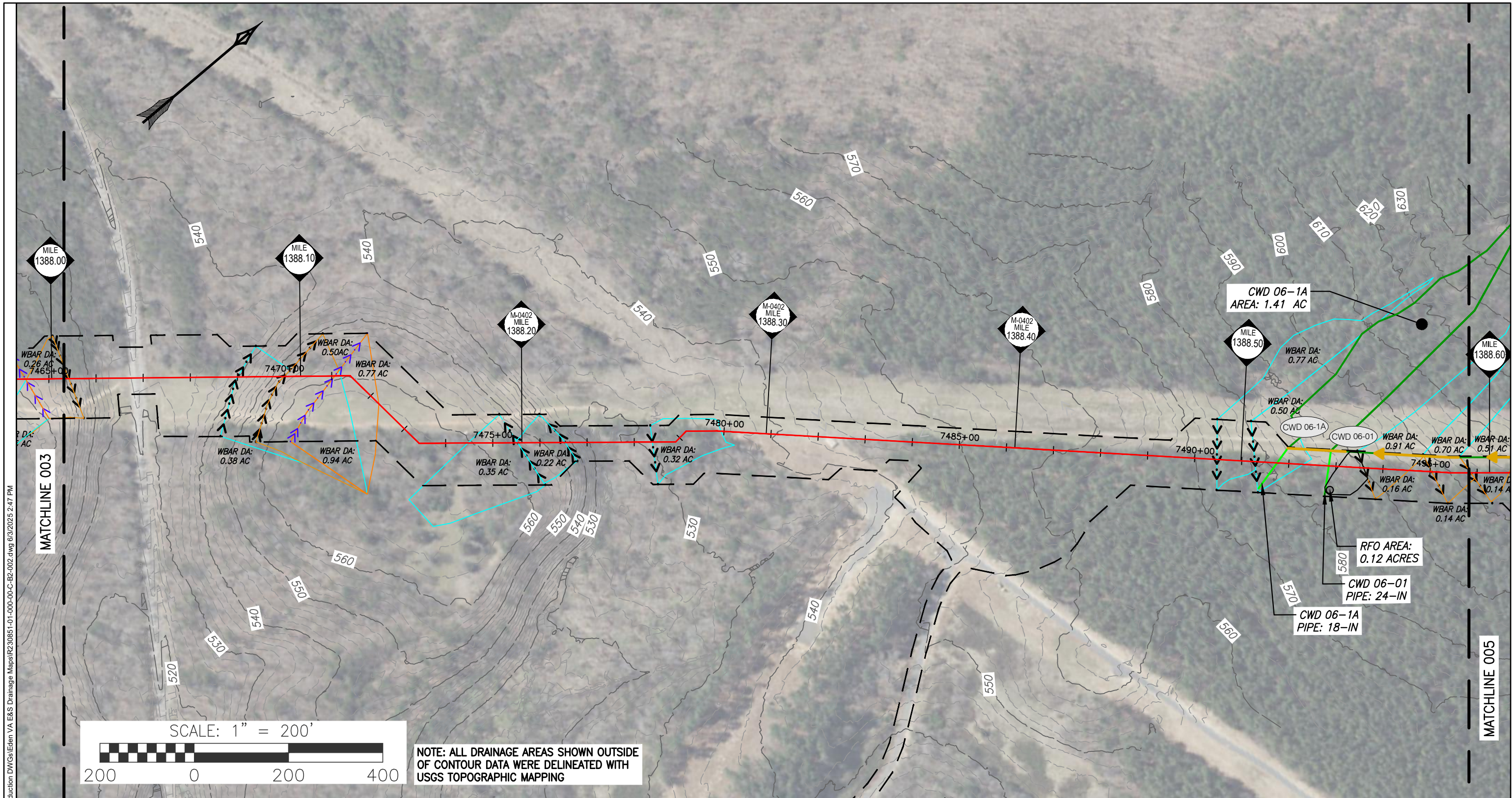
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- LIMIT OF DISTURBANCE
- PROPOSED PIPELINE
- EXISTING WATERBAR
- PROPOSED TEMPORARY WATERBAR
- PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

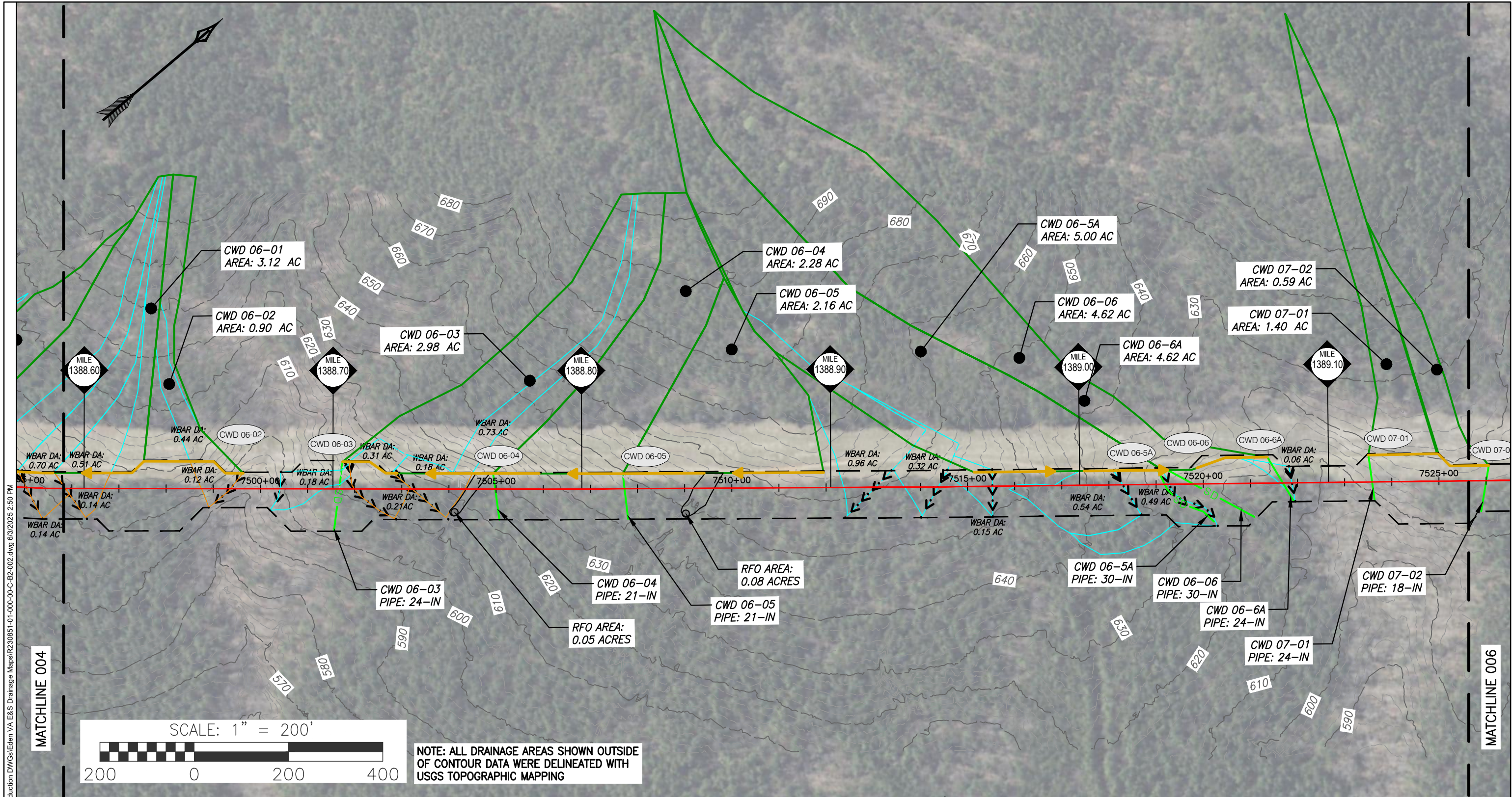
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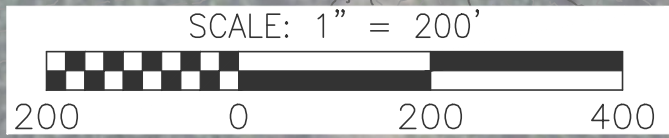
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MATCHLINE 004

MATCHLINE 006



NOTE: ALL DRAINAGE AREAS SHOWN OUTSIDE OF CONTOUR DATA WERE DELINEATED WITH USGS TOPOGRAPHIC MAPPING

LEGEND

- | | | | |
|-----|--|-----|--|
| --- | LIMIT OF DISTURBANCE | --- | WATERBAR DRAINAGE AREA PERMANENT CONDITION |
| --- | PROPOSED PIPELINE | --- | PROPOSED CLEAN WATER DIVERSION DIKE/FENCE |
| --- | EXISTING WATERBAR | --- | PROPOSED CLEAN WATER DIVERSION SLOPE DRAIN |
| --- | PROPOSED TEMPORARY WATERBAR | --- | CLEAN WATER DIVERSION DRAINAGE AREA |
| --- | PROPOSED PERMANENT WATERBAR | --- | PROPOSED COMPOST FILTER SOCK TRAP |
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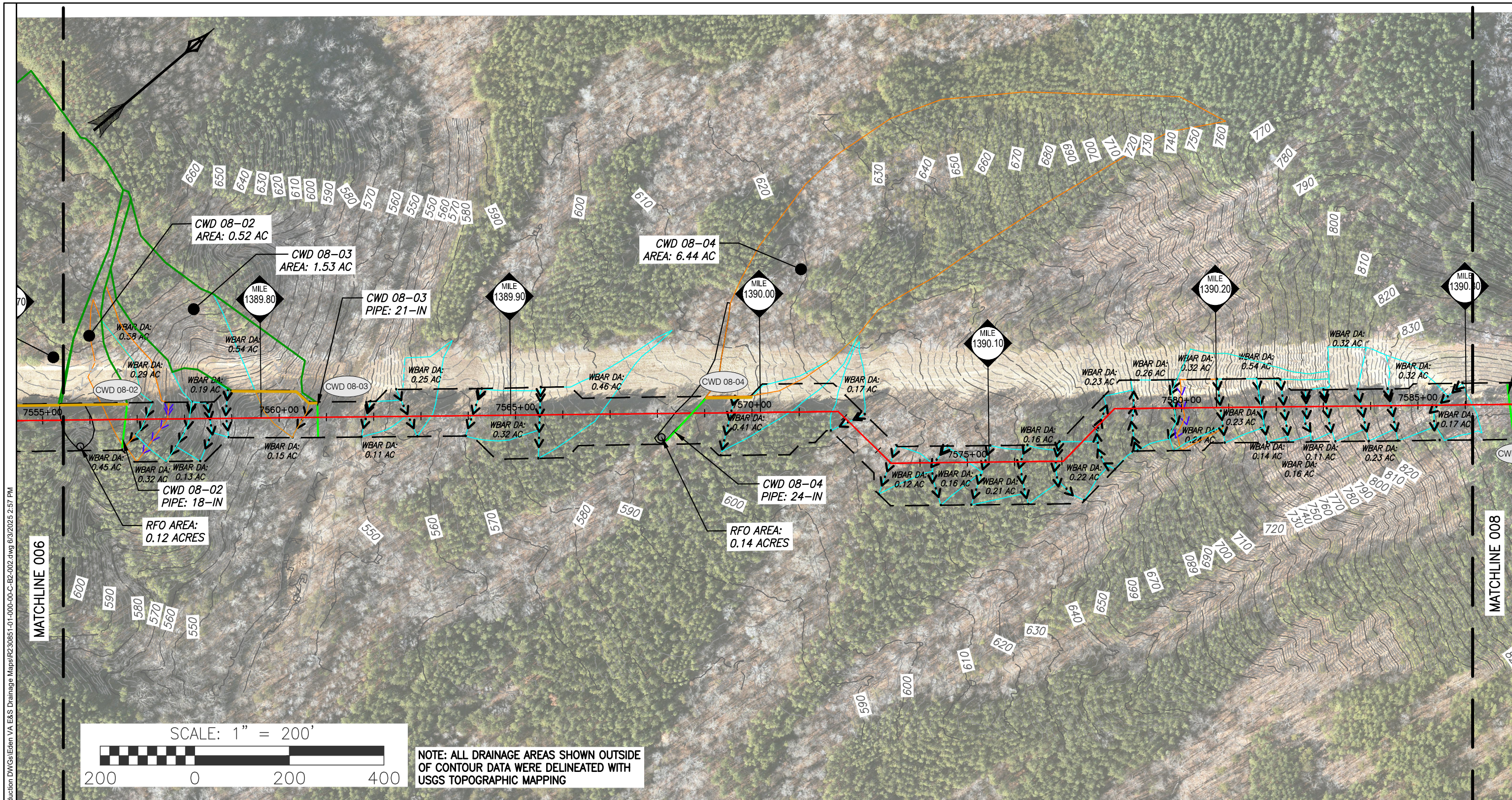
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- LIMIT OF DISTURBANCE
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LEGEND

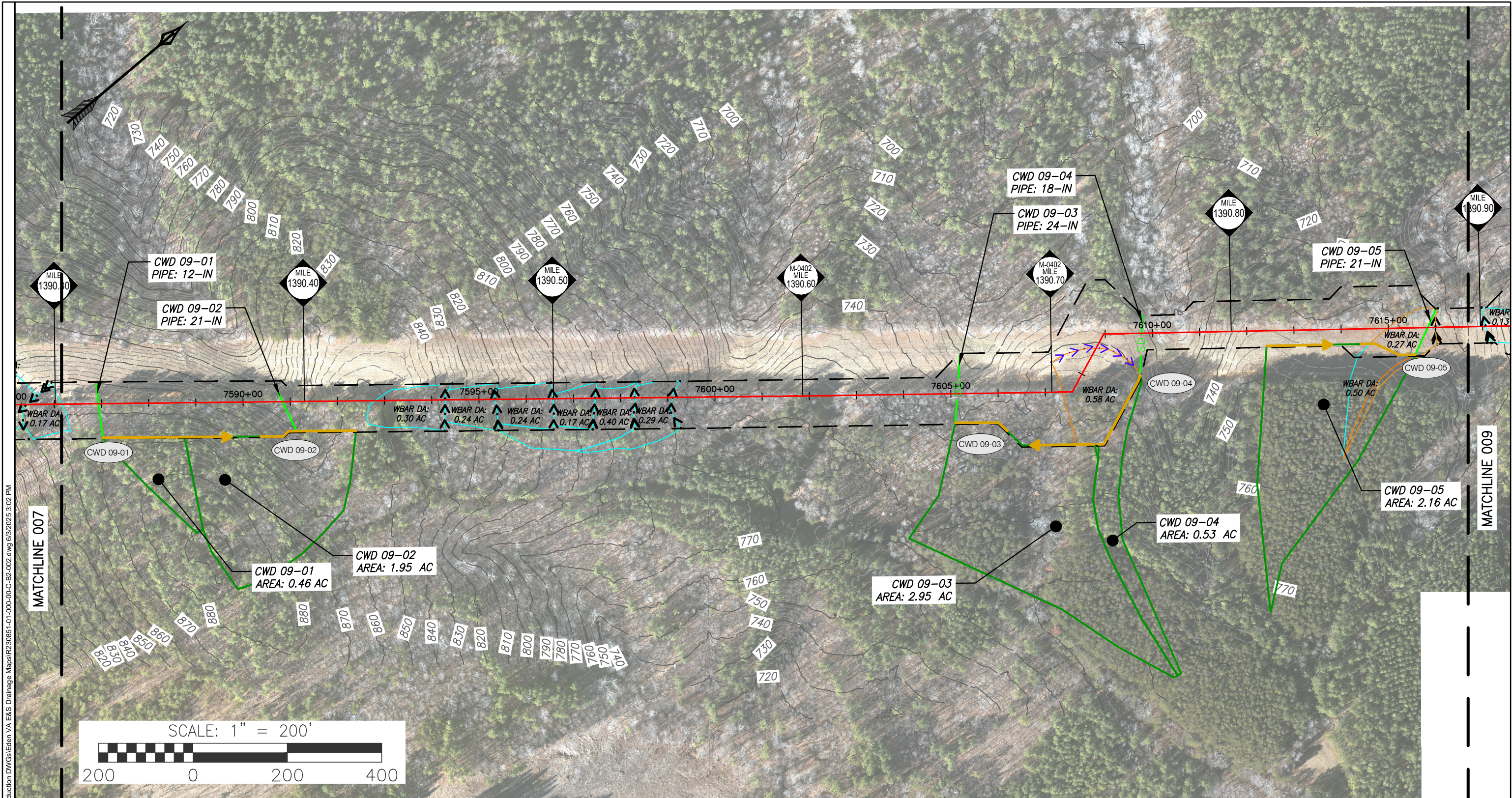
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- LIMIT OF DISTURBANCE
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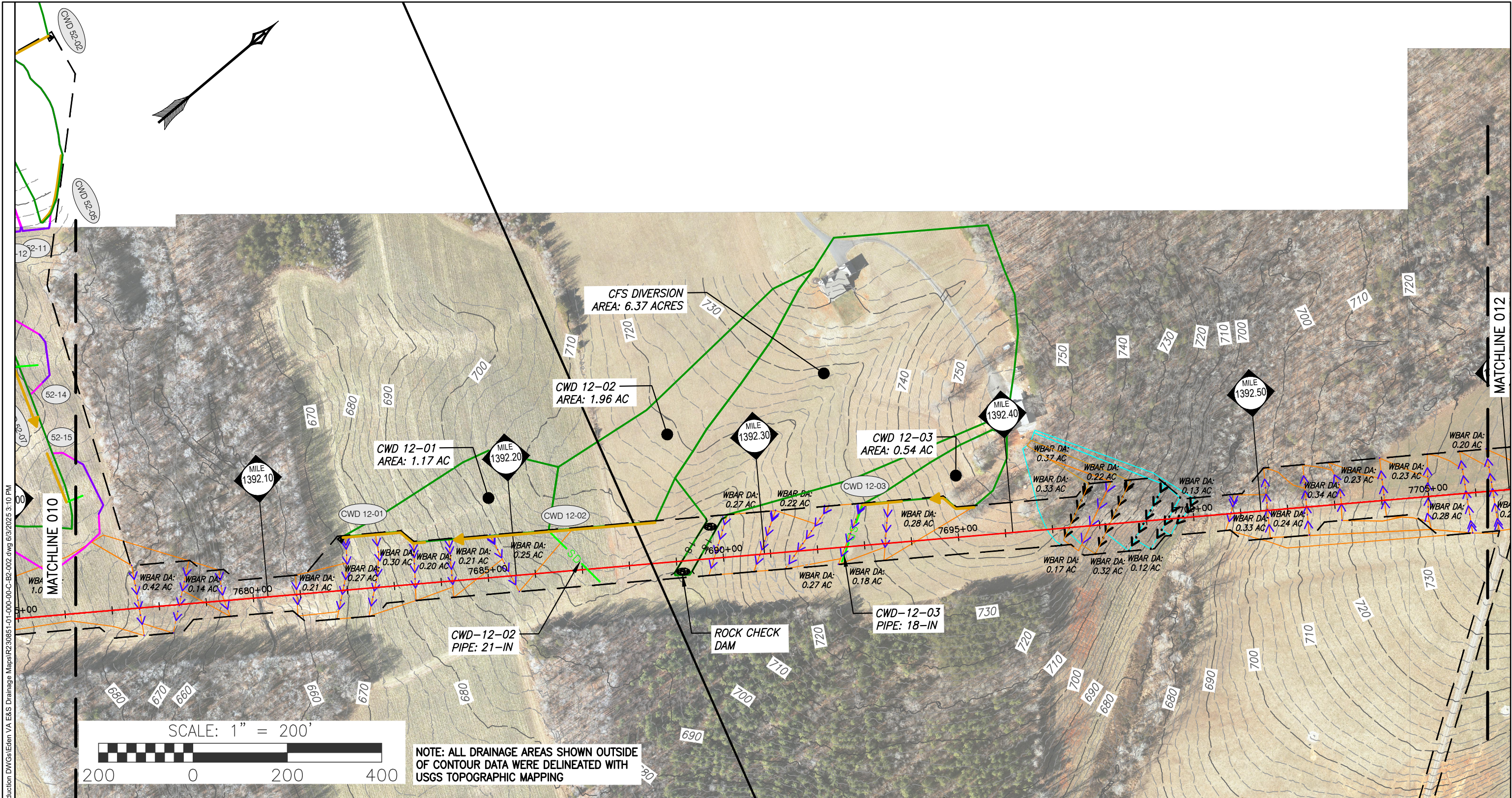
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- LIMIT OF DISTURBANCE
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- PROPOSED TEMPORARY WATERBAR
- PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

LEGEND

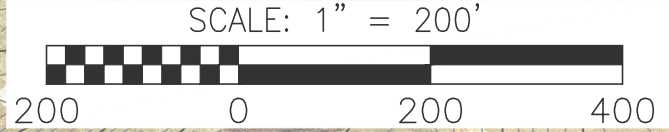
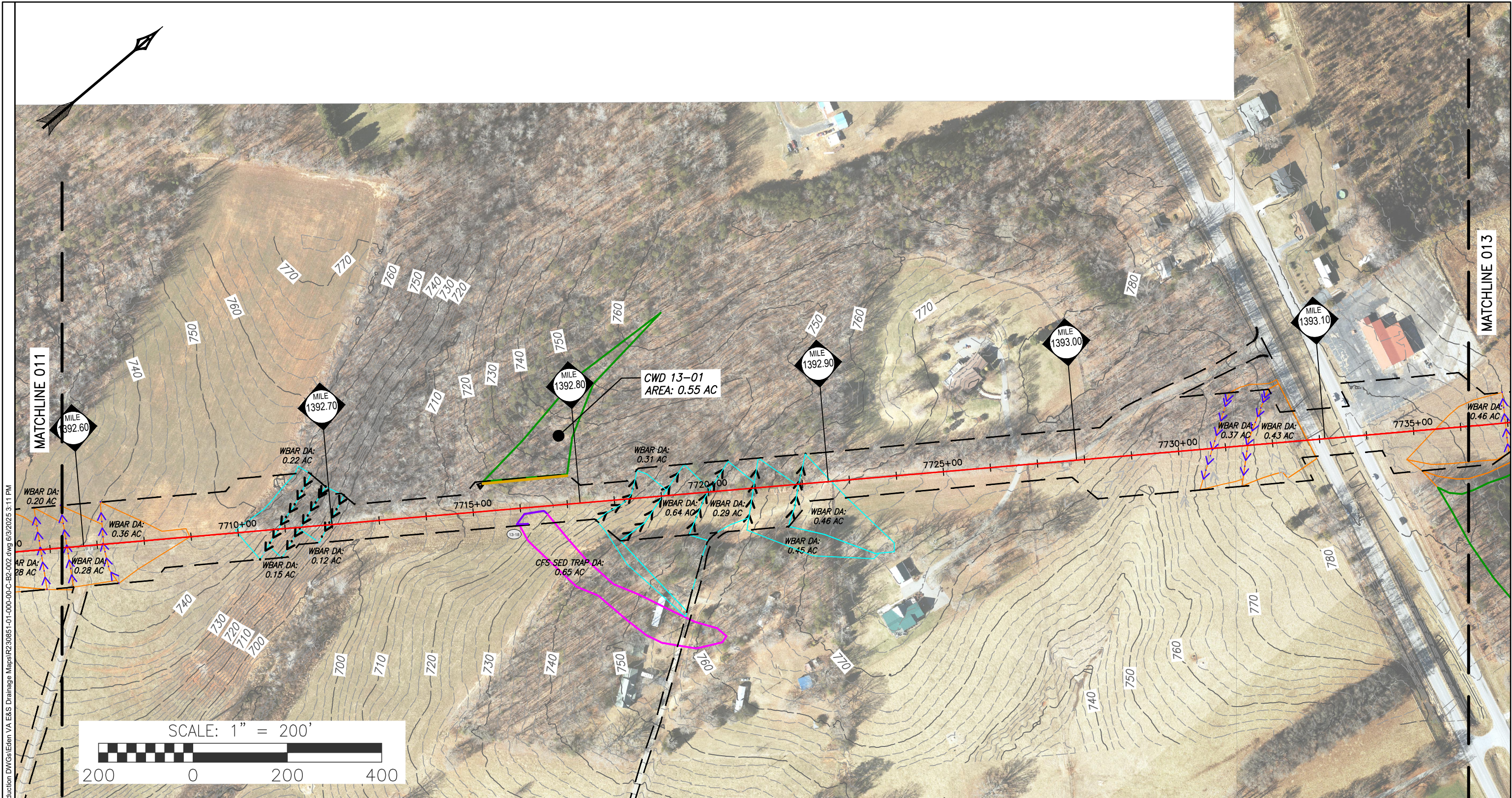
- WATERBAR DRAINAGE AREA PERMANENT CONDITION
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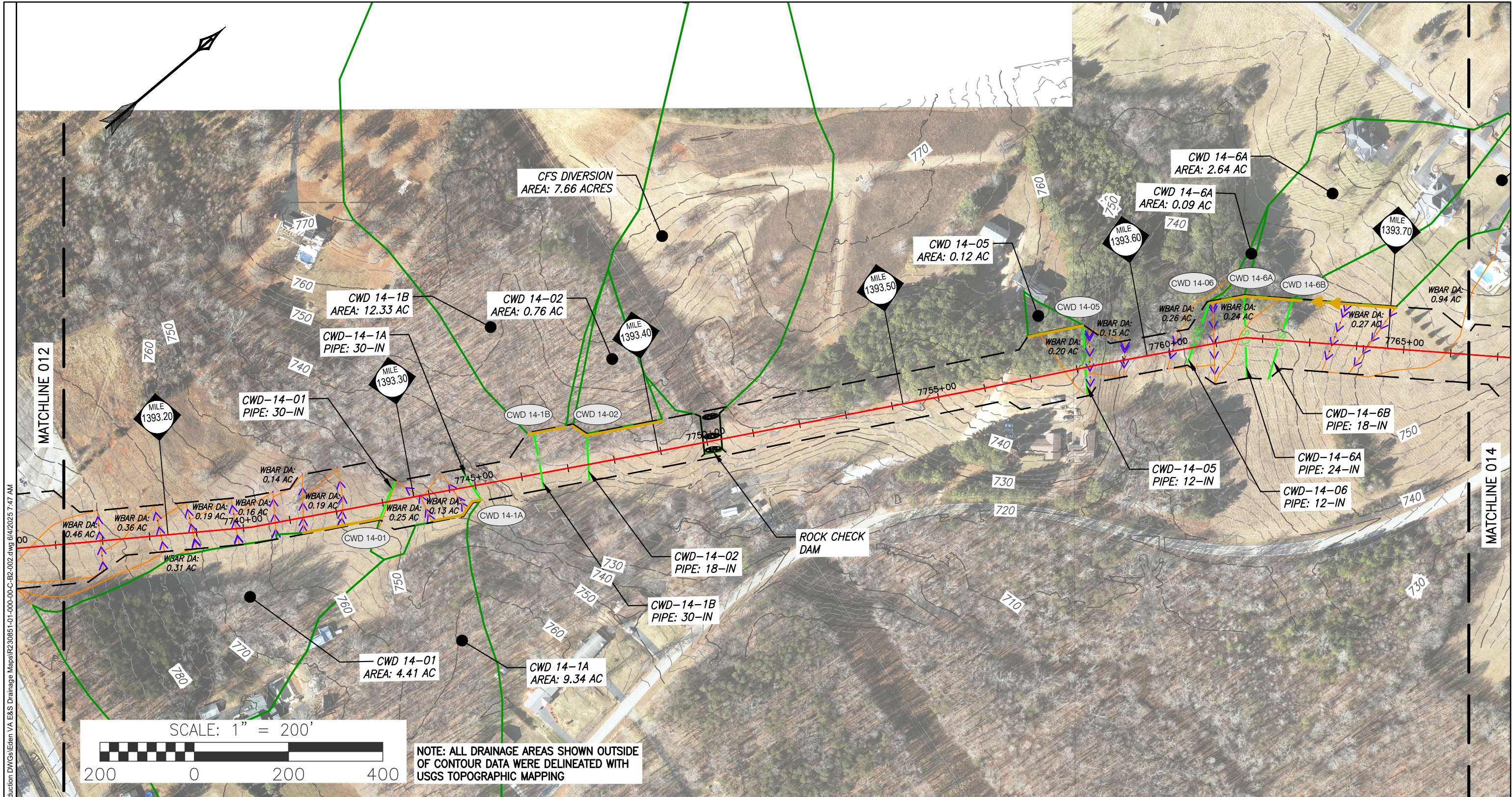
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| --- | LIMIT OF DISTURBANCE | --- | WATERBAR DRAINAGE AREA PERMANENT CONDITION |
| --- | PROPOSED PIPELINE | --- | PROPOSED CLEAN WATER DIVERSION DIKE/FENCE |
| - - - - - | EXISTING WATERBAR | SD SD SD | PROPOSED CLEAN WATER DIVERSION SLOPE DRAIN |
| - - - - - | PROPOSED TEMPORARY WATERBAR | --- | CLEAN WATER DIVERSION DRAINAGE AREA |
| - - - - - | PROPOSED PERMANENT WATERBAR | CFS | PROPOSED COMPOST FILTER SOCK TRAP |
| --- | WATERBAR DRAINAGE AREA TEMPORARY CONDITION | --- | COMPOST FILTER SOCK TRAP DRAINAGE AREA |

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- LIMIT OF DISTURBANCE
- PROPOSED PIPELINE
- EXISTING WATERBAR
- PROPOSED TEMPORARY WATERBAR
- PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

LEGEND

- WATERBAR DRAINAGE AREA PERMANENT CONDITION
- PROPOSED CLEAN WATER DIVERSION DIKE/FENCE
- SD --- SD --- SD --- PROPOSED CLEAN WATER DIVERSION SLOPE DRAIN
- CLEAN WATER DIVERSION DRAINAGE AREA
- CFS --- PROPOSED COMPOST FILTER SOCK TRAP
- COMPOST FILTER SOCK TRAP DRAINAGE AREA

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SOUTHEAST SUPPLY ENHANCEMENT PROJECT
E&SC DRAINAGE AREA MAPS
PITTSYLVANIA COUNTY, VIRGINIA



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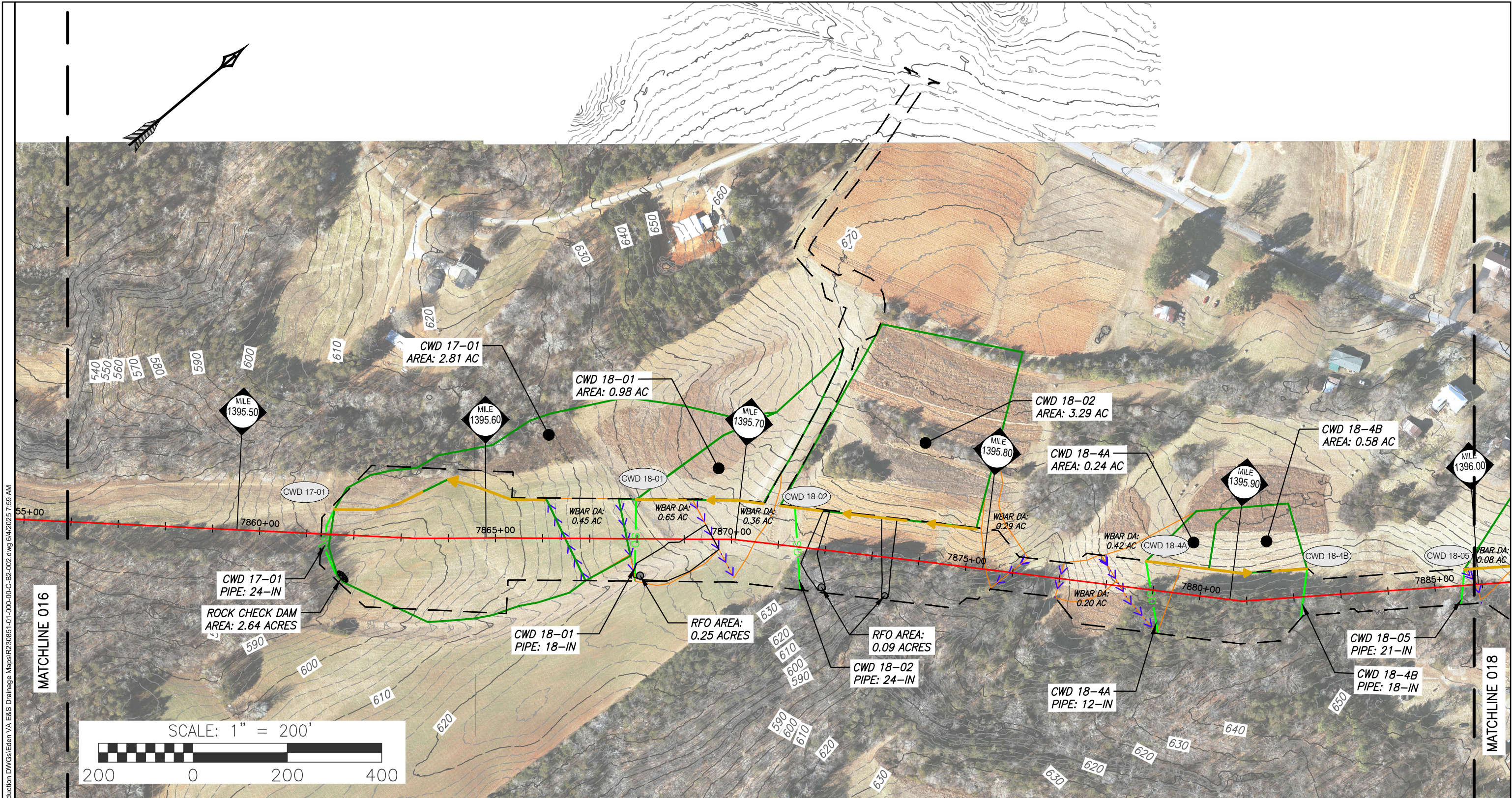
MATCHLINE 014

SCALE: 1" = 200'

LEGEND

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E&SC DRAINAGE AREA MAPS
PITTSYLVANIA COUNTY, VIRGINIA

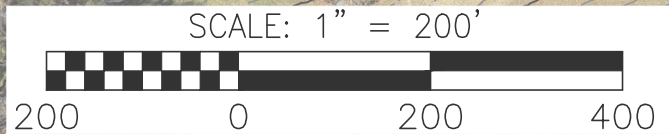
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MATCHLINE 016

MATCHLINE 018



LEGEND

- | | | | |
|-----|--|-----|--|
| --- | LIMIT OF DISTURBANCE | --- | WATERBAR DRAINAGE AREA PERMANENT CONDITION |
| --- | PROPOSED PIPELINE | --- | PROPOSED CLEAN WATER DIVERSION DIKE/FENCE |
| --- | EXISTING WATERBAR | --- | PROPOSED CLEAN WATER DIVERSION SLOPE DRAIN |
| --- | PROPOSED TEMPORARY WATERBAR | --- | CLEAN WATER DIVERSION DRAINAGE AREA |
| --- | PROPOSED PERMANENT WATERBAR | --- | PROPOSED COMPOST FILTER SOCK TRAP |
| --- | WATERBAR DRAINAGE AREA TEMPORARY CONDITION | --- | COMPOST FILTER SOCK TRAP DRAINAGE AREA |

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- LIMIT OF DISTURBANCE
- PROPOSED PIPELINE
- - - - - EXISTING WATERBAR
- · · · · PROPOSED TEMPORARY WATERBAR
- · · · · PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

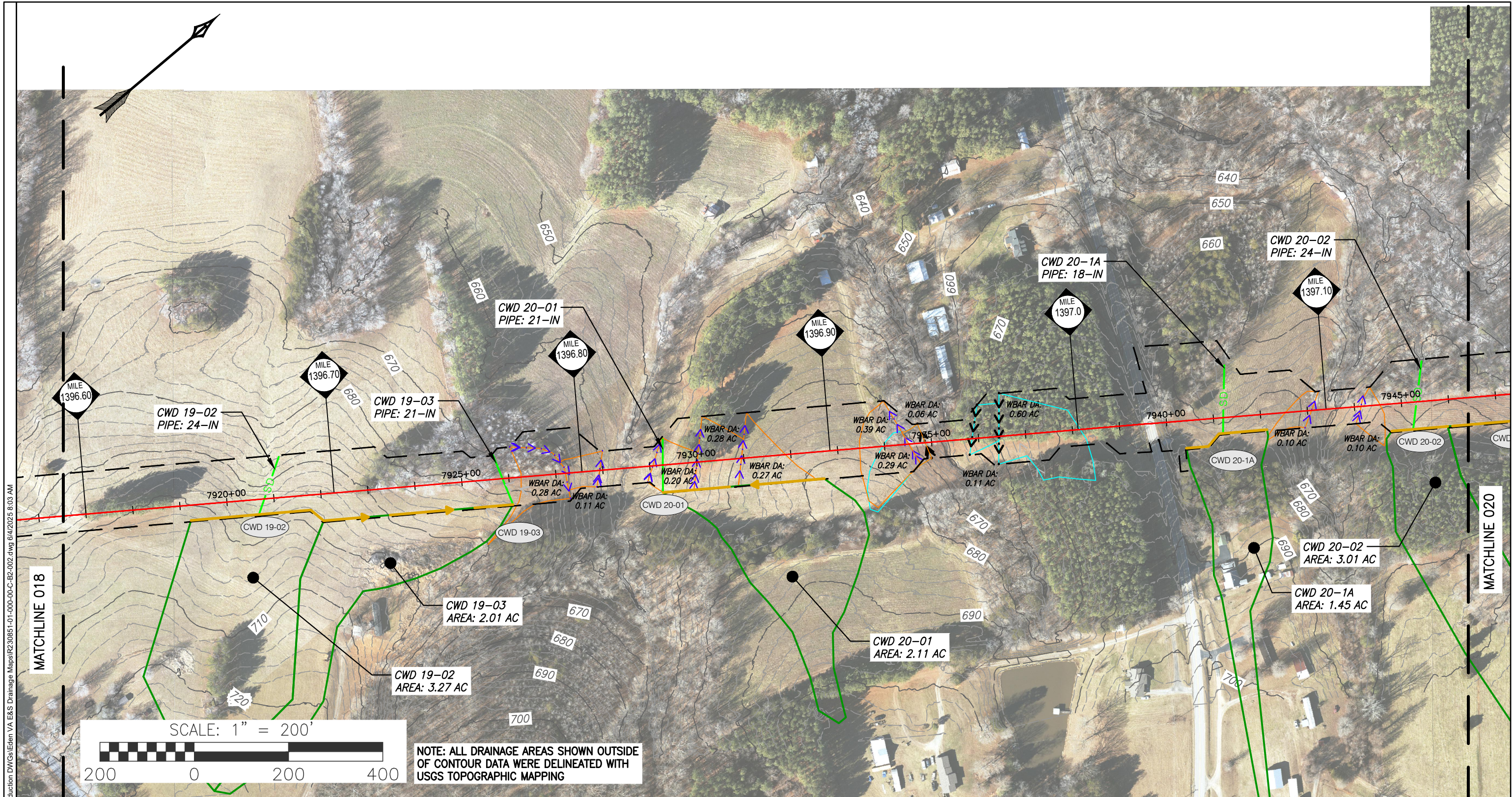
LEGEND

- WATERBAR DRAINAGE AREA PERMANENT CONDITION
- PROPOSED CLEAN WATER DIVERSION DIKE/FENCE
- SD SD SD PROPOSED CLEAN WATER DIVERSION SLOPE DRAIN
- CLEAN WATER DIVERSION DRAINAGE AREA
- CFS PROPOSED COMPOST FILTER SOCK TRAP
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SOUTHEAST SUPPLY ENHANCEMENT PROJECT
E&SC DRAINAGE AREA MAPS
PITTSYLVANIA COUNTY, VIRGINIA



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- LIMIT OF DISTURBANCE
- PROPOSED PIPELINE
- EXISTING WATERBAR
- PROPOSED TEMPORARY WATERBAR
- PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

LEGEND

- WATERBAR DRAINAGE AREA PERMANENT CONDITION
- PROPOSED CLEAN WATER DIVERSION DIKE/FENCE
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- CLEAN WATER DIVERSION DRAINAGE AREA
- CFS --- PROPOSED COMPOST FILTER SOCK TRAP
- COMPOST FILTER SOCK TRAP DRAINAGE AREA

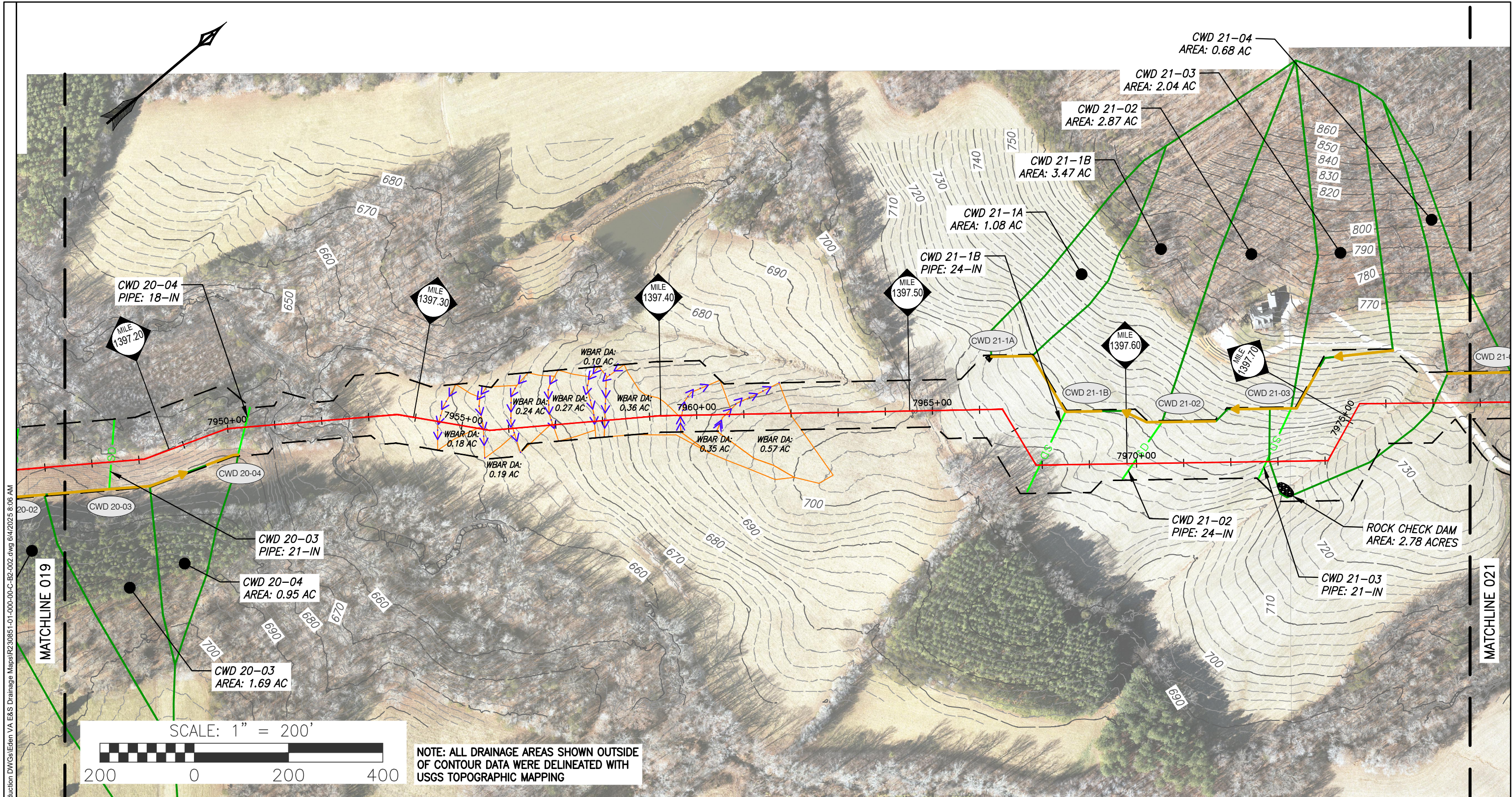
NOTE: ALL DRAINAGE AREAS SHOWN OUTSIDE OF CONTOUR DATA WERE DELINEATED WITH USGS TOPOGRAPHIC MAPPING

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- LIMIT OF DISTURBANCE
- PROPOSED PIPELINE
- EXISTING WATERBAR
- PROPOSED TEMPORARY WATERBAR
- PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

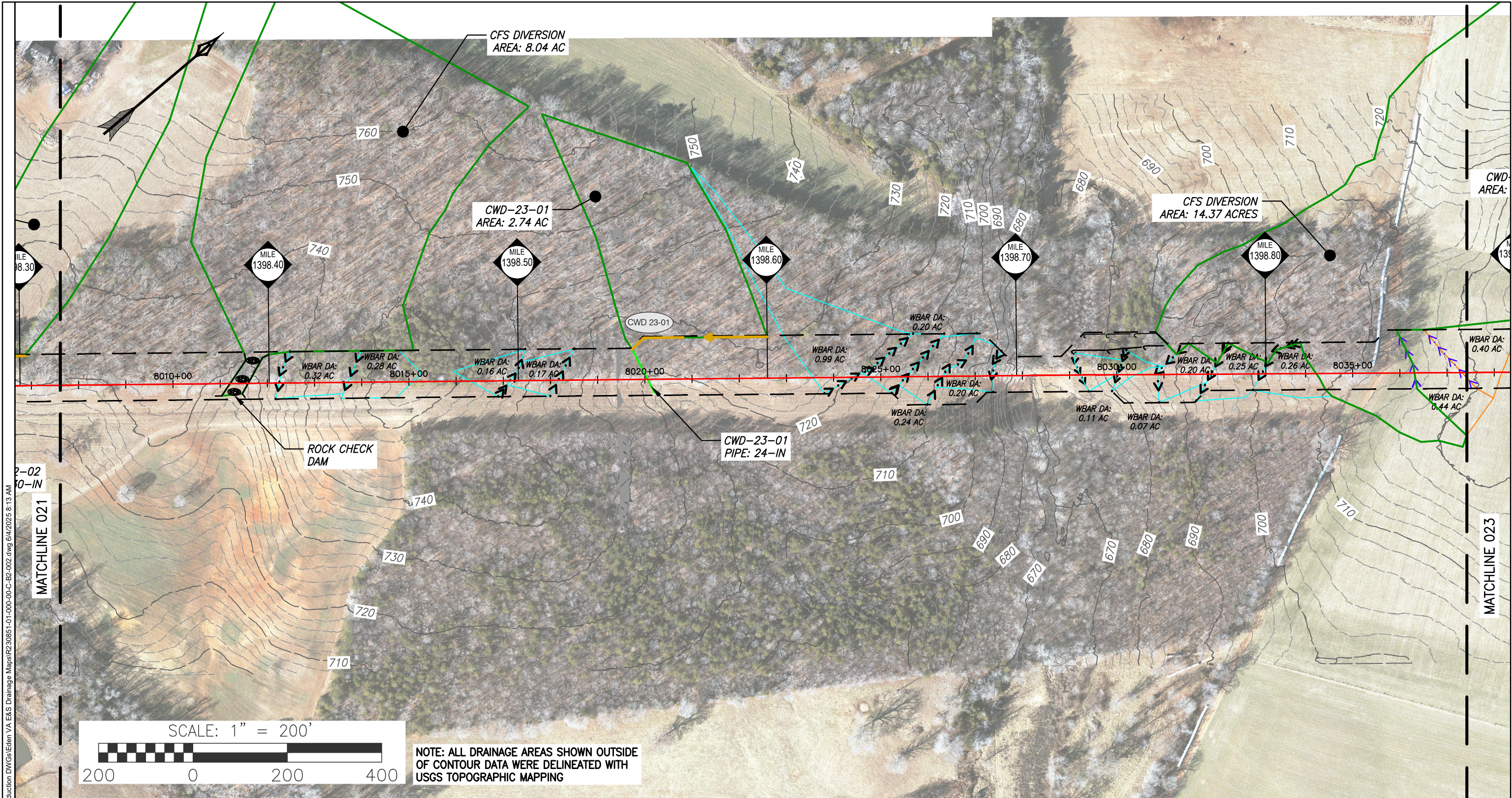
LEGEND

- WATERBAR DRAINAGE AREA PERMANENT CONDITION
- PROPOSED CLEAN WATER DIVERSION DIKE/FENCE
- SD --- SD --- SD --- PROPOSED CLEAN WATER DIVERSION SLOPE DRAIN
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- LIMIT OF DISTURBANCE
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- · · · · EXISTING WATERBAR
- · · · · PROPOSED TEMPORARY WATERBAR
- · · · · PROPOSED PERMANENT WATERBAR
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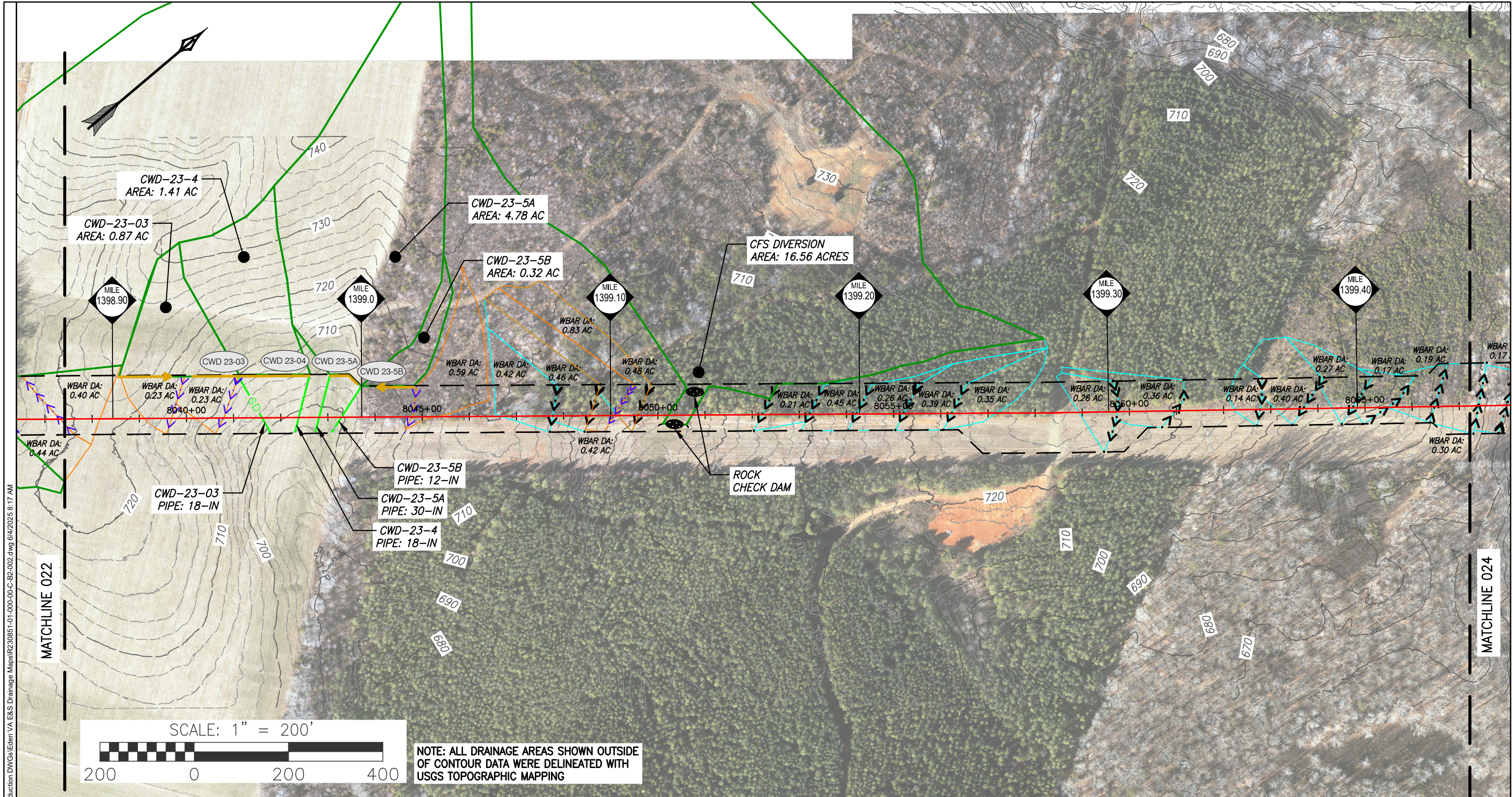
LEGEND

- WATERBAR DRAINAGE AREA PERMANENT CONDITION
- PROPOSED CLEAN WATER DIVERSION DIKE/FENCE
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- LIMIT OF DISTURBANCE
- PROPOSED PIPELINE
- · · · · EXISTING WATERBAR
- · · · · PROPOSED TEMPORARY WATERBAR
- · · · · PROPOSED PERMANENT WATERBAR
- WATERBAR DRAINAGE AREA TEMPORARY CONDITION

LEGEND

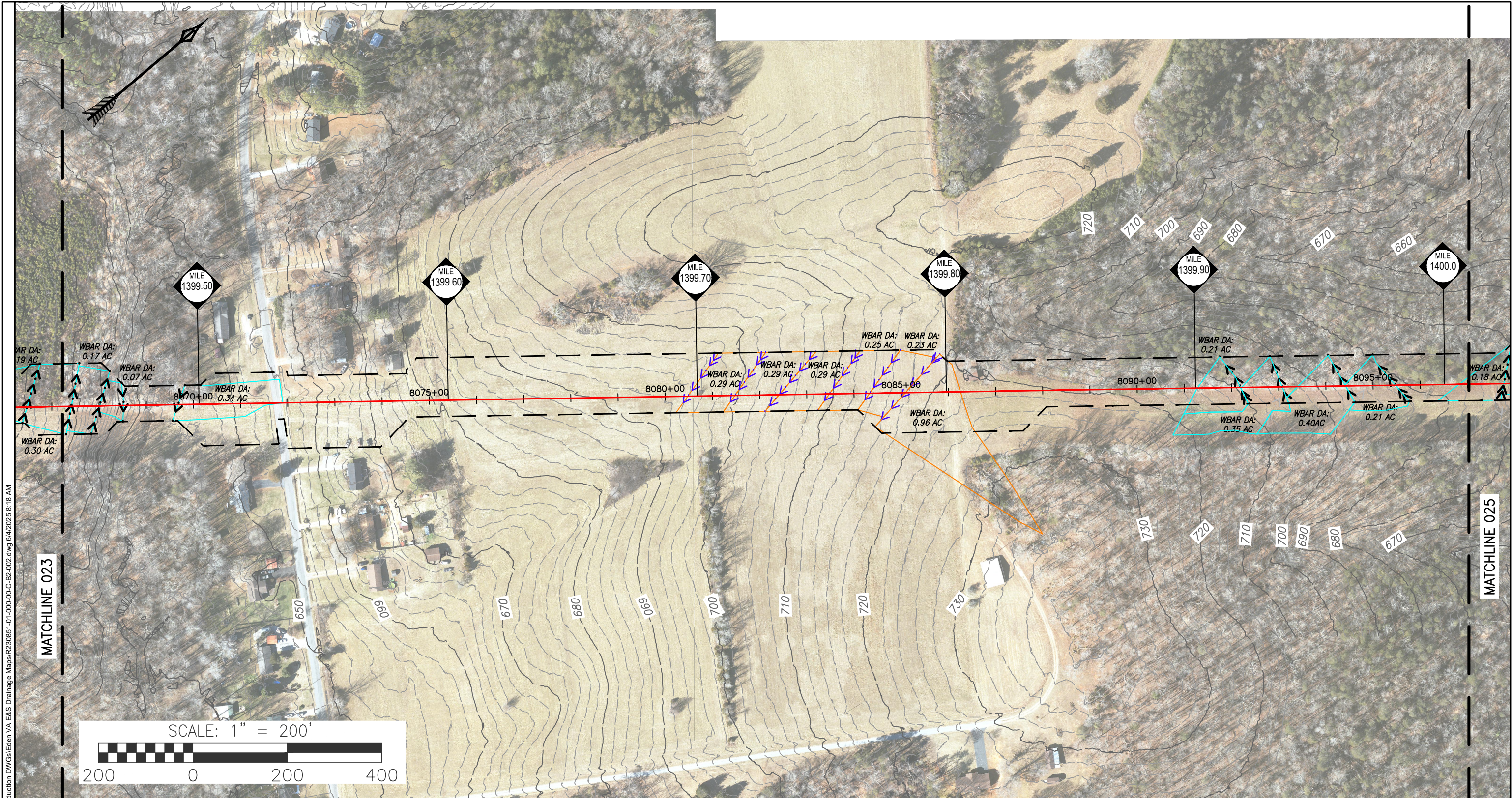
- WATERBAR DRAINAGE AREA PERMANENT CONDITION
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- LIMIT OF DISTURBANCE
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- PROPOSED PERMANENT WATERBAR
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LEGEND

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