

Attachment G

Dewatering Sump Analytical Results and Field Logs

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ANALYTICAL RESULTS FOR DEWATERING SUMPS
GUDE LANDFILL

Parameters	Daily Maximum Limits*	Units	DS-0	DS-1	DS-3	DS-4	DS-5
			10/27/2020	10/27/2020	10/27/2020	10/27/2020	10/27/2020
			Sampling Results	Sampling Results	Sampling Results	Sampling Results	Sampling Results
Total Inorganic Parameters							
Ammonia Nitrogen	Monitoring only	mg/L	31.4	50.9	60.8	46.5	44.5
Biochemical Oxygen Demand	Monitoring only	mg/L	21.5	15.4	23.8	20.0	16.4
Chemical Oxygen Demand	--	mg/L	97.1	95.9	102	91.2	112
Total Phosphorus	Monitoring only	mg/L	0.21	0.37	0.25	0.21	0.27
pH	6.0 - 10.0	mg/L	6.54	6.47	6.59	6.55	6.58
Total Dissolved Solids	Monitoring only	mg/L	1280	1110	1290	1330	1600
Total Suspended Solids	3000	mg/L	54.8	55.0	52.9	57.5	84.1
Cyanide, Total	0.56	mg/L	0.01 U	0.034	0.020	0.01 U	0.010
Total Metals							
Arsenic, total	0.23	mg/L	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Cadmium, total	0.07	mg/L	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Copper, total	2.3	mg/L	0.001 U	0.001 U	0.001 U	0.001 U	0.002
Lead, total	1.0	mg/L	0.001 U	0.001 U	0.001 U	0.001 U	0.001
Mercury, total	<0.001	mg/L	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U
Molybdenum, total	0.89	mg/L	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U
Nickel, total	2.2	mg/L	0.00508	0.00607	0.00549	0.00567	0.00808
Silver, total	1.3	mg/L	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Zinc, total	3.4	mg/L	0.004 U	0.004 U	0.004 U	0.501	0.004 U
Organic Compounds							
Oil and Grease (Polar)	200	mg/L	0.0048 U	0.0048 U	0.0048 U	0.0048 U	0.0048 U
Oil and Grease (Nonpolar, Total Petroleum Hydrocarbons)	100	mg/L	0.0048 U	0.0048 U	0.0048 U	0.0048 U	0.0011
PCB-1016 (Aroclor 1016)	<0.001	mg/L	0.00028 U	0.00024 U	0.00024 U	0.00024 U	0.00025 U
PCB-1221 (Aroclor 1221)	<0.001	mg/L	0.00028 U	0.00024 U	0.00024 U	0.00024 U	0.00025 U
PCB-1232 (Aroclor 1232)	<0.001	mg/L	0.00057	0.00024 U	0.00024 U	0.0013	0.00025 U
PCB-1242 (Aroclor 1242)	<0.001	mg/L	0.00028 U	0.00024 U	0.00024 U	0.00024 U	0.00025 U
PCB-1248 (Aroclor 1248)	<0.001	mg/L	0.00028 U	0.00024 U	0.00024 U	0.00024 U	0.00025 U
PCB-1254 (Aroclor 1254)	<0.001	mg/L	0.00028 U	0.00024 U	0.00024 U	0.00024 U	0.00025 U
PCB-1260 (Aroclor 1260)	<0.001	mg/L	0.00028 U	0.00024 U	0.00024 U	0.00024 U	0.00025 U
Tetrachloroethene	0.0945	mg/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Trichloroethene	0.026	mg/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Toluene	--	mg/L	0.0021	0.005 U	0.005 U	0.005 U	0.005 U
Xylenes, Total	--	mg/L	0.0041	0.0023	0.005 U	0.005 U	0.005 U

* Discharge limits adopted from Oaks Sanitary Landfill Discharge Authorization Permit No. 07741.

Daily maximum limit exceedances shaded in grey.

06 November 2020

Laura Oakes
EA Engineering
225 Schilling Circle, STE 400
Hunt Valley, MD 21031
RE: GUDE LANDFILL

Enclosed are the results of analyses for samples received by the laboratory on 10/27/20 14:51.

Please visit our website at www.mdspectral.com for a complete listing of our accreditations.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,



Rabecka Koons
Quality Assurance Officer

1500 Caton Center Dr Suite G
Baltimore MD 21227
410-247-7600
www.mdspectral.com
MD DW LabID 153

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Client Sample ID	Alternate Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
DS-0		0102714-01	Nonpotable Water	10/27/20 09:25	10/27/20 14:51
DS-1		0102714-02	Nonpotable Water	10/27/20 10:35	10/27/20 14:51
DS-3		0102714-03	Nonpotable Water	10/27/20 11:35	10/27/20 14:51
DS-4		0102714-04	Nonpotable Water	10/27/20 12:25	10/27/20 14:51
DS-5		0102714-05	Nonpotable Water	10/27/20 13:30	10/27/20 14:51

Rabecka Koons

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-0

**0102714-01 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
pH measurement by EPA 9040C Prepared by pH (Paper or Meter)									
pH	6.54		pH Units			1	10/27/20	10/27/20 18:57	RH
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES									
Benzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Bromodichloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Bromoform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Bromomethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Carbon tetrachloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Chlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Chloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Chloroform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Chloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Dibromochloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,2-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,3-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,4-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,1-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,2-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,1-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
cis-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
trans-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,2-Dichloropropane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
cis-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
trans-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Ethylbenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Methyl tert-butyl ether (MTBE)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Methylene chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,1,1,2-Tetrachloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Tetrachloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Toluene	2.1	J	ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,1,1-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
1,1,2-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Trichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-0

**0102714-01 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES (continued)									
Trichlorofluoromethane (Freon 11)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Vinyl chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
Xylenes, Total	4.1	J	ug/L	5.0	2.0	1	10/29/20	10/29/20 15:04	AS
<i>Surrogate: 1,2-Dichloroethane-d4</i>			<i>70-130</i>	<i>117 %</i>	<i>10/29/20</i>		<i>10/29/20 15:04</i>		
<i>Surrogate: Toluene-d8</i>			<i>75-120</i>	<i>104 %</i>	<i>10/29/20</i>		<i>10/29/20 15:04</i>		
<i>Surrogate: 4-Bromofluorobenzene</i>			<i>75-120</i>	<i>105 %</i>	<i>10/29/20</i>		<i>10/29/20 15:04</i>		
Total Metals Analysis by EPA 200.8 Prepared by 3010A-Metals Digestion									
Arsenic	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:51	KD
Cadmium	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:51	KD
Copper	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:51	KD
Lead	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:51	KD
Molybdenum	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:51	KD
Nickel	5.08		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:51	KD
Silver	ND		ug/L	1.0	1.0	1	10/28/20	10/29/20 11:51	KD
Zinc	ND		ug/L	5.00	5.00	1	10/28/20	10/29/20 11:51	KD
Total Metals by EPA 245.1 Performed at Enviro-Chem									
Mercury	ND		mg/L	0.0002	0.0002	1	11/02/20	11/02/20 12:42	RAS
Chemical Oxygen Demand by EPA 410.4 Prepared by COD (03) Prep									
COD	97.1		mg/L	3.0	3.0	1	11/03/20	11/03/20 20:51	KD
Total Suspended Solids by USGS I-3765-85 Prepared by TSS PREP									
Solids, Suspended	54.8		mg/L	16.1	16.1	1	10/29/20	10/30/20 17:54	WEG



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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-0

0102714-01 (Nonpotable Water)
Sample Date: 10/27/20

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Total Dissolved Solids by SM 2540C Prepared by TDS Prep									
Solids, Dissolved	1280		mg/L	10.0	10.0	1	11/02/20	11/03/20 18:01	VVD
Wet Chemistry Performed at Enviro-Chem									
Ammonia Nitrogen	31.4		mg/L	1.00	0.50	10	10/30/20	10/30/20 14:38	FRD
Phosphorus, P	0.21		mg/L	0.05	0.01	1	10/30/20	10/30/20 13:54	FD
Biochemical Oxygen Demand SM 5210B Performed at Enviro-Chem									
BOD, 5 Day	21.5		mg/L	10.0	10.0	5	10/28/20	11/02/20 16:00	SES
Cyanide ASTM D7511-12 Performed at Enviro-Chem									
Cyanide, Total	ND		mg/L	0.010	0.010	1	10/29/20	10/29/20 10:48	FRD
EPA 1664A Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
Oil and Grease	ND	3c	mg/L	4.8	0.92	1	11/03/20	11/02/20 17:20	SEF
Total Petroleum Hydrocarbons	ND	2c, 3c	mg/L	4.8	0.95	1	11/03/20	11/03/20 14:11	SEF
EPA 608.3 Dec 2016 Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
PCB-1016 (Aroclor 1016)	ND	L2, P2, 1c	ug/L	0.28	0.16	1	11/02/20	11/03/20 11:26	CWB
PCB-1221 (Aroclor 1221)	ND	P2, 1c	ug/L	0.28	0.19	1	11/02/20	11/03/20 11:26	CWB
PCB-1232 (Aroclor 1232)	0.57	P2, 1c	ug/L	0.28	0.082	1	11/02/20	11/03/20 11:26	CWB
PCB-1242 (Aroclor 1242)	ND	P2, 1c	ug/L	0.28	0.12	1	11/02/20	11/03/20 11:26	CWB
PCB-1248 (Aroclor 1248)	ND	P2, 1c	ug/L	0.28	0.11	1	11/02/20	11/03/20 11:26	CWB
PCB-1254 (Aroclor 1254)	ND	P2, 1c	ug/L	0.28	0.051	1	11/02/20	11/03/20 11:26	CWB
PCB-1260 (Aroclor 1260)	ND	1c	ug/L	0.28	0.028	1	11/02/20	11/03/20 11:26	CWB
Surrogate: Decachlorobiphenyl (S)			10-146	48 %	11/02/20		11/03/20 11:26		
Surrogate: Tetrachloro-m-xylene (S)			16-117	54 %	11/02/20		11/03/20 11:26		



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-1

**0102714-02 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
pH measurement by EPA 9040C Prepared by pH (Paper or Meter)									
pH	6.47		pH Units			1	10/27/20	10/27/20 18:57	RH
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES									
Benzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Bromodichloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Bromoform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Bromomethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Carbon tetrachloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Chlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Chloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Chloroform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Chloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Dibromochloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,2-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,3-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,4-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,1-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,2-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,1-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
cis-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
trans-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,2-Dichloropropane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
cis-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
trans-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Ethylbenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Methyl tert-butyl ether (MTBE)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Methylene chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,1,1,2-Tetrachloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Tetrachloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Toluene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,1,1-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
1,1,2-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Trichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-1

**0102714-02 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES (continued)									
Trichlorofluoromethane (Freon 11)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Vinyl chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Xylenes, Total	2.3	J	ug/L	5.0	2.0	1	10/29/20	10/29/20 15:28	AS
Surrogate: 1,2-Dichloroethane-d4			70-130	118 %	10/29/20		10/29/20 15:28		
Surrogate: Toluene-d8			75-120	102 %	10/29/20		10/29/20 15:28		
Surrogate: 4-Bromofluorobenzene			75-120	104 %	10/29/20		10/29/20 15:28		
Total Metals Analysis by EPA 200.8 Prepared by 3010A-Metals Digestion									
Arsenic	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:53	KD
Cadmium	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:53	KD
Copper	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:53	KD
Lead	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:53	KD
Molybdenum	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:53	KD
Nickel	6.07		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:53	KD
Silver	ND		ug/L	1.0	1.0	1	10/28/20	10/29/20 11:53	KD
Zinc	ND		ug/L	5.00	5.00	1	10/28/20	10/29/20 11:53	KD
Total Metals by EPA 245.1 Performed at Enviro-Chem									
Mercury	ND		mg/L	0.0002	0.0002	1	11/02/20	11/02/20 12:49	RAS
Chemical Oxygen Demand by EPA 410.4 Prepared by COD (03) Prep									
COD	95.9		mg/L	3.0	3.0	1	11/03/20	11/03/20 20:51	KD
Total Suspended Solids by USGS I-3765-85 Prepared by TSS PREP									
Solids, Suspended	55.0		mg/L	15.6	15.6	1	10/29/20	10/30/20 17:54	WEG

Rabecka Koons

Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-1

0102714-02 (Nonpotable Water)
Sample Date: 10/27/20

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Total Dissolved Solids by SM 2540C Prepared by TDS Prep									
Solids, Dissolved	1110		mg/L	10.0	10.0	1	11/02/20	11/03/20 18:01	VVD
Wet Chemistry Performed at Enviro-Chem									
Ammonia Nitrogen	50.9		mg/L	2.00	1.00	20	10/30/20	10/30/20 15:15	FRD
Phosphorus, P	0.37		mg/L	0.05	0.01	1	10/30/20	10/30/20 13:58	FD
Biochemical Oxygen Demand SM 5210B Performed at Enviro-Chem									
BOD, 5 Day	15.4		mg/L	10.0	10.0	5	10/28/20	11/02/20 16:00	SES
Cyanide ASTM D7511-12 Performed at Enviro-Chem									
Cyanide, Total	0.034		mg/L	0.010	0.010	1	10/29/20	10/29/20 10:54	FRD
EPA 1664A Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
Oil and Grease	ND	3c	mg/L	4.8	0.92	1	11/03/20	11/02/20 17:20	SEF
Total Petroleum Hydrocarbons	ND	2c, 3c	mg/L	4.8	0.95	1	11/03/20	11/03/20 14:11	SEF
EPA 608.3 Dec 2016 Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
PCB-1016 (Aroclor 1016)	ND	L2, P2, 1c	ug/L	0.24	0.13	1	11/02/20	11/03/20 11:35	CWB
PCB-1221 (Aroclor 1221)	ND	P2, 1c	ug/L	0.24	0.16	1	11/02/20	11/03/20 11:35	CWB
PCB-1232 (Aroclor 1232)	ND	P2, 1c	ug/L	0.24	0.069	1	11/02/20	11/03/20 11:35	CWB
PCB-1242 (Aroclor 1242)	ND	P2, 1c	ug/L	0.24	0.10	1	11/02/20	11/03/20 11:35	CWB
PCB-1248 (Aroclor 1248)	ND	P2, 1c	ug/L	0.24	0.089	1	11/02/20	11/03/20 11:35	CWB
PCB-1254 (Aroclor 1254)	ND	P2, 1c	ug/L	0.24	0.043	1	11/02/20	11/03/20 11:35	CWB
PCB-1260 (Aroclor 1260)	ND	1c	ug/L	0.24	0.023	1	11/02/20	11/03/20 11:35	CWB
Surrogate: Decachlorobiphenyl (S)			10-146	29 %	11/02/20		11/03/20 11:35		
Surrogate: Tetrachloro-m-xylene (S)			16-117	55 %	11/02/20		11/03/20 11:35		



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-3

0102714-03 (Nonpotable Water)
Sample Date: 10/27/20

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
pH measurement by EPA 9040C Prepared by pH (Paper or Meter)									
pH	6.59		pH Units			1	10/27/20	10/27/20 18:57	RH
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES									
Benzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Bromodichloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Bromoform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Bromomethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Carbon tetrachloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Chlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Chloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Chloroform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Chloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Dibromochloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,2-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,3-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,4-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,1-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,2-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,1-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
cis-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
trans-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,2-Dichloropropane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
cis-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
trans-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Ethylbenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Methyl tert-butyl ether (MTBE)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Methylene chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,1,1,2-Tetrachloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Tetrachloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Toluene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,1,1-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
1,1,2-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Trichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-3

**0102714-03 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES (continued)									
Trichlorofluoromethane (Freon 11)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Vinyl chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Xylenes, Total	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:17	AS
Surrogate: 1,2-Dichloroethane-d4			70-130	118 %	10/29/20		10/29/20 16:17		
Surrogate: Toluene-d8			75-120	103 %	10/29/20		10/29/20 16:17		
Surrogate: 4-Bromofluorobenzene			75-120	104 %	10/29/20		10/29/20 16:17		
Total Metals Analysis by EPA 200.8 Prepared by 3010A-Metals Digestion									
Arsenic	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:56	KD
Cadmium	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:56	KD
Copper	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:56	KD
Lead	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:56	KD
Molybdenum	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:56	KD
Nickel	5.49		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:56	KD
Silver	ND		ug/L	1.0	1.0	1	10/28/20	10/29/20 11:56	KD
Zinc	ND		ug/L	5.00	5.00	1	10/28/20	10/29/20 11:56	KD
Total Metals by EPA 245.1 Performed at Enviro-Chem									
Mercury	ND		mg/L	0.0002	0.0002	1	11/02/20	11/02/20 12:52	RAS
Chemical Oxygen Demand by EPA 410.4 Prepared by COD (03) Prep									
COD	102		mg/L	3.0	3.0	1	11/03/20	11/03/20 20:51	KD
Total Suspended Solids by USGS I-3765-85 Prepared by TSS PREP									
Solids, Suspended	52.9		mg/L	11.1	11.1	1	10/29/20	10/30/20 17:54	WEG



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-3

0102714-03 (Nonpotable Water)
Sample Date: 10/27/20

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Total Dissolved Solids by SM 2540C Prepared by TDS Prep									
Solids, Dissolved	1290		mg/L	10.0	10.0	1	11/02/20	11/03/20 18:01	VVD
Wet Chemistry Performed at Enviro-Chem									
Ammonia Nitrogen	60.8		mg/L	2.00	1.00	20	10/30/20	10/30/20 15:18	FRD
Phosphorus, P	0.25		mg/L	0.05	0.01	1	10/30/20	10/30/20 13:59	FD
Biochemical Oxygen Demand SM 5210B Performed at Enviro-Chem									
BOD, 5 Day	23.8		mg/L	10.0	10.0	5	10/28/20	11/02/20 16:00	SES
Cyanide ASTM D7511-12 Performed at Enviro-Chem									
Cyanide, Total	0.020		mg/L	0.010	0.010	1	10/29/20	10/29/20 10:56	FRD
EPA 1664A Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
Oil and Grease	ND	3c	mg/L	4.8	0.92	1	11/03/20	11/02/20 17:21	SEF
Total Petroleum Hydrocarbons	ND	2c, 3c	mg/L	4.8	0.95	1	11/03/20	11/03/20 14:11	SEF
EPA 608.3 Dec 2016 Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
PCB-1016 (Aroclor 1016)	ND	L2, P2, 1c	ug/L	0.24	0.13	1	11/02/20	11/03/20 11:43	CWB
PCB-1221 (Aroclor 1221)	ND	P2, 1c	ug/L	0.24	0.16	1	11/02/20	11/03/20 11:43	CWB
PCB-1232 (Aroclor 1232)	ND	P2, 1c	ug/L	0.24	0.070	1	11/02/20	11/03/20 11:43	CWB
PCB-1242 (Aroclor 1242)	ND	P2, 1c	ug/L	0.24	0.10	1	11/02/20	11/03/20 11:43	CWB
PCB-1248 (Aroclor 1248)	ND	P2, 1c	ug/L	0.24	0.090	1	11/02/20	11/03/20 11:43	CWB
PCB-1254 (Aroclor 1254)	ND	P2, 1c	ug/L	0.24	0.043	1	11/02/20	11/03/20 11:43	CWB
PCB-1260 (Aroclor 1260)	ND	1c	ug/L	0.24	0.024	1	11/02/20	11/03/20 11:43	CWB
Surrogate: Decachlorobiphenyl (S)			10-146	33 %	11/02/20		11/03/20 11:43		
Surrogate: Tetrachloro-m-xylene (S)			16-117	62 %	11/02/20		11/03/20 11:43		



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-4

**0102714-04 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
pH measurement by EPA 9040C Prepared by pH (Paper or Meter)									
pH	6.55		pH Units			1	10/27/20	10/27/20 18:57	RH
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES									
Benzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Bromodichloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Bromoform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Bromomethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Carbon tetrachloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Chlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Chloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Chloroform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Chloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Dibromochloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,2-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,3-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,4-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,1-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,2-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,1-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
cis-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
trans-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,2-Dichloropropane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
cis-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
trans-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Ethylbenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Methyl tert-butyl ether (MTBE)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Methylene chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,1,1,2-Tetrachloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Tetrachloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Toluene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,1,1-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
1,1,2-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Trichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-4

**0102714-04 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES (continued)									
Trichlorofluoromethane (Freon 11)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Vinyl chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Xylenes, Total	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 16:42	AS
Surrogate: 1,2-Dichloroethane-d4		70-130		116 %	10/29/20		10/29/20 16:42		
Surrogate: Toluene-d8		75-120		103 %	10/29/20		10/29/20 16:42		
Surrogate: 4-Bromofluorobenzene		75-120		102 %	10/29/20		10/29/20 16:42		
Total Metals Analysis by EPA 200.8 Prepared by 3010A-Metals Digestion									
Arsenic	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:58	KD
Cadmium	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:58	KD
Copper	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:58	KD
Lead	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:58	KD
Molybdenum	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:58	KD
Nickel	5.67		ug/L	1.00	1.00	1	10/28/20	10/29/20 11:58	KD
Silver	ND		ug/L	1.0	1.0	1	10/28/20	10/29/20 11:58	KD
Zinc	ND		ug/L	5.00	5.00	1	10/28/20	10/29/20 11:58	KD
Total Metals by EPA 245.1 Performed at Enviro-Chem									
Mercury	ND		mg/L	0.0002	0.0002	1	11/02/20	11/02/20 12:54	RAS
Chemical Oxygen Demand by EPA 410.4 Prepared by COD (03) Prep									
COD	91.2		mg/L	3.0	3.0	1	11/03/20	11/03/20 20:51	KD
Total Suspended Solids by USGS I-3765-85 Prepared by TSS PREP									
Solids, Suspended	57.5		mg/L	8.9	8.9	1	10/29/20	10/30/20 17:54	WEG



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-4

0102714-04 (Nonpotable Water)
Sample Date: 10/27/20

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Total Dissolved Solids by SM 2540C Prepared by TDS Prep									
Solids, Dissolved	1330		mg/L	10.0	10.0	1	11/02/20	11/03/20 18:01	VVD
Wet Chemistry Performed at Enviro-Chem									
Ammonia Nitrogen	46.5		mg/L	1.00	0.50	10	10/30/20	10/30/20 14:44	FRD
Phosphorus, P	0.21		mg/L	0.05	0.01	1	10/30/20	10/30/20 14:00	FD
Biochemical Oxygen Demand SM 5210B Performed at Enviro-Chem									
BOD, 5 Day	20.0		mg/L	10.0	10.0	5	10/28/20	11/02/20 16:00	SES
Cyanide ASTM D7511-12 Performed at Enviro-Chem									
Cyanide, Total	ND		mg/L	0.010	0.010	1	10/29/20	10/29/20 10:58	FRD
EPA 1664A Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
Oil and Grease	ND	3c	mg/L	4.8	0.92	1	11/03/20	11/02/20 17:21	SEF
Total Petroleum Hydrocarbons	ND	2c, 3c	mg/L	4.8	0.95	1	11/03/20	11/03/20 14:11	SEF
EPA 608.3 Dec 2016 Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
PCB-1016 (Aroclor 1016)	ND	L2, P2, 1c	ug/L	0.24	0.13	1	11/02/20	11/03/20 11:52	CWB
PCB-1221 (Aroclor 1221)	ND	P2, 1c	ug/L	0.24	0.16	1	11/02/20	11/03/20 11:52	CWB
PCB-1232 (Aroclor 1232)	1.3	P2, 1c	ug/L	0.24	0.071	1	11/02/20	11/03/20 11:52	CWB
PCB-1242 (Aroclor 1242)	ND	P2, 1c	ug/L	0.24	0.10	1	11/02/20	11/03/20 11:52	CWB
PCB-1248 (Aroclor 1248)	ND	P2, 1c	ug/L	0.24	0.091	1	11/02/20	11/03/20 11:52	CWB
PCB-1254 (Aroclor 1254)	ND	P2, 1c	ug/L	0.24	0.044	1	11/02/20	11/03/20 11:52	CWB
PCB-1260 (Aroclor 1260)	ND	1c	ug/L	0.24	0.024	1	11/02/20	11/03/20 11:52	CWB
Surrogate: Decachlorobiphenyl (S)			10-146	40 %	11/02/20		11/03/20 11:52		
Surrogate: Tetrachloro-m-xylene (S)			16-117	51 %	11/02/20		11/03/20 11:52		



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-5

0102714-05 (Nonpotable Water)
Sample Date: 10/27/20

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
pH measurement by EPA 9040C Prepared by pH (Paper or Meter)									
pH	6.58		pH Units			1	10/27/20	10/27/20 18:57	RH
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES									
Benzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Bromodichloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Bromoform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Bromomethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Carbon tetrachloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Chlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Chloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Chloroform	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Chloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Dibromochloromethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,2-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,3-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,4-Dichlorobenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,1-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,2-Dichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,1-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
cis-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
trans-1,2-Dichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,2-Dichloropropane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
cis-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
trans-1,3-Dichloropropene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Ethylbenzene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Methyl tert-butyl ether (MTBE)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Methylene chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,1,1,2-Tetrachloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Tetrachloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Toluene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,1,1-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
1,1,2-Trichloroethane	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Trichloroethene	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-5

**0102714-05 (Nonpotable Water)
Sample Date: 10/27/20**

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Volatile Organics by EPA 624.1 (GC/MS) Prepared by GCMS-WATER-VOLATILES (continued)									
Trichlorofluoromethane (Freon 11)	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Vinyl chloride	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Xylenes, Total	ND		ug/L	5.0	2.0	1	10/29/20	10/29/20 17:06	AS
Surrogate: 1,2-Dichloroethane-d4			70-130	116 %	10/29/20		10/29/20 17:06		
Surrogate: Toluene-d8			75-120	103 %	10/29/20		10/29/20 17:06		
Surrogate: 4-Bromofluorobenzene			75-120	104 %	10/29/20		10/29/20 17:06		
Total Metals Analysis by EPA 200.8 Prepared by 3010A-Metals Digestion									
Arsenic	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 12:01	KD
Cadmium	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 12:01	KD
Copper	2.00	B	ug/L	1.00	1.00	1	10/28/20	10/29/20 12:01	KD
Lead	1.00		ug/L	1.00	1.00	1	10/28/20	10/29/20 12:01	KD
Molybdenum	ND		ug/L	1.00	1.00	1	10/28/20	10/29/20 12:01	KD
Nickel	8.08		ug/L	1.00	1.00	1	10/28/20	10/29/20 12:01	KD
Silver	ND		ug/L	1.0	1.0	1	10/28/20	10/29/20 12:01	KD
Zinc	ND		ug/L	5.00	5.00	1	10/28/20	10/29/20 12:01	KD
Total Metals by EPA 245.1 Performed at Enviro-Chem									
Mercury	ND		mg/L	0.0002	0.0002	1	11/02/20	11/02/20 13:02	RAS
Chemical Oxygen Demand by EPA 410.4 Prepared by COD (03) Prep									
COD	112		mg/L	3.0	3.0	1	11/03/20	11/03/20 20:52	KD
Total Suspended Solids by USGS I-3765-85 Prepared by TSS PREP									
Solids, Suspended	84.1		mg/L	11.4	11.4	1	10/29/20	10/30/20 17:54	WEG

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

DS-5

0102714-05 (Nonpotable Water)
Sample Date: 10/27/20

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Detection Limit (LOD)	Dilution	Prepared	Analyzed	Analyst
Total Dissolved Solids by SM 2540C Prepared by TDS Prep									
Solids, Dissolved	1600		mg/L	10.0	10.0	1	11/02/20	11/03/20 18:01	VVD
Wet Chemistry Performed at Enviro-Chem									
Ammonia Nitrogen	44.5		mg/L	1.00	0.50	10	10/30/20	10/30/20 14:46	FRD
Phosphorus, P	0.27		mg/L	0.05	0.01	1	10/30/20	10/30/20 14:02	FD
Biochemical Oxygen Demand SM 5210B Performed at Enviro-Chem									
BOD, 5 Day	16.4		mg/L	10.0	10.0	5	10/28/20	11/02/20 16:00	SES
Cyanide ASTM D7511-12 Performed at Enviro-Chem									
Cyanide, Total	0.010		mg/L	0.010	0.010	1	10/29/20	10/29/20 11:00	FRD
EPA 1664A Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
Oil and Grease	ND	3c	mg/L	4.8	0.92	1	11/03/20	11/02/20 17:21	SEF
Total Petroleum Hydrocarbons	1.1	I, 2c, 3c	mg/L	4.8	0.95	1	11/03/20	11/03/20 14:11	SEF
EPA 608.3 Dec 2016 Performed at Pace Analytical Services, LLC - Pittsburgh Lab									
PCB-1016 (Aroclor 1016)	ND	L2, P2, 1c	ug/L	0.25	0.14	1	11/02/20	11/03/20 12:00	CWB
PCB-1221 (Aroclor 1221)	ND	P2, 1c	ug/L	0.25	0.16	1	11/02/20	11/03/20 12:00	CWB
PCB-1232 (Aroclor 1232)	ND	P2, 1c	ug/L	0.25	0.072	1	11/02/20	11/03/20 12:00	CWB
PCB-1242 (Aroclor 1242)	ND	P2, 1c	ug/L	0.25	0.11	1	11/02/20	11/03/20 12:00	CWB
PCB-1248 (Aroclor 1248)	ND	P2, 1c	ug/L	0.25	0.093	1	11/02/20	11/03/20 12:00	CWB
PCB-1254 (Aroclor 1254)	ND	P2, 1c	ug/L	0.25	0.045	1	11/02/20	11/03/20 12:00	CWB
PCB-1260 (Aroclor 1260)	ND	1c	ug/L	0.25	0.024	1	11/02/20	11/03/20 12:00	CWB
Surrogate: Decachlorobiphenyl (S)			10-146	46 %	11/02/20		11/03/20 12:00		
Surrogate: Tetrachloro-m-xylene (S)			16-117	57 %	11/02/20		11/03/20 12:00		



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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Volatile Organics by EPA 624.1 (GC/MS) - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010385 - GCMS-WATER-VOLATILES

Blank (B010385-BLK1)

Prepared & Analyzed: 10/29/20

Acetone	ND		10.0	ug/L						
Benzene	ND		5.0	ug/L						
Bromodichloromethane	ND		5.0	ug/L						
Bromoform	ND		5.0	ug/L						
Bromomethane	ND		5.0	ug/L						
Carbon tetrachloride	ND		5.0	ug/L						
Chlorobenzene	ND		5.0	ug/L						
Chloroethane	ND		5.0	ug/L						
Chloroform	ND		5.0	ug/L						
Chloromethane	ND		5.0	ug/L						
Dibromochloromethane	ND		5.0	ug/L						
1,2-Dichlorobenzene	ND		5.0	ug/L						
1,3-Dichlorobenzene	ND		5.0	ug/L						
1,4-Dichlorobenzene	ND		5.0	ug/L						
1,1-Dichloroethane	ND		5.0	ug/L						
1,2-Dichloroethane	ND		5.0	ug/L						
1,1-Dichloroethene	ND		5.0	ug/L						
cis-1,2-Dichloroethene	ND		5.0	ug/L						
trans-1,2-Dichloroethene	ND		5.0	ug/L						
1,2-Dichloropropane	ND		5.0	ug/L						
cis-1,3-Dichloropropene	ND		5.0	ug/L						
trans-1,3-Dichloropropene	ND		5.0	ug/L						
Ethylbenzene	ND		5.0	ug/L						
Methyl tert-butyl ether (MTBE)	ND		5.0	ug/L						
Methylene chloride	ND		5.0	ug/L						
1,1,2,2-Tetrachloroethane	ND		5.0	ug/L						
Tetrachloroethene	ND		5.0	ug/L						
Toluene	ND		5.0	ug/L						
1,1,1-Trichloroethane	ND		5.0	ug/L						
1,1,2-Trichloroethane	ND		5.0	ug/L						
Trichloroethene	ND		5.0	ug/L						



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Volatile Organics by EPA 624.1 (GC/MS) - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010385 - GCMS-WATER-VOLATILES

Blank (B010385-BLK1)

Prepared & Analyzed: 10/29/20

Trichlorofluoromethane (Freon 11)	ND		5.0	ug/L						
Vinyl chloride	ND		5.0	ug/L						
o-Xylene	ND		5.0	ug/L						
m- & p-Xylenes	ND		5.0	ug/L						
Xylenes, Total	ND		5.0	ug/L						
<i>Surrogate: 1,2-Dichloroethane-d4</i>	62.4			ug/L	50.0		125	70-130		
<i>Surrogate: Toluene-d8</i>	50.7			ug/L	50.0		101	75-120		
<i>Surrogate: 4-Bromofluorobenzene</i>	50.1			ug/L	50.0		100	75-120		

LCS (B010385-BS1)

Prepared & Analyzed: 10/29/20

Acetone	8.5	J	10.0	ug/L	10.0		85	50-150		
Benzene	3.9	J	5.0	ug/L	5.00		79	37-151		
Bromodichloromethane	3.7	J	5.0	ug/L	5.00		74	35-155		
Bromoform	2.6	J	5.0	ug/L	5.00		52	45-169		
Bromomethane	3.1	J	5.0	ug/L	5.00		63	0-242		
Carbon tetrachloride	3.9	J	5.0	ug/L	5.00		78	70-140		
Chlorobenzene	3.9	J	5.0	ug/L	5.00		78	37-160		
Chloroethane	6.5		5.0	ug/L	5.00		129	14-230		
Chloroform	4.1	J	5.0	ug/L	5.00		83	51-138		
Chloromethane	5.9		5.0	ug/L	5.00		119	0-273		
Dibromochloromethane	2.9	J	5.0	ug/L	5.00		58	53-149		
1,2-Dichlorobenzene	3.6	J	5.0	ug/L	5.00		73	18-190		
1,3-Dichlorobenzene	3.7	J	5.0	ug/L	5.00		74	59-156		
1,4-Dichlorobenzene	4.0	J	5.0	ug/L	5.00		80	18-190		
1,1-Dichloroethane	4.5	J	5.0	ug/L	5.00		89	59-155		
1,2-Dichloroethane	4.7	J	5.0	ug/L	5.00		93	49-155		
1,1-Dichloroethene	3.9	J	5.0	ug/L	5.00		78	0-234		
cis-1,2-Dichloroethene	3.9	J	5.0	ug/L	5.00		79	80-120		
trans-1,2-Dichloroethene	4.4	J	5.0	ug/L	5.00		87	54-156		
1,2-Dichloropropane	4.5	J	5.0	ug/L	5.00		90	0-210		
cis-1,3-Dichloropropene	3.3	J	5.0	ug/L	5.00		66	0-227		
trans-1,3-Dichloropropene	3.0	J	5.0	ug/L	5.00		60	17-183		

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Volatile Organics by EPA 624.1 (GC/MS) - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010385 - GCMS-WATER-VOLATILES

LCS (B010385-BS1)

Prepared & Analyzed: 10/29/20

Ethylbenzene	3.8	J	5.0	ug/L	5.00		75	37-162		
Methyl tert-butyl ether (MTBE)	3.9	J	5.0	ug/L	5.00		78	50-150		
Methylene chloride	4.8	J	5.0	ug/L	5.00		97	0-221		
1,1,2,2-Tetrachloroethane	3.9	J	5.0	ug/L	5.00		77	46-157		
Tetrachloroethene	3.1	J	5.0	ug/L	5.00		62	64-148		
Toluene	3.8	J	5.0	ug/L	5.00		75	47-150		
1,1,1-Trichloroethane	3.9	J	5.0	ug/L	5.00		78	52-162		
1,1,2-Trichloroethane	3.7	J	5.0	ug/L	5.00		75	52-150		
Trichloroethene	3.4	J	5.0	ug/L	5.00		67	71-157		
Trichlorofluoromethane (Freon 11)	5.7		5.0	ug/L	5.00		114	17-181		
Vinyl chloride	6.0		5.0	ug/L	5.00		119	0-251		
o-Xylene	3.4	J	5.0	ug/L	5.00		68	80-120		
m- & p-Xylenes	7.1		5.0	ug/L	10.0		71	80-120		
Xylenes, Total	10.5		5.0	ug/L	15.0		70	70-130		
Surrogate: 1,2-Dichloroethane-d4	60.0			ug/L	50.0		120	70-130		
Surrogate: Toluene-d8	51.2			ug/L	50.0		102	75-120		
Surrogate: 4-Bromofluorobenzene	51.1			ug/L	50.0		102	75-120		

Duplicate (B010385-DUP1)

Source: 0102832-04

Prepared & Analyzed: 10/29/20

Acetone	ND		10.0	ug/L		ND				200
Benzene	ND		5.0	ug/L		ND				200
Bromodichloromethane	ND		5.0	ug/L		ND				200
Bromoform	ND		5.0	ug/L		ND				200
Bromomethane	ND		5.0	ug/L		ND				200
Carbon tetrachloride	ND		5.0	ug/L		ND				200
Chlorobenzene	ND		5.0	ug/L		ND				200
Chloroethane	ND		5.0	ug/L		ND				200
Chloroform	ND		5.0	ug/L		ND				200
Chloromethane	ND		5.0	ug/L		ND				200
Dibromochloromethane	ND		5.0	ug/L		ND				200
1,2-Dichlorobenzene	ND		5.0	ug/L		ND				200
1,3-Dichlorobenzene	ND		5.0	ug/L		ND				200

Rabecka Koons

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Volatile Organics by EPA 624.1 (GC/MS) - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010385 - GCMS-WATER-VOLATILES

Duplicate (B010385-DUP1)		Source: 0102832-04		Prepared & Analyzed: 10/29/20						
1,4-Dichlorobenzene	ND		5.0	ug/L		ND				200
1,1-Dichloroethane	ND		5.0	ug/L		ND				200
1,2-Dichloroethane	ND		5.0	ug/L		ND				200
1,1-Dichloroethene	ND		5.0	ug/L		ND				200
cis-1,2-Dichloroethene	ND		5.0	ug/L		ND				200
trans-1,2-Dichloroethene	ND		5.0	ug/L		ND				200
1,2-Dichloropropane	ND		5.0	ug/L		ND				200
cis-1,3-Dichloropropene	ND		5.0	ug/L		ND				200
trans-1,3-Dichloropropene	ND		5.0	ug/L		ND				200
Ethylbenzene	ND		5.0	ug/L		ND				200
Methyl tert-butyl ether (MTBE)	ND		5.0	ug/L		ND				200
Methylene chloride	ND		5.0	ug/L		ND				200
1,1,2,2-Tetrachloroethane	ND		5.0	ug/L		ND				200
Tetrachloroethene	ND		5.0	ug/L		ND				200
Toluene	ND		5.0	ug/L		ND				200
1,1,1-Trichloroethane	ND		5.0	ug/L		ND				200
1,1,2-Trichloroethane	ND		5.0	ug/L		ND				200
Trichloroethene	ND		5.0	ug/L		ND				200
Trichlorofluoromethane (Freon 11)	ND		5.0	ug/L		ND				200
Vinyl chloride	ND		5.0	ug/L		ND				200
o-Xylene	ND		5.0	ug/L		ND				200
m- & p-Xylenes	ND		5.0	ug/L		ND				200
Xylenes, Total	ND		5.0	ug/L		ND				30
<i>Surrogate: 1,2-Dichloroethane-d4</i>		<i>60.0</i>		<i>ug/L</i>	<i>50.0</i>		<i>120</i>	<i>70-130</i>		
<i>Surrogate: Toluene-d8</i>		<i>51.4</i>		<i>ug/L</i>	<i>50.0</i>		<i>103</i>	<i>75-120</i>		
<i>Surrogate: 4-Bromofluorobenzene</i>		<i>48.8</i>		<i>ug/L</i>	<i>50.0</i>		<i>98</i>	<i>75-120</i>		

Matrix Spike (B010385-MS1)		Source: 0102830-01		Prepared & Analyzed: 10/29/20						
Benzene	8.4		5.0	ug/L	10.0	ND	84	80-120		
Bromodichloromethane	7.4		5.0	ug/L	10.0	ND	74	80-120		
Bromoform	4.1	J	5.0	ug/L	10.0	ND	41	80-120		
Bromomethane	8.7		5.0	ug/L	10.0	ND	87	80-120		

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Rabecka Koons, Quality Assurance Officer

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Volatile Organics by EPA 624.1 (GC/MS) - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010385 - GCMS-WATER-VOLATILES

Matrix Spike (B010385-MS1)	Source: 0102830-01		Prepared & Analyzed: 10/29/20							
Carbon tetrachloride	7.7		5.0	ug/L	10.0	ND	77	80-120		
Chlorobenzene	7.4		5.0	ug/L	10.0	ND	74	80-120		
Chloroethane	11.5		5.0	ug/L	10.0	ND	115	80-120		
Chloroform	8.9		5.0	ug/L	10.0	ND	89	80-120		
Chloromethane	12.7		5.0	ug/L	10.0	ND	127	80-120		
Dibromochloromethane	5.1		5.0	ug/L	10.0	ND	51	80-120		
1,2-Dichlorobenzene	7.2		5.0	ug/L	10.0	ND	72	80-120		
1,3-Dichlorobenzene	7.2		5.0	ug/L	10.0	ND	72	80-120		
1,4-Dichlorobenzene	7.2		5.0	ug/L	10.0	ND	72	80-120		
1,1-Dichloroethane	9.8		5.0	ug/L	10.0	ND	98	80-120		
1,2-Dichloroethane	8.5		5.0	ug/L	10.0	ND	85	80-120		
1,1-Dichloroethene	8.2		5.0	ug/L	10.0	ND	82	80-120		
cis-1,2-Dichloroethene	8.2		5.0	ug/L	10.0	ND	82	80-120		
trans-1,2-Dichloroethene	8.8		5.0	ug/L	10.0	ND	88	80-120		
1,2-Dichloropropane	8.1		5.0	ug/L	10.0	ND	81	80-120		
cis-1,3-Dichloropropene	5.5		5.0	ug/L	10.0	ND	55	80-120		
trans-1,3-Dichloropropene	5.0	J	5.0	ug/L	10.0	ND	50	80-120		
Ethylbenzene	7.8		5.0	ug/L	10.0	ND	78	80-120		
Methyl tert-butyl ether (MTBE)	5.4		5.0	ug/L	10.0	ND	54	0-200		
Methylene chloride	9.5		5.0	ug/L	10.0	ND	95	80-120		
1,1,2,2-Tetrachloroethane	5.8		5.0	ug/L	10.0	ND	58	80-120		
Tetrachloroethene	3.3	J	5.0	ug/L	10.0	ND	33	80-120		
Toluene	7.7		5.0	ug/L	10.0	ND	77	80-120		
1,1,1-Trichloroethane	8.2		5.0	ug/L	10.0	ND	82	80-120		
1,1,2-Trichloroethane	6.0		5.0	ug/L	10.0	ND	60	80-120		
Trichloroethene	6.4		5.0	ug/L	10.0	ND	64	80-120		
Trichlorofluoromethane (Freon 11)	9.9		5.0	ug/L	10.0	ND	99	80-120		
Vinyl chloride	11.4		5.0	ug/L	10.0	ND	114	80-120		
o-Xylene	6.9		5.0	ug/L	10.0	ND	69	80-120		
m- & p-Xylenes	14.2		5.0	ug/L	20.0	ND	71	80-120		
Xylenes, Total	21.1		5.0	ug/L	30.0	ND	70	70-130		



Rabecka Koons, Quality Assurance Officer

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MD DW LabID 153

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Volatile Organics by EPA 624.1 (GC/MS) - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010385 - GCMS-WATER-VOLATILES

Matrix Spike (B010385-MS1)

Source: 0102830-01

Prepared & Analyzed: 10/29/20

Surrogate: 1,2-Dichloroethane-d4	58.1			ug/L	50.0		116	70-130		
Surrogate: Toluene-d8	51.6			ug/L	50.0		103	75-120		
Surrogate: 4-Bromofluorobenzene	50.8			ug/L	50.0		102	75-120		

Rabecka Koons

Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Total Metals Analysis by EPA 200.8 - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010375 - 3010A-Metals Digestion

Blank (B010375-BLK1)

Prepared: 10/28/20 Analyzed: 10/29/20

Arsenic	ND		1.00	ug/L						
Cadmium	ND		1.00	ug/L						
Copper	2.52	B	1.00	ug/L						
Lead	ND		1.00	ug/L						
Molybdenum	ND		1.00	ug/L						
Nickel	ND		1.00	ug/L						
Silver	ND		1.0	ug/L						
Zinc	ND		5.00	ug/L						

LCS (B010375-BS1)

Prepared: 10/28/20 Analyzed: 10/29/20

Arsenic	49.2		1.00	ug/L	50.0		98	80-120		
Cadmium	48.0		1.00	ug/L	50.0		96	80-120		
Copper	50.8	B	1.00	ug/L	50.0		102	80-120		
Lead	47.6		1.00	ug/L	50.0		95	80-120		
Molybdenum	47.4		1.00	ug/L	50.0		95	80-120		
Nickel	50.5		1.00	ug/L	50.0		101	80-120		
Silver	49.5		1.0	ug/L	50.0		99	80-120		
Zinc	98.1		5.00	ug/L	100		98	80-120		

Duplicate (B010375-DUP1)

Source: 0102714-01

Prepared: 10/28/20 Analyzed: 10/29/20

Arsenic	ND		1.00	ug/L		ND				20
Cadmium	ND		1.00	ug/L		ND				20
Copper	ND		1.00	ug/L		ND				20
Lead	ND		1.00	ug/L		ND				20
Molybdenum	ND		1.00	ug/L		ND				20
Nickel	5.52		1.00	ug/L		5.08			8	20
Silver	ND		1.0	ug/L		ND				20
Zinc	ND		5.00	ug/L		ND				20

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MD DW LabID 153

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Total Metals Analysis by EPA 200.8 - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B010375 - 3010A-Metals Digestion

Matrix Spike (B010375-MS1)	Source: 0102714-01		Prepared: 10/28/20		Analyzed: 10/29/20			
Arsenic	49.4		1.00	ug/L	50.0	ND	99	80-120
Cadmium	49.4		1.00	ug/L	50.0	ND	99	80-120
Copper	48.1	B	1.00	ug/L	50.0	ND	96	80-120
Lead	48.7		1.00	ug/L	50.0	ND	97	80-120
Molybdenum	47.8		1.00	ug/L	50.0	ND	96	80-120
Nickel	53.6		1.00	ug/L	50.0	5.08	97	80-120
Silver	49.7		1.0	ug/L	50.0	ND	99	80-120
Zinc	95.2		5.00	ug/L	100	ND	95	80-120



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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Total Metals by EPA 245.1 - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Batch B0K0002 - EPA 245.1/7470										
Blank (B0K0002-BLK1)					Prepared & Analyzed: 11/02/20					
Mercury	ND		0.0002	mg/L						
LCS (B0K0002-BS1)					Prepared & Analyzed: 11/02/20					
Mercury	0.0043		0.0002	mg/L	0.00400		107	85-115		
Duplicate (B0K0002-DUP1)					Source: 0102714-01		Prepared & Analyzed: 11/02/20			
Mercury	ND		0.0002	mg/L		ND				20
Matrix Spike (B0K0002-MS1)					Source: 0102714-01		Prepared & Analyzed: 11/02/20			
Mercury	0.0044		0.0002	mg/L	0.00400	ND	109	70-130		



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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Chemical Oxygen Demand by EPA 410.4 - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Batch B010373 - COD (03) Prep										
Blank (B010373-BLK1)					Prepared & Analyzed: 11/03/20					
COD	ND		3.0	mg/L						
LCS (B010373-BS1)					Prepared & Analyzed: 11/03/20					
COD	53.8		3.0	mg/L	50.0		108	90-110		
Duplicate (B010373-DUP1)					Source: 0102714-01 Prepared & Analyzed: 11/03/20					
COD	96.0		3.0	mg/L		97.1			1	20
Matrix Spike (B010373-MS1)					Source: 0102714-01 Prepared & Analyzed: 11/03/20					
COD	148		3.0	mg/L	50.0	97.1	102	90-110		



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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Total Suspended Solids by USGS I-3765-85 - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Batch B010381 - TSS PREP										
Blank (B010381-BLK1)										
					Prepared: 10/29/20 Analyzed: 10/30/20					
Solids, Suspended	ND		2.5	mg/L						
LCS (B010381-BS1)										
					Prepared: 10/29/20 Analyzed: 10/30/20					
Solids, Suspended	51.2		2.5	mg/L	57.6		89	70-130		
Duplicate (B010381-DUP1)										
			Source: 0102830-01			Prepared: 10/29/20 Analyzed: 10/30/20				
Solids, Suspended	72.8		8.6	mg/L		79.2			8	20

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Total Dissolved Solids by SM 2540C - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Batch B011024 - TDS Prep										
Blank (B011024-BLK1)					Prepared: 11/02/20 Analyzed: 11/03/20					
Solids, Dissolved	ND		10.0	mg/L						
LCS (B011024-BS1)					Prepared: 11/02/20 Analyzed: 11/03/20					
Solids, Dissolved	445	S-98	10.0	mg/L	713		62	90-110		
Duplicate (B011024-DUP1)			Source: 0102714-01			Prepared: 11/02/20 Analyzed: 11/03/20				
Solids, Dissolved	1280		10.0	mg/L		1280			0.3	20



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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Wet Chemistry - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Batch B0J0211 - No Prep WC										
Blank (B0J0211-BLK1)					Prepared & Analyzed: 10/30/20					
Phosphorus, P	ND		0.05	mg/L						
LCS (B0J0211-BS1)					Prepared & Analyzed: 10/30/20					
Phosphorus, P	0.39		0.05	mg/L	0.400		98.4	90-110		
Duplicate (B0J0211-DUP1)					Source: 0102714-01		Prepared & Analyzed: 10/30/20			
Phosphorus, P	0.20		0.05	mg/L		0.21			2.65	20
Matrix Spike (B0J0211-MS1)					Source: 0102714-01		Prepared & Analyzed: 10/30/20			
Phosphorus, P	0.60		0.05	mg/L	0.400	0.21	96.7	90-110		
Batch B0J0212 - No Prep WC										
Blank (B0J0212-BLK1)					Prepared & Analyzed: 10/30/20					
Ammonia Nitrogen	ND		0.10	mg/L						
LCS (B0J0212-BS1)					Prepared & Analyzed: 10/30/20					
Ammonia Nitrogen	1.97		0.10	mg/L	1.99		98.9	90-110		
Duplicate (B0J0212-DUP1)					Source: E064989-01		Prepared & Analyzed: 10/30/20			
Ammonia Nitrogen	0.07		0.10	mg/L		0.09			25.7	20
Matrix Spike (B0J0212-MS1)					Source: E064989-01		Prepared & Analyzed: 10/30/20			
Ammonia Nitrogen	1.95		0.10	mg/L	1.99	0.09	93.1	90-110		

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MD DW LabID 153

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Biochemical Oxygen Demand SM 5210B - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch B0J0192 - No Prep WC

Blank (B0J0192-BLK1)

Prepared: 10/28/20 Analyzed: 11/02/20

BOD, 5 Day	ND		2.0	mg/L						
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LCS (B0J0192-BS1)

Prepared: 10/28/20 Analyzed: 11/02/20

BOD, 5 Day	197		2.0	mg/L	198		99.3	85-115		
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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Cyanide ASTM D7511-12 - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Batch B0J0201 - No Prep WC										
Blank (B0J0201-BLK1)					Prepared & Analyzed: 10/29/20					
Cyanide, Total	ND		0.010	mg/L						
LCS (B0J0201-BS1)					Prepared & Analyzed: 10/29/20					
Cyanide, Total	0.103		0.010	mg/L	0.100		103	85-115		
Duplicate (B0J0201-DUP1)					Source: 0102714-01 Prepared & Analyzed: 10/29/20					
Cyanide, Total	ND		0.010	mg/L		ND				20
Matrix Spike (B0J0201-MS1)					Source: 0102714-01 Prepared & Analyzed: 10/29/20					
Cyanide, Total	0.116		0.010	mg/L	0.100	ND	116	85-115		

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MD DW LabID 153

Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

EPA 1664A - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
Batch 421141 - EPA 1664A										
BLANK (2035887)					Prepared & Analyzed: 11/03/20					421141-1
Total Petroleum Hydrocarbons	<0.95		4.8	mg/L				-		
LCS (2035888)					Prepared & Analyzed: 11/03/20					421141-1
Total Petroleum Hydrocarbons	115%		4.8	mg/L	20		115	64-132		
LCSD (2035889)					Prepared & Analyzed: 11/03/20					421141-1
Total Petroleum Hydrocarbons	118%		4.8	mg/L	20		118	64-132	3	34



Rabecka Koons, Quality Assurance Officer

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

EPA 608.3 Dec 2016 - Quality Control

Analyte	Result	Notes	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit
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Batch 421245 - EPA 608.3 Dec 2016

BLANK (2035766)

Prepared: 11/02/20 Analyzed: 11/03/20

PCB-1248 (Aroclor 1248)	<0.094		0.25	ug/L				-		
PCB-1254 (Aroclor 1254)	<0.045		0.25	ug/L				-		
PCB-1242 (Aroclor 1242)	<0.11		0.25	ug/L				-		
PCB-1232 (Aroclor 1232)	<0.073		0.25	ug/L				-		
PCB-1221 (Aroclor 1221)	<0.17		0.25	ug/L				-		
PCB-1016 (Aroclor 1016)	<0.14		0.25	ug/L				-		
PCB-1260 (Aroclor 1260)	<0.025		0.25	ug/L				-		
Surrogate: Tetrachloro-m-xylene (S)	0.00029			ug/L	0.0005		58	16-117		
Surrogate: Decachlorobiphenyl (S)	0.00023			ug/L	0.0005		46	10-146		

LCS (2035767)

Prepared: 11/02/20 Analyzed: 11/03/20

PCB-1260 (Aroclor 1260)	55%		0.25	ug/L	2.5		55	37-130		
PCB-1016 (Aroclor 1016)	58%	L2	0.25	ug/L	2.5		58	61-103		
Surrogate: Tetrachloro-m-xylene (S)	0.00029			ug/L	0.0005		58	16-117		
Surrogate: Decachlorobiphenyl (S)	0.00018			ug/L	0.0005		35	10-146		

Rabecka Koons

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Project: GUDE LANDFILL

Project Number: 1556404
Project Manager: Laura Oakes

Reported:
11/06/20 16:02

Notes and Definitions

- S-98 Spike recovery outside of established control limits.
- P2 Re-extraction or re-analysis could not be performed due to insufficient sample amount.
- L2 Analyte recovery in the laboratory control sample (LCS) was below QC limits. Results for this analyte in associated samples may be biased low.
- J Detected but below the reporting limit; therefore, result is an estimated concentration (CLP J-Flag).
- I Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.
- B Analyte is found in the associated blank as well as in the sample (CLP B-flag).
- 421141-1 Due to insufficient volume for MS and MSD, LCS and LCSD were ran as QC for this batch.
- 3c pH adjusted to <2 in lab at bench prior to analysis.
- 2c Due to insufficient volume for MS and MSD, LCS and LCSD were ran as QC for this batch.
- 1c A matrix spike/matrix spike duplicate was not performed for this batch due to insufficient sample volume.
- DET Analyte DETECTED
- ND Analyte NOT DETECTED at or above the reporting limit
- NR Not Reported
- dry Sample results reported on a dry weight basis
- RPD Relative Percent Difference
- %-Solids Percent Solids is a supportive test and as such does not require accreditation



Rabecka Koons, Quality Assurance Officer

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CHAIN-OF-CUSTODY RECORD

Company Name:
EA Engineering

Project Manager:
Laura Oakes

Project ID:
1556404

P.O. Number:

Sampler(s):
M Thornton

Maryland Spectral Services, Inc.
1500 Caton Center Drive, Suite G
Baltimore, MD 21227
410-247-7600 • Fax 410-247-7602
reporting@mdspectral.com

Matrix Codes: NW (non-potable water) PW (potable water)

Field Sample ID	Date	Time	No. of Containers			Analysis Requested										MSS Lab ID			
			Water	Soil	Other	PCB, low level by EPA 608	Total Petroleum Hydrocarbon, TPH by 1664	Silver, Arsenic, Cadmium, Copper, Molybdenum, Nickel, Lead & Zinc by Method 200.8	Mercury by 245.1	Oil and Grease (HEM) by EPA 1664	Total Suspended Solids by USGS 1-3765-85	VOCs by EPA 624.1	BOD5 by SM6210 B	COD by EPA 410.4	Total Cyanide by D7511-12		Total Dissolved Solids by SM2540C	pH, Ammonia-N (350.1), Total Phosphorus (365.3)	Preservative: 1+1 HCl, H ₂ SO ₄ , Methanol, Na ₂ S ₂ O ₃ , NaHCO ₃	Field pH, Residual Chlorine, OC Request, Trip Blank, Field Blank
DS-0	10/27/20	0925	X			X	X	X	X	X	X	X	X	X	X	X	X	X	0102714-01
DS-1	10/27/20	1035	X			X	X	X	X	X	X	X	X	X	X	X	X	X	-02
DS-3	10/27/20	1135	X			X	X	X	X	X	X	X	X	X	X	X	X	X	-03
DS-4	10/27/20	1225	X			X	X	X	X	X	X	X	X	X	X	X	X	X	-04
DS-5	10/27/20	1330	X			X	X	X	X	X	X	X	X	X	X	X	X	X	-05

Relinquished by: (Signature) (Printed) Michael Thornton	Date/Time	10/27/20	1445	Received by: (Signature)	Received by: (Signature)	Date/Time	10/27/20	14:51	Relinquished by: (Signature)	Received by: (Signature)
	Relinquished by: (Signature) (Printed)	Date/Time 10/27/20 14:51	Received by: (Signature) (Printed) Rachel Horner	Received by: (Signature) (Printed)	Received by: (Signature) (Printed)	Date/Time 10/27/20 14:51	Lab Use: Temp: 18.3 °C <input type="checkbox"/> Received on Ice <input type="checkbox"/> Received same day <input type="checkbox"/> Preservation Appropriate	Turn Around Time: <input checked="" type="checkbox"/> Normal (7 day) <input type="checkbox"/> 5 day <input type="checkbox"/> 4 day <input type="checkbox"/> 3 day <input type="checkbox"/> Rush (2 day) <input type="checkbox"/> Next Day <input type="checkbox"/> Other: _____ <input type="checkbox"/> Specific Due Date: _____	Sample Disposal: <input type="checkbox"/> Return to Client <input checked="" type="checkbox"/> Disposal by lab <input type="checkbox"/> Archive for _____ days	

Delivery Method:
 Courier
 Client
 UPS
 FedEx
 USPS
 Other: _____

Special Instructions/QC Requirements & Comments:

SUBCONTRACT ORDER
Maryland Spectral Services

0102714

SENDING LABORATORY:

Maryland Spectral Services
1500 Caton Center Dr. Suite G
Halethorpe, MD 21227
Phone: 410.247.7600
Project Manager: Cory Koons
Reports Email: Reporting@mdspectral.com

RECEIVING LABORATORY:

Pace Labs-PA
1638 Roseytown Rd
Greensburg, PA 15601
Phone :(724) 850-5600
Fax:

WO#: 30389810



30389810

Due 4:00 PM 11/05/20

Laboratory ID Comments

Sample ID: 0102714-01 DS-0 Water Sampled: 10/27/20 09:25

1664 (O&G-HEM) 1664 TPH (SGT-HEM) 608LL (PCB)

Containers Supplied:

Amber Glass, 1L (G) Amber Glass, 1L
HCl/H2SO4 (H) HCl/H2SO4 (I)

001

Sample ID: 0102714-02 DS-1 Water Sampled: 10/27/20 10:35

1664 (O&G-HEM) 1664 TPH (SGT-HEM) 608LL (PCB)

Containers Supplied:

Amber Glass, 1L (G) Amber Glass, 1L
HCl/H2SO4 (H) HCl/H2SO4 (I)

002

Sample ID: 0102714-03 DS-3 Water Sampled: 10/27/20 11:35

1664 (O&G-HEM) 1664 TPH (SGT-HEM) 608LL (PCB)

Containers Supplied:

Amber Glass, 1L (G) Amber Glass, 1L
HCl/H2SO4 (H) HCl/H2SO4 (I)

003

Received By: *[Signature]* Date: 10/28/20 16:02
 Received By: *[Signature]* Date: 10/28/20 18:30
 Received By: *[Signature]* Date: 10/28/20 19:45
 Received By: *[Signature]* Date: 10/28/20 22:15
 Received By: *[Signature]* Date: 10/28/20 22:15

SUBCONTRACT ORDER
Maryland Spectral Services

30389810

0102714

Due 4:00 PM 11/05/20

Laboratory ID

Comments

004

Sampled: 10/27/20 12:25

Water

DS-4

Sample ID: 0102714-04

608LL (PCB)

1664 TPH (SGT-HEM)

Containers Supplied:

Amber Glass, 1L
HCl/H2SO4 (H)

Amber Glass, 1L
HCl/H2SO4 (I)

005

Sampled: 10/27/20 12:25

Water

DS-5

Sample ID: 0102714-05

608LL (PCB)

1664 TPH (SGT-HEM)

Containers Supplied:

Amber Glass, 1L
HCl/H2SO4 (H)

Amber Glass, 1L
HCl/H2SO4 (I)

16:02
10/28/20
16:02
10/28/20

Received By: [Signature] Date: 10/28/20
Received By: RDS ACE Date: 10/28/20 1845

10/28/20 1830
10/28/20 2215
10/28/20 2215
10/28/20 2215

Received By: [Signature] Date: 10/28/20
Received By: RDS ACE Date: 10/28/20 1845

10/28/20 2215
10/28/20 2215
10/28/20 2215

SUBCONTRACT ORDER
Maryland Spectral Services

0102714

64914

SENDING LABORATORY:

Maryland Spectral Services
1500 Caton Center Dr. Suite G
Halethorpe, MD 21227
Phone: 410.247.7600
Project Manager: Cory Koons

RECEIVING LABORATORY:

Enviro-Chem Laboratories, Inc
47 Loveton Circle, Suite K
Sparks, MD 21152
Phone :(410) 472-1112
Fax: (410) 472-1116

Auto-log Sent
Date: 10/28/20
RH

Reports Email: Reporting@mdspectral.com

Due 4:00 PM 11/05/20

Laboratory ID Comments

Sample ID: 0102714-01 DS-0 Water Sampled: 10/27/20 09:25

245.1W-Hg	BOD	Cyanide (Total)	Nitrogen, Ammonia
Phosphorus (T) (0.5)			

Containers Supplied:

Plastic, 0.125L NaOH (J) Plastic, 0.25L HNO3 (K) Plastic, 0.25L H2SO4 (L) Plastic, 0.5L None (M)

Sample ID: 0102714-02 DS-1 Water Sampled: 10/27/20 10:35

245.1W-Hg	BOD	Cyanide (Total)	Nitrogen, Ammonia
Phosphorus (T) (0.5)			

Containers Supplied:



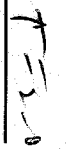
Plastic, 0.125L NaOH (J) Plastic, 0.25L HNO3 (K) Plastic, 0.25L H2SO4 (L) Plastic, 0.5L None (M)

Sample ID: 0102714-03 DS-3 Water Sampled: 10/27/20 11:35

245.1W-Hg	BOD	Cyanide (Total)	Nitrogen, Ammonia
Phosphorus (T) (0.5)			

Containers Supplied:

Plastic, 0.125L NaOH (J) Plastic, 0.25L HNO3 (K) Plastic, 0.25L H2SO4 (L) Plastic, 0.5L None (M)

Released By:  Date: 10/28/20 9:14
 Received By:  Date: 10/28/20 9:14
 Received By:  Date: 10/28/20 9:14

Released By _____ Date _____ Received By _____ Date _____

SUBCONTRACT ORDER
Maryland Spectral Services

0102714

64966

Due 4:00 PM 11/05/20

Laboratory ID

Comments

Sample ID: 0102714-04 DS-4

Water Sampled: 10/27/20 12:25

245.1W-Hg

BOD

Cyanide (Total)

Nitrogen, Ammonia

Phosphorus (T) (0.5)

Containers Supplied:

Plastic, 0.125L NaOH (J) Plastic, 0.25L HNO3 (K) Plastic, 0.25L H2SO4 (L) Plastic, 0.5L None (M)

Sample ID: 0102714-05 DS-5

Water Sampled: 10/27/20 12:25

245.1W-Hg

BOD

Cyanide (Total)

Nitrogen, Ammonia

Phosphorus (T) (0.5)

Containers Supplied:

Plastic, 0.125L NaOH Plastic, 0.25L HNO3 (N) Plastic, 0.25L H2SO4 (O) Plastic, 0.5L None (P) (M)

9:14

[Signature]

Date 10/28/20

Received By *[Signature]* 914 10/28/20

Date T=2.0

Released By _____ Date _____

Received By _____ Date _____



EA Engineering, Science,
and Technology, Inc.

WELL PURGING AND SAMPLING RECORD

WELL ID DS-0 SAMPLE ID. DS-0

WELL/SITE DESCRIPTION Gude Landfill

SAMPLING PERSONNEL M Thornton

DATE 10/27/20 TIME 0850 WEATHER 55° Cloudy

WELL DEPTH 15.70 ft bgs CASING HEIGHT 2 ft
 WATER DEPTH 3.95 ft WELL DIAMETER 24 in
 SCREEN INTERVAL - ft bgs PUMP DEPTH 12 ft
 PUMP START TIME 0850 min PUMP END TIME 0920 min
 PUMP RATE 0.5 LPM
 SAMPLING METHOD Low-flow SAMPLING TIME 0925

Date	Time	Volume Removed	pH	Cond.	Temp.	ORP	Turb.	DO	Depth to Water from TOC	Pump Rate
		Unit: Gal L	--	µS/cm ^c	°C	mV	NTU	mg/L		LPM
10/27/20	0850	-	6.49	1997	16.4	-71.8	38.5	2.21	3.95	0.5
	0855	2.5	6.50	1967	16.2	-40.5	35.8	1.94	3.95	
	0900	5	6.50	1956	16.1	-35.7	36.1	1.76	3.95	
	0905	7.5	6.45	2236	17.6	-52.4	33.3	1.04	3.95	
	0910	10	6.46	2281	17.8	-58.4	32.5	0.79	3.95	
	0915	12.5	6.47	2309	17.9	-61.0	33.1	0.80	3.95	
	0920	15	6.46	2341	17.9	-63.0	31.5	0.79	3.95	

METHANE READING (GEM) 0.1

COMMENTS _____

SIGNATURE



WELL PURGING AND SAMPLING RECORD

WELL ID DS-1 SAMPLE ID. DS-1
 WELL/SITE DESCRIPTION Gude Landfill
 SAMPLING PERSONNEL M Thornton

DATE 10/27/20 TIME 1010 WEATHER 60° Cloudy

WELL DEPTH 40 ft bgs CASING HEIGHT 3 ft
 WATER DEPTH 20.20 ft WELL DIAMETER 6 in
 SCREEN INTERVAL - ft bgs PUMP DEPTH 35 ft
 PUMP START TIME 1010 min PUMP END TIME 1030 min
 PUMP RATE 0.5 LPM
 SAMPLING METHOD Low-flow SAMPLING TIME 1035

Date	Time	Volume Removed	pH	Cond. μS/cm ^c	Temp. °C	ORP mV	Turb. NTU	DO mg/L	Depth to Water from TOC	Pump Rate
		Unit: Gal								LPM
10/27/20	1010	-	6.45	2289	18.2	-58.5	8.6	1.61	20.20	0.5
	1015	2.5	6.42	2345	19.3	-77.1	4.3	0.69	20.22	
	1020	5	6.41	2346	19.4	-81.2	4.0	0.66	20.22	
	1025	7.5	6.41	2350	19.4	-86.0	3.2	0.63	20.22	
	1030	10	6.41	2347	19.4	-87.7	3.3	0.63	20.22	

METHANE READING (GEM) 0.1

COMMENTS _____

SIGNATURE



EA Engineering, Science,
and Technology, Inc.

WELL PURGING AND SAMPLING RECORD

WELL ID DS-3 SAMPLE ID. DS-3

WELL/SITE DESCRIPTION Gude Landfill

SAMPLING PERSONNEL M Thornton

DATE 10/27/20 TIME 1105 WEATHER 60° Cloudy

WELL DEPTH <u>44</u> ft bgs	CASING HEIGHT <u>3</u> ft
WATER DEPTH <u>11.30</u> ft	WELL DIAMETER <u>12</u> in
SCREEN INTERVAL <u>-</u> ft bgs	PUMP DEPTH <u>40</u> ft
PUMP START TIME <u>1105</u> min	PUMP END TIME <u>1130</u> min
PUMP RATE <u>0.5</u> LPM	
SAMPLING METHOD <u>Low-flow</u>	SAMPLING TIME <u>1135</u>

Date	Time	Volume Removed	pH	Cond. μS/cm ²	Temp. °C	ORP mV	Turb. NTU	DO mg/L	Depth to Water from TOC	Pump Rate
		Unit: Gal L								LPM
10/27/20	1105	-	6.55	2671	17.9	-66.4	3.0	1.81	11.30	0.5
	1110	2.5	6.56	2672	17.8	-63.1	3.2	1.40	11.32	
	1115	5	6.56	2674	17.8	-60.5	3.3	1.09	11.32	
	1120	7.5	6.52	2708	18.4	-77.9	2.5	0.76	11.32	
	1125	10	6.52	2715	18.5	-86.0	2.1	0.67	11.32	
	1130	12.5	6.52	2717	18.5	-90.6	2.1	0.64	11.32	

METHANE READING (GEM) 0.1

COMMENTS _____

SIGNATURE



WELL PURGING AND SAMPLING RECORD

WELL ID DS-4 SAMPLE ID. DS-4
 WELL/SITE DESCRIPTION Gude Landfill
 SAMPLING PERSONNEL M Thornton


DATE 10 / 27 / 20 TIME 1200 WEATHER 65° Cloudy

WELL DEPTH 45 ft bgs CASING HEIGHT 1 ft
 WATER DEPTH 14.95 ft WELL DIAMETER 12 in
 SCREEN INTERVAL - ft bgs PUMP DEPTH 40 ft
 PUMP START TIME 1200 min PUMP END TIME 1220 min
 PUMP RATE 0.5 LPM
 SAMPLING METHOD Low-flow SAMPLING TIME 1225

Date	Time	Volume Removed	pH	Cond.	Temp.	ORP	Turb.	DO	Depth to Water from TOC	Pump Rate
		Unit: Gal L	--	µS/cm ²	°C	mV	NTU	mg/L		LPM
10/27/20	1200	-	6.53	2593	18.7	-49.8	7.9	2.21	14.95	0.5
	1205	2.5	6.47	2629	19.3	-68.1	17.4	0.70	14.97	
	1210	5	6.47	2629	19.3	-72.9	10.1	0.66	14.97	
	1215	7.5	6.47	2629	19.4	-78.6	7.5	0.63	14.97	
	1220	10	6.47	2629	19.3	-80.3	3.2	0.62	14.97	

METHANE READING (GEM) 0.1

COMMENTS _____

SIGNATURE 



EA Engineering, Science,
and Technology, Inc.

WELL PURGING AND SAMPLING RECORD

WELL ID DS-5 SAMPLE ID. DS-5

WELL/SITE DESCRIPTION Gude Landfill

SAMPLING PERSONNEL M Thornton

DATE 10 / 27 / 20 TIME 1255 WEATHER 65° Cloudy

WELL DEPTH <u>46</u> ft bgs	CASING HEIGHT <u>2</u> ft
WATER DEPTH <u>10.00</u> ft	WELL DIAMETER <u>12</u> in
SCREEN INTERVAL <u>-</u> ft bgs	PUMP DEPTH <u>41</u> ft
PUMP START TIME <u>1255</u> min	PUMP END TIME <u>1325</u> min
PUMP RATE <u>0.5</u> LPM	
SAMPLING METHOD <u>Low-flow</u>	SAMPLING TIME <u>1330</u>

Date	Time	Volume Removed	pH	Cond.	Temp.	ORP	Turb.	DO	Depth to Water	Pump Rate
		Unit: <u>Gal</u>	--	$\mu\text{S}/\text{cm}^\circ$	$^\circ\text{C}$	mV	NTU	mg/L	from TOC	LPM
10/27/20	1255	-	6.51	2934	17.8	-52.8	25.1	1.57	10.00	0.5
	1300	2.5	6.51	2932	17.8	-48.0	23.3	1.15	10.02	
	1305	5	6.52	2930	17.7	-45.1	30.1	1.01	10.02	
	1310	7.5	6.52	2928	17.7	-43.2	31.6	0.93	10.02	
	1315	10	6.48	2954	18.0	-57.0	21.5	0.78	10.02	
	1320	12.5	6.48	2960	18.1	-60.0	19.9	0.73	10.02	
	1325	15	6.48	2965	18.1	-63.4	18.0	0.70	10.02	

METHANE READING (GEM) 0.1

COMMENTS Collect additional volume for QC.

SIGNATURE

Attachment H
Permit Compliance Report

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Gude Landfill Remediation Design Permitting Compliance Report Montgomery County, Maryland

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

December 2020
EA Project No. 15646.01

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Gude Landfill Remediation Design Permitting Compliance Report Montgomery County, Maryland

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

December 2020
EA Project No. 15646.01

Recycled Paper

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APPENDIX A: WRITTEN DOCUMENTATION AND CORRESPONDENCE RECORDS

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LIST OF ACRONYMS AND ABBREVIATIONS

14GP	2014 General Permit for Stormwater Associated with Construction Activity
ACM the Authority	Assessment of Corrective Measures Northeast Maryland Waste Disposal Authority
CFR	Code of Federal Regulations
COMAR	Code of Maryland Regulations
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DPS	Department of Permitting Services
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
MDE	Maryland Department of the Environment
NOI	Notice of Intent
the Remediation Design	Gude Landfill Remediation Project for Montgomery County, Maryland

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1. INTRODUCTION

This Permitting Compliance Report was prepared for the Engineering, Procurement, Preparation, And Support Services for the Gude Landfill (the Landfill) Remediation Project for Montgomery County, Maryland (the Remediation Design), under the Northeast Maryland Waste Disposal Authority (the Authority) and the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County).

The Landfill Remediation Design is for the recommended Corrective Measure Alternative, Toupee Capping and Additional Landfill Gas Collection, as approved by the Maryland Department of the Environment (MDE) on July 8, 2016.

1.1 PURPOSE

The purpose of this Permitting Compliance Report is to present the permits and approvals that are required for the project, the reviewing agencies for each permit, and a description of the permit application process with anticipated timelines. The required permits and approvals for the Remediation Design include:

- Maryland-National Capital Park and Planning Commission (M-NCPPC) Mandatory Referral,
- Montgomery County Department of Permitting Services (DPS) Sediment Control Permit, Floodplain Study Approval, Floodplain District Permit, and Stormwater Management Approval,
- MDE Solid Waste Program Approval, and
- 2014 General Permit for Stormwater Associated with Construction Activity (14GP).

Each of these permits or approvals is discussed in a separate section of this report. **Appendix A** provides the detailed written documentation and records for correspondence with all applicable federal, state, and local permitting agencies.

2. MARYLAND-NATIONAL CAPITAL PARK AND PLANNING COMMISSION MANDATORY REFERRAL

According to State law (Maryland LAND USE Code Ann. § 20-301 through 305), all federal, state, and local governments and public utilities are required to submit proposed projects involving construction of or impacts to any road, park, public ground, public building, or public utility in Montgomery County for a Mandatory Referral review by the Montgomery County Planning Board. The Mandatory Referral review process includes the following:

I. Preapplication Submission

- Determination of Type of Review
 - Determine if project is eligible for Mandatory Referral:
 - Exempt from Mandatory Referral Process
 - Subject to the Entitlement Process Instead of Mandatory Referral
 - Move Forward as a Mandatory Referral
 - If eligible for Mandatory Referral, determine what type of review is required:
 - Administrative Review by staff for minor projects
 - Full Planning Board Review
- Hold Pre-request Meeting
- Determine Submission Requirements

II. Public Hearing Notification

III. Planning Board Consideration and Recommendation

Table 1 summarizes the reviewing agencies, permit application process, and anticipated timeline for the M-NCPPC Mandatory Referral.

Table 1 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Maryland-National Capital Park and Planning Commission (M-NCPPC) Mandatory Referral

Reviewing Agencies	Permit Application Process	Anticipated Timeline ^(a)
Maryland-National Capital Park and Planning Commission	Pre-submission meeting	1 day
	Draft application	30 days
	Authority/County review	15 days
	Final application and submittal to M-NCPPC	15 days
	M-NCPPC review	30 days
	Public Notice Period	45 days
	Planning Board Hearing	1 day
	Anticipated Total Duration	137 days
(a) Timeline is presented in working days (Monday – Friday).		

3. MONTGOMERY COUNTY DEPARTMENT OF PERMITTING SERVICES

Permitting for sediment control and stormwater management is required per Montgomery County Code Chapter 19 because land-disturbance for this project will exceed five thousand (5,000) square feet and one hundred (100) cubic yards. The existing drainage area to the eastern side of the site is approximately 96 acres and the proposed drainage area will be approximately 99 acres. A Floodplain Study Approval and Floodplain District Permit are required because drainage area is over 30 acres.

This will require an Engineered Plan Sediment Control Permit application, including a Stormwater Management Concept, Erosion and Sediment Control Plan with Stormwater Management design (plans and computations). The plans will be prepared and certified by a Professional Engineer.

The plans will be prepared in accordance with the 2011 Standards and Specifications for Soil Erosion and Sediment Control, the 2000 Maryland Stormwater Design Manual, and any other County DPS requirements.

A pre-application meeting will be held with DPS prior to submitting any applications to ensure all requirements are being met.

Table 2 summarizes the reviewing agencies, permit application process, and anticipated timeline for the DPS Design Permit.

Table 2 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Montgomery County Department of Permitting Services (DPS)

Reviewing Agencies	Permit Application Process	Anticipated Timeline ^(a)
Montgomery County Department of Permitting Services	60% Design Draft Permit Application (to start during 60% Design)	10 days
	Authority/County Review	5 days
	60% Final Permit Application to DPS	5 days
	DPS Review	15 days
	Draft Responses to DPS Comments (after receiving comments on 60% Design from Authority/County)	15 days
	Authority/County Review	5 days
	Final Responses to DPS Comments	5 days
	90% Design Draft Permit Application (to start during 90% Design)	10 days
	Authority/County Review	5 days
	90% Final Permit Application to DPS	5 days
	DPS Review	15 days
	Draft Responses to DPS Comments (after receiving comments on 90% Design from Authority/County)	15 days
	Authority/County Review	5 days
	Final Responses to DPS Comments	5 days
	100% Draft Permit Application (to start during 100% Design)	10 days
	Authority/County Review	5 days
	100% Final Permit Application to DPS	5 days
	DPS Backcheck and Approval	20 days
	Anticipated Total Duration	160 days

Table 2 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Montgomery County Department of Permitting Services (DPS)

Reviewing Agencies	Permit Application Process	Anticipated Timeline ^(a)
(a) Timeline is presented in working days (Monday – Friday).		

**4. MARYLAND DEPARTMENT OF THE ENVIRONMENT
LAND ADMINISTRATION SOLID WASTE PROGRAM**

MDE Land Administration Solid Waste Program approval will be required. A Consent Order, MDE Case No. CO-11-SW-036, was executed in 2013 between MDE and the County, which ordered the County to implement the MDE-approved corrective measures for the Landfill, per the approved Revised Assessment of Corrective Measures (ACM) Report incorporated by reference into the Consent Order. The Revised ACM was approved per MDE's letter dated July 8, 2016, including the recommended corrective measure of Toupee Capping and Additional Landfill Gas Collection.

Table 3 summarizes the reviewing agencies, permit application process, and anticipated timeline for the MDE Solid Waste Program approval. Documents will be reviewed by MDE for compliance with the Code of Maryland Regulations (COMAR) 26.04.07.21 Sanitary Landfill – Closure and COMAR 26.04.07.22 Sanitary Landfills –Post Closure Monitoring and Maintenance.

**Table 3 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Maryland Department of the Environment (MDE)
Land Administration Solid Waste Program**

Reviewing Agencies	Permit Application Process	Anticipated Timeline ^(a)
Maryland Department of the Environment	90% Design Submission to MDE	45 days
	MDE Review	15 days
	Draft Responses to MDE Comments	15 days
	Authority/County Review of Draft Responses to MDE Comments	5 days
	Final Responses to MDE Comments	5 days
	100% Design Submission to MDE	20 days
	MDE Backcheck and Approval	20 days
	Anticipated Total Duration	125 days
(a) Timeline is presented in working days (Monday – Friday).		

5. NOTICE OF INTENT FOR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT 2014 GENERAL PERMIT FOR STORMWATER

This project will require coverage under the General Permit for Stormwater Associated with Construction Activity (14GP) issued by MDE because the project will disturb more than one (1) acre of land. To obtain coverage under the permit, a Notice of Intent (NOI) will be filed.

Table 4 summarizes the reviewing agencies, permit application process, and anticipated timeline for the NOI for the MDE 14GP.

Table 4 Reviewing Agencies, Permit Application Process, and Anticipated Timeline for the Notice of Intent (NOI) for the Maryland Department of the Environment (MDE) 2014 General Permit for Stormwater

Reviewing Agencies	Permit Application Process	Anticipated Timeline ^(a)
Maryland Department of the Environment	Draft NOI	10 days
	Authority/County Review	10 days
	Final NOI Submission to MDE	2 days
	Public Notification Period	10 days
	MDE Approval	10 days
	Anticipated Total Duration	42 days
(a) Timeline is presented in working days (Monday – Friday).		

Appendix A

Written Documentation and Correspondence Records

[To Be Included Upon Permitting Completion]

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Attachment I
Settlement Analysis

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HISTORICAL SETTLEMENT

ID	ELEVATION (SURVEY DATE)				SETTLEMENT RATE (IN/YR)				Current Settlement Percentage of Historical Settlement	Notes
	6/24/2009	4/28/2015	4/16/2018	10/6/2020	2009-2018	2009-2015	2015-2018	2018-2020		
SM-01	462	457.8	456.42	455.00	7.6	8.6	5.6	6.9	91%	
SM-02	460.56	458.01	456.97	456.81	4.9	5.2	4.2	0.8	16%	
SM-03	462	458.64	458.04	457.39	5.4	6.9	2.4	3.1	58%	
SM-04	458.21	454.63	453.26	452.70	6.7	7.4	5.5	2.7	40%	
SM-05	464	461.53	460.8	460.35	4.4	5.1	3.0	2.2	50%	
SM-06	464.38	458.76	456.41	455.35	10.9	11.5	9.5	5.1	47%	
SM-07	468	461.88	460.86	460.10	9.7	12.6	4.1	3.7	38%	
SM-08	465.16	461.92	460.67	460.17	6.1	6.7	5.1	2.5	40%	
SM-09	445.87	442.52	442.03	441.17	5.2	6.9	2.0	4.2	80%	
SM-10	450.59	447.36	447.46	446.82	4.3	6.6	-0.4	3.1	73%	
SM-11	447.86	443.63	443.12	442.92	6.5	8.7	2.1	1.0	15%	
SM-12	451.55	448.4	448.25	447.93	4.5	6.5	0.6	1.6	35%	
SM-13	473.22	470.52	469.9	469.40	4.5	5.5	2.5	2.4	54%	
SM-14	460.86	458.16	457.23	457.06	4.9	5.5	3.8	0.8	16%	
SM-15	444.67	442.17	441.57	456.02	4.2	5.1	2.4	-70.1	Purple Line Stockpile	
SM-16	459.28	456.56	455.84	458.21	4.7	5.6	2.9	-11.5	Purple Line Stockpile	
SM-17	417.14	413.1	413.28	412.95	5.3	8.3	-0.7	1.6	30%	
								average	45%	
								maximum	91%	



SETTLEMENT MONITORING POINT TABLE				
POINT NO.	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	524672.22	1271839.76	0.00	SM-01
2	524720.26	1272234.14	0.00	SM-02
3	524986.01	1272112.69	0.00	SM-03
4	525072.69	1271941.31	0.00	SM-04
5	525127.09	1272551.66	0.00	SM-05
6	524674.33	1272781.70	0.00	SM-06
7	525907.48	1272804.30	0.00	SM-07
8	525369.24	1272721.64	0.00	SM-08
9	525163.45	1273303.39	0.00	SM-09
10	524546.41	1273098.95	0.00	SM-10
11	524518.24	1273393.34	0.00	SM-11
12	525122.82	1273623.77	0.00	SM-12
13	525341.02	1273627.28	0.00	SM-13
14	525104.08	1274137.38	0.00	SM-14
15	524935.46	1274369.71	0.00	SM-15
16	524934.29	1274746.57	0.00	SM-16
17	524453.14	1274279.12	0.00	SM-17

FILE PATH: G:\PROJECTS\164661 - GDEE - FUNDAMENTAL DESIGN\164661 - SETTLEMENT ANALYSIS 2015-2016 - 02.DWG (P1) (TUL) - 08/10/2016 10:48:30 AM





Project Gude Landfill Remediation Project No. 1564601
Subject Differential Settlement Analysis Sheet No. 1 of 5
Drawing No. _____
Computed by MJG Date 11/24/20 Checked by GAT Date 12/10/20

OBJECTIVE:

Estimate the potential differential settlement of the landfill cap along Swale 8 (as defined on the drawings) to determine the final cap geometry and identify potential drainage problems.

PROCEDURE:

1) Determine critical points along the cross-section where settlement should be calculated to locate the post-settlement cap slopes. Several key factors will affect the differential settlement of the cap and were used to select critical points: variation in fill thickness/loading, variation in the landfill material properties, and variation in stress history of the landfill material.

Variation in fill thickness/loading:

The variation in fill thickness is illustrated on the attached figure. For the purposes of the calculation, the fill thickness was estimated from the existing grade to the final grade, assuming that where existing material is being excavated and re-filled, there will be minimal difference between the rebound and recompression of the soil.

Swale 8 represents the most critical alignment for evaluation of differential settlement of the landfill due to waste relocation and cap construction. Along the alignment, cut and fill varies from approximately 8 feet of fill at its western end to approximately 8 feet of cut 500 feet to the east.

Variation in landfill material properties:

The waste materials have not been characterized at the site nor evaluated for potential compressibility due to changes in loading. Therefore, the waste material is assumed to have consistent properties within the study area. The material characteristics were estimated based on "Settlement of Waste Disposal Fills" by George Sowers (1973). For these calculations, an average thickness of 50 ft was assumed for the waste material.

Variation in stress history of the landfill material:

No known surcharging of the landfill has occurred that would indicate the waste may be over consolidated. The waste is assumed to be normally consolidated.

Sowers, 1973.



2) Calculate settlement based on the material properties and the changes in stress. While landfills do not exhibit traditional compression settlement, Sowers recommends this calculation methodology as an approximation of long-term settlement of waste material due to loading. Conservative estimates of initial void ratio and coefficient of consolidation were made to estimate a worst-case scenario for differential settlement. The values were estimated based on Figure 2 from Sowers.

$$\text{Settlement} = H \frac{C_c}{1 + e_o} \log \left(\frac{P_f}{P_o} \right) + H \frac{C_r}{1 + e_o} \log \left(\frac{P_p}{P_o} \right)$$

where:

- H = height of fill (ft)
- C_c = coefficient of consolidation = 0.5
- e_o = initial void ratio = 2.0
- P_f = final effective stress (psf)
- C_r = coefficient of reconsolidation = 0.05
- P_o = initial effective stress (psf)

See attached figure
 Sowers, 1973.
 Sowers, 1973.
 See attached calculations

 See attached calculations

 See attached calculations

3) Divide the waste into sublayers to account for the variation in initial effective stress. Calculate the settlement for each layer and add them together to determine the total settlement.

4) Calculate the post-settlement cap slopes and determine if differential settlement will impact drainage.

CONCLUSION:

The landfill may settle approximately 1.4 feet from 8 feet of waste placement and may rebound 0.14 feet from 8 feet of waste excavation. Over the 500 feet between these extreme case locations, the landfill slope may be reduced by approximately 0.3 percent. The post-settlement slope of Swale 8 is estimated to be approximately 1.7%. **Based on the available information, the long-term settlement of the landfill is not anticipated to adversely affect drainage of surface water from the landfill.**

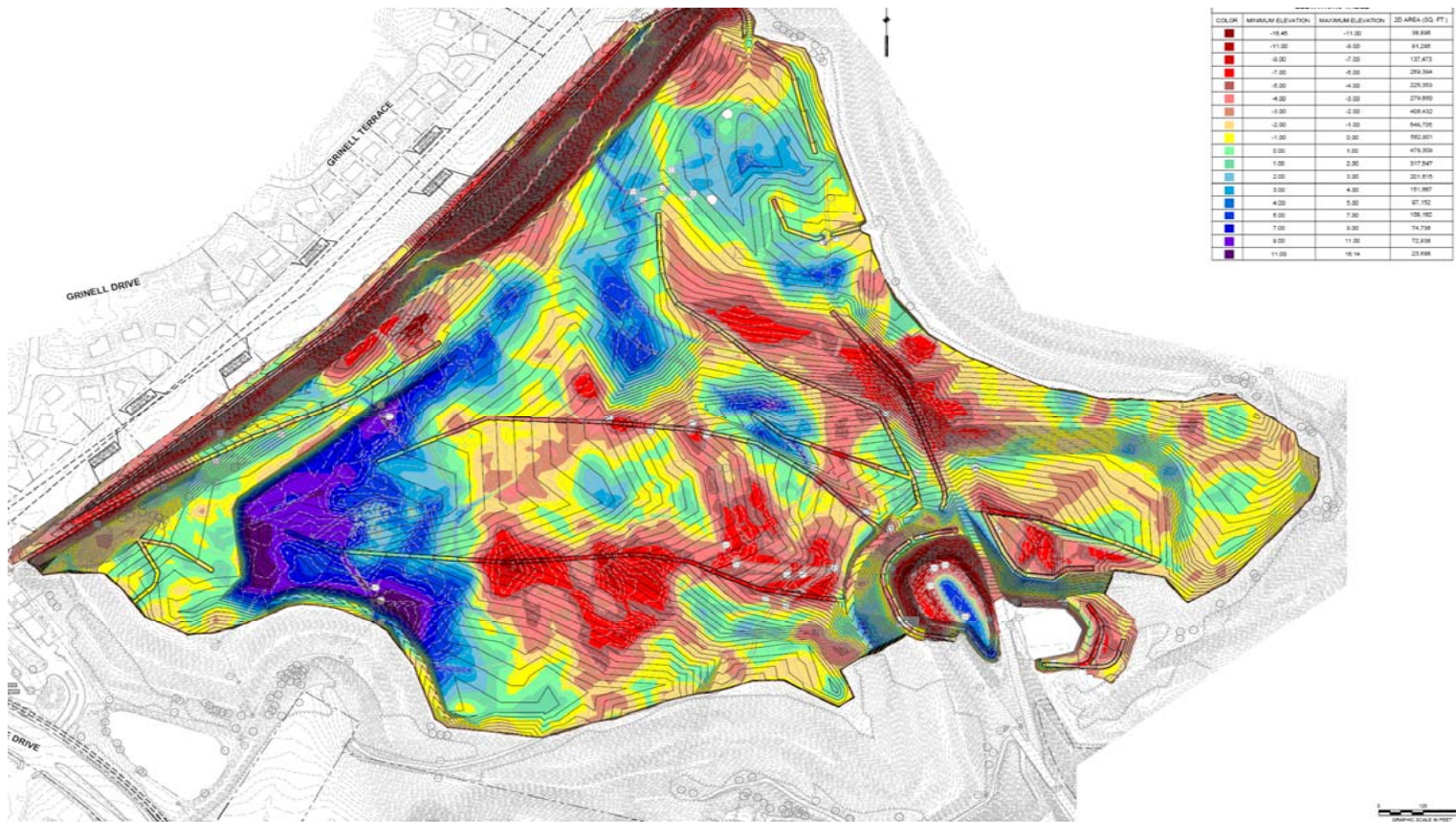
GUDE LANDFILL
Estimate of Change in Slope Due to Long-Term Settlement/Rebound of the Landfill Cap

Fill on landfill (ft) = 8
 Anticipated settlement (ft) = 1.47

Excavation on landfill (ft) = -8
 Anticipated rebound (ft) = -0.14

Distance between elevations (ft) = 500

Fill/Excavation Thickness	8	7	6	5	4	2	0	-2	-4	-5	-6	-7	-8
Settlement	1.4	1.3	1.1	1.0	0.8	0.4	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
Slope Change		0.0%	0.1%	0.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
			0.0%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%
				0.0%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
					0.1%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
						0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%



GUDE LANDFILL
Estimate of Long-Term Settlement of the Landfill Cap

Layer Geometry				Layer Stresses			Material Properties				Settlement		
Layer	Top of Layer (ft)	Bottom of Layer (ft)	Center of Layer (ft)	Layer Thickness H, (ft)	In-situ Effective Stress P_o , (psf)	Change in Stress ΔP , (psf)	Final Effective Stress P_f , (psf)	Preconsolidation Pressure P_p , (psf)	Initial Void Ratio e_o	Recompression Index C_r	Compression Index C_c	Settlement Equation	Settlement (ft)
Waste	0.0	10.0	5.00	10.0	575.0	920.0	1495.0	575.0	2.00	0.05	0.50	1	0.69
	10.0	20.0	15.00	10.0	1725.0	920.0	2645.0	1725.0	2.00	0.05	0.50	1	0.31
	20.0	30.0	25.00	10.0	2875.0	920.0	3795.0	2875.0	2.00	0.05	0.50	1	0.20
	30.0	40.0	35.00	10.0	4025.0	920.0	4945.0	4025.0	2.00	0.05	0.50	1	0.15
	40.0	50.0	45.00	10.0	5175.0	920.0	6095.0	5175.0	2.00	0.05	0.50	1	0.12
													1.47

unit weight of existing waste $\gamma_w =$ 115 pcf
unit weight of additional load, $\gamma =$ 115 pcf
load thickness, D = 8 ft

Settlement Equations:

$$1: \text{Settlement} = H \frac{C_c}{1 + e_o} \log \left(\frac{P_f}{P_o} \right)$$

$$2: \text{Settlement} = H \frac{C_r}{1 + e_o} \log \left(\frac{P_f}{P_o} \right)$$

$$3: \text{Settlement} = H \frac{C_c}{1 + e_o} \log \left(\frac{P_f}{P_o} \right) + H \frac{C_r}{1 + e_o} \log \left(\frac{P_p}{P_o} \right)$$

GUDE LANDFILL
Estimate of Long-Term Settlement of the Landfill Cap

Layer Geometry					Layer Stresses			Material Properties				Settlement	
Layer	Top of Layer (ft)	Bottom of Layer (ft)	Center of Layer (ft)	Layer Thickness H, (ft)	In-situ Effective Stress P_o , (psf)	Change in Stress ΔP , (psf)	Final Effective Stress P_f , (psf)	Preconsolidation Pressure P_p , (psf)	Initial Void Ratio e_o	Recompression Index C_r	Compression Index C_c	Settlement Equation	Settlement (ft)
Waste	8.0	16.4	12.20	8.4	1403.0	-920.0	483.0	1403.0	2.00	0.05	0.50	2	-0.06
	16.4	24.8	20.60	8.4	2369.0	-920.0	1449.0	2369.0	2.00	0.05	0.50	2	-0.03
	24.8	33.2	29.00	8.4	3335.0	-920.0	2415.0	3335.0	2.00	0.05	0.50	2	-0.02
	33.2	41.6	37.40	8.4	4301.0	-920.0	3381.0	4301.0	2.00	0.05	0.50	2	-0.01
	41.6	50.0	45.80	8.4	5267.0	-920.0	4347.0	5267.0	2.00	0.05	0.50	2	-0.01
													-0.14

unit weight of existing waste $\gamma_w =$ 115 pcf
unit weight of additional load, $\gamma =$ 115 pcf
load thickness, D = -8 ft

Settlement Equations:

$$1: \text{Settlement} = H \frac{C_c}{1 + e_o} \log \left(\frac{P_f}{P_o} \right)$$

$$2: \text{Settlement} = H \frac{C_r}{1 + e_o} \log \left(\frac{P_f}{P_o} \right)$$

$$3: \text{Settlement} = H \frac{C_c}{1 + e_o} \log \left(\frac{P_f}{P_o} \right) + H \frac{C_r}{1 + e_o} \log \left(\frac{P_p}{P_o} \right)$$

Attachment J

Global Stability Analysis

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OBJECTIVE:

Evaluate the stability of the northwest slope final grading for the Gude Landfill under static and seismic loading.

DESIGN PARAMETERS AND ASSUMPTIONS:

Utilize the computer software PC STABL Version 6H to evaluate the stability of the landfill. A cross-section was identified as the potentially most critical cross-section and are shown on the attached Figure 1. Section A-A' crosses the longest length of the steepest slope (3H:1V) of the landfill.

The grades and elevations used in the creation of the top profile represent the final closure cap grades for the Gude Landfill to provide the maximum height and slope possible. That is the most conservative evaluation for slope stability.

Geotechnical Properties of Soil and Waste

Boring logs from a geotechnical investigation performed by Robert B. Balter Company in October 2020 for the assessment of subsurface conditions for the slope stability analysis as part of Gude Landfill Remediation were used to determine existing soil strata in the cross-sections. The boring logs and geotechnical information are included in Attachment A.

Water was encountered in the borings approximately 10-ft below ground surface. While it is likely perched water, for the purposes of this evaluation, it was modeled as the water table, resulting in a more conservative evaluation. EA assumed the groundwater table was at elevation 455.

The material properties used in the analysis are listed in the following table:

MATERIAL PROPERTIES

Material	Total Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Friction Angle (°)
Vegetative Support Soil ¹	115	130	0	30
Geosynthetics ²	59	59	0	26
Subgrade ³	115	130	0	30

PC STABL 6H, Purdue University, West Lafayette, Indiana.



Material	Total Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Friction Angle (°)
Waste ⁴	60	90	0	29
Native Soil ⁵	115	130	0	34

Oweis, Issa S. and Raj P. Khera (1998). *Geotechnology of Waste Management, 2nd Edition*. PWS Publishing Co., Boston, MA.

Das, Braja M. (1990) *Principles of Geotechnical Engineering, Third Edition*. PWS Publishing Company.

¹ Material properties for vegetative support soil are assumed based on the material specified in the technical specifications.

² Material properties for geosynthetics are assumed based on product specifications for materials in landfill cap designs. A minimum interface friction angle of 26 degrees will be specified for the liner system.

³ Material properties for the subgrade soil are assumed based on the material specified in the technical specifications.

⁴ The material properties of the waste were taken from the geotechnical evaluation by the Robert B. Balter Company. The Standard Penetration Number, N, was used to correlate to representative compressive strength values and friction angles. Das (1990) illustrates the correlation between the Standard Penetration Number, N, and cohesion values and friction angles (see Attachment A).

⁵ The material properties of the subsurface sand layer were taken from the geotechnical evaluation by the Robert B. Balter Company. The Standard Penetration Number, N, was used to correlate to representative compressive strength values and friction angles. Das (1990) illustrates the correlation between the Standard Penetration Number, N, and cohesion values and friction angles (see Attachment A).

Slope stability was evaluated using PC STABL. The method selected, the Modified Bishop Method, searches for the most critical, circular failure plane through the landfill. PC STABL generated 100 random circular surfaces to determine the minimum factor of safety. Output from the model and cross section showing computed factors of safety are included in Attachment B.

Scenarios were evaluated for static and seismic loading. According to 40 CFR 258.14, a seismic impact zone is identified as an area with a 10% or greater probability that the maximum horizontal acceleration (MHA) of lithified earth material, expressed as percentage of the earth's gravitational pull (g), will exceed 0.06g in 250 years. The MHA in



Project Gude Landfill Remediation Design Project No. 15646.01
 Subject Global Stability Calculation Sheet No. 3 of 15
 Drawing No. _____
 Computed by SS 11/28/2020 Checked by MJH Date 12/10/20

Petersen, M.D., et al. 2008.
 Documentation for the 2008
 Update of the United States
 National Seismic Hazard
 Maps: U.S. Geological
 Survey Open-File Report
 2008-1128, 61 p.

bedrock for the proposed facility is estimated to be 0.06g, based on the USGS Seismic map shown in Figure 3 (Petersen, 2008) with contours of peak acceleration with 2% probability of exceedance in 50 years. A 2% probability in 50 years is approximately equal to a 10% probability of exceedance in 250 years. Therefore, the landfill is not considered to be located in a seismic impact zone. While the Gude Landfill location is not considered to be located in a seismic impact zone, the stability of the landfill subsurface was completed to evaluate landfill stability in accordance with 40 CFR 258.14.

Output from the model and cross-section showing computed factors of safety are included in Attachment B.

CONCLUSIONS:

A minimum factor of safety of 1.5 is the industry standard for landfills under static loading and is applicable to the Landfill. The minimum calculated factor of safety of 1.81 indicates the landfill cell will be stable when filled to permitted grades.

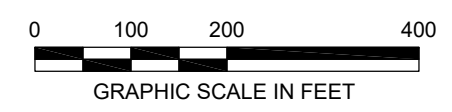
A minimum factor of safety of 1.0 is the industry standard for landfills under seismic loading and is applicable to the Landfill. The minimum calculated factor of safety of 1.18 indicates the landfill cell will be stable when filled to permitted grades for a seismic event with 0.06g horizontal acceleration.

The calculated factors of safety are summarized below:

Analysis Condition	FS (Static)	FS (Seismic)
Section A-A' – Overall Global Stability	1.81	1.18

FIGURE 1

FILE PATH: G:\PROJECTS\1564601 - GUIDE OF REMEDIATION PRODUCTION\WORKSHEETS\1564601 - GUIDE OF REMEDIATION PRODUCTION - SURFACE ELEVATION.DWG, 3/21/2020 11:52:AM



<p>EA EA Engineering, Science, and Technology, Inc., PBC Hunt Valley Center 225 Schilling Circle, Suite 400 Hunt Valley, Maryland 21031 (410) 584-7000</p>		<p>DATE: DECEMBER 2020</p>	
		<p>PROJECT NUMBER: 1564601</p>	
<p>C-301 SHEET: 87 OF 146</p>		<p>100% DESIGN PLANS - NOT FOR CONSTRUCTION</p>	
<p>GUIDE LANDFILL REMEDIATION DESIGN NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY MONTGOMERY COUNTY DEPARTMENT OF ENVIRONMENTAL PROTECTION MONTGOMERY COUNTY, MARYLAND</p>			
<p>SITE CROSS SECTIONS - KEY SHEET</p>			
<p>SEAL</p>			
<p>PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A FULLY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND. LICENSE NO. 23402 EXPIRATION DATE: 8/25/2022</p>			
<p>DESIGNED BY: KEF / SMB</p>		<p>NO. DATE BY</p>	
<p>DRAWN BY: SMB</p>		<p>DESCRIPTION</p>	
<p>CHECKED BY: LJO / GAT</p>		<p>PROJECT MANAGER: MJG</p>	

ATTACHMENT A



The Robert B. Balter Company
 Geotechnical and Environmental Engineers
 Materials and Construction Inspection and Testing
 Telephone No. (410) 363-1555
 www.balterco.com

BORING LOG

BORING B-4

PAGE 1 OF 1

CLIENT EA Engineering PROJECT NAME Gude Landfill
 PROJECT LOCATION Rockville, MD PROJECT NUMBER 17359-0 DATE TESTED _____

RIG Mobil B45 METHOD Hollow Stem Auger SAMPLER: 2-in OD SS HAMMER: 140# FALL: 30" AUTO? Yes

DATE STARTED 10/1/20 COMPLETED 10/1/20 WATER LEVELS
 DRILLER Dan Ditman HELPER Kenny Putman
 REVIEWED BY Chris Karg SITE DELAYS _____
 LOCATION approximately 40' South BULK SAMPLES 1'-5'

DATE	TIME	ELAPSED HOURS	CASING DEPTH (ft)	HOLE DEPTH (ft)	WATER DEPTH (ft)	WATER ELEV (ft)
10/1/20		0		20.5	13.3	443.7
10/2/20		26		17.0	9.8	447.2

DEPTH (ft)	SAMPLE TYPE AND NUMBER	SPT BLOWS/6" OR REC IN/IN %	N VALUE OR CORE RQD	STRATUM CHANGE DEPTH/ELEV (ft)	GRAPHIC LOG	USCS	WATER LEVEL	MATERIAL DESCRIPTION	PP (tsf)	NMC %	#200	ATTERBERGS			REMARKS
												PL	LL	PI	
				0.3 456.7				SURFACE EL = 457.0 ft							
	S1	4-6-4	10			SM		Topsoil (4") Moist, Loose, Brown Silty Sand with Small Rock Fragments (Fill)		5		26	30	4	(1)
5				4.0 453.0		CL		Moist, Medium Stiff, Grayish Sandy Clay (Fill)	1.90	19					
	S2	3-2-3	5							27					
	T1	11 / 24		8.0 449.0				LANDFILL							
10						SM		Wet, Medium Dense, Brown Silty Sand and Trash (Plastic, Wood, etc.)							
	S3	5-11-3	14												
				13.0 444.0				Wet, Stiff, Brown Sandy Silt							
15						ML									
	S4	9-9-5	14												
				17.0 440.0				Moist, Stiff, Brown Sandy, Clayey Silt with Rock and Trash (Wallpaper, etc.)							
20						CL-ML									
	S5	3-4-6	10						3.25						
25															
	S6	9-5-6	11	26.5 430.5				Terminated at 26.5 feet							

REMARKS: (1)Water encountered on spoon at 10'

NEW GEOTECH BH LOG 17359-0 GUDE LANDFILL - PURPLE LINE STOCKPILE.GPJ MTA REDLINE.GDT 10/26/20



BORING LOG

BORING B-5

CLIENT EA Engineering PROJECT NAME Gude Landfill
 PROJECT LOCATION Rockville, MD PROJECT NUMBER 17359-0 DATE TESTED _____

RIG Mobil B45 METHOD Hollow Stem Auger SAMPLER: 2-in OD SS HAMMER: 140# FALL: 30" AUTO? Yes

DATE STARTED 10/1/20 COMPLETED 10/2/20 WATER LEVELS
 DRILLER Dan Ditman HELPER Kenny Putman
 REVIEWED BY Chris Karg SITE DELAYS _____
 LOCATION As Staked BULK SAMPLES 1'-5'

DATE	TIME	ELAPSED HOURS	CASING DEPTH (ft)	HOLE DEPTH (ft)	WATER DEPTH (ft)	WATER ELEV (ft)
10/2/20		0		15.2	14.3	457.2
10/5/20		68		12.3	11.0	460.5

DEPTH (ft)	SAMPLE TYPE AND NUMBER	SPT BLOWS/6" OR REC IN/IN %	N VALUE OR CORE RQD	STRATUM CHANGE DEPTH/ELEV (ft)	GRAPHIC LOG	USCS	WATER LEVEL	MATERIAL DESCRIPTION	PP (tsf)	NMC %	#200	ATTERBERGS			REMARKS
												PL	LL	PI	
				0.3 471.2				SURFACE EL = 471.5 ft							
5	S1	1-2-2	4			SM		Topsoil (4") Moist, Loose to Medium Dense, Orangish Brown Silty Sand (Fill) Tube at 4' in offset hole (Recovery = 13")	1.80	16					
	S2	7-9-9	18			SM				15					
10	S3	8-8-5	13	8.0 463.5		ML		LANDFILL Moist, Stiff, Orangish Brown/Black Sandy Silt (Fill, Possible wood obstruction augering)							
15	S4	4-3-2	5	13.0 458.5		SM		Wet, Loose, Grayish Silty Sand with Trash (Wood, Metal)							(1)
20	S5	15-10-10	20	18.0 453.5				Offset hole 5' West at approximately 18' after hitting obstruction (possible steel pieces) Moist, Medium Dense Trash (Wood, Newspaper)							(2)
25	S6	14-9-8	17	22.0 449.5		SM		Wet, Medium Dense, Light Brown Silty Sand with Trash (Wood)							
30	S7	50		27.0 444.5		GC		Wet, Very Dense, Gravel with Sand and Trash (Wood)							
35	S8	15-20-	36	31.0 440.5				Wet, Medium Dense to Very Dense, Dark Gray Trash (Rubber, Plastic Pieces)							

REMARKS: (1)Water encountered on spoon at 14' (2)Hole offset 5' West after hitting obstruction/refusal

NEW GEOTECH BH LOG 17359-0 GUDE LANDFILL - PURPLE LINE STOCKPILE.GPJ MTA REDLINE.GDT 10/26/20



BORING LOG

CLIENT EA Engineering PROJECT NAME Gude Landfill
 PROJECT LOCATION Rockville, MD PROJECT NUMBER 17359-0 DATE TESTED _____

DEPTH (ft)	SAMPLE TYPE AND NUMBER	SPT BLOWS/6" OR REC IN/IN %	N VALUE OR CORE RQD	STRATUM CHANGE DEPTH/EL (ft)	GRAPHIC LOG	USCS	WATER LEVEL	MATERIAL DESCRIPTION	PP (tsf)	NMC %	- #200	ATTERBERGS			REMARKS	
												PL	LL	PI		
		16			F F			Wet, Medium Dense to Very Dense, Dark Gray Trash (Rubber, Plastic Pieces) (continued)								
40	S9	18-25-14	39		F F											
45	S10	24-33-27	60		F F											
50	S11	20-11-7	18		F F											
				50.5	F F				Terminated at 50.5 feet							

NEW GEOTECH BH LOG 17359-0 GUDE LANDFILL - PURPLE LINE STOCKPILE.GPJ MTA REDLINE.GDT 10/26/20

REMARKS: (1)Water encountered on spoon at 14' (2)Hole offset 5' West after hitting obstruction/refusal



BORING LOG

BORING B-6

CLIENT EA Engineering PROJECT NAME Gude Landfill
 PROJECT LOCATION Rockville, MD PROJECT NUMBER 17359-0 DATE TESTED _____

RIG Mobil B45 METHOD Hollow Stem Auger SAMPLER: 2-in OD SS HAMMER: 140# FALL: 30" AUTO? Yes

DATE STARTED 10/5/20 COMPLETED 10/5/20 WATER LEVELS

DATE	TIME	ELAPSED HOURS	CASING DEPTH (ft)	HOLE DEPTH (ft)	WATER DEPTH (ft)	WATER ELEV (ft)
10/5/20		0 ∇		16.3	Dry	

DRILLER Dan Ditman HELPER Kenny Putman
 REVIEWED BY Chris Karg SITE DELAYS _____
 LOCATION As Staked BULK SAMPLES 1'-14'

NEW GEOTECH BH LOG 17359-0 GUDE LANDFILL - PURPLE LINE STOCKPILE.GPJ MTA REDLINE.GDT 10/26/20

DEPTH (ft)	SAMPLE TYPE AND NUMBER	SPT BLOWS/6" OR REC IN/IN %	N VALUE OR CORE RQD	STRATUM CHANGE DEPTH/ELEV (ft)	GRAPHIC LOG	USCS	WATER LEVEL	MATERIAL DESCRIPTION	PP (tsf)	NMC %	-#200	ATTERBERGS			REMARKS
												PL	LL	PI	
				0.3				SURFACE EL = 413.5 ft							
	S1	1-1-2	3	413.2		ML		Topsoil (4")							
5	T1	23 / 24		410.5		SC-SM		Moist, Soft, Brown Clayey Silt, little Sand, trace roots (Fill)							
				3.0				Moist, Loose to Medium Dense, Reddish Brown Silty Clayey Sand (Residual)	21	50	20	27	7		
10	S2	2-3-4	7	405.5		SM		Moist, Loose to Medium Dense, Reddish Brown Silty Sand (Residual)	18						
15	S3	5-6-8	14			SM		Relic Rock Structure	16						
				8.0				Color to Light Brown							
20	S4	8-11-12	23			SM		Decomposed Rock sampled as: Moist, Very Dense, Brown Silty Sand	13	32	22	26	4		
				22.0											
25	S5	14-24-27	51	391.5		SM		Decomposed Rock sampled as: Moist, Very Dense, Brown Silty Sand							
				25.5				Terminated at 25.5 feet							
				388.0											

REMARKS:

CORRECTED STANDARD PENETRATION TEST RESULTS AND ESTIMATED STRENGTH

$$N' = \sqrt{\frac{2000}{\sigma_v'}} \times N$$

where:

N' = corrected SPT N-value

σ_v' = effective overburden pressure (psf)

N = field SPT N-value

$$\sigma_v' = Z \times \gamma$$

where:

Z = depth (ft)

γ = unit weight of soil (pcf)

unit weight of soil, γ = 115 pcf

	Z (ft)	N	σ_v' (psf)	N'	Stratigraphy	N'_{min}	Sands ϕ (deg)	Clays q_u (tsf)
B-4 - Waste Only	6	5	690	9				
	11	14	1265	18		9	34	1.13
	16	14	1840	15				
	21	10	2415	9				
	26	11	2990	9				
B-5 - Waste Only	11	13	1265	16		5	29	0.63
	16	5	1840	5				
	20	20	2300	19				
	25	17	2875	14				
	30	50	3450	38				
	35	36	4025	25				
	40	39	4600	26				
	45	60	5175	37				
	50	18	5750	11				
B-6	10	7	1150	9				
	15	14	1725	15	SM	9	34	1.13
	20	23	2300	21				
	25	51	2875	43				

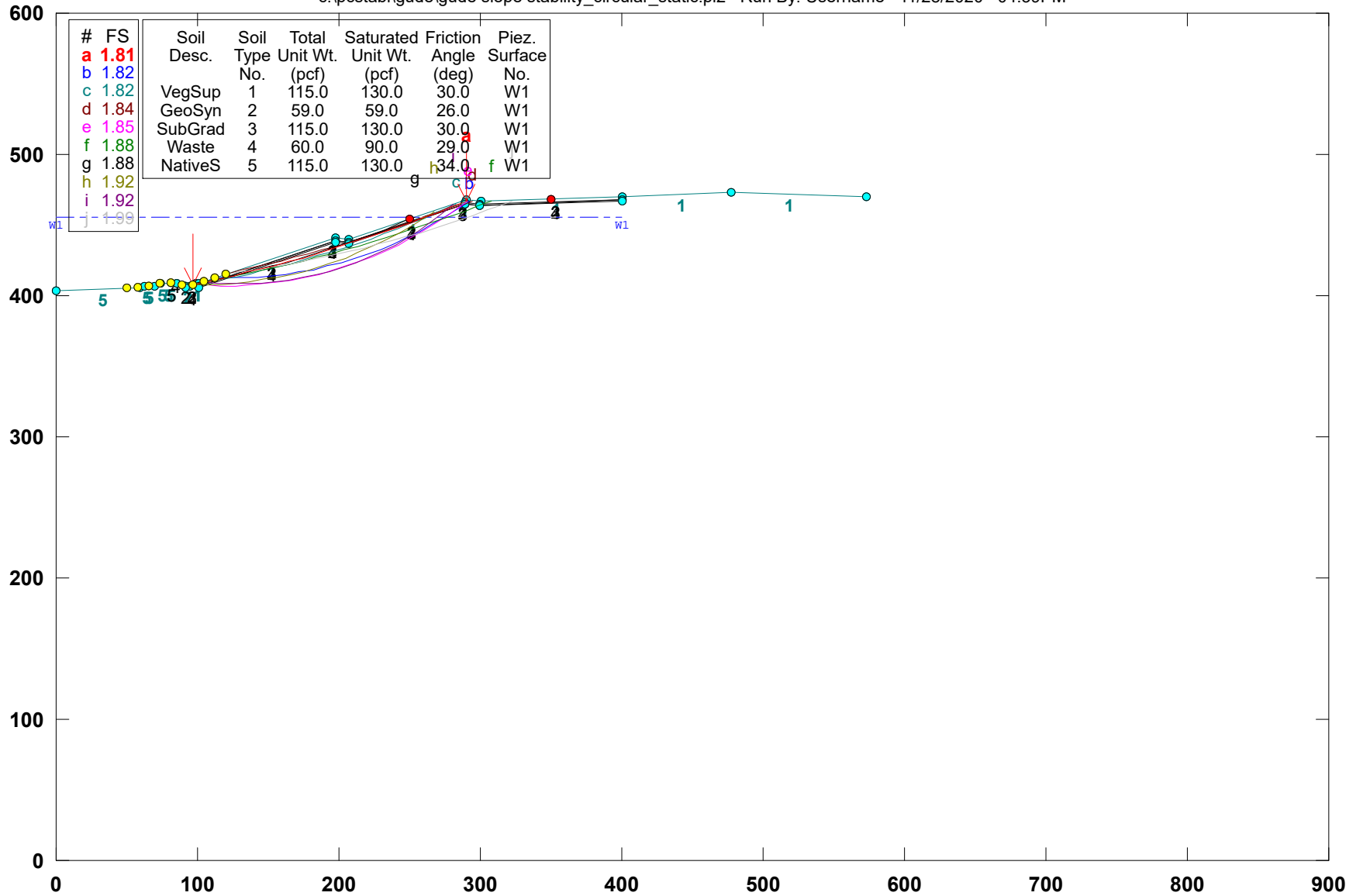
Estimated Soil Strengths (Das, 1990):

Sands		Clays	
N'	ϕ (deg)	N'	q_u (tsf)
0	26	0	0.00
5	29	2	0.25
10	35	4	0.50
30	40	8	1.00
50	46	16	2.00
		32	4.00

ATTACHMENT B

Gude Overall Global Stability, Static

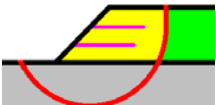
c:\pcstabl\gude\gude slope stability_circular_static.pl2 Run By: Username 11/28/2020 04:39PM



STABL6H FSmin=1.81

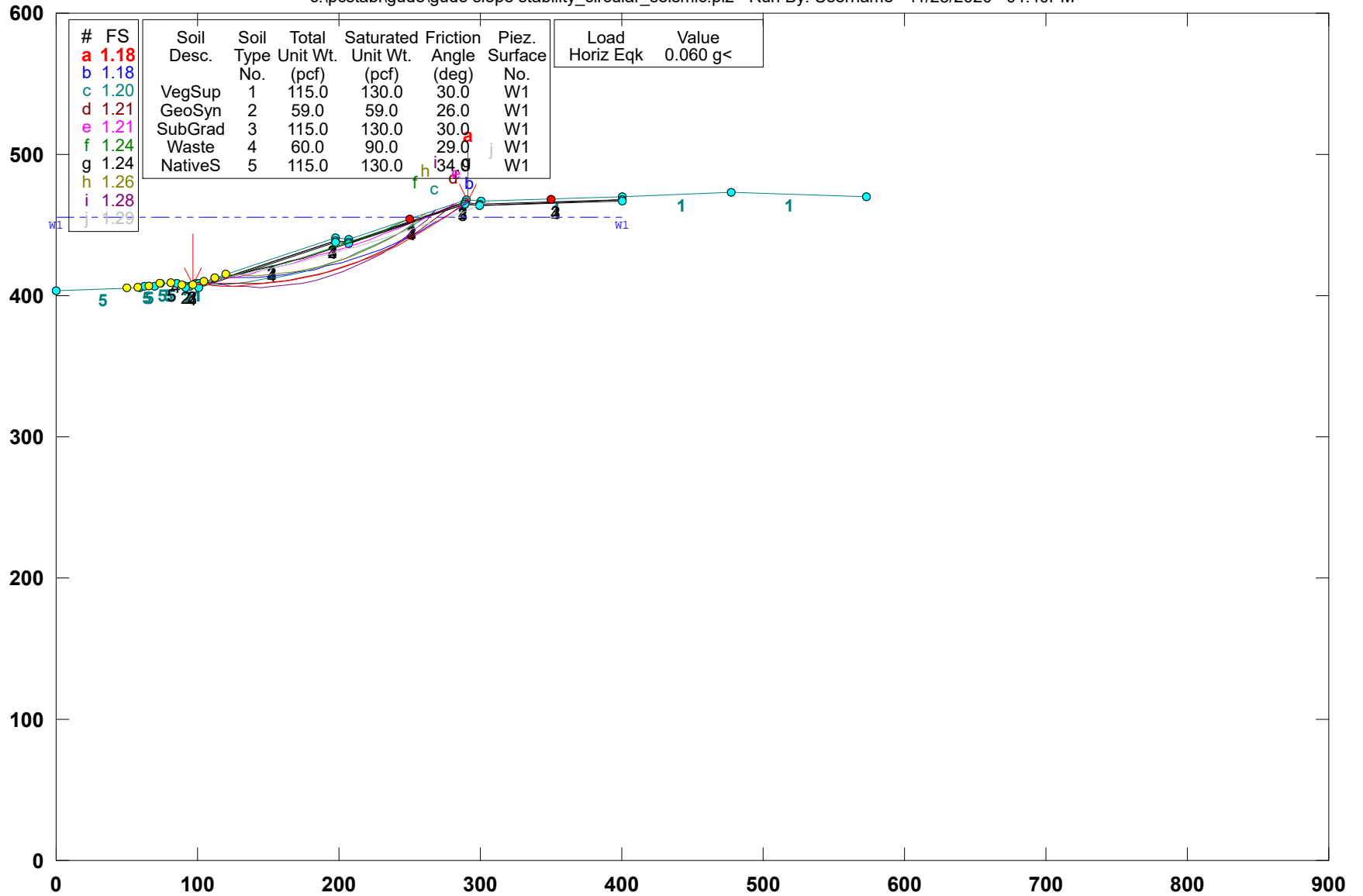
Safety Factors Are Calculated By The Modified Bishop Method

STED



Gude Overall Global Stability, Seismic

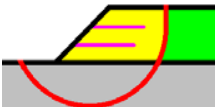
c:\pcstabl\gude\gude slope stability_circular_seismic.pl2 Run By: Username 11/28/2020 04:40PM



STABL6H FSmin=1.18

Safety Factors Are Calculated By The Modified Bishop Method

STED



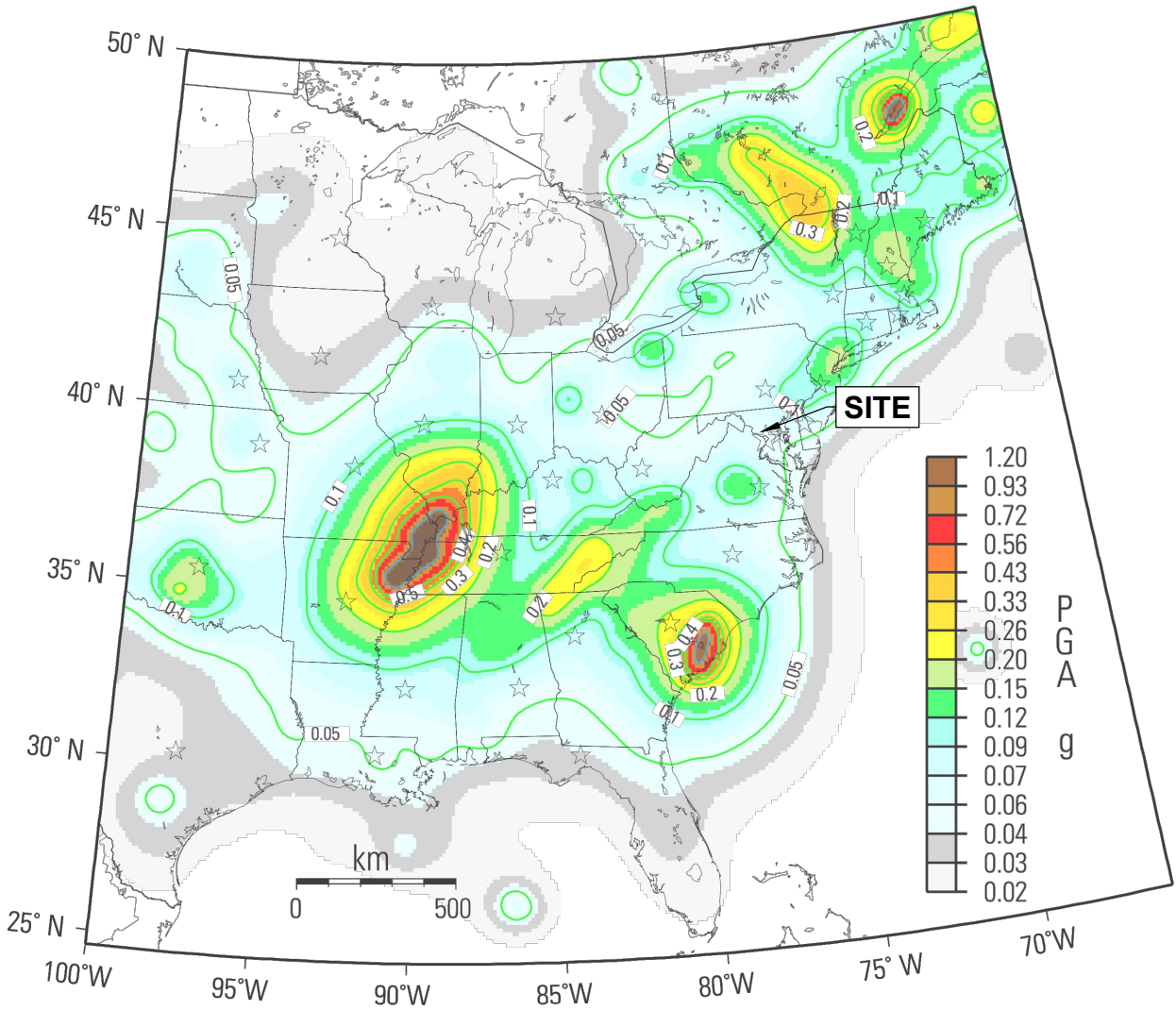


Figure 3. Map of peak ground acceleration (PGA) for 2-percent probability of exceedance in 50 years in the Central and Eastern United States in standard gravity (g).

SOURCE: PETERSEN, M.D., ET AL. 2008. DOCUMENTATION FOR THE 2008 UPDATE OF THE UNITED STATES NATIONAL SEISMIC HAZARD MAPS: U.S. GEOLOGICAL SURVEY OPEN-FILE REPORT 2008-1128, 61 P.

	EA Engineering, Science, and Technology, Inc., PBC 225 SCHILLING CIRCLE, SUITE 400 HUNT VALLEY, MARYLAND 21031		GUDE LANDFILL REMEDIATION DESIGN NORTHWEST MARYLAND WASTE DISPOSAL AUTHORITY MONTGOMERY COUNTY, MARYLAND			MAP OF PEAK GROUND ACCELERATION	
	DATE:	PROJECT NUMBER:	DESIGNED BY:	DRAWN BY:	CHECKED BY:	PROJECT MGR.:	SHEET NUMBER:	FIGURE:
DEC. 2020	1564601	EF	SS	MJG	MJG	-	1

FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\1564601 - GUDE SLOPE STABILITY GROUND ACCELERATION.DWG [FIGURE 1] 12/20/16

Attachment K

Stormwater Management and Erosion and Sediment Control

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Attachment K1

Stormwater Management Concept Report

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**Gude Landfill Remediation Design
Stormwater Management Report
Montgomery County, Maryland**

Stormwater Concept Resubmission

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

February 2020
EA Project No. 15646.01

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**Gude Landfill Remediation Design
Stormwater Management Report
Montgomery County, Maryland**

Stormwater Concept Resubmission

Prepared for

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1	Soil Map Units and Soil Hydrologic Groups
2	Existing Conditions Hydrology Summary
3	Hydrology Comparison Summary

LIST OF ACRONYMS AND ABBREVIATIONS

cfs	Cubic feet per second
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DA	Drainage Area
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
ESD	Environmental Site Design
HSG	Hydrologic soil group
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
MDE	Maryland Department of the Environment
NRCS	Natural Resources Conservation Service
Q ₂	2-Year peak flow
Q ₁₀	10-Year peak flow
Q ₁₀₀	100-Year peak flow

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1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has been contracted to provide engineering, permitting, and support services for developing a remediation design to address the remedial action objectives at the Gude Landfill (“the Landfill”) in order to achieve compliance with the consent order for the Landfill (Maryland Department of the Environment [MDE] and Montgomery County 2013).

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. Refer to **Figure 1** for a vicinity and location map. The site is accessed at two locations: East Gude Drive from the south-southwest and Southlawn Lane from the east-southeast.

The Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. An additional 17 acres of waste disposal area were delineated in 2009 on Maryland-National Capital Park and Planning Commission (M-NCPPC) property, beyond the northeastern property boundary of the Landfill. A land exchange between the County and M-NCPPC on October 21, 2014 transferred ownership of this additional waste disposal area to the County in exchange for a similar area of land without waste, which was transferred to M-NCPPC.

Landfill capping was selected as a corrective measure for the upper surface of the Landfill, as well as portions of the side-slopes of the Landfill where placement of a closure capping system is feasible. EA’s design includes the following major elements as part of the corrective measure:

- Erosion and sediment control,
- Existing waste reconfiguration and subgrade establishment,
- Landfill closure cap construction,
- Landfill gas management, and
- Stormwater management.

Stormwater management is necessary to mitigate the effects of development on the receiving stream system. The post-development ground surface, including impervious area, will be similar to the pre-development ground surface; however, the post-development ground surface slopes may be steeper than the pre-development slopes to promote drainage and minimize the potential for stormwater ponding on the Landfill cap.

A stormwater management design must ensure mitigation through practices described in the *2000 Maryland Stormwater Design Manual* as amended and with Montgomery County design requirements based on Chapter 19 of the Montgomery County Code. Environmental Site Design (ESD) features must be used to the maximum extent practicable to reduce stream pollution, erosion, and flooding based on the guidelines. Pre-development runoff characteristics must be maintained as nearly as possible.

Based on discussions with the Montgomery County Department of Permitting Services (DPS), this project is considered a “maintenance” activity since no new impervious area is proposed. Due to this classification, no ESD treatment is required.

This stormwater management report has been prepared to document the stormwater management design associated with the remediation design.

2. HYDROLOGY ANALYSIS

Stormwater quantity control must be provided to ensure that pre-development runoff characteristics are maintained as nearly as possible. EA analyzed the 2-year, 10-year, and 100-year storm events. The existing and proposed conditions hydrology was analyzed to establish runoff characteristics.

2.1 SOILS ANALYSIS

The Natural Resources Conservation Service (NRCS) Web Soil Survey was used to determine the soils onsite and in the vicinity and their properties. The NRCS Web Soil Survey report is included in **Appendix A**. The soils found throughout the project and in the vicinity have also been summarized in **Table 1**.

Table 1 Soil Map Units and Soil Hydrologic Groups

Map Symbol	Soils Series	Hydrologic Soils Group
1B	Gaila silt loam, 3 to 8 percent slopes	B
1C	Gaila silt loam, 8 to 15 percent slopes	B
2B	Glenelg silt loam, 3 to 8 percent slopes	B
4B	Eliok silt loam, 3 to 8 percent slopes	C
5A	Glenville silt loam, 0 to 3 percent slopes	C
5B	Glenville silt loam, 3 to 8 percent slopes	C/D
6A	Baile silt loam, 0 to 3 percent slopes	C/D
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	C
17C	Ococoquan loam, 8 to 15 percent slopes	B
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B/D
100	Dumps, refuse	Not applicable
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	D
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	D

2.2 CURVE NUMBER DETERMINATION

The top of the Landfill consists of tall grasses with several dirt/gravel access roads. Runoff characteristics were determined by SCS Engineers in 1992 as part of developing the *Gude Landfill Post Closure Engineering Design and Management Tasks* plans. The SCS Engineers analysis considered the grassed areas to be “pasture.” Applicable drawings from the SCS Engineers plans are included in **Appendix B**.

EA’s analysis assumes the same land use category for the grassed areas as the SCS Engineers analysis. While there is no hydrologic soil group (HSG) rating for the soil within the footprint of the Landfill, the SCS Engineers analysis assumed HSG D soils. EA is maintaining this assumption.

2.3 EXISTING DRAINAGE AREA ANALYSIS

The hydrologic analyses contained within this report are based upon the methods outlined in the NRCS TR-55 Manual, WinTR-55 software, and the *2000 Maryland Stormwater Design Manual*.

The TR-55 hydrologic method computations and procedures were utilized to determine the weighted runoff curve number and time of concentration for the existing conditions of the site. Rainfall depths associated with Montgomery County from NOAA Atlas 14 were used for design. Drainage at the Landfill can be divided into 12 drainage areas (DAs), shown in the existing conditions drainage area map (**Figure 2**). **Table 2** summarizes the existing conditions hydrology at the Landfill. Calculations are included in **Appendix C**.

Table 2 Existing Conditions Hydrology Summary

Drainage Area	Existing					Discharge Point
	Area (acres)	Runoff Curve Number	Q ₂ (cfs)	Q ₁₀ (cfs)	Q ₁₀₀ (cfs)	
DA-1A	36.50	80	42.2	86.1	182.8	Pond 3 Bypass
DA-1B	15.69	81	22.6	45.0	93.9	Pond 3
DA-2	27.61	80	31.8	64.9	137.9	Pond 1
DA-3	12.68	80	14.8	30.2	64.1	Sheet Flow
DA-4	9.10	78	9.1	19.3	42.5	Pond 2
DA-5	17.70	77	18.7	40.5	90.2	M-NCPPC Pond
DA-6	15.19	67	9.2	26.8	72.1	Southlawn Branch
DA-7	5.80	78	7.8	16.4	35.7	Southlawn Branch
DA-8	3.88	80	5.4	10.9	23.2	Southlawn Branch
DA-9	4.16	79	5.4	11.2	24.0	Southlawn Branch
DA-10	0.99	80	1.3	2.6	5.6	Southlawn Branch
DA-11	3.15	78	4.1	8.7	19.0	Southlawn Branch

Notes: cfs = Cubic feet per second.
 Q₂ = 2-Year peak flow.
 Q₁₀ = 10-Year peak flow.
 Q₁₀₀ = 100-Year peak flow.

DA-1A and DA-1B

DA-1A consists of a 36.50-acre area while DA-1B is 15.69 acres. These drainage areas are located centrally at the site. Both DA-1A and DA-1B drain toward Pond 3, located on the east side of Incinerator Lane at the southern portion of the Landfill. According to a drawing developed by SCS Engineers in 2008, a stormwater bypass system was installed at Pond 3 to divert drainage from DA-1A into a 36-inch-diameter high-density polyethylene pipe and ultimately to the Southlawn Branch Stream. The stormwater bypass drawing is included in **Appendix D**. Pond 3 receives drainage from DA-1B and also discharges to Southlawn Branch.

DA-2

DA-2 receives drainage from a 27.61-acre area on the western portion of the Landfill. Drainage from DA-2 is conveyed to Pond 1, which is located at the base of the Landfill in the southeast portion of the site. Based on discussion with the Department of Permitting Services, Pond 1 functions as a regional stormwater pond for Montgomery County and receives drainage from the commercial property to the west and a portion of East Gude Drive. Pond 1 discharges to Southlawn Branch to the south.

DA-3

DA-3 is an approximate 12.68-acre area located on the northwest portion of the Landfill. Drainage from a portion of the upper Landfill surface and the majority of the northwest slope is conveyed to a low spot and discharges by sheet flow to the northwest.

DA-4

DA-4 receives drainage from a 9.10-acre area located at the northeast portion of the site. Drainage is conveyed to a depressed area (Pond 2) and ultimately discharges to Crabbs Branch to the north. The topography in the vicinity of this pond is very steep.

DA-5

DA-5 is a 17.70-acre area located at the northeastern portion of the site, primarily consisting of the Landfill side slopes. Discharge from DA-5 is conveyed to M-NCPPC Pond, which discharges to Rock Creek to the east.

DA-6

DA-6 receives drainage from an approximate 15.19-acre area on the east portion of the Landfill. Discharge from DA-6 is conveyed to the south and ultimately Southlawn Branch.

DA-7

DA-7 receives drainage from an approximate 5.80-acre area on the southeast portion of the Landfill. Discharge from DA-7 is conveyed southeast to a stormdrain system and ultimately Southlawn Branch.

DA-8

DA-8 receives drainage from an approximate 3.88-acre area on the southern portion of the Landfill. Discharge from DA-8 is conveyed to southeast to a stormdrain system and ultimately Southlawn Branch.

DA-9

DA-9 is located at the southern portion of the Landfill and receives drainage from approximately 4.16 acres. The majority of this drainage area consists of the Landfill side slopes. Drainage from DA-9 is conveyed south to Sediment Basin B and ultimately Southlawn Branch.

DA-10

DA-10 receives drainage from an approximate 0.99-acre area on the southern portion of the Landfill. The majority of this drainage area consists of the Landfill side slopes. Discharge from DA-10 is conveyed overland and discharges offsite in a southerly direction to Southlawn Branch.

DA-11

DA-11 receives drainage from an approximate 3.15-acre area on the southern portion of the Landfill. The majority of this drainage area consists of the Landfill side slopes. Discharge from DA-11 enters a yard inlet, is conveyed through a culvert under an access road, and is ultimately discharged in a southerly direction to Southlawn Branch.

2.4 PROPOSED DRAINAGE AREA ANALYSIS

Drainage areas were delineated for the proposed grading plan and are identified in the proposed conditions drainage area map (**Figure 3**). Existing drainage patterns were maintained to the greatest extent possible. EA assumed HSG D soils for the cap conditions. **Table 3** summarizes the changes in peak discharges from existing conditions to proposed conditions at the Landfill.

Table 3 Hydrology Comparison Summary

Drainage Area	Existing			Proposed			Discharge Point
	Q ₂ (cfs)	Q ₁₀ (cfs)	Q ₁₀₀ (cfs)	Q ₂ (cfs)	Q ₁₀ (cfs)	Q ₁₀₀ (cfs)	
DA-1A	42.2	86.1	182.8	36.8	75.3	160.3	Pond 3 Bypass – Southlawn Branch
DA-1B	22.6	45.0	93.9	32.8	66.8	142.3	Pond 3 – Southlawn Branch
DA-2	31.8	64.9	137.9	29.1	59.1	125.1	Pond 1
DA-3	14.8	30.2	64.1	13.7	27.3	56.8	Sheet Flow
DA-4	9.1	19.3	42.5	9.6	20.3	44.3	Pond 2
DA-5	18.7	40.5	90.2	17.1	38.7	89.2	M-NCPPC Pond
DA-6	9.2	26.8	72.1	9.0	26.3	70.7	Southlawn Branch
DA-7	7.8	16.4	35.7	7.8	16.4	35.7	Southlawn Branch
DA-8	5.4	10.9	23.2	4.6	9.4	20.0	Southlawn Branch
DA-9	5.4	11.2	24.0	5.2	10.8	23.3	Southlawn Branch
DA-10	1.3	2.6	5.6	1.3	2.5	5.3	Southlawn Branch
DA-11	4.1	8.7	19.0	4.1	8.6	18.8	Southlawn Branch

Notes: cfs = Cubic feet per second.
 Q₂ = 2-Year peak flow.
 Q₁₀ = 10-Year peak flow.
 Q₁₀₀ = 100-Year peak flow.

DA-1A and DA-1B

DA 1-A (34.78 acres) and DA 1-B (28.82 acres) will drain to a stormdrain that conveys discharge to Southlawn Branch. As the discharge from DA-1B increases from existing conditions, the stormdrain will provide safe conveyance of the 10-year storm. Additional discussion of the stormdrain is included in Section 3.1.

DA-2

DA-2 (21.47 acres) discharges to Pond 1. Pond 1 is a regional stormwater pond that receives discharge from the commercial property to the west owned by EB Rockville, LLC and a portion

of East Gude Drive. The design approach will decrease the size of DA-2. Discharge from DA-2 will not significantly change from existing conditions.

DA-3

DA-3 will decrease from 12.68 to 9.43 acres. Discharge from DA-3 is conveyed by sheet flow to the northwest in existing conditions. Under proposed conditions, the same method of conveyance is proposed, but the quantity of discharge is reduced.

DA-4

DA-4 will decrease from 9.10 to 8.01 acres. The decrease in drainage area limits proposed conditions discharges to quantities comparable to existing discharges.

DA-5

DA-5 will slightly increase in size from 17.70 to 17.94 acres. However, discharge will decrease from existing conditions.

DA-9

DA-9 will slightly increase in size from 4.16 to 4.24 acres. However, discharge will decrease from existing conditions.

DA-11

DA-11 will slightly increase in size from 3.15 to 3.18 acres. However, discharge will decrease from existing conditions.

Drainage Areas 6, 7, 8, and 10

DA-6 and DA-7 will slightly decrease from 15.19 to 15.13 acres and 5.80 to 5.78 acres, respectively. DA-8 will decrease from 3.88 to 3.34 acres and DA-10 will decrease from 0.99 to 0.84 acre. The decrease in drainage areas limit proposed conditions discharges to quantities below existing discharges. The ultimate manner of discharge does not change and no modifications are proposed.

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3. STORMWATER MANAGEMENT

3.1 PROVIDING SAFE CONVEYANCE

Based on the results presented in **Table 3**, runoff flow rates increase in DA-1B. The receiving stormdrain will provide safe conveyance of the 10-year storm based on DPS requirements. Outlet protection will be provided to ensure non-erosive discharges at the outlet at Southlawn Branch.

3.2 NEW CONSTRUCTION OF NORTHWEST SLOPE DISCHARGE FACILITY

Drainage on the upper surface of the Landfill is conveyed primarily by a network of open channel swales. Check dams as necessary will be used to reduce the velocity of the flow within the swales. The swales convey drainage to stormdrain networks along the perimeter of the Landfill. Stormwater runoff on the west and northwest slope will be conveyed by benches and downchutes to a swale at the base of the slope. The benches and downchutes will be protected from erosive impacts as necessary based on the velocity of the flow. A facility will be designed at the low point of the swale to discharge stormwater as sheet flow offsite.

3.3 INTEGRATION OF STORMWATER MANAGEMENT AND EROSION AND SEDIMENT CONTROL

The design will include a phased construction approach. Grading will be limited to 20-acre areas based on the limit imposed by the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. Phase boundaries will consider the drainage patterns. Pond 3 may be used as a sediment basin during construction. Further analysis will be required in future design stages.

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4. REFERENCES

Maryland Department of the Environment (MDE). 2011. *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*.

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Montgomery County Department of Permitting Services. 2016. *Water Resources Technical Policy 5; Computation of Required ESD Volume*. January.

Natural Resources Conservation Service (NRCS). 1986. *Urban Hydrology for Small Watersheds; Technical Release 55*. June.

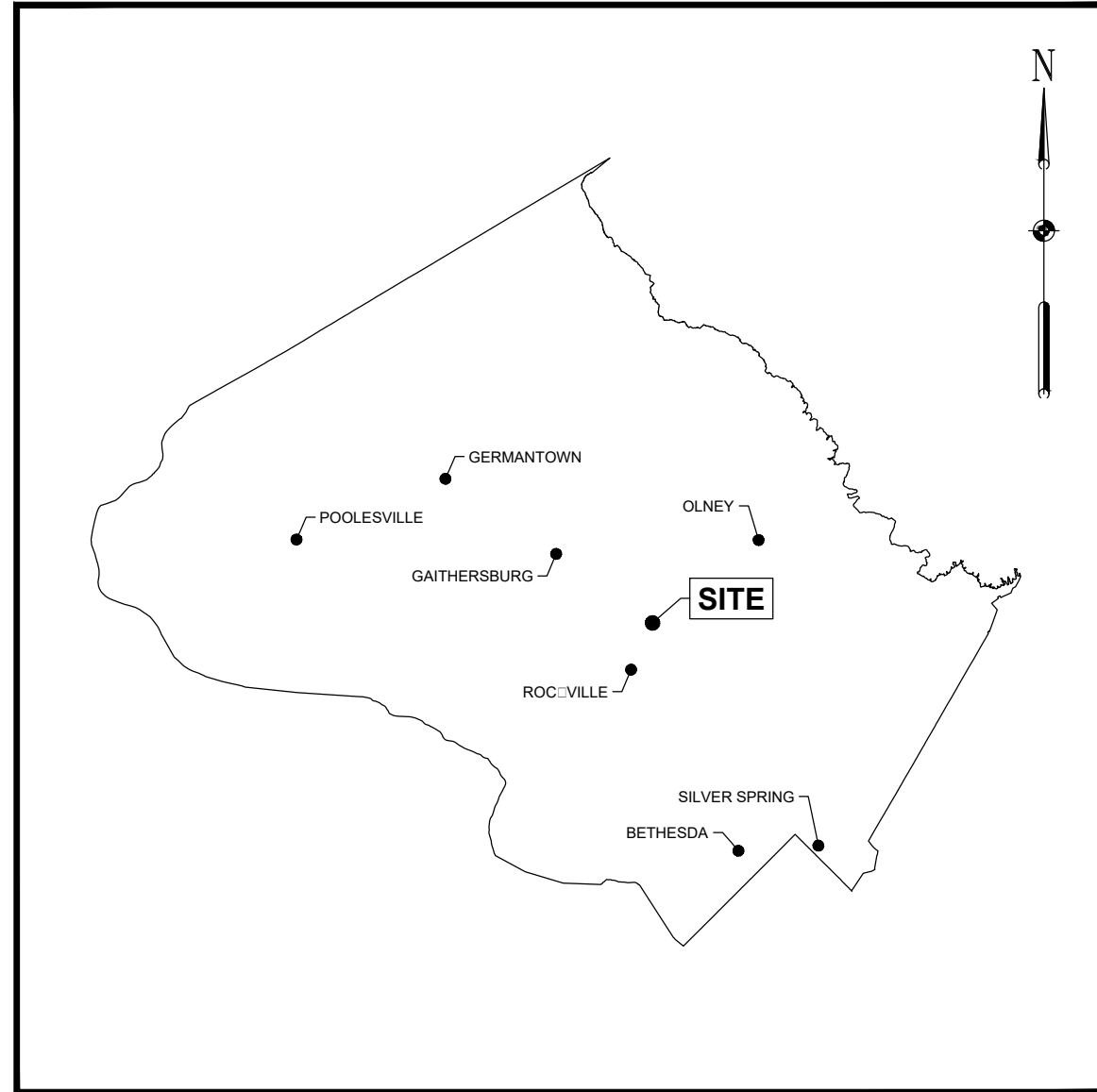
SCS Engineers. 1992. *Gude Landfill Post Closure Engineering Design and Management Tasks*. Drawings.

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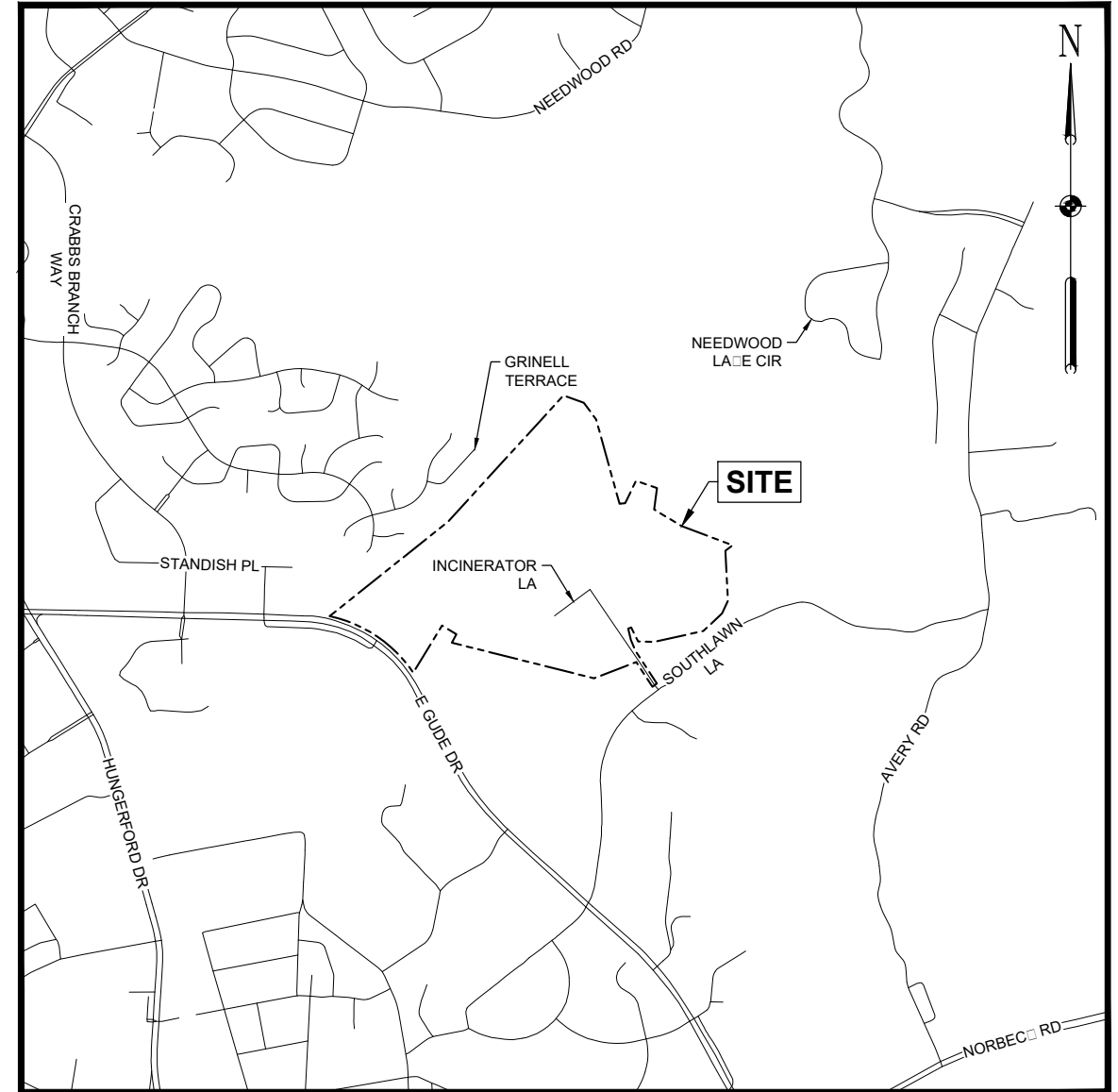
Figures

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FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\WM\FIGURE 1 - VICINITY AND LOCATION MAP.DWG (FIGURE 1) 4/30/19



LOCATION MAP - MONTGOMERY COUNTY, MARYLAND
NOT TO SCALE



VICINITY MAP
SCALE: 1" = 2,000'



EA Engineering, Science, and Technology, Inc., PBC
Hunt Valley Center
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

PROJECT NUMBER:
1564601
DATE:
DECEMBER 2019

DESIGNED BY:
EF/SMB
CHECKED BY:
LJO

DRAWN BY:
SMB
PROJECT MGR.:
MJG

FIGURE:
1
SHEET NUMBER:
1 OF 1

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY, MARYLAND

FIGURE 1 - LOCATION AND VICINITY MAP

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DRAINAGE AREA	PATH	FLOW TYPE	N	LENGTH (FT)	SLOPE (FT/FT)	Tc (HR)
1A	A TO B	SHEET FLOW	0.24	100	0.020	0.240
	B TO C	SHALLOW CONCENTRATED	UNPAVED	760	0.022	0.088
	C TO D	CHANNEL		1000	0.050	0.013
1B	A TO B	SHEET FLOW	0.24	100	0.062	0.153
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1150	0.062	0.080
2	A TO B	SHEET FLOW	0.24	100	0.015	0.269
	B TO C	SHALLOW CONCENTRATED	UNPAVED	600	0.023	0.068
	C TO D	CHANNEL		540	0.082	0.006
3	A TO B	SHEET FLOW	0.24	100	0.011	0.311
	B TO C	SHALLOW CONCENTRATED	UNPAVED	420	0.101	0.023
4	A TO B	SHEET FLOW	0.24	100	0.010	0.317
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1020	0.113	0.052
	A TO B	SHEET FLOW	0.24	100	0.027	0.213
5	B TO C	SHALLOW CONCENTRATED	UNPAVED	330	0.015	0.046
	C TO D	CHANNEL		1200	0.098	0.032
	A TO B	SHEET FLOW	0.24	100	0.045	0.174
6	B TO C	SHALLOW CONCENTRATED	UNPAVED	660	0.190	0.026
	A TO B	SHEET FLOW	0.24	100	0.050	0.166
	B TO C	SHALLOW CONCENTRATED	UNPAVED	580	0.198	0.022
7	C TO D	CHANNEL		120	0.420	0.002
	A TO B	SHEET FLOW	0.24	100	0.029	0.207
	B TO C	SHALLOW CONCENTRATED	UNPAVED	400	0.215	0.015
8	C TO D	CHANNEL		40	0.071	0.002
	A TO B	SHEET FLOW	0.24	100	0.028	0.210
	B TO C	SHALLOW CONCENTRATED	UNPAVED	590	0.164	0.025
9	A TO B	SHEET FLOW	0.24	100	0.020	0.240
	B TO C	SHALLOW CONCENTRATED	UNPAVED	360	0.076	0.022
	A TO B	SHEET FLOW	0.24	100	0.050	0.166
11	B TO C	SHALLOW CONCENTRATED	UNPAVED	600	0.098	0.033



DESCRIPTION	EXISTING	PROPOSED
	STORM DRAIN PIPE	(Symbol)	(Symbol)
STORM DRAIN UTILITY MARKING	(Symbol)	(Symbol)
STORM DRAIN MANHOLE	(Symbol)	(Symbol)
STORM DRAIN INLET	(Symbol)	(Symbol)
SANITARY SEWER PIPE	(Symbol)	(Symbol)
SANITARY SEWER UTILITY MARKING	(Symbol)	(Symbol)
SANITARY SEWER MANHOLE	(Symbol)	(Symbol)
SANITARY SEWER CLEANOUT	(Symbol)	(Symbol)
WATER PIPE	(Symbol)	(Symbol)
WATER UTILITY MARKING	(Symbol)	(Symbol)
WATER MANHOLE	(Symbol)	(Symbol)
WATER METER	(Symbol)	(Symbol)
WATER VALVE	(Symbol)	(Symbol)
WELL	(Symbol)	(Symbol)
FIRE HYDRANT	(Symbol)	(Symbol)
ELECTRIC LINE - UNDERGROUND	(Symbol)	(Symbol)
ELECTRIC LINE UTILITY MARKING (UNDERGROUND)	(Symbol)	(Symbol)
ELECTRIC LINE - OVERHEAD	(Symbol)	(Symbol)
ELECTRIC MANHOLE	(Symbol)	(Symbol)
ELECTRIC JUNCTION BOX	(Symbol)	(Symbol)
ELECTRIC TRANSFORMER	(Symbol)	(Symbol)
LIGHT POLE	(Symbol)	(Symbol)
UTILITY POLE	(Symbol)	(Symbol)
GUY WIRE	(Symbol)	(Symbol)
GUY POLE	(Symbol)	(Symbol)
GAS LINE	(Symbol)	(Symbol)
GAS LINE UTILITY MARKING	(Symbol)	(Symbol)
GAS MANHOLE	(Symbol)	(Symbol)
GAS METER	(Symbol)	(Symbol)
GAS VALVE	(Symbol)	(Symbol)
COMMUNICATIONS/CATV - UNDERGROUND	(Symbol)	(Symbol)
COMMUNICATIONS/CATV - UTILITY MARKING	(Symbol)	(Symbol)
COMMUNICATIONS/CATV MANHOLE	(Symbol)	(Symbol)
COMMUNICATIONS/CATV PEDESTAL	(Symbol)	(Symbol)
TELEPHONE - UNDERGROUND	(Symbol)	(Symbol)
TELEPHONE - UTILITY MARKING	(Symbol)	(Symbol)
TELEPHONE MANHOLE	(Symbol)	(Symbol)
TELEPHONE PEDESTAL	(Symbol)	(Symbol)

REVISIONS
 DESCRIPTION
 NO.
 DATE
 BY

DESIGN INFORMATION
 DESIGNED BY: L.E.F./S.M.B.
 DRAWN BY: S.M.B.
 CHECKED BY: L.J.O./G.A.T.
 PROJECT MANAGER: M.J.G.

SEAL

PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND. LICENSE NO. 23402 EXPIRATION DATE: 8/25/2020

GUIDE LANDFILL REMEDIATION DESIGN

NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY

MONTGOMERY COUNTY DEPARTMENT OF ENVIRONMENTAL PROTECTION

MONTGOMERY COUNTY, MARYLAND

FIGURE 2: DRAINAGE AREA MAP - EXISTING CONDITIONS

EA
Engineering, Science,
and Technology, Inc., PBC
 Hunt Valley Center
 225 Schilling Circle, Suite 400
 Hunt Valley, Maryland 21031
 (410) 584-7000

DATE: FEBRUARY 2020

PROJECT NUMBER: 1564601

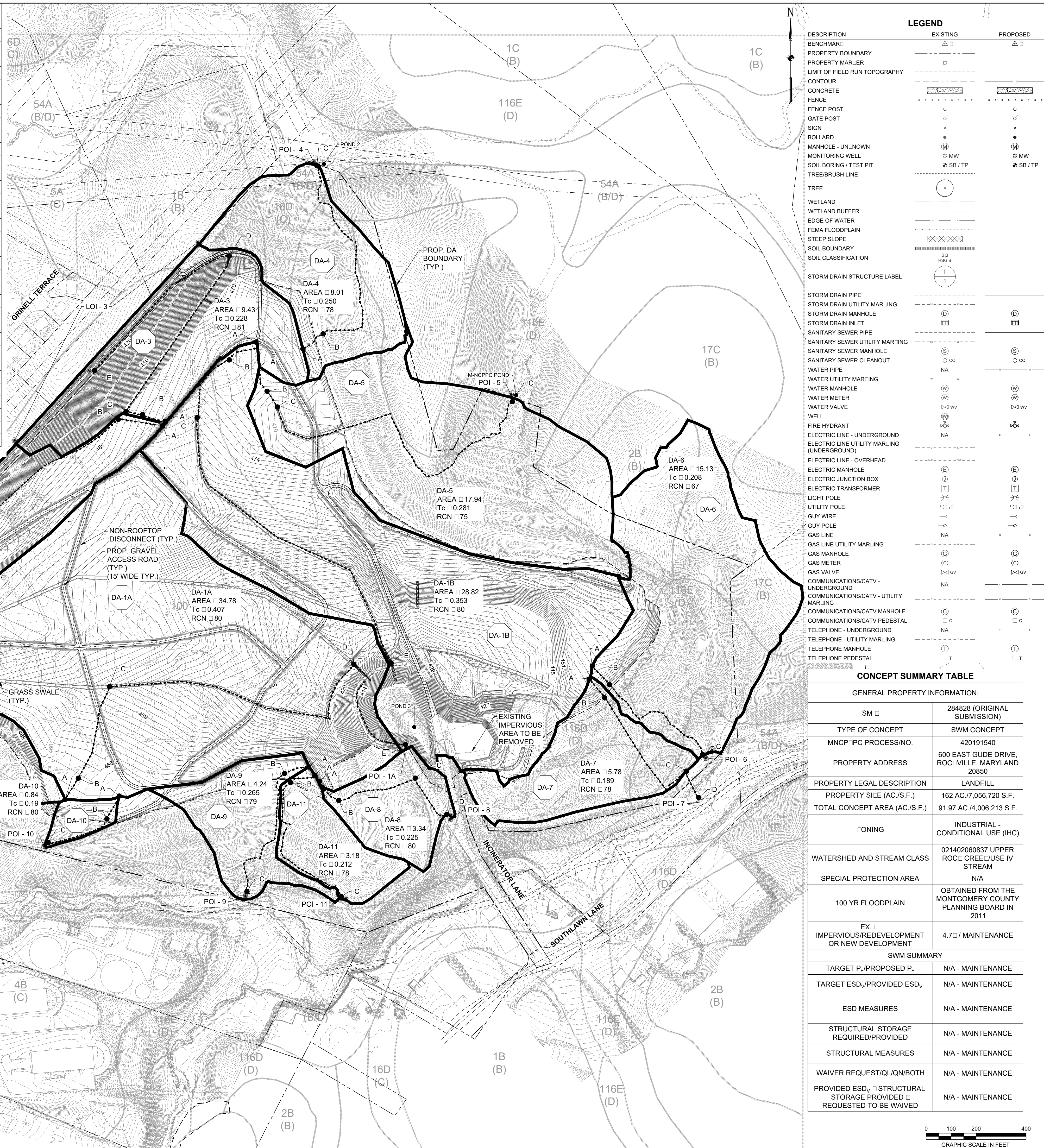
FIGURE 2
 SHEET: - OF -

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DRAINAGE AREA ID	PEAK FLOW (CFS)		
	2-YR STORM	10-YR STORM	100-YR STORM
1A	42.2	86.1	182.8
1B	22.6	45.0	93.9
2	31.8	64.9	137.9
3	14.8	30.2	64.1
4	9.1	19.3	42.5
5	18.7	40.5	90.2
6	9.2	26.8	72.1
7	7.8	16.4	35.7
8	5.4	10.9	23.2
9	5.4	11.2	24.0
10	1.3	2.6	5.6
11	4.1	8.7	19.0



DRAINAGE AREA	PATH	FLOW TYPE	N	LENGTH (FT)	SLOPE (FT/FT)	Tc (HR)
1A	A TO B	SHEET FLOW	0.24	100	0.009	0.330
	B TO C	SHALLOW CONCENTRATED	UNPAVED	391	0.036	0.035
	C TO D	CHANNEL		1153	0.024	0.033
1B	E TO F	CHANNEL		485	0.060	0.009
	A TO B	SHEET	0.24	100	0.013	0.285
	B TO C	SHALLOW CONCENTRATED	UNPAVED	339	0.021	0.040
2	C TO D	CHANNEL		1331	0.034	0.028
	A TO B	SHEET	0.24	100	0.040	0.182
	B TO C	SHALLOW CONCENTRATED	UNPAVED	78	0.056	0.006
3	C TO D	CHANNEL		771	0.130	0.007
	E TO F	CHANNEL		1680	0.016	0.044
	A TO B	SHEET FLOW	0.24	100	0.035	0.192
4	B TO C	SHALLOW CONCENTRATED	UNPAVED	68	0.035	0.006
	C TO D	CHANNEL		817	0.028	0.016
	D TO E	CHANNEL		716	0.038	0.014
5	A TO B	SHEET FLOW	0.24	100	0.030	0.204
	B TO C	SHALLOW CONCENTRATED	UNPAVED	894	0.112	0.046
	A TO B	SHEET FLOW	0.24	100	0.020	0.240
6	B TO C	SHALLOW CONCENTRATED	UNPAVED	75	0.053	0.006
	C TO D	CHANNEL		1265	0.090	0.035
	A TO B	SHEET FLOW	0.24	100	0.040	0.182
7	B TO C	SHALLOW CONCENTRATED	UNPAVED	660	0.190	0.026
	A TO B	SHEET FLOW	0.24	100	0.050	0.166
	B TO C	SHALLOW CONCENTRATED	UNPAVED	540	0.194	0.021
8	C TO D	CHANNEL		120	0.420	0.002
	A TO B	SHEET FLOW	0.24	100	0.030	0.204
	B TO C	SHALLOW CONCENTRATED	UNPAVED	500	0.215	0.019
9	C TO D	CHANNEL		40	0.071	0.002
	A TO B	SHEET FLOW	0.24	100	0.020	0.240
	B TO C	SHALLOW CONCENTRATED	UNPAVED	590	0.164	0.025
10	A TO B	SHEET FLOW	0.24	100	0.045	0.174
	B TO C	SHALLOW CONCENTRATED	UNPAVED	281	0.091	0.016
	A TO B	SHEET FLOW	0.24	100	0.042	0.178
11	B TO C	SHALLOW CONCENTRATED	UNPAVED	621	0.100	0.034



LEGEND

DESCRIPTION	EXISTING	PROPOSED
BENCHMARK		
PROPERTY BOUNDARY		
PROPERTY MARKER		
LIMIT OF FIELD RUN TOPOGRAPHY		
CONTOUR		
CONCRETE		
FENCE		
FENCE POST		
GATE POST		
SIGN		
BOLLARD		
MANHOLE - UNKNOWN		
MONITORING WELL		
SOIL BORING / TEST PIT		
TREE/BRUSH LINE		
TREE		
WETLAND		
WETLAND BUFFER		
EDGE OF WATER		
FEMA FLOODPLAIN		
STEEP SLOPE		
SOIL BOUNDARY		
SOIL CLASSIFICATION		
STORM DRAIN STRUCTURE LABEL		
STORM DRAIN PIPE		
STORM DRAIN UTILITY MARKING		
STORM DRAIN MANHOLE		
STORM DRAIN INLET		
SANITARY SEWER PIPE		
SANITARY SEWER UTILITY MARKING		
SANITARY SEWER MANHOLE		
SANITARY SEWER CLEANOUT		
WATER PIPE		
WATER UTILITY MARKING		
WATER MANHOLE		
WATER METER		
WATER VALVE		
WELL		
FIRE HYDRANT		
ELECTRIC LINE - UNDERGROUND		
ELECTRIC LINE UTILITY MARKING (UNDERGROUND)		
ELECTRIC LINE - OVERHEAD		
ELECTRIC MANHOLE		
ELECTRIC JUNCTION BOX		
ELECTRIC TRANSFORMER		
LIGHT POLE		
UTILITY POLE		
GUY WIRE		
GUY WIRE		
GAS LINE		
GAS LINE UTILITY MARKING		
GAS MANHOLE		
GAS METER		
GAS VALVE		
COMMUNICATIONS/CATV - UNDERGROUND		
COMMUNICATIONS/CATV - UTILITY MARKING		
COMMUNICATIONS/CATV MANHOLE		
COMMUNICATIONS/CATV PEDESTAL		
TELEPHONE - UNDERGROUND		
TELEPHONE - UTILITY MARKING		
TELEPHONE MANHOLE		
TELEPHONE PEDESTAL		

DRAINAGE AREA	PEAK FLOW (CFS)		
ID	2-YR STORM	10-YR STORM	100-YR STORM
1A	36.8	75.3	160.3
1B	32.8	66.8	142.3
2	29.1	59.1	125.1
3	13.7	27.3	56.8
4	9.6	20.3	44.3
5	17.1	38.7	89.2
6	9.0	26.3	70.7
7	7.8	16.4	35.7
8	4.6	9.4	20.0
9	5.2	10.8	23.3
10	1.3	2.5	5.3
11	4.1	8.6	18.8

CONCEPT SUMMARY TABLE

GENERAL PROPERTY INFORMATION:	
SM	284828 (ORIGINAL SUBMISSION)
TYPE OF CONCEPT	SWM CONCEPT
MNCP_PC PROCESS/NO.	420191540
PROPERTY ADDRESS	600 EAST GUIDE DRIVE, ROCKVILLE, MARYLAND 20850
PROPERTY LEGAL DESCRIPTION	LANDFILL
PROPERTY SIZE (AC./S.F.)	162 AC./7,056,720 S.F.
TOTAL CONCEPT AREA (AC./S.F.)	91.97 AC./4,006,213 S.F.
ZONING	INDUSTRIAL - CONDITIONAL USE (IHC)
WATERSHED AND STREAM CLASS	021402060837 UPPER ROC: CREEK/USE IV STREAM
SPECIAL PROTECTION AREA	N/A
100 YR FLOODPLAIN	OBTAINED FROM THE MONTGOMERY COUNTY PLANNING BOARD IN 2011
EX/REDEVELOPMENT OR NEW DEVELOPMENT	4.7% MAINTENANCE
SWM SUMMARY	
TARGET P ₂ /PROPOSED P _e	N/A - MAINTENANCE
TARGET ESD _v /PROVIDED ESD _v	N/A - MAINTENANCE
ESD MEASURES	N/A - MAINTENANCE
STRUCTURAL STORAGE REQUIRED/PROVIDED	N/A - MAINTENANCE
STRUCTURAL MEASURES	N/A - MAINTENANCE
WAIVER REQUEST/QL/QN/BOTH	N/A - MAINTENANCE
PROVIDED ESD _v / STRUCTURAL STORAGE PROVIDED / REQUESTED TO BE WAIVED	N/A - MAINTENANCE

DESIGNED BY: LEF / SMB
DRAWN BY: SMB
CHECKED BY: LJO / GAT
PROJECT MANAGER: MJG

PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 23402, EXPIRATION DATE: 8/25/2020

DESIGN INFORMATION

REVISIONS

DATE

NO.

BY

DESCRIPTION

SEAL

MONTGOMERY COUNTY, MARYLAND

GUIDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY DEPARTMENT OF ENVIRONMENTAL PROTECTION

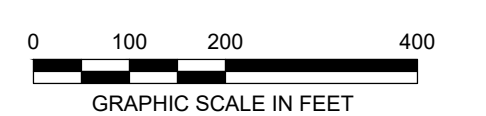
FIGURE 3: DRAINAGE AREA MAP - PROPOSED CONDITIONS

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

DATE: FEBRUARY 2020
PROJECT NUMBER: 1564601

FIGURE 3
SHEET: - OF -

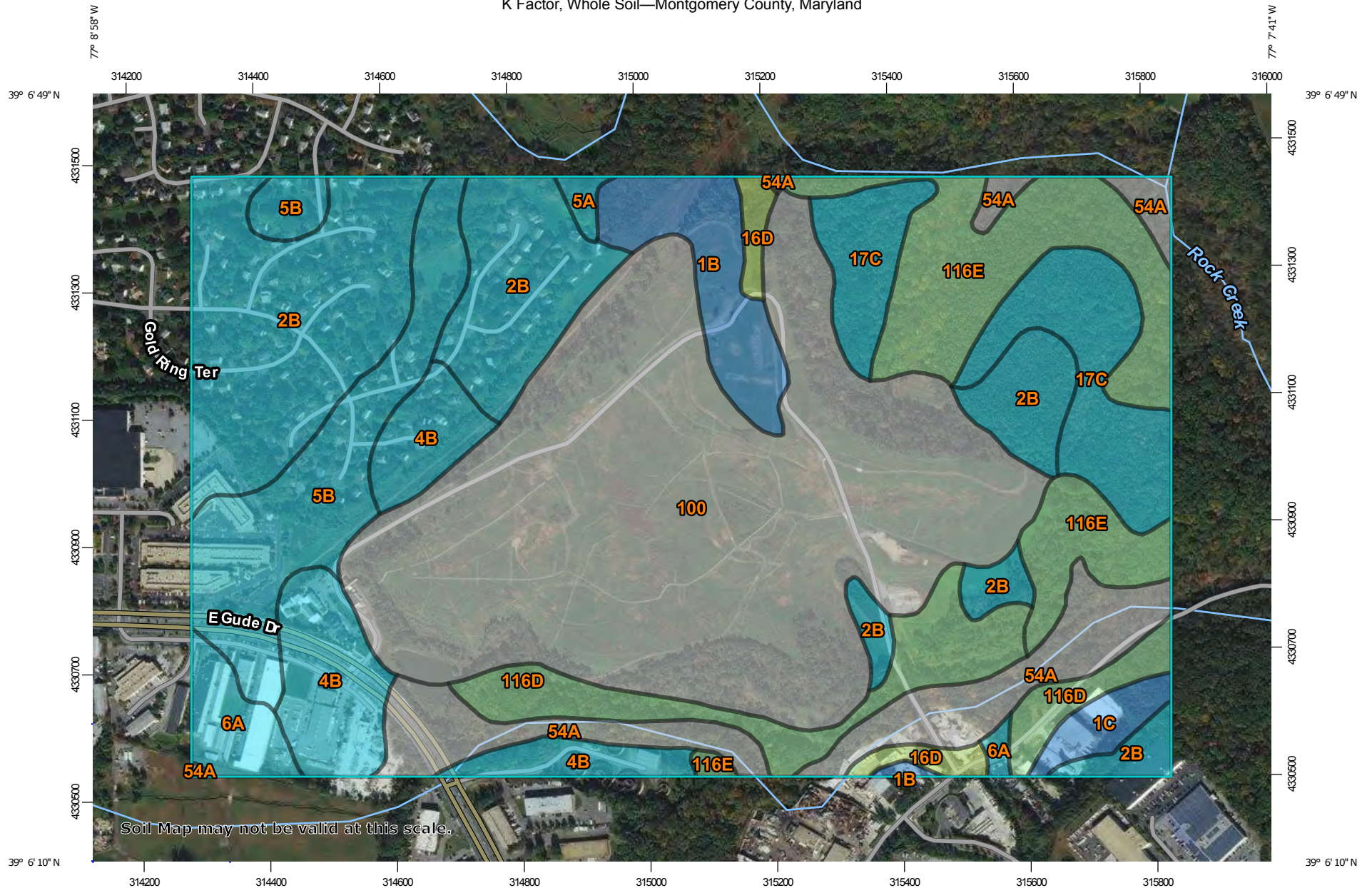
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DATE PLOTTED: 2/10/2020 11:57 AM



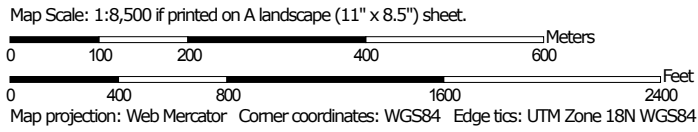
Appendix A
Web Soil Survey

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K Factor, Whole Soil—Montgomery County, Maryland




Soil Map may not be valid at this scale.


















MAP LEGEND

Area of Interest (AOI)







 Area of Interest (AOI)










Soils

Soil Rating Polygons
















-  .02
-  .05
-  .10
-  .15
-  .17
-  .20
-  .24
-  .28
-  .32
-  .37
-  .43
-  .49
-  .55
-  .64
-  Not rated or not available

Soil Rating Lines








-  .02
-  .05
-  .10
-  .15
-  .17
-  .20

-  .24
-  .28
-  .32
-  .37
-  .43
-  .49
-  .55
-  .64
-  Not rated or not available

Soil Rating Points

-  .02
-  .05
-  .10
-  .15
-  .17
-  .20
-  .24
-  .28
-  .32
-  .37
-  .43
-  .49
-  .55
-  .64
-  Not rated or not available

Water Features

-  Streams and Canals
- Transportation**
-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads
- Background**
-  Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Montgomery County, Maryland
 Survey Area Data: Version 13, Sep 18, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Gaila silt loam, 3 to 8 percent slopes	.43	12.9	3.6%
1C	Gaila silt loam, 8 to 15 percent slopes	.43	3.9	1.1%
2B	Glenelg silt loam, 3 to 8 percent slopes	.37	61.9	17.1%
4B	Elioak silt loam, 3 to 8 percent slopes	.37	22.3	6.2%
5A	Glenville silt loam, 0 to 3 percent slopes	.37	1.2	0.3%
5B	Glenville silt loam, 3 to 8 percent slopes	.37	27.1	7.5%
6A	Baile silt loam, 0 to 3 percent slopes	.37	6.5	1.8%
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	.24	3.8	1.0%
17C	Occoquan loam, 8 to 15 percent slopes	.37	23.8	6.6%
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded		24.9	6.9%
100	Dumps, refuse		121.9	33.7%
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	.28	19.9	5.5%
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	.28	31.6	8.7%
Totals for Area of Interest			361.8	100.0%

Description

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

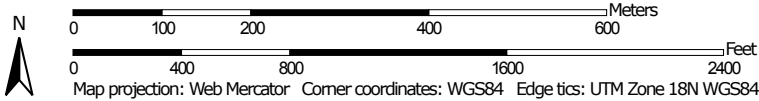
Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Hydrologic Soil Group—Montgomery County, Maryland




Map Scale: 1:8,500 if printed on A landscape (11" x 8.5") sheet.




MAP LEGEND

Area of Interest (AOI)









 Area of Interest (AOI)

Soils

Soil Rating Polygons





 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Lines


 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Points






 A
 A/D
 B
 B/D

 C
 C/D
 D
 Not rated or not available

Water Features

 Streams and Canals

Transportation

 Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Montgomery County, Maryland
 Survey Area Data: Version 13, Sep 18, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Gaila silt loam, 3 to 8 percent slopes	B	12.9	3.6%
1C	Gaila silt loam, 8 to 15 percent slopes	B	3.9	1.1%
2B	Glenelg silt loam, 3 to 8 percent slopes	B	61.9	17.1%
4B	Elioak silt loam, 3 to 8 percent slopes	C	22.3	6.2%
5A	Glenville silt loam, 0 to 3 percent slopes	C	1.2	0.3%
5B	Glenville silt loam, 3 to 8 percent slopes	C/D	27.1	7.5%
6A	Baile silt loam, 0 to 3 percent slopes	C/D	6.5	1.8%
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	C	3.8	1.0%
17C	Occoquan loam, 8 to 15 percent slopes	B	23.8	6.6%
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B/D	24.9	6.9%
100	Dumps, refuse		121.9	33.7%
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	D	19.9	5.5%
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	D	31.6	8.7%
Totals for Area of Interest			361.8	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix B
SCS Engineers Plans

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MATCH LINE - SEE SHEET 5

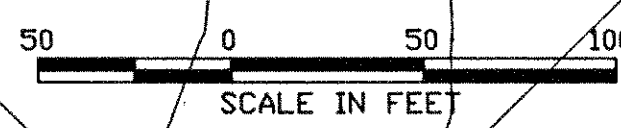
MATCH LINE - SEE SHEET 6

FOR FINAL COVERING SYSTEM SEE DETAIL 5

DRAINAGE CENTERLINE CURVE/COORDINATE DATA									
STRUCT./INLET	SWALE	CURVE	RADIUS	TANGENT	LENGTH	CHORD	DELTA	CHORD BEARING	COORDINATES
								NORTHING	EASTING
H1									79,194.00 -36,007.50
H2									79,303.50 -36,041.50
H3									79,486.50 -36,085.74
H4		1	168.08	68.27	129.69	126.51	44 12'45"	N32 14'43"W	79,691.60 -36,188.36
H5									79,519.00 -36,952.50
I1	H	1	530.50	49.81	99.33	99.19	10 43'43"	N63 01'18"W	79,190.00 -36,022.00
I2									79,316.00 -36,162.50
I3									79,381.00 -36,237.50
I4									79,490.00 -36,364.00
J1								Centerline Bearing From Station 0+00 N57 02'41"W	79,176.00 -36,032.00
J2									79,190.00 -36,140.00
J3								Centerline Bearing From Station 0+00 N86 19'24"W	79,206.00 -36,389.00



STRUCT./INLET	COORDINATES	
NORTHING		EASTING
D8	79,988.50	-35,962.00
D9	79,077.50	-35,948.50
B1	80,256.50	-35,533.00
B2	80,242.00	-35,504.00
B3	80,008.00	-35,440.00
B4	80,004.50	-35,409.00
B5	79,807.00	-36,000.00
B6	79,797.00	-36,016.00



MATCH LINE - SEE SHEET 10

NO.	REVISION	DATE

SHEET TITLE: **SITE PLAN 6 SWM AND EROSION CONTROL**

PROJECT TITLE: **GUDE LANDFILL POST CLOSURE ENGINEERING DESIGN AND MANAGEMENT TASKS**

CLIENT: **MONTGOMERY COUNTY, MARYLAND**

SCS ENGINEERS
 STEARNS, CONRAD AND SCHMIDT
 CONSULTING ENGINEERS
 1650 ROBERT BACON DRIVE - RESTON, VA 20190
 PH. 703 471-6660 FAX. 703 471-6676

DATE: 6-22-92

SCALE: 1" = 50'

SHEET NO. 8 of 30

SEDIMENTATION BASIN A

***** SUMMARY OF ROUTING COMPUTATIONS *****

Summary of routing computations for SEDA .PND. Inflow Hydrograph: SEDA2 .HYD. Outflow Hydrograph: SEDA-2 .HYD. Starting Pond W.S. Elevation = 389.00 ft. Summary of Peak Outflow and Peak Elevation: Peak Inflow = 45.00 cfs, Peak Outflow = 39.99 cfs, Peak Elevation = 393.00 ft.

ROUTING COMPUTATIONS table with columns: TIME (hrs), INFLOW (cfs), 11+I2 (cfs), 2S/t - 0 (cfs), 2S/t + 0 (cfs), OUTFLOW (cfs), ELEVATION (ft).

CALCULATED 06-24-1992 13:26:21
DISK FILE: SEDA .VOL

Planimeter scale: 1 inch = 30 ft. Table with columns: Elevation (ft), Planimeter (sq.in.), Area (acres), A1+A2+sqrt(A1*A2) (acres), Volume (acre-ft), Volume Sum (acre-ft).

IA = (sqrt(Areal) + ((E1-E1)/(E2-E1))*(sqrt(Areal2)-sqrt(Areal)))^2
where: E1, E2 = Closest two elevations with planimeter data
E1 = Elevation at which to interpolate area
Areal, Area2 = Areas computed for E1, E2, respectively
IA = Interpolated area for E1

* Incremental volume computed by the Conic Method for Reservoir Volumes.
Volume = (1/3) * (E2-E1) * (Areal + Area2 + sqrt(Areal*Area2))
where: E1, E2 = Lower and upper elevations of the increment
Areal, Area2 = Areas computed for E1, E2, respectively
Volume = Incremental volume between E1 and E2

Tc COMPUTATIONS FOR: DA7

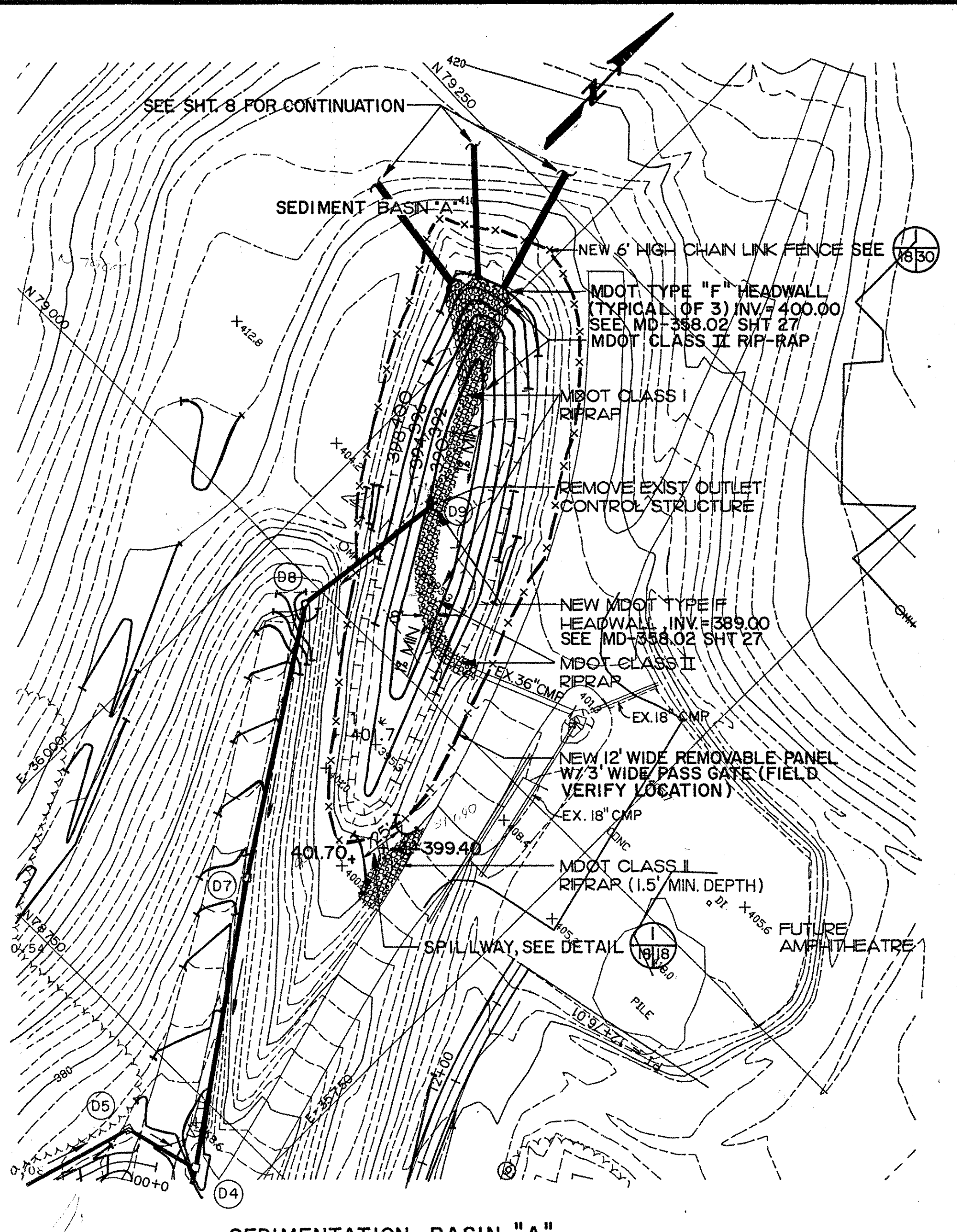
SHEET FLOW (Applicable to Tc only) table with columns: Segment ID, Surface description, Manning's roughness coeff., n, Flow length, L (total < or = 300), Two-yr 24-hr rainfall, P2, Land slope, s.

SHALLOW CONCENTRATED FLOW table with columns: Segment ID, Surface (paved or unpaved)?, Flow length, L, Watercourse slope, s, Avg. V = Csf * (s), where: Unpaved Csf = 16.1345, Paved Csf = 20.3282.

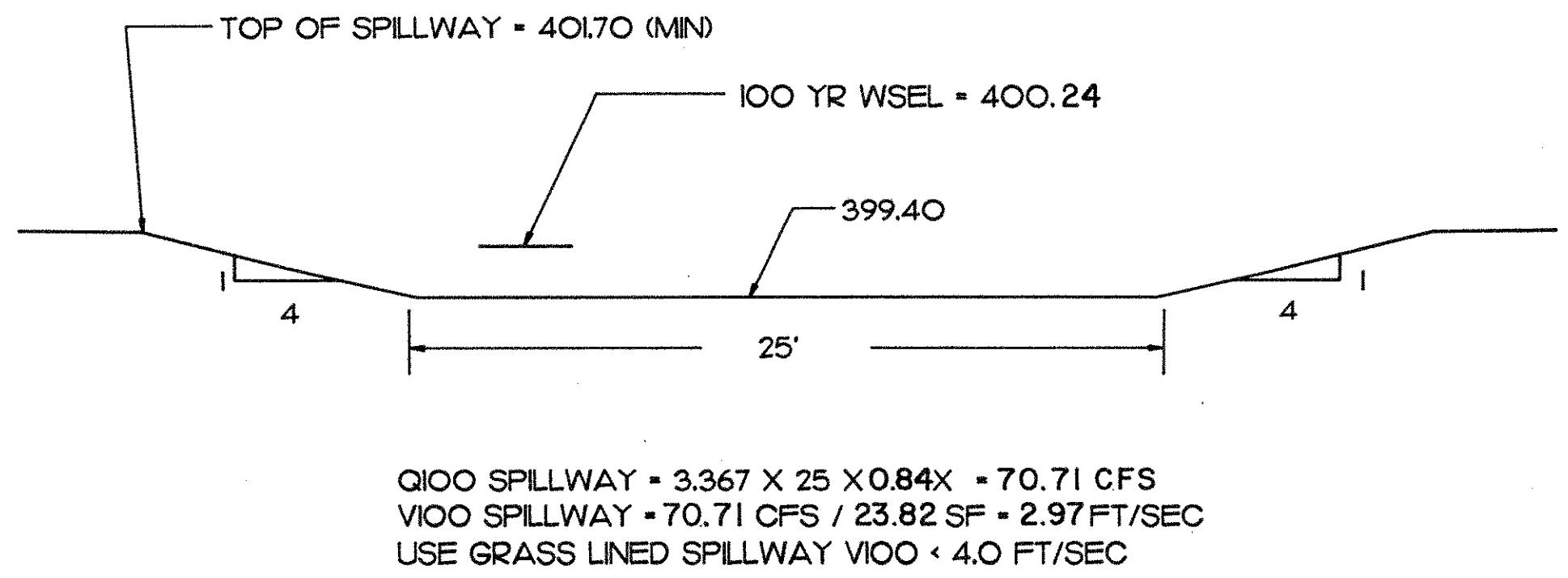
CHANNEL FLOW table with columns: Segment ID, Cross Sectional Flow Area, a, Wetted perimeter, Pw, Hydraulic radius, r = a/Pw, Channel slope, s, Manning's roughness coeff., n.

V = (1.49 * r^(2/3) * s^(1/2)) / n
Flow length, L
T = L / (3600*V)
TOTAL TIME (hrs) = 0.66

GUDE LANDFILL SEDIMENTATION BASIN A DRAINAGE AREA 7 POST DEVELOPED CONDITIONS. RUNOFF CURVE NUMBER DATA table with columns: SURFACE DESCRIPTION, AREA (acres), CN.



SEDIMENTATION BASIN "A" SCALE IN FEET



TYPICAL X-SECTION THROUGH SPILLWAY NO SCALE

***** SUMMARY OF ROUTING COMPUTATIONS *****

Summary of routing computations for SEDA .PND. Inflow Hydrograph: SEDA10 .HYD. Outflow Hydrograph: SEDA-10 .HYD. Starting Pond W.S. Elevation = 389.00 ft. Summary of Peak Outflow and Peak Elevation: Peak Inflow = 102.00 cfs, Peak Outflow = 73.70 cfs, Peak Elevation = 397.28 ft.

ROUTING COMPUTATIONS table with columns: TIME (hrs), INFLOW (cfs), 11+I2 (cfs), 2S/t - 0 (cfs), 2S/t + 0 (cfs), OUTFLOW (cfs), ELEVATION (ft).

***** SUMMARY OF ROUTING COMPUTATIONS *****

Summary of routing computations for SEDA .PND. Inflow Hydrograph: SEDA25 .HYD. Outflow Hydrograph: SEDA-25 .HYD. Starting Pond W.S. Elevation = 389.00 ft. Summary of Peak Outflow and Peak Elevation: Peak Inflow = 123.00 cfs, Peak Outflow = 80.48 cfs, Peak Elevation = 398.83 ft.

ROUTING COMPUTATIONS table with columns: TIME (hrs), INFLOW (cfs), 11+I2 (cfs), 2S/t - 0 (cfs), 2S/t + 0 (cfs), OUTFLOW (cfs), ELEVATION (ft).

***** SUMMARY OF ROUTING COMPUTATIONS *****

Summary of routing computations for SEDA .PND. Inflow Hydrograph: SEDA100 .HYD. Outflow Hydrograph: SEDA-100 .HYD. Starting Pond W.S. Elevation = 389.00 ft. Summary of Peak Outflow and Peak Elevation: Peak Inflow = 170.00 cfs, Peak Outflow = 158.26 cfs, Peak Elevation = 400.24 ft.

ROUTING COMPUTATIONS table with columns: TIME (hrs), INFLOW (cfs), 11+I2 (cfs), 2S/t - 0 (cfs), 2S/t + 0 (cfs), OUTFLOW (cfs), ELEVATION (ft).

Project information block including SCS ENGINEERS logo, client name (MONTGOMERY COUNTY, MARYLAND), project title (DETENTION BASIN 'A'), sheet title (GUIDE LANDFILL), and drawing number (18 of 30).

Appendix C

TR-55 Calculations – Existing and Proposed

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/11/2019
Project: Gude Units: English
SubTitle: DA-1A Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1A EX		Outlet	36.5	80	.341
DA-1A PR		Outlet	34.78	80	.407

Total area: 71.28 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-1A EX	42.15	86.07	182.78
DA-1A PR	36.82	75.34	160.29
REACHES			
OUTLET	78.38	160.18	340.80

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period		
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-1A EX	42.15	86.07	182.78
	12.26	12.25	12.24

DA-1A PR	36.82	75.34	160.29
	12.29	12.28	12.30

REACHES

OUTLET	78.38	160.18	340.80
--------	-------	--------	--------

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-1A EX	36.50	0.341	80	Outlet	
DA-1A PR	34.78	0.407	80	Outlet	
Total Area:	71.28 (ac)				

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-1A EX							
SHEET	100	0.0200	0.240				0.240
SHALLOW	760	0.0220	0.050				0.088
CHANNEL	1000	0.0500	0.013	7.07	9.40	21.368	0.013
							Time of Concentration .341
							=====
DA-1A PR							
SHEET	100	0.0090	0.240				0.330
SHALLOW	391	0.0360	0.050				0.035
CHANNEL	1153	0.0240	0.030	18.00	12.47	9.705	0.033
CHANNEL	485	0.0600	0.030	18.00	12.47	14.969	0.009
							Time of Concentration .407
							=====

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-1A EX	Dirt (w/ right-of-way)	D	.36	89
	Pasture, grassland or range	(good) D	36.14	80
	Total Area / Weighted Curve Number		36.5	80
			====	==
DA-1A PR	Gravel (w/ right-of-way)	D	1.49	91
	Pasture, grassland or range	(good) D	33.29	80
	Total Area / Weighted Curve Number		34.78	80
			=====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/11/2019
 Project: Gude Units: English
 SubTitle: DA-1B Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1B EX		Outlet	15.69	81	0.233
DA-1B PR		Outlet	28.82	80	.353

Total area: 44.51 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-1B EX	22.61	44.98	93.88
DA-1B PR	32.75	66.75	142.26
REACHES			
OUTLET	53.34	108.12	229.00

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

DA-1B EX 22.61 44.98 93.88
12.19 12.18 12.18

DA-1B PR 32.75 66.75 142.26
12.27 12.27 12.26

REACHES

OUTLET 53.34 108.12 229.00

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-1B EX	15.69	0.233	81	Outlet	
DA-1B PR	28.82	0.353	80	Outlet	

Total Area:	44.51 (ac)				

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-1B EX							
SHEET	100	0.0620	0.240				0.153
SHALLOW	1150	0.0616	0.050				0.080
						Time of Concentration	0.233
							=====
DA-1B PR							
SHEET	100	0.0130	0.240				0.285
SHALLOW	339	0.0210	0.050				0.040
CHANNEL	1331	0.0340	0.013	3.14	6.30	13.204	0.028
						Time of Concentration	.353
							=====

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-1B EX	Paved parking lots, roofs, driveways	D	.55	98
	Dirt (w/ right-of-way)	D	.62	89
	Pasture, grassland or range (good)	D	14.33	80
	Woods (good)	D	.19	77
	Total Area / Weighted Curve Number		15.69	81
			=====	==
DA-1B PR	Gravel (w/ right-of-way)	D	1.07	91
	Pasture, grassland or range (good)	D	27.75	80
	Total Area / Weighted Curve Number		28.82	80
			=====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/12/2019
 Project: Gude Units: English
 SubTitle: DA-2 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-2 EX		Outlet	27.61	80	.343
DA-2 PR		Outlet	21.47	80	.239

Total area: 49.08 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-2 EX	31.76	64.87	137.87
DA-2 PR	29.07	59.05	125.13
REACHES			
OUTLET	59.29	120.94	256.74

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

DA-2 EX 31.76 64.87 137.87
12.25 12.26 12.24

DA-2 PR 29.07 59.05 125.13
12.19 12.19 12.19

REACHES

OUTLET 59.29 120.94 256.74

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-2 EX	27.61	0.343	80	Outlet	
DA-2 PR	21.47	0.239	80	Outlet	

Total Area:	49.08 (ac)				

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-2 EX							
SHEET	100	0.0150	0.240				0.269
SHALLOW	600	0.0233	0.050				0.068
CHANNEL	540	0.0820	0.013	4.91	7.90	25.000	0.006
							Time of Concentration .343
							=====
DA-2 PR							
SHEET	100	0.0400	0.240				0.182
SHALLOW	78	0.0560	0.050				0.006
CHANNEL	771	0.1300	0.013	4.91	7.90	30.595	0.007
CHANNEL	1680	0.0160	0.013	4.91	7.90	10.606	0.044
							Time of Concentration .239
							=====

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-2 EX	Dirt (w/ right-of-way)	D	.69	89
	Pasture, grassland or range	(good) D	26.06	80
	Woods	(good) D	.86	77
	Total Area / Weighted Curve Number		27.61	80
			=====	==
DA-2 PR	Gravel (w/ right-of-way)	D	.98	91
	Pasture, grassland or range	(good) D	19.63	80
	Woods	(good) D	.86	77
	Total Area / Weighted Curve Number		21.47	80
			=====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/12/2019
Project: Gude Units: English
SubTitle: DA-3 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-3 EX		Outlet	12.68	80	.334
DA-3 PR		Outlet	9.43	81	.228

Total area: 22.11 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-3 EX	14.77	30.15	64.06
DA-3 PR	13.68	27.31	56.82
REACHES			
OUTLET	27.61	55.86	117.88

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
 (hr) (hr) (hr)

SUBAREAS

DA-3 EX 14.77 30.15 64.06
 12.26 12.25 12.23

DA-3 PR 13.68 27.31 56.82
 12.19 12.19 12.18

REACHES

OUTLET 27.61 55.86 117.88

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-3 EX	12.68	0.334	80	Outlet	
DA-3 PR	9.43	0.228	81	Outlet	

Total Area:	22.11 (ac)				

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-3 EX							
SHEET	100	0.0105	0.240				0.311
SHALLOW	420	0.1010	0.050				0.023
						Time of Concentration	.334
							=====
DA-3 PR							
SHEET	100	0.0350	0.240				0.192
SHALLOW	68	0.0350	0.050				0.006
CHANNEL	817	0.0280	0.022	18.00	12.47	14.184	0.016
CHANNEL	716	0.0380	0.013	3.14	6.30	14.206	0.014
						Time of Concentration	.228
							=====

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-3 EX	Paved parking lots, roofs, driveways	D	.07	98
	Dirt (w/ right-of-way)	D	.25	89
	Pasture, grassland or range (good)	D	10.74	80
	Woods (good)	D	1.62	77
	Total Area / Weighted Curve Number		12.68	80
			=====	==
DA-3 PR	Gravel (w/ right-of-way)	D	.6	91
	Pasture, grassland or range (good)	D	8.83	80
	Total Area / Weighted Curve Number		9.43	81
			====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/13/2019
 Project: Gude Units: English
 SubTitle: DA-4 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-4 EX		Outlet	9.1	78	0.369
DA-4 PR		Outlet	8.01	78	.25

Total area: 17.11 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-4 EX	9.07	19.33	42.49
DA-4 PR	9.56	20.27	44.29
REACHES			
OUTLET	18.04	38.43	84.44

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

DA-4 EX 9.07 19.33 42.49
12.29 12.27 12.27

DA-4 PR 9.56 20.27 44.29
12.21 12.20 12.19

REACHES

OUTLET 18.04 38.43 84.44

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-4 EX	9.10	0.369	78	Outlet	
DA-4 PR	8.01	0.250	78	Outlet	

Total Area:	17.11 (ac)				

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-4 EX							
SHEET	100	0.0100	0.240				0.317
SHALLOW	1020	0.1130	0.050				0.052
						Time of Concentration	0.369
							=====
DA-4 PR							
SHEET	100	0.0300	0.240				0.204
SHALLOW	894	0.1120	0.050				0.046
						Time of Concentration	.25
							=====

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-4 EX	Dirt (w/ right-of-way)		D	.24	89
	Pasture, grassland or range	(good)	D	1.47	80
	Woods	(good)	D	7.39	77
	Total Area / Weighted Curve Number			9.1	78
				===	==
DA-4 PR	Pasture, grassland or range	(good)	D	1.46	80
	Woods	(good)	D	6.55	77
	Total Area / Weighted Curve Number			8.01	78
				====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/9/2019
 Project: Gude Units: English
 SubTitle: DA-5 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-5 EX		Outlet	17.7	77	.291
DA-5 PR		Outlet	17.94	75	.281

Total area: 35.64 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-5 EX	18.66	40.48	90.17
DA-5 PR	17.05	38.71	89.23
REACHES			
OUTLET	35.64	79.09	179.09

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period		
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-5 EX	18.66	40.48	90.17
	12.23	12.23	12.22

DA-5 PR	17.05	38.71	89.23
	12.22	12.22	12.21

REACHES

OUTLET	35.64	79.09	179.09
--------	-------	-------	--------

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-5 EX	17.70	0.291	77	Outlet	
DA-5 PR	17.94	0.281	75	Outlet	
Total Area:	35.64 (ac)				

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-5 EX							
SHEET	100	0.0270	0.240				0.213
SHALLOW	330	0.0150	0.050				0.046
CHANNEL	1200	0.0980	0.030	3.00	5.50	10.417	0.032
							Time of Concentration .291
							=====
DA-5 PR							
SHEET	100	0.0200	0.240				0.240
SHALLOW	75	0.0530	0.050				0.006
CHANNEL	1265	0.0900	0.030	3.00	5.50	10.040	0.035
							Time of Concentration .281
							=====

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-5 EX	Paved parking lots, roofs, driveways	D	.28	98
	Dirt (w/ right-of-way)	D	.09	89
	Pasture, grassland or range (good)	C	3.65	74
	Woods (good)	D	13.68	77
	Total Area / Weighted Curve Number		17.7	77
			====	==
DA-5 PR	Gravel (w/ right-of-way)	D	.12	91
	Pasture, grassland or range (good)	C	14.97	74
	Pasture, grassland or range (good)	D	2.85	80
	Total Area / Weighted Curve Number		17.94	75
			=====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/10/2019
 Project: Gude Units: English
 SubTitle: DA-6 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-6 EX		Outlet	15.19	67	.2
DA-6 PR		Outlet	15.13	67	.208

Total area: 30.32 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-6 EX	9.18	26.77	72.12
DA-6 PR	9.00	26.26	70.65
REACHES			
OUTLET	18.15	53.02	142.75

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
 (hr) (hr) (hr)

SUBAREAS

DA-6 EX 9.18 26.77 72.12
 12.18 12.18 12.17

DA-6 PR 9.00 26.26 70.65
 12.19 12.19 12.17

REACHES

OUTLET 18.15 53.02 142.75

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-6 EX	15.19	0.200	67	Outlet	
DA-6 PR	15.13	0.208	67	Outlet	

Total Area:	30.32 (ac)				

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-6 EX							
SHEET	100	0.0450	0.240				0.174
SHALLOW	660	0.1900	0.050				0.026
					Time of Concentration		.2
							=====
DA-6 PR							
SHEET	100	0.0400	0.240				0.182
SHALLOW	660	0.1900	0.050				0.026
					Time of Concentration		.208
							=====

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-6 EX	Dirt (w/ right-of-way)		D	.03	89
	Pasture, grassland or range	(good)	D	1.96	80
	Woods	(good)	B	7.44	55
	Woods	(good)	D	5.76	77
	Total Area / Weighted Curve Number			15.19	67
				=====	==
DA-6 PR	Gravel (w/ right-of-way)		D	.12	91
	Pasture, grassland or range	(good)	D	1.81	80
	Woods	(good)	B	7.44	55
	Woods	(good)	D	5.76	77
	Total Area / Weighted Curve Number			15.13	67
				=====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/10/2019
 Project: Gude Units: English
 SubTitle: DA-7 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-7 EX		Outlet	5.8	78	.19
DA-7 PR		Outlet	5.78	78	.189

Total area: 11.58 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-7 EX	7.77	16.38	35.70
DA-7 PR	7.76	16.35	35.65
REACHES			
OUTLET	15.53	32.71	71.34

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

DA-7 EX 7.77 16.38 35.70
12.17 12.17 12.16

DA-7 PR 7.76 16.35 35.65
12.17 12.17 12.16

REACHES

OUTLET 15.53 32.71 71.34

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-7 EX	5.80	0.190	78	Outlet	
DA-7 PR	5.78	0.189	78	Outlet	

Total Area:	11.58 (ac)				

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-7 EX							
SHEET	100	0.0500	0.240				0.166
SHALLOW	580	0.1980	0.050				0.022
CHANNEL	120	0.4200	0.011	0.10	1.00	16.667	0.002
							Time of Concentration .19
							=====
DA-7 PR							
SHEET	100	0.0500	0.240				0.166
SHALLOW	540	0.1940	0.050				0.021
CHANNEL	120	0.4200	0.011	0.10	1.00	16.667	0.002
							Time of Concentration .189
							=====

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-7 EX	Pasture, grassland or range	(good)	D	1.16	80
	Woods	(good)	D	4.64	77
	Total Area / Weighted Curve Number			5.8	78
				===	==
DA-7 PR	Pasture, grassland or range	(good)	D	1.14	80
	Woods	(good)	D	4.64	77
	Total Area / Weighted Curve Number			5.78	78
				====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/10/2019
 Project: Gude Units: English
 SubTitle: DA-8 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-8 EX		Outlet	3.88	80	.224
DA-8 PR		Outlet	3.34	80	.225

Total area: 7.22 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-8 EX	5.40	10.94	23.19
DA-8 PR	4.64	9.44	19.97
REACHES			
OUTLET	10.04	20.34	43.13

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

DA-8 EX 5.40 10.94 23.19
12.19 12.18 12.18

DA-8 PR 4.64 9.44 19.97
12.18 12.19 12.18

REACHES

OUTLET 10.04 20.34 43.13

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-8 EX	3.88	0.224	80	Outlet	
DA-8 PR	3.34	0.225	80	Outlet	

Total Area:	7.22 (ac)				

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-8 EX							
SHEET	100	0.0290	0.240				0.207
SHALLOW	400	0.2150	0.050				0.015
CHANNEL	40	0.0710	0.030	0.90	3.50	5.556	0.002
							Time of Concentration .224
							=====
DA-8 PR							
SHEET	100	0.0300	0.240				0.204
SHALLOW	500	0.2150	0.050				0.019
CHANNEL	40	0.0710	0.030	0.80	2.90	5.556	0.002
							Time of Concentration .225
							=====

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-8 EX	Pasture, grassland or range	(good)	D	3.88	80
	Total Area / Weighted Curve Number			3.88	80
				====	==
DA-8 PR	Pasture, grassland or range	(good)	D	3.34	80
	Total Area / Weighted Curve Number			3.34	80
				====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/13/2019
 Project: Gude Units: English
 SubTitle: DA-9 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-9 EX		Outlet	4.16	79	.235
DA-9 PR		Outlet	4.24	79	.265

Total area: 8.40 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-9 EX	5.39	11.15	24.03
DA-9 PR	5.21	10.81	23.34
REACHES			
OUTLET	10.56	21.92	47.17

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

DA-9 EX 5.39 11.15 24.03
12.19 12.20 12.19

DA-9 PR 5.21 10.81 23.34
12.21 12.21 12.20

REACHES

OUTLET 10.56 21.92 47.17

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-9 EX	4.16	0.235	79	Outlet	
DA-9 PR	4.24	0.265	79	Outlet	

Total Area:	8.40 (ac)				

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-9 EX							
SHEET	100	0.0280	0.240				0.210
SHALLOW	590	0.1640	0.050				0.025
						Time of Concentration	.235
							=====
DA-9 PR							
SHEET	100	0.0200	0.240				0.240
SHALLOW	590	0.1640	0.050				0.025
						Time of Concentration	.265
							=====

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-9 EX	Dirt (w/ right-of-way)	D	.23	89
	Pasture, grassland or range	(good) D	1.85	80
	Woods	(good) D	2.08	77
	Total Area / Weighted Curve Number		4.16	79
			====	==
DA-9 PR	Gravel (w/ right-of-way)	D	.15	91
	Pasture, grassland or range	(good) D	2.01	80
	Woods	(good) D	2.08	77
	Total Area / Weighted Curve Number		4.24	79
			====	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/10/2019
 Project: Gude Units: English
 SubTitle: DA-10 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-10		Outlet	0.99	80	.262
DA-10 PR		Outlet	0.84	80	.19

Total area: 1.83 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-10	1.29	2.62	5.57
DA-10 PR	1.25	2.53	5.34
REACHES			
OUTLET	2.49	5.07	10.73

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

DA-10 1.29 2.62 5.57
12.21 12.21 12.20

DA-10 PR 1.25 2.53 5.34
12.17 12.17 12.16

REACHES

OUTLET 2.49 5.07 10.73

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-10	.99	0.262	80	Outlet	
DA-10 PR	.84	0.190	80	Outlet	
Total Area:	1.83 (ac)				

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-10							
SHEET	100	0.0200	0.240				0.240
SHALLOW	360	0.0760	0.050				0.022
						Time of Concentration	.262
							=====
DA-10 PR							
SHEET	100	0.0450	0.240				0.174
SHALLOW	281	0.0910	0.050				0.016
						Time of Concentration	.19
							=====

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-10	Pasture, grassland or range	(good)	D	.88	80
	Woods	(good)	D	.11	77
	Total Area / Weighted Curve Number			.99	80
				===	==
DA-10 PR	Pasture, grassland or range	(good)	D	.75	80
	Woods	(good)	D	.087	77
	Total Area / Weighted Curve Number			.84	80
				===	==

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/10/2019
Project: Units: English
SubTitle: Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 3 - Engineering Design Services\60% Des

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-11 EX		Outlet	3.15	78	.199
DA-11 PR		Outlet	3.18	78	.212

Total area: 6.33 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	2-Yr (cfs)	10-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
DA-11 EX	4.14	8.73	19.04
DA-11 PR	4.07	8.60	18.77
REACHES			
OUTLET	8.20	17.31	37.79

EA

Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period		
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-11 EX	4.14	8.73	19.04
	12.17	12.17	12.16

DA-11 PR	4.07	8.60	18.77
	12.19	12.18	12.17

REACHES

OUTLET	8.20	17.31	37.79
--------	------	-------	-------

EA

Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-11 EX	3.15	0.199	78	Outlet	
DA-11 PR	3.18	0.212	78	Outlet	
Total Area:	6.33 (ac)				

EA

Montgomery NOAA-C County, Maryland
Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-11 EX							
SHEET	100	0.0500	0.240				0.166
SHALLOW	600	0.0980	0.050				0.033
					Time of Concentration		.199
							=====
DA-11 PR							
SHEET	100	0.0420	0.240				0.178
SHALLOW	621	0.1000	0.050				0.034
					Time of Concentration		.212
							=====

EA

Montgomery NOAA-C County, Maryland
Sub-Area Land Use and Curve Number Details

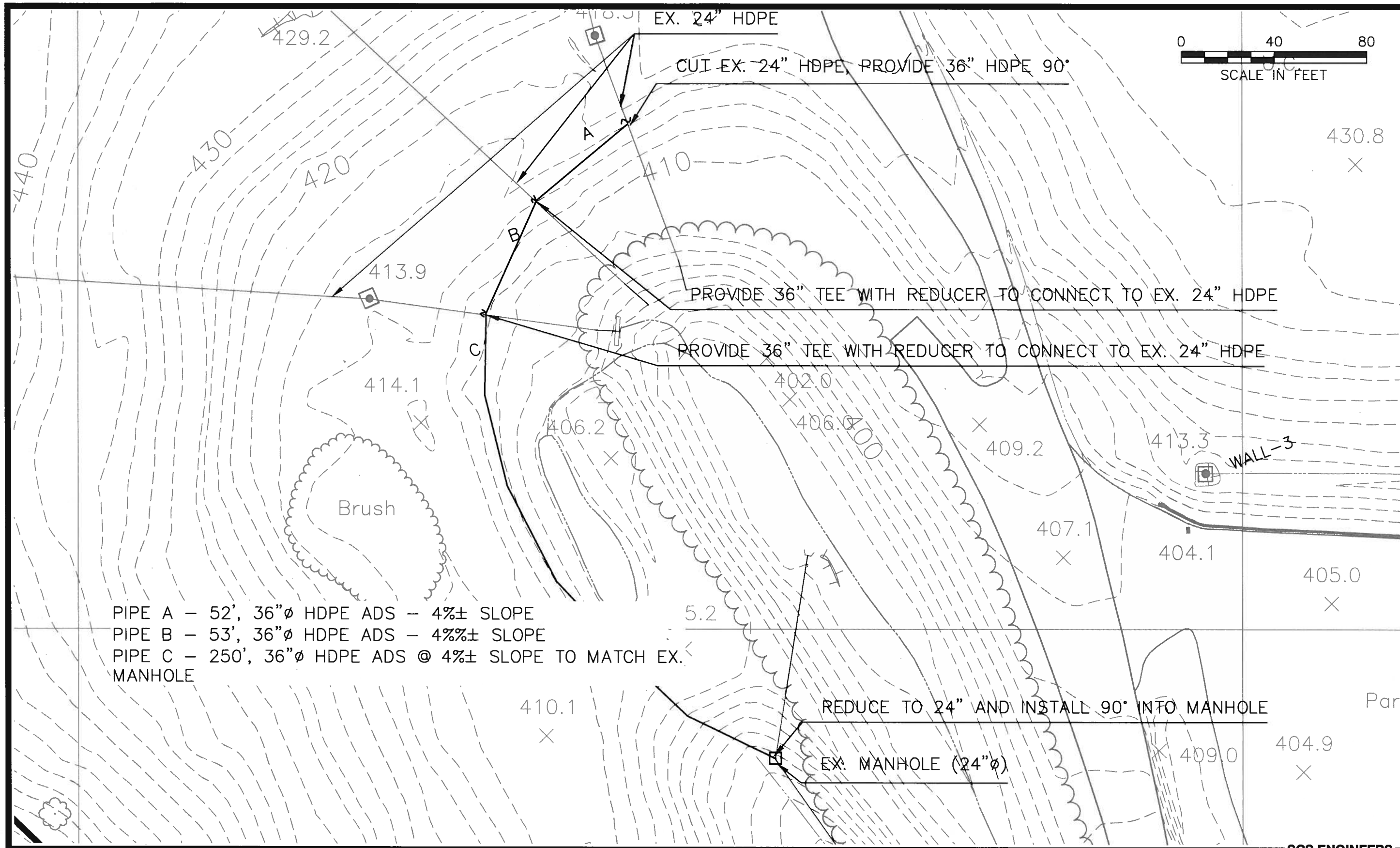
Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-11 EX	Pasture, grassland or range	(good)	D	.88	80
	Woods	(good)	D	2.27	77
	Total Area / Weighted Curve Number			3.15	78
				====	==
DA-11 PR	Gravel (w/ right-of-way)		D	.012	91
	Pasture, grassland or range	(good)	D	.868	80
	Woods	(good)	D	2.3	77
	Total Area / Weighted Curve Number			3.18	78
				====	==

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Appendix D

Stormwater Bypass Drawing

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PIPE A - 52', 36"Ø HDPE ADS - 4%± SLOPE
PIPE B - 53', 36"Ø HDPE ADS - 4%± SLOPE
PIPE C - 250', 36"Ø HDPE ADS @ 4%± SLOPE TO MATCH EX. MANHOLE

REDUCE TO 24" AND INSTALL 90° INTO MANHOLE
EX. MANHOLE (24"Ø)

ROUGH GRADING STORMWATER MANAGEMENT DIVERSION

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Attachment K2

Stormwater Management Report

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Gude Landfill Remediation Design Montgomery County, Maryland

Stormwater Management Design Report

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

Professional Certification: I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed Professional Engineer under the laws of the State of Maryland.
License No. 23402,
Expiration Date: 25 August 2022

December 2020
EA Project No. 15646.01

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Gude Landfill Remediation Design Montgomery County, Maryland

Stormwater Management Design Report

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

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225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

December 2020
EA Project No. 15646.01

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2	Drainage Area Map – Existing Conditions
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1	Soil Map Units and Soil Hydrologic Groups
2	Existing Conditions Hydrology Summary
3	Hydrology Comparison Summary
4	Conveyance Swale Summary

LIST OF ACRONYMS AND ABBREVIATIONS

cfs	Cubic feet per second
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DA	Drainage Area
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
ft	Foot (feet)
HSG	Hydrologic soil group
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
MDE	Maryland Department of the Environment
NRCS	Natural Resources Conservation Service
TR-55	Technical Release 55
Q ₂	2-Year peak flow
Q ₁₀	10-Year peak flow
Q ₁₀₀	100-Year peak flow

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1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has been contracted to provide engineering, permitting, and support services for developing a remediation design to address the remedial action objectives at the Gude Landfill (“the Landfill”) in order to achieve compliance with the consent order for the Landfill (Maryland Department of the Environment [MDE] and Montgomery County 2013). This report summarizes the stormwater management and hydrology design requirements for the Gude Landfill site. The erosion and sediment control design is discussed in the *Sediment Control Report* (EA 2020), under separate cover.

1.1 SITE INFORMATION

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. Refer to **Figure 1** for a vicinity and location map. The site is accessed at two locations: East Gude Drive from the south-southwest and Southlawn Lane from the east-southeast.

The Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. An additional 17 acres of waste disposal area were delineated in 2009 on Maryland-National Capital Park and Planning Commission (M-NCPPC) property, beyond the northeastern property boundary of the Landfill. A land exchange between the County and M-NCPPC on October 21, 2014 transferred ownership of this additional waste disposal area to the County in exchange for a similar area of land without waste, which was transferred to M-NCPPC.

Landfill capping was selected as a corrective measure for the upper surface of the Landfill, as well as portions of the side-slopes of the Landfill where placement of a closure capping system is feasible. EA’s design includes the following major elements as part of the corrective measure:

- Erosion and sediment control,
- Existing waste reconfiguration and subgrade establishment,
- Landfill closure cap construction,
- Landfill gas management, and
- Stormwater management.

Stormwater management is necessary to mitigate the effects of development on the receiving stream system and other existing features. The post-development ground surface, including impervious area, will be similar to the pre-development ground surface; however, the post-development ground surface slopes may be steeper than the pre-development slopes to promote drainage and minimize the potential for stormwater ponding on the Landfill cap.

Montgomery County Department of Permitting Services (DPS) has determined this project is “maintenance” activity. Due to this classification, no Environmental Site Design treatment in

accordance with the *2000 Maryland Stormwater Design Manual* is required. This stormwater management report has been prepared to present the quantitative analysis associated with the remediation design.

2. STORMWATER MANAGEMENT

Montgomery County requires safe and stable conveyance of stormwater discharges at all points of discharge from the site. The site's pre-development runoff characteristics were maintained to the greatest extent possible. EA analyzed the 2-year, 10-year, and 100-year storm events for existing and proposed conditions.

The hydrologic analyses contained within this report are based upon the methods outlined in the Natural Resources Conservation Service (NRCS) Technical Release 55 (TR-55) Manual, Montgomery County Government (2013; Revised 2014) Drainage Design Criteria, and the *2000 Maryland Stormwater Design Manual*. The U.S. Department of Agriculture Soil Conservation Service's "SCS Runoff Curve Number Method" (utilizing TR-55 Software) computations and procedures were utilized to determine the weighted runoff curve number and time of concentration for the existing conditions of the site.

2.1 SOILS ANALYSIS

The NRCS Web Soil Survey was used to determine the soils onsite, and in the vicinity, and their properties. The NRCS Web Soil Survey report is included in **Appendix A**. The soils found throughout the project and in the vicinity have also been summarized in **Table 1**.

Table 1 Soil Map Units and Soil Hydrologic Groups

Map Symbol	Soils Series	Hydrologic Soils Group
1B	Gaila silt loam, 3 to 8 percent slopes	B
1C	Gaila silt loam, 8 to 15 percent slopes	B
2B	Glenelg silt loam, 3 to 8 percent slopes	B
4B	Eliok silt loam, 3 to 8 percent slopes	C
5A	Glenville silt loam, 0 to 3 percent slopes	C
5B	Glenville silt loam, 3 to 8 percent slopes	C/D
6A	Baile silt loam, 0 to 3 percent slopes	C/D
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	C
17C	Ococoquan loam, 8 to 15 percent slopes	B
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B/D
100	Dumps, refuse	Not applicable
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	D
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	D

2.2 RUNOFF CHARACTERISTICS

The Landfill consists of tall grasses with several dirt/gravel access roads. Runoff characteristics for existing conditions were determined by SCS Engineers in 1992 as part of developing the *Gude Landfill Post Closure Engineering Design and Management Tasks* plans. SCS Engineers' analysis considered the grassed areas of the Landfill to be "pasture." Applicable drawings from SCS Engineers' plans are included in **Appendix B**.

For both existing and proposed conditions, EA will assume the same land use category for the grassed areas of the Landfill. In addition, while there is no hydrologic soil group (HSG) rating for the soil within the footprint of the Landfill, SCS Engineers' analysis assumed HSG D soils. In keeping with this assumption, EA will utilize HSG D soils for the existing and proposed analyses throughout the site. HSG D is typically utilized for landfill projects where surficial soils are disturbed and compacted.

2.3 EXISTING DRAINAGE AREA ANALYSIS

The Landfill in existing condition has been divided into 13 drainage areas (DAs), shown on the existing conditions drainage area map (**Figure 2**). **Table 2** summarizes the existing condition hydrology for the Landfill. Calculations are included in **Appendix C**.

Table 2 Existing Conditions Hydrology Summary

Drainage Area	Existing					Discharge Point
	Area (acres)	Runoff Curve Number	Q ₂ (cfs)	Q ₁₀ (cfs)	Q ₁₀₀ (cfs)	
DA-1A	36.95	80	39.86	81.52	173.52	Pond 3 Bypass
DA-1B	16.07	81	21.64	43.20	90.22	Pond 3
DA-2	28.63	80	35.82	72.89	155.01	Pond 1
DA-3	11.90	80	14.99	30.51	64.81	Sheet Flow
DA-4	9.06	78	8.88	18.91	41.56	Pond 2
DA-5	17.47	78	20.41	43.24	94.76	M-NCPPC Pond
DA-6	15.65	77	19.81	42.70	94.54	Southlawn Branch
DA-7	5.78	78	8.02	16.92	36.76	Southlawn Branch
DA-8	3.88	79	5.03	10.43	22.44	Southlawn Branch
DA-9	8.10	78	9.90	20.94	45.84	Southlawn Branch
DA-10	1.53	80	1.85	3.77	8.00	Southlawn Branch
DA-11	0.39	88	1.00	1.76	3.31	Southlawn Branch
DA-12	0.47	79	0.71	1.47	3.14	Southlawn Branch
Total	155.88		187.92	388.26	833.91	
Notes: cfs = Cubic feet per second. Q ₂ = 2-Year peak flow. Q ₁₀ = 10-Year peak flow. Q ₁₀₀ = 100-Year peak flow.						

DA-1A and DA-1B

DA-1A consists of a 36.95-acre area while DA-1B is 16.07 acres. These drainage areas are located centrally on the site. Both DA-1A and DA-1B drain toward Pond 3, located on the west side of Incinerator Lane at the southern portion of the Landfill. According to a drawing developed by SCS Engineers in 2008, a stormwater bypass system was installed at Pond 3 to divert drainage from DA-1A into a 36-inch-diameter high-density polyethylene pipe and ultimately to the Southlawn Branch Stream. The stormwater bypass drawing is included in **Appendix D**. Pond 3 receives drainage from DA-1B and also discharges to Southlawn Branch.

DA-2

DA-2 receives drainage from a 28.63-acre area on the western portion of the Landfill. Drainage from DA-2 is conveyed, via overland flow and an existing stormdrain system, to Pond 1, which is located at the base of the Landfill in the southwest portion of the site. Based on discussion with DPS, Pond 1 functions as a regional stormwater pond for Montgomery County and receives drainage from the commercial property to the west and a portion of East Gude Drive. Pond 1 discharges to Southlawn Branch to the south.

DA-3

DA-3 is an approximate 11.90-acre area located on the northwest portion of the Landfill. Drainage from a portion of the upper Landfill surface and the majority of the northwest slope is conveyed to a low spot and discharges by sheet flow to the northwest.

DA-4

DA-4 receives drainage from a 9.06-acre area located at the northern point of the site. Drainage is conveyed to a depressed area (Pond 2) and ultimately discharges to Crabbs Branch to the north. The topography in the vicinity of this pond is very steep.

DA-5

DA-5 is a 17.47-acre area located at the northeastern portion of the site, primarily consisting of the Landfill side slopes. Discharge from DA-5 is conveyed to M-NCPPC Pond, which discharges to Rock Creek to the east.

DA-6

DA-6 receives drainage from an approximate 15.65-acre area on the east portion of the Landfill. Discharge from DA-6 is conveyed to the south and ultimately Southlawn Branch.

DA-7

DA-7 receives drainage from an approximate 5.78-acre area on the southeast portion of the Landfill. Discharge from DA-7 is conveyed to an existing culvert and ultimately discharges into Southlawn Branch.

DA-8

DA-8 receives drainage from an approximate 3.88-acre area on the southern portion of the Landfill. Discharge from DA-8 is conveyed to an existing stormdrain system and ultimately discharges into Southlawn Branch.

DA- 9

DA- 9 is located at the southern portion of the Landfill and receives drainage from approximately 8.10 acres. The majority of this drainage area consists of the Landfill side slopes. Drainage from DA-9 is conveyed south to Sediment Basin B and ultimately discharges into Southlawn Branch.

DA-10

DA-10 receives drainage from an approximate 1.53-acre area on the southern portion of the Landfill. The majority of this drainage area consists of the Landfill side slopes. Discharge from DA-10 is conveyed to an existing culvert and ultimately discharges offsite to Southlawn Branch.

DA-11

DA-11 receives drainage from an approximate 0.39-acre area at the entrance road to the Landfill. Drainage from DA-11 is conveyed via overland flow offsite and ultimately discharges into Southlawn Branch.

DA-12

DA-12 receives drainage from an approximate 0.47-acre area on the southern portion of the Landfill. The majority of this drainage area consists of the Landfill side slopes. Discharge from DA-12 is conveyed to an existing roadside ditch and discharges offsite to the west and ultimately to Southlawn Branch.

2.4 PROPOSED DRAINAGE AREA ANALYSIS

Drainage areas were delineated for the proposed grading plan and are identified on the proposed conditions drainage area map (**Figure 3**). Existing drainage patterns were maintained to the greatest extent possible in the development of the proposed grading plans. However, in order to maintain the project's phasing to comply with erosion and sediment control requirements and the project's overall cut/fill balancing, there are adjustments to the drainage divides. **Table 3** summarizes the changes in peak discharges from existing conditions to proposed conditions at the Landfill and provides a sitewide discharge total for each storm event. The proposed sitewide discharges for the project are less than the sitewide discharges for each of the evaluated storm events.

Table 3 Hydrology Comparison Summary

Drainage Area	Area (acres)	Existing			Proposed			Discharge Point
		Q ₂ (cfs)	Q ₁₀ (cfs)	Q ₁₀₀ (cfs)	Q ₂ (cfs)	Q ₁₀ (cfs)	Q ₁₀₀ (cfs)	
DA-1A	32.83	39.86	81.52	173.52	36.8	75.11	159.79	Pond 3 Bypass – Southlawn Branch
DA-1B	29.17	21.64	43.2	90.22	34.47	70.34	149.37	Pond 3 – Southlawn Branch
DA-2	22.42	35.82	72.89	155.01	24.42	49.82	106.16	Pond 1
DA-3	10.02	14.99	30.51	64.81	12.87	25.74	53.87	Point Discharge/Sheet Flow
DA-4	8.01	8.88	18.91	41.56	12.23	25.63	55.55	Pond 2
DA-5	17.58	20.41	43.24	94.76	16.25	34.62	76.21	M-NCPPC Pond
DA-6	15.62	19.81	42.7	94.54	20.5	44.1	97.44	Southlawn Branch
DA-7	5.80	8.02	16.92	36.76	8.48	17.84	38.72	Southlawn Branch
DA-8	4.13	5.03	10.43	22.44	6.83	13.8	29.02	Southlawn Branch
DA-9	8.42	9.9	20.94	45.84	11.04	22.90	49.11	Southlawn Branch
DA-10	0.89	1.85	3.77	8	1.47	2.96	6.23	Southlawn Branch
DA-11	0.55	1	1.76	3.31	1.36	2.42	4.62	Southlawn Branch
DA-12	0.45	0.71	1.47	3.14	0.78	1.59	3.38	Southlawn Branch
Total	155.88	187.92	388.26	833.91	187.50	386.87	829.47	
Notes: cfs = Cubic feet per second. Q ₂ = 2-Year peak flow. Q ₁₀ = 10-Year peak flow. Q ₁₀₀ = 100-Year peak flow.								

DA-1A and DA-1B

DA 1-A (32.83 acres) and DA 1-B (29.17 acres) will eventually drain to an existing stormdrain that conveys discharge to Southlawn Branch. DA-1A is conveyed in proposed swales to the stormdrain system. DA-1B drains to Pond 3 and then into the stormdrain system. Although the peak discharge from DA-1B increases in proposed conditions, the stormdrain system maintains safe conveyance of the 10-year storm. Additional discussion of the stormdrain is included in Section 3.2.

DA-2

DA-2 (22.42 acres) discharges to the banks of Pond 1. Pond 1 is a regional stormwater pond that receives discharge from the commercial property to the west owned by EB Rockville, LLC and a portion of East Gude Drive. The proposed design reduces DA-2 area, which reduces the onsite area draining to Pond 1.

DA-3

DA-3 decreases from 11.90 to 10.02 acres. The majority of the runoff from DA-3 is conveyed by one of the proposed conveyance swales onsite to a low point, and then discharges via proposed culverts. The remainder of the area discharges by sheet flow to the northwest.

DA-4

DA-4 decreases from 9.06 to 8.01 acres. Drainage is conveyed to a depressed area (Pond 2) and ultimately discharges to Crabbs Branch to the north. The topography in the vicinity of this pond is very steep.

DA-5

DA-5 increases from 17.47 to 17.58 acres. Peak discharges decrease from existing conditions.

DA-6

DA-6 receives drainage from an approximate 15.62-acre area on the east portion of the Landfill. Discharge from DA-6 is conveyed to the south and ultimately Southlawn Branch. There is a slight increase in discharge given the steep slopes of the site.

DA-7

DA-7 increases from a 5.78-acre area in existing condition to a 5.8-acre area in proposed conditions, resulting in a slight increase in peak discharge.

DA-8

DA-8 increases from 3.88 acres in existing condition to 4.13 acres in proposed conditions, resulting in a slight increase in peak discharge.

DA-9

DA-9 increases from 8.10 acres in existing condition to 8.42 acres in proposed conditions, resulting in a slight increase in peak discharge.

DA-10

DA-10 decreases from 1.53 to 0.89 acre. Peak discharges decrease from existing conditions.

DA-11

DA-11 increases from 0.39 to 0.55 acre, resulting in a slight increase of the peak discharges.

DA-12

DA-12 decreases from 0.47 to 0.45 acre; however, there is a slight increase in the peak discharges given the fast time of concentration path due to steeper slopes.

2.5 CONCLUSIONS

Based on the results presented in **Table 3**, peak discharge rates increase slightly in several of the drainage areas largely due to the adjustments to the drainage areas between existing and proposed conditions. However, the overall site provides an overall decrease of runoff after construction completion. For DA-1A and DA-1B, the receiving stormdrain has capacity to handle the increase in flow for the proposed condition and will provide safe conveyance of the 10-year storm based on DPS requirements.

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3. STORM DRAINAGE

3.1 CONVEYANCE SWALES

Drainage on the upper surface of the Landfill is conveyed primarily by a network of open channel swales. Design standards for the conveyance swales were based on the Montgomery County Drainage Design Criteria dated June 10, 2014. The swales were designed to convey the 10-year peak discharge while providing the minimum freeboard of 0.5 foot (ft) from the design storm flow depth to the top of the channel.

Several of the swales convey drainage to small stormdrain networks along the perimeter of the Landfill and tie into existing stormdrains. The drainage from the remaining swales will be conveyed by benches and downchutes.

Swales will be lined with turf reinforcement materials to avoid erosion issues. Where swales intersect their point of outfalling, riprap outlet protection or gabion outlet protection will be provided to prevent erosion at the transition points. The benches and downchutes will also be protected from erosive impacts as necessary.

Table 4 summarizes the 10-year peak discharges and the flow depth in the swales. TR-55 was used to determine the 10-year storm flows in the conveyance swale. Hydraflow was used to determine the flow depth for the 10-year design storm. Calculations are provided in **Appendix E**.

Table 4 Conveyance Swale Summary

Swale	Q ₁₀ (cfs)	Depth (ft)
1	13.26	0.66
2	4.61	0.27
3	23.03	0.77
4	18.29	0.30
4A	3.30	0.20
5	26.57	0.53
6	3.28	0.19
7	0.46	0.05
8	41.81	0.82
9A	4.83	0.29
9	6.63	0.34
10	86.66	0.90
11	6.19	0.20
12	9.54	0.35
13	36.14	0.75
14A	1.53	0.10
14B	4.75	0.21
14	6.65	0.34
15	34.53	0.69
16	27.45	0.57
17	70.32	1.33
18	2.39	0.16
19	0.54	0.04

3.2 STORMDRAIN SYSTEMS

There are two separate, proposed stormdrain systems location on the site. The first system ties into the existing 60-inch stormdrain that drains to Pond 1 on the southwestern edge of the site. The second stormdrain systems collects runoff from DA-1B and discharges to Pond 3.

All of the proposed inlets are located within conveyance swales and are in a sumped condition. Montgomery County Type J inlets will be utilized throughout except for Inlet 2. Inlet 2 will be an open yard inlet.

The NRCS (TR-55) method was used to determine the 10-year storm flows that enter the stormdrain systems. The Design Spreadsheets in Appendix D of the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria were utilized to summarize the stormdrain system analysis and calculate the velocity in the storm drainpipe networks, based on size and slope of the pipes.

Design standards for inlets, piping material, piping alignment, and piping slope and depth are based on the Montgomery County Drainage Design Criteria dated 10 June 2014:

- Preferred piping materials consist of reinforced concrete pipe.
- Minimum allowable pipe size of 15 inches.
- Minimum slope is 0.5 percent, with preferred minimum slope of 1 percent.
- One foot minimum cover over the outside of the pipe.
- All closed systems shall be designed so that the 10-year hydraulic grade line is no higher than 1 ft above the crown of the pipe and at least 1 ft below the top of any inlet grate or manhole cover.

Supporting calculations are included in **Appendix E**.

DA-1A and DA-1B both drain to an existing stormdrain system that conveys discharge to Southlawn Branch. DA-1A is conveyed in proposed swales, which then tie into the stormdrain system. DA-1B drains to Pond 3 and then into the stormdrain system. Although the peak discharge from DA-1B increases in proposed conditions, the stormdrain system maintains stable conveyance of the 10-year storm.

3.3 CULVERTS

There are 10 culverts proposed throughout the site. The proposed culverts convey swale flow under the site access roads and walking paths.

TR-55 was used to determine the 10-year storm flows in the conveyance swales draining to the culverts. HY-8 was used to design each culvert crossing. A 3.25-ft-wide by 1.5-ft-high, double-span box culvert is proposed at the majority of the crossings. A 3.67-ft-wide by 2-ft high, double-span box culvert is proposed at three locations. The Design Sheet in Appendix D of the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria was utilized to summarize the HY-8 analysis for each the culverts.

Supporting calculations are included in **Appendix E**.

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4. EROSION AND SEDIMENT CONTROL

The erosion and sediment control design includes a phased construction approach. Grading will be limited to 20-acre areas based on the limit imposed by the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. Phase boundaries will consider the proposed drainage patterns. Existing Pond 3 is proposed to be converted to a temporary sediment basin during construction and decommissioned after construction is completed. Further discussion is provided in the *Sediment Control Report* (EA 2020), under separate cover.

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5. POND 3 / SEDIMENT BASIN NO. 1 FINAL CONDITIONS

As previously stated, existing Pond No. 3 will be expanded and converted to Sediment Basin No. 1 during Phase S-IV of the project and will be utilized through the remainder of the subgrade phases and through final grading. As a last step in construction, Sediment Basin No. 1 will be decommissioned by removing the dewatering device, riser structure, and outfall pipe. In addition, a portion of the constructed embankment will be removed and replaced with a 30-ft-wide channel to allow stormwater runoff to flow out of the decommissioned sediment basin to the downstream inlet structures and ultimately offsite.

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6. REFERENCES

EA Engineering, Science, and Technology, Inc., PBC (EA). 2020. *Sediment Control Report*.

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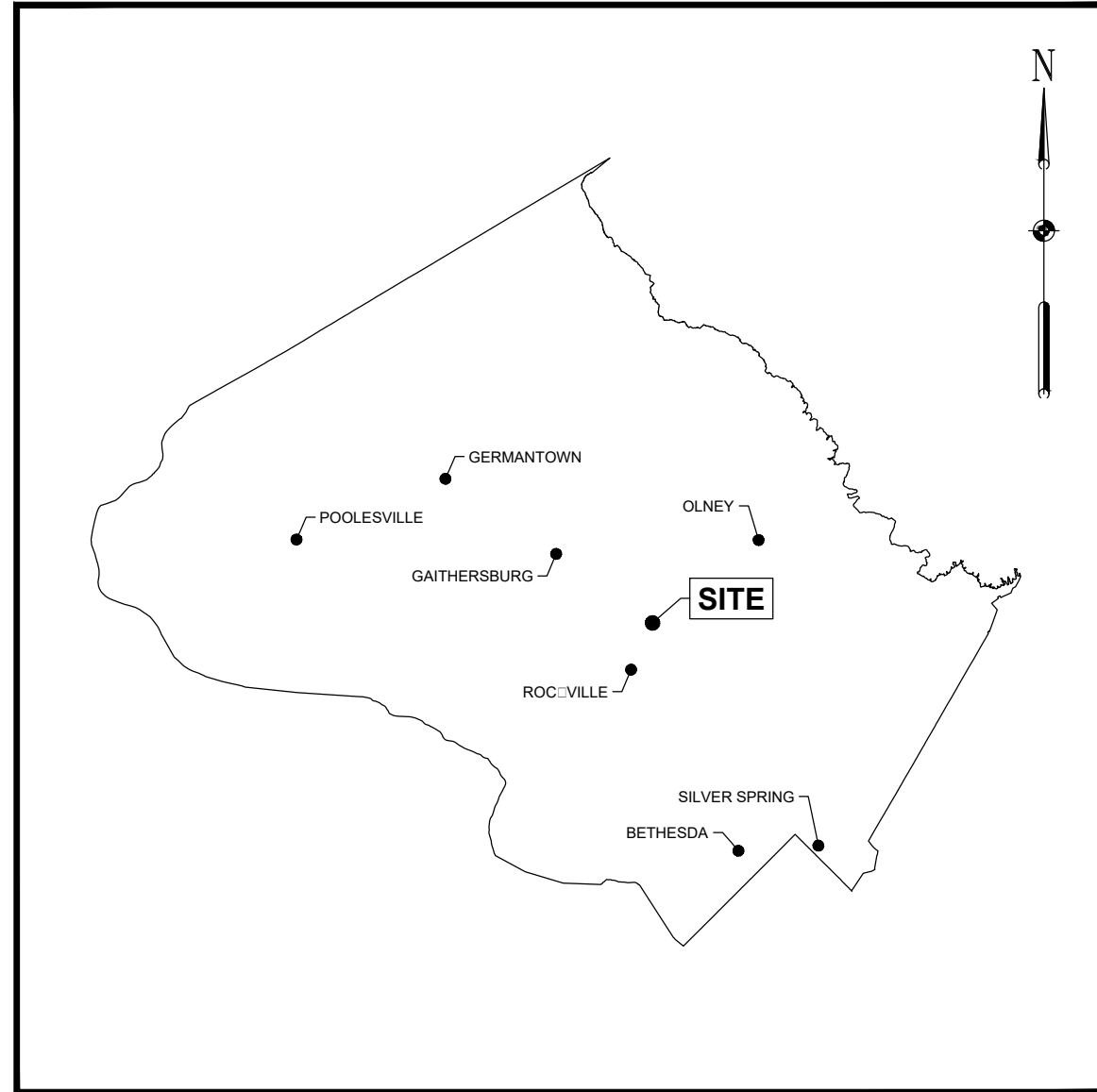
SCS Engineers. 1992. *Gude Landfill Post Closure Engineering Design and Management Tasks*. Drawings.

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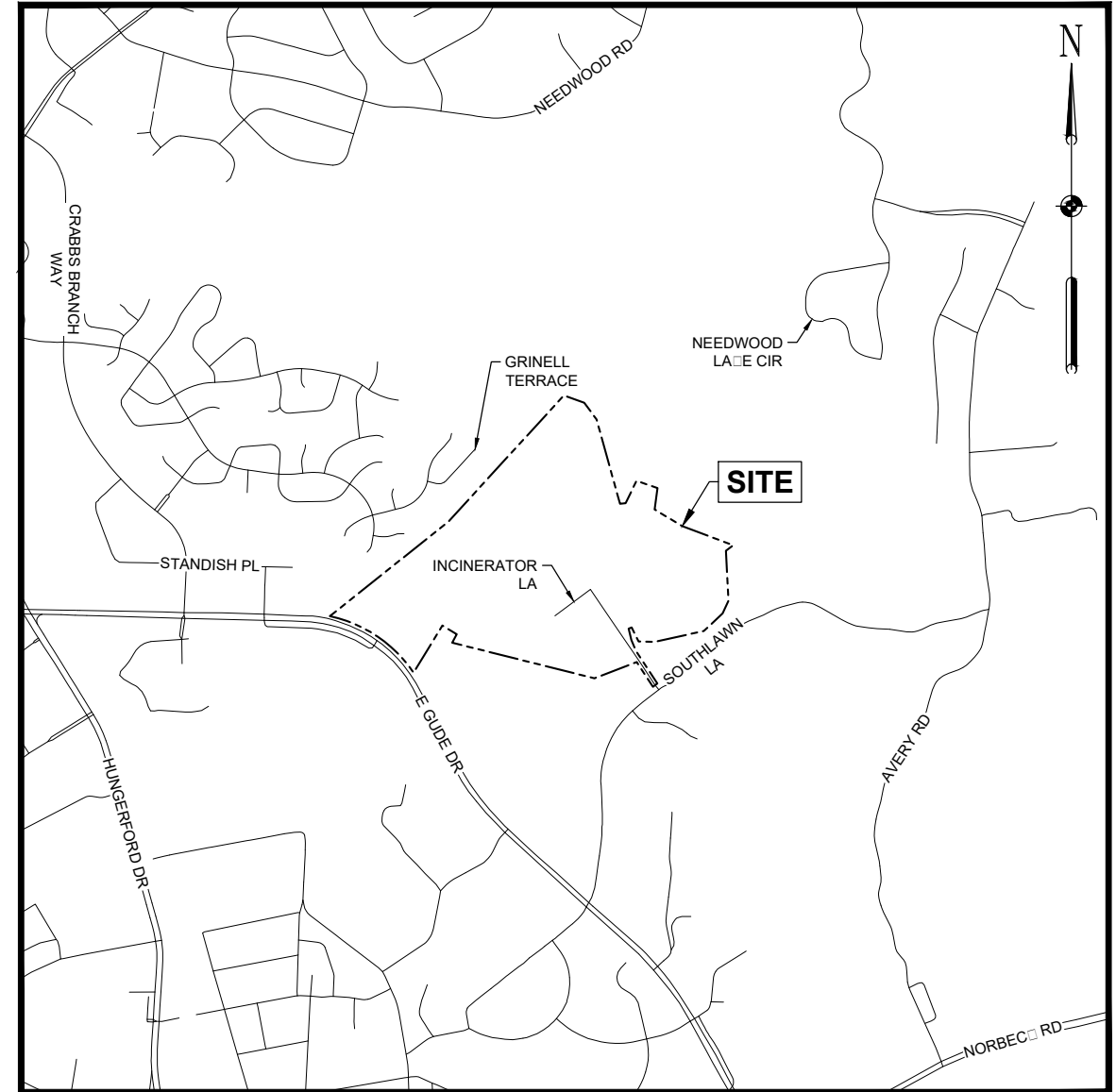
Figures

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FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\SWM\FIGURE 1 - VICINITY AND LOCATION MAP.DWG (FIGURE 1) 4/30/19



LOCATION MAP - MONTGOMERY COUNTY, MARYLAND
NOT TO SCALE



VICINITY MAP
SCALE: 1" = 2,000'



EA Engineering, Science, and Technology, Inc., PBC
Hunt Valley Center
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

PROJECT NUMBER:
1564601
DATE:
DECEMBER 2019

DESIGNED BY:
EF/SMB
CHECKED BY:
LJO

DRAWN BY:
SMB
PROJECT MGR.:
MJG

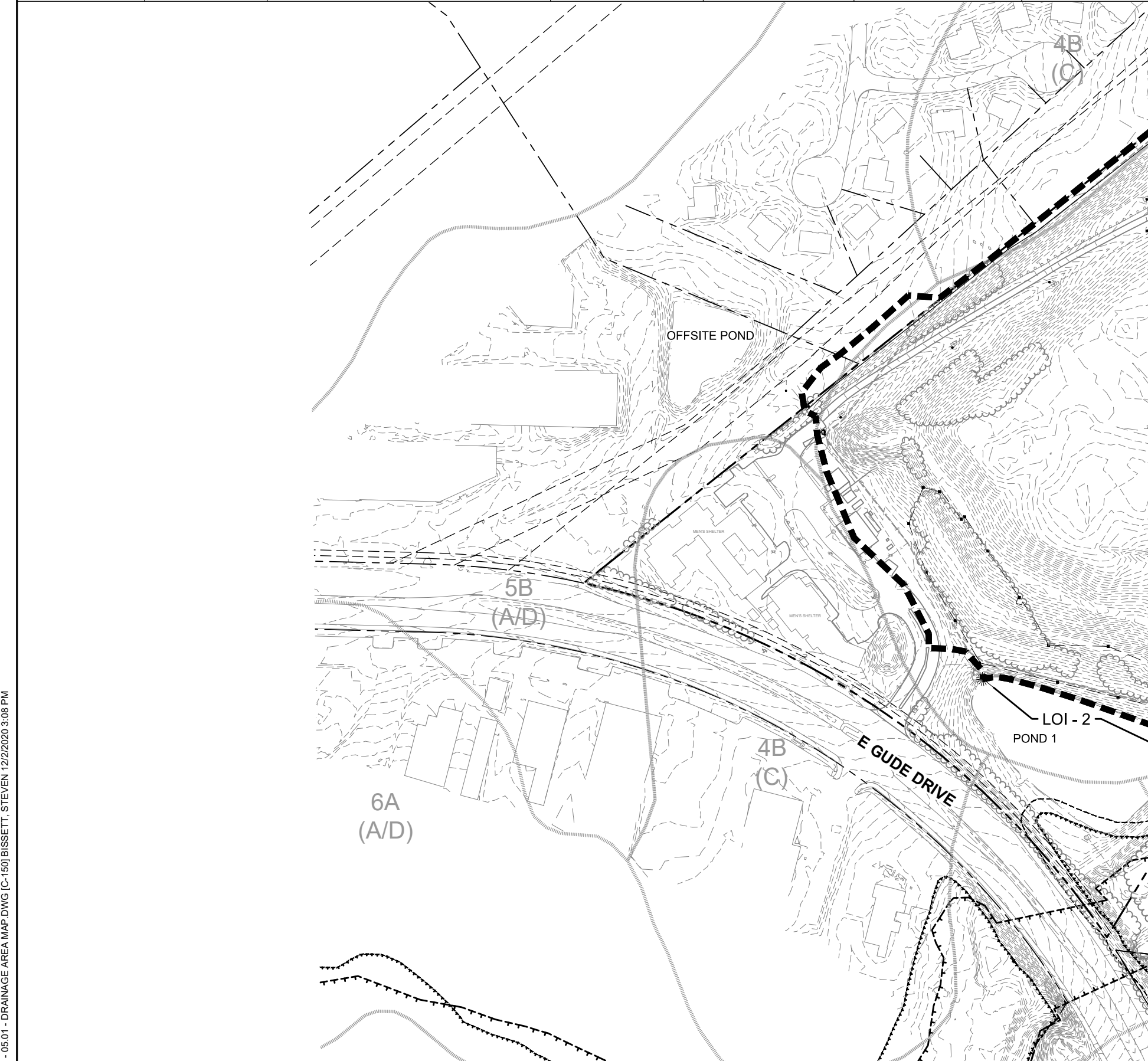
FIGURE:
1
SHEET NUMBER:
1 OF 1

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY, MARYLAND

FIGURE 1 - LOCATION AND VICINITY MAP

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DRAINAGE AREA	PATH	FLOW TYPE	N	LENGTH (FT)	SLOPE (FT/FT)	Tc (HR)
1A	A TO B	SHEET FLOW	0.24	100	0.018	0.250
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1122	0.022	0.130
	C TO D	CHANNEL		688	0.050	0.012
1B	A TO B	SHEET	0.24	100	0.044	0.175
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1234	0.050	0.095
	C TO D	CHANNEL		89	0.0320	0.0020
2	A TO B	SHEET FLOW	0.24	100	0.024	0.223
	B TO C	SHALLOW CONCENTRATED	UNPAVED	521	0.025	0.056
	C TO D	CHANNEL		576	0.076	0.007
3	A TO B	SHEET FLOW	0.24	100	0.020	0.240
	B TO C	SHALLOW CONCENTRATED	UNPAVED	272	0.016	0.037
	C TO D	SHALLOW CONCENTRATED	UNPAVED	158	0.248	0.005
4	A TO B	SHEET FLOW	0.24	100	0.009	0.330
	B TO C	SHALLOW CONCENTRATED	UNPAVED	1020	0.110	0.053
	A TO B	SHEET FLOW	0.24	100	0.035	0.192
5	B TO C	SHALLOW CONCENTRATED	UNPAVED	311	0.016	0.042
	C TO D	CHANNEL		1222	0.148	0.029
	A TO B	SHEET FLOW	0.24	100	0.049	0.168
6	B TO C	SHALLOW CONCENTRATED	UNPAVED	616	0.238	0.022
	A TO B	SHEET FLOW	0.24	100	0.068	0.147
	B TO C	SHALLOW CONCENTRATED	UNPAVED	694	0.246	0.024
7	C TO D	CHANNEL		120	0.410	0.002
	A TO B	SHEET FLOW	0.24	100	0.028	0.210
	B TO C	SHALLOW CONCENTRATED	UNPAVED	485	0.181	0.020
8	C TO D	CHANNEL		40	0.013	0.002
	D TO E	CHANNEL		230	0.0675	0.002
	A TO B	SHEET FLOW	0.24	100	0.026	0.216
9	B TO C	SHALLOW CONCENTRATED	UNPAVED	586	0.222	0.021
	A TO B	SHEET FLOW	0.24	100	0.016	0.263
	B TO C	SHALLOW CONCENTRATED	UNPAVED	83	0.066	0.006
10	C TO D	CHANNEL		249	0.091	0.038
	D TO E	CHANNEL		31	0.023	0.002
	A TO B	SHEET FLOW	0.24	100	0.043	0.015
11	B TO C	SHALLOW CONCENTRATED	UNPAVED	237	0.010	0.032
	A TO B	SHEET	0.24	100	0.083	0.136
	B TO C	SHALLOW CONCENTRATED	UNPAVED	124	0.218	0.005
12	C TO D	CHANNEL		115	0.138	0.014



DRAINAGE AREA	PEAK FLOW (CFS)		
	2-YR STORM	10-YR STORM	100-YR STORM
1A	39.86	81.52	173.52
1B	21.64	43.20	90.22
2	35.82	72.89	155.01
3	14.99	30.51	64.81
4	8.88	18.91	41.56
5	20.41	43.24	94.76
6	19.81	42.70	94.54
7	8.02	16.92	36.76
8	5.03	10.43	22.44
9	9.90	20.94	45.84
10	1.85	3.77	8.00
11	1.00	1.76	3.31
12	0.7100	1.4700	3.14



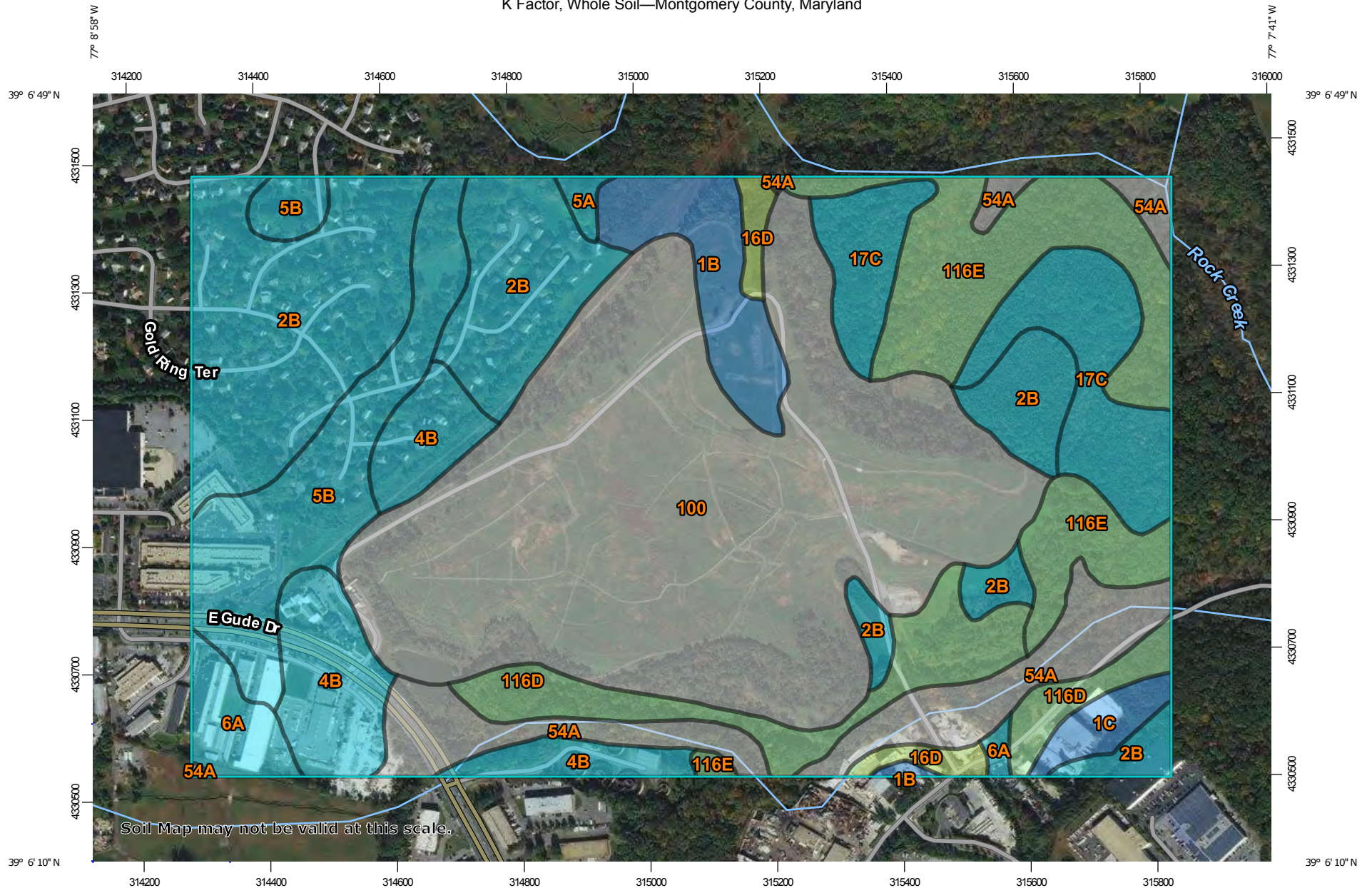
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DRAWN BY:	SMB	DATE	BY
CHECKED BY:	LJO / GAT		
PROJECT MANAGER:	M/JG		
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SEAL GUDE LANDFILL REMEDIATION DESIGN NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY MONTGOMERY COUNTY DEPARTMENT OF ENVIRONMENTAL PROTECTION MONTGOMERY COUNTY, MARYLAND		DRAINAGE AREA MAP - EXISTING CONDITIONS SCISWM SHEET 19 OF 53	
 EA Engineering, Science, and Technology, Inc., PBC Hunt Valley Center 225 Schilling Circle, Suite 400 Hunt Valley, Maryland 21031 (410) 584-7000		DATE: DECEMBER 2020 PROJECT NUMBER: 1564601 C-150 SHEET: 53 OF 146	

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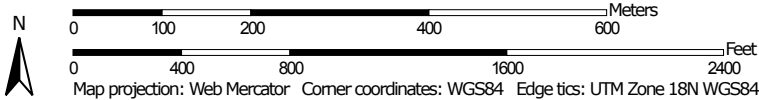
Appendix A
Web Soil Survey

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K Factor, Whole Soil—Montgomery County, Maryland




Map Scale: 1:8,500 if printed on A landscape (11" x 8.5") sheet.


















MAP LEGEND

Area of Interest (AOI)







 Area of Interest (AOI)










Soils

Soil Rating Polygons
















-  .02
-  .05
-  .10
-  .15
-  .17
-  .20
-  .24
-  .28
-  .32
-  .37
-  .43
-  .49
-  .55
-  .64
-  Not rated or not available

Soil Rating Lines








-  .02
-  .05
-  .10
-  .15
-  .17
-  .20

-  .24
-  .28
-  .32
-  .37
-  .43
-  .49
-  .55
-  .64
-  Not rated or not available

Soil Rating Points

-  .02
-  .05
-  .10
-  .15
-  .17
-  .20
-  .24
-  .28
-  .32
-  .37
-  .43
-  .49
-  .55
-  .64
-  Not rated or not available

Water Features

-  Streams and Canals
- Transportation**
-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads
- Background**
-  Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.
 Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Montgomery County, Maryland
 Survey Area Data: Version 13, Sep 18, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Gaila silt loam, 3 to 8 percent slopes	.43	12.9	3.6%
1C	Gaila silt loam, 8 to 15 percent slopes	.43	3.9	1.1%
2B	Glenelg silt loam, 3 to 8 percent slopes	.37	61.9	17.1%
4B	Elioak silt loam, 3 to 8 percent slopes	.37	22.3	6.2%
5A	Glenville silt loam, 0 to 3 percent slopes	.37	1.2	0.3%
5B	Glenville silt loam, 3 to 8 percent slopes	.37	27.1	7.5%
6A	Baile silt loam, 0 to 3 percent slopes	.37	6.5	1.8%
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	.24	3.8	1.0%
17C	Occoquan loam, 8 to 15 percent slopes	.37	23.8	6.6%
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded		24.9	6.9%
100	Dumps, refuse		121.9	33.7%
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	.28	19.9	5.5%
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	.28	31.6	8.7%
Totals for Area of Interest			361.8	100.0%

Description

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

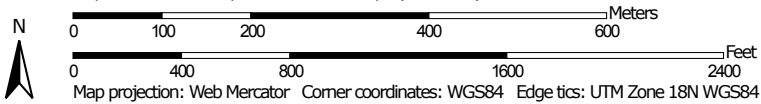
Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

Hydrologic Soil Group—Montgomery County, Maryland




Map Scale: 1:8,500 if printed on A landscape (11" x 8.5") sheet.




MAP LEGEND

Area of Interest (AOI)









 Area of Interest (AOI)

Soils

Soil Rating Polygons





 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Lines


 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Points






 A
 A/D
 B
 B/D

 C
 C/D
 D
 Not rated or not available


Water Features

 Streams and Canals

Transportation

 Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Montgomery County, Maryland
 Survey Area Data: Version 13, Sep 18, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Gaila silt loam, 3 to 8 percent slopes	B	12.9	3.6%
1C	Gaila silt loam, 8 to 15 percent slopes	B	3.9	1.1%
2B	Glenelg silt loam, 3 to 8 percent slopes	B	61.9	17.1%
4B	Elioak silt loam, 3 to 8 percent slopes	C	22.3	6.2%
5A	Glenville silt loam, 0 to 3 percent slopes	C	1.2	0.3%
5B	Glenville silt loam, 3 to 8 percent slopes	C/D	27.1	7.5%
6A	Baile silt loam, 0 to 3 percent slopes	C/D	6.5	1.8%
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	C	3.8	1.0%
17C	Occoquan loam, 8 to 15 percent slopes	B	23.8	6.6%
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B/D	24.9	6.9%
100	Dumps, refuse		121.9	33.7%
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	D	19.9	5.5%
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	D	31.6	8.7%
Totals for Area of Interest			361.8	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix B
SCS Engineers Plans

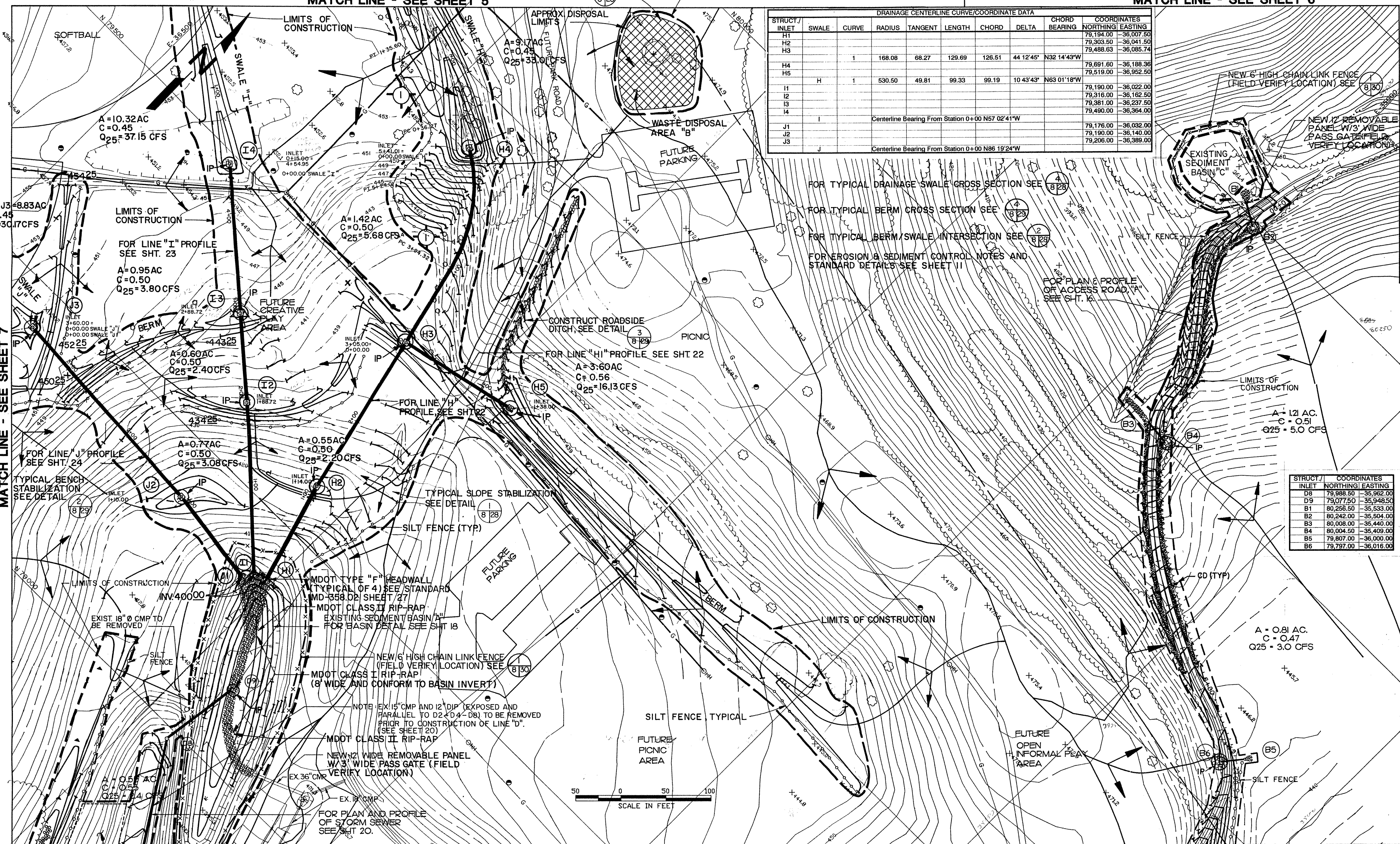
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MATCH LINE - SEE SHEET 5

MATCH LINE - SEE SHEET 6

STRUCT/INLET	SWALE	CURVE	RADIUS	TANGENT	LENGTH	CHORD	DELTA	CHORD BEARING	COORDINATES NORTHING EASTING
H1									79,194.00 -36,007.50
H2									79,303.50 -36,041.50
H3									79,486.50 -36,085.74
H4		1	168.08	68.27	129.69	126.51	44 12'45"	N32 14'43"W	79,691.60 -36,188.36
H5									79,519.00 -36,952.50
I1	H								79,190.00 -36,022.00
I2									79,316.00 -36,162.50
I3									79,381.00 -36,237.50
I4									79,490.00 -36,364.00
J1			Centerline Bearing From Station 0+00 N57 02'41"W						79,176.00 -36,032.00
J2									79,190.00 -36,140.00
J3			Centerline Bearing From Station 0+00 N86 19'24"W						79,206.00 -36,389.00



STRUCT/INLET	COORDINATES NORTHING EASTING
D8	79,988.50 -35,962.00
D9	79,077.50 -35,948.50
B1	80,256.50 -35,533.00
B2	80,242.00 -35,504.00
B3	80,008.00 -35,440.00
B4	80,004.50 -35,409.00
B5	79,807.00 -36,000.00
B6	79,797.00 -36,016.00

MATCH LINE - SEE SHEET 10

DATE

REVISION

NO.

SHEET TITLE: **SITE PLAN 6**
SWM AND EROSION CONTROL

PROJECT TITLE: **GUDE LANDFILL**
POST CLOSURE ENGINEERING
DESIGN AND MANAGEMENT TASKS

CLIENT: **MONTGOMERY COUNTY, MARYLAND**

SCS ENGINEERS
 STEARNS, CONRAD AND SCHMIDT
 CONSULTING ENGINEERS
 1680 ROBER BACON DRIVE - RESTON, VA 22090
 PH: 703 471-6660 FAX: 703 471-6676

CADD FILE: **SHT6**

DATE: **6-22-92**

SCALE: **1" = 50'**

SHEET NO. **8** of 30

***** SUMMARY OF ROUTING COMPUTATIONS *****

INFLOW HYDROGRAPH

TIME (hrs)	INFLOW (cfs)
11.000	1.00
11.100	1.00
11.200	1.00
11.300	1.00
11.400	1.00
11.500	2.00
11.600	2.00
11.700	2.00
11.800	3.00
11.900	3.00
12.000	4.00
12.100	4.00
12.200	10.00
12.300	18.00
12.400	29.00
12.500	39.00
12.600	45.00
12.700	44.00
12.800	40.00
12.900	34.00
13.000	28.00

Starting Pond W.S. Elevation = 389.00 ft

**** Summary of Peak Outflow and Peak Elevation ****

Peak Inflow = 45.00 cfs
 Peak Outflow = 39.99 cfs
 Peak Elevation = 393.00 ft

**** Summary of Approximate Peak Storage ****

Initial Storage = 0.00 ac-ft
 Peak Storage From Storm = 0.44 ac-ft
 Total Storage in Pond = 0.44 ac-ft

ROUTING COMPUTATIONS

TIME (hrs)	INFLOW (cfs)	11+I2 (cfs)	2S/t - 0 (cfs)	2S/t + 0 (cfs)	OUTFLOW (cfs)	ELEVATION (ft)
11.000	1.00	2.00	0.0	0.0	0.00	389.00
11.100	1.00	2.00	-0.1	1.06	1.06	389.13
11.200	1.00	2.00	-0.1	1.9	1.9	389.12
11.300	1.00	2.00	-0.1	1.9	1.9	389.12
11.400	1.00	2.00	-0.1	1.9	1.9	389.12
11.500	2.00	3.00	-0.2	2.9	1.53	389.19
11.600	2.00	4.00	-0.2	3.8	2.03	389.25
11.700	2.00	4.00	-0.2	3.8	2.00	389.24
11.800	3.00	5.00	-0.3	4.8	2.53	389.31
11.900	3.00	6.00	-0.3	5.7	3.03	389.37
12.000	4.00	7.00	-0.4	6.6	3.52	389.43
12.100	4.00	7.00	-0.4	7.6	4.03	389.49
12.200	10.00	10.00	-0.6	9.6	5.09	389.62
12.300	18.00	12.00	-0.9	15.4	8.18	390.00
12.400	29.00	15.00	-1.5	27.1	11.29	390.35
12.500	39.00	18.00	-2.1	41.5	17.74	391.07
12.600	45.00	22.00	-3.0	60.0	25.71	391.79
12.700	44.00	25.00	-3.9	84.0	35.19	392.60
12.800	40.00	28.00	-4.8	111.2	46.68	393.59
12.900	34.00	31.00	-5.7	141.9	60.95	395.59
13.000	28.00	34.00	-6.6	185.2	78.27	398.00

CALCULATED 06-24-1992 13:26:21
 DISK FILE: SEDA .VOL

Planimeter scale: 1 inch = 30 ft.

Elevation (ft)	Planimeter (sq.in.)	Area (acres)	A1+A2+sqrt(A1*A2) (acres)	Volume (acre-ft)	Volume Sum (acre-ft)
389.00	0.00	0.00	0.00	0.00	0.00
390.00	4.02	0.08	0.08	0.03	0.03
391.00	5.82	0.12	0.30	0.10	0.13
392.00	7.61	0.16	0.41	0.14	0.27
393.00	9.58	0.20	0.53	0.18	0.44
394.00	11.55	0.24	0.65	0.22	0.66
395.00	13.32	0.28	0.77	0.26	0.92
396.00	15.11	0.31	0.88	0.29	1.21
397.00	17.05	0.35	1.00	0.33	1.54
398.00	19.03	0.39	1.12	0.37	1.92
399.00	20.59	0.43	1.23	0.41	2.33
399.40	21.50	0.44	1.30	0.41	2.50
400.00	22.59	0.47	1.37	0.27	2.77
401.00	24.54	0.51	1.46	0.49	3.26

$$IA = (\text{sqrt}(\text{Areal}) + ((E1-E2)/(E2-E1)) * (\text{sqrt}(\text{Area}2) - \text{sqrt}(\text{Area}1)))^2$$

where: E1, E2 = Closest two elevations with planimeter data
 E1 = Elevation at which to interpolate area
 Areal, Area2 = Areas computed for E1, E2, respectively
 IA = Interpolated area for E1

* Incremental volume computed by the Conic Method for Reservoir Volumes.

$$\text{Volume} = (1/3) * (E2-E1) * (\text{Areal} + \text{Area}2 + \text{sqrt}(\text{Areal} * \text{Area}2))$$

where: E1, E2 = Lower and upper elevations of the increment
 Areal, Area2 = Areas computed for E1, E2, respectively
 Volume = Incremental volume between E1 and E2

Tc COMPUTATIONS FOR: DA7

SHEET FLOW (Applicable to Tc only)

Segment ID	Surface description	Surface	Manning's roughness coeff., n	Flow length, L (total < or = 300)	Two-yr 24-hr rainfall, P2	Land slope, s	T
	GRASS	SCF	0.2400	300.0	3.200	0.0230	0.54
	Unpaved	SCF	16.1345	240.0	0.0300	0.0125	0.04
	Paved	SCF	20.3282	240.0	0.0300	0.0125	0.02

SHALLOW CONCENTRATED FLOW
 Segment ID
 Surface (paved or unpaved)?
 Flow length, L
 Watercourse slope, s
 Avg. V = Csf * (s)
 where: Unpaved Csf = 16.1345
 Paved Csf = 20.3282

T = L / (3600*V)
 T = 530 / (3600 * 4.1834) = 0.04 + 0.00 = 0.04

CHANNEL FLOW
 Segment ID
 Cross Sectional Flow Area, a
 Wetted perimeter, Pw
 Hydraulic radius, r = a/Pw
 Channel slope, s
 Manning's roughness coeff., n

V = (1.49 * r^(2/3) * s^(1/2)) / n
 V = (1.49 * 7.91^(2/3) * 0.0300^(1/2)) / 0.0400 = 4.1834

Flow length, L = 530 ft
 T = L / (3600*V) = 530 / (3600 * 4.1834) = 0.04 + 0.00 = 0.04

..... TOTAL TIME (hrs) = 0.66

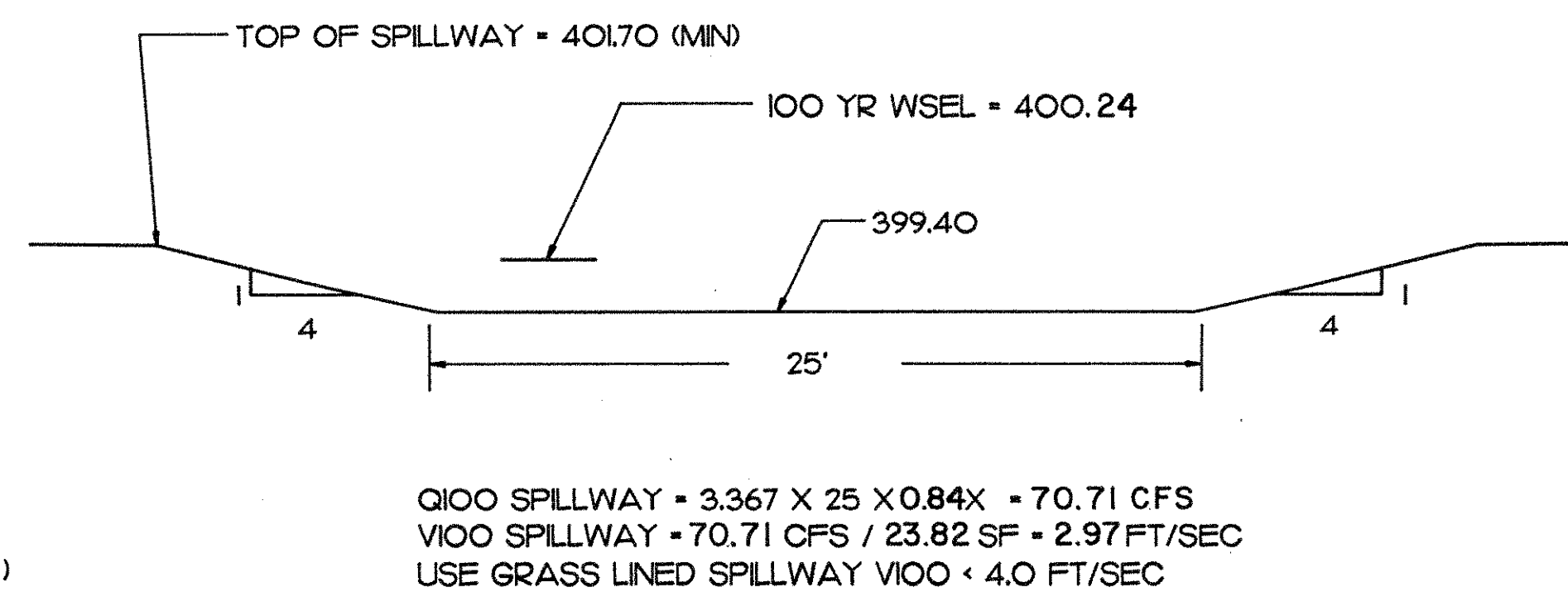
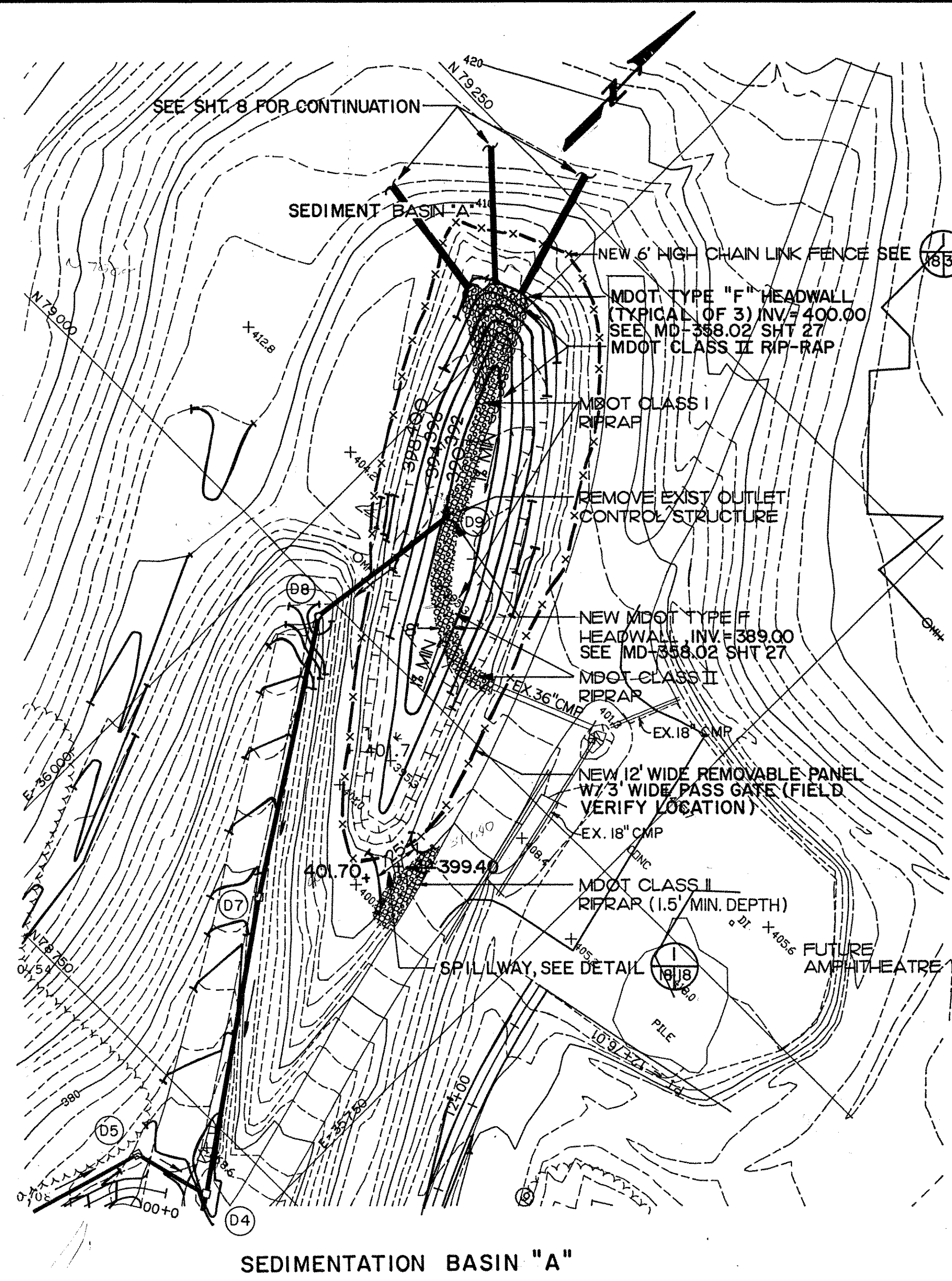
GUIDE LANDFILL SEDIMENTATION BASIN A
 DRAINAGE AREA 7 POST DEVELOPED CONDITIONS

RUNOFF CURVE NUMBER DATA

Composite Area: DA7

SURFACE DESCRIPTION	AREA (acres)	CN
GRAVEL ROAD D	0.50	91
WOODED POOR D	1.83	83
WOODED FAIR D	40.59	79
PASTURE GOOD D	48.28	80
IMPERVIOUS D	0.50	98

COMPOSITE AREA ----> 51.70 80.4 (80)



TYPICAL X-SECTION THROUGH SPILLWAY

NO SCALE



DATE	REVISION	NO.

SHEET TITLE: DETENTION BASIN "A"
 PROJECT TITLE: GUIDE LANDFILL POST CLOSURE ENGINEERING DESIGN AND MANAGEMENT TASKS

CLIENT: MONTGOMERY COUNTY, MARYLAND

SCS ENGINEERS
 STEARNS, CONRAD AND SCHMIDT
 CONSULTING ENGINEERS
 1080 ROBERT BACON DRIVE - RESTON, VA. 20190
 PH: (703) 475-9800 FAX: 703 477-6676

CADD FILE: BASIN

DATE: 6-22-92

SCALE: 1"=50'

SHEET NO.

Appendix C

TR-55 Calculations – Existing and Proposed

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/10/2020
 Project: Gude Units: English
 SubTitle: DA-1A Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\slemasters\Downloads\DA-1A (1).w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1A EX		Outlet	36.95	80	.392
DA-1A PR		Outlet	32.83	80	.363

Total area: 69.78 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-1A EX	39.86	81.52	117.24	173.52
DA-1A PR	36.80	75.11	108.09	159.97
REACHES				
OUTLET	76.50	156.55	224.61	332.92

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-1A EX	39.86	81.52	117.24	173.52
	12.29	12.27	12.28	12.27

DA-1A PR	36.80	75.11	108.09	159.97
	12.28	12.27	12.26	12.26

REACHES

OUTLET	76.50	156.55	224.61	332.92
--------	-------	--------	--------	--------

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-1A EX	36.95	0.392	80	Outlet	
DA-1A PR	32.83	0.363	80	Outlet	
Total Area:	69.78 (ac)				

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-1A EX							
SHEET	100	0.0180	0.240				0.250
SHALLOW	1122	0.0220	0.050				0.130
CHANNEL	668	0.0500	0.013	3.12	6.28	15.463	0.012
							Time of Concentration .392
							=====
DA-1A PR							
SHEET	100	0.0150	0.240				0.269
SHALLOW	422	0.0200	0.050				0.051
CHANNEL	900	0.0200	0.030	14.04	13.90	7.143	0.035
CHANNEL	271	0.0250	0.030	20.12	15.83	9.410	0.008
							Time of Concentration .363
							=====

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-1A EX	Dirt (w/ right-of-way)	D	1.13	89
	Pasture, grassland or range	(good) D	35.78	80
	Woods	(good) D	.04	77
	Total Area / Weighted Curve Number		36.95	80
			=====	==
DA-1A PR	Gravel (w/ right-of-way)	D	1.44	91
	Pasture, grassland or range	(good) D	31.39	80
	Total Area / Weighted Curve Number		32.83	80
			=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: DA-1B Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1B EX		Outlet	16.07	81	.272
DA-1B PR		Outlet	29.17	80	0.325

Total area: 45.24 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-1B EX	21.64	43.20	61.55	90.22
DA-1B PR	34.47	70.34	100.77	149.37
REACHES				
OUTLET	55.70	112.77	161.47	237.89

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-1B EX	21.64	43.20	61.55	90.22
	12.22	12.21	12.21	12.21

DA-1B PR	34.47	70.34	100.77	149.37
	12.25	12.24	12.23	12.24

REACHES

OUTLET	55.70	112.77	161.47	237.89
--------	-------	--------	--------	--------

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-1B EX	16.07	0.272	81	Outlet	
DA-1B PR	29.17	0.325	80	Outlet	
Total Area:	45.24 (ac)				

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-1B EX							
SHEET	100	0.0440	0.240				0.175
SHALLOW	1234	0.0500	0.050				0.095
CHANNEL	89	0.0320	0.013	4.99	7.85	12.361	0.002
						Time of Concentration	.272
							=====
DA-1B PR							
SHEET	100	0.0150	0.240				0.269
SHALLOW	300	0.0250	0.050				0.033
CHANNEL	1260	0.0300	0.013	9.71	12.38	16.667	0.021
CHANNEL	169	0.1290	0.013	1.59	4.62	23.472	0.002
						Time of Concentration	0.325
							=====

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-1B EX	Paved parking lots, roofs, driveways	D	.55	98
	Dirt (w/ right-of-way)	D	.58	89
	Pasture, grassland or range (good)	D	14.75	80
	Woods (good)	D	.19	77
	Total Area / Weighted Curve Number		16.07	81
			=====	==
DA-1B PR	Gravel (w/ right-of-way)	D	1.27	91
	Pasture, grassland or range (good)	D	27.75	80
	Woods (good)	D	.15	77
	Total Area / Weighted Curve Number		29.17	80
			=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: DA-2 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-2 EX		Outlet	28.63	80	.286
DA-2 PR		Outlet	22.42	80	.386

Total area: 51.05 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-2 EX	35.82	72.89	104.81	155.01
DA-2 PR	24.42	49.82	71.60	106.16
REACHES				
OUTLET	59.11	120.73	173.45	256.74

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-2 EX	35.82	72.89	104.81	155.01
	12.23	12.23	12.22	12.21

DA-2 PR	24.42	49.82	71.60	106.16
	12.29	12.27	12.28	12.28

REACHES

OUTLET	59.11	120.73	173.45	256.74
--------	-------	--------	--------	--------

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-2 EX	28.63	0.286	80	Outlet	
DA-2 PR	22.42	0.386	80	Outlet	

Total Area:	51.05 (ac)				

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-2 EX							
SHEET	100	0.0240	0.240				0.223
SHALLOW	521	0.0253	0.050				0.056
CHANNEL	576	0.0760	0.013	4.91	7.90	22.857	0.007
						Time of Concentration	.286
							=====
DA-2 PR							
SHEET	100	0.0350	0.240				0.192
SHALLOW	752	0.0200	0.050				0.092
CHANNEL	861	0.0100	0.030	6.74	8.87	4.124	0.058
CHANNEL	1680	0.0160	0.013	4.91	7.90	10.606	0.044
						Time of Concentration	.386
							=====

EA

Gude
DA-2
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-2 EX	Dirt (w/ right-of-way)		D	.914	89
	Pasture, grassland or range	(good)	D	26.098	80
	Woods	(good)	D	1.615	77
	Total Area / Weighted Curve Number			28.63	80
				=====	==
DA-2 PR	Gravel (w/ right-of-way)		D	1.04	91
	Pasture, grassland or range	(good)	D	20.36	80
	Woods	(good)	D	1.02	77
	Total Area / Weighted Curve Number			22.42	80
				=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: DA-3 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-3 EX		Outlet	11.9	80	.282
DA-3 PR		Outlet	10.02	81	.302

Total area: 21.92 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-3 EX	14.99	30.51	43.80	64.81
DA-3 PR	12.87	25.74	36.68	53.87
REACHES				
OUTLET	27.84	56.12	80.40	118.37

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-3 EX	14.99	30.51	43.80	64.81
	12.23	12.21	12.22	12.21

DA-3 PR	12.87	25.74	36.68	53.87
	12.24	12.23	12.23	12.22

REACHES

OUTLET	27.84	56.12	80.40	118.37
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EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-3 EX	11.90	0.282	80	Outlet	
DA-3 PR	10.02	0.302	81	Outlet	
Total Area:	21.92 (ac)				

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-3 EX							
SHEET	100	0.0200	0.240				0.240
SHALLOW	272	0.0160	0.050				0.037
SHALLOW	158	0.2480	0.050				0.005
						Time of Concentration	.282
							=====
DA-3 PR							
SHEET	100	0.0360	0.240				0.190
SHALLOW	794	0.0210	0.050				0.094
CHANNEL	172	0.0930	0.030	24.00	16.94	15.926	0.003
CHANNEL	517	0.0240	0.030	24.00	16.94	9.574	0.015
						Time of Concentration	.302
							=====

EA

Gude
DA-3
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-3 EX	Paved parking lots, roofs, driveways	D	.02	98
	Dirt (w/ right-of-way)	D	.19	89
	Pasture, grassland or range (good)	D	11.11	80
	Woods (good)	D	.58	77
	Total Area / Weighted Curve Number		11.9	80
			====	==
DA-3 PR	Gravel (w/ right-of-way)	D	.47	91
	Pasture, grassland or range (good)	D	9.55	80
	Total Area / Weighted Curve Number		10.02	81
			=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: DA-4 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-4 EX		Outlet	9.06	78	.383
DA-4 PR		Outlet	8.01	78	.132

Total area: 17.07 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-4 EX	8.88	18.91	27.62	41.56
DA-4 PR	12.23	25.63	37.25	55.55
REACHES				
OUTLET	18.19	38.94	57.10	85.91

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-4 EX	8.88	18.91	27.62	41.56
	12.28	12.29	12.29	12.27

DA-4 PR	12.23	25.63	37.25	55.55
	12.14	12.14	12.13	12.14

REACHES

OUTLET	18.19	38.94	57.10	85.91
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EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-4 EX	9.06	0.383	78	Outlet	
DA-4 PR	8.01	0.132	78	Outlet	

Total Area:	17.07 (ac)				

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-4 EX							
SHEET	100	0.0090	0.240				0.330
SHALLOW	1020	0.1100	0.050				0.053
					Time of Concentration		.383
							=====
DA-4 PR							
SHEET	62	0.1060	0.240				0.084
SHALLOW	929	0.1100	0.050				0.048
					Time of Concentration		.132
							=====

EA

Gude
DA-4
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-4 EX	Dirt (w/ right-of-way)		D	.227	89
	Pasture, grassland or range	(good)	D	2.357	80
	Woods	(good)	D	6.476	77
	Total Area / Weighted Curve Number			9.06	78
				====	==
DA-4 PR	Pasture, grassland or range	(good)	D	1.535	80
	Woods	(good)	D	6.477	77
	Total Area / Weighted Curve Number			8.01	78
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: DA-5 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-5 EX		Outlet	17.48	78	.263
DA-5 PR		Outlet	17.58	78	.431

Total area: 35.06 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-5 EX	20.41	43.24	63.11	94.76
DA-5 PR	16.25	34.62	50.70	76.21
REACHES				
OUTLET	34.79	74.25	108.51	163.29

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-5 EX	20.41	43.24	63.11	94.76
	12.21	12.20	12.20	12.20

DA-5 PR	16.25	34.62	50.70	76.21
	12.33	12.32	12.31	12.30

REACHES

OUTLET	34.79	74.25	108.51	163.29
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EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-5 EX	17.48	0.263	78	Outlet	
DA-5 PR	17.58	0.431	78	Outlet	

Total Area:	35.06 (ac)				

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-5 EX							
SHEET	100	0.0350	0.240				0.192
SHALLOW	311	0.0160	0.050				0.042
CHANNEL	1222	0.1477	0.030	3.00	6.32	11.705	0.029
						Time of Concentration	.263
							=====
DA-5 PR							
SHEET	100	0.0440	0.240				0.175
SHALLOW	35	0.0660	0.050				0.002
CHANNEL	383	0.0050	0.030	24.00	516.94	0.453	0.235
CHANNEL	961	0.2160	0.030	3.00	6.32	14.050	0.019
						Time of Concentration	.431
							=====

EA

Gude
DA-5
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-5 EX	Paved parking lots, roofs, driveways	D	.238	98
	Dirt (w/ right-of-way)	D	.101	89
	Pasture, grassland or range (good)	D	3.64	80
	Woods (good)	D	13.5	77
	Total Area / Weighted Curve Number		17.48	78
			=====	==
DA-5 PR	Gravel (w/ right-of-way)	D	.113	91
	Pasture, grassland or range (good)	D	3.88	80
	Woods (good)	D	13.586	77
	Total Area / Weighted Curve Number		17.58	78
			=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: DA-6 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-6 EX		Outlet	15.65	77	.19
DA-6 PR		Outlet	15.62	77	0.174

Total area: 31.27 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-6 EX	19.81	42.70	62.70	94.54
DA-6 PR	20.50	44.10	64.69	97.44
REACHES				
OUTLET	40.25	86.50	127.19	191.79

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-6 EX	19.81	42.70	62.70	94.54
	12.17	12.16	12.17	12.17

DA-6 PR	20.50	44.10	64.69	97.44
	12.16	12.16	12.16	12.16

REACHES

OUTLET	40.25	86.50	127.19	191.79
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EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-6 EX	15.65	0.190	77	Outlet	
DA-6 PR	15.62	0.174	77	Outlet	

Total Area:	31.27 (ac)				

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-6 EX							
SHEET	100	0.0490	0.240				0.168
SHALLOW	616	0.2380	0.050				0.022
					Time of Concentration		.19
							=====
DA-6 PR							
SHEET	100	0.0630	0.240				0.152
SHALLOW	616	0.2380	0.050				0.022
					Time of Concentration		0.174
							=====

EA

Gude
DA-6
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-6 EX	Dirt (w/ right-of-way)	D	.045	89
	Pasture, grassland or range	(good) D	2.132	80
	Woods	(good) D	13.474	77
	Total Area / Weighted Curve Number		15.65	77
			=====	==
DA-6 PR	Gravel (w/ right-of-way)	D	.05	91
	Pasture, grassland or range	(good) D	2.1	80
	Woods	(good) D	13.47	77
	Total Area / Weighted Curve Number		15.62	77
			=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: DA-7 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-7 EX		Outlet	5.78	78	.173
DA-7 PR		Outlet	5.8	78	0.150

Total area: 11.58 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-7 EX	8.02	16.92	24.59	36.76
DA-7 PR	8.48	17.84	25.87	38.72
REACHES				
OUTLET	16.46	34.62	50.35	75.12

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-7 EX	8.02	16.92	24.59	36.76
	12.16	12.16	12.16	12.16

DA-7 PR	8.48	17.84	25.87	38.72
	12.15	12.15	12.15	12.14

REACHES

OUTLET	16.46	34.62	50.35	75.12
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EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-7 EX	5.78	0.173	78	Outlet	
DA-7 PR	5.80	0.150	78	Outlet	

Total Area:	11.58 (ac)				

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-7 EX							
SHEET	100	0.0680	0.240				0.147
SHALLOW	694	0.2460	0.050				0.024
CHANNEL	120	0.4096	0.013	1.77	14.71	16.667	0.002
						Time of Concentration	.173
							=====
DA-7 PR							
SHEET	100	0.0945	0.240				0.129
SHALLOW	550	0.2460	0.050				0.019
CHANNEL	120	0.4096	0.013	1.77	14.71	16.667	0.002
						Time of Concentration	0.150
							=====

EA

Gude
DA-7
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-7 EX	Pasture, grassland or range	(good)	D	2.65	80
	Woods	(good)	D	3.13	77
	Total Area / Weighted Curve Number			5.78	78
				====	==
DA-7 PR	Pasture, grassland or range	(good)	D	2.58	80
	Woods	(good)	D	3.22	77
	Total Area / Weighted Curve Number			5.8	78
				===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: DA-8 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-8 EX		Outlet	3.88	79	.234
DA-8 PR		Outlet	4.13	80	.141

Total area: 8.01 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-8 EX	5.03	10.43	15.04	22.44
DA-8 PR	6.83	13.80	19.72	29.02
REACHES				
OUTLET	11.44	23.43	33.68	49.91

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-8 EX	5.03	10.43	15.04	22.44
	12.20	12.19	12.18	12.19

DA-8 PR	6.83	13.80	19.72	29.02
	12.14	12.14	12.14	12.14

REACHES

OUTLET	11.44	23.43	33.68	49.91
--------	-------	-------	-------	-------

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-8 EX	3.88	0.234	79	Outlet	
DA-8 PR	4.13	0.141	80	Outlet	

Total Area:	8.01 (ac)				

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-8 EX							
SHEET	100	0.0280	0.240				0.210
SHALLOW	485	0.1810	0.050				0.020
CHANNEL	40	0.0133	0.013	1.77	4.71	5.556	0.002
CHANNEL	230	0.0675	0.013	9.12	8.75	31.944	0.002
						Time of Concentration	.234
							=====
DA-8 PR							
SHEET	100	0.1235	0.240				0.116
SHALLOW	434	0.1810	0.050				0.018
CHANNEL	40	0.0133	0.013	1.77	24.71	2.222	0.005
CHANNEL	230	0.0675	0.013	9.12	8.75	31.944	0.002
						Time of Concentration	.141
							=====

EA

Gude
DA-8
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-8 EX	Pasture, grassland or range	(good)	D	1.9	80
	Woods - grass combination	(good)	D	1.98	79
	Total Area / Weighted Curve Number			3.88	79
				====	==
DA-8 PR	Pasture, grassland or range	(good)	D	2.11	80
	Woods - grass combination	(good)	D	2.02	79
	Total Area / Weighted Curve Number			4.13	80
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/1/2020
 Project: Gude Units: English
 SubTitle: DA-9 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-9 EX		Outlet	8.1	78	.237
DA-9 PR		Outlet	8.42	79	.228

Total area: 16.52 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-9 EX	9.90	20.94	30.50	45.84
DA-9 PR	11.04	22.90	33.01	49.11
REACHES				
OUTLET	20.90	43.79	63.49	94.90

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-9 EX	9.90	20.94	30.50	45.84
	12.20	12.20	12.20	12.19

DA-9 PR	11.04	22.90	33.01	49.11
	12.19	12.19	12.19	12.18

REACHES

OUTLET	20.90	43.79	63.49	94.90
--------	-------	-------	-------	-------

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-9 EX	8.10	0.237	78	Outlet	
DA-9 PR	8.42	0.228	79	Outlet	

Total Area:	16.52 (ac)				

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-9 EX							
SHEET	100	0.0260	0.240				0.216
SHALLOW	586	0.2220	0.050				0.021
					Time of Concentration		.237
							=====
DA-9 PR							
SHEET	100	0.0290	0.240				0.207
SHALLOW	586	0.2220	0.050				0.021
					Time of Concentration		.228
							=====

EA

Gude
DA-9
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-9 EX	Dirt (w/ right-of-way)		D	.27	89
	Pasture, grassland or range	(good)	D	2.84	80
	Woods	(good)	D	4.99	77
	Total Area / Weighted Curve Number			8.1	78
				===	==
DA-9 PR	Gravel (w/ right-of-way)		D	.375	91
	Pasture, grassland or range	(good)	D	3.055	80
	Woods	(good)	D	4.992	77
	Total Area / Weighted Curve Number			8.42	79
				====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: DA-10 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-10 EX		Outlet	1.53	80	.309
DA-10 PR		Outlet	0.89	80	.143

Total area: 2.42 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-10 EX	1.85	3.77	5.40	8.00
DA-10 PR	1.47	2.96	4.23	6.23
REACHES				
OUTLET	3.00	6.15	8.85	13.11

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 2-Yr 10-Yr 25-Yr 100-Yr
Identifier (cfs) (cfs) (cfs) (cfs)
(hr) (hr) (hr) (hr)

SUBAREAS

DA-10 EX 1.85 3.77 5.40 8.00
12.24 12.23 12.24 12.22

DA-10 PR 1.47 2.96 4.23 6.23
12.14 12.14 12.14 12.14

REACHES

OUTLET 3.00 6.15 8.85 13.11

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-10 EX	1.53	0.309	80	Outlet	
DA-10 PR	.89	0.143	80	Outlet	

Total Area:	2.42 (ac)				

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-10 EX							
SHEET	100	0.0160	0.240				0.263
SHALLOW	83	0.0660	0.050				0.006
CHANNEL	249	0.0910	0.150	3.00	6.32	1.820	0.038
CHANNEL	31	0.0232	0.019	1.23	3.93	4.306	0.002
						Time of Concentration	.309
							=====
DA-10 PR							
SHEET	66	0.0750	0.240				0.101
SHALLOW	30	0.1000	0.050				0.002
CHANNEL	249	0.0910	0.150	3.00	6.32	1.820	0.038
CHANNEL	31	0.0232	0.019	1.23	3.93	4.306	0.002
						Time of Concentration	.143
							=====

EA

Gude
DA-10
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-10 EX	Dirt (w/ right-of-way)	D	.07	89
	Pasture, grassland or range	(good) D	1.37	80
	Woods	(good) D	.09	77
	Total Area / Weighted Curve Number		1.53	80
			====	==
DA-10 PR	Dirt (w/ right-of-way)	D	.04	89
	Pasture, grassland or range	(good) D	.76	80
	Woods	(good) D	.09	77
	Total Area / Weighted Curve Number		.89	80
			===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Units: English
 SubTitle: Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-11 EX		Outlet	0.39	88	0.1
DA-11 PR		Outlet	0.55	87	0.1

Total area: .94 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-11 EX	1.00	1.76	2.37	3.31
DA-11 PR	1.36	2.42	3.29	4.62
REACHES				
OUTLET	2.37	4.18	5.66	7.93

EA

Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-11 EX	1.00	1.76	2.37	3.31
	12.12	12.12	12.12	12.12

DA-11 PR	1.36	2.42	3.29	4.62
	12.12	12.12	12.12	12.12

REACHES

OUTLET	2.37	4.18	5.66	7.93
--------	------	------	------	------

EA

Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-11 EX	.39	0.100	88	Outlet	
DA-11 PR	.55	0.100	87	Outlet	
Total Area:	.94 (ac)				

EA

Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-11 EX							
SHEET	100	0.0430	0.011				0.015
SHALLOW	237	0.0100	0.025				0.032
					Time of Concentration		0.1
							=====
DA-11 PR							
SHEET	100	0.0770	0.011				0.012
SHALLOW	198	0.1070	0.025				0.008
					Time of Concentration		0.1
							=====

EA

Montgomery NOAA-C County, Maryland
Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-11 EX	Paved parking lots, roofs, driveways	D	.18	98
	Pasture, grassland or range (good)	D	.21	80
	Total Area / Weighted Curve Number		.39	88
			===	==
DA-11 PR	Paved parking lots, roofs, driveways	D	.2	98
	Pasture, grassland or range (good)	D	.35	80
	Total Area / Weighted Curve Number		.55	87
			===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: DA-12 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-12 EX		Outlet	0.47	79	.155
DA-12 PR		Outlet	0.45	79	0.1

Total area: .92 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-12
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-12
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DA-12 EX	0.71	1.47	2.12	3.14
DA-12 PR	0.78	1.59	2.28	3.38
REACHES				
OUTLET	1.46	3.00	4.32	6.41

EA

Gude
DA-12
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DA-12 EX	0.71	1.47	2.12	3.14
	12.15	12.15	12.14	12.15

DA-12 PR	0.78	1.59	2.28	3.38
	12.12	12.12	12.12	12.12

REACHES

OUTLET	1.46	3.00	4.32	6.41
--------	------	------	------	------

EA

Gude
DA-12
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-12 EX	.47	0.155	79	Outlet	
DA-12 PR	.45	0.100	79	Outlet	
Total Area:	.92 (ac)				

EA

Gude
DA-12
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

DA-12 EX							
SHEET	100	0.0830	0.240				0.136
SHALLOW	124	0.2180	0.050				0.005
CHANNEL	115	0.1380	0.150	3.00	6.32	2.282	0.014
						Time of Concentration	.155
							=====
DA-12 PR							
SHEET	45	0.1600	0.240				0.055
SHALLOW	124	0.2180	0.050				0.005
CHANNEL	115	0.1380	0.150	3.00	6.32	2.282	0.014
						Time of Concentration	0.1
							=====

EA

Gude
DA-12
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

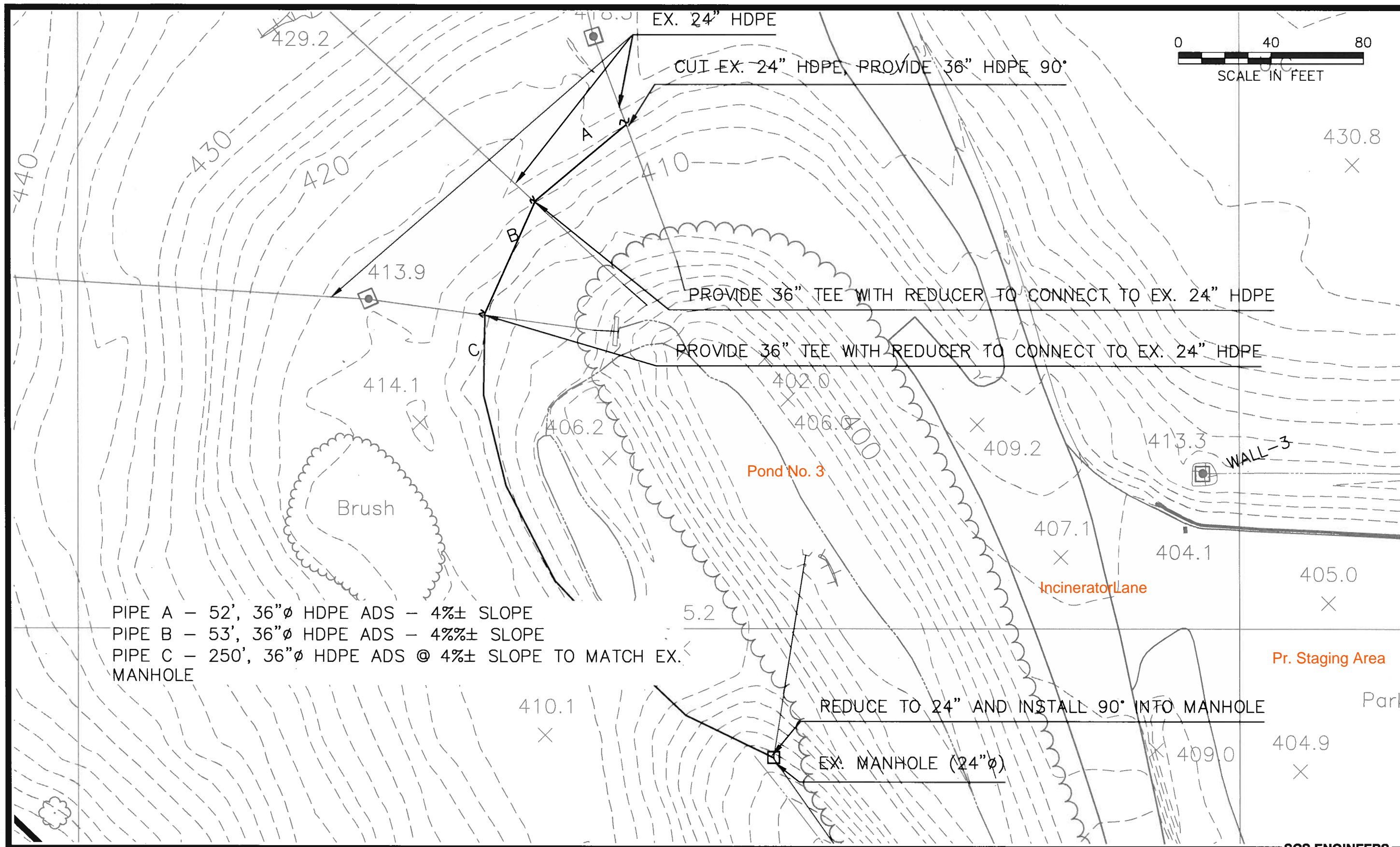
Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-12 EX	Dirt (w/ right-of-way)	D	.05	89
	Pasture, grassland or range	(good) D	.18	80
	Woods	(good) D	.24	77
	Total Area / Weighted Curve Number		.47	79
			===	==
DA-12 PR	Dirt (w/ right-of-way)	D	.046	89
	Pasture, grassland or range	(good) D	.165	80
	Woods	(good) D	.237	77
	Total Area / Weighted Curve Number		.45	79
			===	==

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Appendix D

Stormwater Bypass Drawing

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PIPE A - 52', 36"Ø HDPE ADS - 4%± SLOPE
 PIPE B - 53', 36"Ø HDPE ADS - 4%± SLOPE
 PIPE C - 250', 36"Ø HDPE ADS @ 4%± SLOPE TO MATCH EX. MANHOLE

REDUCE TO 24" AND INSTALL 90° INTO MANHOLE
 EX. MANHOLE (24"Ø)

ROUGH GRADING STORMWATER MANAGEMENT DIVERSION

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Appendix E

Storm Drainage Computations

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Project Gude Landfill Remediation Design Project No. 1564601
Subject Swale Hydraulic Calculations Sheet No. 1 of 18
Drawing No. _____
Computed by SS Date 02/26/2020 Checked by [Signature] Date 11/27/2020

Montgomery County
Drainage Design Criteria.
Montgomery County
Department of
Transportation, Rockville,
Maryland, 10 June 2014.

OBJECTIVE:

Confirm swale size is adequate for peak discharge, velocity and depth of flow.

PROCEDURE:

NRCS (TR-55) was used to determine the peak discharges for 2-year, 10-year, 25-year, and 100-year storm events for the eighteen proposed conveyance swales.

ASSUMPTIONS:

- Swales were sized based on 10-year storm peak discharge
- The minimum freeboard of 0.5 feet to the top of the channel was based on the 10-year storm depth
- Actual time of concentrations were calculated using NRCS (TR-55)

CALCULATIONS:

- 1) Delineate drainage area for each swale.
- 2) Use TR-55 to determine peak discharges for 2-year, 10-year, 25-year, and 100-year storm events.
- 3) Use AutoCAD Civil 3D Hydraflow Express to determine velocity and depth of flow in each swale.

CONCLUSIONS:

The swale sizes are adequate regarding velocity and freeboard required by Montgomery County.

ATTACHMENTS:

Swale Size Summary Table
TR-55 Outputs

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Units: English
SubTitle: Swale 1 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 1		Outlet	5.3	81	.321

Total area: 5.30 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude
Swale 1
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude
Swale 1
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 1	6.61	13.26	18.87	27.74
REACHES				
OUTLET	6.61	13.26	18.87	27.74

SS

Gude
Swale 1
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 1	6.61	13.26	18.87	27.74
	12.26	12.24	12.23	12.24

REACHES

OUTLET	6.61	13.26	18.87	27.74
--------	------	-------	-------	-------

SS

Gude
Swale 1
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 1	5.30	0.321	81	Outlet	
Total Area:	5.30 (ac)				

SS

Gude
Swale 1
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 1							
SHEET	100	0.0350	0.240				0.192
SHALLOW	752	0.0200	0.050				0.092
CHANNEL	91	0.2300	0.030	6.00	4.87	25.278	0.001
CHANNEL	854	0.0130	0.030	6.00	4.87	6.590	0.036
						Time of Concentration	.321
							=====

SS

Gude
Swale 1
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 1	Gravel (w/ right-of-way)	D	.335	91
	Pasture, grassland or range	(good) D	4.963	80
	Total Area / Weighted Curve Number		5.3	81
			===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Landfill Units: English
SubTitle: Swale 2 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 2		Outlet	1.19	82	0.100

Total area: 1.19 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 2
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 2
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 2	2.39	4.61	6.48	9.39
REACHES				
OUTLET	2.39	4.61	6.48	9.39

SS

Gude Landfill
Swale 2
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 2	2.39	4.61	6.48	9.39
	12.12	12.12	12.12	12.12

REACHES

OUTLET	2.39	4.61	6.48	9.39
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SS

Gude Landfill
Swale 2
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 2	1.19	0.100	82	Outlet	

Total Area:	1.19 (ac)				

SS

Gude Landfill
Swale 2
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 2	Gravel (w/ right-of-way)	D	.166	91
	Pasture, grassland or range	(good) D	1.029	80
	Total Area / Weighted Curve Number		1.19	82
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/19/2020
Project: Gude Landfill Units: English
SubTitle: Swale 3 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 3		Outlet	1.22	82	0.1

Total area: 1.22 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 3
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 3
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 3	2.45	4.74	6.65	9.64
REACHES				
OUTLET	2.45	4.74	6.65	9.64

SS

Gude Landfill
Swale 3
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 3	2.45	4.74	6.65	9.64
	12.12	12.12	12.12	12.12

REACHES

OUTLET	2.45	4.74	6.65	9.64
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SS

Gude Landfill
Swale 3
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 3	1.22	0.100	82	Outlet	
Total Area:	1.22 (ac)				

SS

Gude Landfill
Swale 3
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 3							
SHEET	100	0.1160	0.011				0.010
SHALLOW	50	0.1040	0.050				0.003
CHANNEL	578	0.0250	0.030	6.00	4.87	8.920	0.018
						Time of Concentration	0.1
							=====

SS

Gude Landfill
Swale 3
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 3	Gravel (w/ right-of-way)	D	.18	91
	Pasture, grassland or range	(good) D	1.036	80
	Total Area / Weighted Curve Number		1.22	82
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 4 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 4		Outlet	5.76	80	.273

Total area: 5.76 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 4
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 4
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 4	7.36	14.99	21.50	31.74
REACHES				
OUTLET	7.36	14.99	21.50	31.74

SS

Gude Landfill
Swale 4
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 4	7.36	14.99	21.50	31.74
	12.22	12.21	12.21	12.22

REACHES

OUTLET	7.36	14.99	21.50	31.74
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SS

Gude Landfill
Swale 4
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 4	5.76	0.273	80	Outlet	
Total Area:		5.76 (ac)			

SS

Gude Landfill
Swale 4
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 4	Gravel (w/ right-of-way)	D	.232	91
	Pasture, grassland or range	(good) D	5.532	80
	Total Area / Weighted Curve Number		5.76	80
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Landfill Units: English
SubTitle: Swale 4A Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 4A		Outlet	1.4	81	.366

Total area: 1.40 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 4A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 4A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 4A	1.65	3.30	4.70	6.92
REACHES				
OUTLET	1.65	3.30	4.70	6.92

SS

Gude Landfill
Swale 4A
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 4A	1.65	3.30	4.70	6.92
	12.28	12.26	12.26	12.26

REACHES

OUTLET	1.65	3.30	4.70	6.92
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SS

Gude Landfill
Swale 4A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 4A	1.40	0.366	81	Outlet	
Total Area:	1.40 (ac)				

SS

Gude Landfill
Swale 4A
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 4A	Gravel (w/ right-of-way)	D	.11	91
	Pasture, grassland or range	(good) D	1.288	80
	Total Area / Weighted Curve Number		1.4	81
			===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 5 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 5		Outlet	7.73	81	.142

Total area: 7.73 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 5
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 5
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 5	13.45	26.57	37.68	55.11
REACHES				
OUTLET	13.45	26.57	37.68	55.11

SS

Gude Landfill
Swale 5
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 5	13.45	26.57	37.68	55.11
	12.14	12.14	12.14	12.14

REACHES

OUTLET	13.45	26.57	37.68	55.11
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SS

Gude Landfill
Swale 5
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 5	7.73	0.142	81	Outlet	

Total Area:	7.73 (ac)				

SS

Gude Landfill
Swale 5
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 5	Gravel (w/ right-of-way)	D	.569	91
	Pasture, grassland or range	(good) D	7.163	80
	Total Area / Weighted Curve Number		7.73	81
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 6 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 6		Outlet	1.1	80	.195

Total area: 1.10 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 6
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 6
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 6	1.62	3.28	4.71	6.94
REACHES				
OUTLET	1.62	3.28	4.71	6.94

SS

Gude Landfill
Swale 6
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 6	1.62	3.28	4.71	6.94
	12.17	12.17	12.16	12.17

REACHES

OUTLET	1.62	3.28	4.71	6.94
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SS

Gude Landfill
Swale 6
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 6	1.10	0.195	80	Outlet	

Total Area:	1.10 (ac)				

SS

Gude Landfill
Swale 6
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 6	Pasture, grassland or range	(good) D	1.1	80
Total Area / Weighted Curve Number			1.1 ===	80 ==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Landfill Units: English
SubTitle: Swale 7 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 7		Outlet	0.16	80	.218

Total area: .16 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 7
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 7
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 7	0.23	0.46	0.66	0.97
REACHES				
OUTLET	0.23	0.46	0.66	0.97

SS

Gude Landfill
Swale 7
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 7	0.23	0.46	0.66	0.97
	12.18	12.18	12.18	12.17

REACHES

OUTLET	0.23	0.46	0.66	0.97
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SS

Gude Landfill
Swale 7
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 7	.16	0.218	80	Outlet	
Total Area:	.16 (ac)				

SS

Gude Landfill
Swale 7
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 7							
SHEET	82	0.0180	0.240				0.214
CHANNEL	118	0.0400	0.030	10.00	12.47	8.194	0.004
						Time of Concentration	.218
							=====

SS

Gude Landfill
Swale 7
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 7	Pasture, grassland or range	(good) D	.159	80
Total Area / Weighted Curve Number			.16 ===	80 ==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Landfill Units: English
SubTitle: Swale 8 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 8		Outlet	16.12	80	.275

Total area: 16.12 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 8
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 8
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 8	20.51	41.81	60.03	88.58
REACHES				
OUTLET	20.51	41.81	60.03	88.58

SS

Gude Landfill
Swale 8
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 8	20.51	41.81	60.03	88.58
	12.23	12.21	12.21	12.20

REACHES

OUTLET	20.51	41.81	60.03	88.58
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SS

Gude Landfill
Swale 8
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 8	16.12	0.275	80	Outlet	
Total Area:		16.12 (ac)			

SS

Gude Landfill
Swale 8
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 8							
SHEET	100	0.0330	0.240				0.197
CHANNEL	1607	0.0180	0.030	10.00	12.47	5.723	0.078
						Time of Concentration	.275
							=====

SS

Gude Landfill
Swale 8
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 8	Gravel (w/ right-of-way)	D	.694	91
	Pasture, grassland or range	(good) D	15.426	80
	Total Area / Weighted Curve Number		16.12	80
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Landfill Units: English
SubTitle: Swale 9 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 9		Outlet	0.63	80	.215

Total area: .63 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 9
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 9
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 9	0.89	1.80	2.58	3.81
REACHES				
OUTLET	0.89	1.80	2.58	3.81

SS

Gude Landfill
Swale 9
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 9	0.89	1.80	2.58	3.81
	12.18	12.19	12.18	12.18

REACHES

OUTLET	0.89	1.80	2.58	3.81
--------	------	------	------	------

SS

Gude Landfill
Swale 9
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 9	.63	0.215	80	Outlet	
Total Area:	.63 (ac)				

SS

Gude Landfill
Swale 9
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 9	Pasture, grassland or range	(good) D	.628	80
Total Area / Weighted Curve Number			.63	80
			===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 9A Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 9A		Outlet	1.58	81	.199

Total area: 1.58 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 9A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 9A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 9A	2.42	4.83	6.86	10.05
REACHES				
OUTLET	2.42	4.83	6.86	10.05

SS

Gude Landfill
Swale 9A
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 9A	2.42	4.83	6.86	10.05
	12.17	12.17	12.17	12.17

REACHES

OUTLET	2.42	4.83	6.86	10.05
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SS

Gude Landfill
Swale 9A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 9A	1.58	0.199	81	Outlet	
Total Area:	1.58 (ac)				

SS

Gude Landfill
Swale 9A
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 9A	Gravel (w/ right-of-way)	D	.113	91
	Pasture, grassland or range	(good) D	1.465	80
	Total Area / Weighted Curve Number		1.58	81
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 10 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 10		Outlet	2.67	80	.152

Total area: 2.67 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 10
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 10
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 10	4.32	8.71	12.44	18.33
REACHES				
OUTLET	4.32	8.71	12.44	18.33

SS

Gude Landfill
Swale 10
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 10	4.32	8.71	12.44	18.33
	12.15	12.14	12.14	12.14

REACHES

OUTLET	4.32	8.71	12.44	18.33
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SS

Gude Landfill
Swale 10
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 10	2.67	0.152	80	Outlet	
Total Area:		2.67 (ac)			

SS

Gude Landfill
Swale 10
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 10	Gravel (w/ right-of-way)	D	.029	91
	Pasture, grassland or range	(good) D	2.645	80
	Total Area / Weighted Curve Number		2.67	80
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 11 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 11		Outlet	2.23	82	.27

Total area: 2.23 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 11
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 11
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 11	3.16	6.19	8.74	12.72
REACHES				
OUTLET	3.16	6.19	8.74	12.72

SS

Gude Landfill
Swale 11
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 11	3.16	6.19	8.74	12.72
	12.22	12.21	12.21	12.20

REACHES

OUTLET	3.16	6.19	8.74	12.72
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SS

Gude Landfill
Swale 11
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 11	2.23	0.270	82	Outlet	
Total Area:	2.23 (ac)				

SS

Gude Landfill
Swale 11
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 11							
SHEET	100	0.0200	0.240				0.240
SHALLOW	57	0.0190	0.050				0.007
SHALLOW	80	0.0750	0.025				0.004
CHANNEL	692	0.0530	0.030	10.00	12.47	10.117	0.019
				Time of Concentration			.27
							=====

SS

Gude Landfill
Swale 11
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 11	Gravel (w/ right-of-way)	D	.393	91
	Pasture, grassland or range	(good) D	1.835	80
	Total Area / Weighted Curve Number		2.23	82
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Landfill Units: English
SubTitle: Swale 12 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 12		Outlet	3.31	81	.23

Total area: 3.31 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 12
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 12
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 12	4.79	9.54	13.57	19.92
REACHES				
OUTLET	4.79	9.54	13.57	19.92

SS

Gude Landfill
Swale 12
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 12	4.79	9.54	13.57	19.92
	12.19	12.19	12.19	12.19

REACHES

OUTLET	4.79	9.54	13.57	19.92
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SS

Gude Landfill
Swale 12
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 12	3.31	0.230	81	Outlet	
Total Area:		3.31 (ac)			

SS

Gude Landfill
Swale 12
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 12							
SHEET	100	0.0400	0.240				0.182
SHALLOW	294	0.0400	0.050				0.025
CHANNEL	500	0.0200	0.030	10.00	12.47	6.039	0.023
						Time of Concentration	.23
							=====

SS

Gude Landfill
Swale 12
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 12	Gravel (w/ right-of-way)	D	.238	91
	Pasture, grassland or range	(good) D	3.075	80
	Total Area / Weighted Curve Number		3.31	81
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/19/2020
Project: Gude Landfill Units: English
SubTitle: Swale 13 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 13		Outlet	14.04	81	.3

Total area: 14.04 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 13
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 13
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 13	18.09	36.14	51.56	75.67
REACHES				
OUTLET	18.09	36.14	51.56	75.67

SS

Gude Landfill
Swale 13
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 13	18.09	36.14	51.56	75.67
	12.24	12.22	12.23	12.23

REACHES

OUTLET	18.09	36.14	51.56	75.67
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SS

Gude Landfill
Swale 13
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 13	14.04	0.300	81	Outlet	
Total Area:	14.04 (ac)				

SS

Gude Landfill
Swale 13
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 13							
SHEET	100	0.0270	0.240				0.213
SHALLOW	116	0.0140	0.050				0.017
CHANNEL	1520	0.0200	0.030	10.00	12.47	6.032	0.070
						Time of Concentration	.3
							=====

SS

Gude Landfill
Swale 13
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 13	Gravel (w/ right-of-way)	D	.717	91
	Pasture, grassland or range	(good) D	13.324	80
	Total Area / Weighted Curve Number		14.04	81
			=====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 14 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 14		Outlet	0.1	80	0.1

Total area: .10 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 14
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 14
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 14	0.19	0.37	0.53	0.78
REACHES				
OUTLET	0.19	0.37	0.53	0.78

SS

Gude Landfill
Swale 14
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 14	0.19	0.37	0.53	0.78
	12.12	12.12	12.12	12.12

REACHES

OUTLET	0.19	0.37	0.53	0.78
--------	------	------	------	------

SS

Gude Landfill
Swale 14
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 14	.10	0.100	80	Outlet	
Total Area:	.10 (ac)				

SS

Gude Landfill
Swale 14
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
-----	-----	-----	-----	-----	-----	-----	-----
Swale 14 CHANNEL	130	0.0130	0.030	10.00	12.47	5.159	0.007
						Time of Concentration	0.1
							=====

SS

Gude Landfill
Swale 14
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 14	Pasture, grassland or range	(good) D	.102	80
Total Area / Weighted Curve Number			.1 ==	80 ==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/19/2020
Project: Gude Landfill Units: English
SubTitle: Swale 14A Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 14A		Outlet	0.44	80	.123

Total area: .44 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 14A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 14A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 14A	0.76	1.53	2.19	3.23
REACHES				
OUTLET	0.76	1.53	2.19	3.23

SS

Gude Landfill
Swale 14A
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 14A	0.76	1.53	2.19	3.23
	12.13	12.13	12.13	12.13

REACHES

OUTLET	0.76	1.53	2.19	3.23
--------	------	------	------	------

SS

Gude Landfill
Swale 14A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 14A	.44	0.123	80	Outlet	
Total Area:	.44 (ac)				

SS

Gude Landfill
Swale 14A
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
-----	-----	-----	-----	-----	-----	-----	-----
Swale 14A							
SHEET	100	0.1380	0.240				0.111
SHALLOW	93	0.1520	0.050				0.004
CHANNEL	150	0.0160	0.030	10.00	12.47	5.208	0.008
						Time of Concentration	.123
							=====

SS

Gude Landfill
Swale 14A
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 14A	Pasture, grassland or range	(good) D	.439	80
Total Area / Weighted Curve Number			.44	80
			===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/19/2020
Project: Gude Landfill Units: English
SubTitle: Swale 14B Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 14B		Outlet	1.56	80	.185

Total area: 1.56 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 14B
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 14B
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 14B	2.35	4.75	6.80	10.04
REACHES				
OUTLET	2.35	4.75	6.80	10.04

SS

Gude Landfill
Swale 14B
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 14B	2.35	4.75	6.80	10.04
	12.17	12.16	12.16	12.16

REACHES

OUTLET	2.35	4.75	6.80	10.04
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SS

Gude Landfill
Swale 14B
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 14B	1.56	0.185	80	Outlet	
Total Area:	1.56 (ac)				

SS

Gude Landfill
Swale 14B
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 14B							
SHEET	100	0.0510	0.240				0.165
SHALLOW	322	0.1200	0.050				0.016
CHANNEL	109	0.0260	0.030	10.00	12.47	7.569	0.004
						Time of Concentration	.185
							=====

SS

Gude Landfill
Swale 14B
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 14B	Pasture, grassland or range	(good) D	1.559	80
Total Area / Weighted Curve Number			1.56	80
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 15 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 15		Outlet	9.31	80	.126

Total area: 9.31 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 15
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 15
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 15	15.98	32.14	45.96	67.55
REACHES				
OUTLET	15.98	32.14	45.96	67.55

SS

Gude Landfill
Swale 15
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 15	15.98	32.14	45.96	67.55
	12.14	12.14	12.13	12.13

REACHES

OUTLET	15.98	32.14	45.96	67.55
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SS

Gude Landfill
Swale 15
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 15	9.31	0.126	80	Outlet	
Total Area:	9.31 (ac)				

SS

Gude Landfill
Swale 15
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 15	Gravel (w/ right-of-way)	D	.362	91
	Pasture, grassland or range	(good) D	8.952	80
	Total Area / Weighted Curve Number		9.31	80
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 16 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 16		Outlet	7.68	80	.349

Total area: 7.68 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 16
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 16
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 16	8.77	17.91	25.69	38.03
REACHES				
OUTLET	8.77	17.91	25.69	38.03

SS

Gude Landfill
Swale 16
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 16	8.77	17.91	25.69	38.03
	12.26	12.26	12.26	12.26

REACHES

OUTLET	8.77	17.91	25.69	38.03
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SS

Gude Landfill
Swale 16
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 16	7.68	0.349	80	Outlet	
Total Area:		7.68 (ac)			

SS

Gude Landfill
Swale 16
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
-----	-----	-----	-----	-----	-----	-----	-----
Swale 16							
SHEET	100	0.0150	0.240				0.269
SHALLOW	300	0.0250	0.050				0.033
CHANNEL	1260	0.0300	0.030	10.00	12.47	7.447	0.047
						Time of Concentration	.349
							=====

SS

Gude Landfill
Swale 16
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 16	Gravel (w/ right-of-way)	D	.163	91
	Pasture, grassland or range	(good) D	7.52	80
	Total Area / Weighted Curve Number		7.68	80
			====	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
Project: Gude Landfill Units: English
SubTitle: Swale 17 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 17		Outlet	0.59	80	0.1

Total area: .59 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 17
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 17
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 17	1.07	2.15	3.07	4.51
REACHES				
OUTLET	1.07	2.15	3.07	4.51

SS

Gude Landfill
Swale 17
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 17	1.07	2.15	3.07	4.51
	12.12	12.12	12.12	12.12

REACHES

OUTLET	1.07	2.15	3.07	4.51
--------	------	------	------	------

SS

Gude Landfill
Swale 17
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 17	.59	0.100	80	Outlet	
Total Area:	.59 (ac)				

SS

Gude Landfill
Swale 17
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 17							
SHEET	53	0.2000	0.240				0.058
CHANNEL	20	0.0100	0.030	10.00	12.47	5.556	0.001
						Time of Concentration	0.1
							=====

SS

Gude Landfill
Swale 17
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 17	Pasture, grassland or range	(good) D	.593	80
Total Area / Weighted Curve Number			.59 ===	80 ==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/18/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 18 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\kblair\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100% D

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 18		Outlet	0.79	80	.185

Total area: .79 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 18
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 18
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 18	1.18	2.39	3.43	5.06
REACHES				
OUTLET	1.18	2.39	3.43	5.06

SS

Gude Landfill
Swale 18
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 18	1.18	2.39	3.43	5.06
	12.17	12.16	12.16	12.16

REACHES

OUTLET	1.18	2.39	3.43	5.06
--------	------	------	------	------

SS

Gude Landfill
Swale 18
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 18	.79	0.185	80	Outlet	
Total Area:	.79 (ac)				

SS

Gude Landfill
Swale 18
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 18							
SHEET	100	0.0510	0.240				0.165
SHALLOW	65	0.0570	0.050				0.005
CHANNEL	167	0.0050	0.030	10.00	12.47	3.093	0.015
						Time of Concentration	.185
							=====

SS

Gude Landfill
Swale 18
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 18	Pasture, grassland or range	(good) D	.791	80
Total Area / Weighted Curve Number			.79	80
			===	==

WinTR-55 Current Data Description

--- Identification Data ---

User: SS Date: 11/30/2020
 Project: Gude Landfill Units: English
 SubTitle: Swale 19 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\londrako\EA Engineering, Science, and Technology, Inc., PBC\Gutberlet, Mark - Gude 100

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Swale 19		Outlet	0.15	80	0.1

Total area: .15 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 19
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

SS

Gude Landfill
Swale 19
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
Swale 19	0.27	0.54	0.77	1.13
REACHES				
OUTLET	0.27	0.54	0.77	1.13

SS

Gude Landfill
Swale 19
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

Swale 19	0.27	0.54	0.77	1.13
	12.12	12.12	12.12	12.12

REACHES

OUTLET	0.27	0.54	0.77	1.13
--------	------	------	------	------

SS

Gude Landfill
Swale 19
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Swale 19	.15	0.100	80	Outlet	
Total Area:	.15 (ac)				

SS

Gude Landfill
Swale 19
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Swale 19							
SHEET	33	0.3380	0.240				0.032
CHANNEL	209	0.1170	0.030	10.00	12.47	14.514	0.004
						Time of Concentration	0.1
							=====

SS

Gude Landfill
Swale 19
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Swale 19	Pasture, grassland or range	(good) D	.148	80
Total Area / Weighted Curve Number			.15	80
			===	==



Project Gude Landfill Project No. 1564601
Subject Storm Drain Pipe Network Calculations Sheet No. 1 of 25
Drawing No. _____
Computed by LMO 11/24/20 Checked by [Signature] Date 11/27/2020

Montgomery County
Government (2013;
Revised 2014). Drainage
Design Criteria,
Department of
Transportation

OBJECTIVE:

Confirm stormdrain pipe size and layout to convey site storm drainage.
Confirm that inlets provide required capacity.

PROCEDURE :

The NRCS (TR-55) Method was used to determine the 10-year storm flows that enter the stormdrain systems. The Design Spreadsheets in Appendix D from the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria was utilized to summarize the storm drain system analysis and calculate the velocity in the storm drainpipe networks, based on size and slope of the pipes. The pipe sizes and slopes were determined to ensure that the hydraulic grade line is not surcharged and is located at least 1 ft below the top of the structure elevation and no more than 1 foot above the crown of the pipe for the 10-year storm.

BACKGROUND:

There are two separate, proposed stormdrain systems location on the site. One system ties into the existing 60” stormdrain that drains to Pond 1 on the south-western edge of the site, and the other section of stormdrain carries flow from a conveyance swale and existing pad to Pond 3.

All of the proposed inlets are located within conveyance swales and are in a sumped condition. Montgomery County Type J inlets will be utilized throughout except for Inlet 2. Inlet 2 will be an open yard inlet.

ASSUMPTIONS:

- Stormdrain piping was sized based on 10-year storm peak discharge at stormdrain inlet drainage areas.
- The capacity of inlets was based on 10-year storm peak discharge at stormdrain inlet drainage areas per Montgomery County Government (2013; Revised 2014). Drainage Design Criteria.
- Actual time of concentrations were calculated using NRCS (TR-55)
- Rainfall Intensities were obtained from Table 3-7 based on the time of concentration computed in TR-55
- Pipe layout placed to maintain the hydraulic grade line (HGL) a minimum of 1-ft below the structure elevation and no more than 1 foot above the crown of pipe.



Project Gude Landfill Project No. 1564601
Subject Storm Drain Pipe Network Calculations Sheet No. 2 of 25
Drawing No. _____
Computed by LMO 11/24/20 Checked by [Signature] Date 11/27/2020

CALCULATIONS:

- 1. Compute a Composite “CN” Value for Drainage Areas-** determine areas of land use soils and cover for each drainage area that enters the stormdrain system.
- 2. Determine Time of Concentration to Inlets** – Determine the flow path and length from the hydraulically most distant point representative of the drainage area
- 3. Determine Flows to Inlets** –NRCS (TR-55) calculates the peak flow as a function of drainage area, time of concentration, land cover/soil type, and peak hour precipitation.

TR-55 Computations are attached.

- 4. Stormdrain Design and Hydraulic Grade Line Calculations** – The Design Spreadsheets in Appendix D from the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria was utilized to summarize the storm drain system analysis and calculate the velocity in the storm drainpipe networks, based on size and slope of the pipes.

Hydraflow Storm Sewers was then used to calculate the Hydraulic Grade Line Location in the proposed stormdrains. Calculations are attached.

- 5. Check Inlet Capacities** – All proposed inlets are in sump condition located within conveyance swales. The Design Spreadsheets in Appendix D from the Montgomery County Government (2013; Revised 2014) Drainage Design Criteria and Hydraflow Express was used to calculate inlet capacities. Hydraflow Express utilizes standard weir and orifice equations for calculating head at sump inlets.

The Design Spreadsheets are attached.

CONCLUSIONS:



Project Gude Landfill Project No. 1564601
Subject Storm Drain Pipe Network Calculations Sheet No. 3 of 25
Drawing No. _____
Computed by LMO 11/24/20 Checked by [Signature] Date 11/27/2020

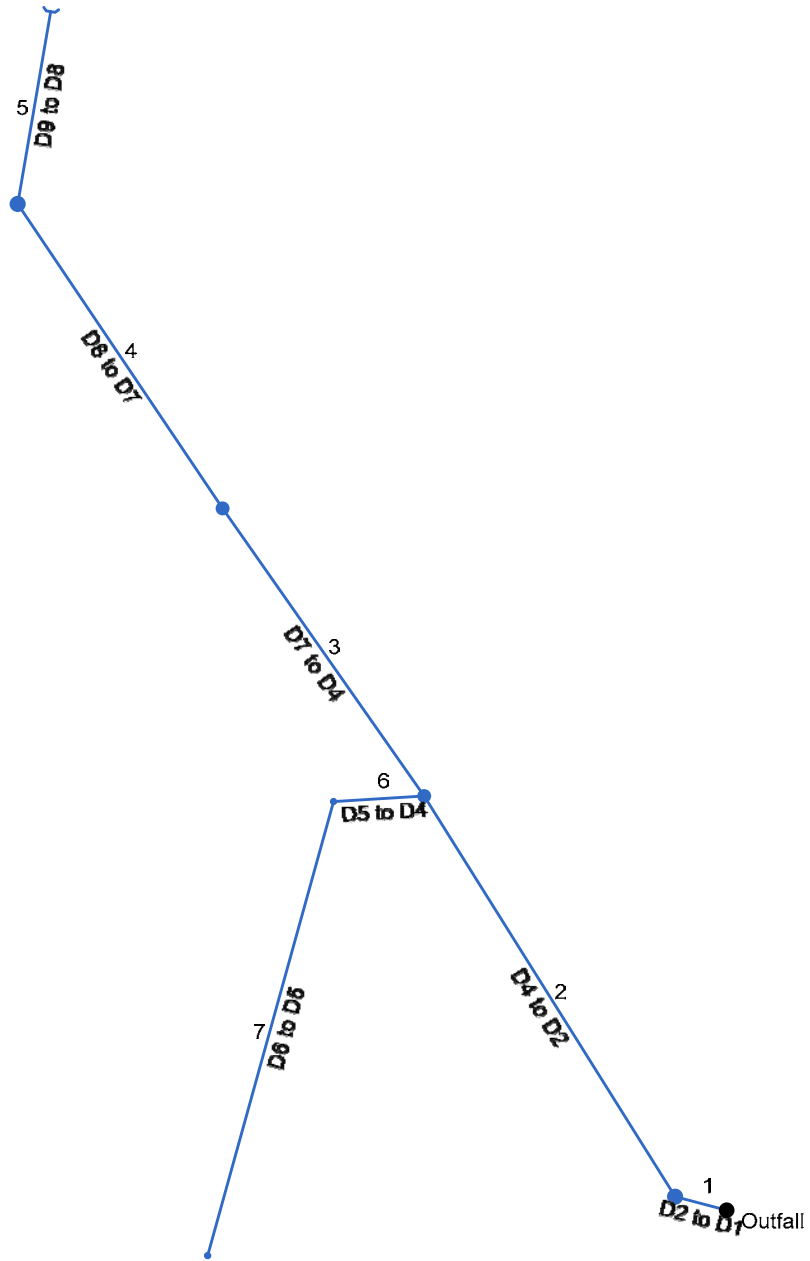
Results from the Stormdrain Design Calculations show that pipe sizes shown on the Contract Drawings can adequately convey the design storm. Inlet capacities are also adequate.

ATTACHMENTS:

Montgomery County Inlet Capacity Computation Table
Montgomery County Storm Drain Computation Table
Hydraflow Express Inlet Capacity Calculations
Hydra Flow Storm Sewers Analysis

PIPE COMPUTATIONS															
PIPE		AREA		R=C	AR	ΣAR	TC	I	Q	PIPE SIZE	MIN SLOPE	V	PIPE LENGTH	TIME IN PIPE	REMARKS
FROM	TO	INCR. AREA	TOTAL AREA													(min)	(in/hr)	(cfs)	(Inches)	(%)	(fps)	(feet)	(min)
I-1	I-5	5.30	5.30	0.57	3.02		19.26	4.45	13.26	18	1.09%	7.61	190	0.42	Q is from TR-55
I-5	A2	7.525	12.824	0.57	7.31	10.33	8.52	6.17	39.83	30	0.99%	6.88	85	0.20	Sum of Q from TR-55
A2	Ex A1	0.206	13.030	0.61	7.95	18.28	6	6.78	40.68	30	2.66%	11.12	46	0.07	Sum - Q from Rational
Z-6	Z-2	2.101	2.101	0.55	1.16	1.16	6	6.78	6.65	24	0.59%	13.01	170	0.22	Q is from TR-55
Z-2	Z-1	0.969	0.969	0.74	0.72	1.87	6	6.78	11.51	24	0.77%	10.31	65	0.11	Sum - Q from Rational
EA ENGINEERING, SCIENCE, AND TECHNOLOGY					PIPE COMPUTATIONS							COMPUTED	LMO	DATE	
												CHECKED		Nov-20	
					GUDE LANDFILL REMEDIATION DESIGN							SHEET NO.		PROJECT NO.	
												1		1564601	

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Ex SD D Analysis.stm

Number of lines: 7

Date: 3/26/2020

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	D2 to D1	135.2	42	Cir	23.994	348.20	348.50	1.250	351.70*	352.13*	2.24	354.37	End	Manhole
2	D4 to D2	135.2	42	Cir	213.738	349.03	359.38	4.842	354.37	362.71	n/a	362.71	1	DropGrate
3	D7 to D4	124.7	42	Cir	158.705	363.70	369.35	3.560	365.77	372.63	n/a	372.63	2	DropGrate
4	D8 to D7	124.7	36	Cir	165.929	372.68	380.62	4.785	374.81	383.58	5.36	383.58	3	DropGrate
5	D9 to D8	43.20	30	Cir	88.349	385.66	388.52	3.237	387.04	390.71	n/a	390.71	4	OpenHeadwall
6	D5 to D4	10.43	18	Cir	40.946	363.82	364.35	1.294	364.84	365.59	0.99	365.59	2	DropGrate
7	D6 to D5	10.43	18	Cir	213.219	364.73	385.61	9.793	365.59	386.85	0.69	386.85	6	DropGrate

Project File: Ex SD D Analysis.stm

Number of lines: 7

Run Date: 3/26/2020

NOTES: Return period = 10 Yrs. ; *Surcharged (HGL above crown).

Storm Sewer Tabulation

Station		Len (ft)	Drng Area		Rnoff coeff (C)	Area x C		Tc		Rain (l) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr (ac)	Total (ac)		Incr	Total	Inlet (min)	Syst (min)					Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	23.994	0.00	0.00	0.00	0.00	0.00	0.0	1.0	0.0	135.2	112.5	14.05	42	1.25	348.20	348.50	351.70	352.13	0.00	356.46	D2 to D1
2	1	213.738	0.00	0.00	0.00	0.00	0.00	0.0	0.7	0.0	135.2	221.4	14.17	42	4.84	349.03	359.38	354.37	362.71	356.46	369.77	D4 to D2
3	2	158.705	0.00	0.00	0.00	0.00	0.00	0.0	0.3	0.0	124.7	189.8	17.18	42	3.56	363.70	369.35	365.77	372.63	369.77	379.33	D7 to D4
4	3	165.929	0.00	0.00	0.00	0.00	0.00	0.0	0.2	0.0	124.7	145.9	20.44	36	4.79	372.68	380.62	374.81	383.58	379.33	391.97	D8 to D7
5	4	88.349	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	43.20	73.79	12.54	30	3.24	385.66	388.52	387.04	390.71	391.97	391.81	D9 to D8
6	2	40.946	0.00	0.00	0.00	0.00	0.00	0.0	0.6	0.0	10.43	12.94	7.41	18	1.29	363.82	364.35	364.84	365.59	369.77	369.78	D5 to D4
7	6	213.219	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	10.43	35.60	8.31	18	9.79	364.73	385.61	365.59	386.85	369.78	390.82	D6 to D5

Project File: Ex SD D Analysis.stm

Number of lines: 7

Run Date: 3/26/2020

NOTES: Intensity = $88.24 / (\text{Inlet time} + 15.50)^{0.83}$; Return period = Yrs. 10 ; c = cir e = ellip b = box

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross SI, Sw (ft/ft)	Cross SI, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	9.62	9.62	n/a	0.20	0.50	0.90	112.50	3.33	....	....	....	-165.229	3.50	3.50	Outfall	0.00	1274096.99	354.77	355.20	0.433
2	9.45	9.45	Sag	0.20	0.50	0.90	221.39	3.33	0.020	0.020	....	43.263	3.50	3.33**	1	0.00	1273983.84	357.44	365.89	3.601
3	5.93	9.37	Sag	0.20	0.50	0.90	189.83	3.28	0.020	0.020	....	-2.941	2.07	3.28**	2	0.00	1273893.02	368.53	375.39	0.000
4	5.38	7.05	Sag	0.20	0.50	0.90	145.89	2.96	0.020	0.020	....	1.054	2.13	2.96**	3	0.00	1273800.59	379.68	388.45	0.000
5	2.77	4.56	n/a	0.20	0.50	0.90	73.79	2.19	....	....	....	43.554	1.38	2.19**	4	0.00	1273815.47	388.43	392.11	0.000
6	1.28	1.56	Sag	0.20	0.50	0.90	12.94	1.24	0.020	0.020	....	-61.536	1.02	1.24**	2	0.00	1273942.97	365.53	366.28	0.000
7	1.05	1.56	Sag	0.20	0.50	0.90	35.60	1.24	0.020	0.020	....	-71.069	0.86	1.24**	6	0.00	1273886.24	366.28	387.54	0.000

Project File: Ex SD D Analysis.stm

Number of lines: 7

Date: 3/26/2020

NOTES: ** Critical depth

Flow Rate	Sf Ave	Sf Dn	Grate Area	Grate Len	Grate Width	Gnd/Rim El Dn	Gnd/Rim El Up	Gutter Depth	Gutter Slope	Gutter Spread	Gutter Width	HGL Dn	HGL Up	HGL Jnct	HGL Jmp Dn	HGL Jmp Up	Incr CxA	Incr Q	Inlet Depth
(cfs)	(ft/ft)	(ft/ft)	(sqft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(cfs)	(ft)
135.15	1.805	1.805	....	....	....	0.00	356.46	....	....	....	....	351.70	352.13	354.37	....	....	0.00	0.00	....
135.15	1.685	1.805	16.00	4.00	4.00	356.46	369.77	0.00	Sag	4.00	2.00	354.37	362.71	362.71	....	....	0.00	0.00	0.00
124.72	0.000	0.000	16.00	4.00	4.00	369.77	379.33	0.00	Sag	4.00	2.00	365.77	372.63	372.63	....	....	0.00	0.00	0.00
124.72	0.000	0.000	16.00	4.00	4.00	379.33	391.97	1.42	Sag	146.37	2.00	374.81	383.58	383.58	....	....	0.00	81.52	1.42
43.20	0.000	0.000	....	....	....	391.97	391.81	....	....	....	....	387.04	390.71	390.71	....	....	0.00	43.20	....
10.43	0.000	0.000	16.00	4.00	4.00	369.77	369.78	0.00	Sag	4.00	2.00	364.84	365.59	365.59	....	....	0.00	0.00	0.00
10.43	0.000	0.000	16.00	4.00	4.00	369.78	390.82	0.36	Sag	40.12	2.00	365.59	386.85	386.85	0.00	10.43	0.36

Project File: Ex SD D Analysis.stm	Number of lines: 7	Date: 3/26/2020
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NOTES: ** Critical depth

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
...	D2	Sag	....	0.0	0.00	0.00	348.20	348.50	....	....	0.00	0.00	0.73	MH	0.00	1,211	1,090	1,029
0	D4	Sag	4.00	0.0	0.00	0.00	349.03	359.38	....	....	0.00	0.00	1.35 z	Dp-Grate	0.00	14,991	13,492	12,742
0	D7	Sag	4.00	0.0	0.00	0.00	363.70	369.35	....	....	0.00	0.00	0.50 z	Dp-Grate	0.00	10,611	9,550	9,019
100	D8	Sag	146.37	0.0	0.00	0.00	372.68	380.62	....	....	0.00	0.00	1.10 z	Dp-Grate	81.52	11,404	10,264	9,693
100	D9	Sag	....	0.0	0.00	0.00	385.66	388.52	....	....	0.00	0.00	1.00 z	Hdwall	43.20	4,132	3,719	3,512
0	D5	Sag	4.00	0.0	0.00	0.00	363.82	364.35	....	....	0.00	0.00	1.43 z	Dp-Grate	0.00	1,740	1,566	1,479
100	D6	Sag	40.12	0.0	0.00	0.00	364.73	385.61	....	....	0.00	0.00	1.00 z	Dp-Grate	10.43	8,640	7,776	7,344

Project File: Ex SD D Analysis.stm

Number of lines: 7

Date: 3/26/2020

NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 – Return period = 10 Yrs. ; ** Critical depth

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)
D2 to D1	23.994	42	1.25	Cir	....	....	0.013	2.24	523991.82	0.03	....	....	....	42	0.00	42	0.00	0.00	0.00
D4 to D2	213.738	42	4.84	Cir	....	....	0.013	n/a	524173.15	0.25	0.00	0.00	0.00	42	0.00	42	0.00	0.00	0.00
D7 to D4	158.705	42	3.56	Cir	....	....	0.013	n/a	524303.30	0.20	0.00	0.00	0.00	42	0.00	42	0.00	0.00	0.00
D8 to D7	165.929	36	4.79	Cir	....	....	0.013	5.36	524441.10	0.16	0.00	81.52	0.00	36	0.00	36	0.00	0.00	0.00
D9 to D8	88.349	30	3.24	Cir	....	....	0.013	n/a	524528.18	0.17	0.00	43.20	0.00	30	0.00	30	0.00	0.00	0.00
D5 to D4	40.946	18	1.29	Cir	....	....	0.012	0.99	524170.65	0.12	0.00	0.00	0.00	18	0.00	18	0.00	0.00	0.00
D6 to D5	213.219	18	9.79	Cir	....	....	0.012	0.69	523965.11	0.60	0.00	10.43	0.00	18	0.00	18	0.00	0.00	0.00

Project File: Ex SD D Analysis.stm Number of lines: 7 Date: 3/26/2020

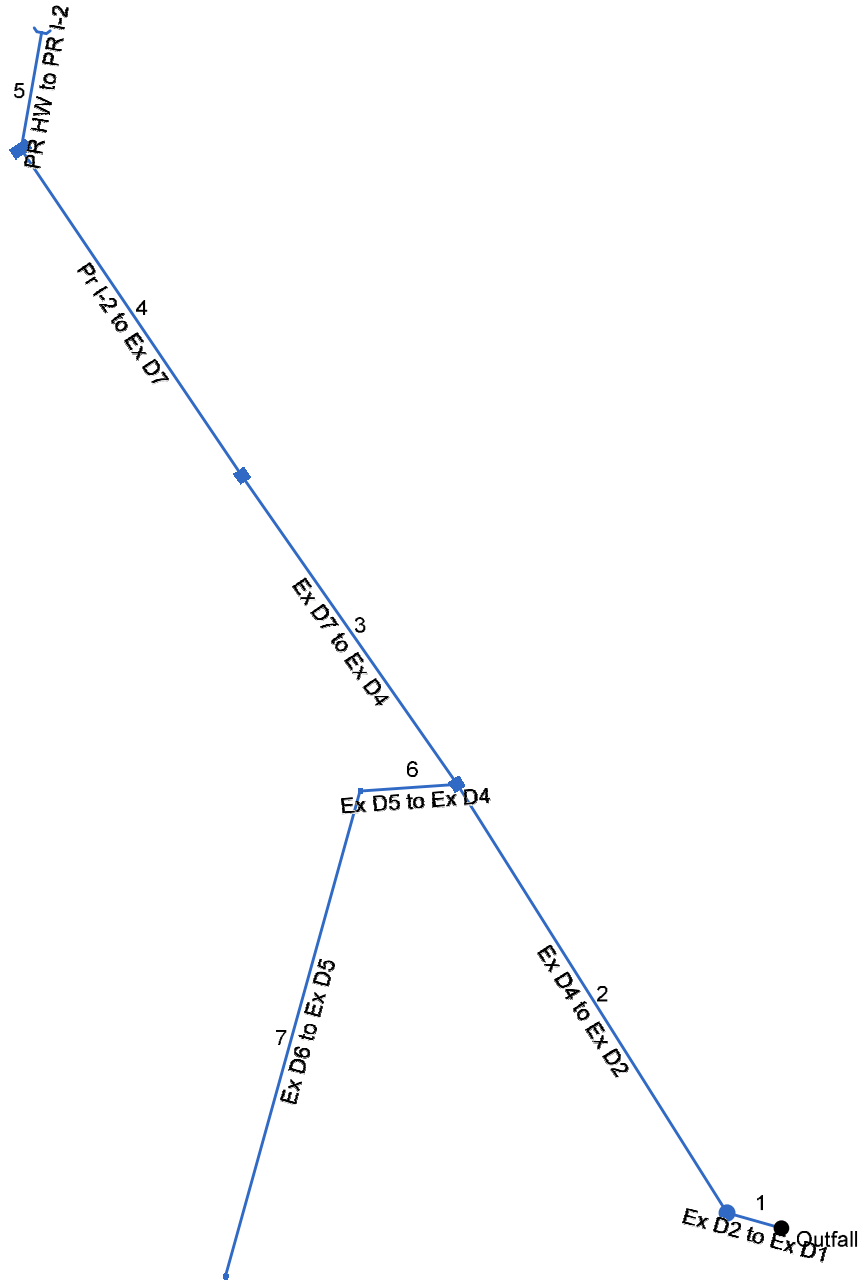
NOTES: ** Critical depth

Tc	Throat Ht	Total Area	Total CxA	Total Runoff	Vel Ave	Vel Dn	Vel Hd Dn	Vel Hd Up	Vel Up	Cover Dn	Cover Up	Storage	
(min)	(in)	(ac)		(cfs)	(ft/s)	(ft/s)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(cft)	
1.0	0.00	0.00	0.00	14.05	14.05	3.07	3.07	14.05	n/a	4.46	230.80	
0.7	0.00	0.00	0.00	14.17	14.05	3.07	3.18	14.30	3.93	6.89	2050.01	
0.3	0.00	0.00	0.00	17.18	21.05	2.76	2.76	13.32	2.57	6.48	1238.97	
0.2	0.00	0.00	0.00	20.44	23.19	4.87	4.87	17.70	3.65	8.35	1050.74	
0.0	0.00	0.00	0.00	12.54	15.62	1.39	1.39	9.47	3.81	0.79	328.57	
0.6	0.00	0.00	0.00	7.41	8.15	0.69	0.69	6.67	4.45	3.93	58.41	
0.0	0.00	0.00	0.00	8.31	9.94	0.69	0.69	6.67	3.55	3.71	280.75	

Project File: Ex SD D Analysis.stm	Number of lines: 7	Date: 3/26/2020
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NOTES: ** Critical depth

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Proposed Ex SD D Analysis.stm

Number of lines: 7

Date: 12/1/2020

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Ex D2 to Ex D1	171.1	42	Cir	23.723	348.20	348.50	1.265	351.70*	352.39*	3.54	355.93	End	Manhole
2	Ex D4 to Ex D2	171.1	42	Cir	213.713	349.03	359.38	4.843	355.93	362.81	6.70	362.81	1	DropGrate
3	Ex D7 to Ex D4	162.5	42	Cir	158.606	363.70	369.35	3.562	366.19	372.77	n/a	372.77	2	DropGrate
4	Pr I-2 to Ex D7	157.0	42	Cir	166.387	372.18	380.12	4.772	374.37	383.52	n/a	383.52	3	DropGrate
5	PR HW to PR I-2	70.34	42	Cir	49.965	384.66	399.00	28.700	385.51	401.63	n/a	401.63	4	OpenHeadwall
6	Ex D5 to Ex D4	8.26	18	Cir	40.967	363.82	364.35	1.294	364.69	365.46	0.77	365.46	2	DropGrate
7	Ex D6 to Ex D5	5.34	18	Cir	212.853	364.73	385.61	9.810	365.46	386.50	n/a	386.50	6	DropGrate

Project File: Proposed Ex SD D Analysis.stm

Number of lines: 7

Run Date: 12/1/2020

NOTES: Return period = 10 Yrs. ; *Surcharged (HGL above crown).

Storm Sewer Tabulation

Station		Len (ft)	Drng Area		Rnoff coeff (C)	Area x C		Tc		Rain (l) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr (ac)	Total (ac)		Incr	Total	Inlet (min)	Syst (min)					Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	23.723	0.00	0.00	0.00	0.00	0.00	0.0	1.5	0.0	171.1	113.1	17.78	42	1.26	348.20	348.50	351.70	352.39	0.00	356.54	Ex D2 to Ex D1
2	1	213.713	0.00	0.00	0.00	0.00	0.00	0.0	1.3	0.0	171.1	221.4	17.82	42	4.84	349.03	359.38	355.93	362.81	356.54	369.77	Ex D4 to Ex D2
3	2	158.606	0.00	0.00	0.00	0.00	0.00	0.0	0.3	0.0	162.5	189.9	19.59	42	3.56	363.70	369.35	366.19	372.77	369.77	379.34	Ex D7 to Ex D4
4	3	166.387	0.00	0.00	0.00	0.00	0.00	0.0	0.1	0.0	157.0	219.8	20.63	42	4.77	372.18	380.12	374.37	383.52	379.34	393.75	Pr I-2 to Ex D7
5	4	49.965	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	70.34	539.0	23.88	42	28.70	384.66	399.00	385.51	401.63	393.75	403.29	PR HW to PR I-2
6	2	40.967	0.00	0.00	0.00	0.00	0.00	0.0	1.2	0.0	8.26	12.94	6.82	18	1.29	363.82	364.35	364.69	365.46	369.77	369.78	Ex D5 to Ex D4
7	6	212.853	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	5.34	35.63	5.56	18	9.81	364.73	385.61	365.46	386.50	369.78	390.81	Ex D6 to Ex D5

Project File: Proposed Ex SD D Analysis.stm

Number of lines: 7

Run Date: 12/1/2020

NOTES: Intensity = $88.24 / (\text{Inlet time} + 15.50)^{0.83}$; Return period = Yrs. 10 ; c = cir e = ellip b = box

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross SI, Sw (ft/ft)	Cross SI, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	9.62	9.62	n/a	0.20	0.50	0.90	113.14	3.43	....	....	....	-164.438	3.50	3.50	Outfall	0.00	1274097.34	356.62	357.30	0.686
2	9.58	9.58	Sag	0.20	0.50	0.90	221.40	3.43	0.020	0.020	....	42.359	3.50	3.43**	1	0.00	1273983.84	360.84	367.77	5.859
3	7.33	9.56	Sag	0.20	0.50	0.90	189.89	3.42	0.020	0.020	....	-2.730	2.49	3.42**	2	0.00	1273893.30	370.68	377.26	0.000
4	6.33	9.55	Sag	0.20	0.50	0.90	219.78	3.40	0.020	0.020	....	0.863	2.19	3.40**	3	0.00	1273800.38	378.57	387.73	0.000
5	1.82	7.74	n/a	0.20	0.50	0.90	538.98	2.63	....	....	....	43.904	0.85	2.63**	4	0.00	1273809.02	386.80	402.91	0.000
6	1.06	1.41	Sag	0.20	0.50	0.90	12.94	1.11	0.020	0.020	....	-61.964	0.87	1.11**	2	0.00	1273942.97	365.23	366.00	0.000
7	0.86	1.09	Sag	0.20	0.50	0.90	35.63	0.89	0.020	0.020	....	-70.519	0.73	0.89**	6	0.00	1273886.31	365.83	386.87	0.000

Project File: Proposed Ex SD D Analysis.stm Number of lines: 7 Date: 12/1/2020

NOTES: ** Critical depth

Flow Rate	Sf Ave	Sf Dn	Grate Area	Grate Len	Grate Width	Gnd/Rim El Dn	Gnd/Rim El Up	Gutter Depth	Gutter Slope	Gutter Spread	Gutter Width	HGL Dn	HGL Up	HGL Jnct	HGL Jmp Dn	HGL Jmp Up	Incr CxA	Incr Q	Inlet Depth
(cfs)	(ft/ft)	(ft/ft)	(sqft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(cfs)	(ft)
171.05	2.891	2.892	....	....	....	0.00	356.54	....	....	....	....	351.70	352.39	355.93	....	....	0.00	0.00	....
171.05	2.741	2.892	16.00	4.00	4.00	356.54	369.77	0.03	Sag	7.23	2.00	355.93	362.81	362.81	....	....	0.00	0.28	0.03
162.51	0.000	0.000	16.00	4.00	4.00	369.77	379.34	0.24	Sag	27.60	2.00	366.19	372.77	372.77	....	....	0.00	5.51	0.24
157.00	0.000	0.000	15.00	2.50	6.00	379.34	393.75	1.42	Sag	150.42	8.00	374.37	383.52	383.52	....	....	0.00	86.66	1.42
70.34	0.000	0.000	....	....	....	393.75	403.29	....	....	....	....	385.51	401.63	401.63	....	....	0.00	70.34	....
8.26	0.000	0.000	16.00	4.00	4.00	369.77	369.78	0.15	Sag	19.45	2.00	364.69	365.46	365.46	....	....	0.00	2.92	0.15
5.34	0.000	0.000	16.00	4.00	4.00	369.78	390.81	0.23	Sag	27.11	2.00	365.46	386.50	386.50	....	....	0.00	5.34	0.23

Project File: Proposed Ex SD D Analysis.stm	Number of lines: 7	Date: 12/1/2020
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NOTES: ** Critical depth

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
....	Ex D2	Sag	....	0.0	0.00	0.00	348.20	348.50	....	....	0.00	0.00	0.72	MH	0.00	1,225	1,103	1,041
100	Ex D4	Sag	7.23	0.0	0.00	0.00	349.03	359.38	....	....	0.00	0.00	1.35 z	Dp-Grate	0.28	15,039	13,535	12,783
100	Ex D7	Sag	27.60	0.0	0.00	0.00	363.70	369.35	....	....	0.00	0.00	0.50 z	Dp-Grate	5.51	10,611	9,550	9,019
100	Pr I-2 - Ex D8	Sag	150.42	0.0	0.00	0.00	372.18	380.12	....	....	0.00	0.00	1.11 z	Dp-Grate	86.66	12,688	11,419	10,785
100	D9 Headwall-Proposed	Sag	....	0.0	0.00	0.00	384.66	399.00	....	....	0.00	0.00	1.00 z	Hdwall	70.34	3,017	2,715	2,564
100	Ex D5	Sag	19.45	0.0	0.00	0.00	363.82	364.35	....	....	0.00	0.00	1.43 z	Dp-Grate	2.92	1,740	1,566	1,479
100	Ex D6	Sag	27.11	0.0	0.00	0.00	364.73	385.61	....	....	0.00	0.00	1.00 z	Dp-Grate	5.34	8,620	7,758	7,327

Project File: Proposed Ex SD D Analysis.stm

Number of lines: 7

Date: 12/1/2020

NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)
Ex D2 to Ex D1	23.723	42	1.26	Cir	....	....	0.013	3.54	523992.07	0.02	....	....	....	42	0.00	42	0.00	0.00	0.00
Ex D4 to Ex D2	213.713	42	4.84	Cir	....	....	0.013	6.70	524173.15	0.20	0.00	0.28	0.00	42	0.00	42	0.00	0.00	0.00
Ex D7 to Ex D4	158.606	42	3.56	Cir	....	....	0.013	n/a	524303.37	0.16	0.00	5.51	0.00	42	0.00	42	0.00	0.00	0.00
Pr I-2 to Ex D7	166.387	42	4.77	Cir	....	....	0.013	n/a	524441.40	0.17	0.00	86.66	0.00	42	0.00	42	0.00	0.00	0.00
PR HW to PR I-2	49.965	42	28.70	Cir	....	....	0.013	n/a	524490.61	0.11	0.00	70.34	0.00	42	0.00	42	0.00	0.00	0.00
Ex D5 to Ex D4	40.967	18	1.29	Cir	....	....	0.012	0.77	524170.26	0.15	0.00	2.92	0.00	18	0.00	18	0.00	0.00	0.00
Ex D6 to Ex D5	212.853	18	9.81	Cir	....	....	0.012	n/a	523965.09	1.17	0.00	5.34	0.00	18	0.00	18	0.00	0.00	0.00

Project File: Proposed Ex SD D Analysis.stm	Number of lines: 7	Date: 12/1/2020
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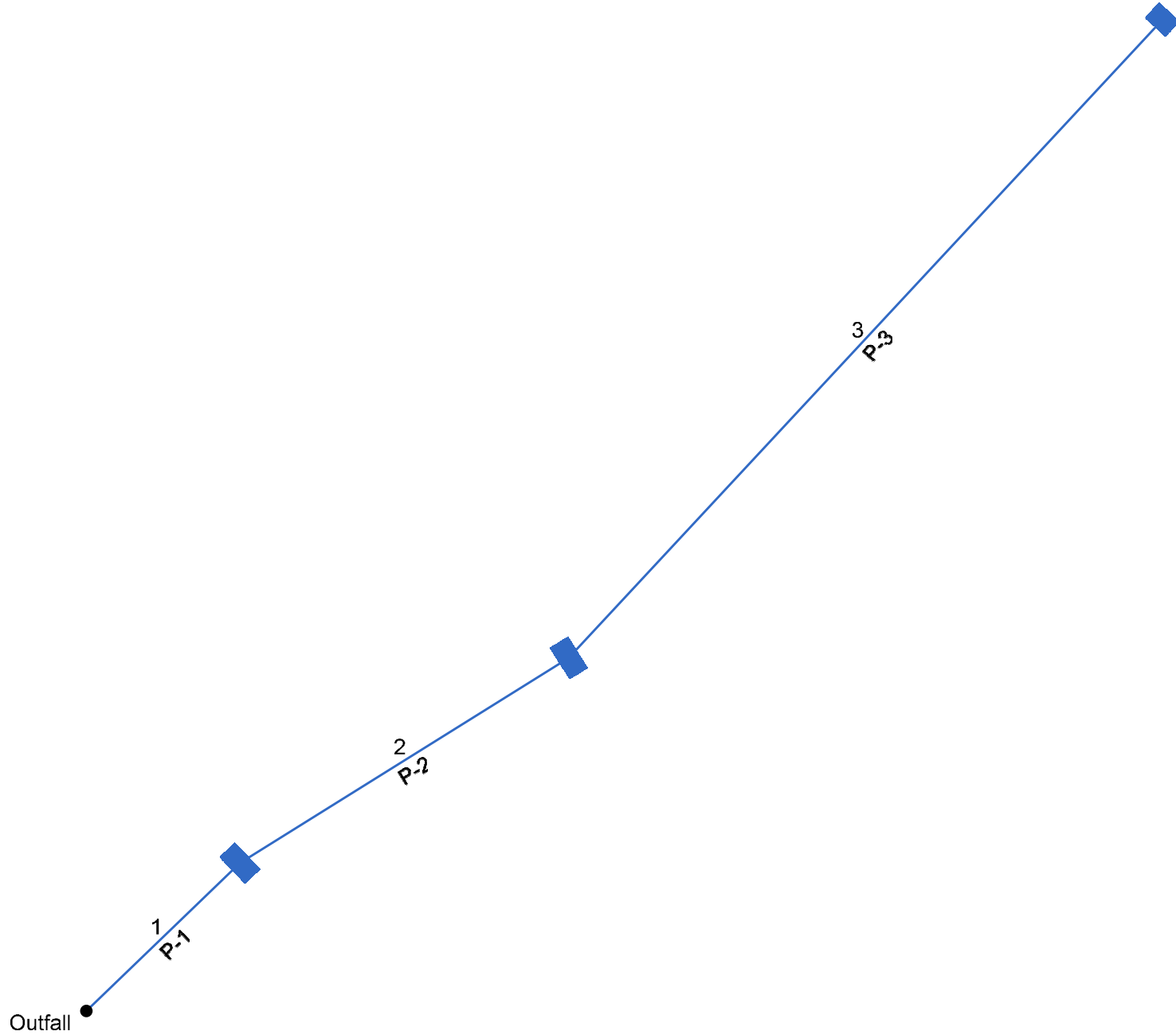
NOTES: ** Critical depth

Tc	Throat Ht	Total Area	Total CxA	Total Runoff	Vel Ave	Vel Dn	Vel Hd Dn	Vel Hd Up	Vel Up	Cover Dn	Cover Up	Storage	
(min)	(in)	(ac)		(cfs)	(ft/s)	(ft/s)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(cft)	
1.5	0.00	0.00	0.00	17.78	17.78	4.92	4.91	17.78	n/a	4.54	228.19	
1.3	0.00	0.00	0.00	17.82	17.78	4.92	4.96	17.86	4.01	6.89	2054.17	
0.3	0.00	0.00	0.00	19.59	22.17	4.49	4.49	17.00	2.57	6.49	1362.58	
0.1	0.00	0.00	0.00	20.63	24.82	4.20	4.20	16.44	3.66	10.13	1354.19	
0.0	0.00	0.00	0.00	23.88	38.68	1.28	1.28	9.08	5.59	0.79	238.69	
1.2	0.00	0.00	0.00	6.82	7.76	0.54	0.54	5.88	4.45	3.93	50.72	
0.0	0.00	0.00	0.00	5.56	6.23	0.37	0.37	4.89	3.55	3.70	207.46	

Project File: Proposed Ex SD D Analysis.stm	Number of lines: 7	Date: 12/1/2020
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NOTES: ** Critical depth

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm

Number of lines: 3

Date: 12/1/2020

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	P-1	40.68	30	Cir	46.560	410.19	411.43	2.663	412.69	413.57	n/a	413.57 j	End	DropGrate
2	P-2	39.83	30	Cir	84.509	411.63	412.47	0.994	413.62	414.59	0.62	414.59	1	DropGrate
3	P-3	13.26	18	Cir	190.517	412.67	414.75	1.092	414.59*	417.63*	0.88	418.51	2	DropGrate

Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm Number of lines: 3 Run Date: 12/1/2020

NOTES: Return period = 10 Yrs. ; *Surcharged (HGL above crown). ; j - Line contains hyd. jump.

Storm Sewer Tabulation

Station		Len (ft)	Drng Area		Rnoff coeff (C)	Area x C		Tc		Rain (l) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr (ac)	Total (ac)		Incr	Total	Inlet (min)	Syst (min)					Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	46.560	0.00	0.00	0.00	0.00	0.00	0.0	0.6	0.0	40.68	66.93	8.69	30	2.66	410.19	411.43	412.69	413.57	416.52	416.17	P-1
2	1	84.509	0.00	0.00	0.00	0.00	0.00	0.0	0.4	0.0	39.83	40.89	9.23	30	0.99	411.63	412.47	413.62	414.59	416.17	418.00	P-2
3	2	190.517	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	13.26	10.97	7.50	18	1.09	412.67	414.75	414.59	417.63	418.00	419.81	P-3

Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm

Number of lines: 3

Run Date: 12/1/2020

NOTES: Intensity = $88.24 / (\text{Inlet time} + 15.50)^{0.83}$; Return period = Yrs. 10 ; c = cir e = ellip b = box

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross SI, Sw (ft/ft)	Cross SI, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	4.48	4.48	Sag	0.20	0.50	0.90	66.93	2.14	0.020	0.020	....	-44.030	2.50	2.14**	Outfall	0.00	1271184.38	413.76	414.86	0.442
2	4.20	4.45	Sag	0.20	0.50	0.90	40.89	2.12	0.020	0.020	....	11.941	1.99	2.12**	1	0.00	1271255.98	414.87	415.84	0.000
3	1.77	1.77	Sag	0.20	0.50	0.90	10.97	1.36	0.020	0.020	....	-15.085	1.50	1.50	2	0.00	1271385.49	415.47	418.51	3.038

Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm

Number of lines: 3

Date: 12/1/2020

NOTES: ** Critical depth

Flow Rate	Sf Ave	Sf Dn	Grate Area	Grate Len	Grate Width	Gnd/Rim El Dn	Gnd/Rim El Up	Gutter Depth	Gutter Slope	Gutter Spread	Gutter Width	HGL Dn	HGL Up	HGL Jnct	HGL Jmp Dn	HGL Jmp Up	Incr CxA	Incr Q	Inlet Depth
(cfs)	(ft/ft)	(ft/ft)	(sqft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(cfs)	(ft)
40.68	0.950	0.984	15.00	2.50	6.00	416.52	416.17	0.07	Sag	14.53	8.00	412.69	413.57 j	413.57	412.69	412.23	0.00	0.85	0.07
39.83	0.000	0.000	15.00	2.50	6.00	416.17	418.00	0.65	Sag	72.73	8.00	413.62	414.59	414.59	....	....	0.00	26.57	0.65
13.26	1.595	1.595	10.00	2.50	4.00	418.00	419.81	0.49	Sag	52.70	4.00	414.59	417.63	418.51	....	....	0.00	13.26	0.49

Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm

Number of lines: 3

Date: 12/1/2020

NOTES: ** Critical depth

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
100	A-2	Sag	14.53	0.0	0.00	0.00	410.19	411.43	4.66	11.90	1.11	2.34	0.50 z	Dp-Grate	0.85	2,428	2,185	2,064
100	I-5	Sag	72.73	0.0	0.00	0.00	411.63	412.47	....	....	0.00	0.00	0.50 z	Dp-Grate	26.57	4,176	3,758	3,550
100	I-1	Sag	52.70	0.0	0.00	0.00	412.67	414.75	....	....	0.00	0.00	1.00	Dp-Grate	13.26	7,740	6,966	6,579

Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm	Number of lines: 3	Date: 12/1/2020
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NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)
P-1	46.560	30	2.66	Cir	....	....	0.013	n/a	524687.85	0.09	0.00	0.85	0.00	30	0.00	30	0.00	0.00	0.00
P-2	84.509	30	0.99	Cir	....	....	0.013	0.62	524732.75	0.17	0.00	26.57	0.00	30	0.00	30	0.00	0.00	0.00
P-3	190.517	18	1.09	Cir	....	....	0.013	0.88	524872.48	0.42	0.00	13.26	0.00	18	0.00	18	0.00	0.00	0.00

Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm

Number of lines: 3

Date: 12/1/2020

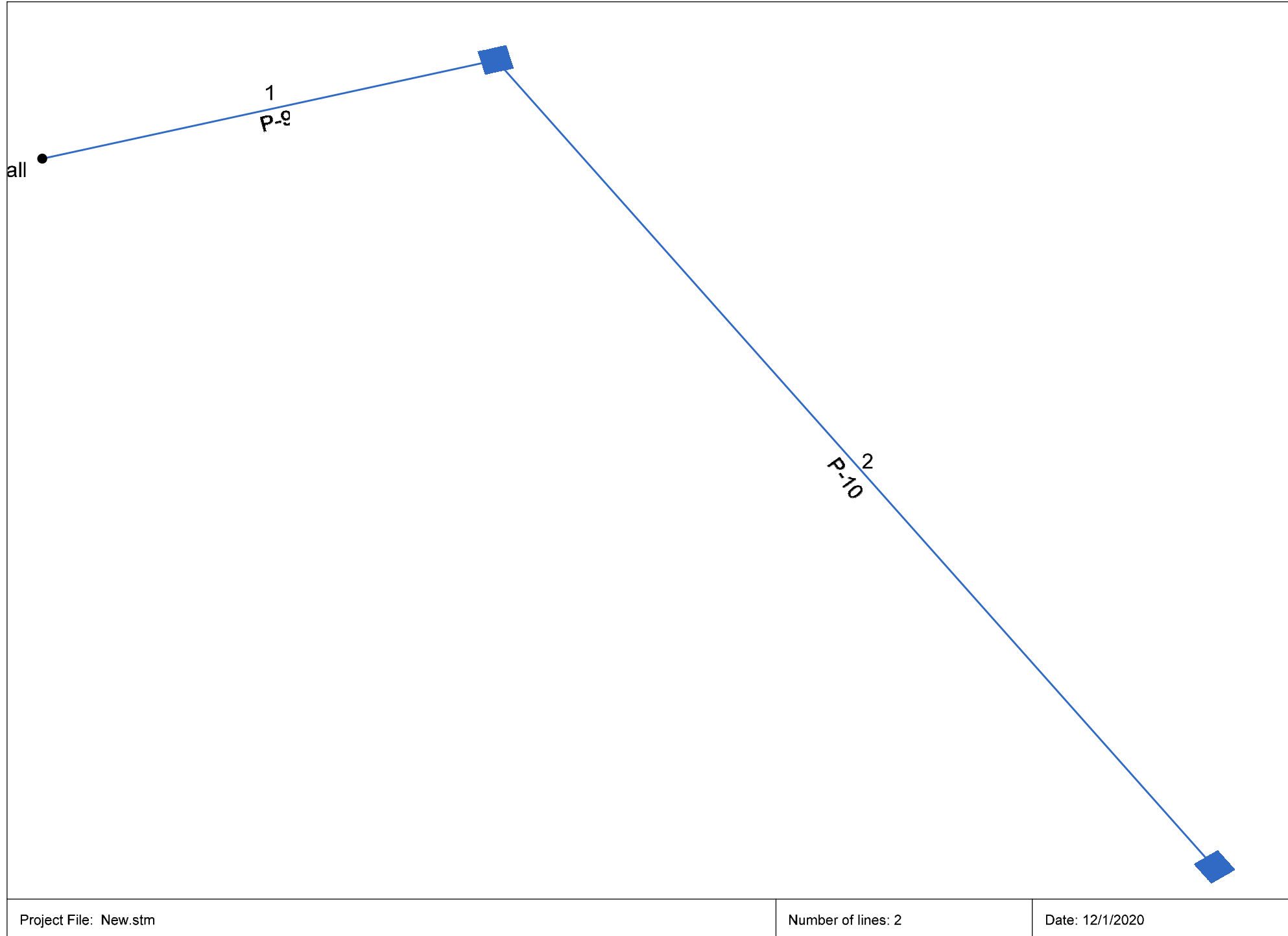
NOTES: ** Critical depth

Tc	Throat Ht	Total Area	Total CxA	Total Runoff	Vel Ave	Vel Dn	Vel Hd Dn	Vel Hd Up	Vel Up	Cover Dn	Cover Up	Storage	
(min)	(in)	(ac)		(cfs)	(ft/s)	(ft/s)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(cft)	
0.6	0.00	0.00	0.00	8.69	8.29	1.07	1.28	9.09	3.83	2.24	220.34	
0.4	0.00	0.00	0.00	9.23	9.49	1.25	1.25	8.96	2.04	3.03	365.31	
0.0	0.00	0.00	0.00	7.50	7.51	0.88	0.88	7.50	3.83	3.56	336.60	

Project File: Inlet 1 to Ex A2 Analysis_12-1-2020.stm	Number of lines: 3	Date: 12/1/2020
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NOTES: ** Critical depth

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: New.stm

Number of lines: 2

Date: 12/1/2020

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	P-9	18.16	24	Cir	65.085	400.00	400.50	0.768	402.00	402.36	0.79	403.14	End	Generic
2	P-10	6.65	24	Cir	170.401	400.50	401.50	0.587	403.14	403.27	0.08	403.35	1	Generic

Project File: New.stm	Number of lines: 2	Run Date: 12/1/2020
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NOTES: Return period = 10 Yrs.

Storm Sewer Tabulation

Station		Len (ft)	Drng Area		Rnoff coeff (C)	Area x C		Tc		Rain (l) (in/hr)	Total flow (cfs)	Cap full (cfs)	Vel (ft/s)	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr (ac)	Total (ac)		Incr	Total	Inlet (min)	Syst (min)					Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	65.085	0.00	0.00	0.00	0.00	0.00	0.0	1.3	0.0	18.16	19.82	5.88	24	0.77	400.00	400.50	402.00	402.36	402.75	404.75	P-9
2	1	170.401	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	6.65	17.33	2.19	24	0.59	400.50	401.50	403.14	403.27	404.75	407.00	P-10

Project File: New.stm

Number of lines: 2

Run Date: 12/1/2020

NOTES: Intensity = $88.24 / (\text{Inlet time} + 15.50)^{0.83}$; Return period = Yrs. 10 ; c = cir e = ellip b = box

Line No.	Area Dn (sqft)	Area Up (sqft)	Byp Ln No	Coeff C1 (C)	Coeff C2 (C)	Coeff C3 (C)	Capac Full (cfs)	Crit Depth (ft)	Cross SI, Sw (ft/ft)	Cross SI, Sx (ft/ft)	Curb Len (ft)	Defl Ang (Deg)	Depth Dn (ft)	Depth Up (ft)	DnStm Ln No	Drng Area (ac)	Easting X (ft)	EGL Dn (ft)	EGL Up (ft)	Energy Loss (ft)
1	3.14	3.04	Offsite	0.20	0.50	0.90	19.82	1.53	0.050	0.020	....	-15.013	2.00	1.86	Outfall	0.00	1273957.44	402.52	402.91	0.391
2	3.14	2.94	Offsite	0.20	0.50	0.90	17.33	0.91	0.050	0.020	....	69.254	2.00	1.77	1	0.00	1274057.02	403.21	403.35	0.139

Project File: New.stm

Number of lines: 2

Date: 12/1/2020

NOTES: ** Critical depth

Flow Rate	Sf Ave	Sf Dn	Grate Area	Grate Len	Grate Width	Gnd/Rim El Dn	Gnd/Rim El Up	Gutter Depth	Gutter Slope	Gutter Spread	Gutter Width	HGL Dn	HGL Up	HGL Jnct	HGL Jmp Dn	HGL Jmp Up	Incr CxA	Incr Q	Inlet Depth
(cfs)	(ft/ft)	(ft/ft)	(sqft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)		(cfs)	(ft)
18.16	0.601	0.645	....	....	....	402.75	404.75	0.35	0.020	14.35	2.00	402.00	402.36	403.14	....	....	0.00	11.51	0.35
6.65	0.082	0.086	404.75	407.00	0.29	0.020	11.55	2.00	403.14	403.27	403.35	0.00	6.65	0.29

Project File: New.stm	Number of lines: 2	Date: 12/1/2020
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NOTES: ** Critical depth

Inlet Eff (%)	Inlet ID	Inlet Loc	Inlet Spread (ft)	Inlet Time (min)	i Sys (in/hr)	i Inlet (in/hr)	Invert Dn (ft)	Invert Up (ft)	Jump Loc (ft)	Jump Len (ft)	Vel Hd Jmp Dn (ft)	Vel Hd Jmp Up (ft)	J-Loss Coeff	Junct Type	Known Q (cfs)	Cost RCP	Cost CMP	Cost PVC
100	INLET Z-2	On Grade	14.35	0.0	0.00	0.00	400.00	400.50	....	....	0.00	0.00	1.42	Generic	11.51	2,548	2,293	2,166
100	INLET Z-6	On Grade	11.55	0.0	0.00	0.00	400.50	401.50	0.00	0.00	1.00	Generic	6.65	7,600	6,840	6,460

Project File: New.stm	Number of lines: 2	Date: 12/1/2020
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NOTES: Intensity = 88.24 / (Inlet time + 15.50) ^ 0.83 -- Return period = 10 Yrs. ; ** Critical depth

Line ID	Line Length (ft)	Line Size (in)	Line Slope (%)	Line Type	Local Depr (in)	n-val Gutter	n-val Pipe	Minor Loss (ft)	Northing Y (ft)	Pipe Travel (min)	Q Byp (cfs)	Q Capt (cfs)	Q Carry (cfs)	Line Rise (in)	Runoff Coeff (C)	Line Span (in)	Area A1 (ac)	Area A2 (ac)	Area A3 (ac)
P-9	65.085	24	0.77	Cir	0.0	0.013	0.013	0.79	524502.49	0.19	0.00	11.51	0.00	24	0.00	24	0.00	0.00	0.00
P-10	170.401	24	0.59	Cir	0.0	0.013	0.013	0.08	524364.21	1.34	0.00	6.65	0.00	24	0.00	24	0.00	0.00	0.00

Project File: New.stm	Number of lines: 2	Date: 12/1/2020
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NOTES: ** Critical depth

Tc	Throat Ht	Total Area	Total CxA	Total Runoff	Vel Ave	Vel Dn	Vel Hd Dn	Vel Hd Up	Vel Up	Cover Dn	Cover Up	Storage	
(min)	(in)	(ac)		(cfs)	(ft/s)	(ft/s)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(cft)	
1.3	0.00	0.00	0.00	5.88	5.78	0.52	0.55	5.97	0.75	2.25	201.80	
0.0	0.00	0.00	0.00	2.19	2.12	0.07	0.08	2.26	2.25	3.50	529.63	

Project File: New.stm	Number of lines: 2	Date: 12/1/2020
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NOTES: ** Critical depth

INLET NO.	INCR. AREA (ac)	TOTAL AREA (ac)	C	C*A	ΣC*A	T.C (min)	I (in/hr)	BASE FLOW (cfs)	OVER FLOW (cfs)	TOTAL INFLOW* (cfs)	FLOW INTER. (cfs)	FLOW BYPASS		INLET LENGTH		STREET SLOPW (%)	CROSS SLOPE (ft/ft)	CURB HEIGHT (ft)	THROAT DEPRESS (in)	GUTTER FLOW		NOTES
												cfs	TO	COMP. (ft)	ACTUAL (ft)					DEPTH (ft)	SPREAD (ft)	
I-1*	5.3	5.3	0.57	3.02	3.02	19.26	4.45	0	-	13.26	-	-	-	-	-	-	-	-	-	-	-	Swale 1 Drainage Area
I-5*	7.525	7.525	0.57	4.29	4.29	8.52	6.17	0	-	26.57	16.21	10.36	A-2									Majority of Swale 5 Drainage Area
A-2	0.206	7.73	0.61	4.72	9.01	6	6.78	0	-	11.21	-	-	-									TOTAL Swale 5 Drainage Area
I-2*	62	62	0.57	35.34	35.34	9.12	6.03	0	-	156.94	57.182	99.758	Ex D7									Swale 10 Area (also picks up Swale 8 and 13)- PR Yard Inlet + Sediment Basin Discharge (Area 1B)
Ex D7	1.536	1.536	0.53	0.81	0.81	6	6.78	5.514	99.76	105.27	56.61	48.66	Ex D5									
Ex D5	0.836	0.836	0.51	0.43	0.43	6	6.78	2.918	48.66	51.58	40.74	10.84	Ex D4									
Ex D4	0.074	0.074	0.55	0.04	0.04	6	6.78	0.275	10.84	11.11	11.11	0.00	-									
Ex D6	1.688	1.688	0.47	0.79	0.79	6	6.78	5.336	-	5.34	5.34	-	Ex D5									
Z-6*	2.095	2.101	0.55	1.16	1.16	6	6.78			6.65												
Z-2	0.969	0.969	0.74	0.72	0.72	6	6.78			4.86												Q is from Rational Calculation

EA ENGINEERING, SCIENCE, AND TECHNOLOGY	INLET COMPUTATIONS												COMPUTED	LMO	DATE
	GUDE LANDFILL REMEDIATION DESIGN												CHECKED		Jul-20
													SHEET NO.		PROJECT NO.
															1564601

*I-1: Total inflow was calculated with TR-55 - located in Swale 1
*I-5: Total inflow was calculated with TR-55 - located in Swale 5
*I-2: Total inflow was calculated with TR-55 - Sum of Swales 8, 13, and 10 + Temporary Sediment Basin Discharge (Area 1B)
*Z-6: Total inflow was calculated with TR-55 - located in Swale 14

Hydraulic Analysis Report

Project Data

Project Title:

Designer:

Project Date: Monday, June 29, 2020

Project Units: U.S. Customary Units

Notes:

Curb and Gutter Analysis: PR I-2

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.5000 ft/ft

Cross-Slope of Pavement: 0.5000 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0300

Gutter Width: 8.0000 ft

Design Flow: 156.9400 cfs

Gutter Result Parameters

Width of Spread: 3.9024 ft

Gutter Depression: 0.0000 in

Area of Flow: 3.8073 ft²

E_o (Gutter Flow to Total Flow): 1.0000

Gutter Depth at Curb: 23.4147 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 10.0000 ft

Local Depression: 10.5600 in

Inlet Result Parameters

Intercepted Flow: 57.1820 cfs

Bypass Flow: 99.7580 cfs

Efficiency: 0.3644

Curb and Gutter Analysis: EX D7

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0700 ft/ft

Cross-Slope of Pavement: 0.2300 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0300

Gutter Width: 2.5000 ft

Design Flow: 105.2700 cfs

Gutter Result Parameters

Width of Spread: 7.8918 ft

Gutter Depression: 0.0000 in

Area of Flow: 7.1623 ft²

E_o (Gutter Flow to Total Flow): 0.6384

Gutter Depth at Curb: 21.7815 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Grate

Grate Type: P - 1-7/8

Grate Width: 2.5000 ft

Grate Length: 4.0000 ft

Local Depression: 0.0000 in

Inlet Result Parameters

Intercepted Flow: 56.6086 cfs

Bypass Flow: 48.6614 cfs

Approach Velocity: 14.6977 ft/s

Splash-over Velocity: 11.5138 ft/s

Efficiency: 0.5377

Curb and Gutter Analysis: EX D5

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0700 ft/ft

Cross-Slope of Pavement: 0.2300 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0300

Gutter Width: 2.0000 ft

Design Flow: 51.5800 cfs

Gutter Result Parameters

Width of Spread: 6.0394 ft

Gutter Depression: 0.0000 in

Area of Flow: 4.1946 ft²

E_o (Gutter Flow to Total Flow): 0.6583

Gutter Depth at Curb: 16.6688 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Grate

Grate Type: P - 1-7/8

Grate Width: 2.5000 ft

Grate Length: 4.0000 ft

Local Depression: 6.3600 in

Inlet Result Parameters

Intercepted Flow: 40.7438 cfs

Bypass Flow: 10.8362 cfs

Approach Velocity: 12.2969 ft/s

Splash-over Velocity: 11.5138 ft/s

Efficiency: 0.7899

Curb and Gutter Analysis: EX D4

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.0700 ft/ft

Cross-Slope of Pavement: 0.2300 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0300

Gutter Width: 2.0000 ft

Design Flow: 11.1100 cfs

Gutter Result Parameters

Width of Spread: 3.3959 ft

Gutter Depression: 0.0000 in

Area of Flow: 1.3262 ft²

E_o (Gutter Flow to Total Flow): 0.9069

Gutter Depth at Curb: 9.3727 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Grate

Grate Type: P - 1-7/8

Grate Width: 2.5000 ft

Grate Length: 4.0000 ft

Local Depression: 0.0000 in

Inlet Result Parameters

Intercepted Flow: 11.1100 cfs

Bypass Flow: 0.0000 cfs

Approach Velocity: 8.3773 ft/s

Splash-over Velocity: 11.5138 ft/s

Efficiency: 1.0084

Curb and Gutter Analysis: PR I-2-JUST SWALE FLOW

Notes:

Gutter Input Parameters

Longitudinal Slope of Road: 0.5000 ft/ft

Cross-Slope of Pavement: 0.5000 ft/ft

Uniform Gutter Geometry

Manning's n: 0.0300

Gutter Width: 8.0000 ft

Width of Spread: 3.2016 ft

Gutter Result Parameters

Design Flow: 92.5700 cfs

Gutter Depression: 0.0000 in

Area of Flow: 2.5625 ft²

E_o (Gutter Flow to Total Flow): 1.0000

Gutter Depth at Curb: 19.2094 in

Inlet Input Parameters

Inlet Location: Inlet on Grade

Inlet Type: Curb Opening

Length of Inlet: 10.0000 ft

Local Depression: 24.0000 in

Inlet Result Parameters

Intercepted Flow: 45.6517 cfs

Bypass Flow: 46.9183 cfs

Efficiency: 0.4932

Inlet Report

Inlet 1

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 4.00
Grate Width (ft)	= 2.50
Grate Length (ft)	= 4.00

Gutter

Slope, Sw (ft/ft)	= 0.500
Slope, Sx (ft/ft)	= 0.500
Local Depr (in)	= 24.00
Gutter Width (ft)	= 4.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

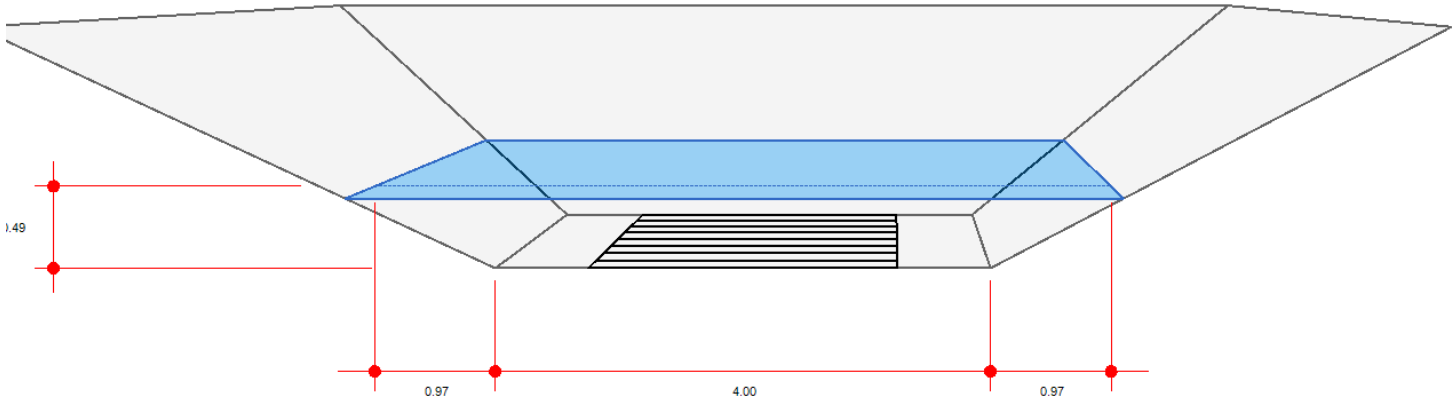
Calculations

Compute by:	Known Q
Q (cfs)	= 13.26

Highlighted

Q Total (cfs)	= 13.26
Q Capt (cfs)	= 13.26
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 5.84
Efficiency (%)	= 100
Gutter Spread (ft)	= 5.95
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet



Inlet Report

Inlet 5

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 6.00
Grate Width (ft)	= 6.00
Grate Length (ft)	= 2.50

Gutter

Slope, Sw (ft/ft)	= 0.500
Slope, Sx (ft/ft)	= 0.500
Local Depr (in)	= 24.00
Gutter Width (ft)	= 8.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

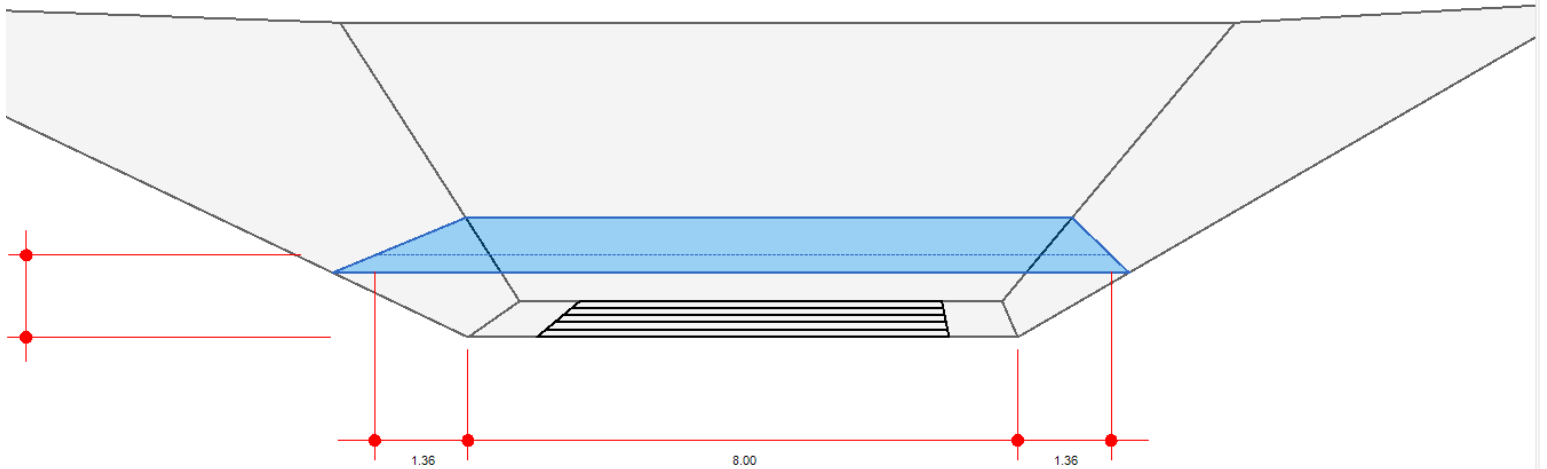
Calculations

Compute by:	Known Q
Q (cfs)	= 26.57

Highlighted

Q Total (cfs)	= 26.57
Q Capt (cfs)	= 26.57
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 8.15
Efficiency (%)	= 100
Gutter Spread (ft)	= 10.72
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet



Inlet Report

Inlet A2

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 6.00
Grate Width (ft)	= 6.00
Grate Length (ft)	= 2.50

Gutter

Slope, Sw (ft/ft)	= 0.500
Slope, Sx (ft/ft)	= 0.500
Local Depr (in)	= 24.00
Gutter Width (ft)	= 8.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

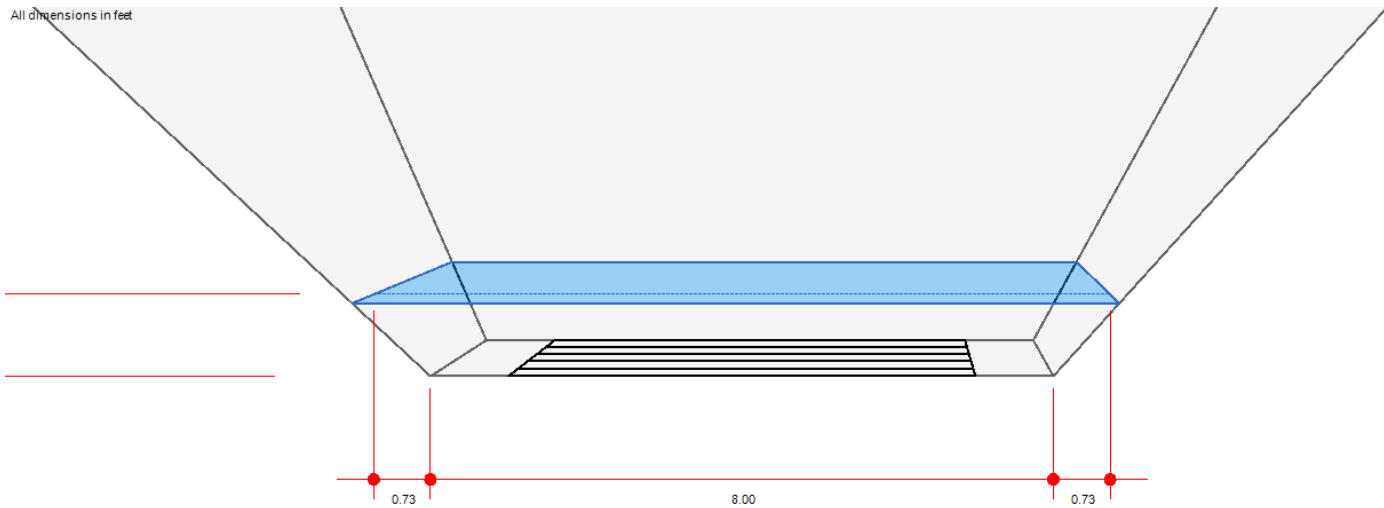
Calculations

Compute by:	Known Q
Q (cfs)	= 11.21

Highlighted

Q Total (cfs)	= 11.21
Q Capt (cfs)	= 11.21
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 4.37
Efficiency (%)	= 100
Gutter Spread (ft)	= 9.46
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet



Inlet Report

Inlet Z6

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 4.00
Grate Width (ft)	= 4.00
Grate Length (ft)	= 2.50

Gutter

Slope, Sw (ft/ft)	= 0.500
Slope, Sx (ft/ft)	= 0.500
Local Depr (in)	= -0-
Gutter Width (ft)	= 8.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

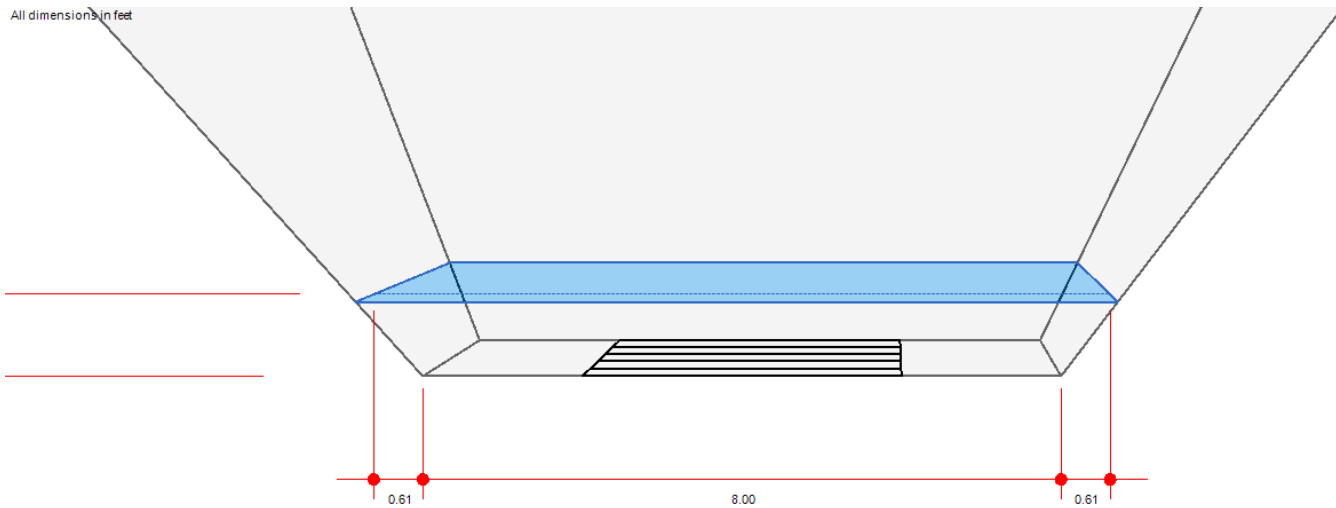
Calculations

Compute by:	Known Q
Q (cfs)	= 6.65

Highlighted

Q Total (cfs)	= 6.65
Q Capt (cfs)	= 6.65
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 3.69
Efficiency (%)	= 100
Gutter Spread (ft)	= 9.23
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet



Inlet Report

Inlet Z2

Drop Grate Inlet

Location	= Sag
Curb Length (ft)	= -0-
Throat Height (in)	= -0-
Grate Area (sqft)	= 4.00
Grate Width (ft)	= 4.00
Grate Length (ft)	= 2.50

Gutter

Slope, Sw (ft/ft)	= 0.020
Slope, Sx (ft/ft)	= 0.020
Local Depr (in)	= -0-
Gutter Width (ft)	= 8.00
Gutter Slope (%)	= -0-
Gutter n-value	= -0-

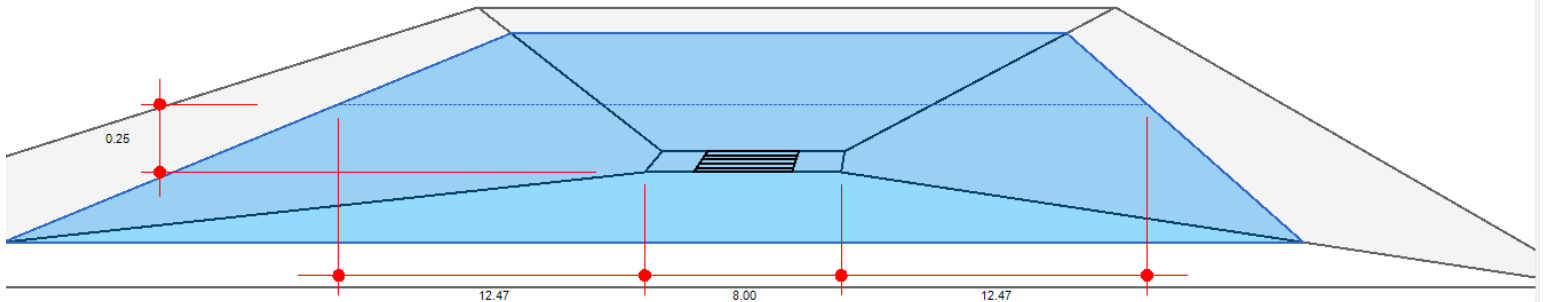
Calculations

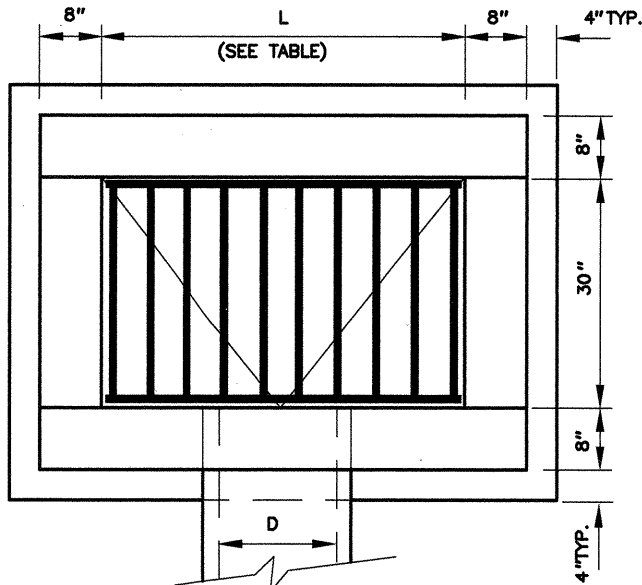
Compute by:	Known Q
Q (cfs)	= 4.86

Highlighted

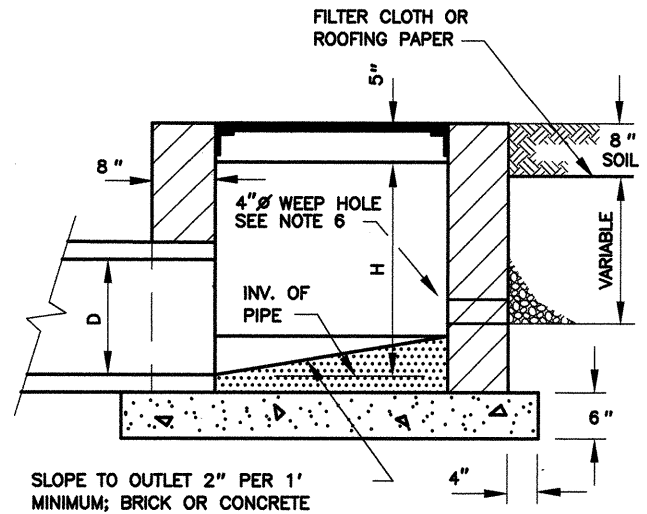
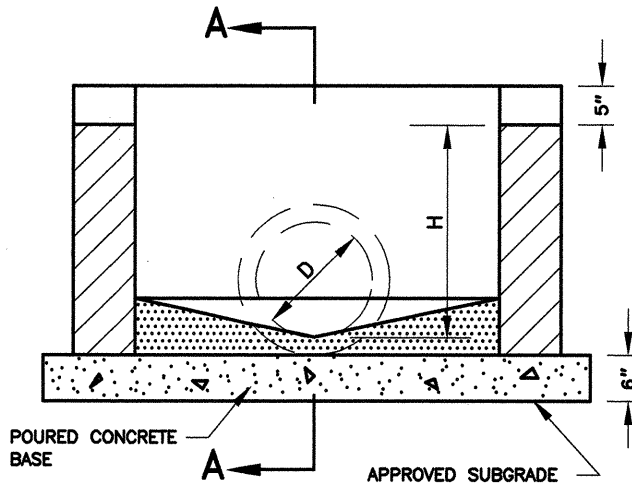
Q Total (cfs)	= 4.86
Q Capt (cfs)	= 4.86
Q Bypass (cfs)	= -0-
Depth at Inlet (in)	= 2.99
Efficiency (%)	= 100
Gutter Spread (ft)	= 32.93
Gutter Vel (ft/s)	= -0-
Bypass Spread (ft)	= -0-
Bypass Depth (in)	= -0-

All dimensions in feet





D	L	H
15"	4' - 0"	2' - 6"
18"	4' - 0"	2' - 9"
21"	4' - 6"	3' - 0"
24"	5' - 0"	3' - 3"
27"	5' - 6"	3' - 7"
30"	6' - 0"	3' - 10"
33"	6' - 0"	4' - 1"
36"	6' - 0"	4' - 4"



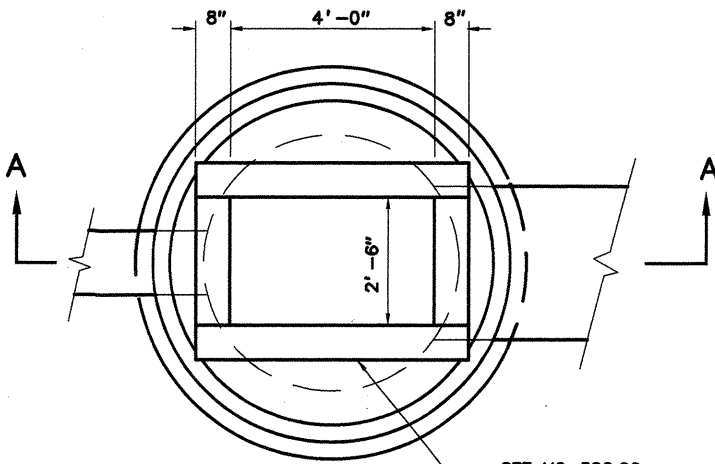
SECTION A-A

GENERAL NOTES

1. REFER TO MARYLAND STATE HIGHWAY ADMINISTRATION SPECIFICATIONS FOR MATERIALS AND METHODS OF CONSTRUCTION.
2. PROVIDE GRATE PER M.S.H.A. STD. NO. MD-377.02 MODIFIED WITH BARS 3" O.C.; TACK WELD IN PLACE.
3. CONSTRUCTION TO BE OF CONCRETE OR BRICK MASONRY.
4. STEEL VERTICAL 1/2" ϕ BARS, 6" C.C., HORIZONTAL 1/2" ϕ BARS, 6" C.C.; BOTTOM 1/2" ϕ BARS 6" C.C. EACH WALL, 2" MIN. COVER. (WITH CONCRETE CONSTRUCTION)
5. MORTAR SHALL CONFORM TO ASTM SPECIFICATION C270 TYPE M.
6. WEEP HOLES TO BE PLACED IN WALL OPPOSITE OUTLET PIPE 5" ABOVE PIPE INVERT. COVER OPENING WITH 1/2" HARDWARE CLOTH. INSTALL FOUNDATION DRAINAGE MATERIAL AROUND STRUCTURE FROM BOTTOM OF WEEP HOLES TO WITHIN 8" OF SURFACE FOR A THICKNESS OF 12" MINIMUM.
7. BRICK SHALL CONFORM TO AASHTO DESIGNATION M-114 GRADE SW.
8. $f'c = 3500$ PSI AT 28 DAYS.
9. PARGE OUTSIDE WALLS.

P:\ADT\STDA\MC506.02 6-24-94 9:42:37 a.m. EST

APPROVED <u>JAN 5 1995</u> DATE	REVISED 	MONTGOMERY COUNTY DEPARTMENT OF TRANSPORTATION
<i>Tracy Hester</i> DIRECTOR, DEPT. OF TRANS.		"J" INLET AS A TERMINUS
<i>Edgemoore</i> CHIEF, DIV. OF ENG. SERVICES		STANDARD NO. MC-506.02

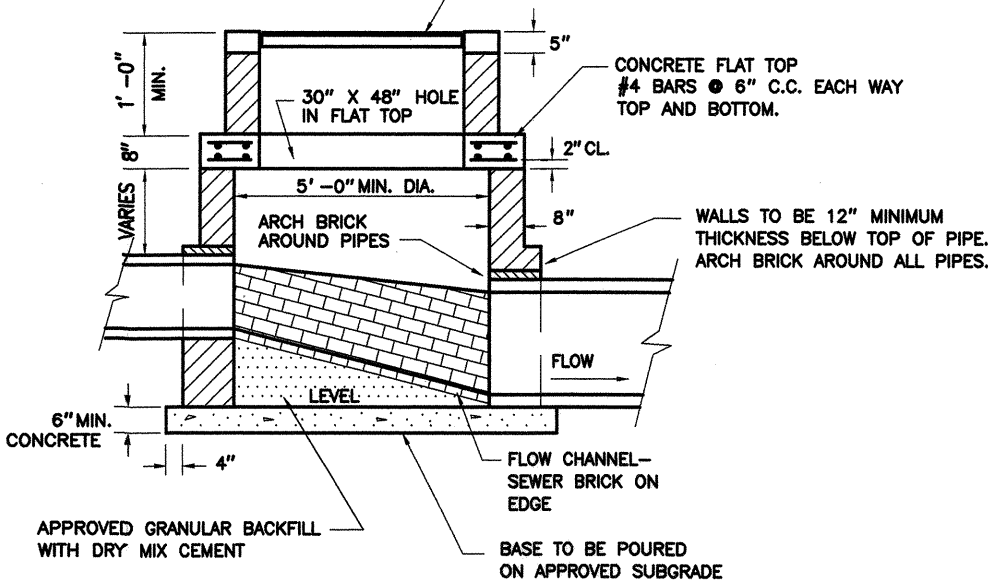


DEPTH OF STR.	WALL THICKNESS	BASE THICKNESS
1' TO 5'	8"	6"
5' TO 8'	12"	6"
8' TO 12'	16"	8"

NOTE: DEPTH OF STRUCTURE TO BE MEASURED FROM BOTTOM OF FLAT TOP TO INVERT OF OUTGOING PIPE.

OUTGOING PIPE SIZE	STRUCTURE DIAMETER
15" - 36"	60"
42" - 48"	72"
54" - 60"	84"
72"	96"

SEE MC-506.02 FOR INLET DETAILS NOT SHOWN



SECTION A-A

GENERAL NOTES

1. REFER TO MARYLAND STATE HIGHWAY ADMINISTRATION FOR MATERIALS AND METHODS OF CONSTRUCTION.
2. USE SOLID MASONRY (BRICK OR CONCRETE BLOCK) OR POURED CONCRETE FOR WALLS. USE OF M.C.D.O.T. APPROVED PRECAST CONCRETE STRUCTURES MAY BE USED IN PLACE OF BRICK MASONRY.
3. MORTAR SHALL CONFORM TO ASTM SPECIFICATION C270 TYPE M.
4. PROVIDE STEPS IN CHANNELS OF STRUCTURES. REFER TO MC-520.01 FOR DETAILS.
5. $f'c = 3,500$ P.S.I. AT 28 DAYS.
6. TWO 4" ϕ WEEP HOLES TO BE PLACED OPPOSITE EACH OTHER AT CROWN OF CHANNEL. COVER OPENING WITH 1/2" HARDWARE CLOTH.
7. INSTALL FOUNDATION DRAINAGE MATERIAL 1' MINIMUM THICKNESS AROUND STRUCTURE FROM BOTTOM OF WEEP HOLES TO WITHIN 8" OF FINISHED GRADE.
8. PARGE OUTSIDE WALLS.

P:\DOTS\DMC\506.01 6-24-94 9:41:06 am EST

APPROVED JAN 5/96
DATE

Tracy Maden
DIRECTOR, DEPT. OF TRANS.
Edgar Bourke
CHIEF, DIV. OF ENG. SERVICES

REVISED

MONTGOMERY COUNTY
DEPARTMENT OF TRANSPORTATION

"J" INLET

STANDARD NO. MC-506.01



Project Gude Landfill Remediation Design Project No. 1564601
Subject Culvert Hydraulic Calculations Sheet No. 1 of 8
Drawing No. _____
Computed by LMO Date 11/25/2020 Checked by [Signature] Date 11/27/2020

Montgomery County
Drainage Design Criteria.
Montgomery County
Department of
Transportation, Rockville,
Maryland, 10 June 2014.

OBJECTIVE:

Design culvert size is adequate for peak discharge, velocity and depth of flow.

PROCEDURE:

- 1) Delineate drainage area for each culvert.
- 2) Use TR-55 to determine peak discharges for 10-year, 25-year, and 100-year storm events.
- 3) Use HY-8 to design the culverts. The outputs are presented on Culvert Design Form in accordance with Montgomery County Drainage Design Criteria.

CONCLUSION:

Based on HY-8 results, box culverts have been selected to convey the peak flow for the 25-yr design storm event. The standard culvert size is 3.25 feet with a rise of 1.5 feet with two barrels. Three culverts contain a 3.67 feet span with a rise of 2.0 feet and are noted in the Culvert Design Forms. The Culvert Design Forms are based on the 10-yr design storm event.

ATTACHMENTS:

Culvert Design Forms
HY-8 Output

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: D-1
SHEET: 1 OF 10

CULVERT DESIGN FORM
DESIGN: LMO DATE: 11/24/2020
REVIEW: [Signature] DATE: 1/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

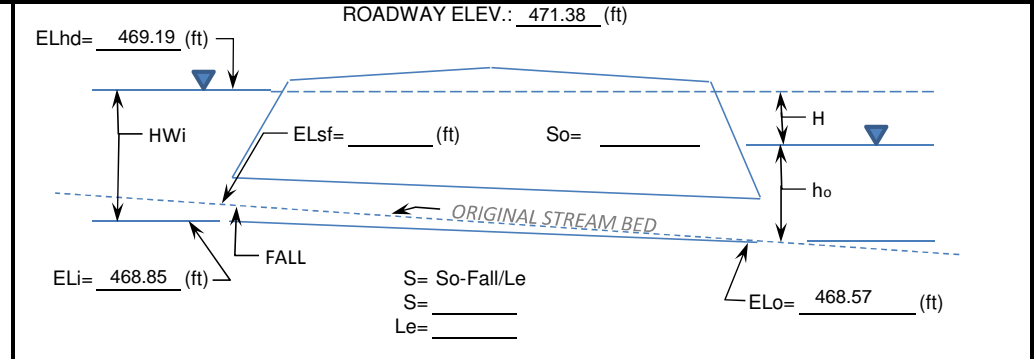
DRAINAGE AREA (AC): 1.40 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>3.30</u>	<u>0.198</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.25	1.5	3.30	1.65	N/A	0.34	N/A	469.19	0.198	0.2	N/A	0.198	0.5	0.142	468.91	469.19	3.95		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (ELhd - ELsf): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + ELi (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
where ~~K_u = 19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = EL_o + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
F = CULVERT FACE
hd = DESIGN HEADWATER
hl = HEADWATER IN INLET CONTROL
ho = HEADWATER IN OUTLET CONTROL
i = INLET CONTROL SECTION
O = OUTLET
sf = STREAMBED AT CULVERT FACE
tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 4A



CULVERT BARREL SELECTED:

SIZE: SPAN 3.25 FT, RISE 1.5 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: E-2
SHEET: 2 OF 10

CULVERT DESIGN FORM
DESIGN: LMO **DATE:** 11/24/2020
REVIEW: [Signature] **DATE:** 1/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

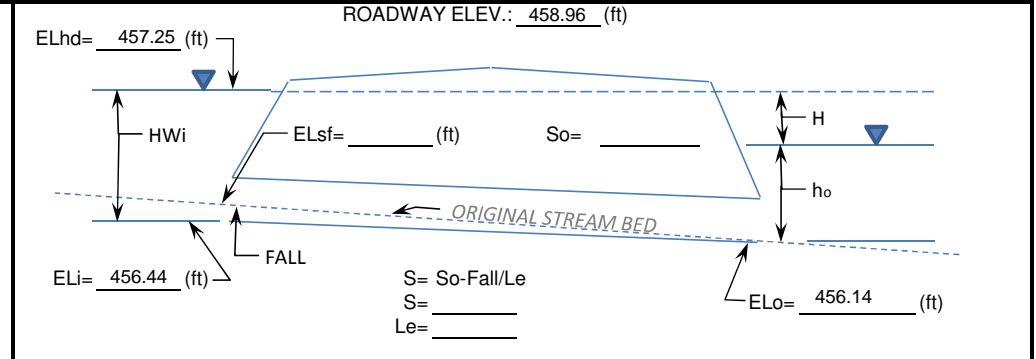
DRAINAGE AREA (AC): 4.38 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>12.45</u>	<u>0.4</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.25	1.5	12.45	6.225	N/A	0.81	N/A	457.25	0.4	0.485	N/A	0.4	0.5	0.41	456.95	457.25	5.98		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i-(EL_{hd}-EL_{sf}): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi}=HW_i+EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c+D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H=HW_i - h_o**
 where K_u = ~~19.63 (20 IN ENGLISH UNITS)~~

(8) EL_{ho} =EL_o+H+h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
 F = CULVERT FACE
 hd = DESIGN HEADWATER
 hi = HEADWATER IN INLET CONTROL
 ho = HEADWATER IN OUTLET CONTROL
 i = INLET CONTROL SECTION
 O = OUTLET
 sf = STREAMBED AT CULVERT FACE
 tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 8 - Upstream

CULVERT BARREL SELECTED:

SIZE: SPAN 3.25 FT, RISE 1.5 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: E-3
SHEET: 3 OF 10

CULVERT DESIGN FORM
DESIGN: LMO DATE: 11/24/2020
REVIEW: [Signature] DATE: 1/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

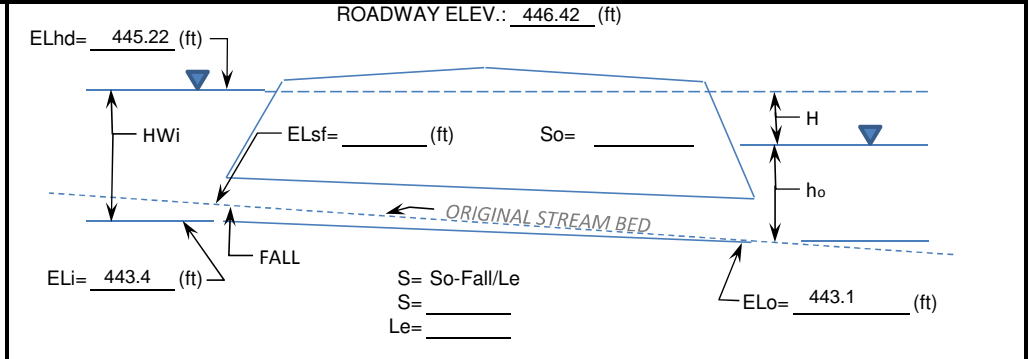
DRAINAGE AREA (AC): 16.12 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>41.81</u>	<u>0.81</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments		
	Material	Entrance				INLET CONTROL				OUTLET CONTROL										
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)
1	REINFORCED CONCRETE BOX CULVERT	3.67	SQUARE EDGE 2	41.81	20.905	N/A	1.68	N/A	445.08	0.81	1.003	N/A	0.81	0.5	0.87	444.78	445.22	7.9		
2																				
3																				
4																				
5																				
6																				

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (ELhd - ELsf): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
where ~~K_u = 19.63 (20 IN ENGLISH UNITS)~~

(8) EL_{ho} = EL_o + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
F = CULVERT FACE
hd = DESIGN HEADWATER
hl = HEADWATER IN INLET CONTROL
ho = HEADWATER IN OUTLET CONTROL
i = INLET CONTROL SECTION
O = OUTLET
sf = STREAMBED AT CULVERT FACE
tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 8 - Downstream

CULVERT BARREL SELECTED:

SIZE: SPAN 3.67 FT, RISE 2 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: A-1
SHEET: 4 OF 10

CULVERT DESIGN FORM
DESIGN: LMO **DATE:** 11/24/2020
REVIEW: [Signature] **DATE:** 1/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

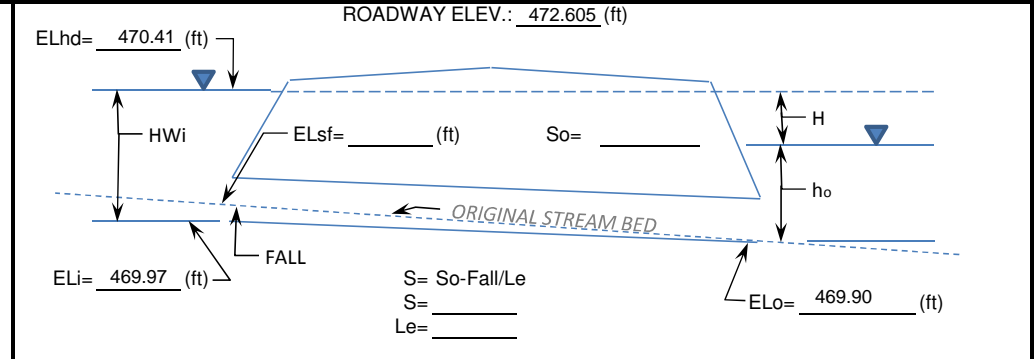
DRAINAGE AREA (AC): 1.58 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>4.83</u>	<u>0.291</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.25	1.5	4.83	2.415	N/A	0.44	N/A	470.41	0.291	0.258	N/A	0.291	0.5	0.149	470.34	470.41	2.554		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (EL_{hd} - EL_{sf}): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
 where K_u = ~~19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = EL_o + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
 F = CULVERT FACE
 hd = DESIGN HEADWATER
 hi = HEADWATER IN INLET CONTROL
 ho = HEADWATER IN OUTLET CONTROL
 i = INLET CONTROL SECTION
 O = OUTLET
 sf = STREAMBED AT CULVERT FACE
 tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 9A



CULVERT BARREL SELECTED:

SIZE: SPAN 3.25 FT, RISE 1.5 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: A-2
SHEET: 5 OF 10

CULVERT DESIGN FORM
DESIGN: LMO DATE: 11/24/2020
REVIEW: [Signature] DATE: 11/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

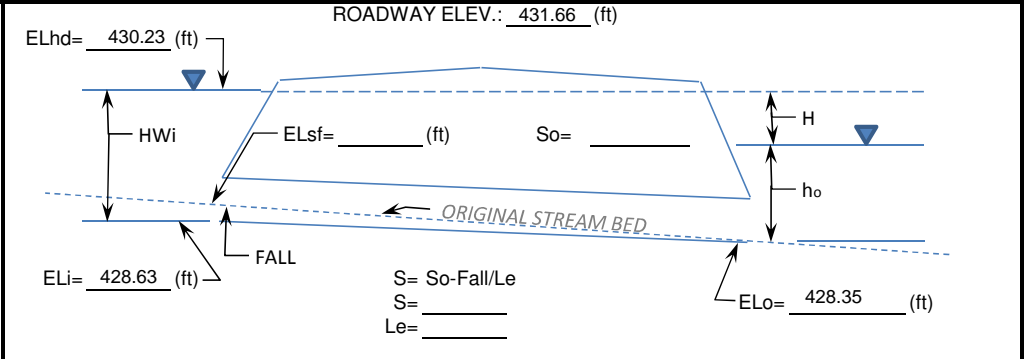
DRAINAGE AREA (AC): 10.11 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>34.53</u>	<u>0.191</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.67	2.0	34.53	17.265	N/A	1.48	N/A	430.11	0.191	0.883	N/A	0.191	0.5	1.289	429.83	430.23	7.624		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (EL_{hd} - EL_{sf}): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}] (V^2/2g)$~~ **H = HW_i - h_o**
where K_u = ~~19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = EL_o + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
F = CULVERT FACE
hd = DESIGN HEADWATER
hl = HEADWATER IN INLET CONTROL
ho = HEADWATER IN OUTLET CONTROL
i = INLET CONTROL SECTION
O = OUTLET
sf = STREAMBED AT CULVERT FACE
tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 15



CULVERT BARREL SELECTED:

SIZE: SPAN 3.67 FT, RISE 2.0 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: E-5
SHEET: 6 OF 10

CULVERT DESIGN FORM
DESIGN: LMO DATE: 11/24/2020
REVIEW: [Signature] DATE: 11/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

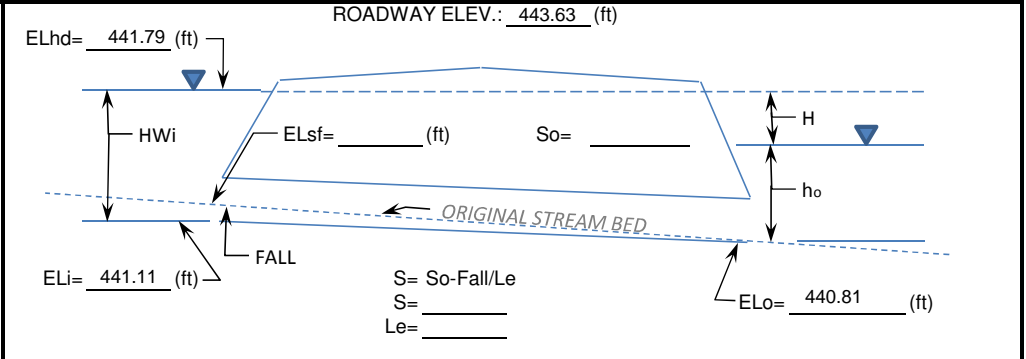
DRAINAGE AREA (AC): 3.31 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>9.54</u>	<u>0.358</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.25	1.5	9.54	4.77	N/A	0.68	N/A	441.79	0.358	0.406	N/A	0.406	0.5	0.274	441.49	441.79	5.576		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (EL_{hd} - EL_{sf}): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
where ~~K_u = 19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = EL_o + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
F = CULVERT FACE
hd = DESIGN HEADWATER
hl = HEADWATER IN INLET CONTROL
ho = HEADWATER IN OUTLET CONTROL
i = INLET CONTROL SECTION
O = OUTLET
sf = STREAMBED AT CULVERT FACE
tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 12



CULVERT BARREL SELECTED:

SIZE: SPAN 3.25 FT, RISE 1.5 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: E-1
SHEET: 7 OF 10

CULVERT DESIGN FORM
DESIGN: LMO **DATE:** 11/24/2020
REVIEW: [Signature] **DATE:** 11/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

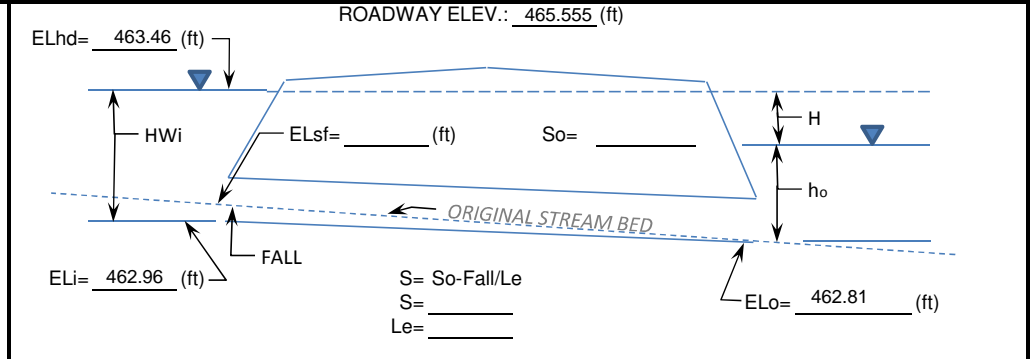
DRAINAGE AREA (AC): 2.11 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>5.97</u>	<u>0.268</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.25	1.5	5.97	2.985	N/A	0.5	N/A	463.46	0.268	0.297	N/A	0.268	0.5	0.232	463.31	463.46	4.031		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (ELhd - ELsf): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + ELi (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
 where ~~K_u = 19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = ELo + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
 F = CULVERT FACE
 hd = DESIGN HEADWATER
 hi = HEADWATER IN INLET CONTROL
 ho = HEADWATER IN OUTLET CONTROL
 i = INLET CONTROL SECTION
 O = OUTLET
 sf = STREAMBED AT CULVERT FACE
 tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 13 - Upstream



CULVERT BARREL SELECTED:

SIZE: SPAN 3.25 FT, RISE 1.5 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: 13-1
SHEET: 8 OF 10

CULVERT DESIGN FORM
DESIGN: LMO **DATE:** 11/24/2020
REVIEW: [Signature] **DATE:** 11/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

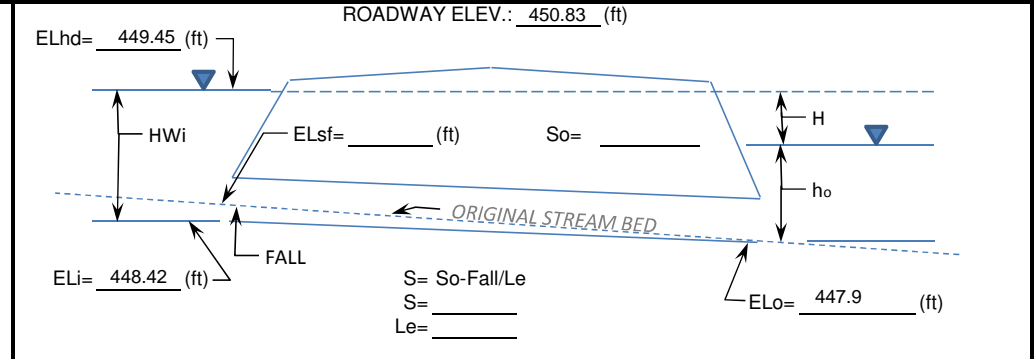
DRAINAGE AREA (AC): 7.02 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>18.07</u>	<u>0.498</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.25	1.5	18.07	9.035	N/A	1.03	N/A	449.45	0.498	0.621	N/A	0.498	0.5	0.532	448.93	449.45	7.58		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (ELhd - ELsf): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + ELi (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + Ke + ((Ku)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
 where Ku = ~~19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = ELo + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
 F = CULVERT FACE
 hd = DESIGN HEADWATER
 hl = HEADWATER IN INLET CONTROL
 ho = HEADWATER IN OUTLET CONTROL
 i = INLET CONTROL SECTION
 O = OUTLET
 sf = STREAMBED AT CULVERT FACE
 tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 13 - Mid



CULVERT BARREL SELECTED:

SIZE: SPAN 3.25 FT, RISE 1.5 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: E-4
SHEET: 9 OF 10

CULVERT DESIGN FORM
DESIGN: LMO DATE: 11/24/2020
REVIEW: [Signature] DATE: 11/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

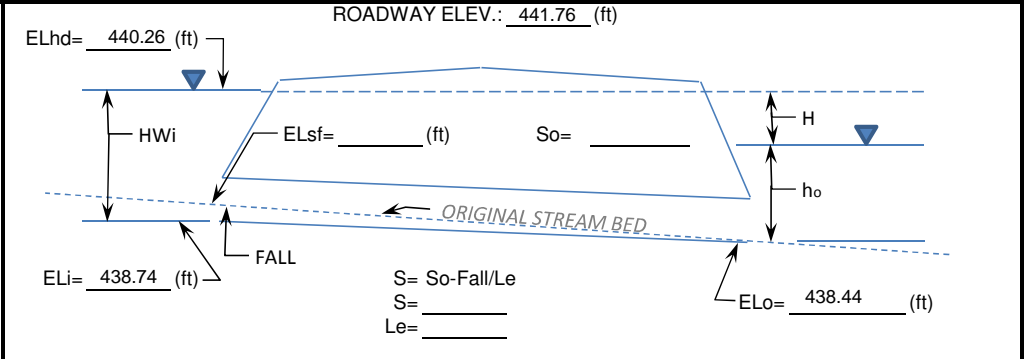
DRAINAGE AREA (AC): 14.04 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>36.14</u>	<u>0.745</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.37	2.0	36.14	18.07	N/A	1.52	N/A	440.26	0.745	0.910	N/A	0.745	0.5	0.775	439.96	440.26	7.621		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (ELhd - ELSf): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + ELi (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
where ~~K_u = 19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = ELo + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
F = CULVERT FACE
hd = DESIGN HEADWATER
hl = HEADWATER IN INLET CONTROL
ho = HEADWATER IN OUTLET CONTROL
i = INLET CONTROL SECTION
O = OUTLET
sf = STREAMBED AT CULVERT FACE
tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 13 - Downstream



CULVERT BARREL SELECTED:

SIZE: SPAN 3.67 FT, RISE 2.0 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

PROJECT: GUDE LANDFILL REMEDIATION DESIGN

STATION: 16-1
SHEET: 10 OF 10

CULVERT DESIGN FORM
DESIGN: LMO **DATE:** 11/24/2020
REVIEW: [Signature] **DATE:** 11/27/2020

HYDROLOGIC DATA

METHOD: RATIONAL/HY-8

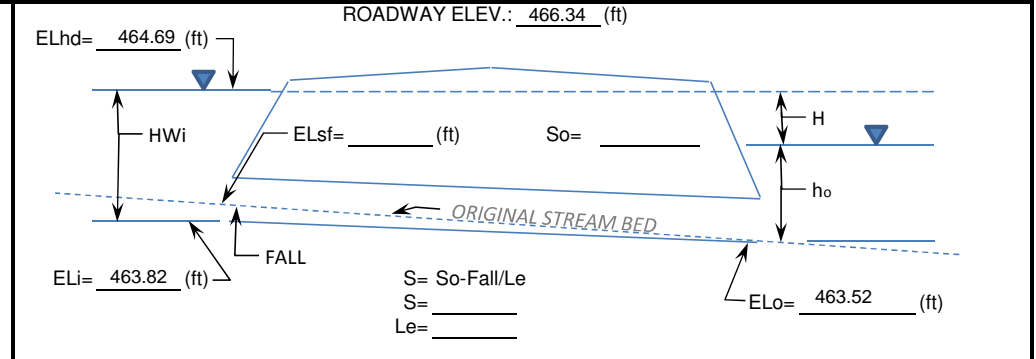
DRAINAGE AREA (AC): 3.842 STREAM SLOPE (FT/FT): _____

CHANNEL SHAPE: TRAPEZOIDAL

ROUTING: _____ OTHER: _____

DESIGN FLOWS / TAILWATER

DESIGN STORM (YRS)	FLOW (CFS)	TW (FT)
<u>10</u>	<u>13.725</u>	<u>0.376</u>
_____	_____	_____
_____	_____	_____



ID NO.	CULVERT DESCRIPTION:			TOTAL FLOW Q (CFS)	FLOW / BARREL Q / N (CFS) (1)	HEADWATER CALCULATIONS										CONTROL HEADWATER ELEVATION (FT)	OUTLET VELOCITY (FPS)	Comments			
	Material	Entrance				INLET CONTROL				OUTLET CONTROL											
		Shape	Span			Size Rise	HW _i /D (2)	HW _i (FT)	FALL (FT) (3)	EL _{hi} (4)	TW (FT) (5)	d _c	(d _c +D)/2	h _o (FT) (6)	Ke				H (FT) (7)	EL _{ho} (FT) (8)	
1	REINFORCED CONCRETE BOX CULVERT	SQUARE EDGE	3.25	1.5	13.725	6.86	N/A	0.87	N/A	464.69	0.376	0.517	N/A	0.376	0.5	0.494	464.39	464.69	6.139		
2																					
3																					
4																					
5																					
6																					

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL - HW_i - (EL_{hd} - EL_{sf}): FALL IS ZERO FOR CULVERTS AT GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWNSTREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or (D_c + D)/2 (whichever is greater)

(7) ~~$H = [1 + K_e + ((K_u)(n^2)(L))/R^{1.33}](V^2/2g)$~~ **H = HW_i - h_o**
 where K_u = ~~19.63 (20 IN ENGLISH UNITS)~~


(8) EL_{ho} = EL_o + H + h_o

SUBSCRIPT DEFINITIONS:

W = APPROXIMATE
 F = CULVERT FACE
 hd = DESIGN HEADWATER
 hi = HEADWATER IN INLET CONTROL
 ho = HEADWATER IN OUTLET CONTROL
 i = INLET CONTROL SECTION
 O = OUTLET
 sf = STREAMBED AT CULVERT FACE
 tw = TAIL WATER

COMMENTS / DISCUSSION:

Swale 16



CULVERT BARREL SELECTED:

SIZE: SPAN 3.25 FT, RISE 1.5 FT

SHAPE: BOX CULVERT

MATERIAL: REINFORCED CONCRETE n: 0.012

ENTRANCE: SQUARE EDGE

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 3.3 cfs

Design Flow: 3.3 cfs

Maximum Flow: 3.3 cfs

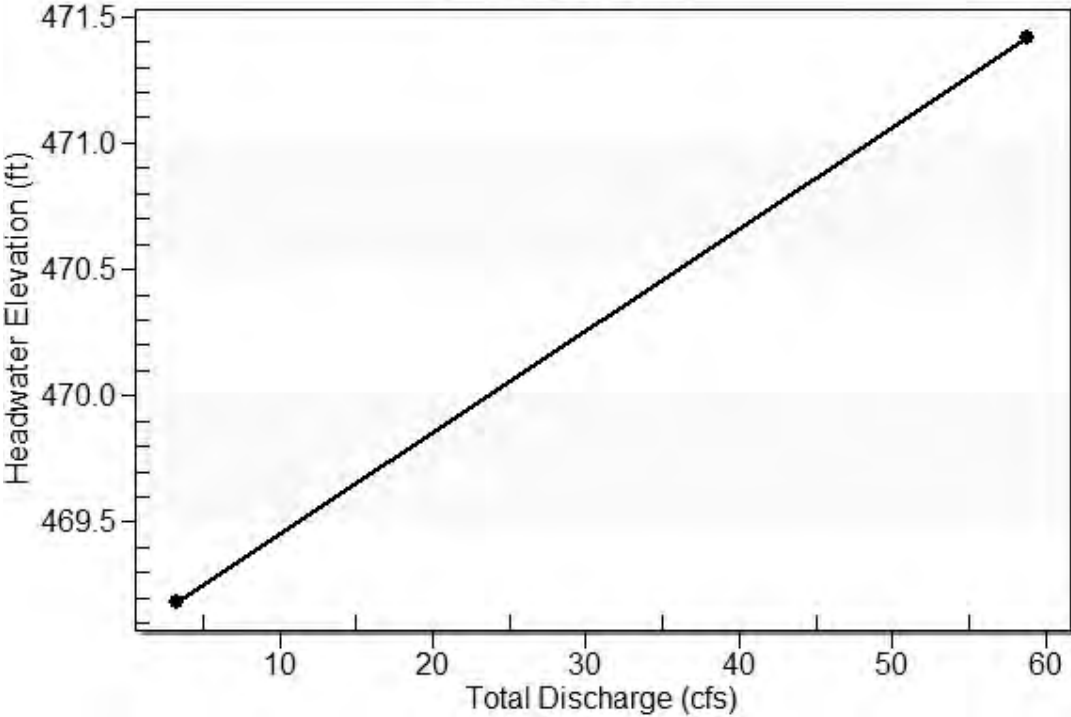
Table 1 - Summary of Culvert Flows at Crossing: D-1 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	D-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
469.19	3.30	3.30	0.00	1
471.38	56.97	56.97	0.00	Overtopping

Rating Curve Plot for Crossing: D-1 (10-YR)

Total Rating Curve

Crossing: D-1 (10-YR)



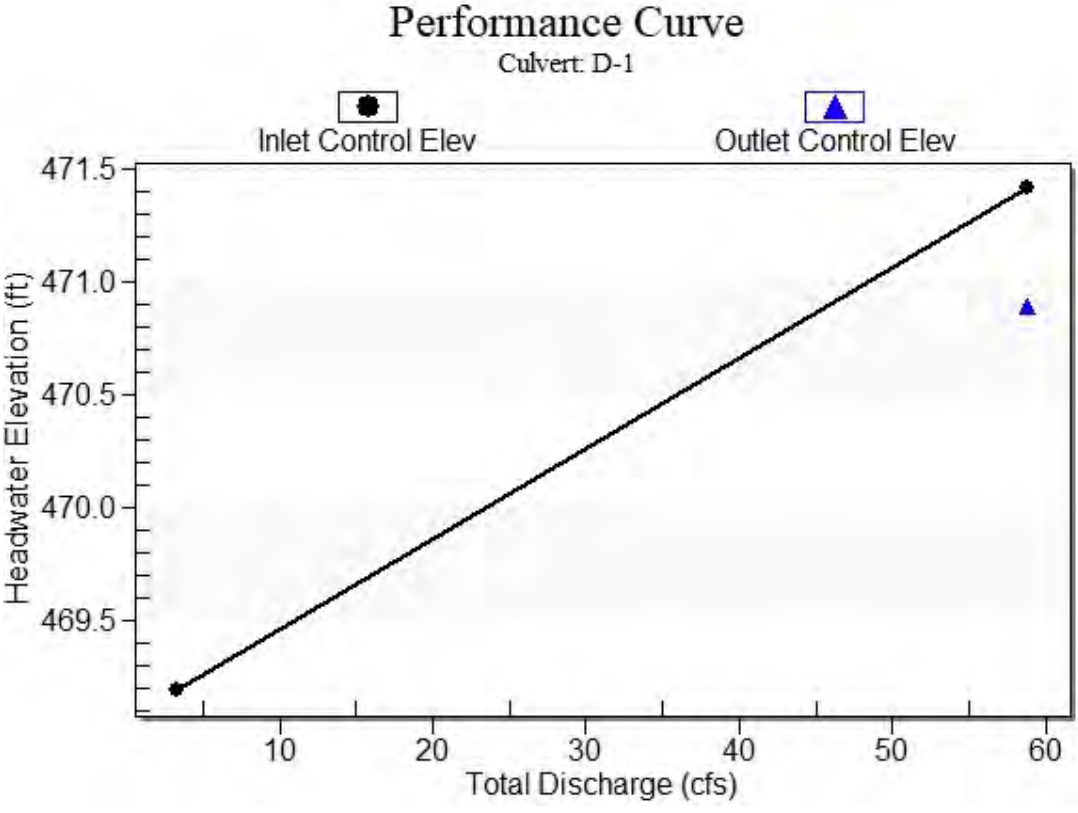
* Full Flow Headwater elevation is below inlet invert.

Straight Culvert

Inlet Elevation (invert): 468.85 ft, Outlet Elevation (invert): 468.57 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0187

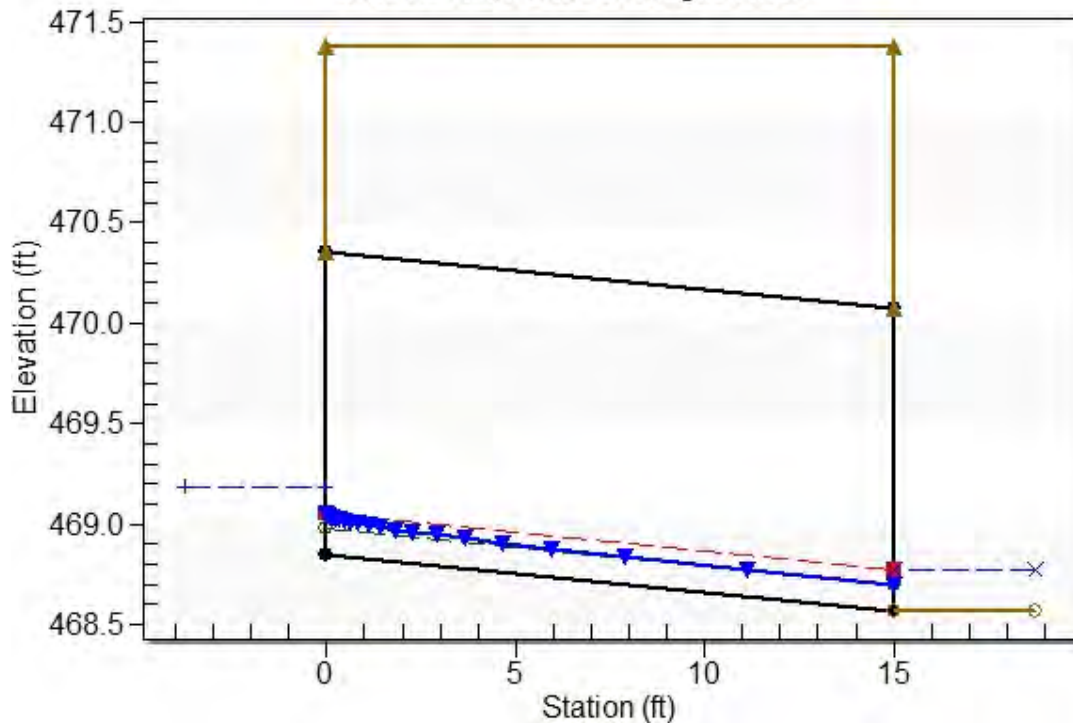
Culvert Performance Curve Plot: D-1



Water Surface Profile Plot for Culvert: D-1

Crossing - D-1 (10-YR), Design Discharge - 3.3 cfs

Culvert - D-1, Culvert Discharge - 3.3 cfs



Site Data - D-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 468.85 ft

Outlet Station: 15.00 ft

Outlet Elevation: 468.57 ft

Number of Barrels: 2

Culvert Data Summary - D-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: D-1 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80
3.30	468.77	0.20	1.99	0.19	0.80

Tailwater Channel Data - D-1 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0300

Channel Invert Elevation: 468.57 ft

Roadway Data for Crossing: D-1 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 471.38 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 41.81 cfs

Design Flow: 41.81 cfs

Maximum Flow: 41.81 cfs

Table 4 - Summary of Culvert Flows at Crossing: E-3 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
445.08	41.81	41.81	0.00	1
446.42	89.07	89.07	0.00	Overtopping

Rating Curve Plot for Crossing: E-3 (10-YR)

Total Rating Curve

Crossing: E-3 (10-YR)

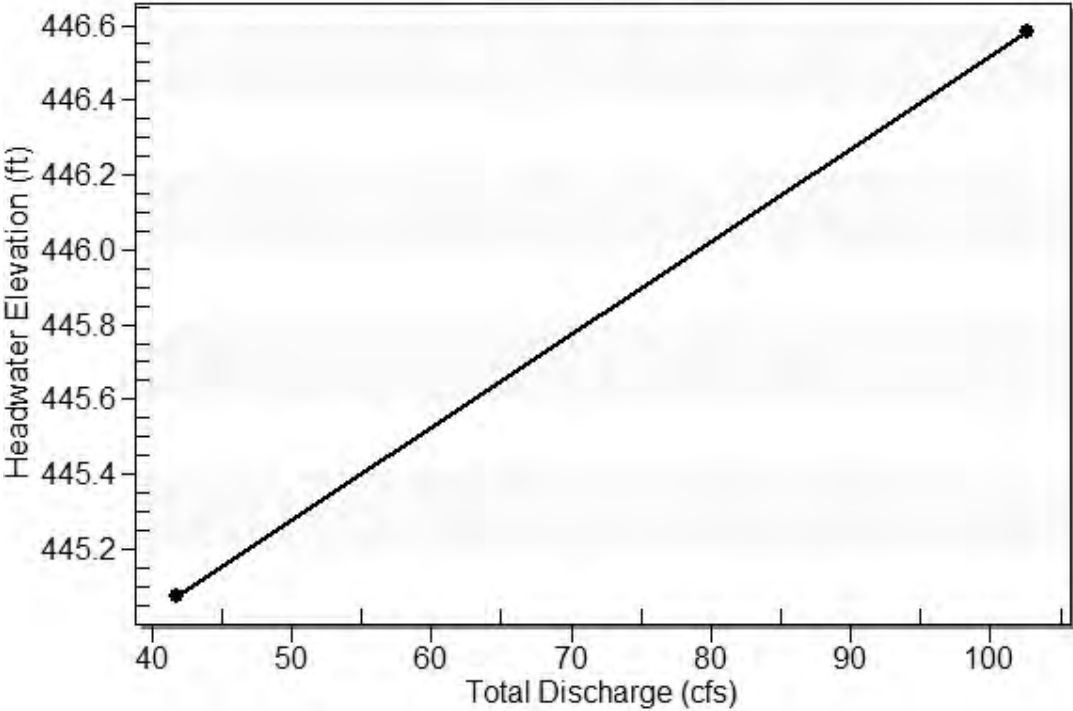


Table 5 - Culvert Summary Table: E-3

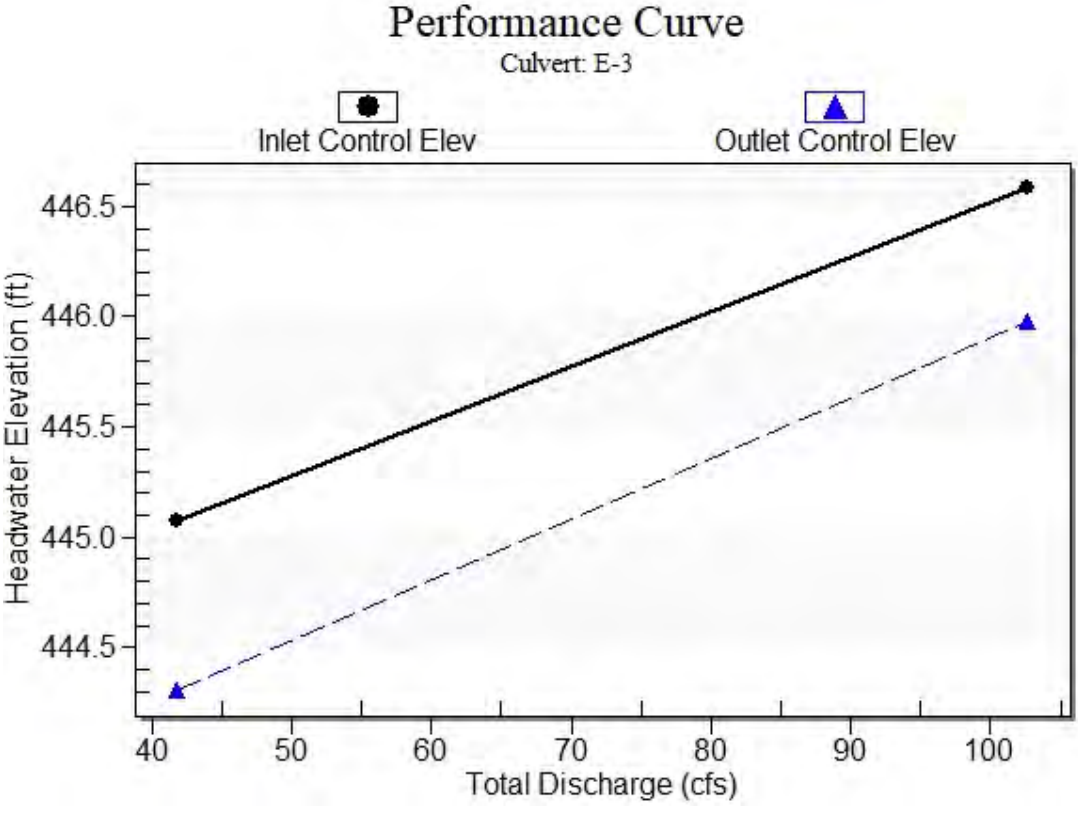
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366
41.81	41.81	445.08	1.676	0.906	1-S2n	0.567	1.003	0.721	0.810	7.900	5.366

Straight Culvert

Inlet Elevation (invert): 443.40 ft, Outlet Elevation (invert): 443.10 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

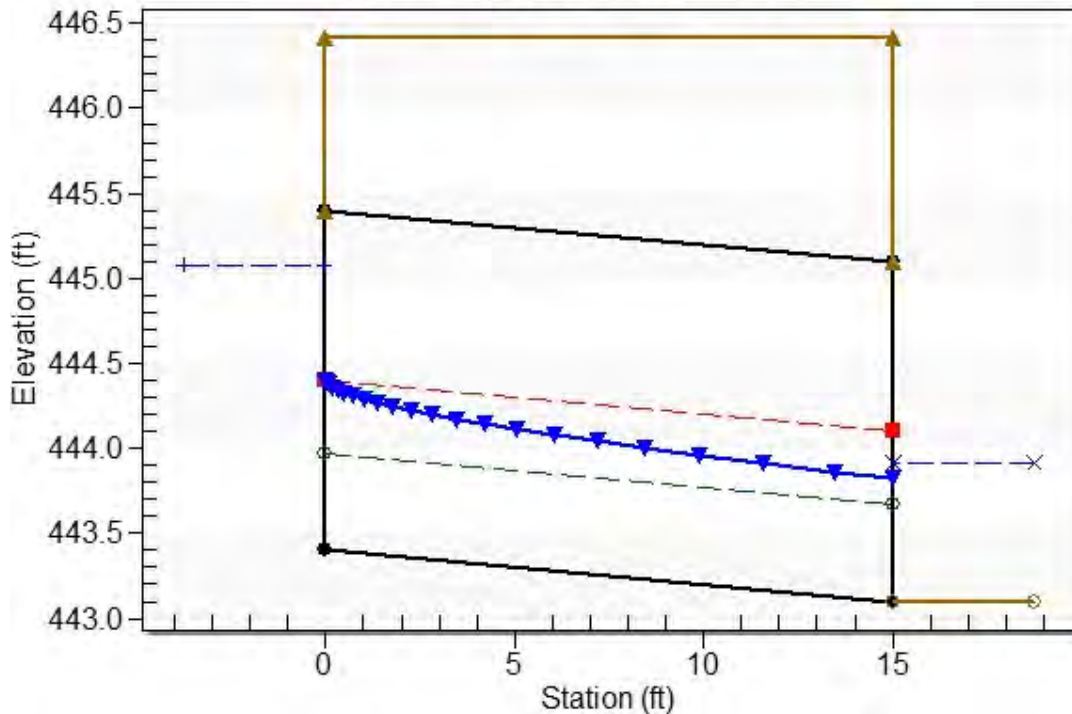
Culvert Performance Curve Plot: E-3



Water Surface Profile Plot for Culvert: E-3

Crossing - E-3 (10-YR), Design Discharge - 41.8 cfs

Culvert - E-3, Culvert Discharge - 41.8 cfs



Site Data - E-3

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 443.40 ft

Outlet Station: 15.00 ft

Outlet Elevation: 443.10 ft

Number of Barrels: 2

Culvert Data Summary - E-3

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: E-3 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14
41.81	443.91	0.81	5.37	1.01	1.14

Tailwater Channel Data - E-3 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 443.10 ft

Roadway Data for Crossing: E-3 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 446.42 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 36.14 cfs

Design Flow: 36.14 cfs

Maximum Flow: 36.14 cfs

Table 7 - Summary of Culvert Flows at Crossing: E-4 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
440.26	36.14	36.14	0.00	1
441.76	89.07	89.07	0.00	Overtopping

Rating Curve Plot for Crossing: E-4 (10-YR)

Total Rating Curve

Crossing: E-4 (10-YR)

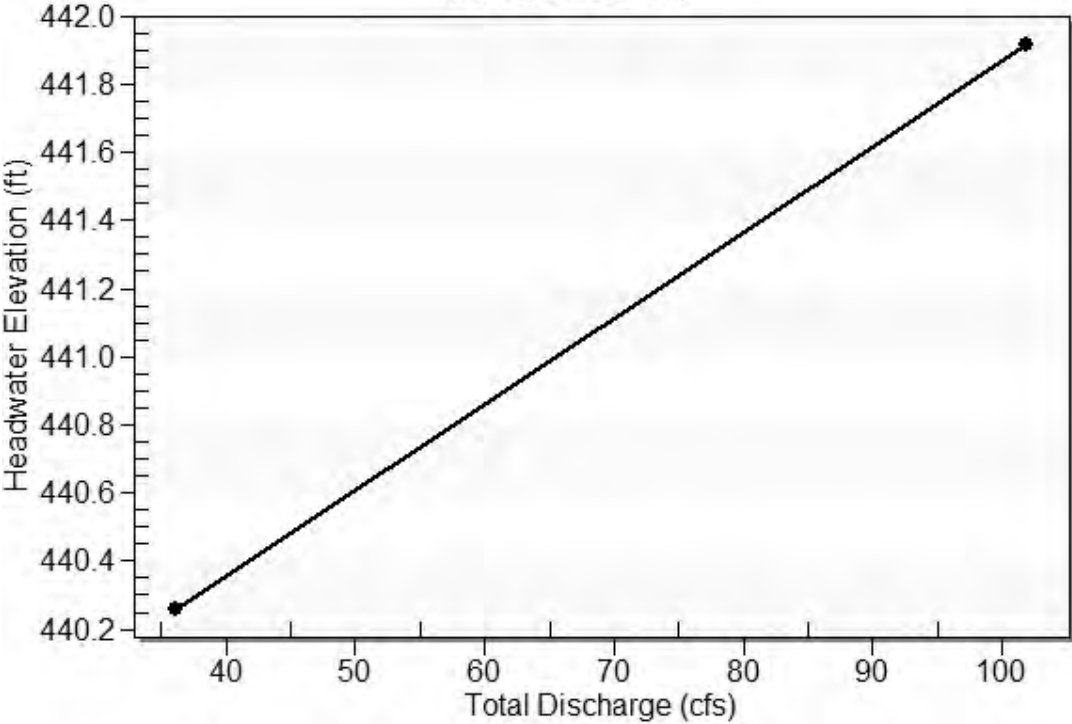


Table 8 - Culvert Summary Table: E-4

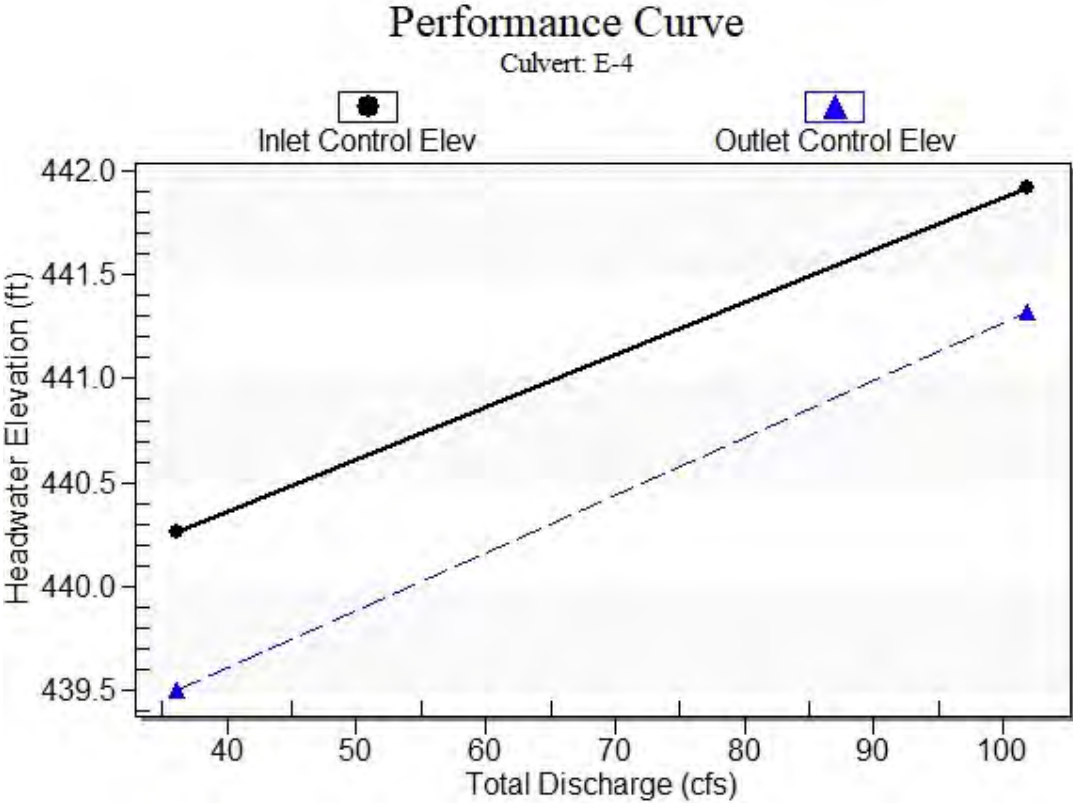
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114
36.14	36.14	440.26	1.521	0.761	1-S2n	0.515	0.910	0.646	0.745	7.621	5.114

Straight Culvert

Inlet Elevation (invert): 438.74 ft, Outlet Elevation (invert): 438.44 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

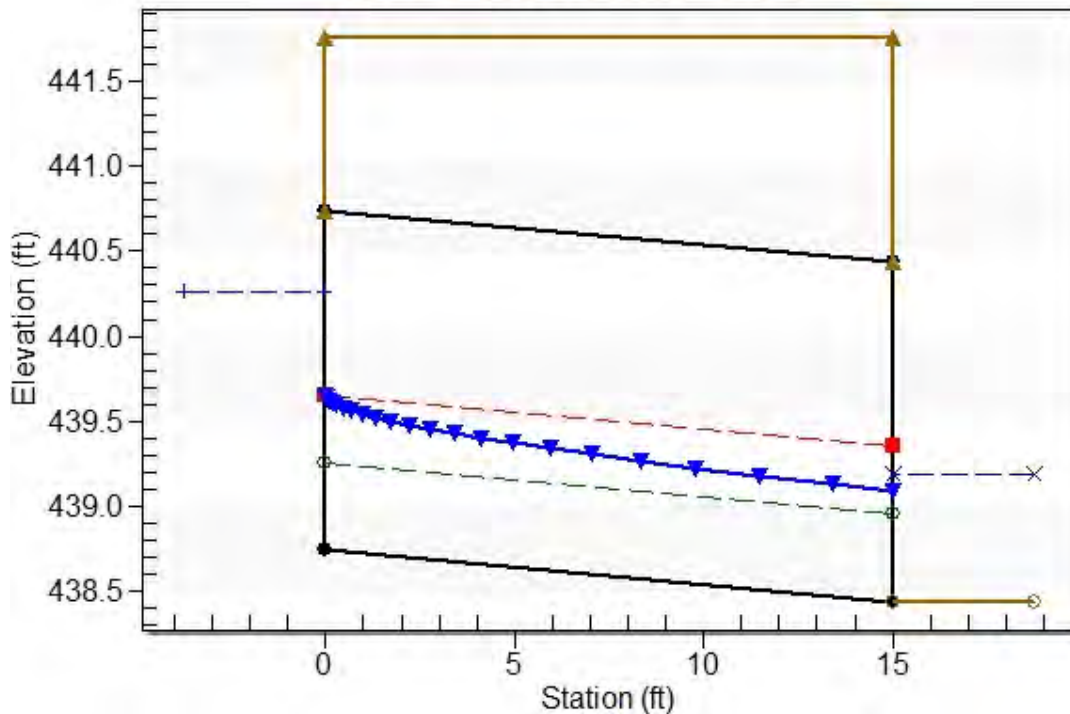
Culvert Performance Curve Plot: E-4



Water Surface Profile Plot for Culvert: E-4

Crossing - E-4 (10-YR), Design Discharge - 36.1 cfs

Culvert - E-4, Culvert Discharge - 36.1 cfs



Site Data - E-4

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 438.74 ft

Outlet Station: 15.00 ft

Outlet Elevation: 438.44 ft

Number of Barrels: 2

Culvert Data Summary - E-4

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: E-4 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12
36.14	439.18	0.74	5.11	0.93	1.12

Tailwater Channel Data - E-4 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 438.44 ft

Roadway Data for Crossing: E-4 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 441.76 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 9.54 cfs

Design Flow: 9.54 cfs

Maximum Flow: 9.54 cfs

Table 10 - Summary of Culvert Flows at Crossing: E-5 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-5 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
441.79	9.54	9.54	0.00	1
443.63	56.78	56.78	0.00	Overtopping

Rating Curve Plot for Crossing: E-5 (10-YR)

Total Rating Curve

Crossing: E-5 (10-YR)

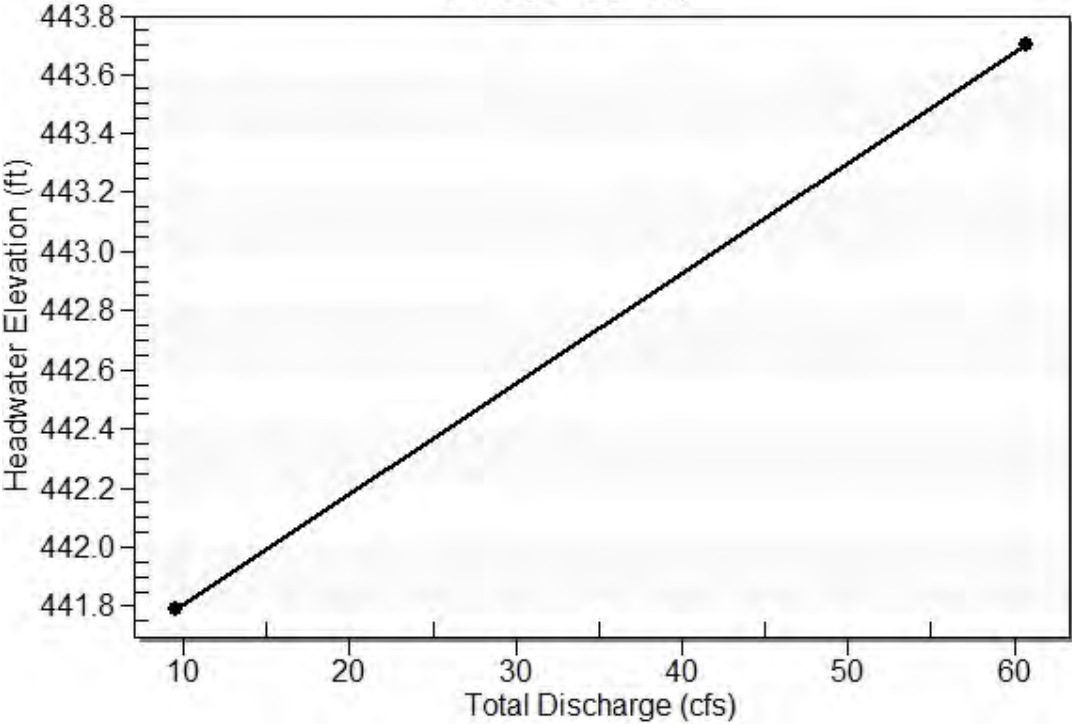


Table 11 - Culvert Summary Table: E-5

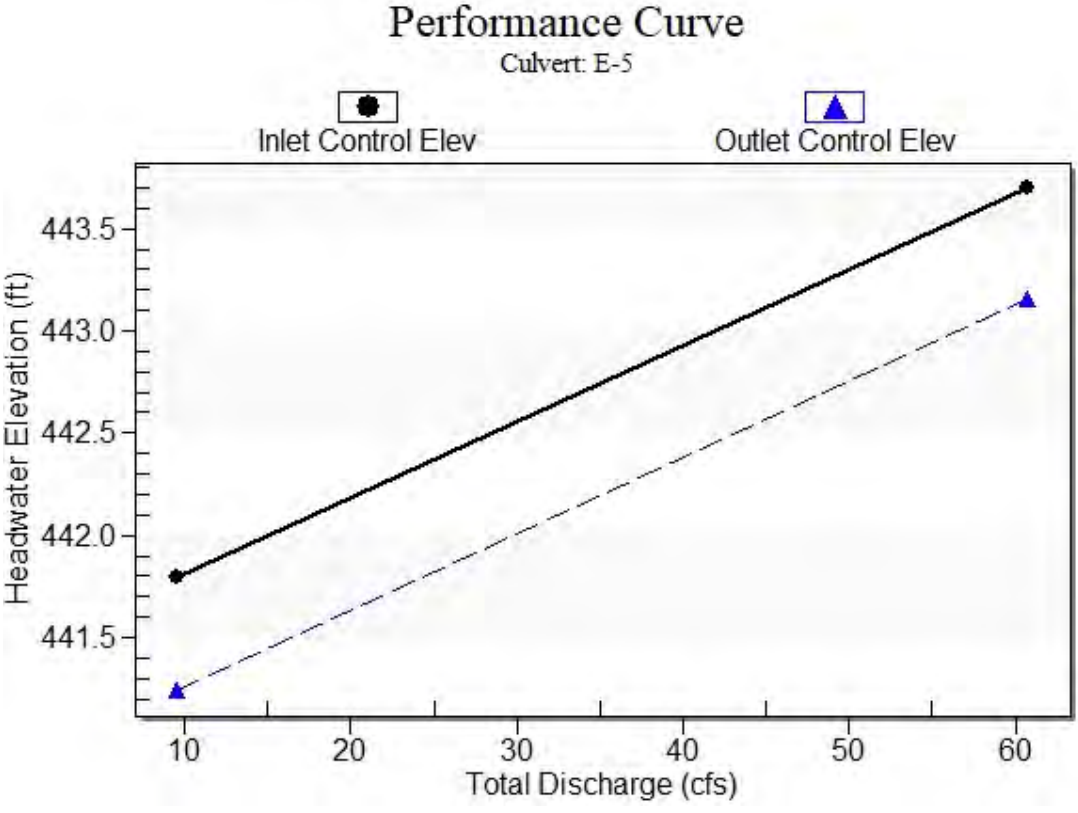
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333
9.54	9.54	441.79	0.683	0.131	1-S2n	0.238	0.406	0.263	0.358	5.576	3.333

Straight Culvert

Inlet Elevation (invert): 441.11 ft, Outlet Elevation (invert): 440.81 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

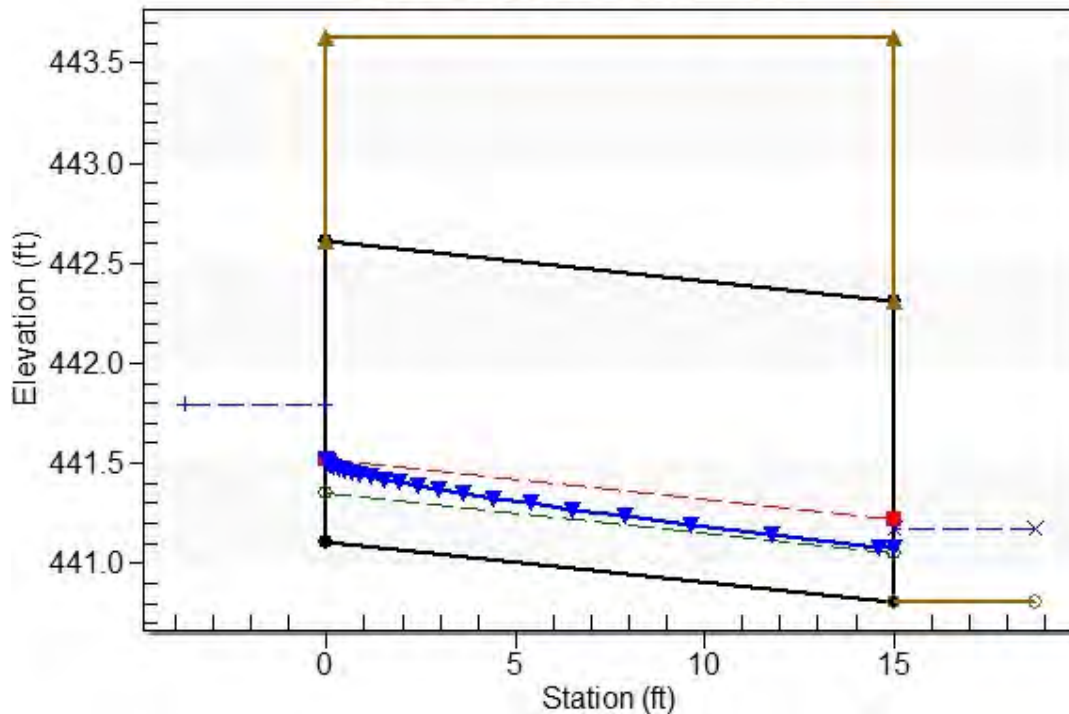
Culvert Performance Curve Plot: E-5



Water Surface Profile Plot for Culvert: E-5

Crossing - E-5 (10-YR), Design Discharge - 9.5 cfs

Culvert - E-5, Culvert Discharge - 9.5 cfs



Site Data - E-5

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 441.11 ft

Outlet Station: 15.00 ft

Outlet Elevation: 440.81 ft

Number of Barrels: 2

Culvert Data Summary - E-5

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: E-5 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98
9.54	441.17	0.36	3.33	0.45	0.98

Tailwater Channel Data - E-5 (10-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 440.81 ft

Roadway Data for Crossing: E-5 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 443.63 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 4.83 cfs

Design Flow: 4.83 cfs

Maximum Flow: 4.83 cfs

Table 13 - Summary of Culvert Flows at Crossing: A-1 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	A-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
470.41	4.83	4.83	0.00	1
472.61	58.89	58.89	0.00	Overtopping

Rating Curve Plot for Crossing: A-1 (10-YR)

Total Rating Curve

Crossing: A-1 (10-YR)

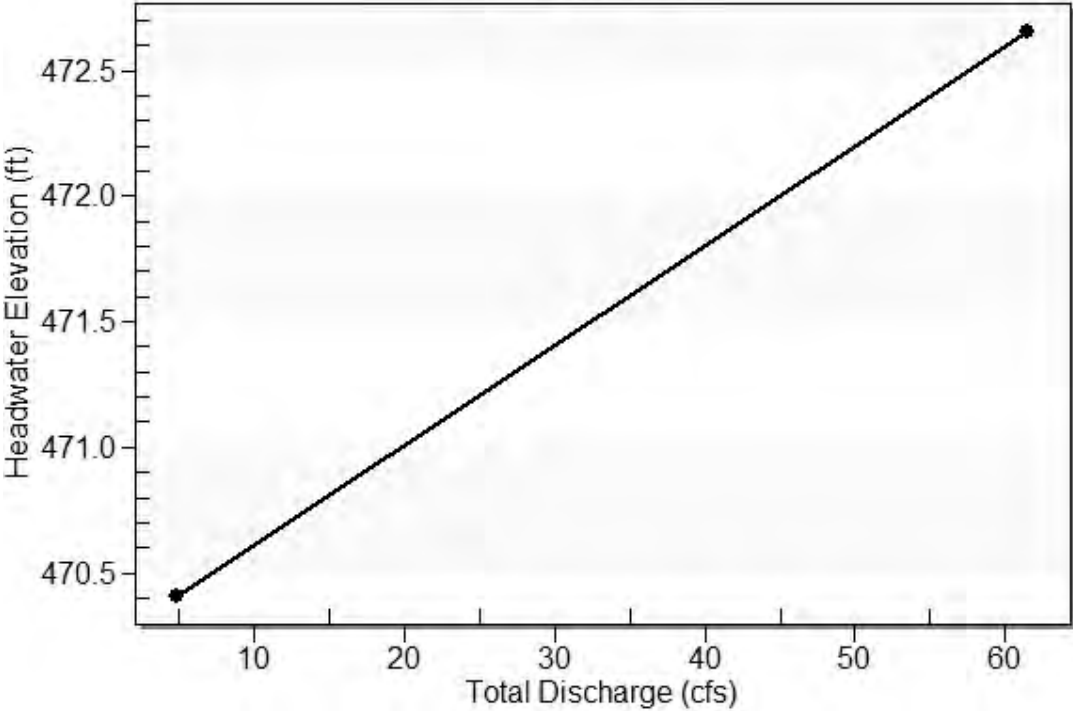


Table 14 - Culvert Summary Table: A-1

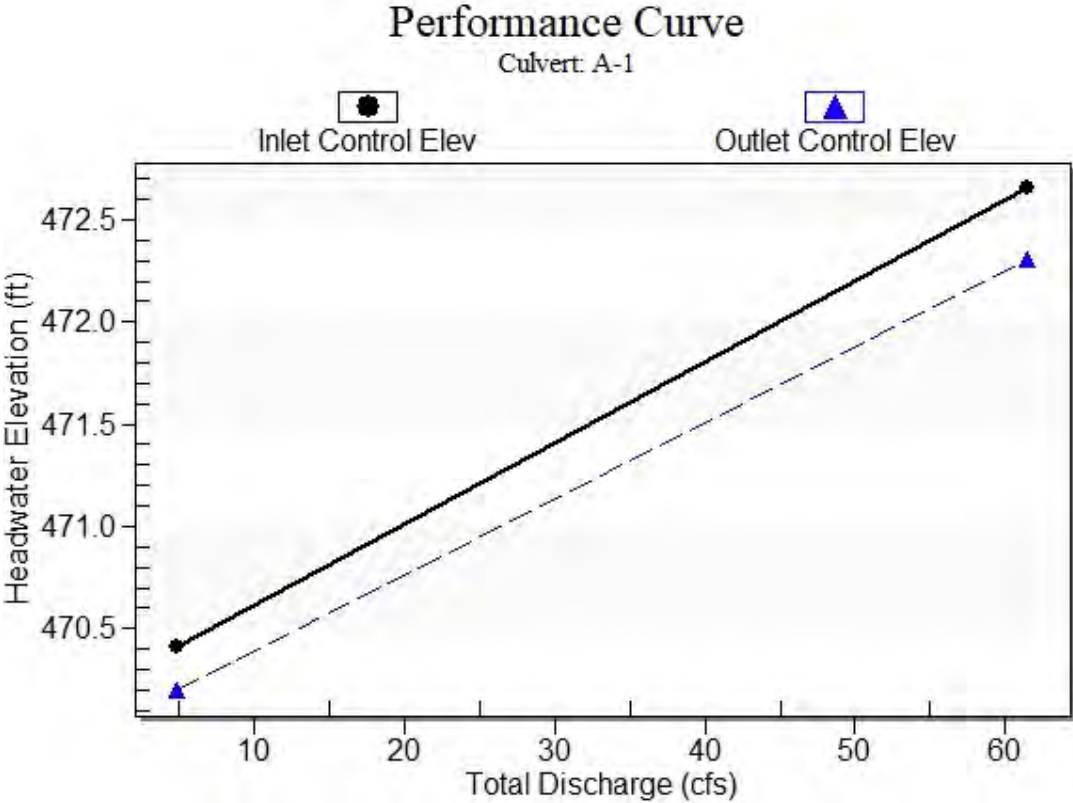
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075
4.83	4.83	470.41	0.441	0.227	1-JS1t	0.245	0.258	0.291	0.291	2.554	2.075

Straight Culvert

Inlet Elevation (invert): 469.97 ft, Outlet Elevation (invert): 469.90 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0047

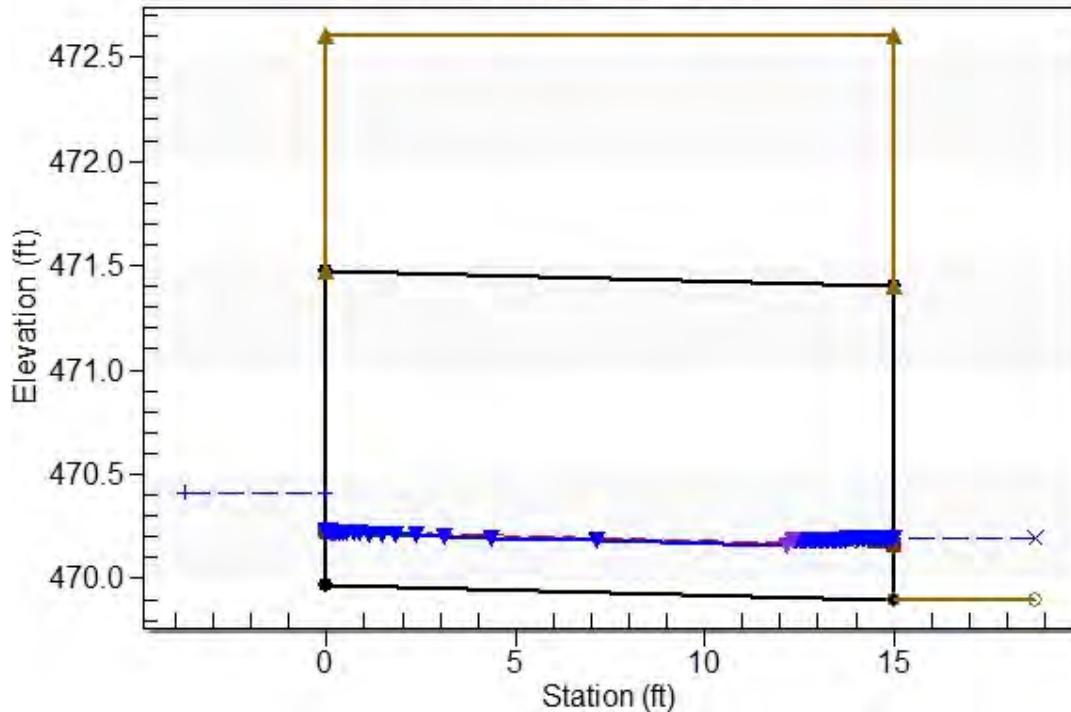
Culvert Performance Curve Plot: A-1



Water Surface Profile Plot for Culvert: A-1

Crossing - A-1 (10-YR), Design Discharge - 4.8 cfs

Culvert - A-1, Culvert Discharge - 4.8 cfs



Site Data - A-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 469.97 ft

Outlet Station: 15.00 ft

Outlet Elevation: 469.90 ft

Number of Barrels: 2

Culvert Data Summary - A-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: A-1 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68
4.83	470.19	0.29	2.07	0.18	0.68

Tailwater Channel Data - A-1 (10-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0100

Channel Manning's n: 0.0300

Channel Invert Elevation: 469.90 ft

Roadway Data for Crossing: A-1 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 472.61 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 12.45 cfs

Design Flow: 12.45 cfs

Maximum Flow: 12.45 cfs

Table 16 - Summary of Culvert Flows at Crossing: E-2 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
457.25	12.45	12.45	0.00	1
458.96	56.79	56.79	0.00	Overtopping

Rating Curve Plot for Crossing: E-2 (10-YR)

Total Rating Curve

Crossing: E-2 (10-YR)

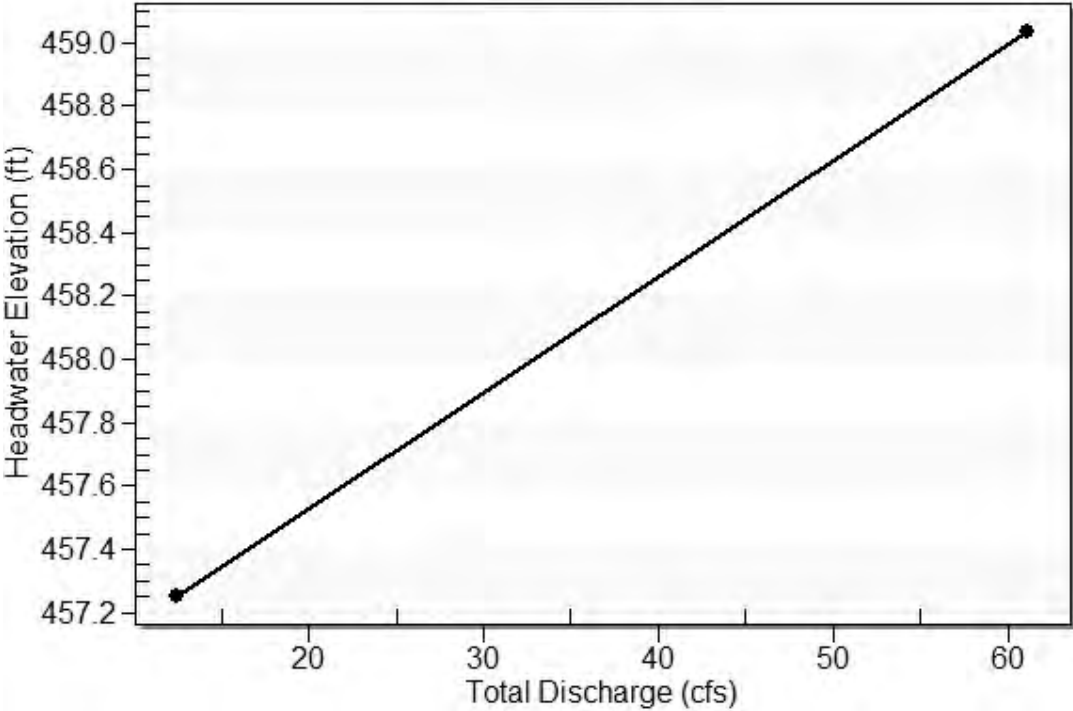


Table 17 - Culvert Summary Table: E-2

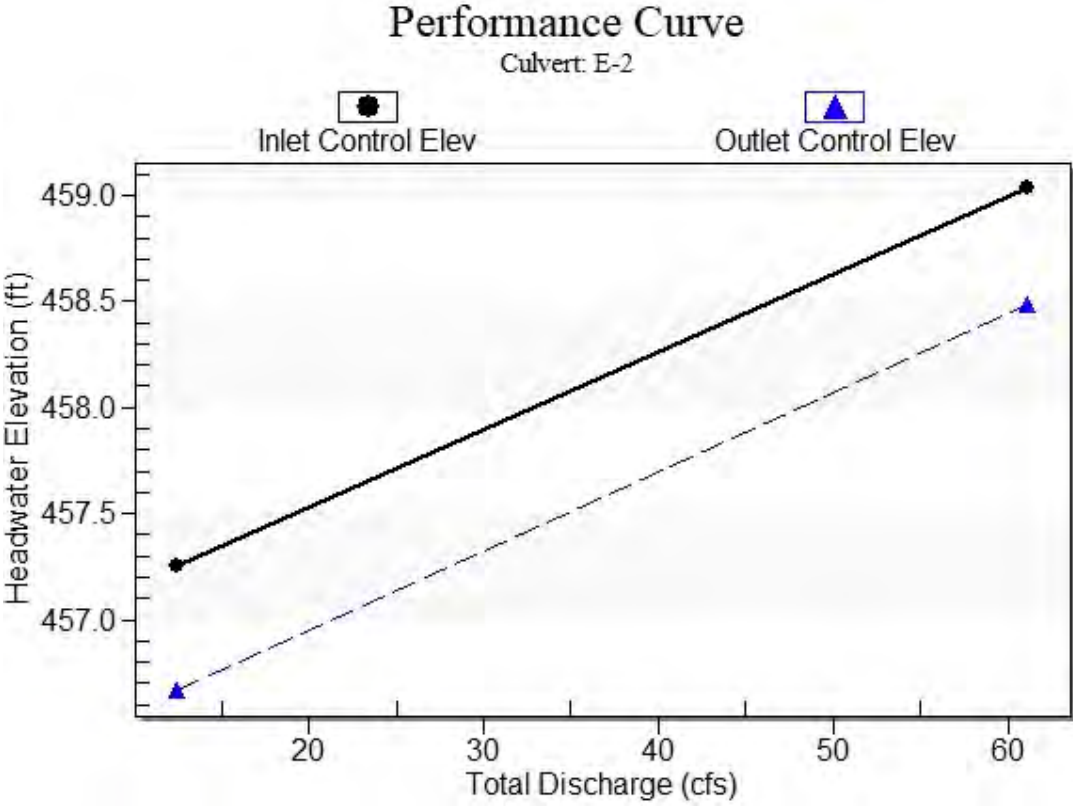
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540
12.45	12.45	457.25	0.815	0.227	1-S2n	0.282	0.485	0.320	0.400	5.984	3.540

Straight Culvert

Inlet Elevation (invert): 456.44 ft, Outlet Elevation (invert): 456.14 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

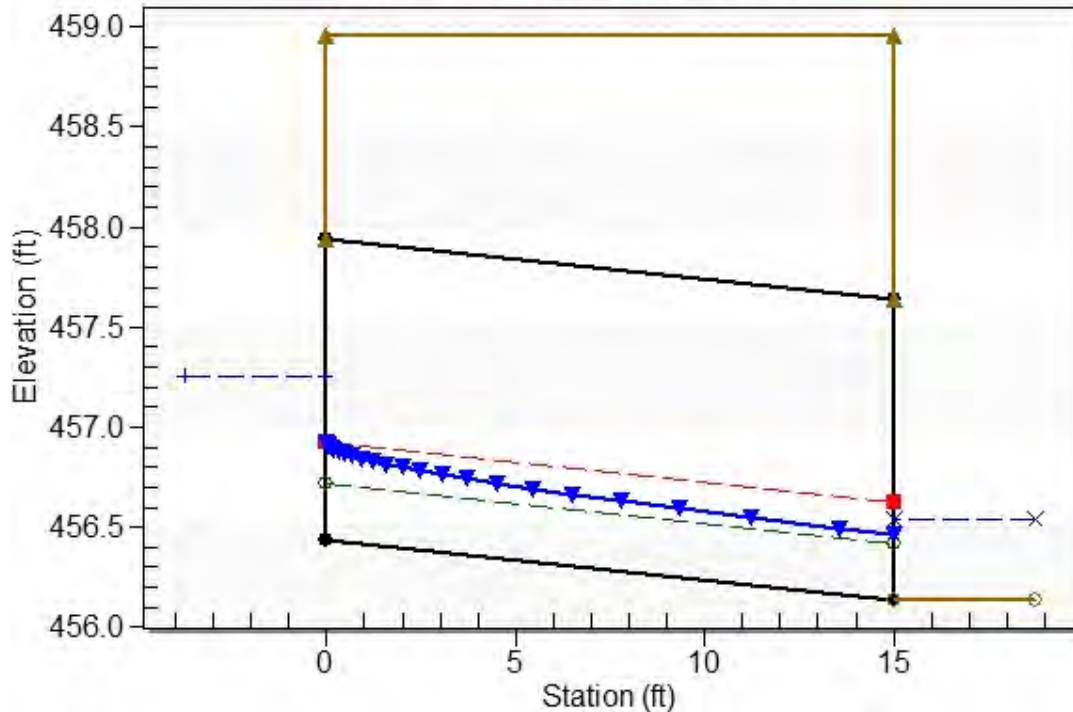
Culvert Performance Curve Plot: E-2



Water Surface Profile Plot for Culvert: E-2

Crossing - E-2 (10-YR), Design Discharge - 12.4 cfs

Culvert - E-2, Culvert Discharge - 12.4 cfs



Site Data - E-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 456.44 ft

Outlet Station: 15.00 ft

Outlet Elevation: 456.14 ft

Number of Barrels: 2

Culvert Data Summary - E-2

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: E-2 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03
12.45	456.54	0.40	3.54	0.50	1.03

Tailwater Channel Data - E-2 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 456.14 ft

Roadway Data for Crossing: E-2 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 458.96 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 5.97 cfs

Design Flow: 5.97 cfs

Maximum Flow: 5.97 cfs

Table 19 - Summary of Culvert Flows at Crossing: E-1 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
463.46	5.97	5.97	0.00	1
465.56	58.17	58.17	0.00	Overtopping

Rating Curve Plot for Crossing: E-1 (10-YR)

Total Rating Curve

Crossing: E-1 (10-YR)

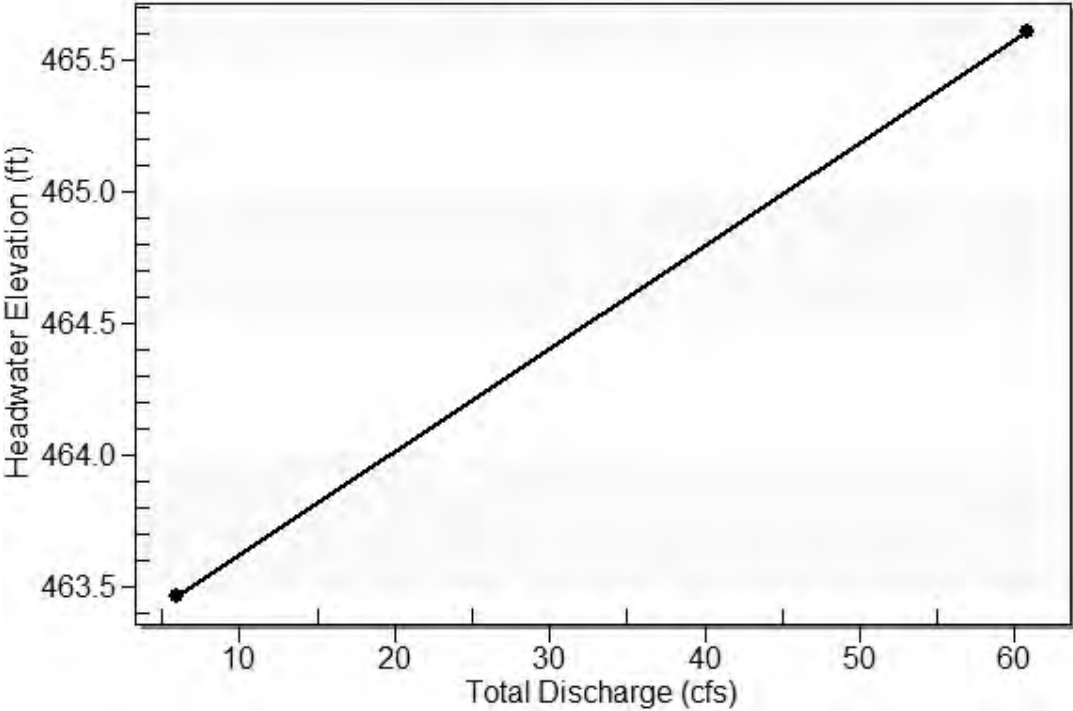


Table 20 - Culvert Summary Table: E-1

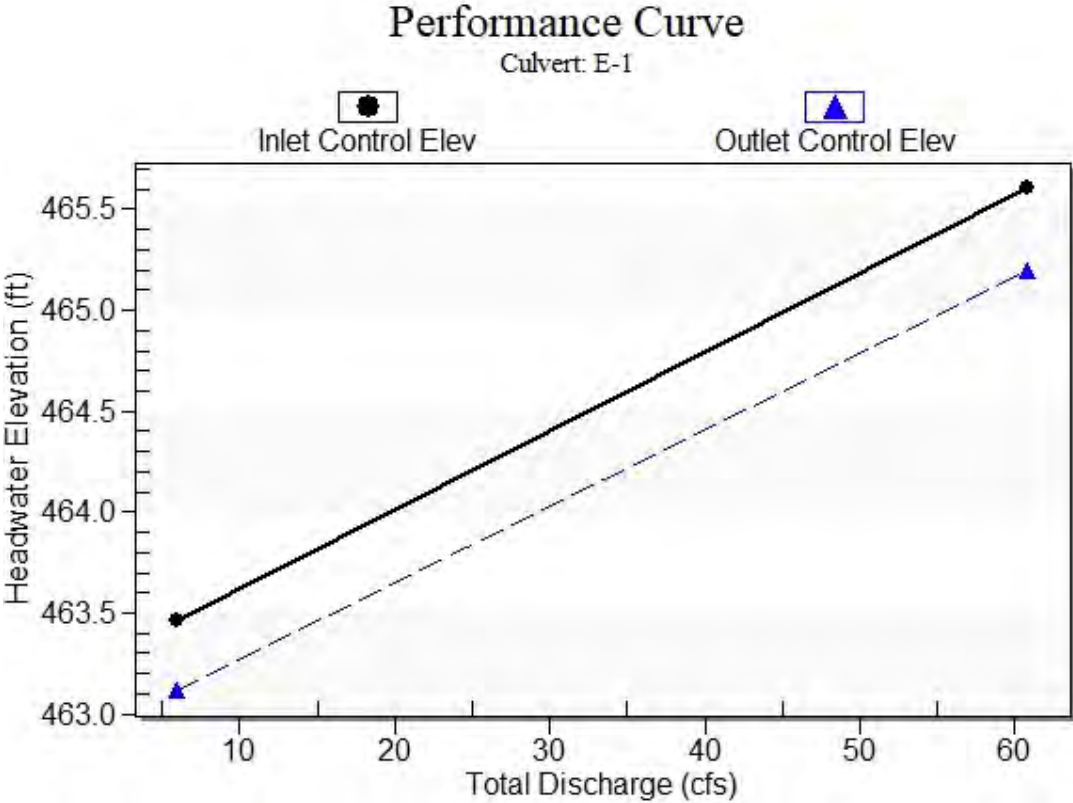
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786
5.97	5.97	463.46	0.505	0.157	1-S2n	0.220	0.297	0.228	0.268	4.031	2.786

Straight Culvert

Inlet Elevation (invert): 462.96 ft, Outlet Elevation (invert): 462.81 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0100

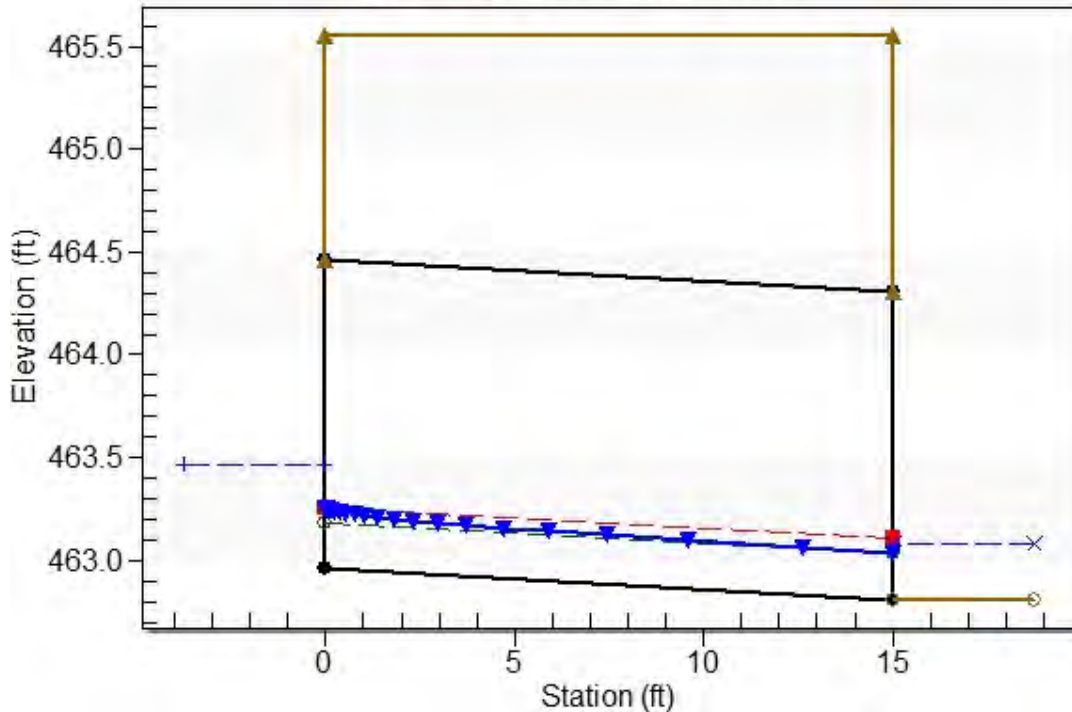
Culvert Performance Curve Plot: E-1



Water Surface Profile Plot for Culvert: E-1

Crossing - E-1 (10-YR), Design Discharge - 6.0 cfs

Culvert - E-1, Culvert Discharge - 6.0 cfs



Site Data - E-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 462.96 ft

Outlet Station: 15.00 ft

Outlet Elevation: 462.81 ft

Number of Barrels: 2

Culvert Data Summary - E-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: E-1 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95
5.97	463.08	0.27	2.79	0.33	0.95

Tailwater Channel Data - E-1 (10-YR)

Tailwater Channel Option: Rectangular Channel
Bottom Width: 8.00 ft
Channel Slope: 0.0200
Channel Manning's n: 0.0300
Channel Invert Elevation: 462.81 ft

Roadway Data for Crossing: E-1 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 50.00 ft
Crest Elevation: 465.56 ft
Roadway Surface: Gravel
Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 18.07 cfs

Design Flow: 18.07 cfs

Maximum Flow: 18.07 cfs

Table 22 - Summary of Culvert Flows at Crossing: 13-1 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	13-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
449.45	18.07	18.07	0.00	1
450.83	54.70	54.70	0.00	Overtopping

Rating Curve Plot for Crossing: 13-1 (10-YR)

Total Rating Curve

Crossing: 13-1 (10-YR)

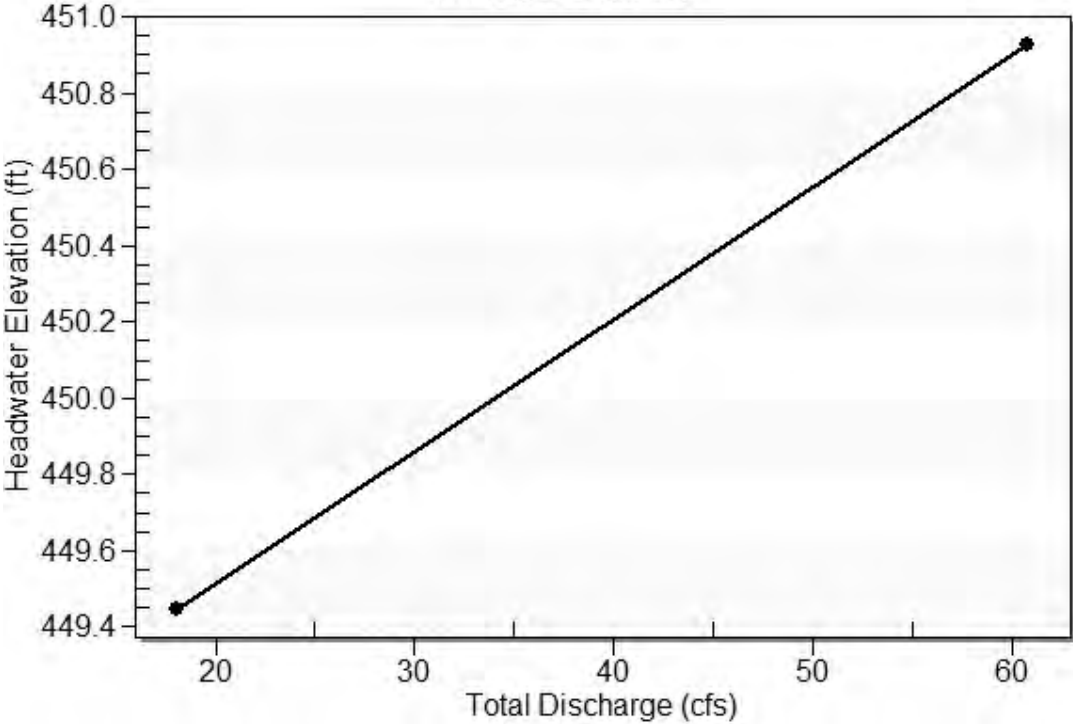


Table 23 - Culvert Summary Table: 13-1

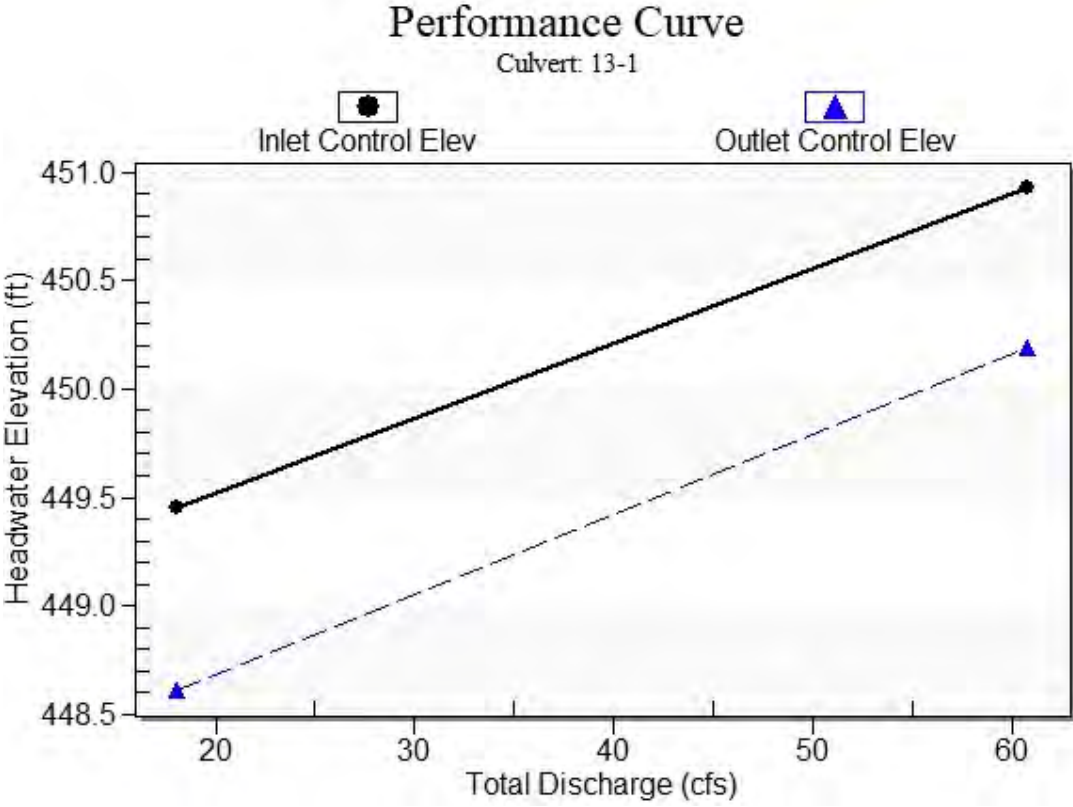
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038
18.07	18.07	449.45	1.029	0.190	1-S2n	0.300	0.621	0.367	0.498	7.580	4.038

Straight Culvert

Inlet Elevation (invert): 448.42 ft, Outlet Elevation (invert): 447.90 ft

Culvert Length: 15.01 ft, Culvert Slope: 0.0347

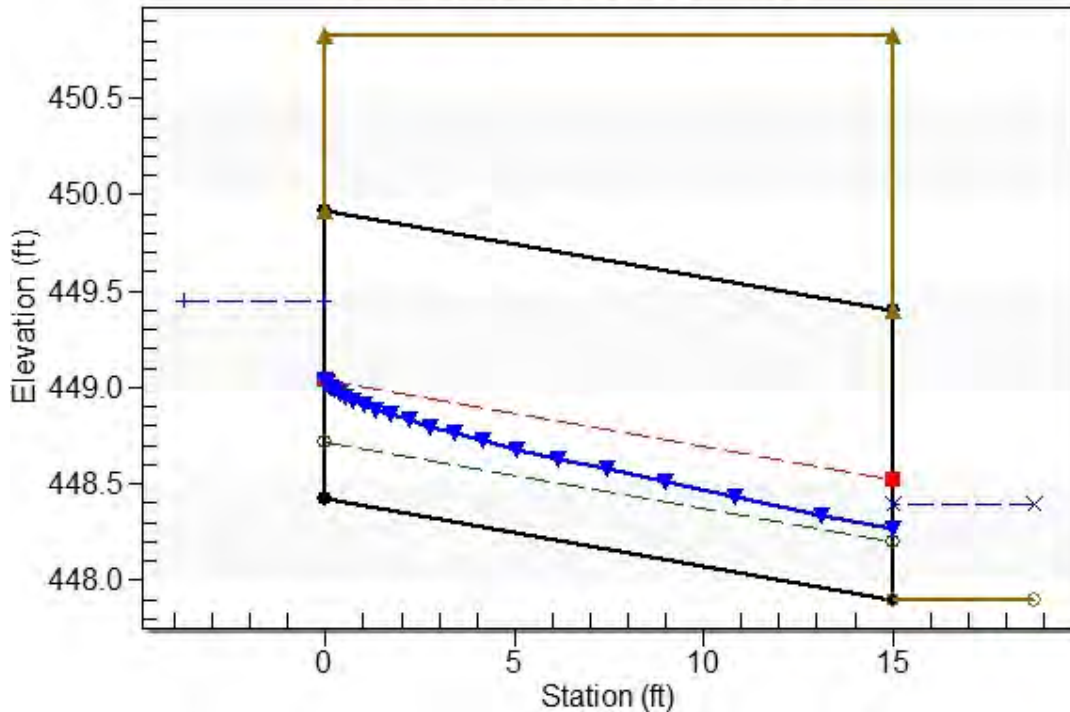
Culvert Performance Curve Plot: 13-1



Water Surface Profile Plot for Culvert: 13-1

Crossing - 13-1 (10-YR) , Design Discharge - 18.1 cfs

Culvert - 13-1, Culvert Discharge - 18.1 cfs



Site Data - 13-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 448.42 ft

Outlet Station: 15.00 ft

Outlet Elevation: 447.90 ft

Number of Barrels: 2

Culvert Data Summary - 13-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: 13-1 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06
18.07	448.40	0.50	4.04	0.62	1.06

Tailwater Channel Data - 13-1 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 447.90 ft

Roadway Data for Crossing: 13-1 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 450.83 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 13.73 cfs

Design Flow: 13.73 cfs

Maximum Flow: 13.73 cfs

Table 25 - Summary of Culvert Flows at Crossing: 16-1 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	16-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
464.69	13.73	13.73	0.00	1
466.34	56.79	56.79	0.00	Overtopping

Rating Curve Plot for Crossing: 16-1 (10-YR)

Total Rating Curve

Crossing: 16-1 (10-YR)

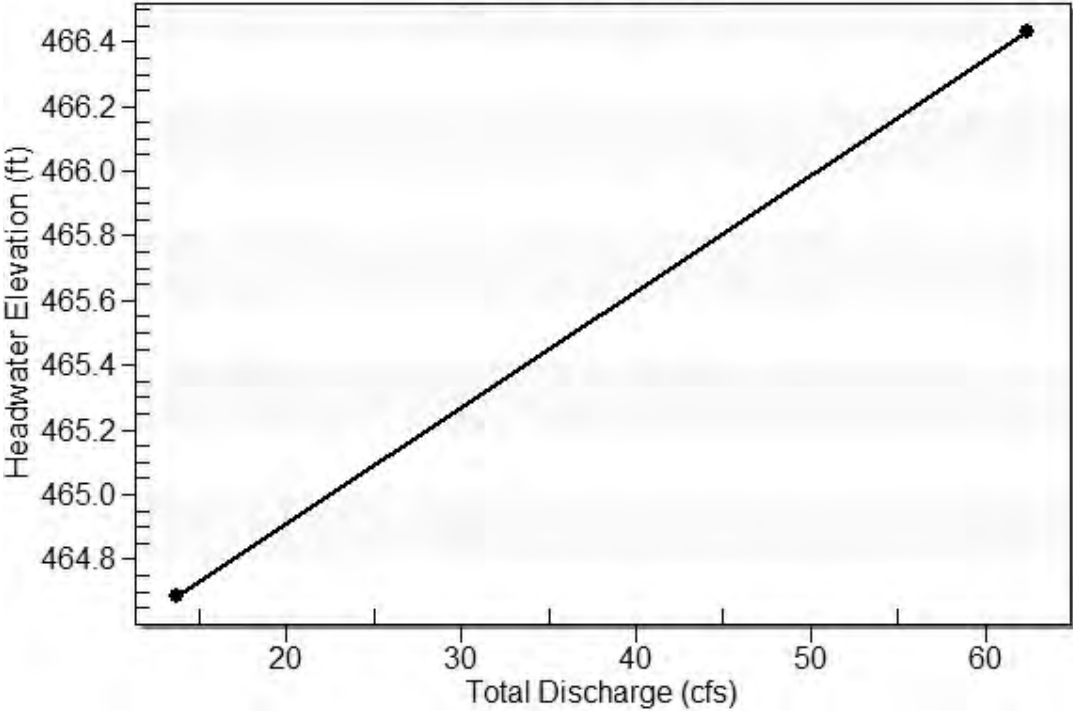


Table 26 - Culvert Summary Table: 16-1

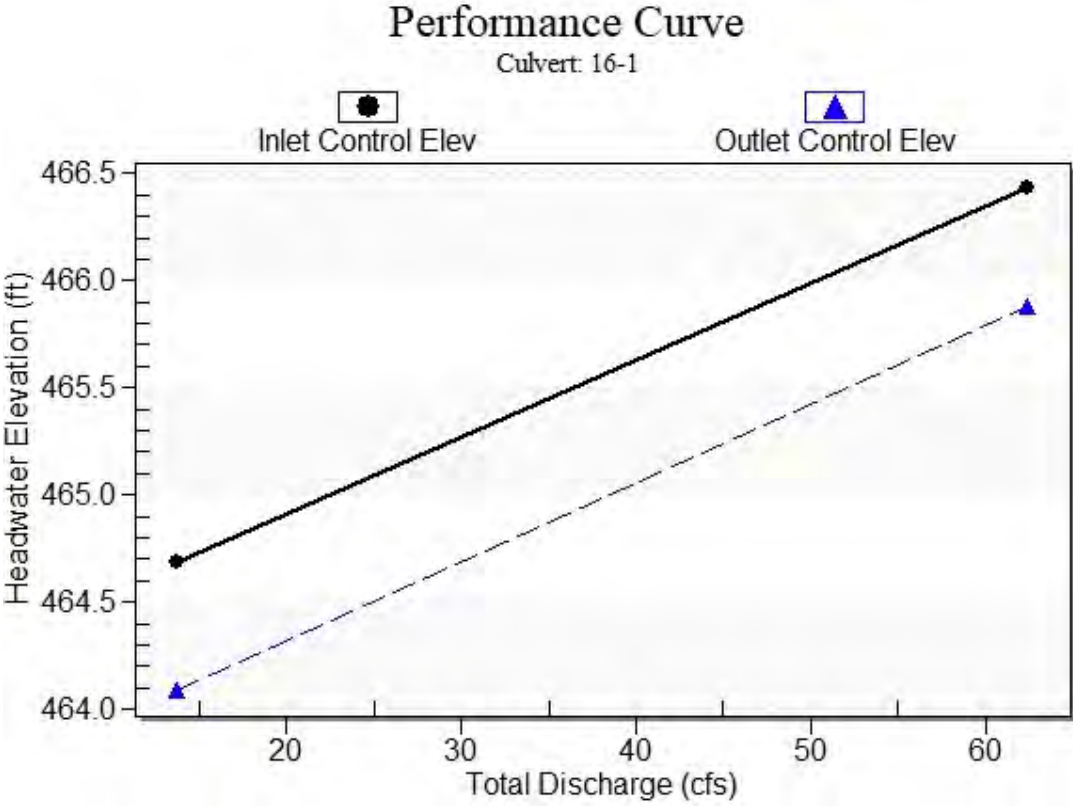
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176
13.73	13.73	464.69	0.869	0.268	1-S2n	0.300	0.517	0.344	0.376	6.139	4.176

Straight Culvert

Inlet Elevation (invert): 463.82 ft, Outlet Elevation (invert): 463.52 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

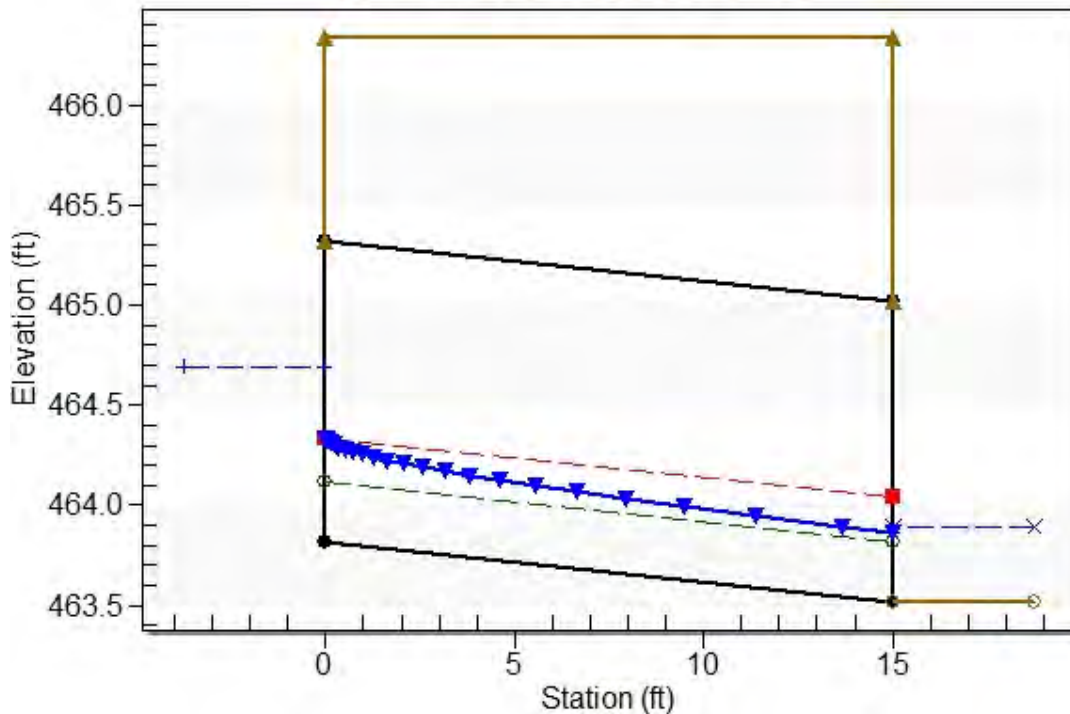
Culvert Performance Curve Plot: 16-1



Water Surface Profile Plot for Culvert: 16-1

Crossing - 16-1 (10-YR) , Design Discharge - 13.7 cfs

Culvert - 16-1, Culvert Discharge - 13.7 cfs



Site Data - 16-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 463.82 ft

Outlet Station: 15.00 ft

Outlet Elevation: 463.52 ft

Number of Barrels: 2

Culvert Data Summary - 16-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 27 - Downstream Channel Rating Curve (Crossing: 16-1 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25
13.73	463.90	0.38	4.18	0.70	1.25

Tailwater Channel Data - 16-1 (10-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0300

Channel Manning's n: 0.0300

Channel Invert Elevation: 463.52 ft

Roadway Data for Crossing: 16-1 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 466.34 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 34.53 cfs

Design Flow: 34.53 cfs

Maximum Flow: 34.53 cfs

Table 28 - Summary of Culvert Flows at Crossing: A-2 (10-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	A-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
430.11	34.53	34.53	0.00	1
431.66	89.34	89.34	0.00	Overtopping

Rating Curve Plot for Crossing: A-2 (10-YR)

Total Rating Curve

Crossing: A-2 (10-YR)

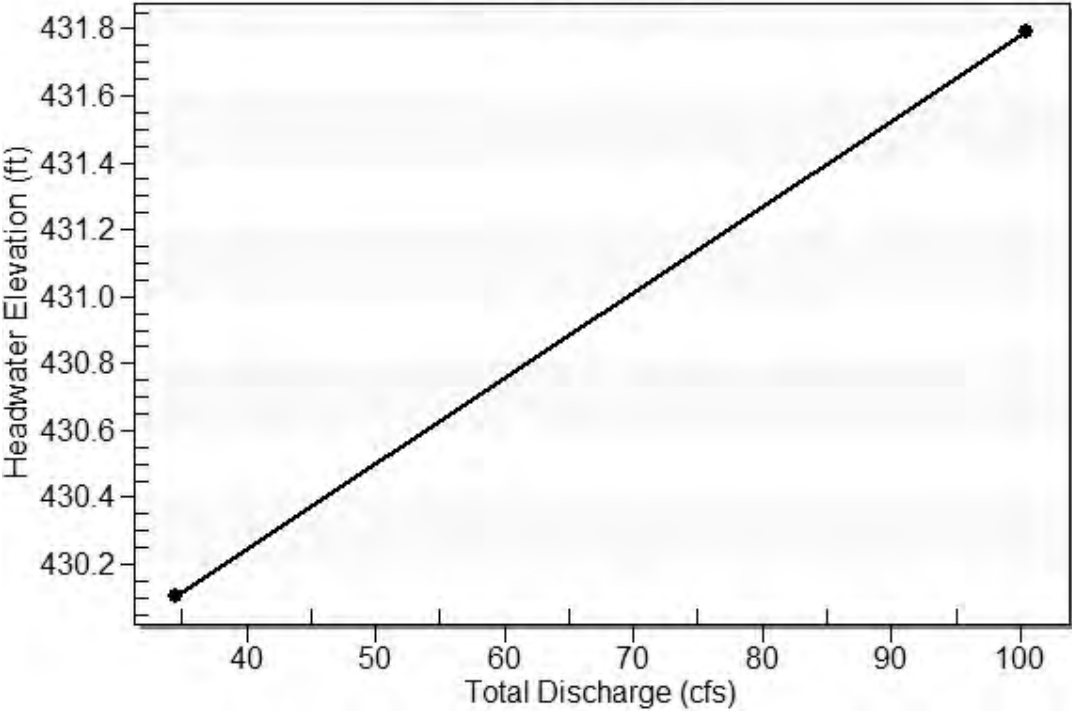


Table 29 - Culvert Summary Table: A-2

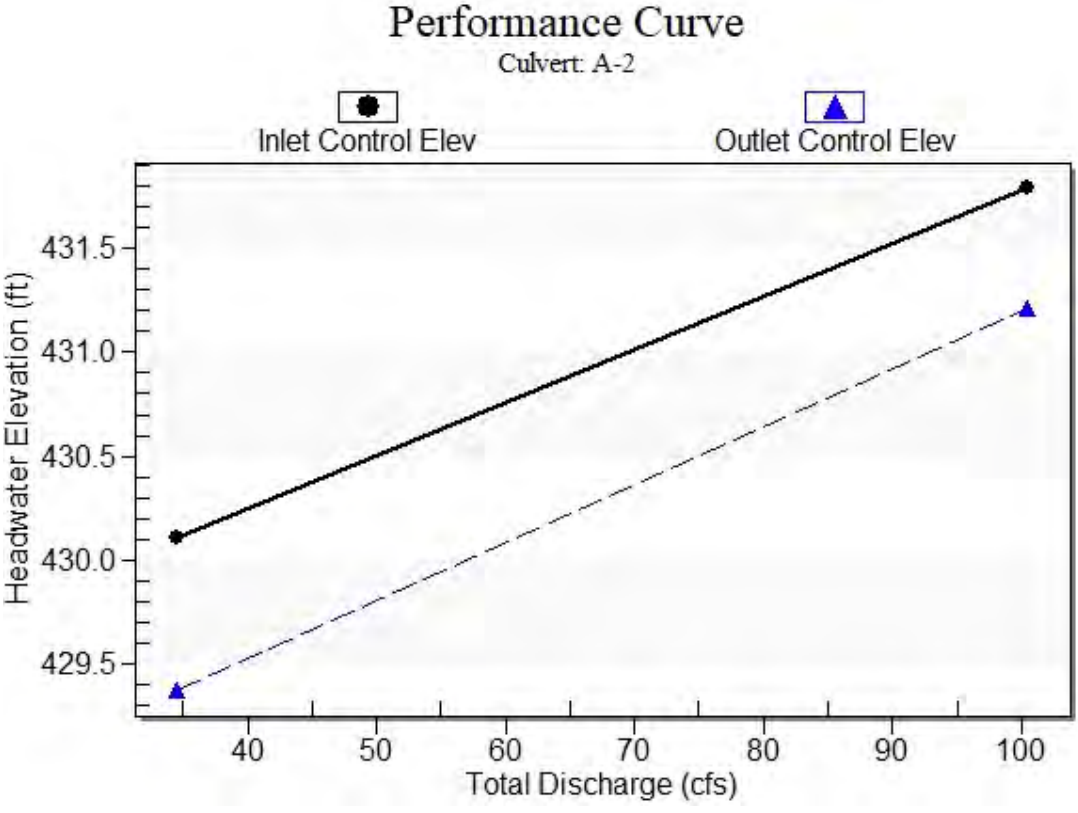
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557
34.53	34.53	430.11	1.477	0.741	1-S2n	0.511	0.883	0.633	0.191	7.426	22.557

Straight Culvert

Inlet Elevation (invert): 428.63 ft, Outlet Elevation (invert): 428.35 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0187

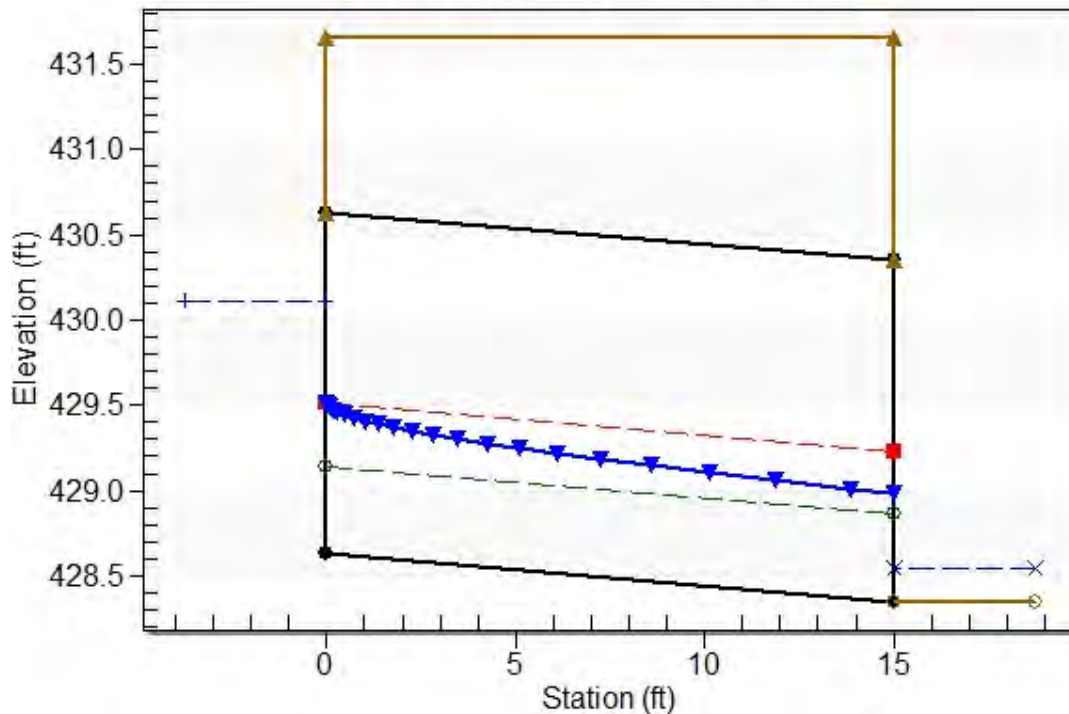
Culvert Performance Curve Plot: A-2



Water Surface Profile Plot for Culvert: A-2

Crossing - A-2 (10-YR), Design Discharge - 34.5 cfs

Culvert - A-2, Culvert Discharge - 34.5 cfs



Site Data - A-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 428.63 ft

Outlet Station: 15.00 ft

Outlet Elevation: 428.35 ft

Number of Barrels: 2

Culvert Data Summary - A-2

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 30 - Downstream Channel Rating Curve (Crossing: A-2 (10-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09
34.53	428.54	0.19	22.56	23.88	9.09

Tailwater Channel Data - A-2 (10-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 2.0000

Channel Manning's n: 0.0300

Channel Invert Elevation: 428.35 ft

Roadway Data for Crossing: A-2 (10-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 431.66 ft

Roadway Surface: Paved

Roadway Top Width: 15.00 ft

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 4.7 cfs

Design Flow: 4.7 cfs

Maximum Flow: 4.7 cfs

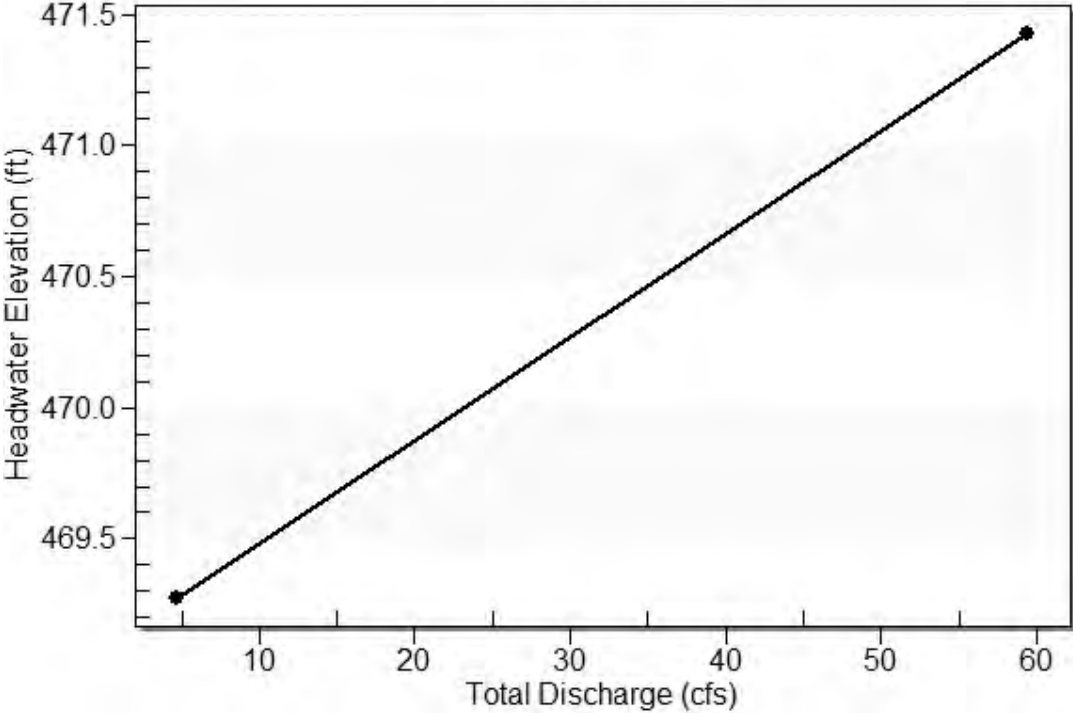
Table 1 - Summary of Culvert Flows at Crossing: D-1 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	D-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
469.28	4.70	4.70	0.00	1
471.38	56.97	56.97	0.00	Overtopping

Rating Curve Plot for Crossing: D-1 (25-YR)

Total Rating Curve

Crossing: D-1 (25-YR)



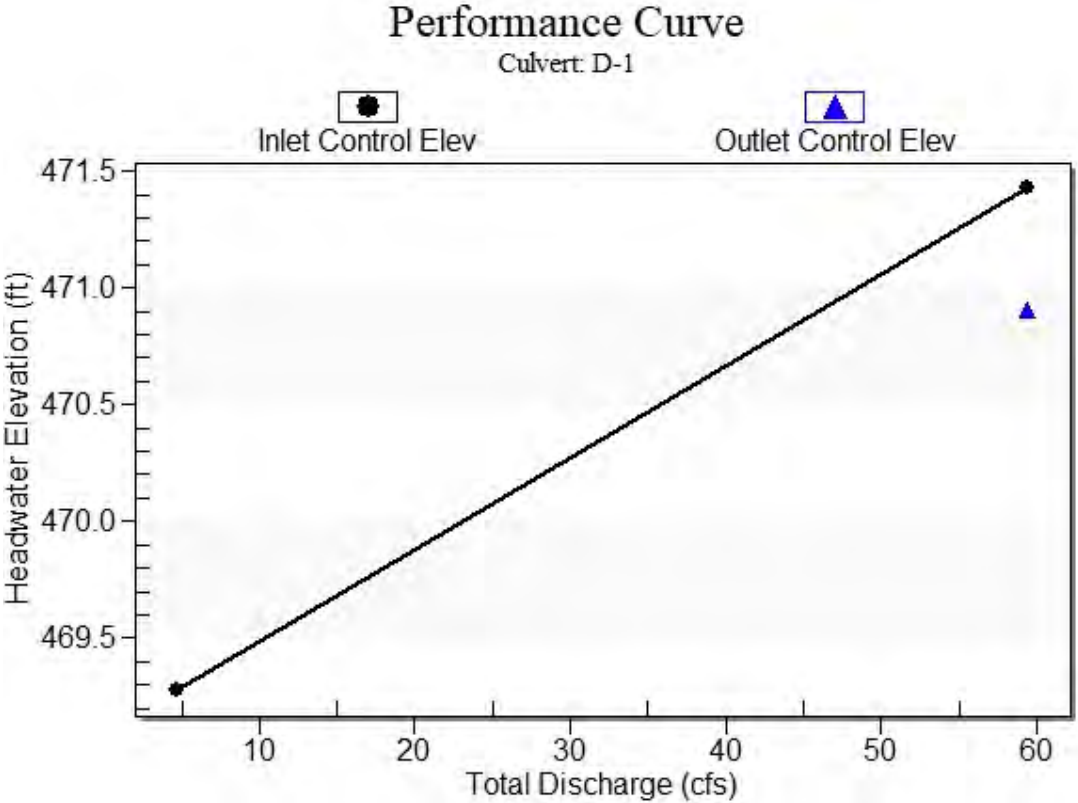
* Full Flow Headwater elevation is below inlet invert.

Straight Culvert

Inlet Elevation (invert): 468.85 ft, Outlet Elevation (invert): 468.57 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0187

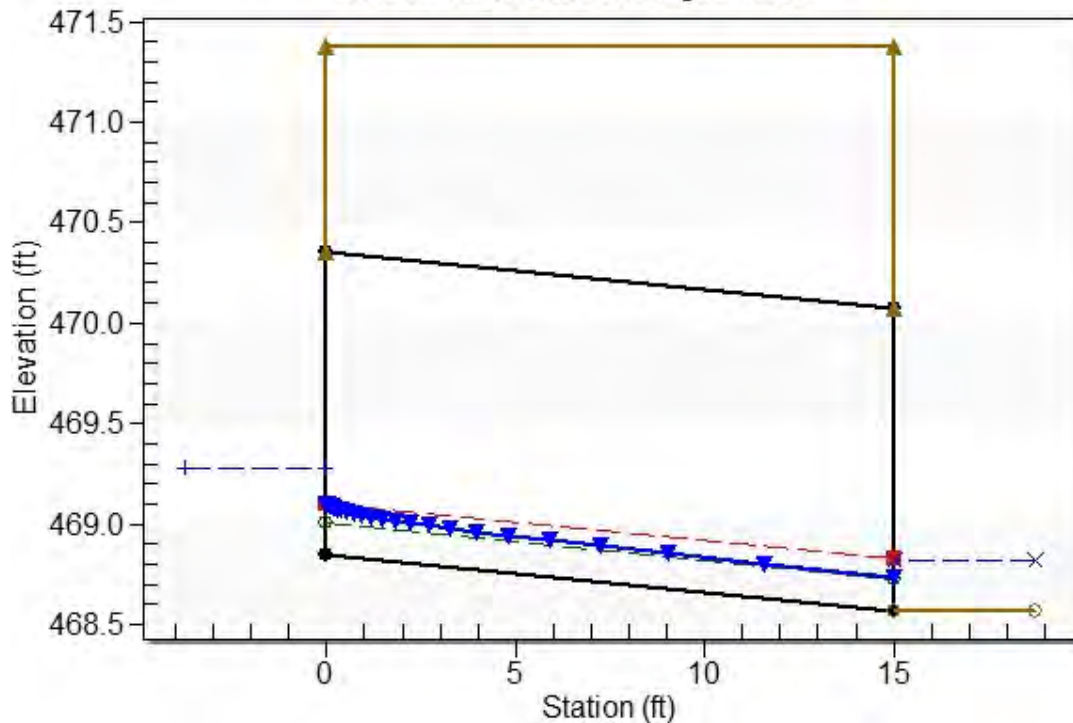
Culvert Performance Curve Plot: D-1



Water Surface Profile Plot for Culvert: D-1

Crossing - D-1 (25-YR), Design Discharge - 4.7 cfs

Culvert - D-1, Culvert Discharge - 4.7 cfs



Site Data - D-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 468.85 ft

Outlet Station: 15.00 ft

Outlet Elevation: 468.57 ft

Number of Barrels: 2

Culvert Data Summary - D-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: D-1 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83
4.70	468.81	0.24	2.27	0.23	0.83

Tailwater Channel Data - D-1 (25-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0300

Channel Invert Elevation: 468.57 ft

Roadway Data for Crossing: D-1 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 471.38 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 60.03 cfs

Design Flow: 60.03 cfs

Maximum Flow: 60.03 cfs

Table 4 - Summary of Culvert Flows at Crossing: E-3 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
445.56	60.03	60.03	0.00	1
446.42	89.07	89.07	0.00	Overtopping

Rating Curve Plot for Crossing: E-3 (25-YR)

Total Rating Curve

Crossing: E-3 (25-YR)

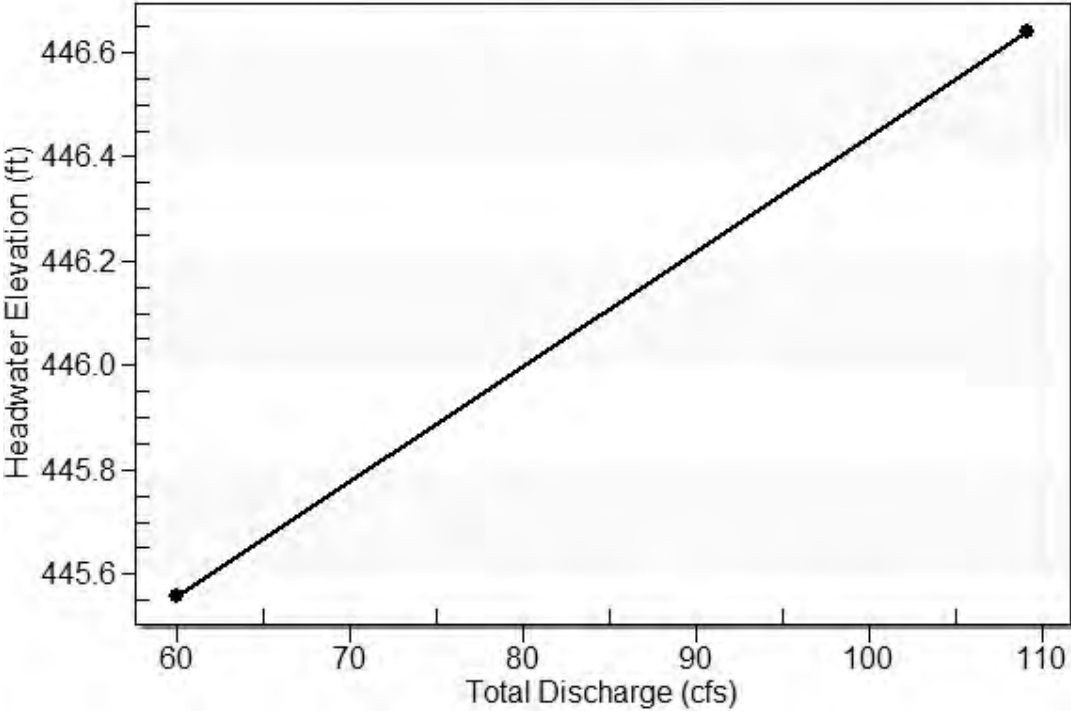


Table 5 - Culvert Summary Table: E-3

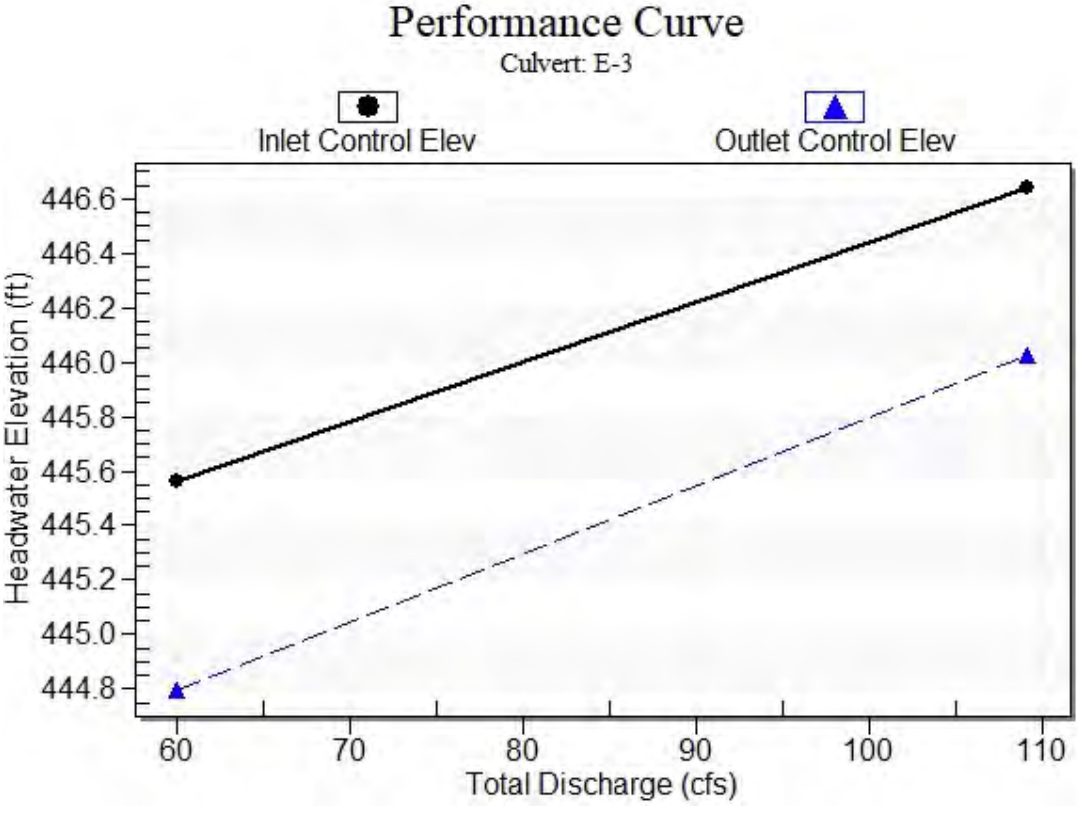
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032
60.03	60.03	445.56	2.159	1.394	5-S2n	0.722	1.276	0.947	0.996	8.638	6.032

Straight Culvert

Inlet Elevation (invert): 443.40 ft, Outlet Elevation (invert): 443.10 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

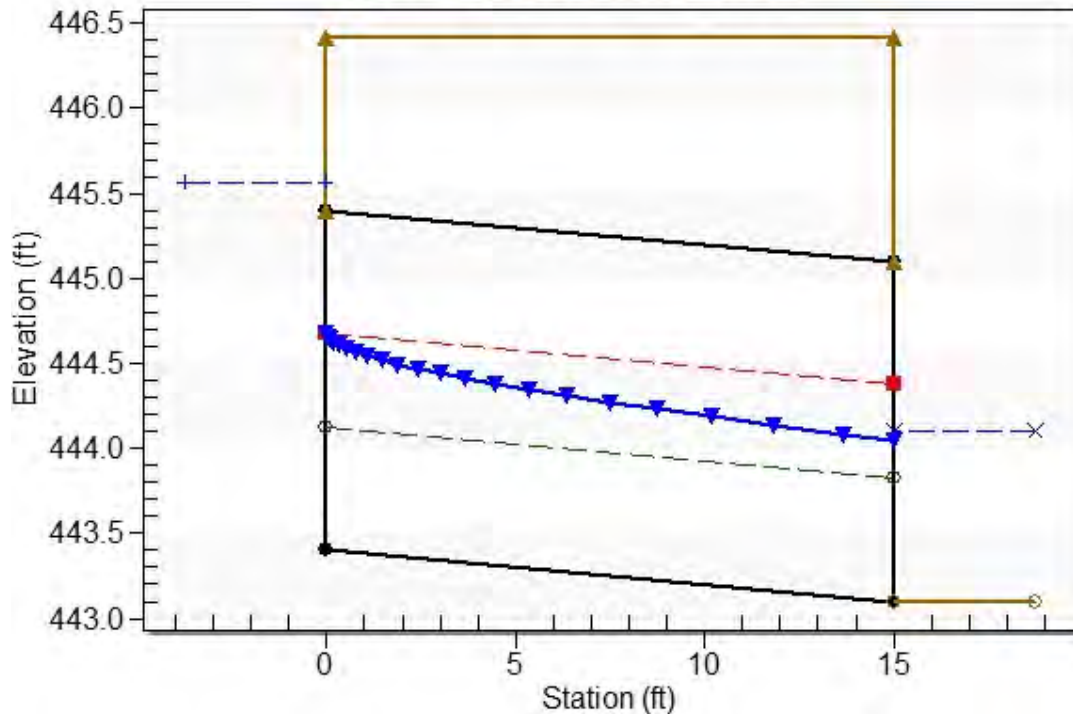
Culvert Performance Curve Plot: E-3



Water Surface Profile Plot for Culvert: E-3

Crossing - E-3 (25-YR), Design Discharge - 60.0 cfs

Culvert - E-3, Culvert Discharge - 60.0 cfs



Site Data - E-3

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 443.40 ft

Outlet Station: 15.00 ft

Outlet Elevation: 443.10 ft

Number of Barrels: 2

Culvert Data Summary - E-3

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: E-3 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17
60.03	444.10	1.00	6.03	1.24	1.17

Tailwater Channel Data - E-3 (25-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 443.10 ft

Roadway Data for Crossing: E-3 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 446.42 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 51.56 cfs

Design Flow: 51.56 cfs

Maximum Flow: 51.56 cfs

Table 7 - Summary of Culvert Flows at Crossing: E-4 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
440.85	51.56	51.56	0.00	1
441.76	78.88	78.88	0.00	Overtopping

Rating Curve Plot for Crossing: E-4 (25-YR)

Total Rating Curve

Crossing: E-4 (25-YR)

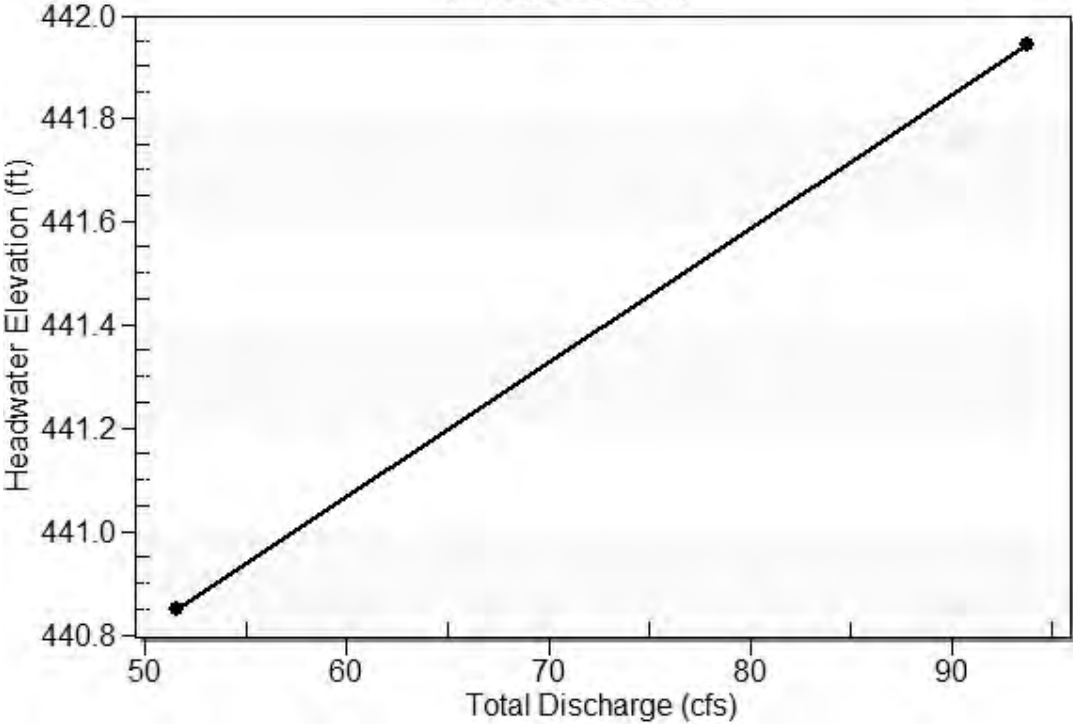


Table 8 - Culvert Summary Table: E-4

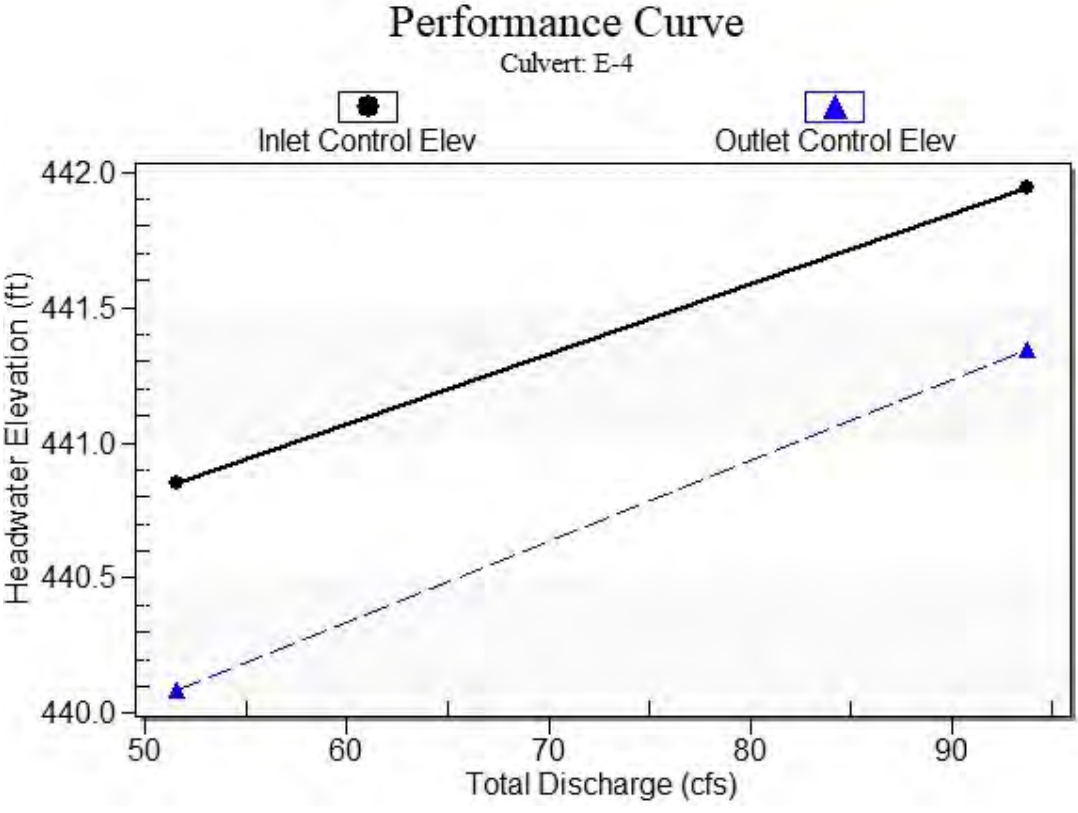
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745
51.56	51.56	440.85	2.111	1.346	5-S2n	0.719	1.250	0.929	0.913	8.537	5.745

Straight Culvert

Inlet Elevation (invert): 438.74 ft, Outlet Elevation (invert): 438.44 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

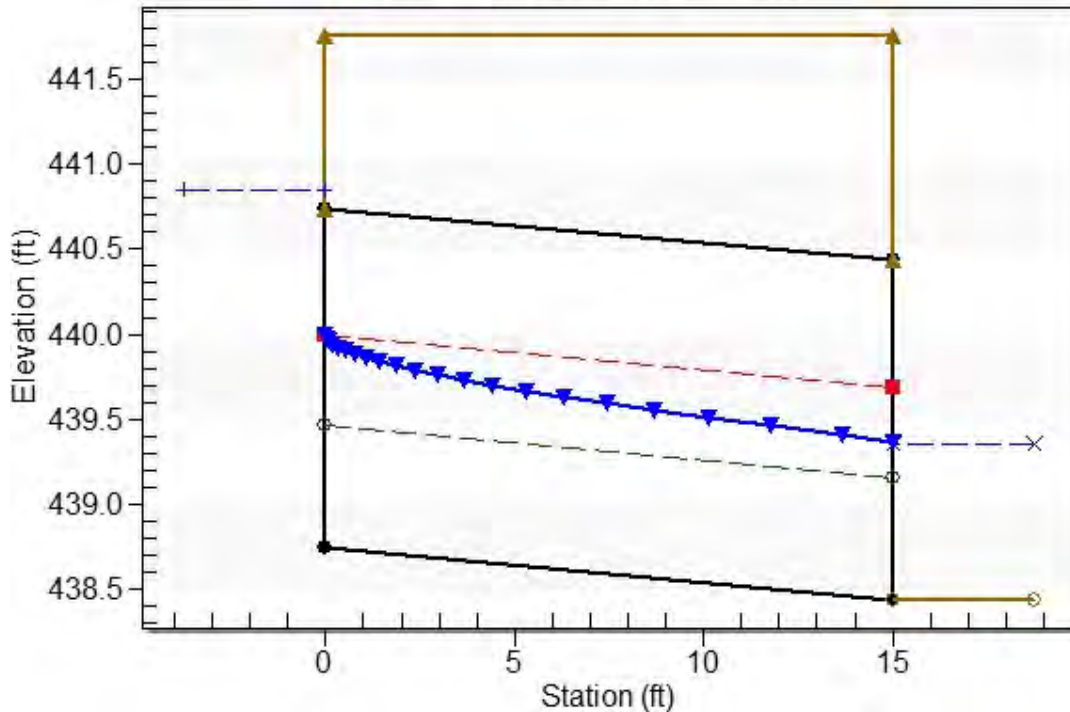
Culvert Performance Curve Plot: E-4



Water Surface Profile Plot for Culvert: E-4

Crossing - E-4 (25-YR), Design Discharge - 51.6 cfs

Culvert - E-4, Culvert Discharge - 51.6 cfs



Site Data - E-4

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 438.74 ft

Outlet Station: 15.00 ft

Outlet Elevation: 438.44 ft

Number of Barrels: 2

Culvert Data Summary - E-4

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: E-4 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15
51.56	439.35	0.91	5.74	1.14	1.15

Tailwater Channel Data - E-4 (25-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 438.44 ft

Roadway Data for Crossing: E-4 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 441.76 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 13.57 cfs

Design Flow: 13.57 cfs

Maximum Flow: 13.57 cfs

Table 10 - Summary of Culvert Flows at Crossing: E-5 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-5 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
441.97	13.57	13.57	0.00	1
443.63	56.80	56.80	0.00	Overtopping

Rating Curve Plot for Crossing: E-5 (25-YR)

Total Rating Curve

Crossing: E-5 (25-YR)

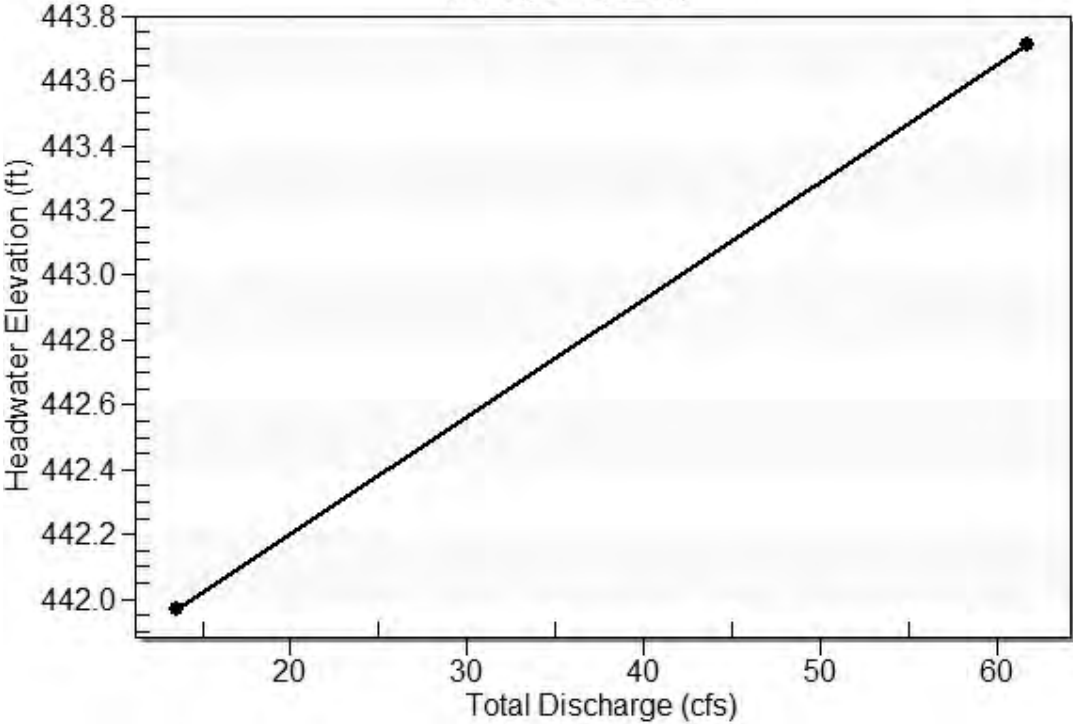


Table 11 - Culvert Summary Table: E-5

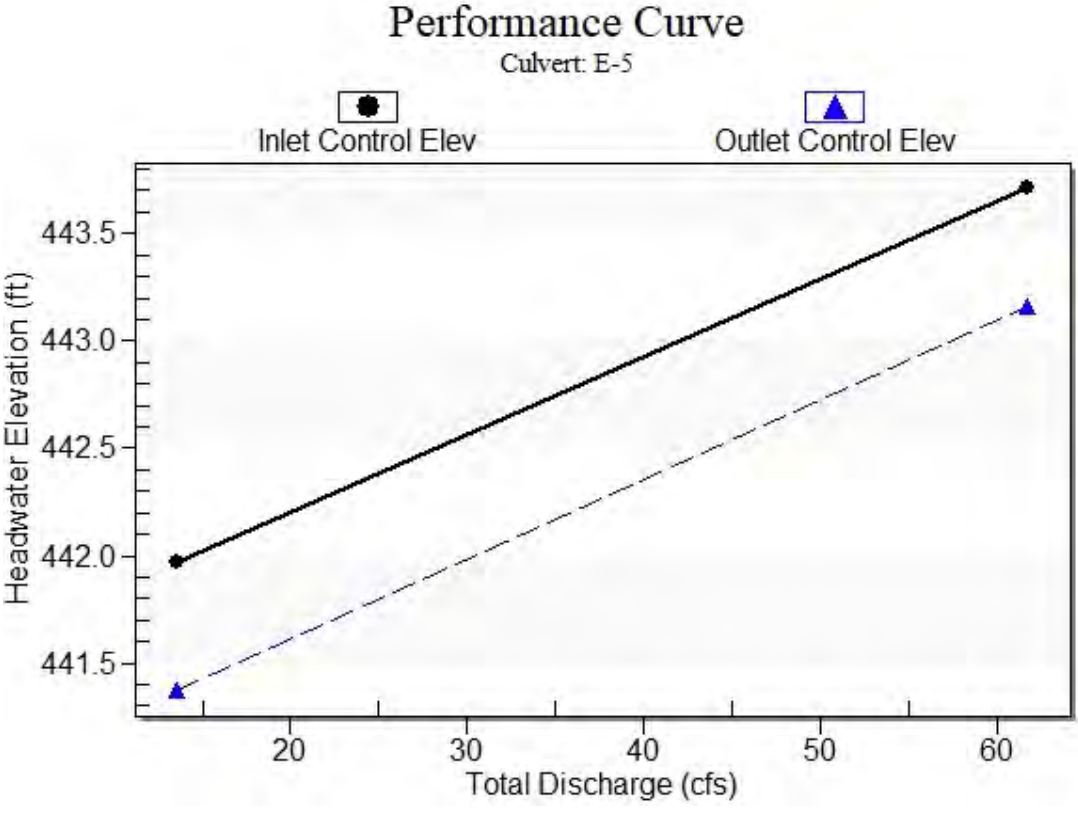
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808
13.57	13.57	441.97	0.862	0.263	1-S2n	0.298	0.513	0.341	0.445	6.120	3.808

Straight Culvert

Inlet Elevation (invert): 441.11 ft, Outlet Elevation (invert): 440.81 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

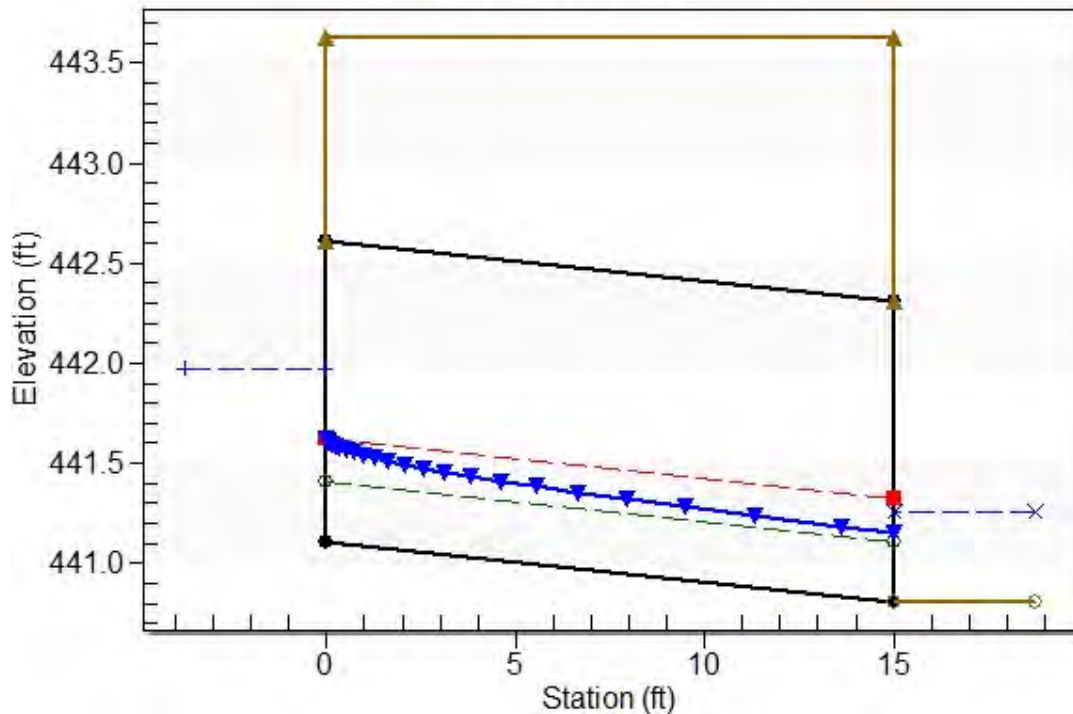
Culvert Performance Curve Plot: E-5



Water Surface Profile Plot for Culvert: E-5

Crossing - E-5 (25-YR), Design Discharge - 13.6 cfs

Culvert - E-5, Culvert Discharge - 13.6 cfs



Site Data - E-5

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 441.11 ft

Outlet Station: 15.00 ft

Outlet Elevation: 440.81 ft

Number of Barrels: 2

Culvert Data Summary - E-5

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: E-5 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01
13.57	441.26	0.45	3.81	0.56	1.01

Tailwater Channel Data - E-5 (25-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 440.81 ft

Roadway Data for Crossing: E-5 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 443.63 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 6.86 cfs

Design Flow: 6.86 cfs

Maximum Flow: 6.86 cfs

Table 13 - Summary of Culvert Flows at Crossing: A-1 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	A-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
470.53	6.86	6.86	0.00	1
472.61	58.89	58.89	0.00	Overtopping

Rating Curve Plot for Crossing: A-1 (25-YR)

Total Rating Curve

Crossing: A-1 (25-YR)

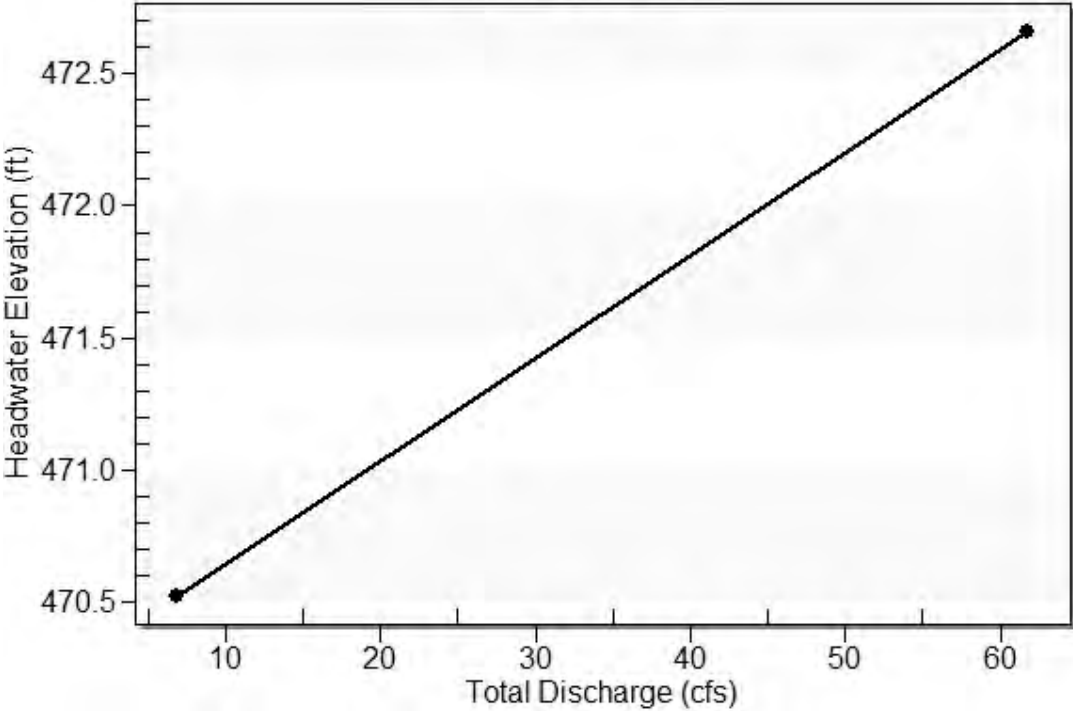


Table 14 - Culvert Summary Table: A-1

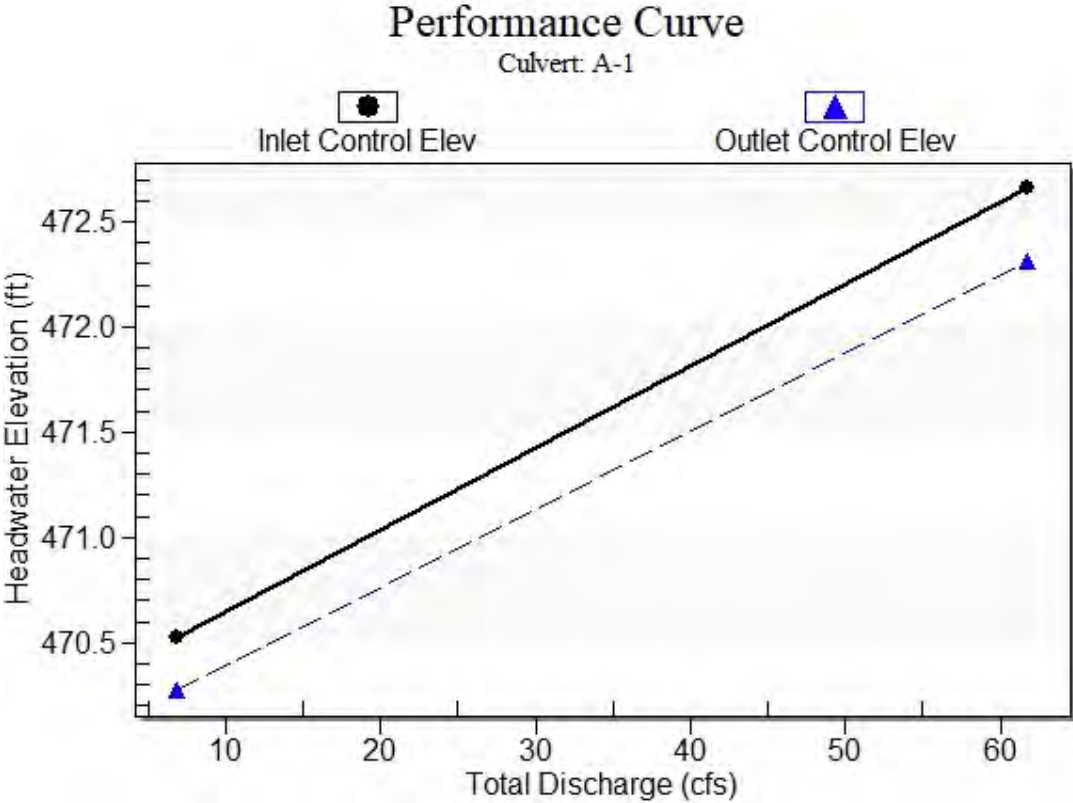
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372
6.86	6.86	470.53	0.557	0.304	1-JS1t	0.307	0.326	0.361	0.361	2.920	2.372

Straight Culvert

Inlet Elevation (invert): 469.97 ft, Outlet Elevation (invert): 469.90 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0047

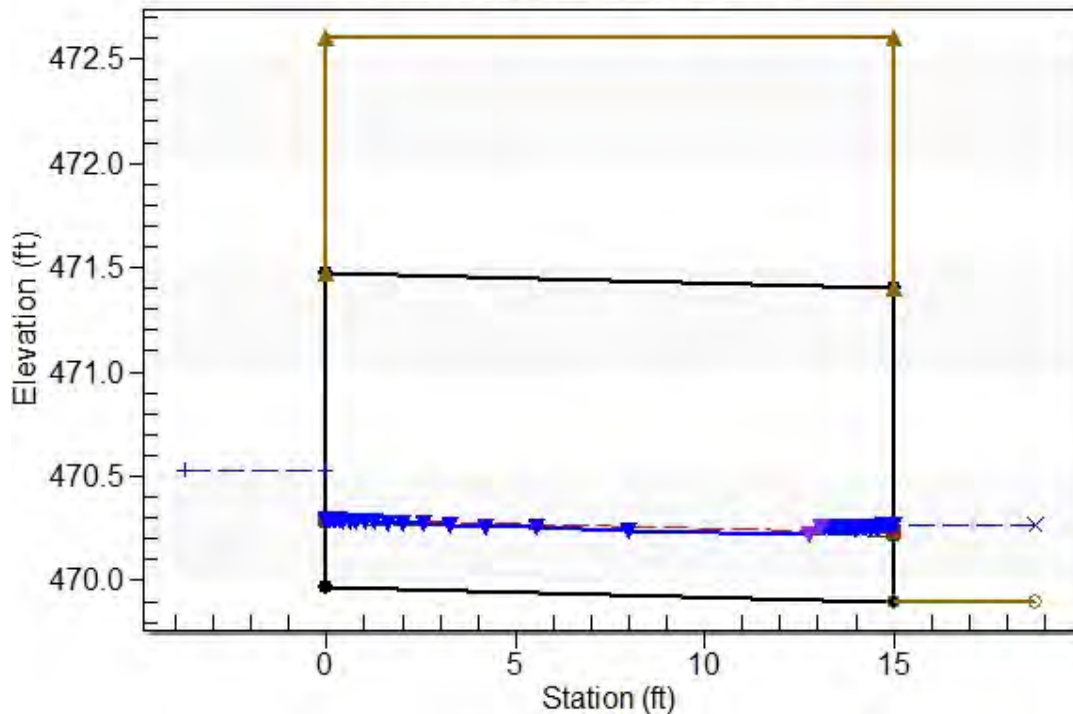
Culvert Performance Curve Plot: A-1



Water Surface Profile Plot for Culvert: A-1

Crossing - A-1 (25-YR), Design Discharge - 6.9 cfs

Culvert - A-1, Culvert Discharge - 6.9 cfs



Site Data - A-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 469.97 ft

Outlet Station: 15.00 ft

Outlet Elevation: 469.90 ft

Number of Barrels: 2

Culvert Data Summary - A-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: A-1 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70
6.86	470.26	0.36	2.37	0.23	0.70

Tailwater Channel Data - A-1 (25-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0100

Channel Manning's n: 0.0300

Channel Invert Elevation: 469.90 ft

Roadway Data for Crossing: A-1 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 472.61 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 17.82 cfs

Design Flow: 17.82 cfs

Maximum Flow: 17.82 cfs

Table 16 - Summary of Culvert Flows at Crossing: E-2 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
457.47	17.82	17.82	0.00	1
458.96	56.80	56.80	0.00	Overtopping

Rating Curve Plot for Crossing: E-2 (25-YR)

Total Rating Curve

Crossing: E-2 (25-YR)

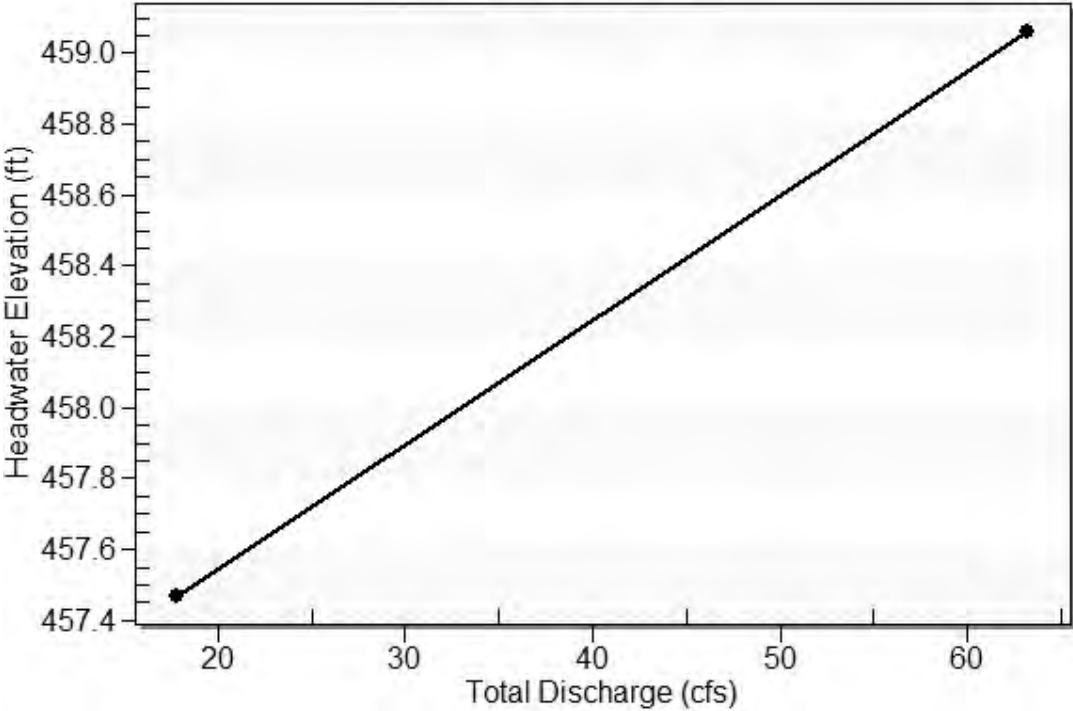


Table 17 - Culvert Summary Table: E-2

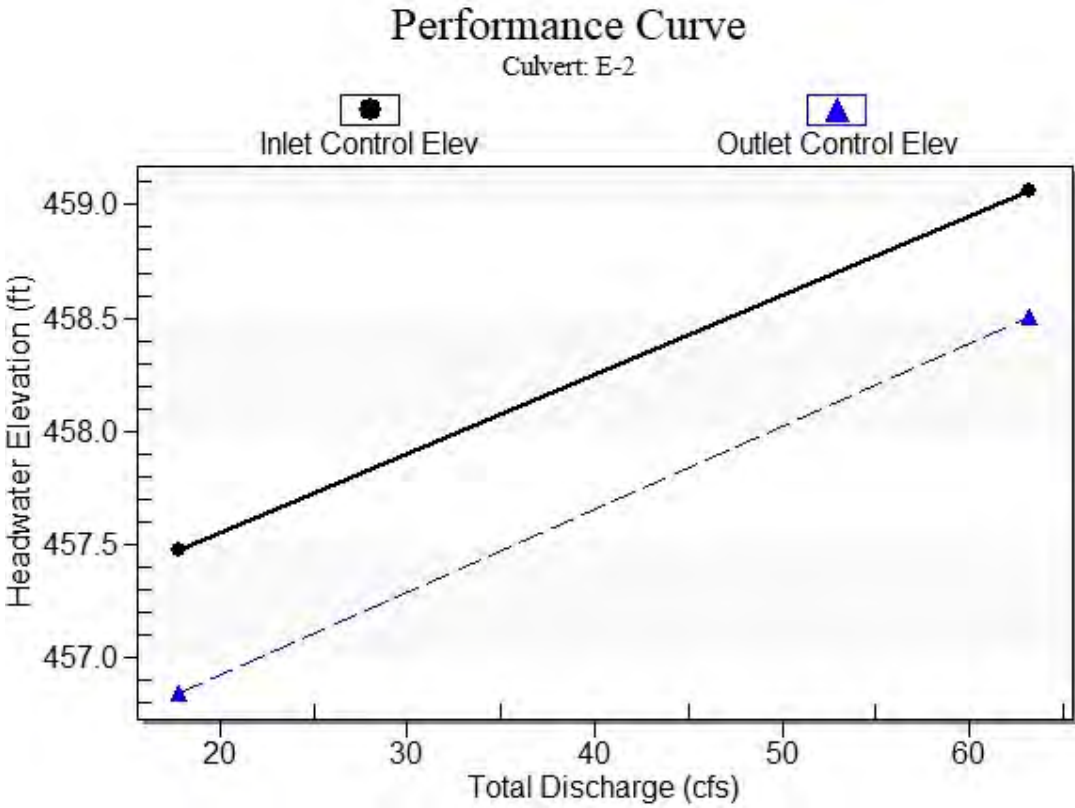
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018
17.82	17.82	457.47	1.031	0.401	1-S2n	0.355	0.616	0.418	0.493	6.561	4.018

Straight Culvert

Inlet Elevation (invert): 456.44 ft, Outlet Elevation (invert): 456.14 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

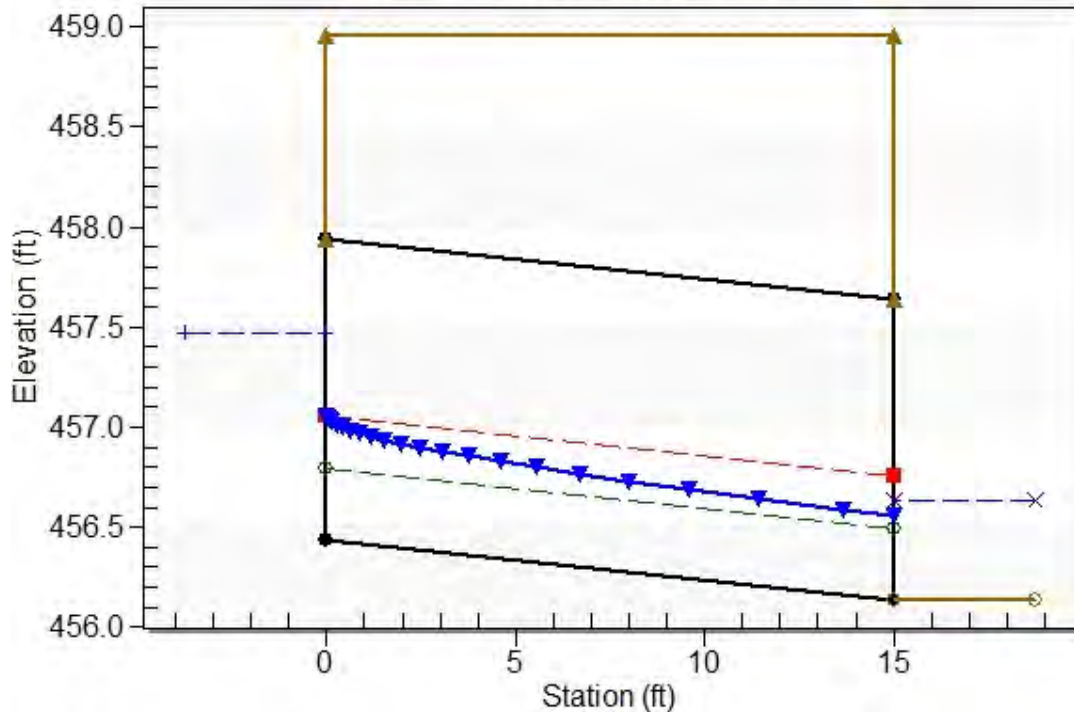
Culvert Performance Curve Plot: E-2



Water Surface Profile Plot for Culvert: E-2

Crossing - E-2 (25-YR), Design Discharge - 17.8 cfs

Culvert - E-2, Culvert Discharge - 17.8 cfs



Site Data - E-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 456.44 ft

Outlet Station: 15.00 ft

Outlet Elevation: 456.14 ft

Number of Barrels: 2

Culvert Data Summary - E-2

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: E-2 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06
17.82	456.63	0.49	4.02	0.62	1.06

Tailwater Channel Data - E-2 (25-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 456.14 ft

Roadway Data for Crossing: E-2 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 458.96 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 8.53 cfs

Design Flow: 8.53 cfs

Maximum Flow: 8.53 cfs

Table 19 - Summary of Culvert Flows at Crossing: E-1 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
463.60	8.53	8.53	0.00	1
465.56	58.17	58.17	0.00	Overtopping

Rating Curve Plot for Crossing: E-1 (25-YR)

Total Rating Curve

Crossing: E-1 (25-YR)

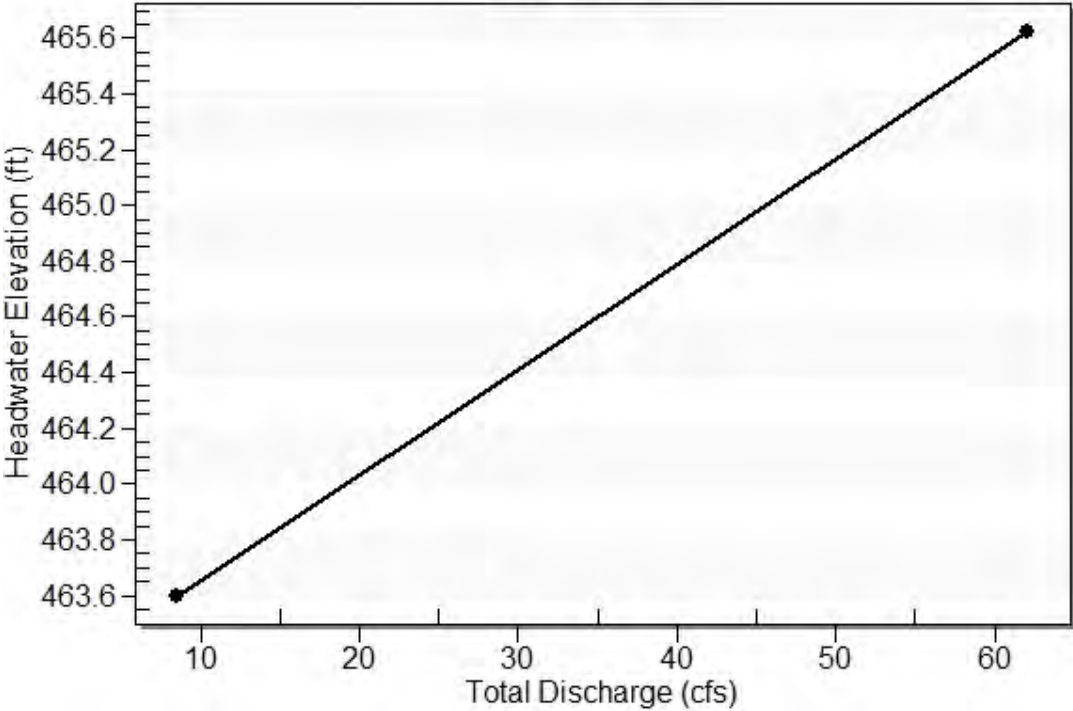


Table 20 - Culvert Summary Table: E-1

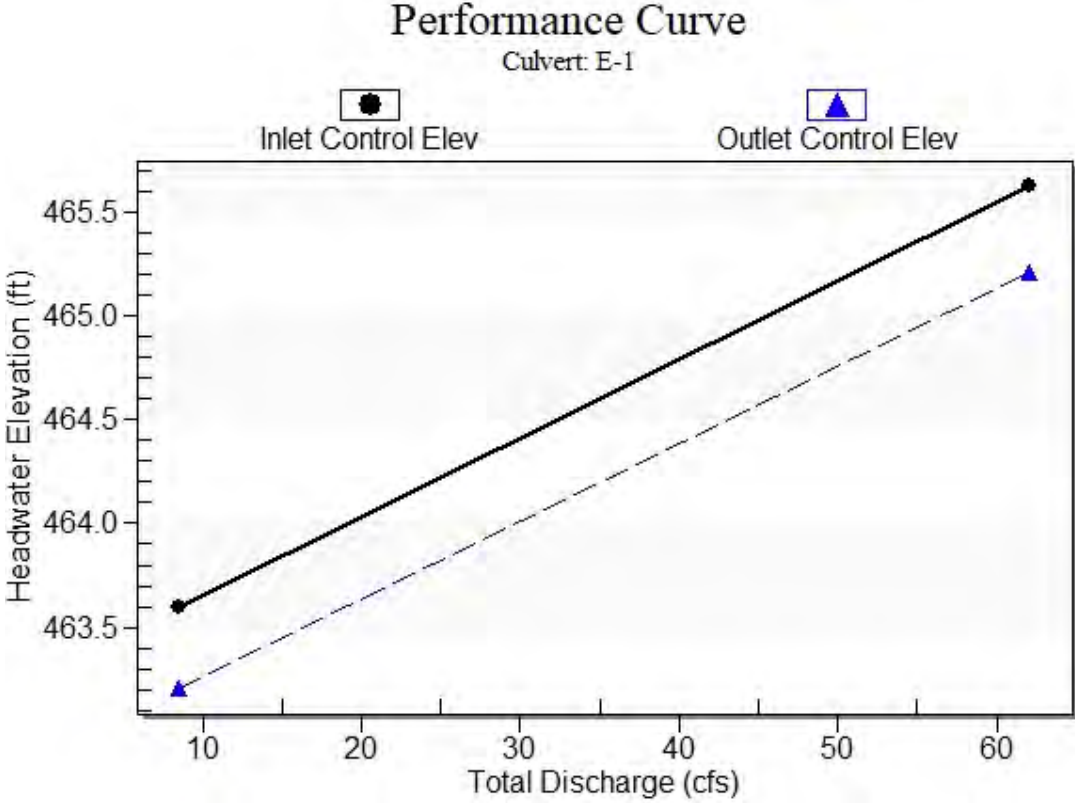
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195
8.53	8.53	463.60	0.640	0.246	1-S2n	0.276	0.377	0.291	0.334	4.516	3.195

Straight Culvert

Inlet Elevation (invert): 462.96 ft, Outlet Elevation (invert): 462.81 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0100

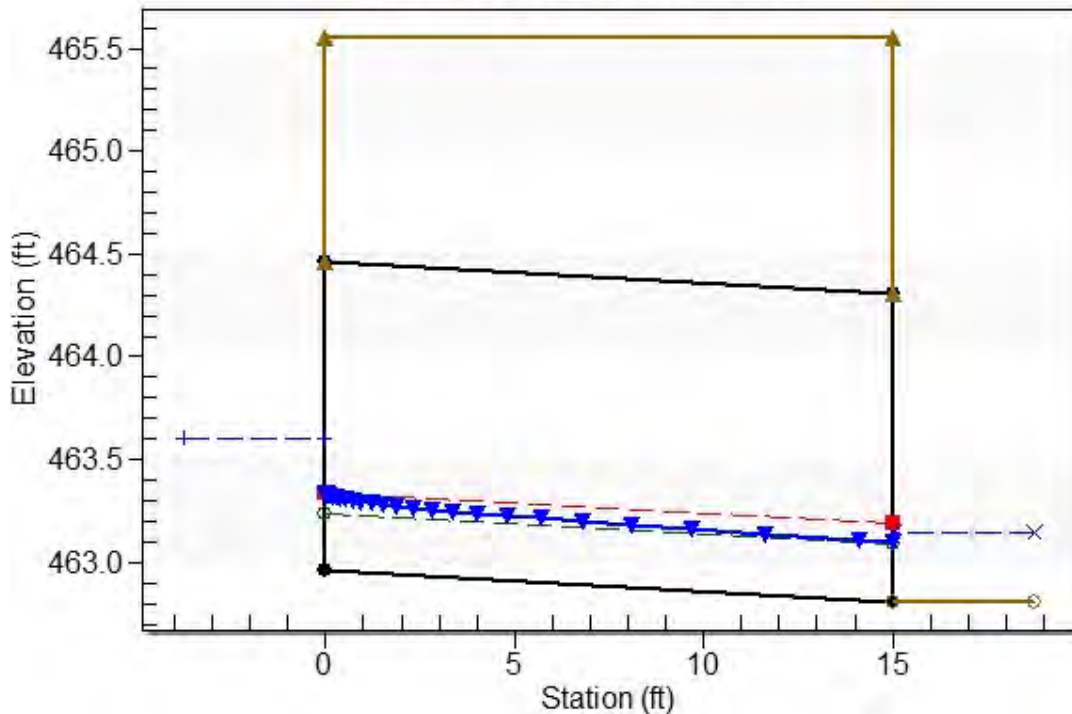
Culvert Performance Curve Plot: E-1



Water Surface Profile Plot for Culvert: E-1

Crossing - E-1 (25-YR), Design Discharge - 8.5 cfs

Culvert - E-1, Culvert Discharge - 8.5 cfs



Site Data - E-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 462.96 ft

Outlet Station: 15.00 ft

Outlet Elevation: 462.81 ft

Number of Barrels: 2

Culvert Data Summary - E-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: E-1 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97
8.53	463.14	0.33	3.19	0.42	0.97

Tailwater Channel Data - E-1 (25-YR)

Tailwater Channel Option: Rectangular Channel
Bottom Width: 8.00 ft
Channel Slope: 0.0200
Channel Manning's n: 0.0300
Channel Invert Elevation: 462.81 ft

Roadway Data for Crossing: E-1 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 50.00 ft
Crest Elevation: 465.56 ft
Roadway Surface: Gravel
Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 25.78 cfs

Design Flow: 25.78 cfs

Maximum Flow: 25.78 cfs

Table 22 - Summary of Culvert Flows at Crossing: 13-1 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	13-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
449.73	25.78	25.78	0.00	1
450.83	54.70	54.70	0.00	Overtopping

Rating Curve Plot for Crossing: 13-1 (25-YR)

Total Rating Curve

Crossing: 13-1 (25-YR)

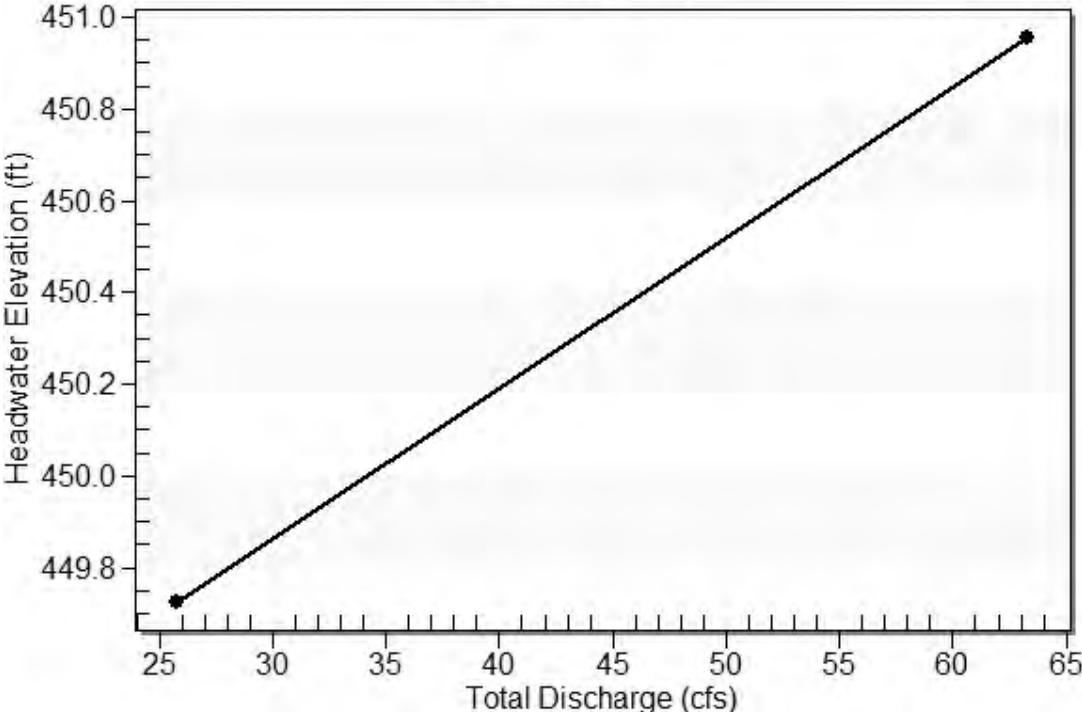


Table 23 - Culvert Summary Table: 13-1

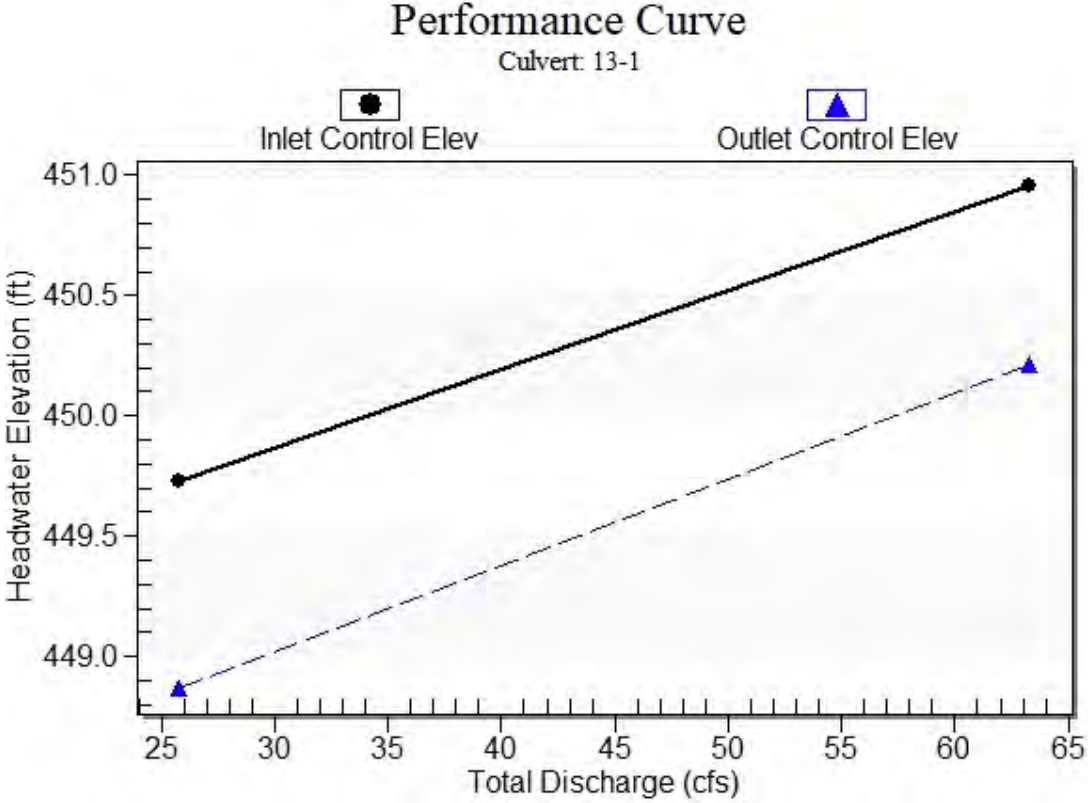
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564
25.78	25.78	449.73	1.307	0.447	1-S2n	0.378	0.788	0.483	0.612	8.207	4.564

Straight Culvert

Inlet Elevation (invert): 448.42 ft, Outlet Elevation (invert): 447.90 ft

Culvert Length: 15.01 ft, Culvert Slope: 0.0347

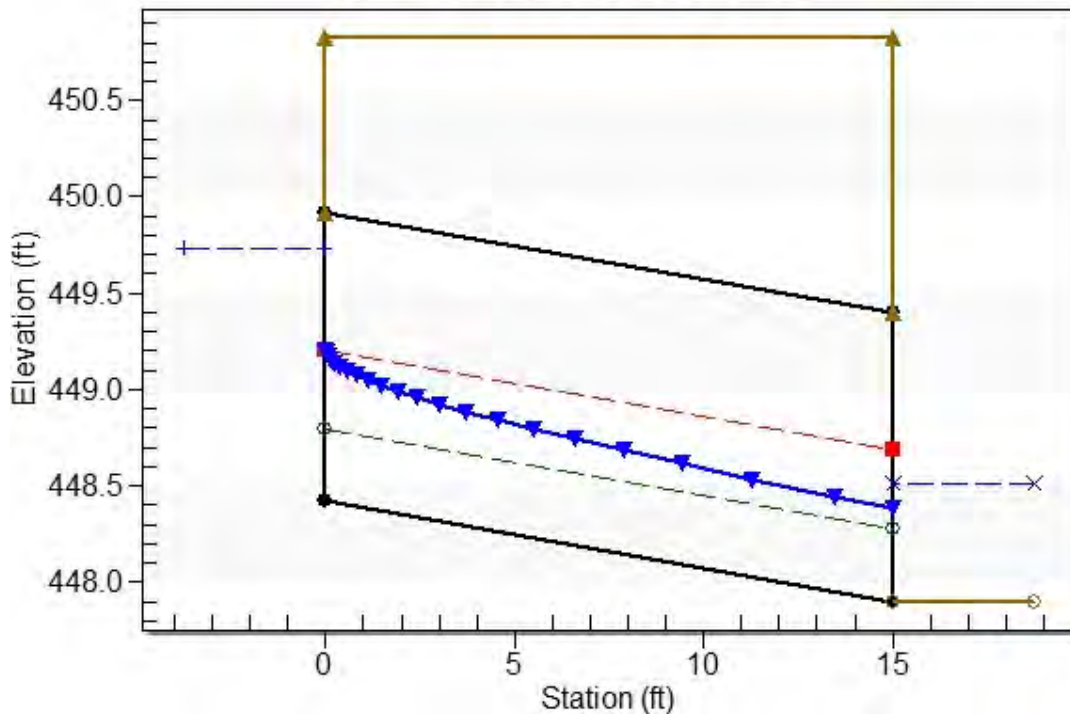
Culvert Performance Curve Plot: 13-1



Water Surface Profile Plot for Culvert: 13-1

Crossing - 13-1 (25-YR) , Design Discharge - 25.8 cfs

Culvert - 13-1, Culvert Discharge - 25.8 cfs



Site Data - 13-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 448.42 ft

Outlet Station: 15.00 ft

Outlet Elevation: 447.90 ft

Number of Barrels: 2

Culvert Data Summary - 13-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: 13-1 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09
25.78	448.51	0.61	4.56	0.76	1.09

Tailwater Channel Data - 13-1 (25-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 447.90 ft

Roadway Data for Crossing: 13-1 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 450.83 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 19.63 cfs

Design Flow: 19.63 cfs

Maximum Flow: 19.63 cfs

Table 25 - Summary of Culvert Flows at Crossing: 16-1 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	16-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
464.92	19.63	19.63	0.00	1
466.34	56.79	56.79	0.00	Overtopping

Rating Curve Plot for Crossing: 16-1 (25-YR)

Total Rating Curve

Crossing: 16-1 (25-YR)

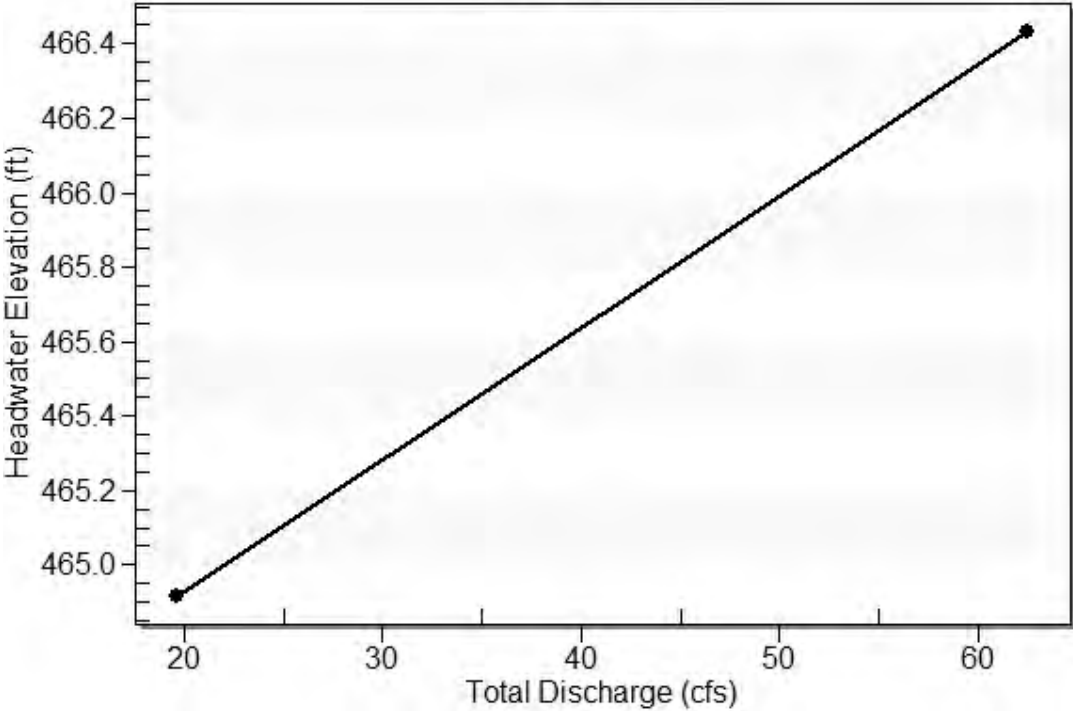


Table 26 - Culvert Summary Table: 16-1

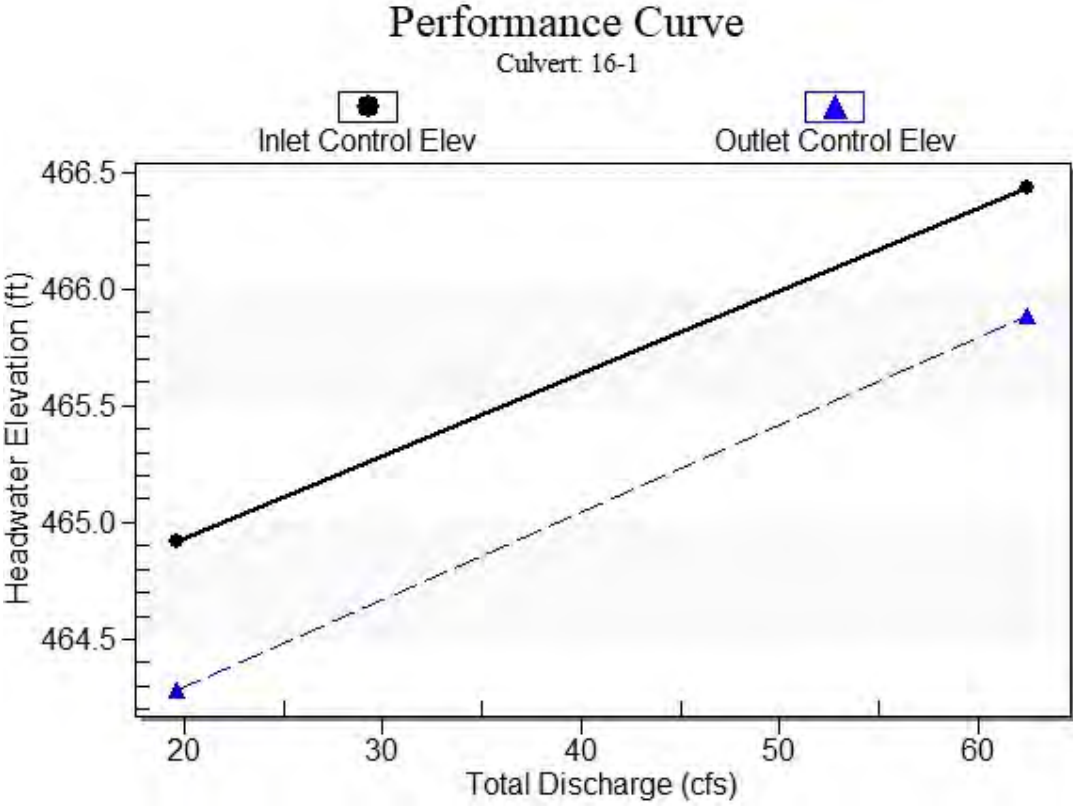
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742
19.63	19.63	464.92	1.099	0.461	1-S2n	0.378	0.657	0.449	0.464	6.725	4.742

Straight Culvert

Inlet Elevation (invert): 463.82 ft, Outlet Elevation (invert): 463.52 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

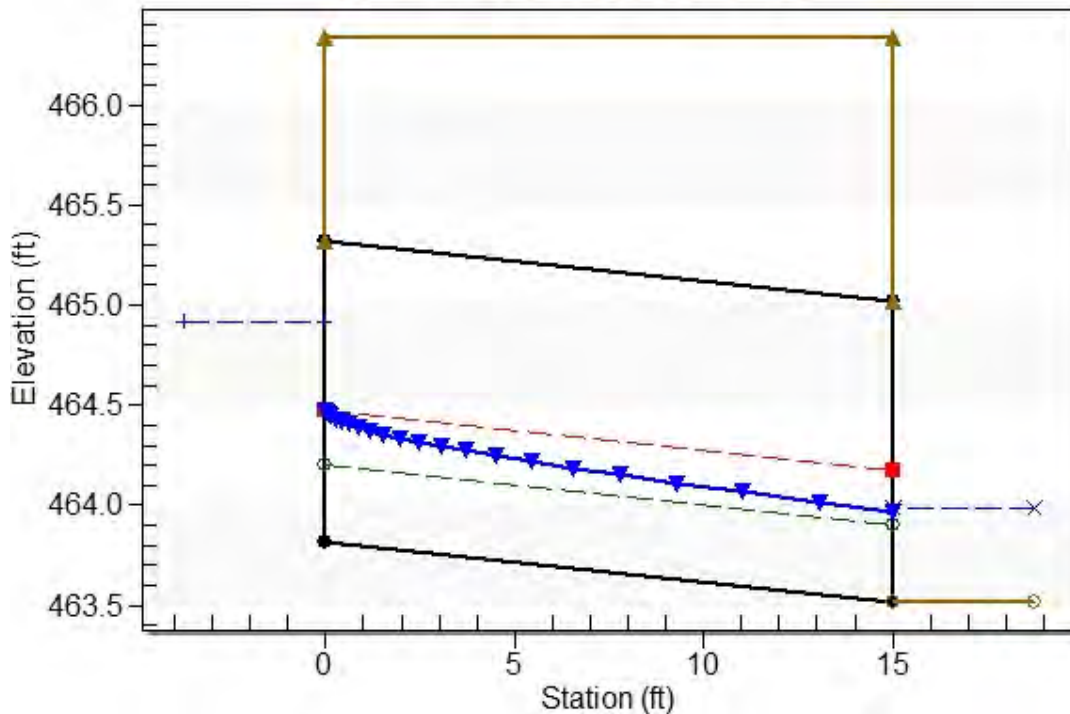
Culvert Performance Curve Plot: 16-1



Water Surface Profile Plot for Culvert: 16-1

Crossing - 16-1 (25-YR) , Design Discharge - 19.6 cfs

Culvert - 16-1, Culvert Discharge - 19.6 cfs



Site Data - 16-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 463.82 ft

Outlet Station: 15.00 ft

Outlet Elevation: 463.52 ft

Number of Barrels: 2

Culvert Data Summary - 16-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 27 - Downstream Channel Rating Curve (Crossing: 16-1 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29
19.63	463.98	0.46	4.74	0.87	1.29

Tailwater Channel Data - 16-1 (25-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0300

Channel Manning's n: 0.0300

Channel Invert Elevation: 463.52 ft

Roadway Data for Crossing: 16-1 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 466.34 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 49.39 cfs

Design Flow: 49.39 cfs

Maximum Flow: 49.39 cfs

Table 28 - Summary of Culvert Flows at Crossing: A-2 (25-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	A-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
430.51	49.39	49.39	0.00	1
431.66	89.34	89.34	0.00	Overtopping

Rating Curve Plot for Crossing: A-2 (25-YR)

Total Rating Curve

Crossing: A-2 (25-YR)

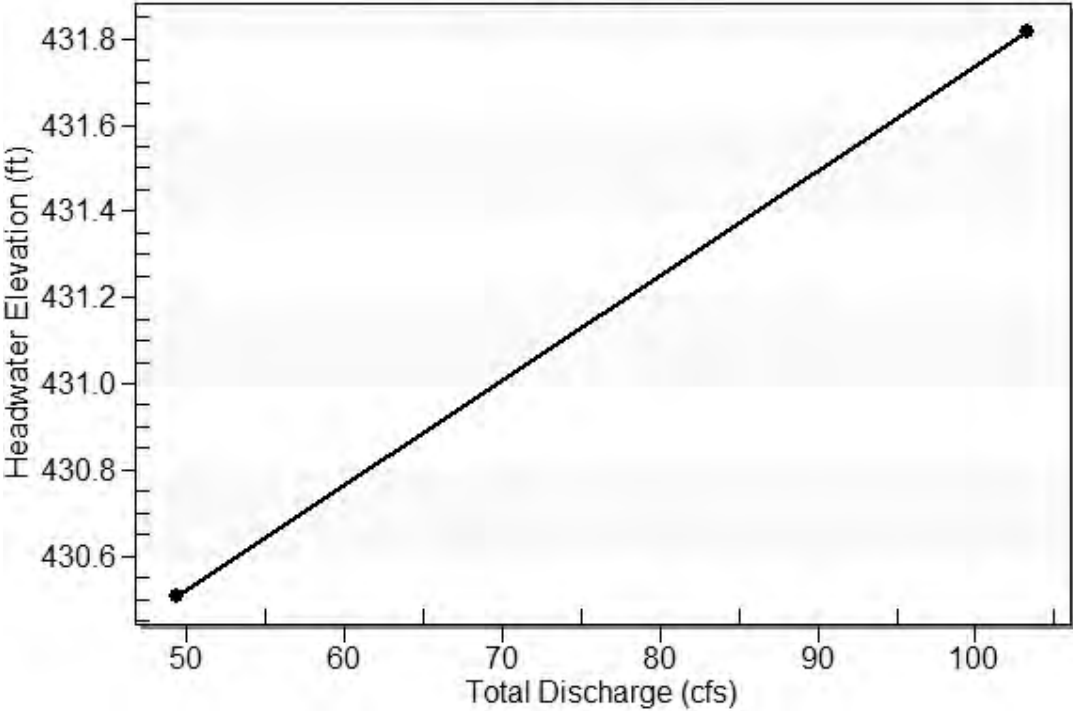


Table 29 - Culvert Summary Table: A-2

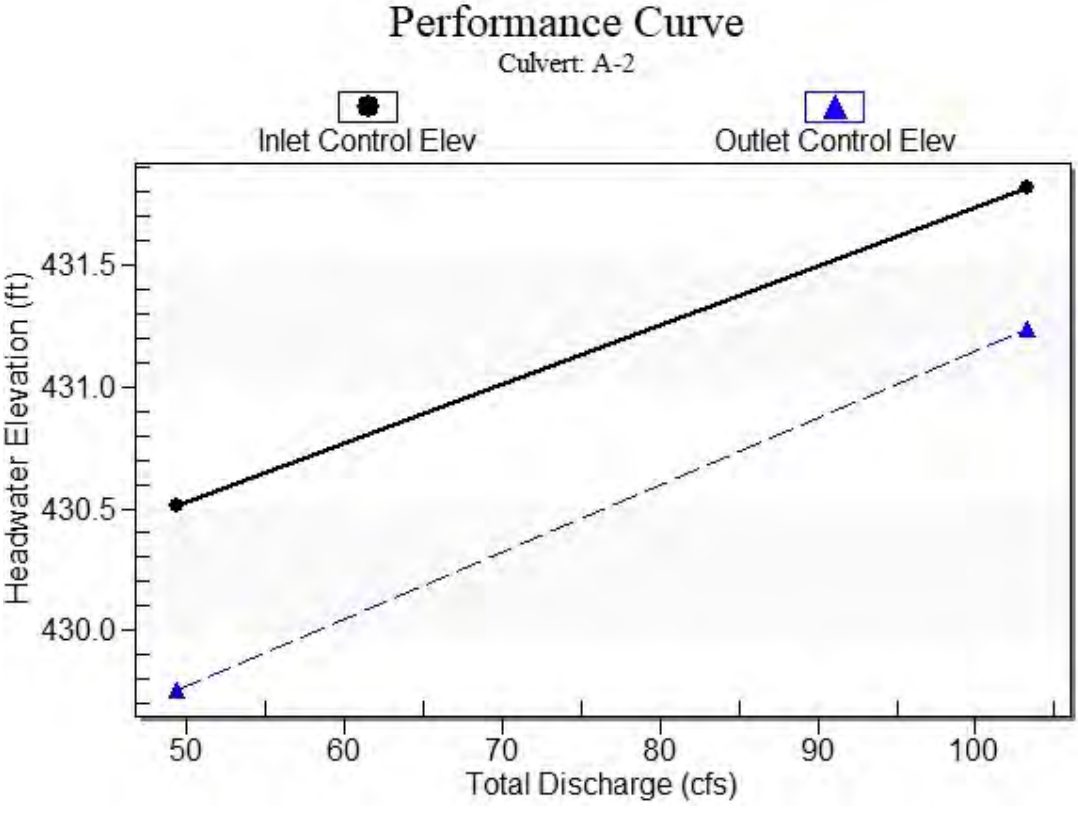
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898
49.39	49.39	430.51	1.879	1.124	1-S2n	0.648	1.120	0.829	0.238	8.121	25.898

Straight Culvert

Inlet Elevation (invert): 428.63 ft, Outlet Elevation (invert): 428.35 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0187

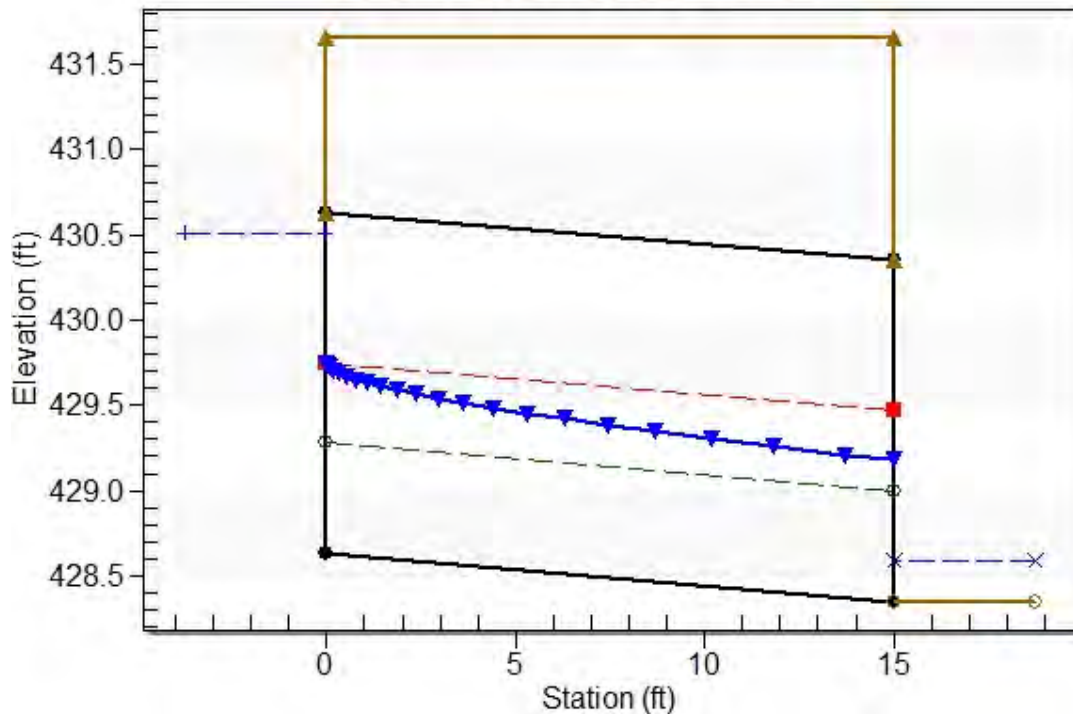
Culvert Performance Curve Plot: A-2



Water Surface Profile Plot for Culvert: A-2

Crossing - A-2 (25-YR), Design Discharge - 49.4 cfs

Culvert - A-2, Culvert Discharge - 49.4 cfs



Site Data - A-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 428.63 ft

Outlet Station: 15.00 ft

Outlet Elevation: 428.35 ft

Number of Barrels: 2

Culvert Data Summary - A-2

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 30 - Downstream Channel Rating Curve (Crossing: A-2 (25-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35
49.39	428.59	0.24	25.90	29.75	9.35

Tailwater Channel Data - A-2 (25-YR)

Tailwater Channel Option: Rectangular Channel
Bottom Width: 8.00 ft
Channel Slope: 2.0000
Channel Manning's n: 0.0300
Channel Invert Elevation: 428.35 ft

Roadway Data for Crossing: A-2 (25-YR)

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 50.00 ft
Crest Elevation: 431.66 ft
Roadway Surface: Paved
Roadway Top Width: 15.00 ft

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 6.92 cfs

Design Flow: 6.92 cfs

Maximum Flow: 6.92 cfs

Table 1 - Summary of Culvert Flows at Crossing: D-1 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	D-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
469.40	6.92	6.92	0.00	1
471.38	56.97	56.97	0.00	Overtopping

Rating Curve Plot for Crossing: D-1 (100-YR)

Total Rating Curve
Crossing: D-1 (100-YR)

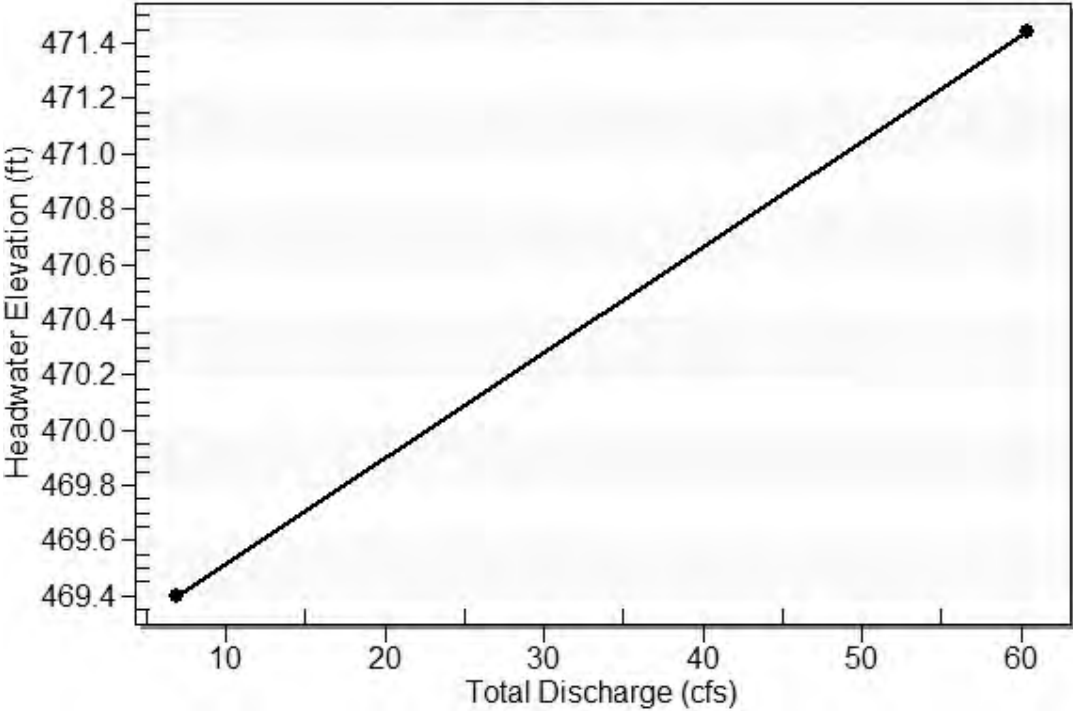


Table 2 - Culvert Summary Table: D-1

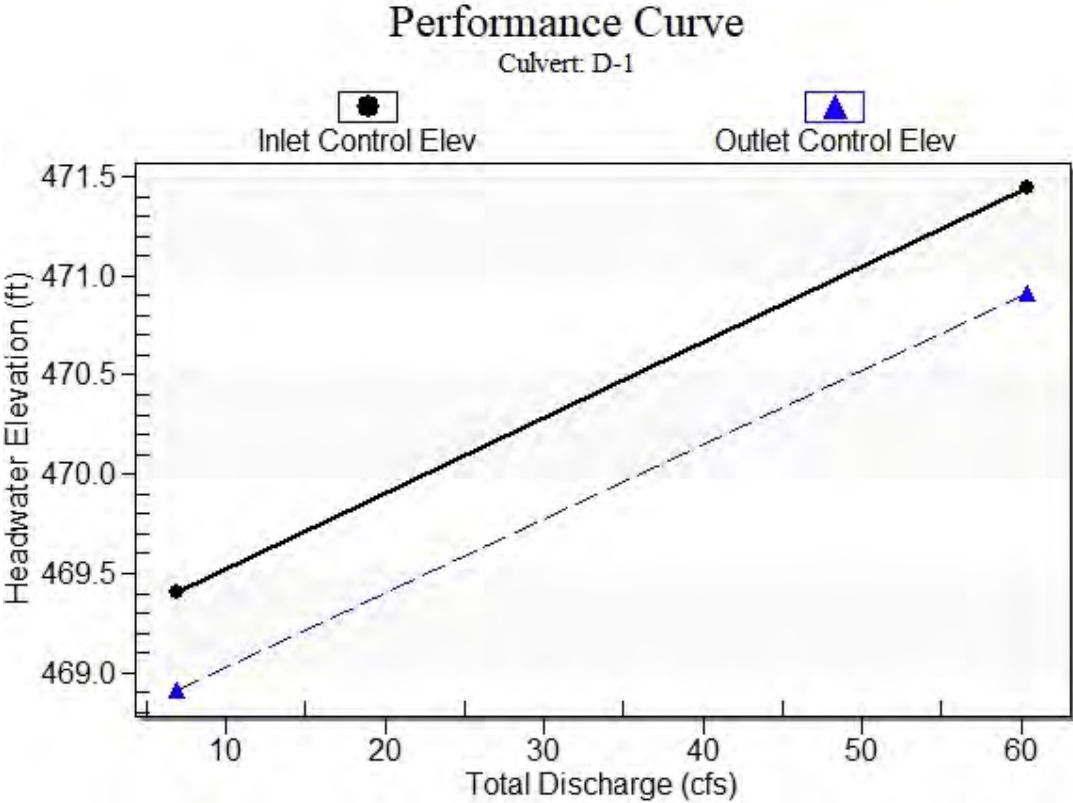
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612
6.92	6.92	469.40	0.552	0.061	1-S2n	0.199	0.328	0.213	0.308	4.995	2.612

Straight Culvert

Inlet Elevation (invert): 468.85 ft, Outlet Elevation (invert): 468.57 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0187

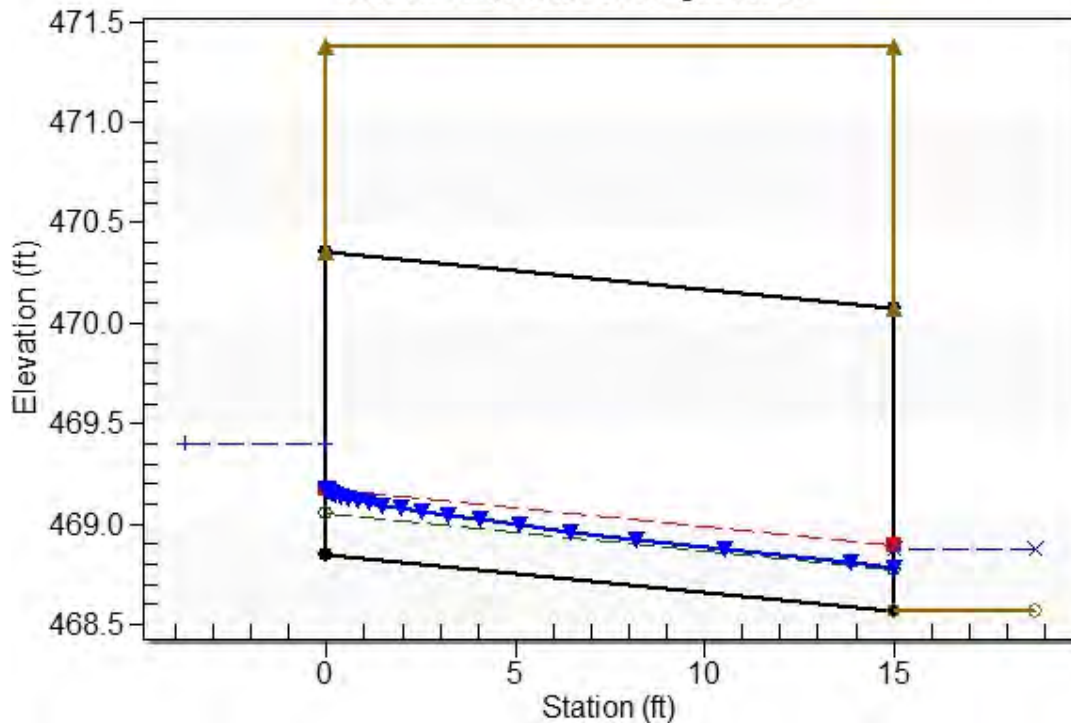
Culvert Performance Curve Plot: D-1



Water Surface Profile Plot for Culvert: D-1

Crossing - D-1 (100-YR), Design Discharge - 6.9 cfs

Culvert - D-1, Culvert Discharge - 6.9 cfs



Site Data - D-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 468.85 ft

Outlet Station: 15.00 ft

Outlet Elevation: 468.57 ft

Number of Barrels: 2

Culvert Data Summary - D-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: D-1 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86
6.92	468.88	0.31	2.61	0.29	0.86

Tailwater Channel Data - D-1 (100-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0300

Channel Invert Elevation: 468.57 ft

Roadway Data for Crossing: D-1 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 471.38 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 88.58 cfs

Design Flow: 88.58 cfs

Maximum Flow: 88.58 cfs

Table 4 - Summary of Culvert Flows at Crossing: E-3 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.40	88.58	88.58	0.00	1
446.42	89.05	89.05	0.00	Overtopping

Rating Curve Plot for Crossing: E-3 (100-YR)

Total Rating Curve

Crossing: E-3 (100-YR)

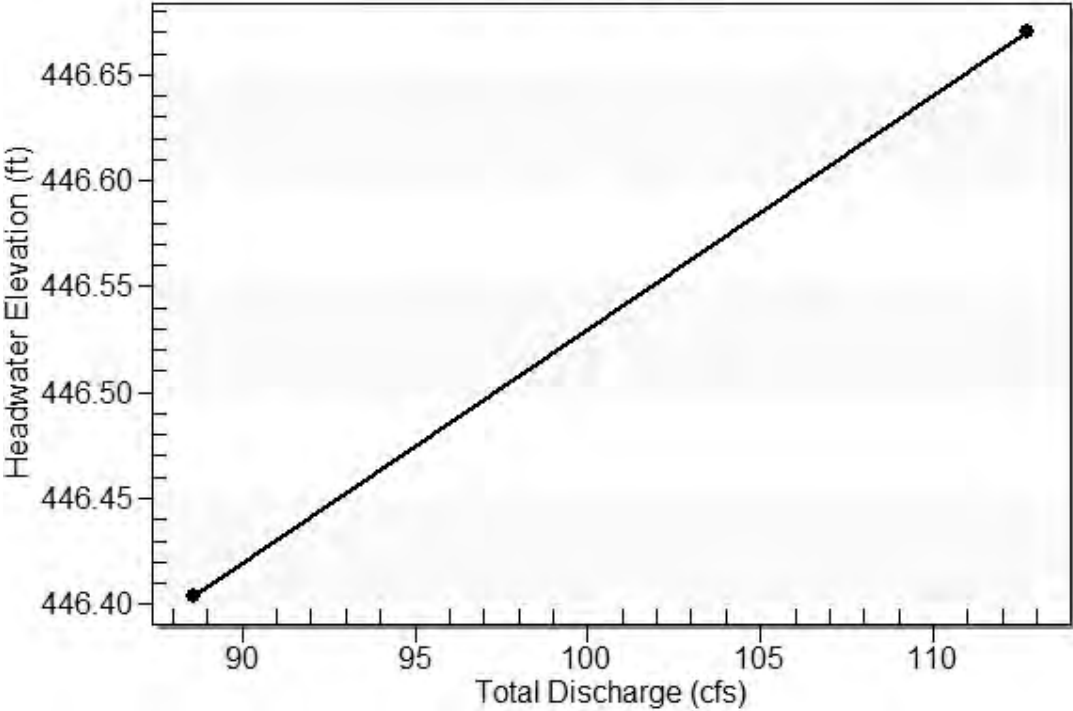


Table 5 - Culvert Summary Table: E-3

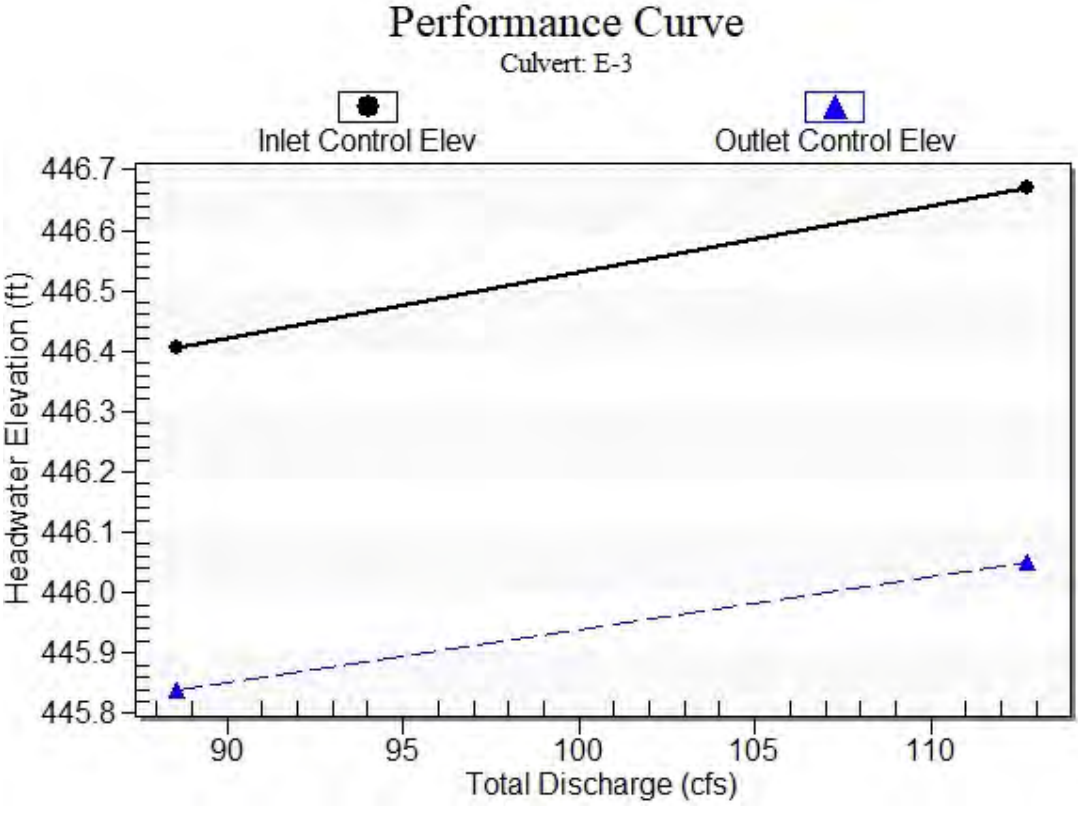
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815
88.58	88.58	446.40	3.004	2.438	5-S2n	0.943	1.654	1.268	1.240	9.517	6.815

Straight Culvert

Inlet Elevation (invert): 443.40 ft, Outlet Elevation (invert): 443.10 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

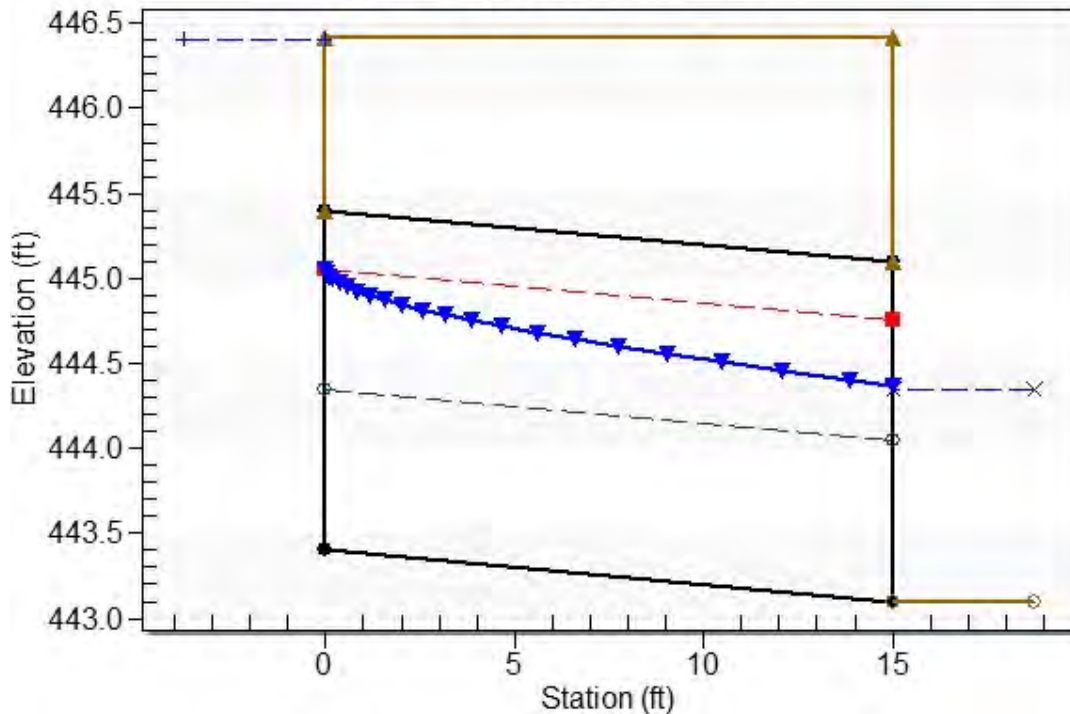
Culvert Performance Curve Plot: E-3



Water Surface Profile Plot for Culvert: E-3

Crossing - E-3 (100-YR), Design Discharge - 88.6 cfs

Culvert - E-3, Culvert Discharge - 88.6 cfs



Site Data - E-3

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 443.40 ft

Outlet Station: 15.00 ft

Outlet Elevation: 443.10 ft

Number of Barrels: 2

Culvert Data Summary - E-3

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: E-3 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20
88.58	444.34	1.24	6.81	1.55	1.20

Tailwater Channel Data - E-3 (100-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 443.10 ft

Roadway Data for Crossing: E-3 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 446.42 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 75.67 cfs

Design Flow: 75.67 cfs

Maximum Flow: 75.67 cfs

Table 7 - Summary of Culvert Flows at Crossing: E-4 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.34	75.67	75.67	0.00	1
441.76	89.04	89.04	0.00	Overtopping

Rating Curve Plot for Crossing: E-4 (100-YR)

Total Rating Curve

Crossing: E-4 (100-YR)

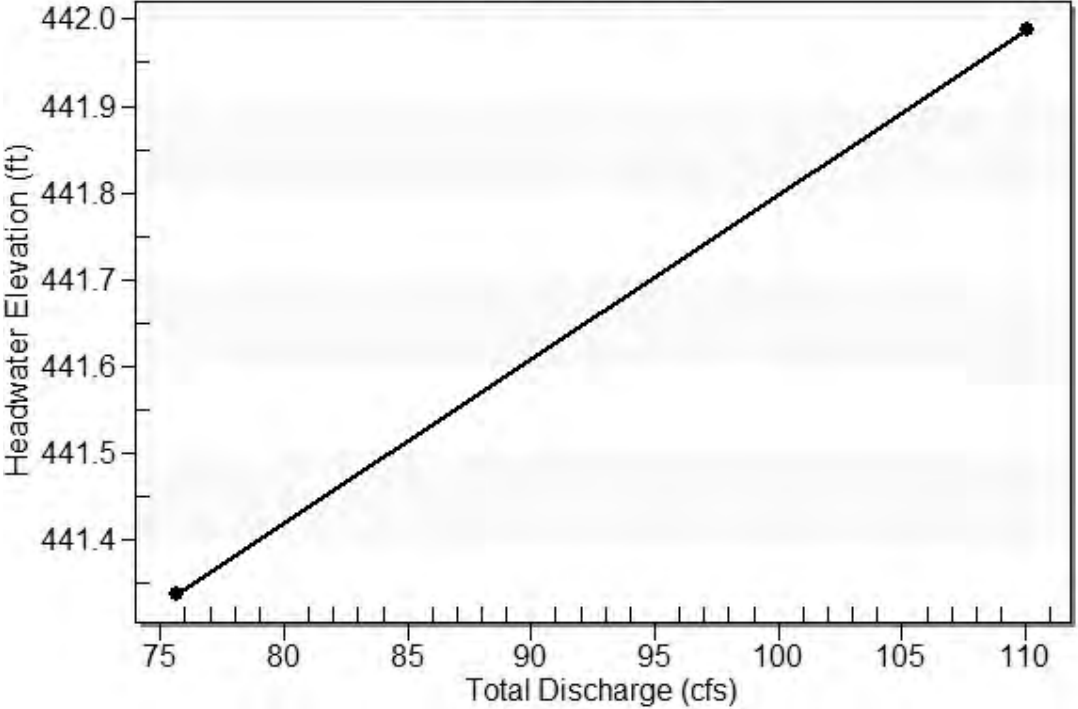


Table 8 - Culvert Summary Table: E-4

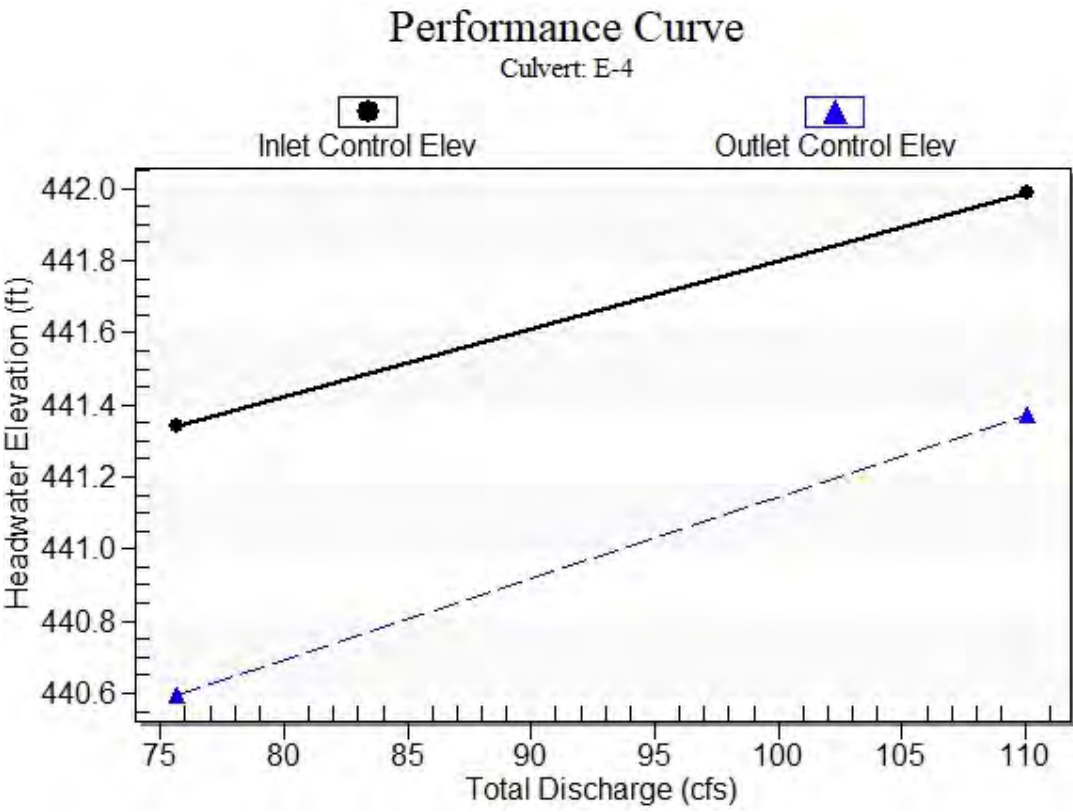
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490
75.67	75.67	441.34	2.599	1.854	5-S2n	0.846	1.489	1.127	1.135	9.150	6.490

Straight Culvert

Inlet Elevation (invert): 438.74 ft, Outlet Elevation (invert): 438.44 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

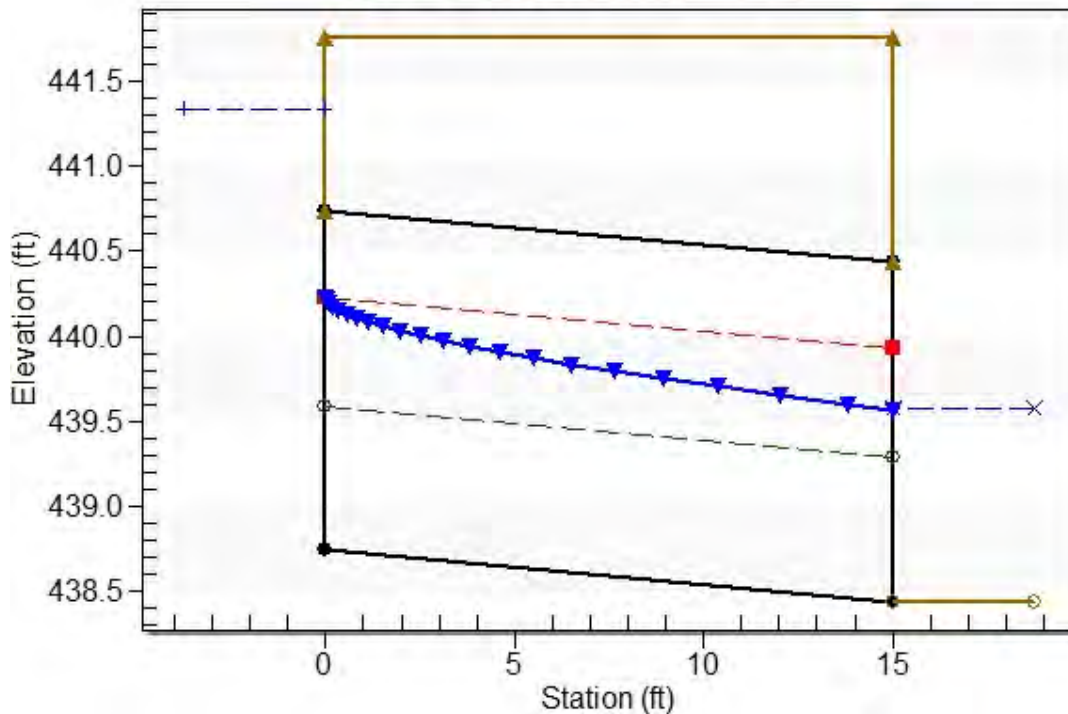
Culvert Performance Curve Plot: E-4



Water Surface Profile Plot for Culvert: E-4

Crossing - E-4 (100-YR), Design Discharge - 75.7 cfs

Culvert - E-4, Culvert Discharge - 75.7 cfs



Site Data - E-4

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 438.74 ft

Outlet Station: 15.00 ft

Outlet Elevation: 438.44 ft

Number of Barrels: 2

Culvert Data Summary - E-4

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: E-4 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19
75.67	439.58	1.14	6.49	1.42	1.19

Tailwater Channel Data - E-4 (100-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 438.44 ft

Roadway Data for Crossing: E-4 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 441.76 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 19.92 cfs

Design Flow: 19.92 cfs

Maximum Flow: 19.92 cfs

Table 10 - Summary of Culvert Flows at Crossing: E-5 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-5 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
442.22	19.92	19.92	0.00	1
443.63	56.79	56.79	0.00	Overtopping

Rating Curve Plot for Crossing: E-5 (100-YR)

Total Rating Curve

Crossing: E-5 (100-YR)

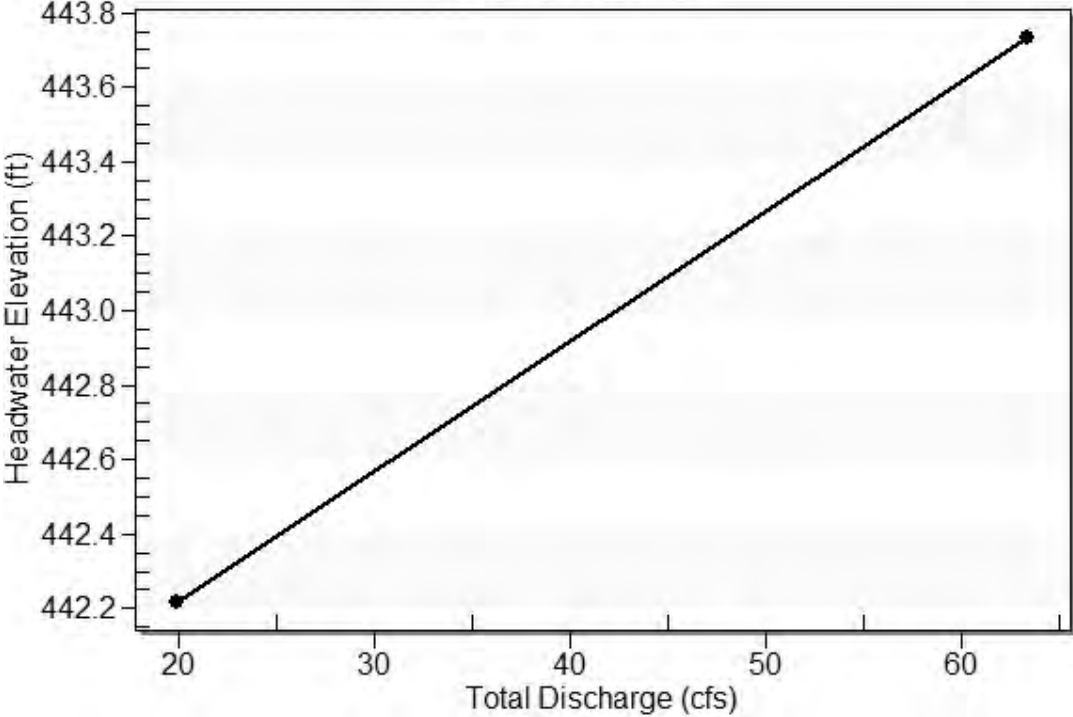


Table 11 - Culvert Summary Table: E-5

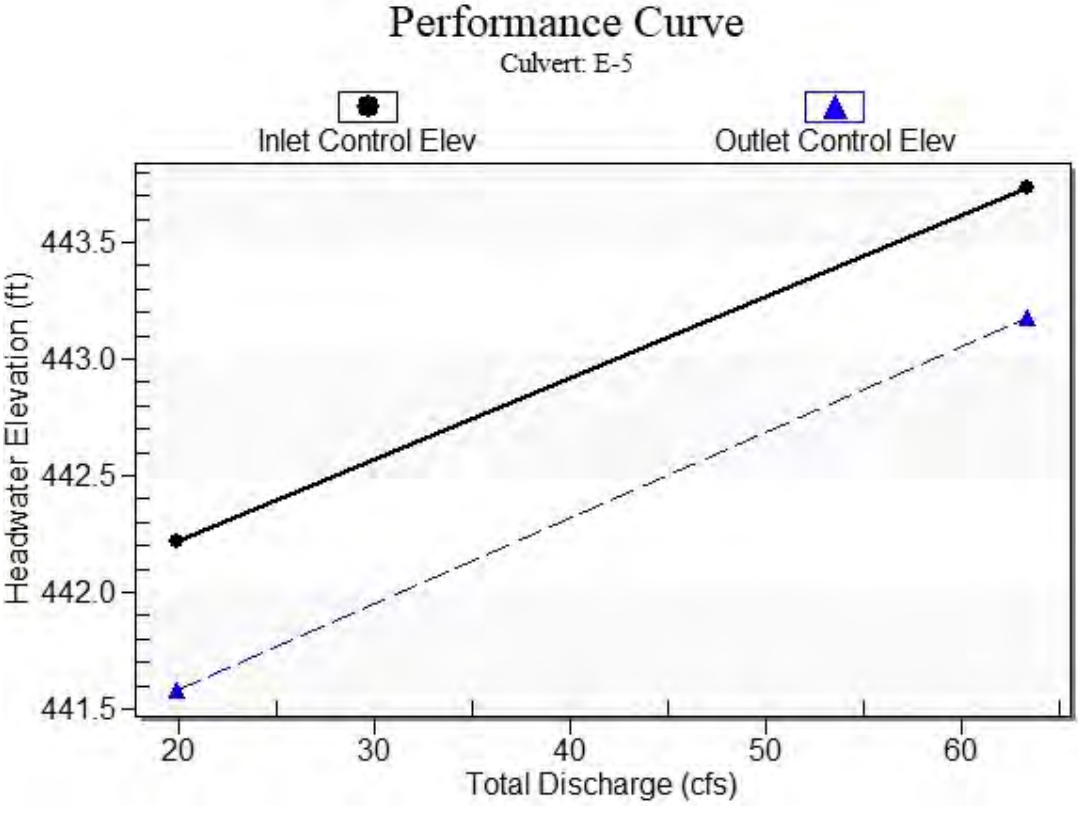
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392
19.92	19.92	442.22	1.109	0.470	1-S2n	0.382	0.663	0.454	0.567	6.750	4.392

Straight Culvert

Inlet Elevation (invert): 441.11 ft, Outlet Elevation (invert): 440.81 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

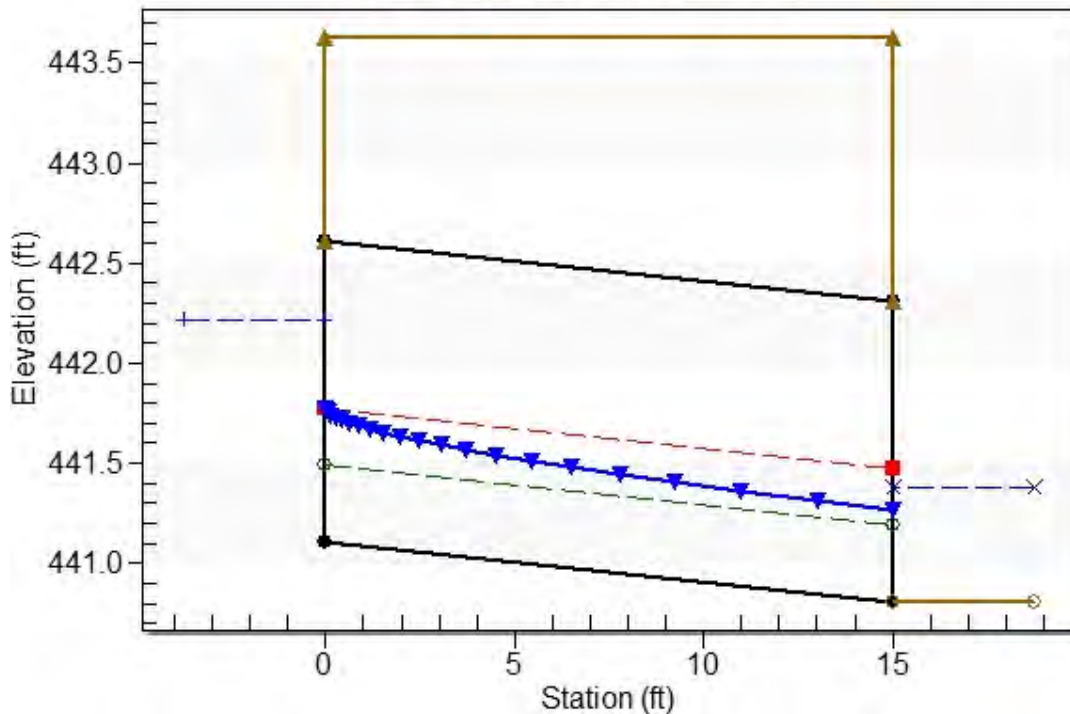
Culvert Performance Curve Plot: E-5



Water Surface Profile Plot for Culvert: E-5

Crossing - E-5 (100-YR), Design Discharge - 19.9 cfs

Culvert - E-5, Culvert Discharge - 19.9 cfs



Site Data - E-5

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 441.11 ft

Outlet Station: 15.00 ft

Outlet Elevation: 440.81 ft

Number of Barrels: 2

Culvert Data Summary - E-5

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: E-5 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03
19.92	441.38	0.57	4.39	0.71	1.03

Tailwater Channel Data - E-5 (100-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 440.81 ft

Roadway Data for Crossing: E-5 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 443.63 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 10.09 cfs

Design Flow: 10.09 cfs

Maximum Flow: 10.09 cfs

Table 13 - Summary of Culvert Flows at Crossing: A-1 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	A-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
470.69	10.09	10.09	0.00	1
472.61	58.91	58.91	0.00	Overtopping

Rating Curve Plot for Crossing: A-1 (100-YR)

Total Rating Curve

Crossing: A-1 (100-YR)

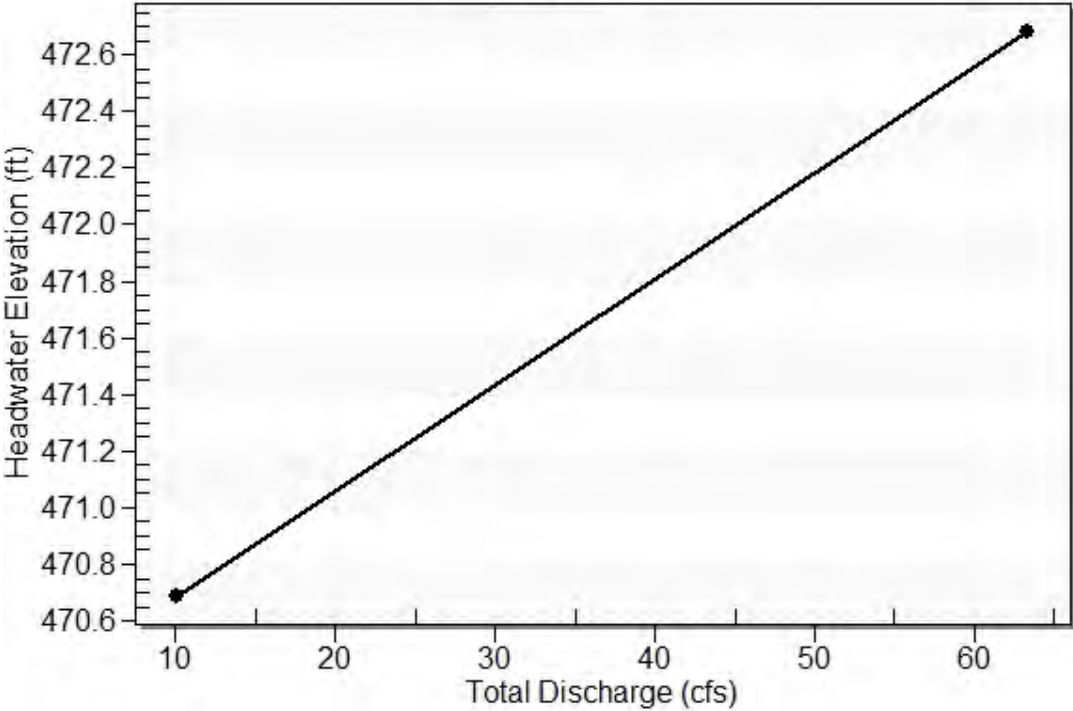


Table 14 - Culvert Summary Table: A-1

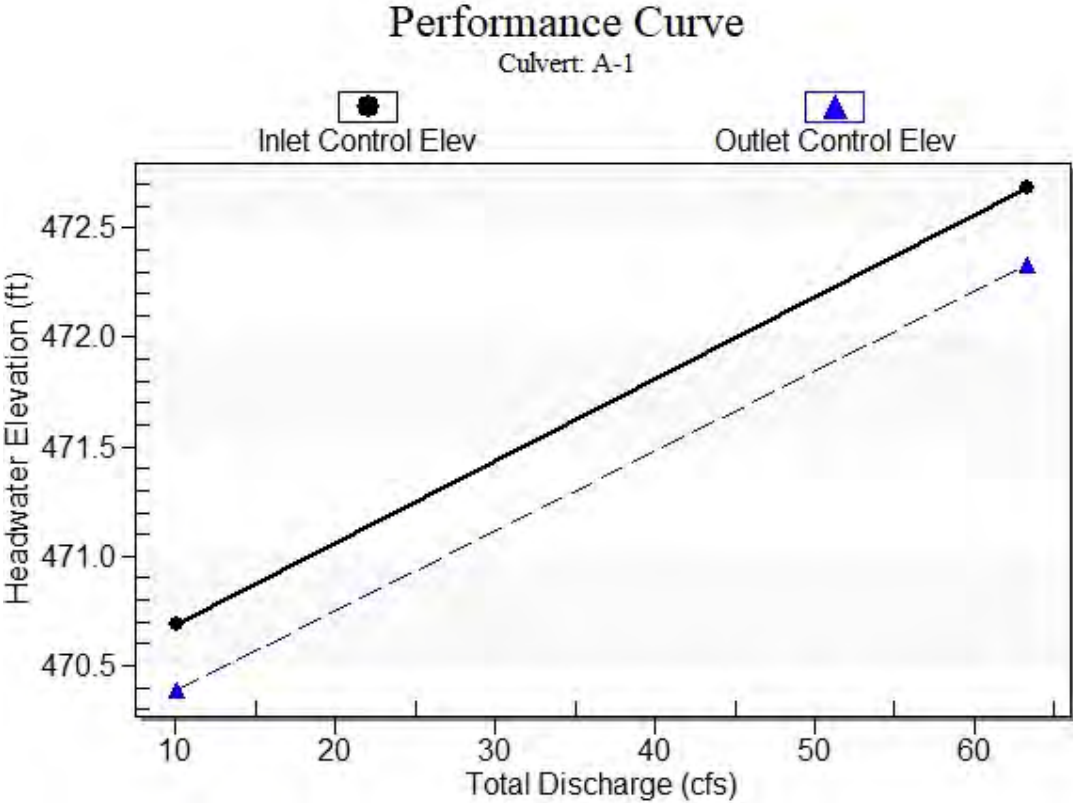
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744
10.09	10.09	470.69	0.720	0.417	1-JS1t	0.394	0.421	0.460	0.460	3.377	2.744

Straight Culvert

Inlet Elevation (invert): 469.97 ft, Outlet Elevation (invert): 469.90 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0047

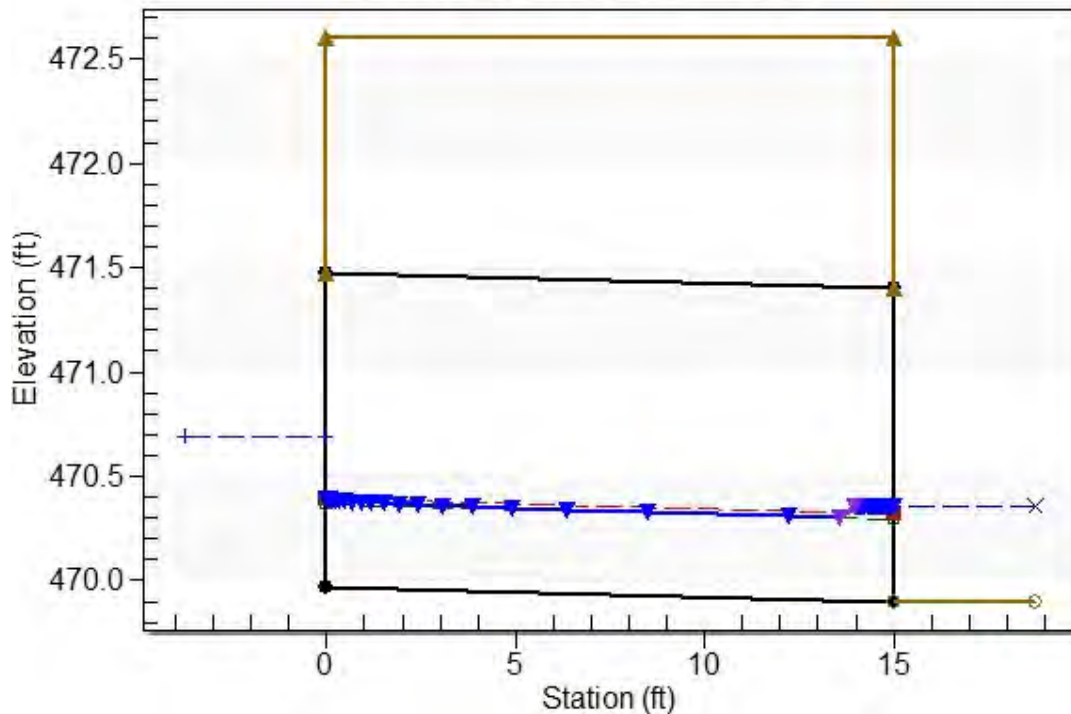
Culvert Performance Curve Plot: A-1



Water Surface Profile Plot for Culvert: A-1

Crossing - A-1 (100-YR), Design Discharge - 10.1 cfs

Culvert - A-1, Culvert Discharge - 10.1 cfs



Site Data - A-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 469.97 ft

Outlet Station: 15.00 ft

Outlet Elevation: 469.90 ft

Number of Barrels: 2

Culvert Data Summary - A-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: A-1 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71
10.09	470.36	0.46	2.74	0.29	0.71

Tailwater Channel Data - A-1 (100-YR)

Tailwater Channel Option: Rectangular Channel
Bottom Width: 8.00 ft
Channel Slope: 0.0100
Channel Manning's n: 0.0300
Channel Invert Elevation: 469.90 ft

Roadway Data for Crossing: A-1 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 50.00 ft
Crest Elevation: 472.61 ft
Roadway Surface: Gravel
Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 26.36 cfs

Design Flow: 26.36 cfs

Maximum Flow: 26.36 cfs

Table 16 - Summary of Culvert Flows at Crossing: E-2 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
457.78	26.36	26.36	0.00	1
458.96	56.79	56.79	0.00	Overtopping

Rating Curve Plot for Crossing: E-2 (100-YR)

Total Rating Curve

Crossing: E-2 (100-YR)

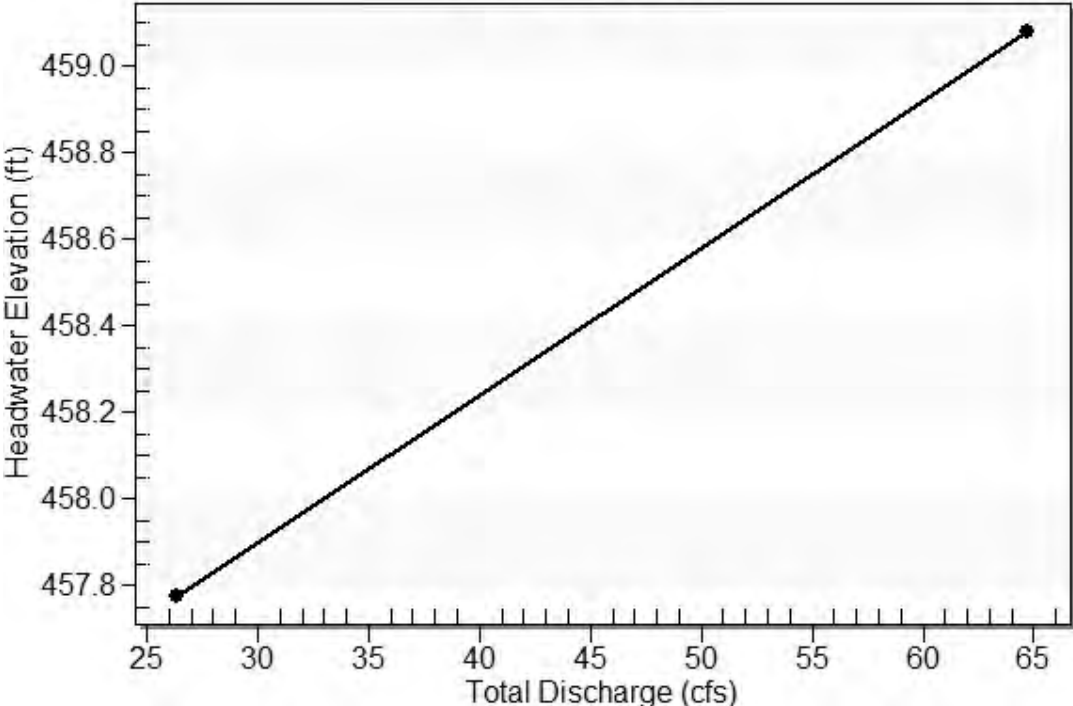


Table 17 - Culvert Summary Table: E-2

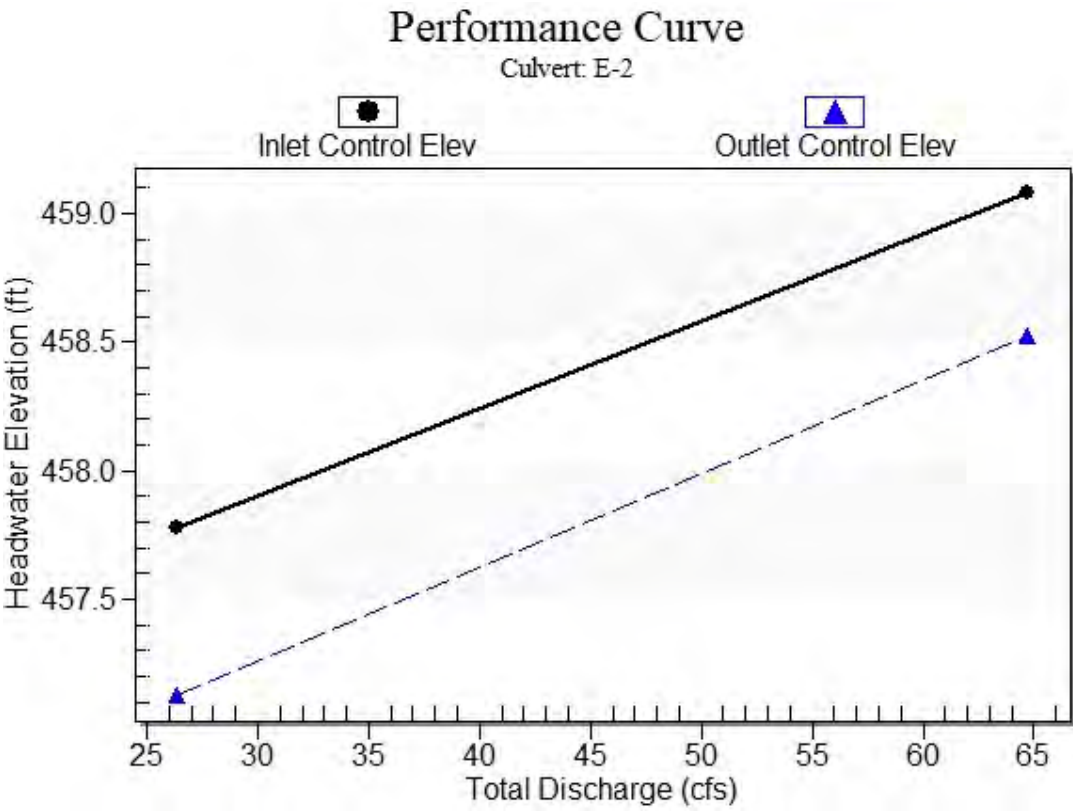
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599
26.36	26.36	457.78	1.338	0.687	1-S2n	0.459	0.799	0.560	0.620	7.236	4.599

Straight Culvert

Inlet Elevation (invert): 456.44 ft, Outlet Elevation (invert): 456.14 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

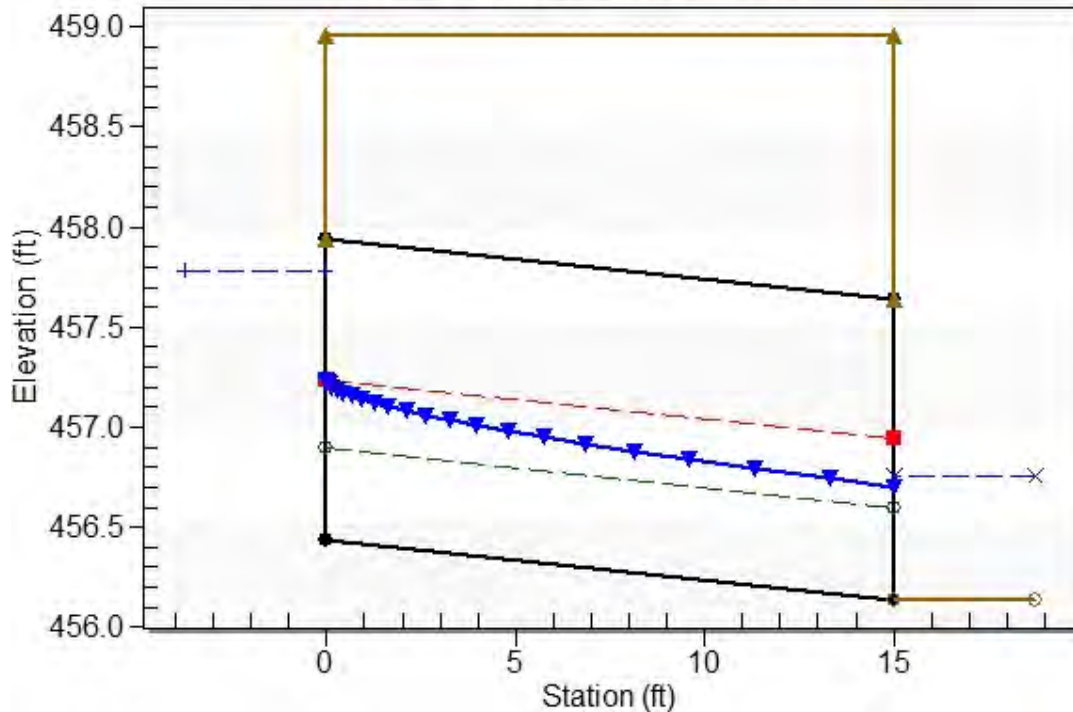
Culvert Performance Curve Plot: E-2



Water Surface Profile Plot for Culvert: E-2

Crossing - E-2 (100-YR), Design Discharge - 26.4 cfs

Culvert - E-2, Culvert Discharge - 26.4 cfs



Site Data - E-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 456.44 ft

Outlet Station: 15.00 ft

Outlet Elevation: 456.14 ft

Number of Barrels: 2

Culvert Data Summary - E-2

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: E-2 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10
26.36	456.76	0.62	4.60	0.77	1.10

Tailwater Channel Data - E-2 (100-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 456.14 ft

Roadway Data for Crossing: E-2 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 458.96 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 12.62 cfs

Design Flow: 12.62 cfs

Maximum Flow: 12.62 cfs

Table 19 - Summary of Culvert Flows at Crossing: E-1 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	E-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
463.79	12.62	12.62	0.00	1
465.56	58.18	58.18	0.00	Overtopping

Rating Curve Plot for Crossing: E-1 (100-YR)

Total Rating Curve

Crossing: E-1 (100-YR)

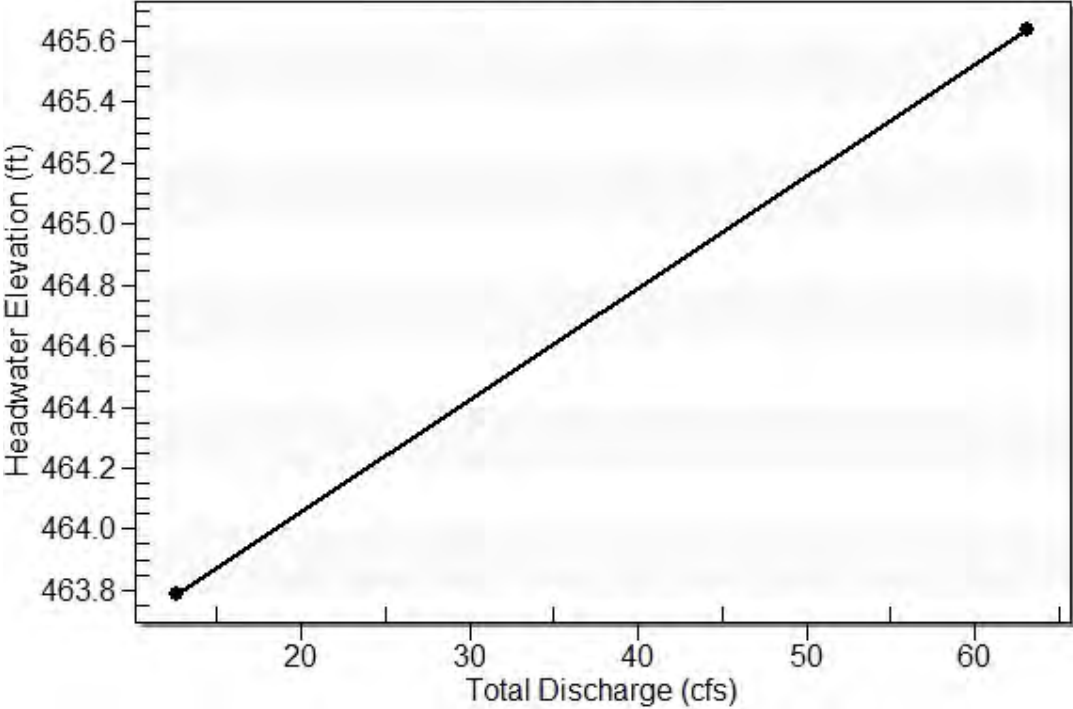


Table 20 - Culvert Summary Table: E-1

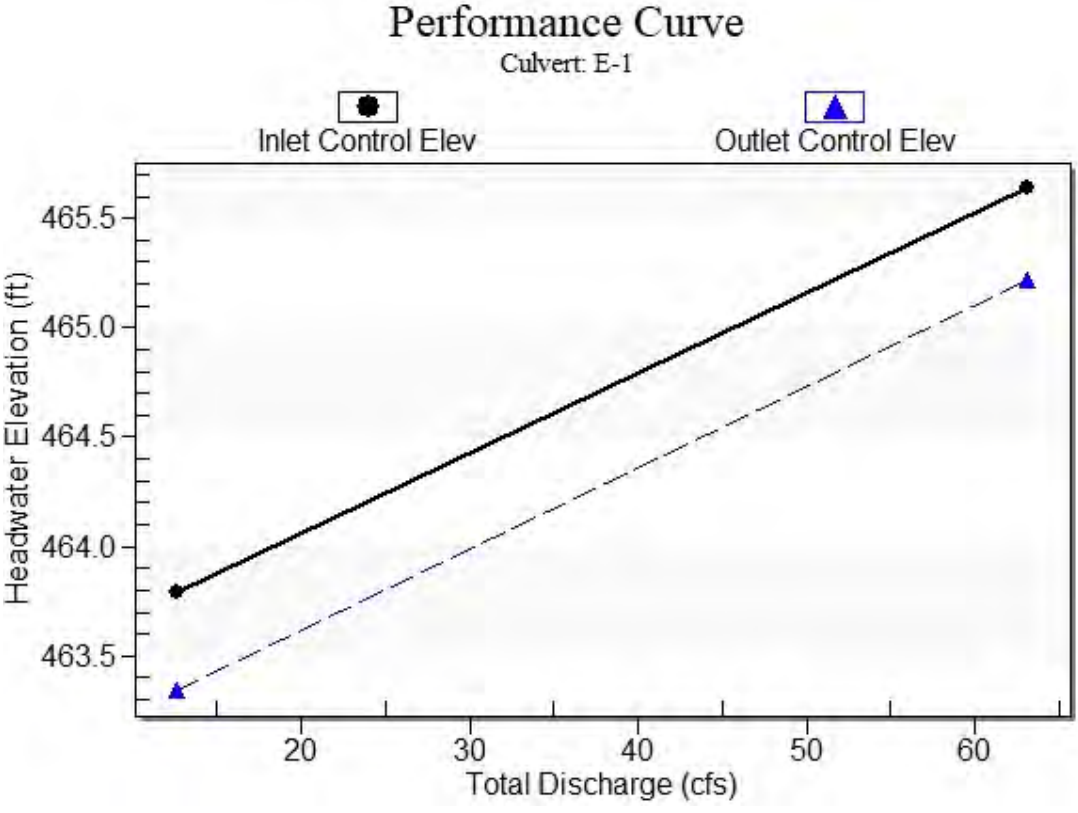
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706
12.62	12.62	463.79	0.829	0.382	1-S2n	0.355	0.489	0.382	0.426	5.082	3.706

Straight Culvert

Inlet Elevation (invert): 462.96 ft, Outlet Elevation (invert): 462.81 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0100

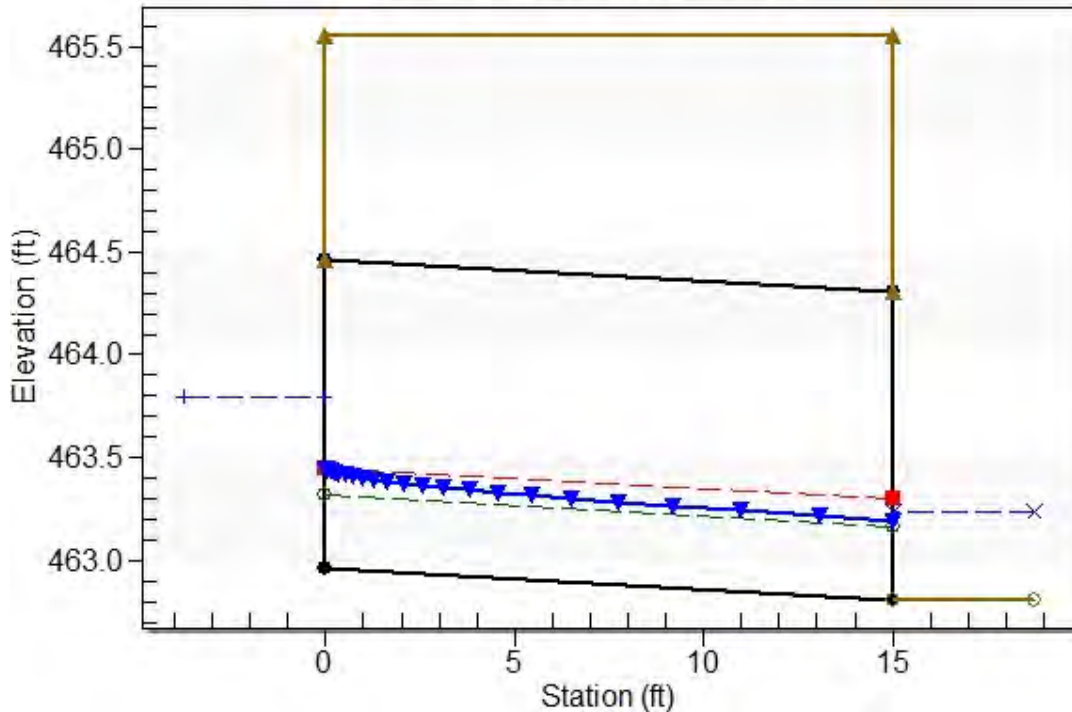
Culvert Performance Curve Plot: E-1



Water Surface Profile Plot for Culvert: E-1

Crossing - E-1 (100-YR), Design Discharge - 12.6 cfs

Culvert - E-1, Culvert Discharge - 12.6 cfs



Site Data - E-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 462.96 ft

Outlet Station: 15.00 ft

Outlet Elevation: 462.81 ft

Number of Barrels: 2

Culvert Data Summary - E-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: E-1 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00
12.62	463.24	0.43	3.71	0.53	1.00

Tailwater Channel Data - E-1 (100-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 462.81 ft

Roadway Data for Crossing: E-1 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 465.56 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 37.835 cfs

Design Flow: 37.835 cfs

Maximum Flow: 37.835 cfs

Table 22 - Summary of Culvert Flows at Crossing: 13-1 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	13-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.15	37.84	37.84	0.00	1
450.83	54.70	54.70	0.00	Overtopping

Rating Curve Plot for Crossing: 13-1 (100-YR)

Total Rating Curve

Crossing: 13-1 (100-YR)

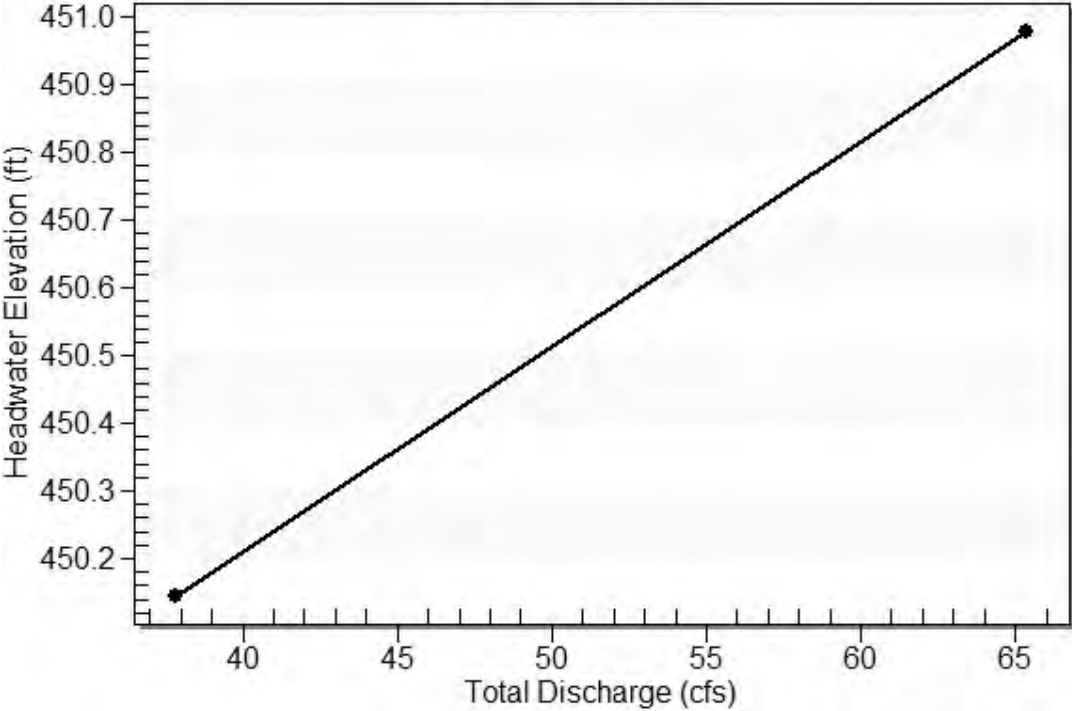


Table 23 - Culvert Summary Table: 13-1

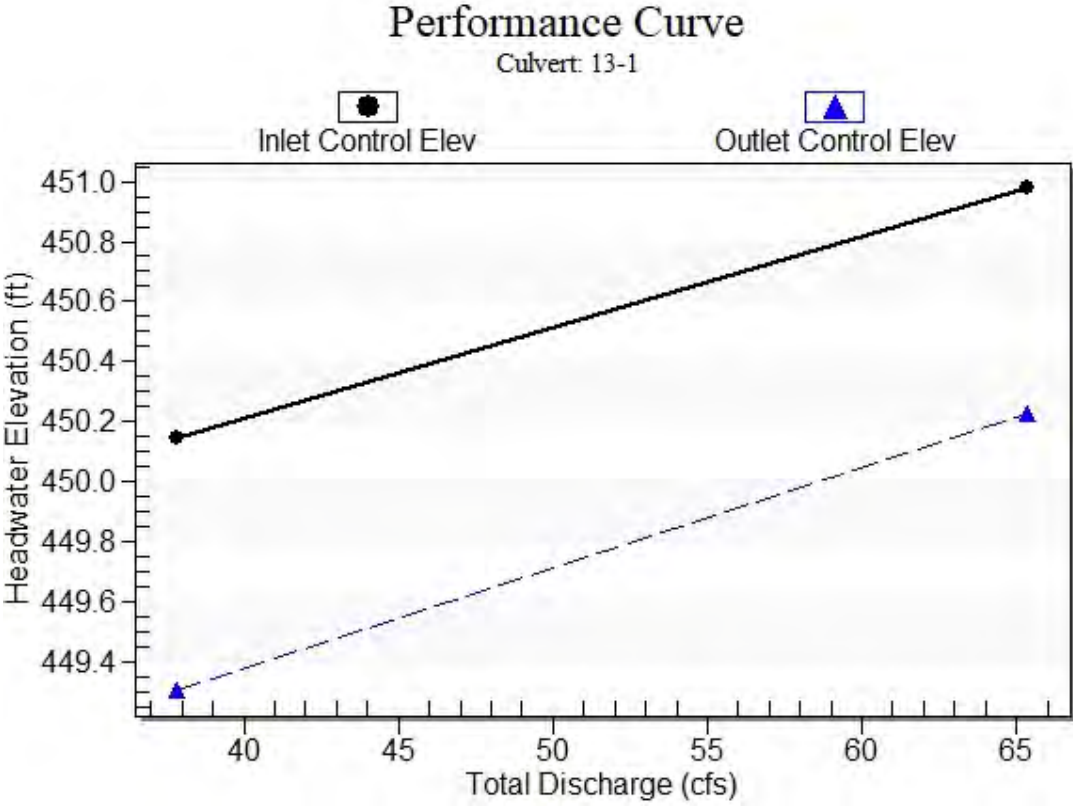
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192
37.84	37.84	450.15	1.726	0.884	5-S2n	0.485	1.017	0.652	0.765	8.930	5.192

Straight Culvert

Inlet Elevation (invert): 448.42 ft, Outlet Elevation (invert): 447.90 ft

Culvert Length: 15.01 ft, Culvert Slope: 0.0347

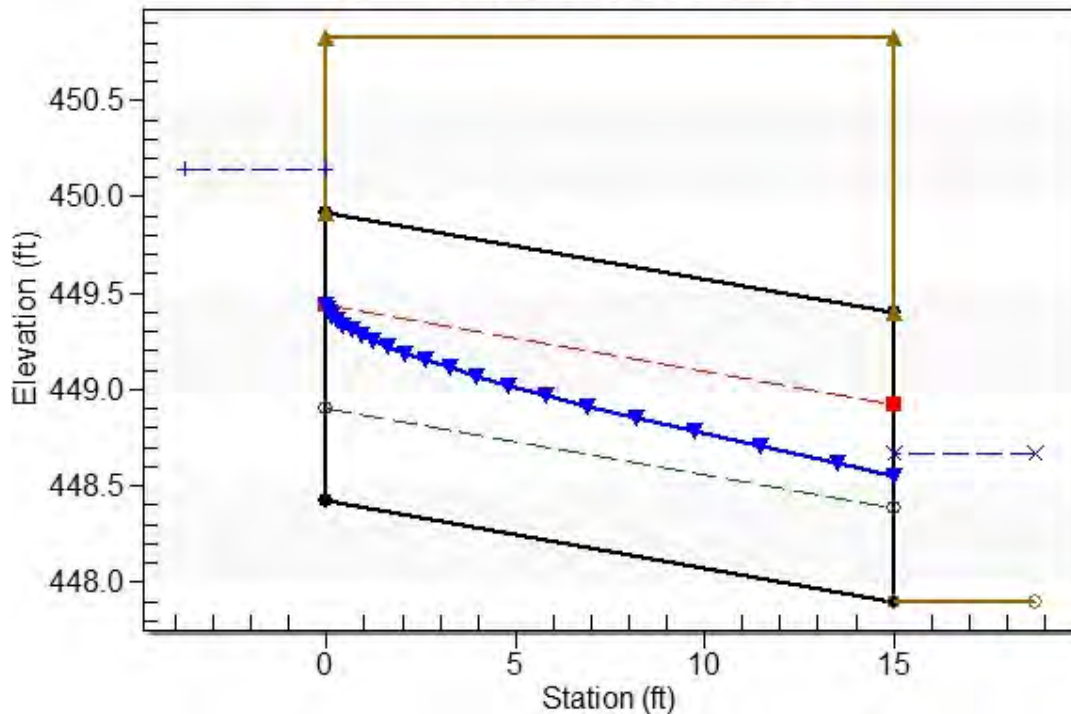
Culvert Performance Curve Plot: 13-1



Water Surface Profile Plot for Culvert: 13-1

Crossing - 13-1 (100-YR) , Design Discharge - 37.8 cfs

Culvert - 13-1, Culvert Discharge - 37.8 cfs



Site Data - 13-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 448.42 ft

Outlet Station: 15.00 ft

Outlet Elevation: 447.90 ft

Number of Barrels: 2

Culvert Data Summary - 13-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: 13-1 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13
37.84	448.66	0.76	5.19	0.95	1.13

Tailwater Channel Data - 13-1 (100-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0200

Channel Manning's n: 0.0300

Channel Invert Elevation: 447.90 ft

Roadway Data for Crossing: 13-1 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 450.83 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 28.975 cfs

Design Flow: 28.975 cfs

Maximum Flow: 28.975 cfs

Table 25 - Summary of Culvert Flows at Crossing: 16-1 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	16-1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
465.25	28.98	28.98	0.00	1
466.34	56.80	56.80	0.00	Overtopping

Rating Curve Plot for Crossing: 16-1 (100-YR)

Total Rating Curve

Crossing: 16-1 (100-YR)

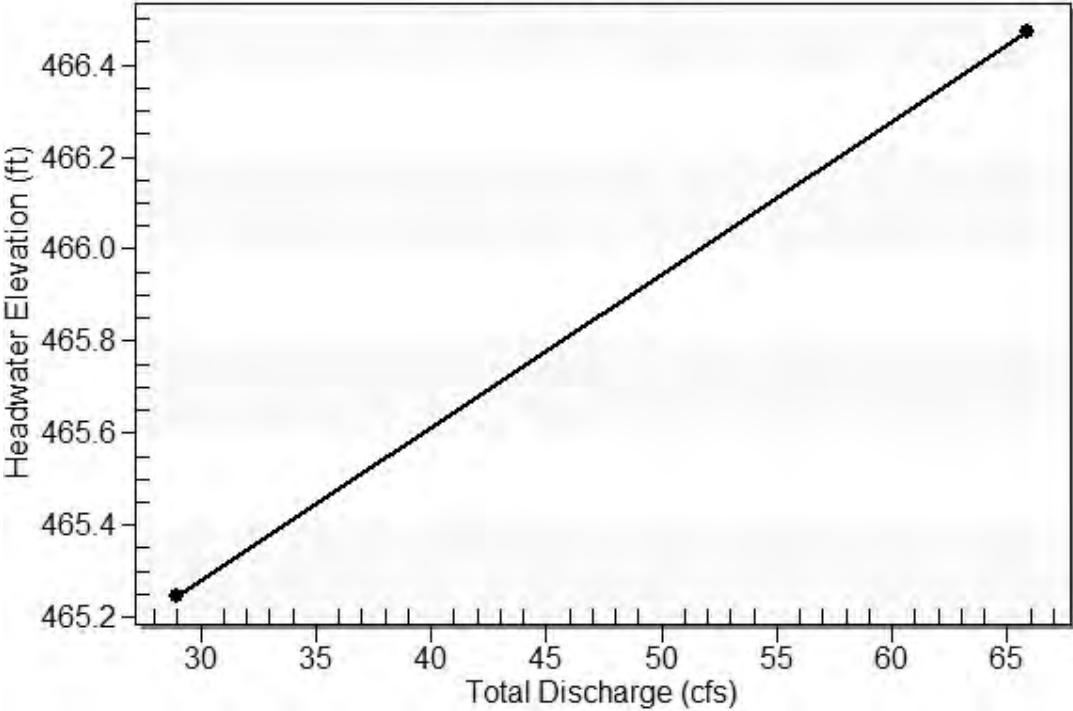


Table 26 - Culvert Summary Table: 16-1

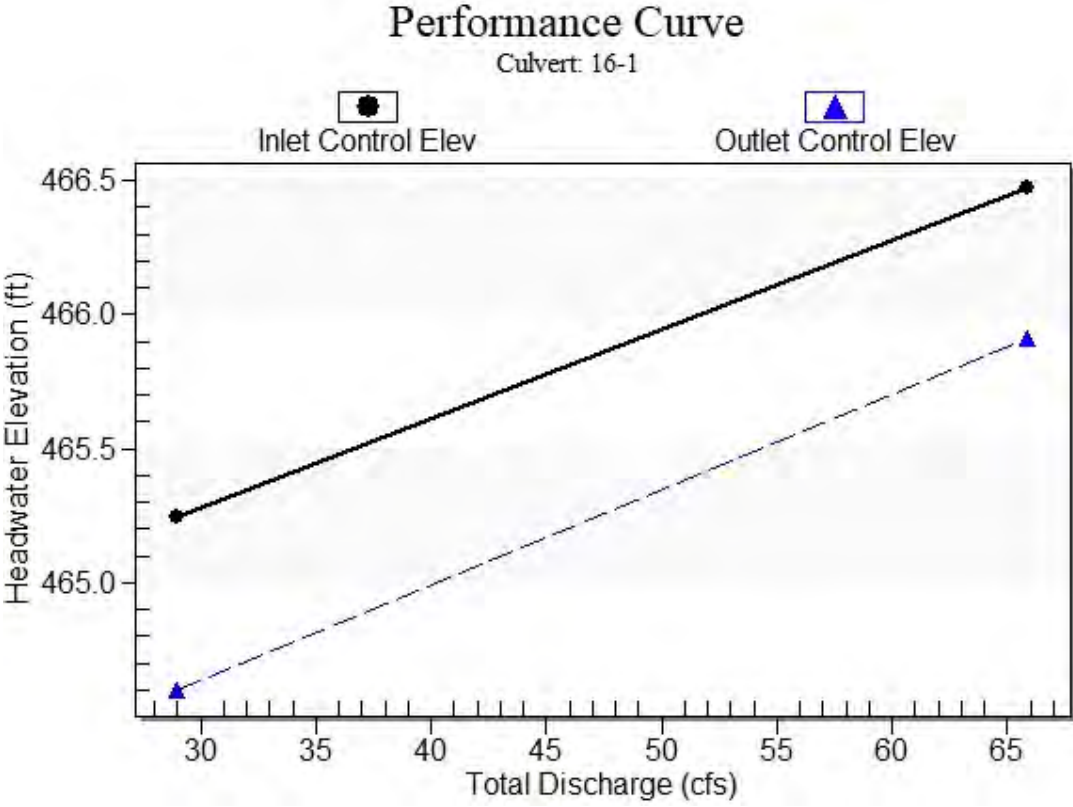
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429
28.98	28.98	465.25	1.428	0.778	1-S2n	0.488	0.851	0.602	0.582	7.406	5.429

Straight Culvert

Inlet Elevation (invert): 463.82 ft, Outlet Elevation (invert): 463.52 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0200

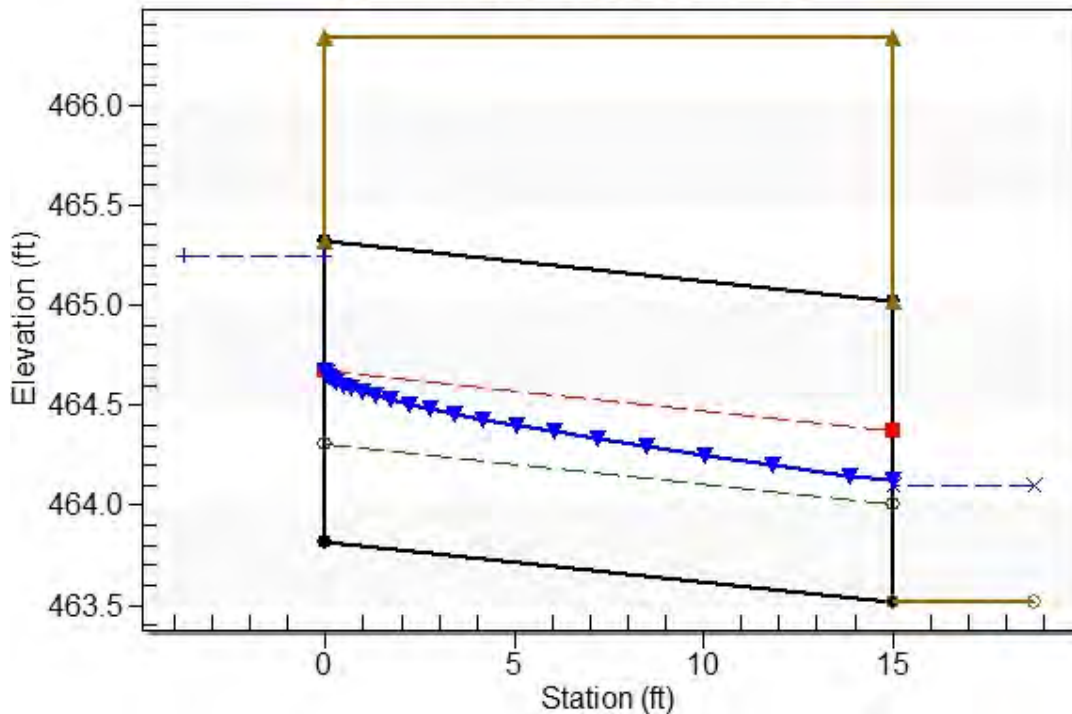
Culvert Performance Curve Plot: 16-1



Water Surface Profile Plot for Culvert: 16-1

Crossing - 16-1 (100-YR) , Design Discharge - 29.0 cfs

Culvert - 16-1, Culvert Discharge - 29.0 cfs



Site Data - 16-1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 463.82 ft

Outlet Station: 15.00 ft

Outlet Elevation: 463.52 ft

Number of Barrels: 2

Culvert Data Summary - 16-1

Barrel Shape: Concrete Box

Barrel Span: 3.25 ft

Barrel Rise: 1.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 27 - Downstream Channel Rating Curve (Crossing: 16-1 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33
28.98	464.10	0.58	5.43	1.09	1.33

Tailwater Channel Data - 16-1 (100-YR)

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 8.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0300

Channel Manning's n: 0.0300

Channel Invert Elevation: 463.52 ft

Roadway Data for Crossing: 16-1 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 466.34 ft

Roadway Surface: Gravel

Roadway Top Width: 15.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 72.61 cfs

Design Flow: 72.61 cfs

Maximum Flow: 72.61 cfs

Table 28 - Summary of Culvert Flows at Crossing: A-2 (100-YR)

Headwater Elevation (ft)	Total Discharge (cfs)	A-2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.14	72.61	72.61	0.00	1
431.66	89.30	89.30	0.00	Overtopping

Rating Curve Plot for Crossing: A-2 (100-YR)

Total Rating Curve

Crossing: A-2 (100-YR)

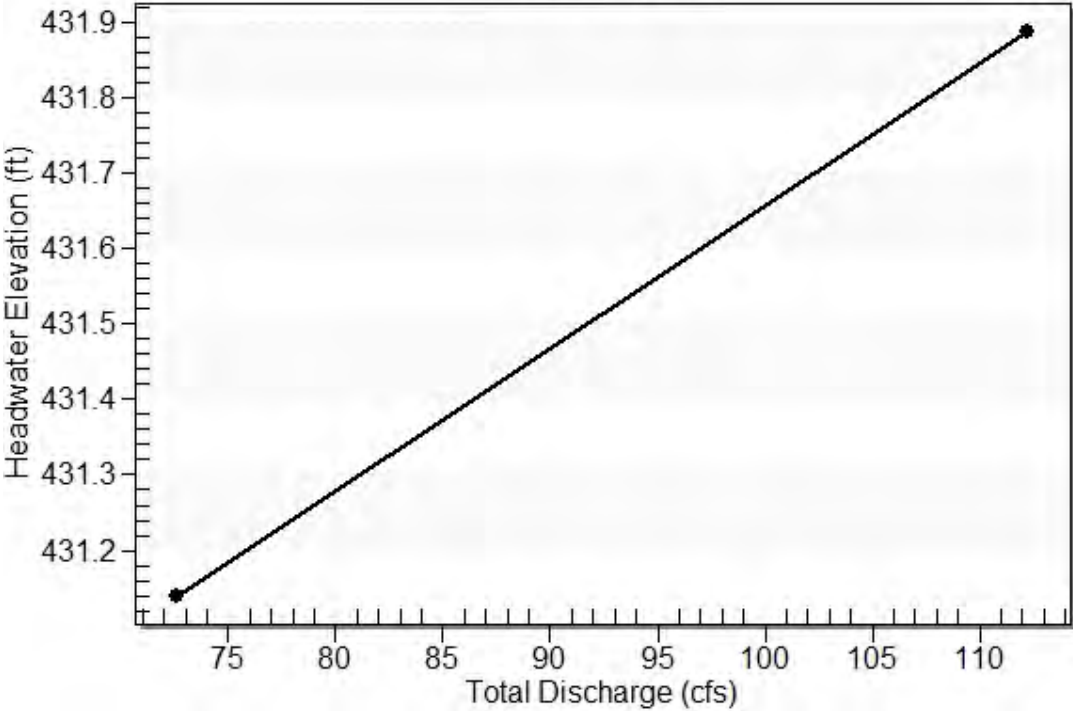


Table 29 - Culvert Summary Table: A-2

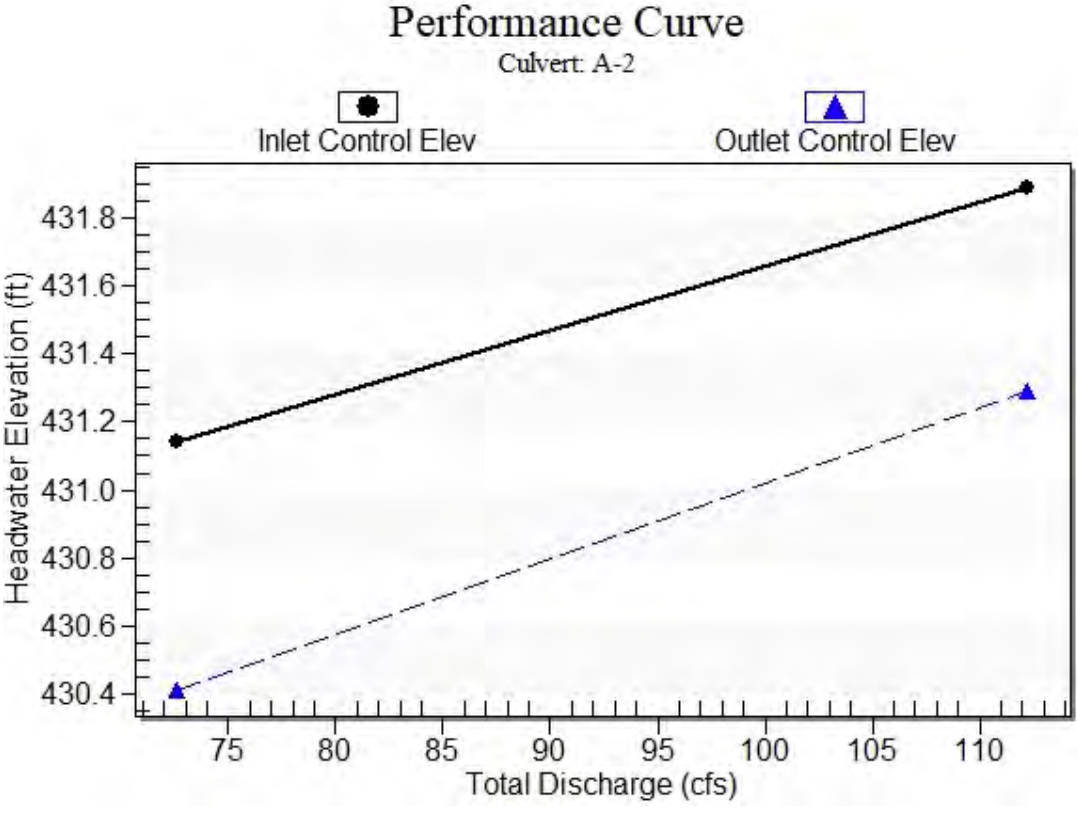
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048
72.61	72.61	431.14	2.510	1.781	5-S2n	0.842	1.448	1.106	0.302	8.946	30.048

Straight Culvert

Inlet Elevation (invert): 428.63 ft, Outlet Elevation (invert): 428.35 ft

Culvert Length: 15.00 ft, Culvert Slope: 0.0187

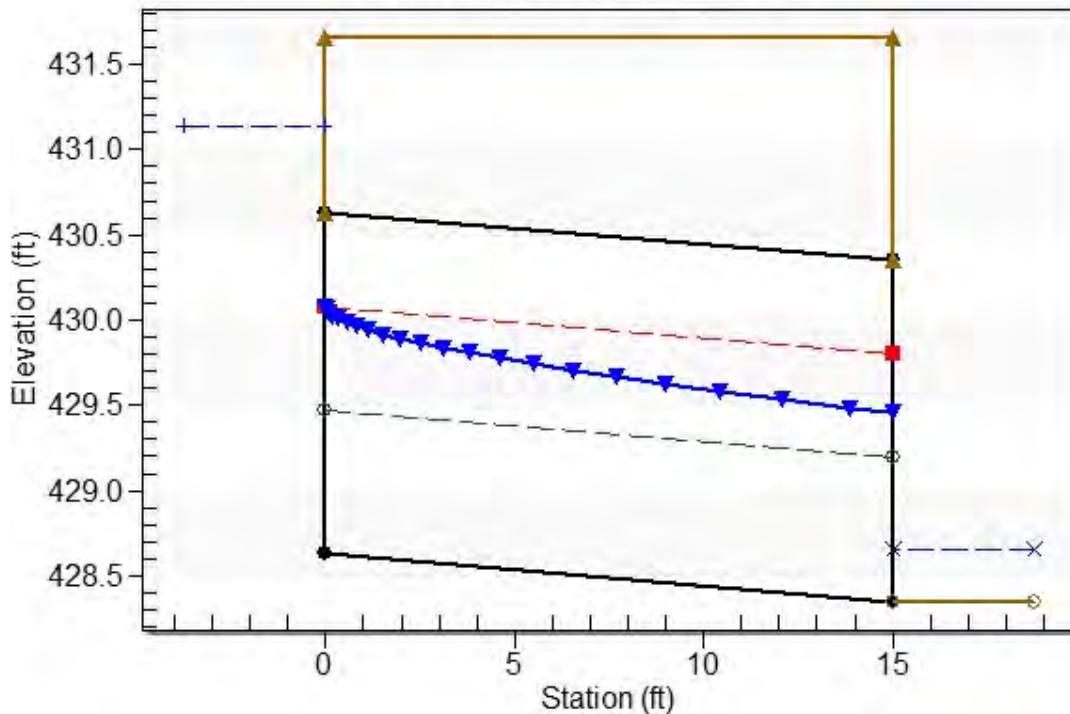
Culvert Performance Curve Plot: A-2



Water Surface Profile Plot for Culvert: A-2

Crossing - A-2 (100-YR), Design Discharge - 72.6 cfs

Culvert - A-2, Culvert Discharge - 72.6 cfs



Site Data - A-2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 428.63 ft

Outlet Station: 15.00 ft

Outlet Elevation: 428.35 ft

Number of Barrels: 2

Culvert Data Summary - A-2

Barrel Shape: Concrete Box

Barrel Span: 3.67 ft

Barrel Rise: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90°) Headwall

Inlet Depression: None

Table 30 - Downstream Channel Rating Curve (Crossing: A-2 (100-YR))

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63
72.61	428.65	0.30	30.05	37.70	9.63

Tailwater Channel Data - A-2 (100-YR)

Tailwater Channel Option: Rectangular Channel

Bottom Width: 8.00 ft

Channel Slope: 2.0000

Channel Manning's n: 0.0300

Channel Invert Elevation: 428.35 ft

Roadway Data for Crossing: A-2 (100-YR)

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 431.66 ft

Roadway Surface: Paved

Roadway Top Width: 15.00 ft

Attachment K3

Erosion and Sediment Control Report

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Gude Landfill Remediation Design Montgomery County, Maryland

Sediment Control Report

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

Professional Certification: I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed Professional Engineer under the laws of the State of Maryland.

License No. 23402

Expiration Date: 25 August 2022

December 2020
EA Project No. 15646.01

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Gude Landfill Remediation Design Montgomery County, Maryland

Sediment Control Report

Prepared for

Northeast Maryland Waste Disposal Authority and
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Recycling and Resource Management Division
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Hunt Valley, Maryland 21031
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December 2020
EA Project No. 15646.01

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<u>Number</u>	<u>Title</u>
1	Location and Vicinity Map

LIST OF ACRONYMS AND ABBREVIATIONS

the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
ft	Foot (Feet)
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
MDE	Maryland Department of the Environment
TGOS	Temporary Gabion Outlet Structure
TSOS	Temporary Stone Outlet Structure

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1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has been contracted to provide engineering, permitting, and support services for developing a remediation design to address the remedial action objectives at the Gude Landfill (“the Landfill”) in order to achieve compliance with the consent order for the Landfill (Maryland Department of the Environment [MDE] and Montgomery County 2013). This report summarizes the sediment control design requirements for the Gude Landfill site. The stormwater management design is discussed in the *Stormwater Management Design Report* (EA 2020), under separate cover.

1.1 SITE INFORMATION

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. Refer to **Figure 1** for a vicinity and location map. The site is accessed at two locations: East Gude Drive from the south-southwest and Southlawn Lane from the east-southeast.

The Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. An additional 17 acres of waste disposal area were delineated in 2009 on Maryland-National Capital Park and Planning Commission (M-NCPPC) property, beyond the northeastern property boundary of the Landfill. A land exchange between the County and M-NCPPC on October 21, 2014, transferred ownership of this additional waste disposal area to the County in exchange for a similar area of land without waste, which was transferred to M-NCPPC.

Landfill capping was selected as a corrective measure for the upper surface of the Landfill, as well as portions of the side slopes of the Landfill where placement of a closure capping system is feasible. EA’s project design includes the following major elements as part of the corrective measure:

- Erosion and sediment control,
- Existing waste reconfiguration and subgrade establishment,
- Landfill closure cap construction,
- Landfill gas management, and
- Stormwater drainage and conveyance

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2. SEDIMENT CONTROL

Montgomery County Code Chapter 19 requires a permit for any land-disturbing activity with a few exceptions. This project does not meet the criteria for the exceptions and thus a permit is required. The permit must be obtained through the Montgomery County Department of Permitting Services (DPS).

DPS approved the Combined Stormwater Management Concept/Site Development Stormwater Management Plan for this project on March 10, 2020 and noted that an Engineered Sediment Control Plan is required. This report describes the sediment control approach that is detailed on the accompanying plans.

The erosion and sediment control design will include a phased construction approach. Grading will be limited to 20-acre areas based on the limit imposed by the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control* (MDE 2011).

Two series of phases have been developed for construction. Subgrade construction has been divided into seven phases (S-I through S-VII) as shown on Drawing C-701 (SC-4). Subgrade work consists primarily of stripping clean soil from the soil to be re-used during construction, excavating and relocating waste onsite, and covering the waste with clean soil. Details illustrating this are included on Drawing C-505 (SC-23). The proposed phases have been defined based on balancing cut and fill of onsite material, maintaining positive drainage, and adhering to the regulated 20-acre maximum grading unit requirement for erosion and sediment control. During each phase, the contractor may be permitted to advance into the subsequent phase if the current working phase is at least 50 percent complete and stabilized. At no point will the contractor be permitted to work within more than two phases and will be limited to 30 acres of open disturbed land within a single watershed.

The second series of phases consist of the closure cap construction which has been divided into six phases (F-I through F-VI) as shown on Drawing C-702 (SC-5). Closure cap construction consists primarily of covering the subgrade with a geosynthetic cap, placing 2 feet of clean soil over the geosynthetics, performing final grading, and establishing permanent vegetation. The proposed phases have been defined based on maintaining positive drainage as much as practical during all phases.

This plan addresses the overall approach for sediment control for the project and the individual sediment controls that will be required for each phase and are outlined below.

2.1 PHASE S-I

Phase S-I is shown on Drawing C-703 (SC-6) and includes significant excavation of waste on the west and northwest slope of the Landfill to create a buffer between the property line and the limit of waste. The excavated waste will be placed in the western portion of Phase S-I on top of the Landfill. Currently, the waste is adjacent to the property boundary and there is no space at the bottom of the Landfill slope to install sediment traps or basins to provide sediment control for a

larger drainage area. The proposed slope is 3H:1V or 33 percent. As a result, same day stabilization is proposed for the northwest slope and benches.

The progression of grading on the west and northwest slope is shown on Drawing C-506 (SC-24). Super silt fence will be placed along the existing slope to provide initial controls to the excavation occurring at the top of slope. The excavation will begin at the top of the slope and work downward in stages to prevent slope failure and potential drainage of leachate offsite. The excavation will be performed in a sump condition. If contaminants are found within the sump condition, the standing water will be pumped, collected, and disposed of as waste material, not sediment-laden water. If contaminants are not found within the standing water, the contractor may choose to perform pumping operations and discharge via filter bag within a stabilized conveyance or collected via portable sediment tank. Otherwise, the collected stormwater will be conveyance to the downstream sediment filtering/capturing device. As construction progresses, temporary gabion outlet structures (TGOS) will be placed along the upper slope of the phase with earth dikes to direct flow to it. Discharge from the facility will be directed into pipe slope drains to convey it to the bottom of the slope. See Appendix A for a schedule of TGOS, TSOS, pipe slope drains, and earth berm structures utilized within the project.

As slope construction progresses downslope, 10-ft benches are proposed along the 3H:1V slope at a maximum interval of 30-ft. Construction will continue approximately 10 horizontal feet downslope of the bench and grading will be tied into existing grade to provide a sump condition for further progression stages. Same day stabilization will be provided to allow the contractor to quickly stabilize disturbed land and continue the progress downslope. This same process as described will continue until the bottom of the slope is reached.

Sediment controls on the northern, eastern, and southern boundaries of Phase S-I will be super silt fence. The slopes that drain to these boundaries are flatter than 10 percent. For slopes flatter than 10 percent, an unlimited slope length is allowed to be controlled with super silt fence.

Some sections of the phase boundary are existing drainage divides and either super silt fence or filter logs will be installed along these sections. The filter log and/or super silt fence will serve as a visual phase boundary and will control any sediment that flows to these boundaries as grading changes to the subgrade condition. However, in locations where the drainage divide is not present, orange construction fence will be utilized to delineate between phase lines.

As Phase S-I progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete Phase F-I concurrent with Phase S-I.

Alternatively, when Phase S-I is 50 percent stabilized, the contractor may request to begin work in Phase S-II. The Phase S-I drawing C-703 (SC-6) shows Phase S-II in existing conditions and Phase S-I in subgrade conditions for illustrative purposes; however, it is expected that grading in Phase S-II will begin before Phase S-I grading is complete.

2.2 PHASE S-II

Phase S-II is shown on Drawing C-704 (SC-7) and includes significant excavation of waste on the west and northwest slope of the Landfill to create a buffer between the property line and the limit of waste. The excavated waste will be placed in the western portion of Phase S-II on the upper surface of the Landfill. Currently, the waste is adjacent to the property boundary and there is no available space at the bottom of the Landfill slope to install sediment traps or basins to provide sediment control for a larger drainage area. The proposed slope is 3H:1V or 33 percent. As a result, same day stabilization is proposed for the northwest slope and benches.

Phase S-II will progress similar to Phase S-I with regard to the downslope progression steps and the same proposed erosion and sediment control methodology.

As Phase S-II progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete Phase F-I and F-II concurrent with Phase S-II.

Alternatively, when Phase S-I is 100 percent and Phase S-II is 50 percent stabilized, the contractor may request to begin work in Phase S-III. Drawing SC-7 shows Phase S-III in existing conditions and Phase S-II in subgrade conditions for illustrative purposes; however, it is expected that grading in Phase S-III will begin before Phase S-II grading is complete.

2.3 PHASE S-III

Phase S-III is shown on Drawing C-705 (SC-8) and includes significant excavation of waste on the west and northwest slope of the Landfill to create a buffer between the property line and the limit of waste. The excavated waste will be placed in the western portion of Phase S-III on the upper surface of the Landfill. Currently, the waste is adjacent to the property boundary and there is no available space at the bottom of the Landfill slope to install sediment traps or basins to provide sediment control for a larger drainage area. The proposed slope is 3H:1V or 33 percent.

The construction and proposed erosion and sediment controls within this phase closely mimics the conditions found within Phase S-I.

As Phase S-III progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete Phase F-II concurrent with Phase S-III.

Alternatively, when Phase S-II is 100-percent and Phase S-III is 50 percent stabilized, the contractor may request to begin work in Phase S-IV or in Phase F-I, depending on sequence selected for execution of the work effort. The drawing sequence assumes the contractor will complete Phases S-I, S-II, and S-III before they begin Phase F-I.

2.4 PHASE F-I

Phase F-I is shown on Drawing C-706 (SC-9) and includes capping of the west and northwest slope of the Landfill. The capping consists of the placement of a geosynthetic liner with two feet of cover soil which will conform to the subgrade grading conditions.

Capping of the phase will progress by deploying the geosynthetic liner downslope to the toe of phase slope. Placement of the cover soil will then process from the toe of slope towards the top of the phase to ensure proper placement and compaction of the placed soil can be achieved without sloughing of the material. As soil cover proceeds upslope, 15-in. filter logs will be installed at 50-ft slope length increments. Super silt fence cannot be installed in the cover soil because the soil will be 2 feet thick and the fence posts cannot penetrate the geosynthetics. Therefore, filter logs will be placed on top of the cover soil to control sedimentation until vegetation is established.

Construction of the permanent benches every 30 vertical feet will be performed using same day stabilization and filter logs will be provided at their cross-section downstream elevation and the equivalent upstream elevation.

Perimeter sediment controls on the northern, eastern, and southern boundaries of Phase F-I will be super silt fence. The slopes that drain to these boundaries are flatter than 10 percent and unlimited slope length is allowed to the super silt fence.

When Phase F-I is 50 percent stabilized, the contractor may request to begin work in Phase F-II. It is anticipated that grading in Phase F-II will begin before Phase F-I grading is complete with the approval of the inspector.

2.5 PHASE F-II

Phase F-I is shown on Drawing C-707 (SC-10) and includes capping of the west and northwest slope of the Landfill. The capping consists of the placement of a geosynthetic liner with two feet of cover soil which will conform to the subgrade grading conditions.

Capping of the phase will progress by deploying the geosynthetic liner downslope to the toe of phase slope. Placement of the cover soil will then process from the toe of slope towards the top of the phase to ensure proper placement and compaction of the placed soil can be achieved without sloughing of the material. As soil cover proceeds upslope, 15-in. filter logs will be installed at 50-ft slope length increments. Super silt fence cannot be installed in the cover soil because the soil will be 2 feet thick and the fence posts cannot penetrate the geosynthetics. Therefore, filter logs will be placed on top of the cover soil to control sedimentation until vegetation is established.

Construction of the permanent benches every 30 vertical feet will be performed using same day stabilization and filter logs will be provided at their cross-section downstream elevation and the equivalent upstream elevation.

Perimeter sediment controls on the northern, eastern, and southern boundaries of Phase F-II will be super silt fence. The slopes that drain to these boundaries are flatter than 10 percent and unlimited slope length is allowed to the super silt fence.

When Phase F-I is 100 percent and Phase F-II is 50 percent stabilized, the contractor may request to begin work in Phase F-II. It is anticipated that grading in Phase F-II will begin before Phase F-I grading is complete with the approval of the inspector.

2.6 PHASE S-IV

Phase S-IV is shown on Drawing C-708 (SC-11) and includes excavation and placement of waste within the phase to reach subgrade. Phase S-IV resides at the southern portion of the project adjacent to the southern access point to the site. Phase S-IV is generally graded to drain to the east with the primary sediment controls will be super silt fence where slopes are flatter and there is no concentrated flow, earth dikes to direct flow along the downstream phase boundary, and construction of Sediment Basin No.1 to manage any sediment-laden runoff.

Pond No. 3 will be converted to Sediment Basin No. 1 at the beginning of this phase. It will serve as the primary sediment device for Phases S-V, S-VI, S-VII, F-III, F-IV, F-V, and F-VI. Sediment Basin No. 1 is discussed in greater detail in Section 2.14.

Super silt fence will be the primary sediment control on the southern boundary of Phase S-IV. The slopes that drain to this boundary are flatter than 10 percent and unlimited slope length is allowed to the super silt fence. Earth dike will be the primary sediment control on the northern boundary, containing and directing flow eastward to Sediment Basin No. 1.

While Phase S-IV is draining to Sediment Basin No. 1, the clear water from the remaining subgrade phases will be directed to bypass with clear water diversion pipes to limit the amount of drainage area that is being managed in Sediment Basin No. 1. The clear water diversion pipes vary in size and receiving drainage area. While the majority clear water diversion pipes receive less than 5 acres of drainage area, which is the maximum drainage area that is standardized within the Manual, there are multiple pipe runs that provide bypassing of flow of larger drainage areas. As required, a hydrologic and hydraulic analysis for the 2-year storm has been performed for those drainage areas in excess of 5 acres which can be found in Appendix A. The analysis found that the amount of runoff produced from the receiving drainage area and the anticipated minimum pipe slope conservatively size the pipe to be 24-inch. In many cases, the pipe could be reduced two pipes sizes smaller and still provide adequate capacity to convey the 2-year storm event. However, the design proposes 24-in. pipes to provide additional capacity for larger events that may occur.

The initial area of fill will be at the western end of Phase S-IV to raise the grades and begin to direct any runoff to the east. There is limited area along the western slope of the initial infill area to install a sediment trap or basin. As a result, same day stabilization is proposed on the slope and bench to limit potential for sediment-laden water from discharging offsite. The initial grading will be treated with perimeter super silt fence and sump pit with filter bags or portable sediment tank.

Phase S-IV also extends to the east of the site's access road adjacent to Sediment Basin No. 1. The access roadway will be graded to provide access to the future phases of work. In addition, the existing concrete and asphalt pad will be utilized during construction for non-erodible material storage for the project. The installation of the access road and storage pad necessitated that grading and drainage be provided around their perimeter and to allow bypassing of the future Phase S-VI runoff. The resulting drainage swales for these improvements will discharge to proposed storm drainage systems that discharge into Sediment Basin No. 1. Inlet protection is provided for these structures.

As Phase S-IV progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete the final phase concurrent with Phase S-IV.

Alternatively, when Phase S-IV is 50 percent stabilized, the contractor may request to begin work in Phase S-V. However, it is expected that grading in Phase S-V will begin before Phase S-IV grading is complete.

2.7 PHASE S-V

Phase S-V is shown on Drawing C-709 (SC-12) and includes excavation and placement of waste within the phase to reach subgrade elevations. Phase S-V consists of a long narrow portion of the site that is utilized the bridge construction between Phase S-IV downstream and Phase XII upstream. This bridging phase provides means of providing clearwater bypassing in subsequent phases. In addition, the downstream edge of the phase is located at existing inlets that discharge water to Pond #3 which also permits a location to perform bypassing for previous phases via clear water diversion pipes.

Due the shape of the land and grading features, Phase S-V provides drainage from the far western extent of the site and from its interface with Phase S-1 along its northern boundary towards the its center and ultimately discharges into Sediment Basin No. 1.

Due to the linearity of the phase, 8-ft wide swales are provided as a means of conveyance the sediment basin. The swales have been sized for the drainage area that they receive while providing a minimum of 6-inches of freeboard for the 10-year storm event.

Super silt fence will be the primary sediment control on the northeastern and southwestern boundary of Phase S-V. Earth dikes are the primary sediment control on the boundary with Phase S-VII, containing and directing flow eastward and southward to Sediment Basin No. 1.

The initial area of fill will be at the western end of Phase S-IV to raise the grades and begin to direct any runoff to the east. There is limited area along the western slope of the initial infill area to install a sediment trap or basin. As a result, same day stabilization is proposed to limit the potential of sediment-laden water from discharging offsite. The initial grading will be treated with perimeter super silt fence and sump pit with filter bags or portable sediment tank.

As Phase S-V progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete the final phase concurrent with Phase S-V.

Alternatively, when Phase S-IV is 100 percent and Phase S-V is 50 percent stabilized, the contractor may request to begin work in Phase S-VI. However, it is expected that grading in Phase S-VI will begin before Phase S-V grading is complete.

2.8 PHASE S-VI

Phase S-VI is shown on Drawing C-710 (SC-13) and includes excavation and placement of waste within the phase to reach subgrade. Phase S-VI resides in the center of protect and abut against Phases S-I, S-II, S-III, and S-IV. Phase S-VI also resides downgradient of portion of Phases S-I, S-II, and S-III and is the recipient of a minimal amount of runoff from those phases. As a result, 8-ft. wide swales are provided to convey both the out-of-phase runoff and runoff from Phase S-VI to Sediment Basin No. 1

Earth dikes are provided around the perimeter of the phase in order to direct out-of-phase runoff to clear water diversion pipes that are closely located to the proposed swales. In addition, in-phase earth dikes are proposed along the southern boundary to direct runoff to either Sediment Basin No. 1 or to a proposed TGOS adjacent to Swale 8 that is in Phase S-V. This treated runoff will flow within Swale 8 until reaching its discharge point into the bypass channel (Swale 10) of Sediment Basin No. 1.

As excavation and filling occurs throughout the phase, there will likely be some sump conditions and any ponded water can be managed with a sump pit and filter bag or portable sediment tank.

When Phase S-V is 100 percent and Phase S-VI is 50 percent stabilized, the contractor may request to begin work in Phase F-III.

2.9 PHASE S-VII

Phase S-VII is shown on Drawing C-711 (SC-14) and includes excavation and placement of waste within the phase to reach subgrade elevation. Phase S-VII drains to the south towards the access road and material staging area constructed during Phase S-IV. Runoff from the phase is directed to the conveyances previously installed during Phase S-IV where it enters the closed storm drainage system and enters Sediment Basin No. 1.

Super silt fence is provided around the project boundary to filter the limited amount of runoff that is directed to project boundary. In addition, an earth dike is provided along the access road to direct runoff toward the south and to storm drainage system.

As Phase S-VII progresses, the contractor will have the option to apply temporary stabilization and return to the area later for capping, or to begin landfill capping as the stabilization measure and complete the final phase concurrent with Phase S-VII.

Alternatively, when Phase S-VI is 100 percent and Phase S-VII is 50 percent stabilized, the contractor may request to begin work in Phase S-VII.

2.10 PHASE F-III

Phase F-III is shown on Drawing C-712 (SC-15) and includes capping of the western section of the Landfill. The capping consists of the placement of a geosynthetic liner with two feet of cover soils which will conform to subgrade grading conditions. Any temporary stabilization measures will be removed before placing geosynthetics. Geosynthetics will be rolled out over the area from the higher elevations to the lower elevations. Once the geosynthetics are anchored, soil cover will be placed over the geosynthetics starting upgradient and continue downgradient to prevent the creation of a sump conditions if construction were to be completed downgradient to upgradient.

However, the initial fill areas of Phases S-IV and S-V is the exception to this as there is not a downstream sediment capturing facility to provide sediment controls. Within this area, soil cover placement will be completed similar to Phase F-I and F-II proceeding from the toe of slope to the top of slope with filter logs installed to provide erosion and sediment control.

The majority of the phase will drain to the east to Sediment Basin No. 1 through the proposed Swale 8 which was graded during Phases S-IV and S-V. As the placement of soil cover proceeds from upgradient to downgradient, the swale will continue to drain to Sediment Basin No. 1.

The phase has been delineated along ridgelines which results in not needing inter-phase sediment control to direct clear water away from the phase.

While Phase F-III is draining to Sediment Basin No. 1, the clear water from the remaining, stabilized subgrade phases will be directed to bypass Sediment Basin No. 1 to limit the drainage area being managed by the basin.

When Phase F-III is 50 percent stabilized, the contractor may request to begin work in Phase F-IV.

2.11 PHASE F-IV

Phase F-IV is shown on Drawing C-713 (SC-16) and is the next phase in the capping of the Landfill and is located within the center of the site. Similar to Phase F-III, the phase has been delineated to utilize the drainage divides to limit the need of inter-phase controls to direct clean water and sediment laden water.

The majority of the phase will drain to the east to Sediment Basin No. 1 through proposed drainage Swale 13. As the placement of soil cover proceeds from upgradient to downgradient, the swale will continue to drain to Sediment Basin No. 1.

Super silt fence will be utilized at the lower limit of the phase where runoff cannot reach the swale for conveyance to the basin. Super silt fence installed at this location will be beyond the limit of the capping system and therefore, will not puncture the geosynthetic liner system.

While Phase F-IV is draining to Sediment Basin No. 1, the clear water from the remaining, stabilized subgrade and final phases will be directed to bypass Sediment Basin No. 1 to limit the drainage area being managed in the basin.

When Phase F-III is 100 percent and Phase F-IV is 50 percent stabilized, the contractor may request to begin work in Phase F-V. Drawing SC-16 shows Phase F-V in subgrade conditions and Phase F-IV in final conditions for illustrative purposes; however, it is expected that grading in Phase F-V will begin before Phase F-IV grading is complete.

2.12 PHASE F-V

Phase F-V is shown on Drawing C-714 (SC-17) and is the next phase in the capping of the Landfill and is located to the east of Phase F-IV. Similar to Phase F-III and F-IV, the phase has been delineated to utilize the drainage divides to limit the need of inter-phase controls to direct clean water and sediment laden water. Temporary stabilization measures will be removed before placing geosynthetics. Geosynthetics will be deployed out over the area from the higher elevations to the lower elevations. Once the geosynthetics are anchored, soil cover will be placed over the geosynthetics upgradient and continue downgradient to prevent the creation of a sump conditions if construction were to be completed downgradient to upgradient.

Sediment controls on the east boundary of Phase F-V will be super silt fence.

The majority of the phase will drain to the southeast to Sediment Basin No. 1 through the Swale 11 and 16. As the placement of soil cover proceeds from upgradient to downgradient, the swale will continue to drain to Sediment Basin No. 1.

While Phase F-V is draining to Sediment Basin No. 1, the clear water from the remaining stabilized subgrade and final phases will be directed to bypass Sediment Basin No. 1 to limit the drainage area being managed by the basin.

When Phase F-IV is 100 percent and Phase F-V is 50 percent stabilized, the contractor may request to begin work in Phase F-VI.

2.13 PHASE F-VI

Phase F-VI is shown on Drawing C-715 (SC-18) and includes capping of the Landfill and is located at the southeastern portion of the project. Any temporary stabilization measures will be removed before placing geosynthetics. Geosynthetics will be deployed out over the area from the higher elevations to the lower elevations. Once the geosynthetics are anchored, soil cover will be placed over the geosynthetics upgradient and continue downgradient to prevent the creation of a sump conditions if construction were to be completed downgradient to upgradient.

Sediment controls on the northern and eastern boundaries of Phase F-VI will be super silt fence. The majority of the phase will drain to the south and southwest to Sediment Basin No. 1 via Swales 14 and 18 to their respective storm inlet structures. As the placement of soil cover proceeds from upgradient to downgradient, the swale will continue to drain to Sediment Basin No. 1.

While Phase F-VI is draining to Sediment Basin No. 1, the clear water from the remaining, stabilized final phases will be directed to bypass Sediment Basin No. 1 via Swale 10 to limit the drainage area being managed by the basin.

Once the majority of Phase F-VI is stabilized, Sediment Basin No. 1 will be decommissioned and will be returned to its existing function as a dry pond.

2.14 SEDIMENT BASIN NO. 1

Entering Phase S-IV from the south, existing Pond No. 3 resides to the west of the road. Pond No. 3 is an excavated dry pond that received runoff from approximately 52 acres of the landfill. Pond No. 3 has multiple storm pipes entering the facility from the north and east with bypass piping diverting water around the pond in larger storm events. Due to these existing conditions, Pond No. 3 is proposed to be converted to Sediment Basin No. 1 and be utilized as such for the duration of construction. The proposed basin is shown in detail on Drawing C-513 (SC-21) and is the only sediment basin for the project due to the physical constraints of the site.

Sediment Basin No. 1 has been sized to provide sediment capturing for approximately 45 acres of drainage area during either subgrade or final grading phases of the project. As a result, it will accommodate approximately three subgrade phases or two final grade phases to utilize it without performing clearwater bypass via Swale 10. The capacity of Sediment Basin No. 1 provides the contractor with flexibility on how to construct the project while not being overly restrictive. This allows for additional competitiveness in the bids and ultimately will be financially beneficial to the County's project.

Sediment Basin No. 1 does not include an emergency spillway due to the site being a filled as a part of previously landfilling operations. The provision of the emergency spillway being required within native soils is therefore not achievable for this project. As a result, the sediment basin has been designed to provide a minimum of 2-ft of freeboard above the 10-yr. storm event to comply with erosion and sediment control regulation. In addition, the 100-yr storm event is fully contained within the pond with approximately 0.67-ft of freeboard.

Similar to the constraints for the inclusion of an emergency spillway, the required cut-off trench and impervious core for the embankment would likely extend into existing waste material and the structural suitability to tie-in the cut-off trench would be limited. In addition, Sediment Basin No. 1 is partially constructed by extending the existing Pond No. 3 embankment to design elevation. The removal of Pond No. 3's embankment and complete reconstruction is not desired as it has been in a stable and stabilized state for over three decades. Complete removal of the embankment could introduce potential undesirable instability of soils and excavation will be limited to that

needed to remove Pond No. 3's outfall pipe. As a result, a clay liner within the interior face of the embankment is proposed to prevent the lateral movement of water through the embankment. The clay liner is proposed to be 2-ft. thick and extend 4-ft below the bottom of the sediment basin. The limits of clay liner and section of the liner, embankment, outfall pipe, etc. can be found on Sheet C-513 (SC-21).

The supporting calculations for Sediment Basin No. 1 are provided in Appendix B inclusive of the hydrologic and hydraulics calculations, draw-down dewatering device, principal spillway, anti-flotation, and rock outlet protection.

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3. REFERENCES

EA Engineering, Science, and Technology, Inc., PBC (EA). 2020. *Stormwater Management Design Report*.

Maryland Department of the Environment (MDE). 2011. *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*.

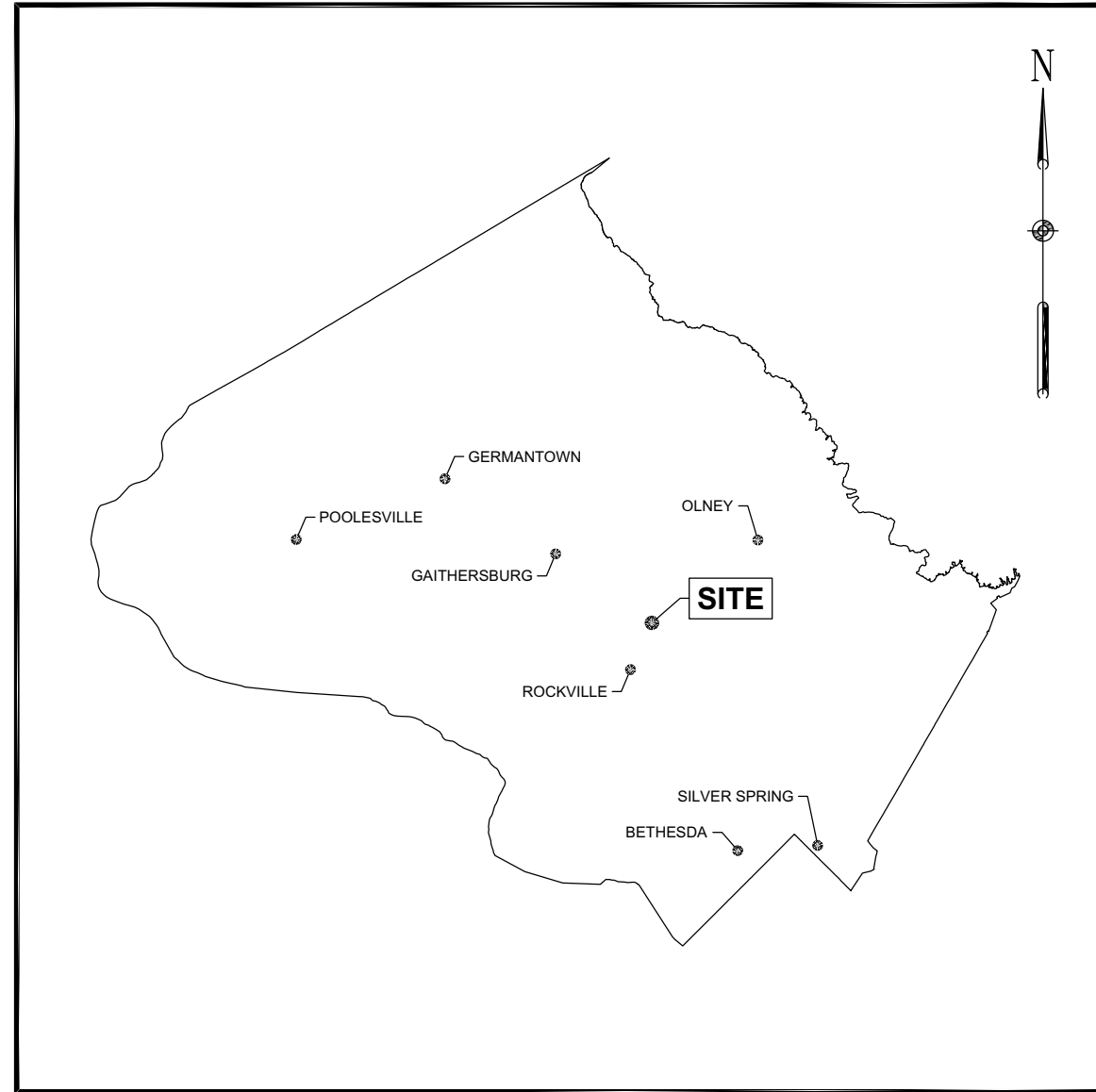
Maryland Department of the Environment (MDE) and Montgomery County. 2013. Consent Order (Gude Landfill). MDE Case Number CO-11-SW-036. 28 May.

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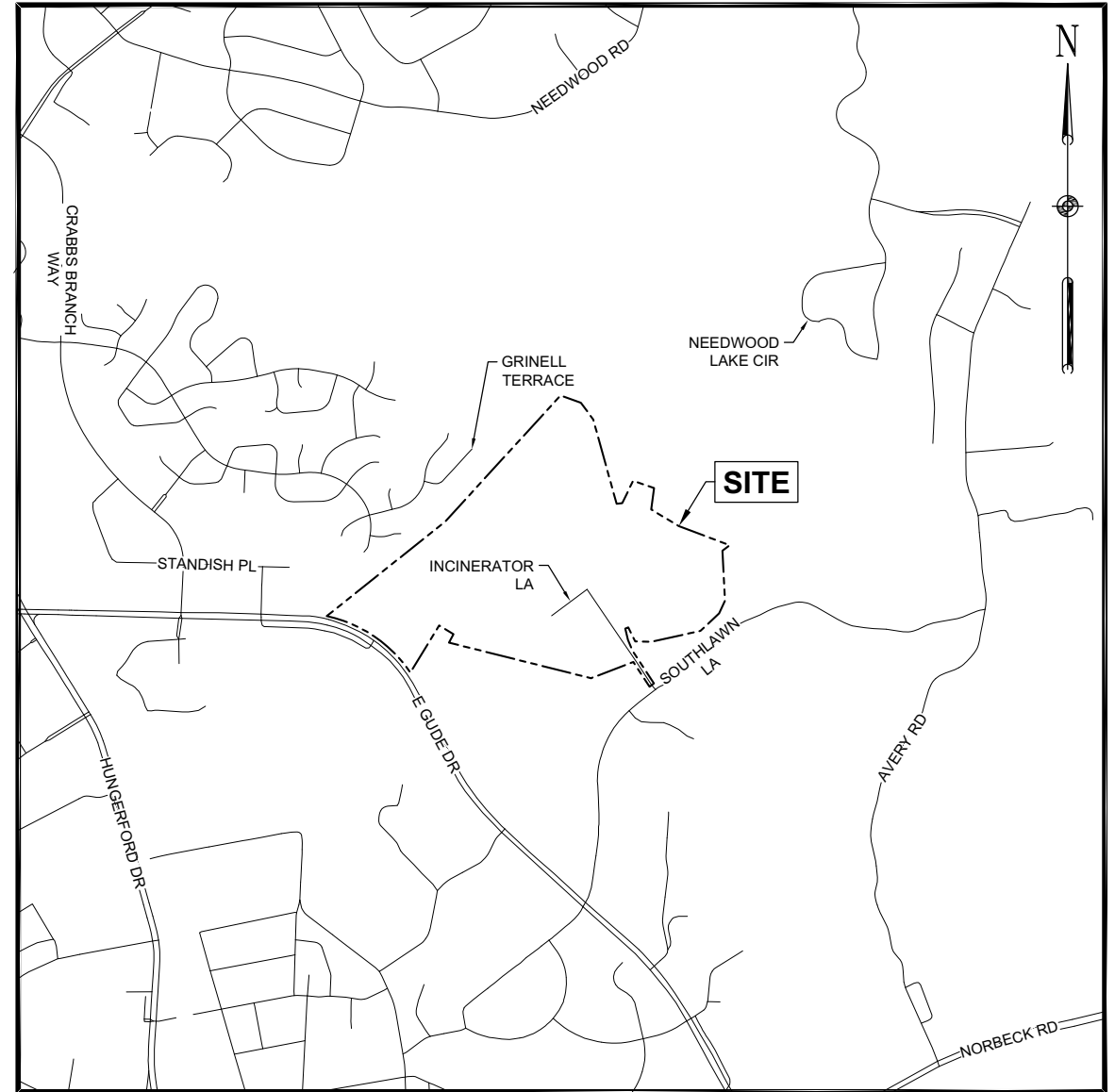
Figures

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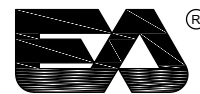
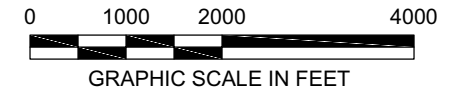
FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\WM\FIGURE 1 - VICINITY AND LOCATION MAP.DWG [FIGURE 1] 4/30/19



LOCATION MAP - MONTGOMERY COUNTY, MARYLAND
NOT TO SCALE



VICINITY MAP
SCALE: 1" = 2,000'



EA Engineering, Science, and Technology, Inc., PBC
Hunt Valley Center
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

PROJECT NUMBER: 1564601	DESIGNED BY: KEF/SMB	DRAWN BY: SMB	FIGURE: 1
DATE: DECEMBER 2019	CHECKED BY: LJO	PROJECT MGR.: MJG	SHEET NUMBER: 1 OF 1

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY, MARYLAND

FIGURE 1 - LOCATION AND VICINITY MAP

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Appendix A

Supporting Documentation and Calculations

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EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
225 Schilling Circle, Suite 400, Hunt Valley, Maryland 21031

Benching Schedule

By: SCL
 Date: 11/18/2020
 Check: _____
 Date: _____
 Sheet: 1 of 1

Project: Gude Landfill
 Job Number: 1564601
 Maryland County: Montgomery
 Study Area Limits: N/A
 Study Area Designator: N/A

ID	Phase (s)	Maximum Drainage Area (AC.)	Length (Feet)	1' Deep Bench Width (feet)	Q10 (cfs)	V10 (fps)	Flow Depth (feet)	Q25 (cfs)	V25 (fps)	Flow Depth (feet)	Treatment
Bench 1	S-I / F-I	3.15	718	10	8.14	3.16	0.63	11.68	3.47	0.72	SSM
Bench 2	S-I / S-II / F-I	1.75	852	10	4.46	2.74	0.5	6.41	2.93	0.58	SSM
Bench 3	S-II / S-III / F-1/ F-II	3.62	520	10	9.44	3.24	0.67	13.55	3.61	0.76	SSM
Bench 4	S-IV / F-VI	17.53	418	20	40.96	4.71	0.87	58.92	5.12	1	TRM
Bench 5	S-IV / F-III	0.39	365	10	1.43	1.99	0.25	2.03	2.25	0.28	SSM
Bench 6	S-V / F-III	0.36	300	10	1.43	1.99	0.25	2.03	2.25	0.28	SSM

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/10/2020
 Project: Gude Units: English
 SubTitle: DA-1A Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\slemasters\Downloads\Benching.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
Bench 4		Outlet	17.53	80	.347
Bench 2		Outlet	1.75	80	.284
Bench 3		Outlet	3.62	80	.272
Bench 1		Outlet	3.15	80	.277
Bench 5		Outlet	0.39	80	0.1
Bench 6		Outlet	0.39	80	0.100

Total area: 26.83 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

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Gude
DA-1A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

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Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period		
	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS			
Bench 4	40.96	58.92	87.00
Bench 2	4.46	6.41	9.49
Bench 3	9.44	13.55	20.04
Bench 1	8.14	11.68	17.26
Bench 5	1.43	2.03	2.99
Bench 6	1.43	2.03	2.99
REACHES			
OUTLET	63.57	91.33	134.92

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Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 10-Yr 25-Yr 100-Yr
Identifier (cfs) (cfs) (cfs)
(hr) (hr) (hr)

SUBAREAS

Bench 4 40.96 58.92 87.00
12.25 12.25 12.24

Bench 2 4.46 6.41 9.49
12.21 12.21 12.21

Bench 3 9.44 13.55 20.04
12.21 12.21 12.21

Bench 1 8.14 11.68 17.26
12.21 12.22 12.20

Bench 5 1.43 2.03 2.99
12.12 12.12 12.12

Bench 6 1.43 2.03 2.99
12.12 12.12 12.12

REACHES

OUTLET 63.57 91.33 134.92

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Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
Bench 4	17.53	0.347	80	Outlet	
Bench 2	1.75	0.284	80	Outlet	
Bench 3	3.62	0.272	80	Outlet	
Bench 1	3.15	0.277	80	Outlet	
Bench 5	.39	0.100	80	Outlet	
Bench 6	.39	0.100	80	Outlet	

Total Area: 26.83 (ac)

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Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

Bench 4							
SHEET	100	0.0150	0.240				0.269
SHALLOW	422	0.0280	0.050				0.043
CHANNEL	900	0.0200	0.030	14.04	13.90	7.143	0.035
							Time of Concentration .347
							=====
Bench 2							
SHEET	100	0.0350	0.240				0.192
SHALLOW	752	0.0200	0.050				0.092
							Time of Concentration .284
							=====
Bench 3							
SHEET	100	0.0500	0.240				0.166
SHALLOW	873	0.0200	0.050				0.106
							Time of Concentration .272
							=====
Bench 1							
SHEET	100	0.0360	0.240				0.190
SHALLOW	718	0.0200	0.050				0.087
							Time of Concentration .277
							=====
Bench 5							
SHEET	50	0.3300	0.240				0.045
SHALLOW	365	0.0300	0.050				0.036
							Time of Concentration 0.1
							=====
Bench 6							
User-provided							0.100
							Time of Concentration 0.100
							=====

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Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
Bench 4	Pasture, grassland or range	(good)	D	17.53	80
	Total Area / Weighted Curve Number			17.53	80
				=====	==
Bench 2	Pasture, grassland or range	(good)	D	1.75	80
	Total Area / Weighted Curve Number			1.75	80
				====	==
Bench 3	Pasture, grassland or range	(good)	D	3.62	80
	Total Area / Weighted Curve Number			3.62	80
				====	==
Bench 1	Pasture, grassland or range	(good)	D	3.15	80
	Total Area / Weighted Curve Number			3.15	80
				====	==
Bench 5	Pasture, grassland or range	(good)	D	.39	80
	Total Area / Weighted Curve Number			.39	80
				===	==
Bench 6	Pasture, grassland or range	(good)	D	.39	80
	Total Area / Weighted Curve Number			.39	80
				===	==

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Channel Report

Bench 1 10-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

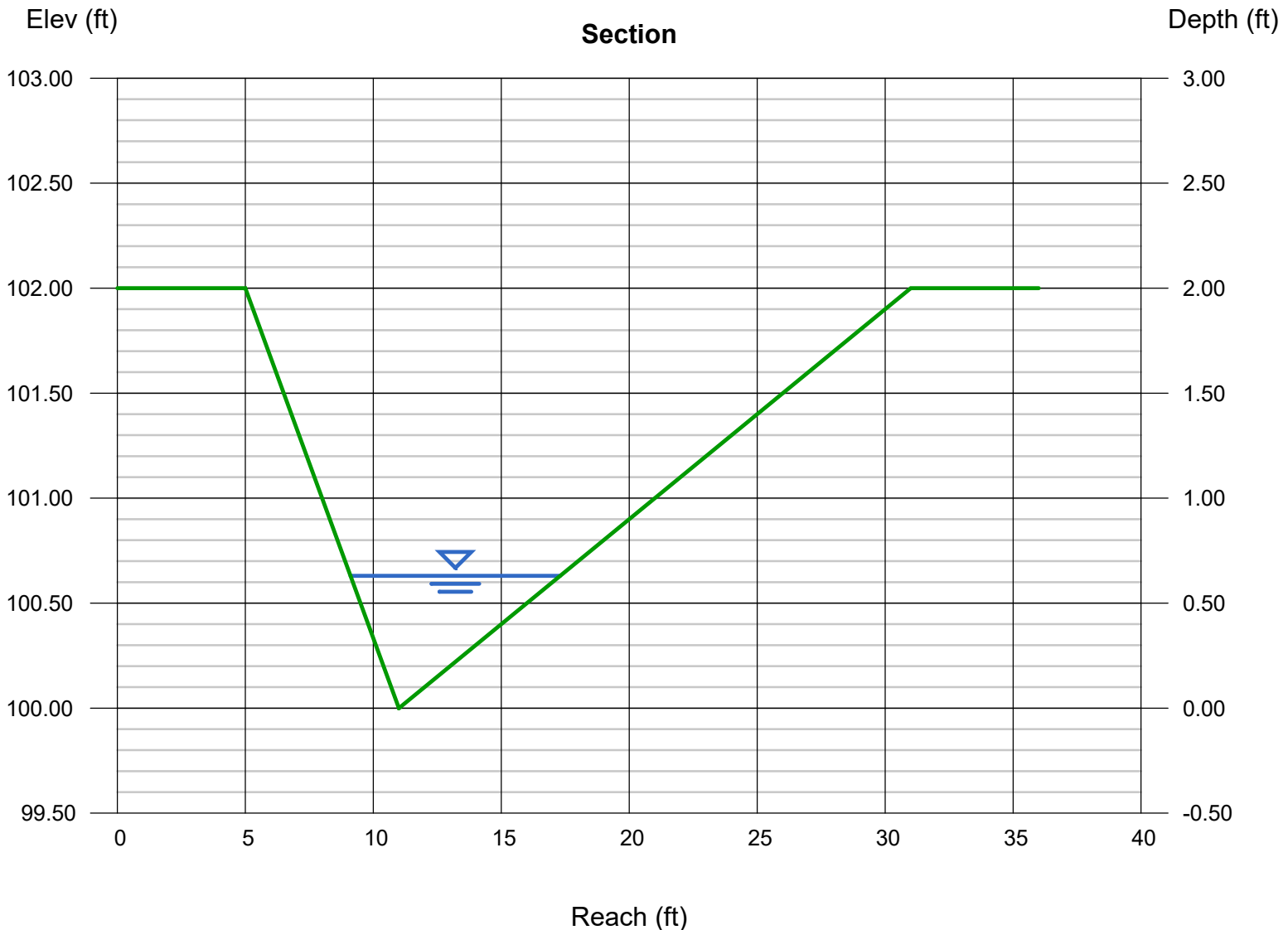
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 8.14

Highlighted

Depth (ft) = 0.63
Q (cfs) = 8.140
Area (sqft) = 2.58
Velocity (ft/s) = 3.16
Wetted Perim (ft) = 8.32
Crit Depth, Yc (ft) = 0.63
Top Width (ft) = 8.19
EGL (ft) = 0.78



Channel Report

Bench 1 25-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

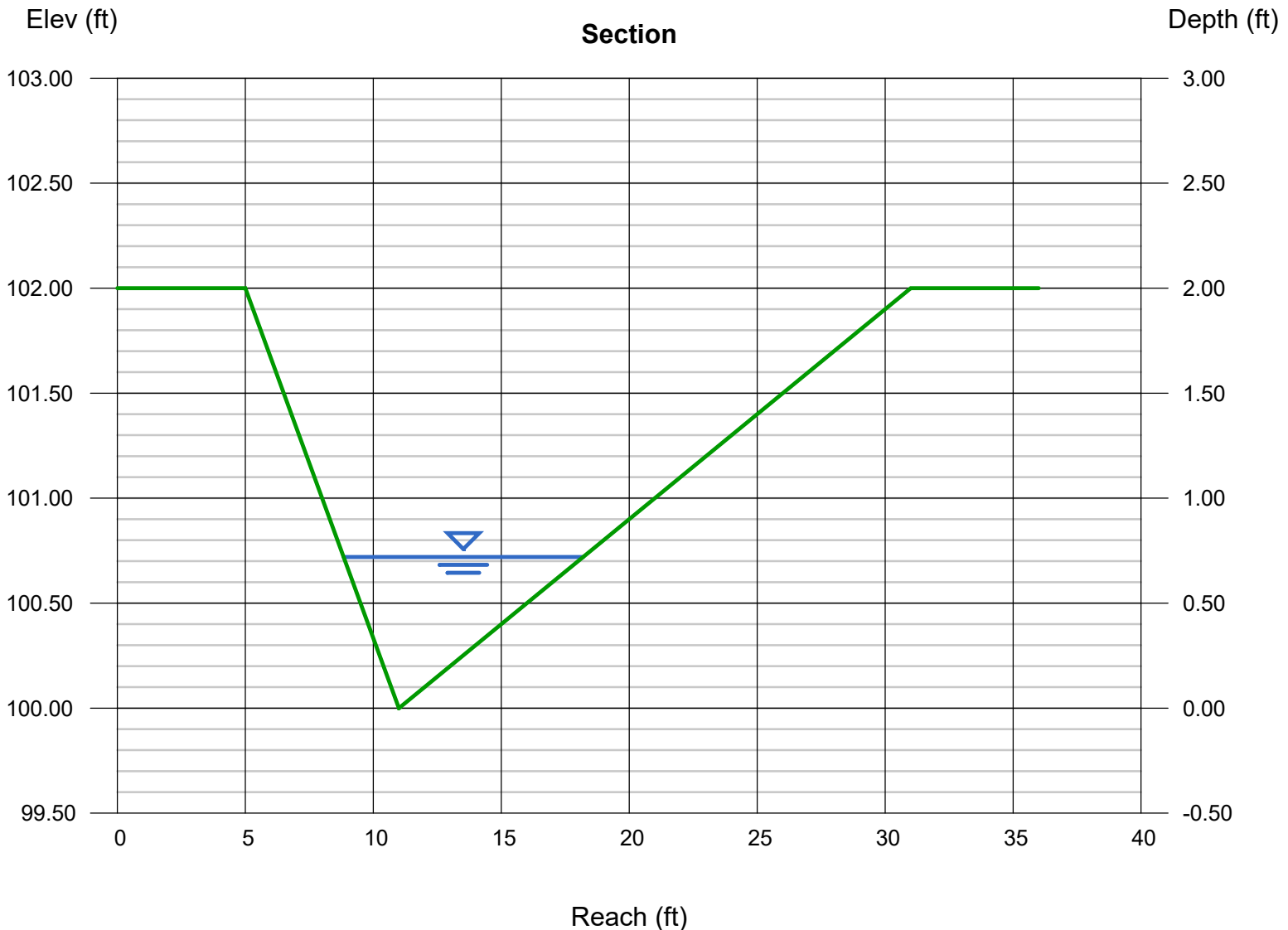
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 11.68

Highlighted

Depth (ft) = 0.72
Q (cfs) = 11.68
Area (sqft) = 3.37
Velocity (ft/s) = 3.47
Wetted Perim (ft) = 9.51
Crit Depth, Yc (ft) = 0.73
Top Width (ft) = 9.36
EGL (ft) = 0.91



Channel Report

Bench 1 100-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

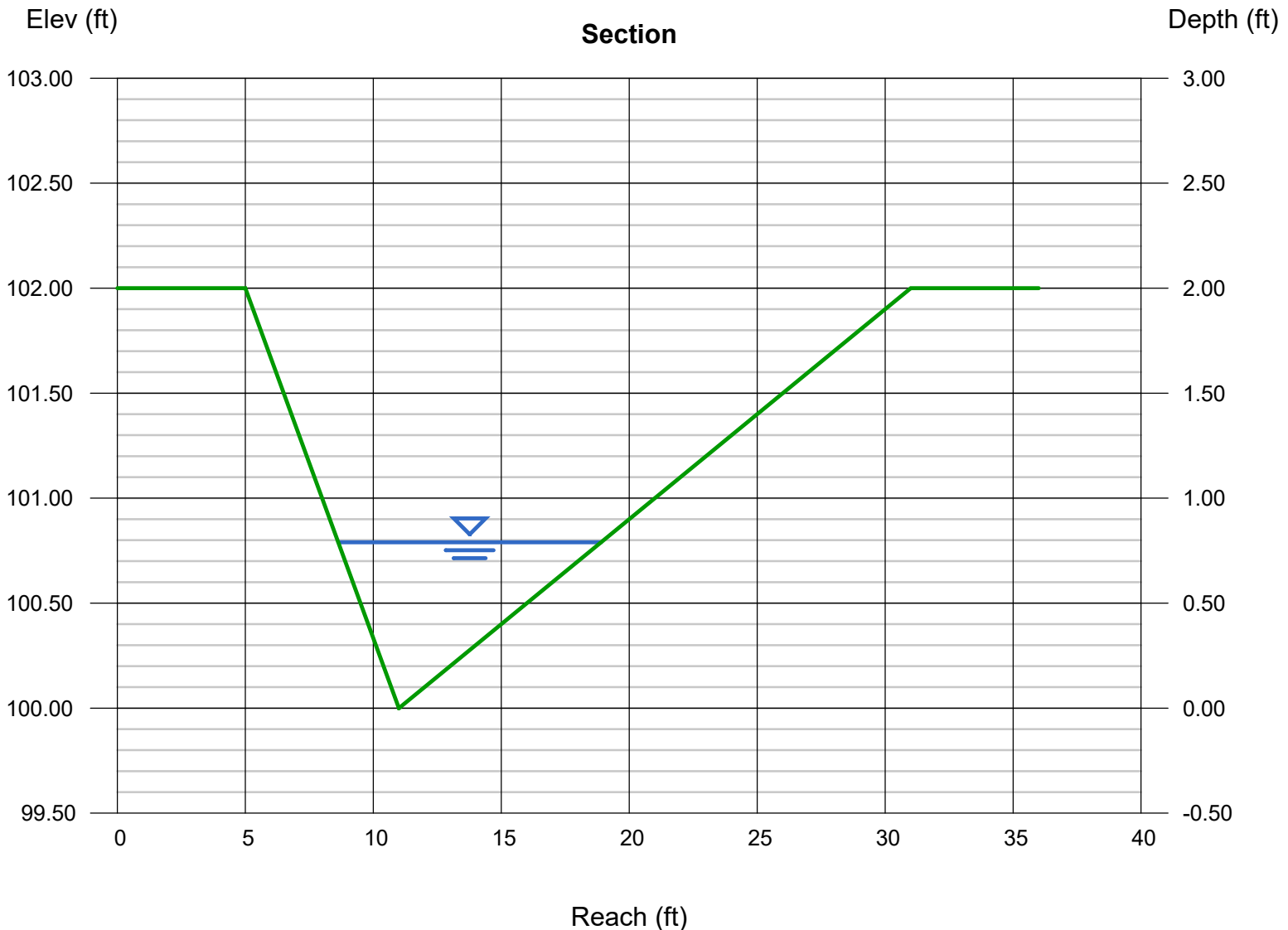
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 14.77

Highlighted

Depth (ft) = 0.79
Q (cfs) = 14.77
Area (sqft) = 4.06
Velocity (ft/s) = 3.64
Wetted Perim (ft) = 10.44
Crit Depth, Yc (ft) = 0.80
Top Width (ft) = 10.27
EGL (ft) = 1.00



Channel Report

Bench 2 10-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

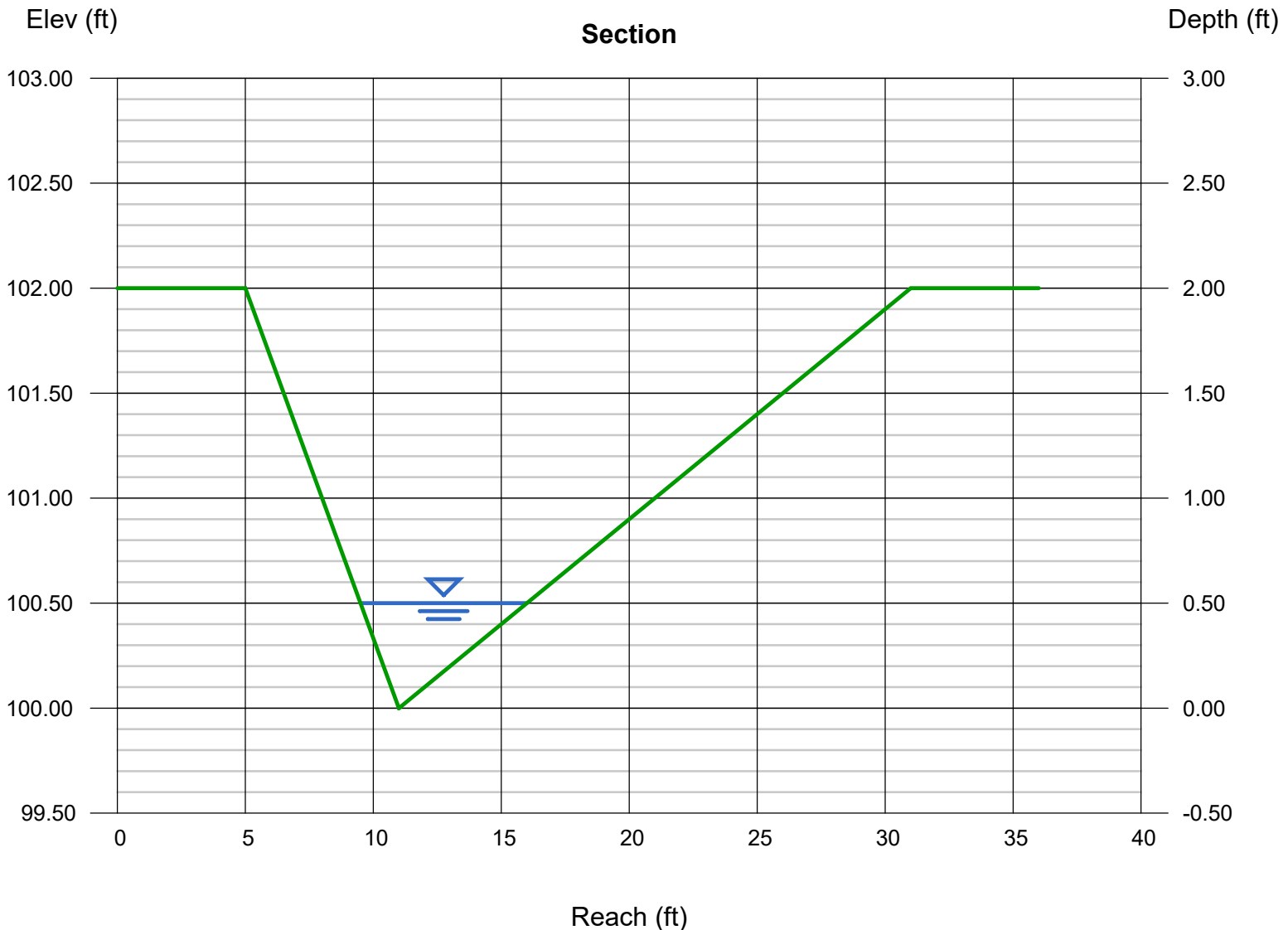
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 4.46

Highlighted

Depth (ft) = 0.50
Q (cfs) = 4.460
Area (sqft) = 1.62
Velocity (ft/s) = 2.74
Wetted Perim (ft) = 6.61
Crit Depth, Yc (ft) = 0.50
Top Width (ft) = 6.50
EGL (ft) = 0.62



Channel Report

Bench 2 25-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

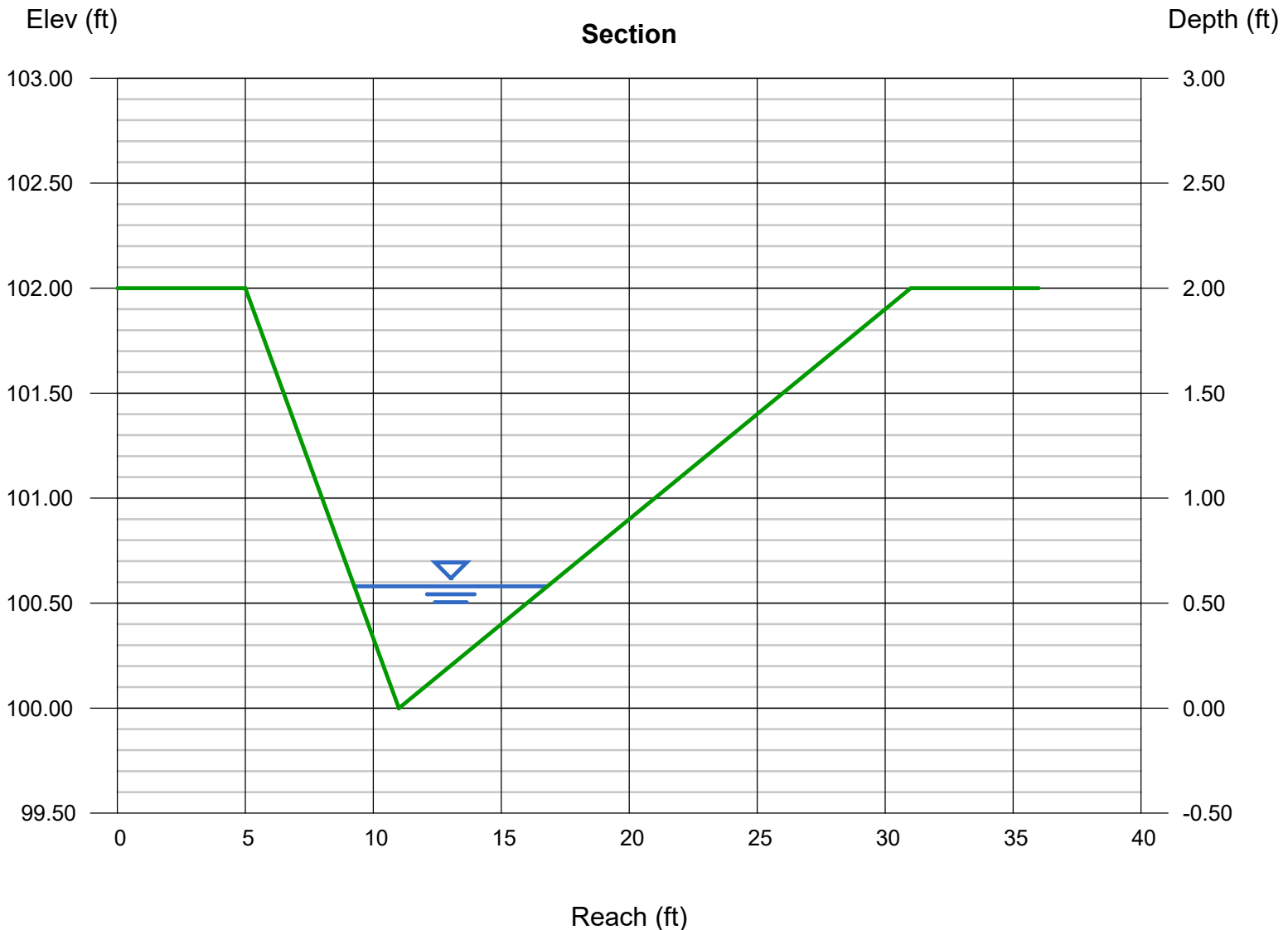
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 6.41

Highlighted

Depth (ft) = 0.58
Q (cfs) = 6.410
Area (sqft) = 2.19
Velocity (ft/s) = 2.93
Wetted Perim (ft) = 7.66
Crit Depth, Yc (ft) = 0.58
Top Width (ft) = 7.54
EGL (ft) = 0.71



Channel Report

Bench 2 100-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

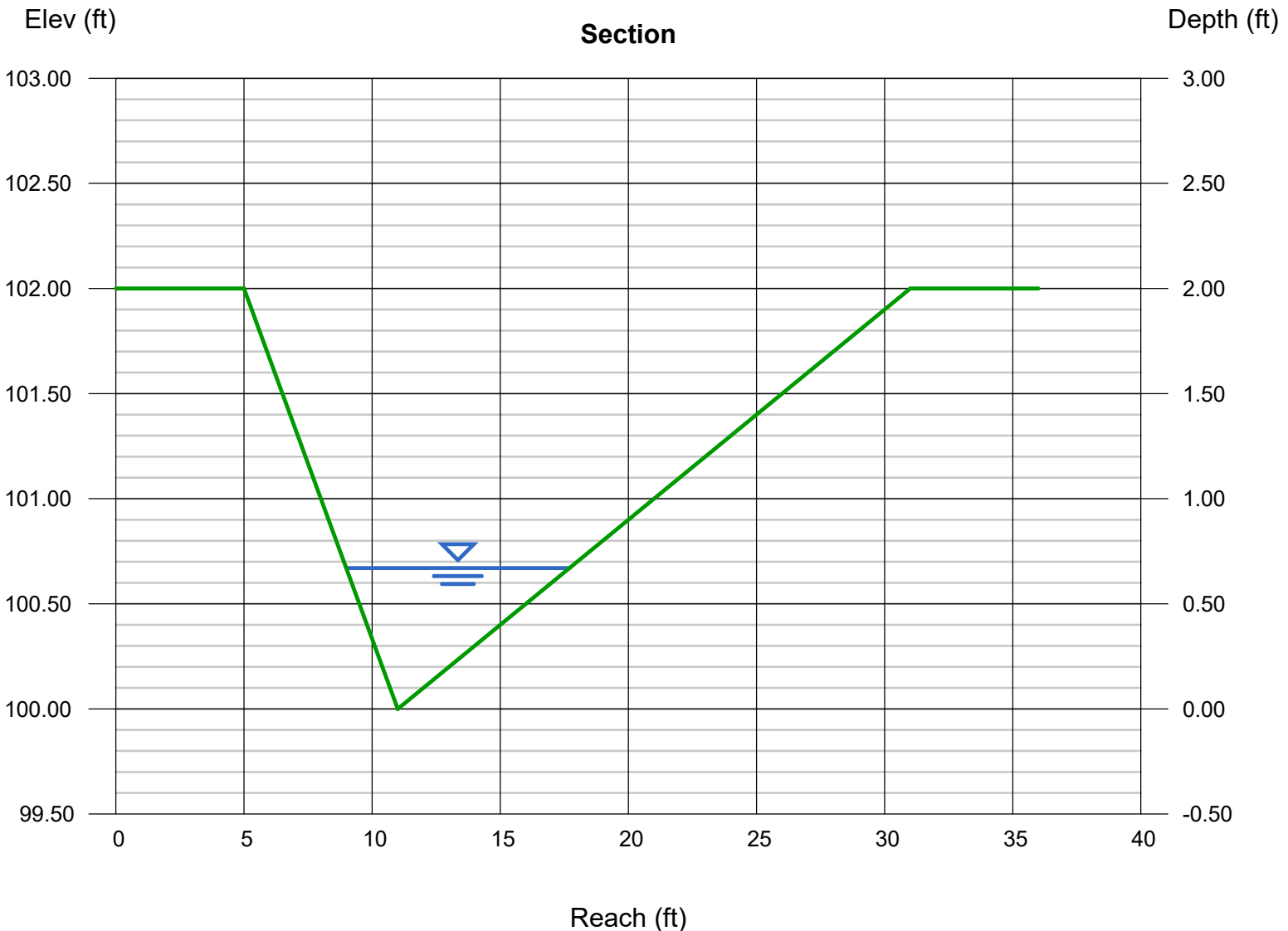
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 9.49

Highlighted

Depth (ft) = 0.67
Q (cfs) = 9.490
Area (sqft) = 2.92
Velocity (ft/s) = 3.25
Wetted Perim (ft) = 8.85
Crit Depth, Yc (ft) = 0.67
Top Width (ft) = 8.71
EGL (ft) = 0.83



Channel Report

Bench 3 10-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

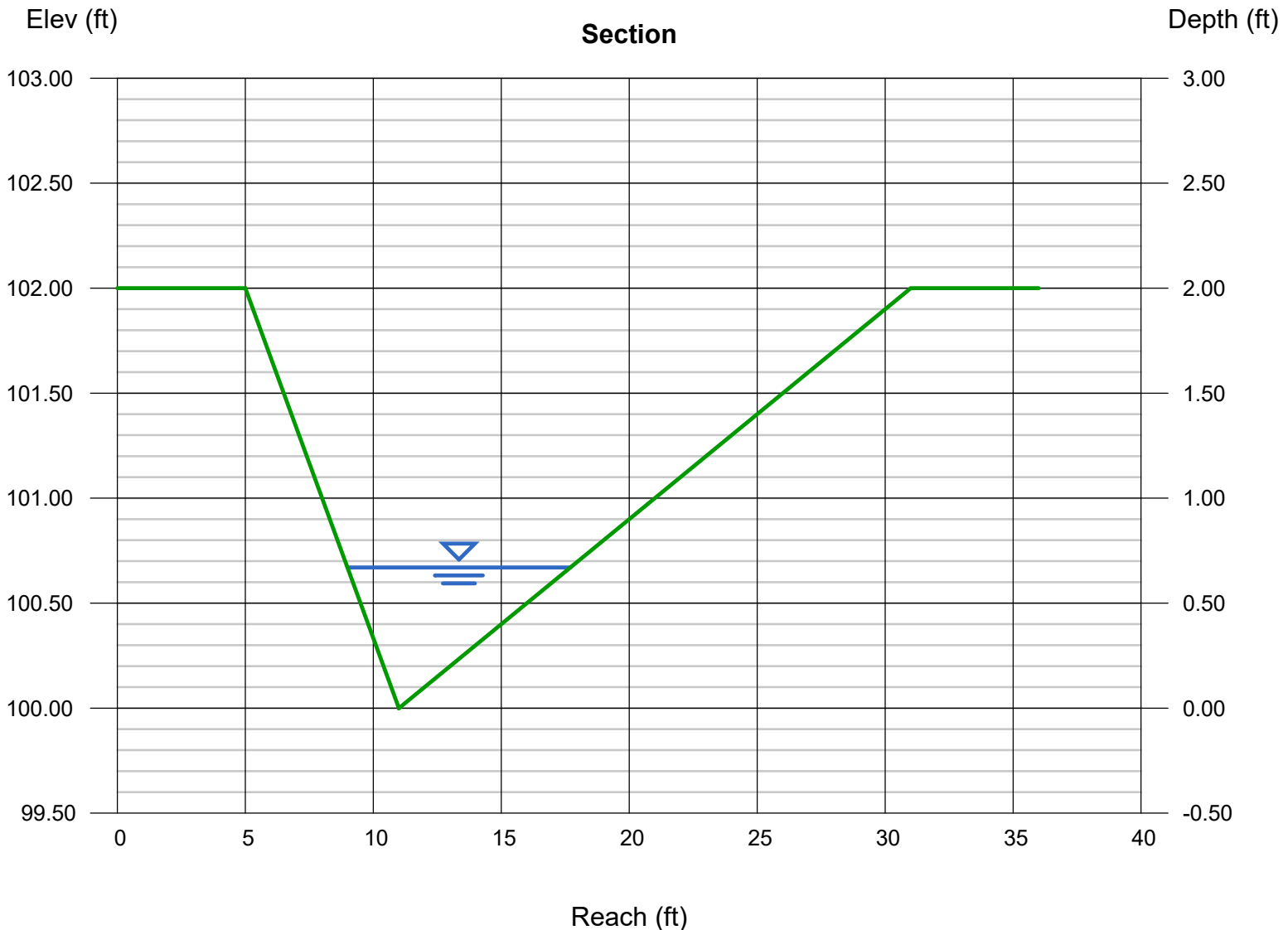
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 9.44

Highlighted

Depth (ft) = 0.67
Q (cfs) = 9.440
Area (sqft) = 2.92
Velocity (ft/s) = 3.24
Wetted Perim (ft) = 8.85
Crit Depth, Yc (ft) = 0.67
Top Width (ft) = 8.71
EGL (ft) = 0.83



Channel Report

Bench 3 25-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

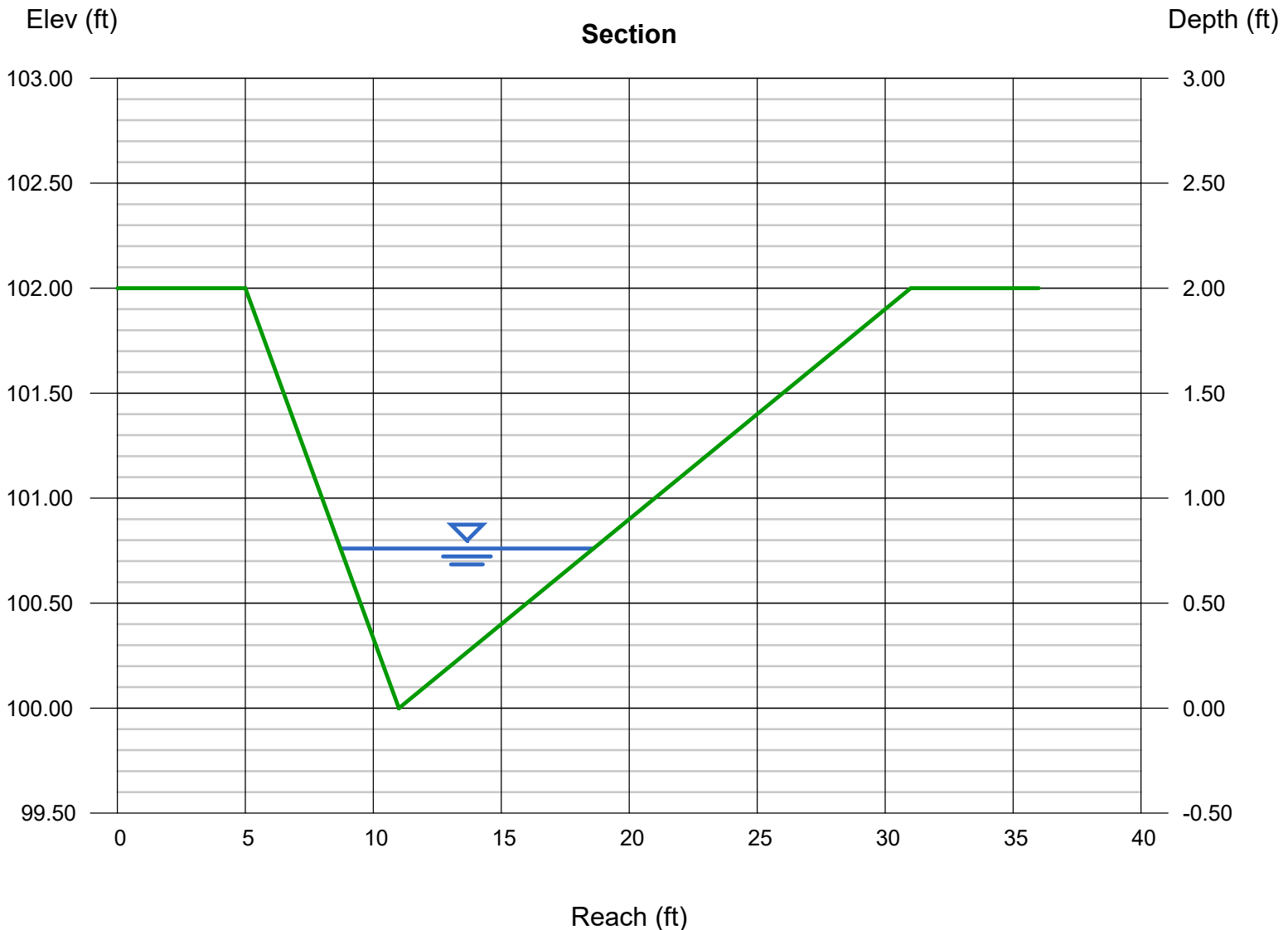
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 13.55

Highlighted

Depth (ft) = 0.76
Q (cfs) = 13.55
Area (sqft) = 3.75
Velocity (ft/s) = 3.61
Wetted Perim (ft) = 10.04
Crit Depth, Yc (ft) = 0.77
Top Width (ft) = 9.88
EGL (ft) = 0.96



Channel Report

Bench 3 100-yr

Triangular

Side Slopes (z:1) = 3.00, 10.00
Total Depth (ft) = 2.00

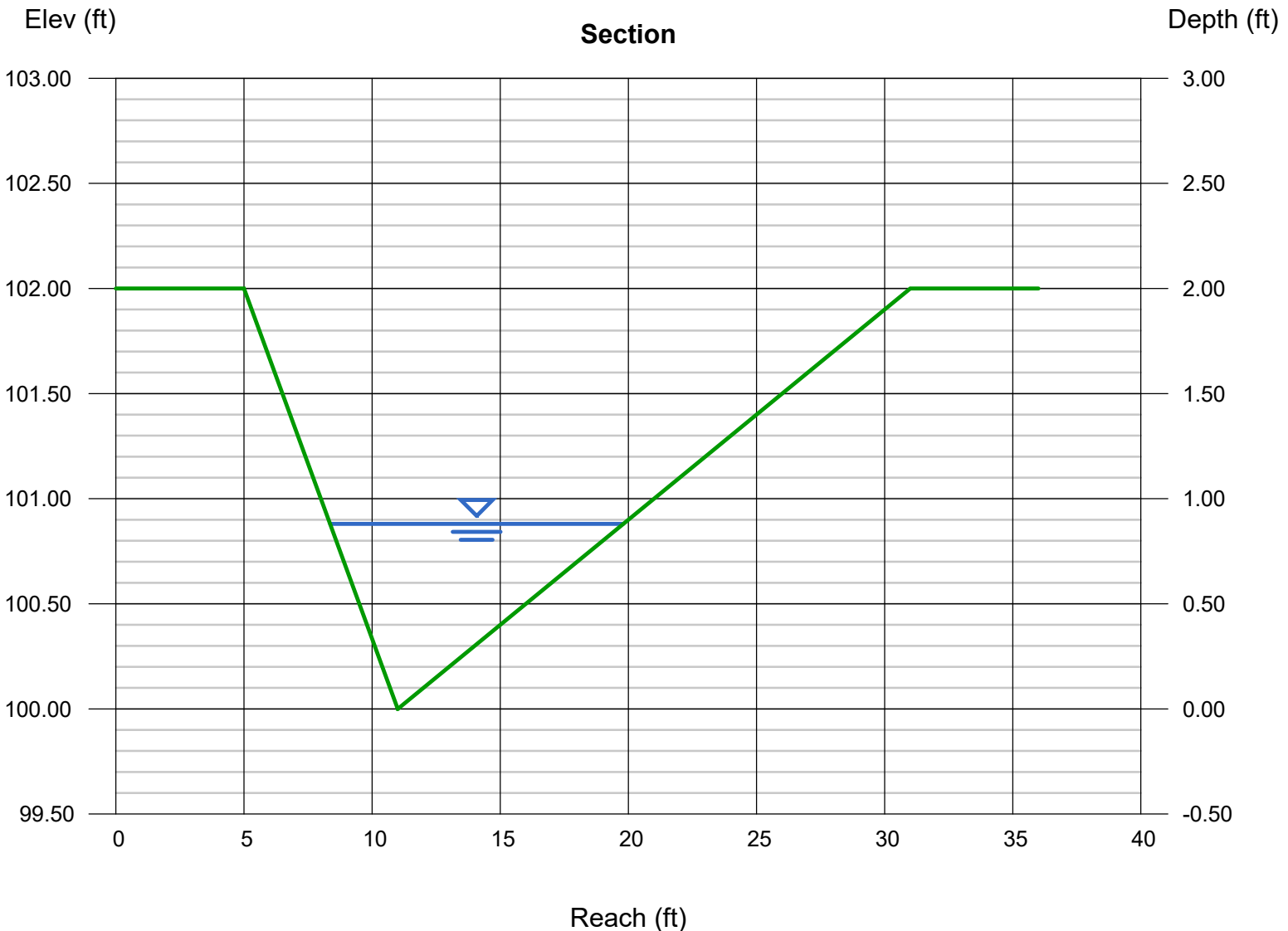
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 20.04

Highlighted

Depth (ft) = 0.88
Q (cfs) = 20.04
Area (sqft) = 5.03
Velocity (ft/s) = 3.98
Wetted Perim (ft) = 11.63
Crit Depth, Yc (ft) = 0.91
Top Width (ft) = 11.44
EGL (ft) = 1.13



Channel Report

Bench 4 10-yr

Triangular

Side Slopes (z:1) = 3.00, 20.00
Total Depth (ft) = 2.00

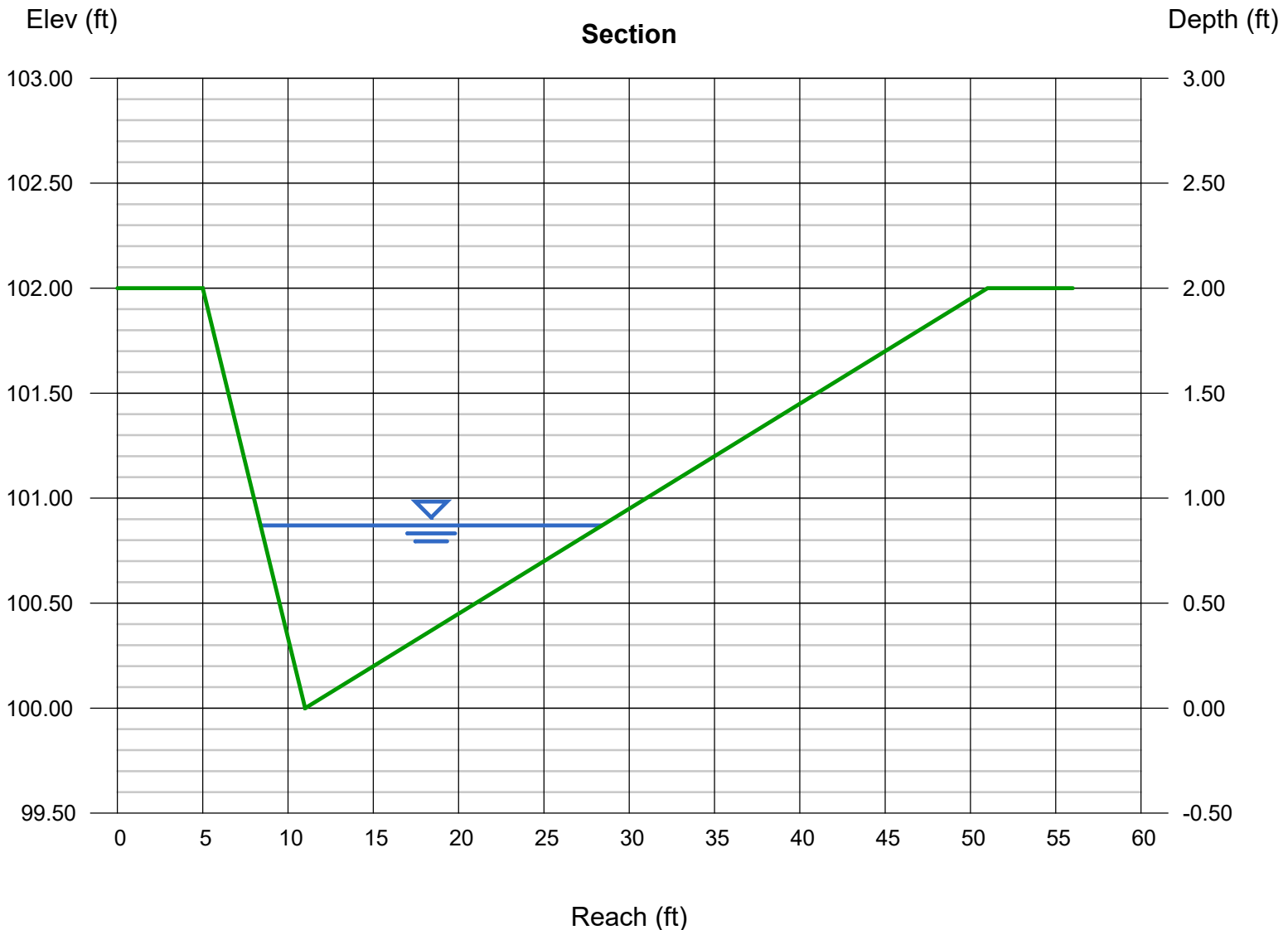
Invert Elev (ft) = 100.00
Slope (%) = 2.80
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 40.96

Highlighted

Depth (ft) = 0.87
Q (cfs) = 40.96
Area (sqft) = 8.70
Velocity (ft/s) = 4.71
Wetted Perim (ft) = 20.17
Crit Depth, Yc (ft) = 0.96
Top Width (ft) = 20.01
EGL (ft) = 1.21



Channel Report

Bench 4 25-yr

Triangular

Side Slopes (z:1) = 3.00, 20.00
Total Depth (ft) = 2.00

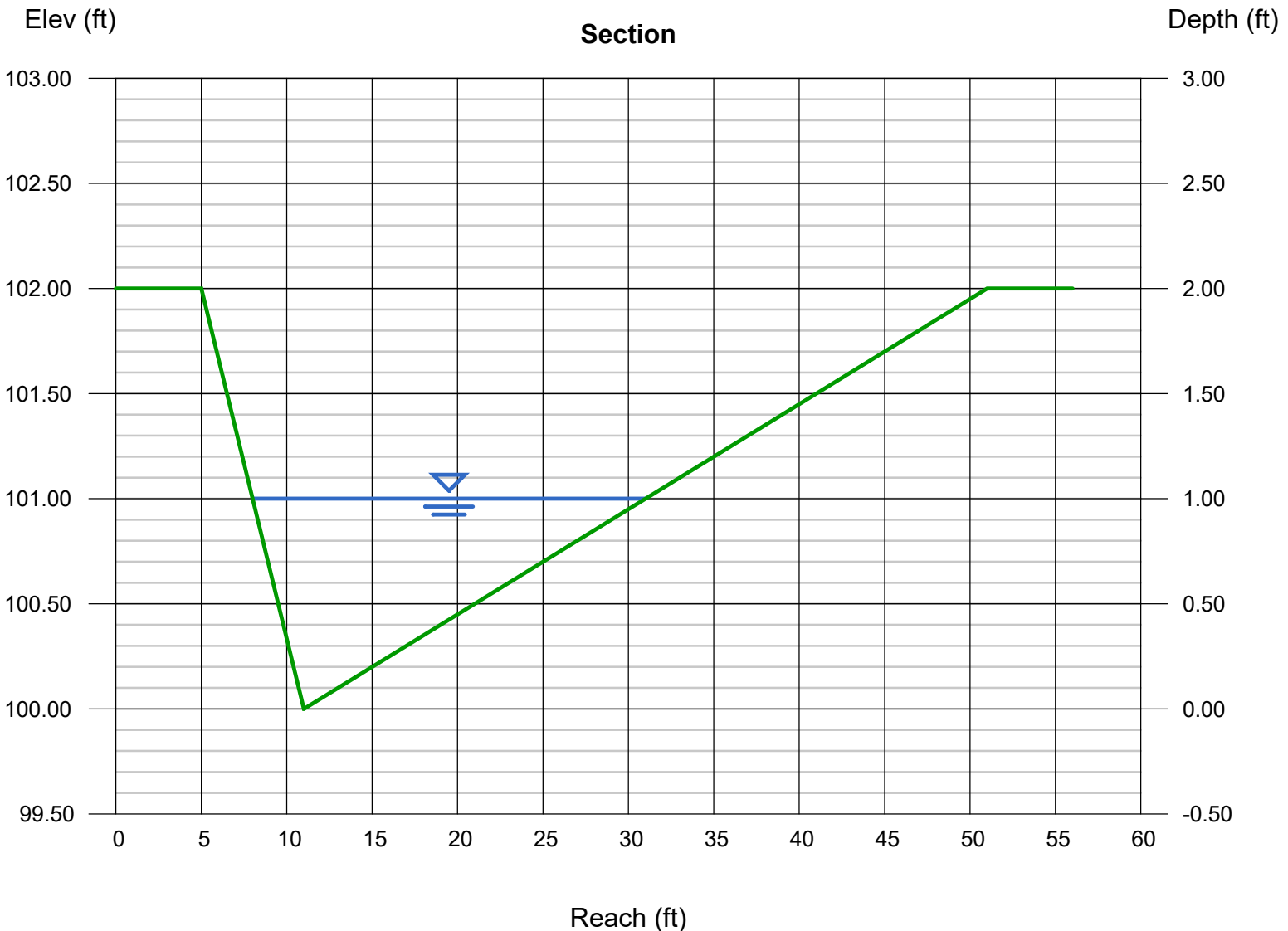
Invert Elev (ft) = 100.00
Slope (%) = 2.80
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 58.92

Highlighted

Depth (ft) = 1.00
Q (cfs) = 58.92
Area (sqft) = 11.50
Velocity (ft/s) = 5.12
Wetted Perim (ft) = 23.19
Crit Depth, Yc (ft) = 1.11
Top Width (ft) = 23.00
EGL (ft) = 1.41



Channel Report

Bench 4 100-yr

Triangular

Side Slopes (z:1) = 3.00, 20.00
Total Depth (ft) = 2.00

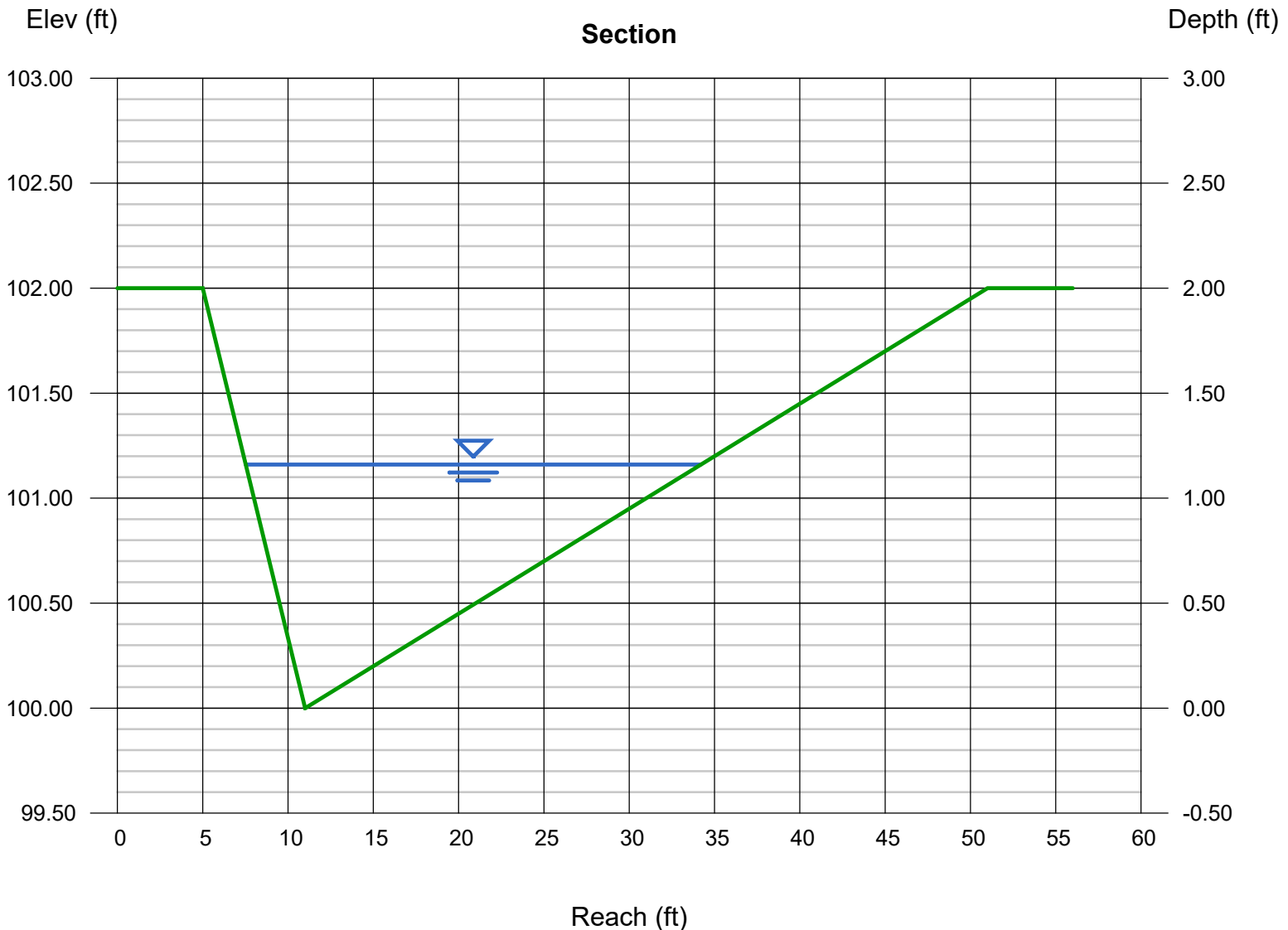
Invert Elev (ft) = 100.00
Slope (%) = 2.80
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 87.00

Highlighted

Depth (ft) = 1.16
Q (cfs) = 87.00
Area (sqft) = 15.47
Velocity (ft/s) = 5.62
Wetted Perim (ft) = 26.90
Crit Depth, Yc (ft) = 1.29
Top Width (ft) = 26.68
EGL (ft) = 1.65



Channel Report

Benches 5 and 6 10-yr

Triangular

Side Slopes (z:1) = 3.00, 20.00
Total Depth (ft) = 2.00

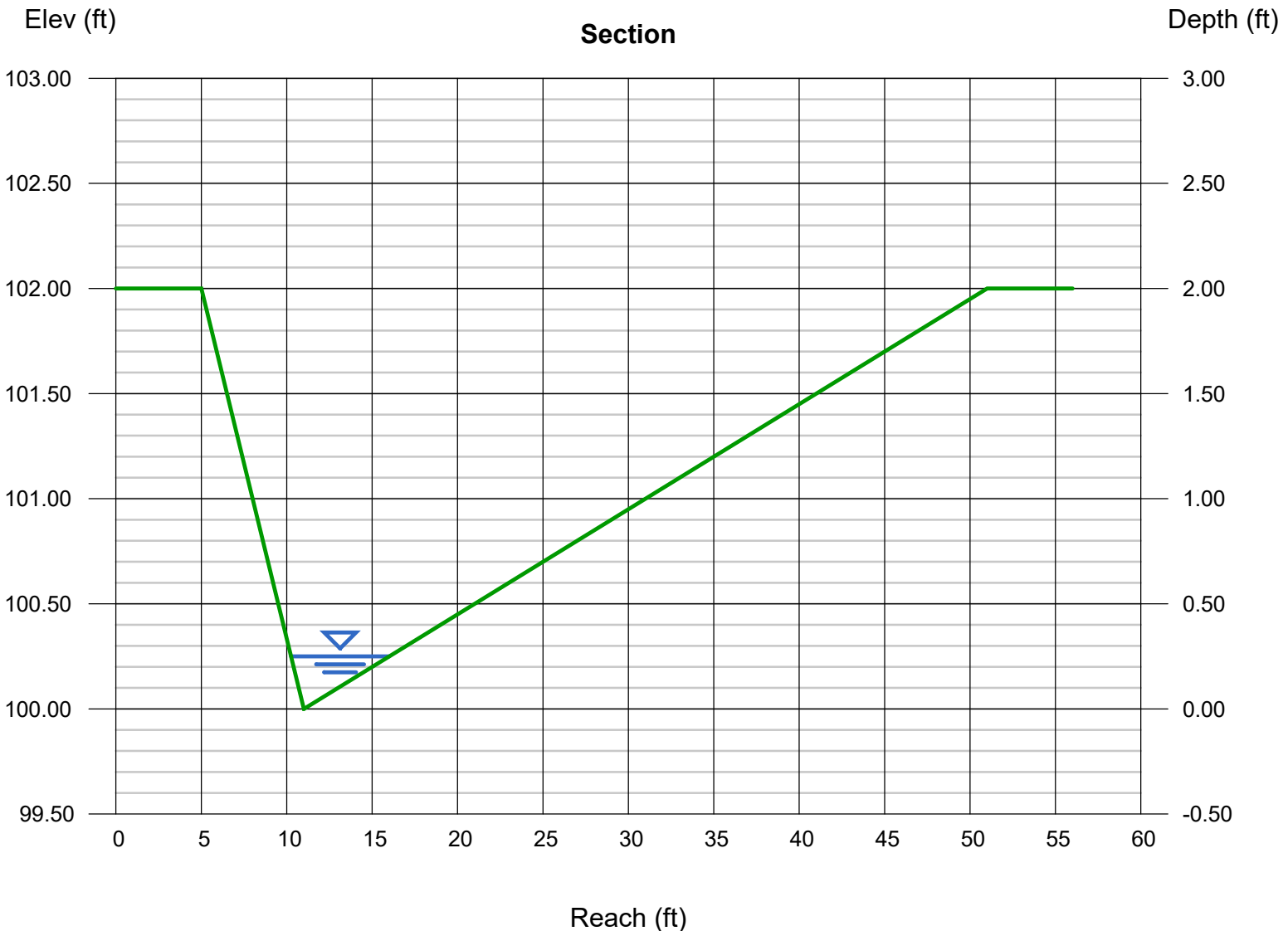
Invert Elev (ft) = 100.00
Slope (%) = 3.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 1.43

Highlighted

Depth (ft) = 0.25
Q (cfs) = 1.430
Area (sqft) = 0.72
Velocity (ft/s) = 1.99
Wetted Perim (ft) = 5.80
Crit Depth, Yc (ft) = 0.25
Top Width (ft) = 5.75
EGL (ft) = 0.31



Channel Report

Benches 5 and 6 25-yr

Triangular

Side Slopes (z:1) = 3.00, 20.00
Total Depth (ft) = 2.00

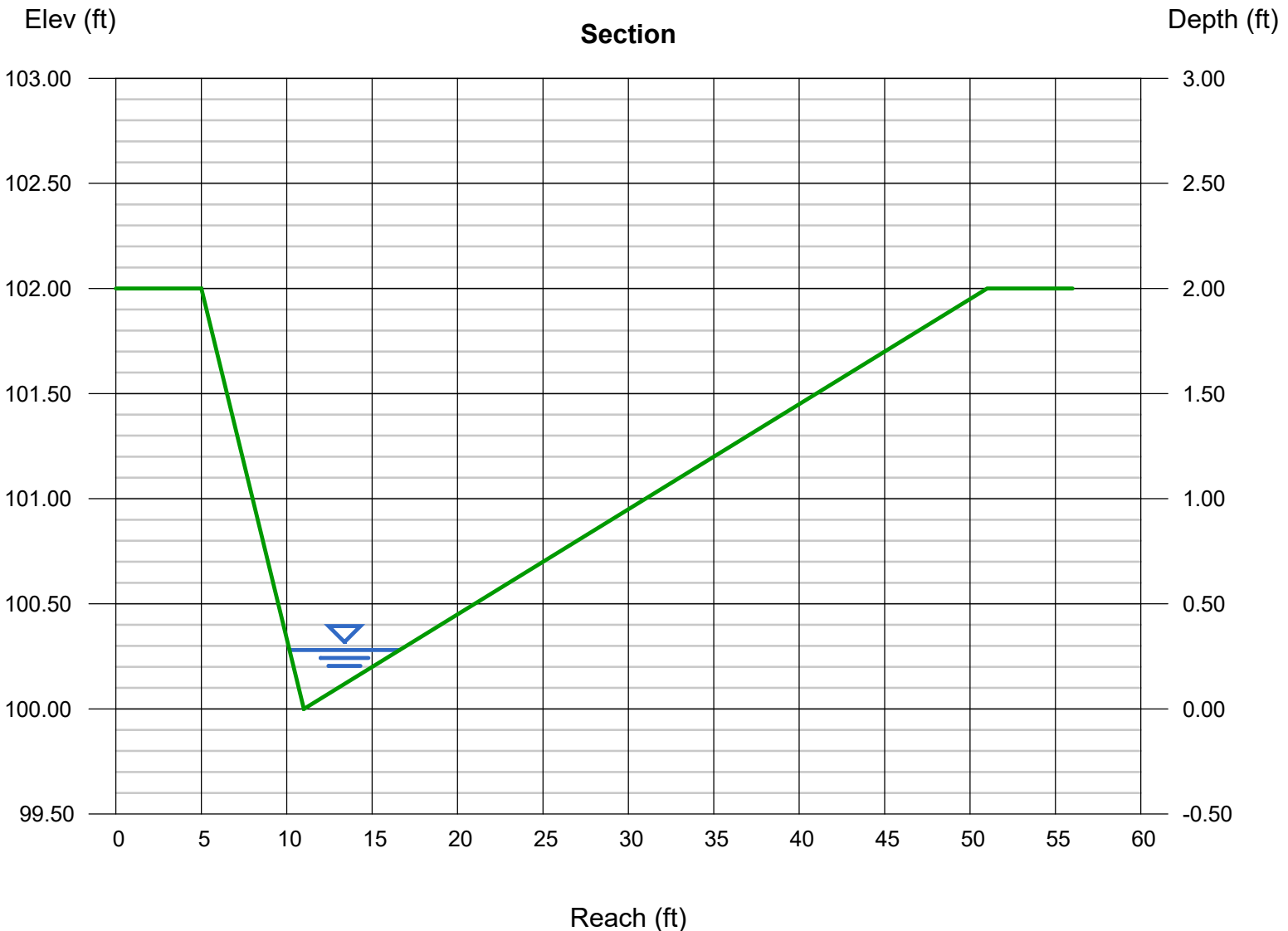
Invert Elev (ft) = 100.00
Slope (%) = 3.00
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 2.03

Highlighted

Depth (ft) = 0.28
Q (cfs) = 2.030
Area (sqft) = 0.90
Velocity (ft/s) = 2.25
Wetted Perim (ft) = 6.49
Crit Depth, Yc (ft) = 0.29
Top Width (ft) = 6.44
EGL (ft) = 0.36



Channel Report

Benches 5 and 6 100-yr

Triangular

Side Slopes (z:1) = 3.00, 20.00
Total Depth (ft) = 2.00

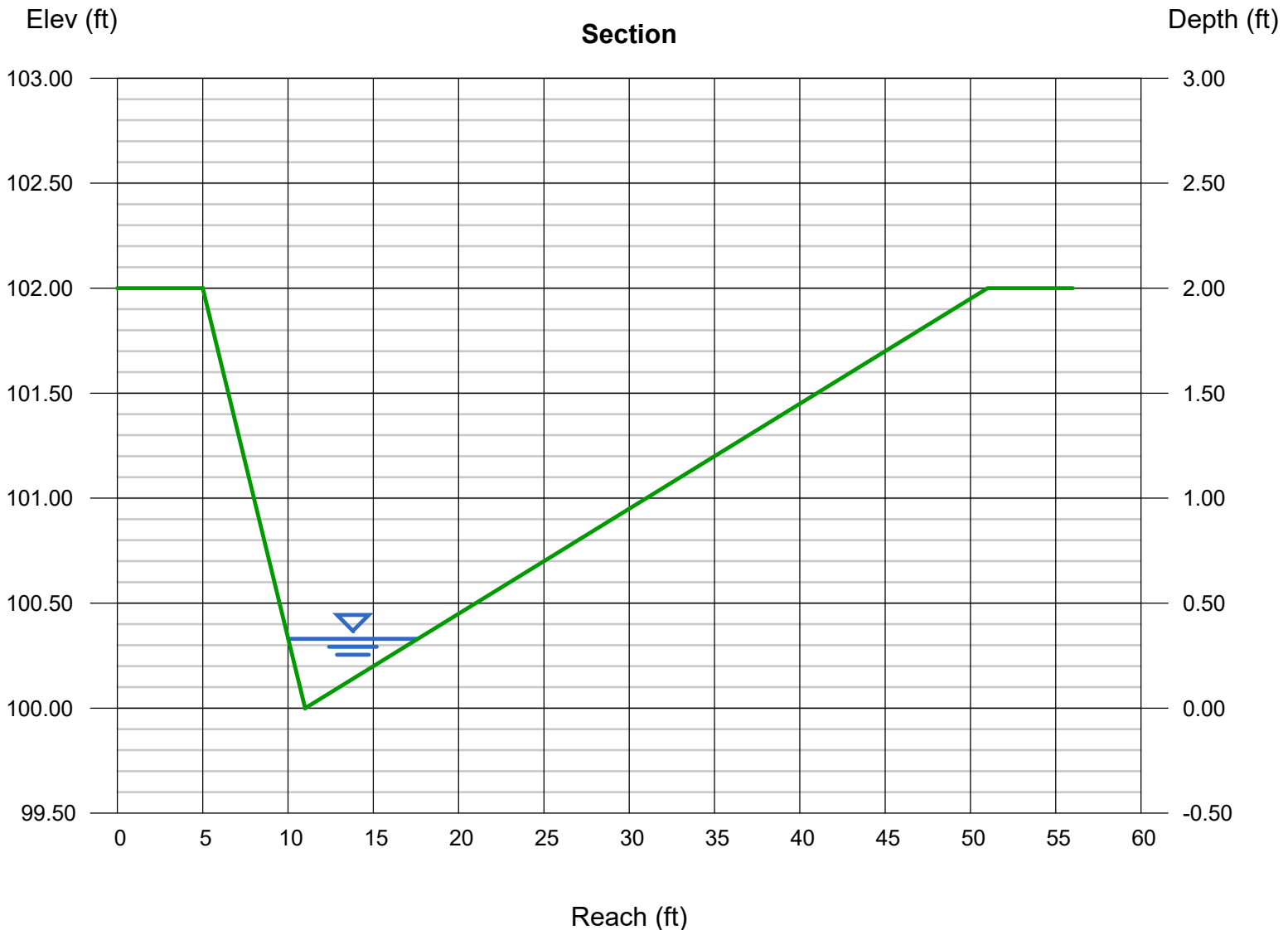
Invert Elev (ft) = 100.00
Slope (%) = 2.80
N-Value = 0.030

Calculations

Compute by: Known Q
Known Q (cfs) = 2.99

Highlighted

Depth (ft) = 0.33
Q (cfs) = 2.990
Area (sqft) = 1.25
Velocity (ft/s) = 2.39
Wetted Perim (ft) = 7.65
Crit Depth, Yc (ft) = 0.34
Top Width (ft) = 7.59
EGL (ft) = 0.42



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EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
225 Schilling Circle, Suite 400, Hunt Valley, Maryland 21031

Pipe Slope Drain Schedule

By: SCL
Date: 11/18/2020
Check: _____
Date: _____
Sheet: 1 of 1

Project: Gude Landfill
Job Number: 1564601
Maryland County: Montgomery
Study Area Limits: N/A
Study Area Designator: N/A

ID	Phase	Drainage Area (AC.)	Pipe Size (inch)
PSD S-I-1	S-I	1.15	18
PSD S-I-2	S-I	1.49	18
PSD S-II-1	S-II	1.31	18
PSD S-II-2	S-II	0.92	18
PSD S-III-1	S-III	0.44	12
PSD S-III-2	S-III	1.46	18



Earth Dike Schedule

By: SCL
 Date: 11/18/2020
 Check: _____
 Date: _____
 Sheet: 1 of 2

Project: Gude Landfill
 Job Number: 1564601
 Maryland County: Montgomery
 Study Area Limits: N/A

ID	Phase	Drainage Area (Ac.)	Maximum Slope	Clear / Dirty Water	Class
ED S-I-1	S-I	0.57	2.0%	Dirty	A-1
ED S-I-2	S-I	0.57	2.0%	Dirty	A-1
ED S-I-3	S-I	1.49	1.0%	Dirty	A-1
ED S-I-4	S-I	1.49	3.3%	Dirty	A-2
ED S-II-1	S-II	1.31	5.0%	Dirty	A-2
ED S-II-2	S-II	0.92	8.3%	Dirty	A-2
ED S-II-3	S-II	0.86	1.8%	Dirty	A-1
ED S-II-4	S-II	0.36	2.2%	Dirty	A-2
ED S-II-5	S-II	0.23	3.8%	Dirty	A-2
ED S-II-6	S-II	0.1	1.0%	Dirty	A-1
ED S-II-7	S-II	0.24	8.3%	Dirty	A-2
ED S-II-8	S-II	0.25	3.3%	Dirty	A-2
ED S-III-1	S-III	0.23	8.3%	Dirty	A-2
ED S-III-2	S-III	0.23	3.3%	Dirty	A-2
ED S-III-3	S-III	0.55	5.6%	Dirty	A-2
ED S-III-4	S-III	0.1	4.3%	Dirty	A-2
ED S-III-5	S-III	0.26	2.1%	Dirty	A-1
ED S-III-6	S-III	0.26	2.1%	Dirty	A-1
ED S-IV-1	S-IV	4.02	4.9%	Clear/Dirty	A-2
ED S-IV-2	S-IV	1.95	9.1%	Dirty	A-2
ED S-IV-3	S-IV	0.34	3.3%	Clear	A-2
ED S-IV-4	S-IV	0.17	1.0%	Clear	A-2
ED S-IV-5	S-IV	1.16	7.7%	Clear	A-2
ED S-IV-6	S-IV	0.62	15.4%	Clear	A-3
ED S-IV-7	S-IV	0.82	10.0%	Clear	A-2
ED S-V-1	S-V	1.16	8.3%	Clear	A-2
ED S-V-2	S-V	0.36	4.6%	Dirty	A-2
ED S-V-3	S-V	0.12	5.0%	Dirty	A-2



Earth Dike Schedule

By: SCL
 Date: 6/26/2020
 Check: _____
 Date: _____
 Sheet: 1 of 2

Project: Gude Landfill
 Job Number: 1564601
 Maryland County: Montgomery
 Study Area Limits: N/A

ID	Phase	Drainage Area (Ac.)	Maximum Slope	Clear / Dirty Water	Class
ED S-I-1	S-I	0.57	2.0%	Dirty	A-1
ED S-I-2	S-I	0.57	2.0%	Dirty	A-1
ED S-I-3	S-I	1.49	1.0%	Dirty	A-1
ED S-I-4	S-I	1.49	3.3%	Dirty	A-2
ED S-II-1	S-II	1.31	5.0%	Dirty	A-2
ED S-II-2	S-II	0.92	8.3%	Dirty	A-2
ED S-II-3	S-II	0.86	1.8%	Dirty	A-1
ED S-II-4	S-II	0.36	2.2%	Dirty	A-2
ED S-II-5	S-II	0.23	3.8%	Dirty	A-2
ED S-II-6	S-II	0.1	1.0%	Dirty	A-1
ED S-II-7	S-II	0.24	8.3%	Dirty	A-2
ED S-II-8	S-II	0.25	3.3%	Dirty	A-2
ED S-III-1	S-III	0.23	8.3%	Dirty	A-2
ED S-III-2	S-III	0.23	3.3%	Dirty	A-2
ED S-III-3	S-III	0.55	5.6%	Dirty	A-2
ED S-III-4	S-III	0.1	4.3%	Dirty	A-2
ED S-III-5	S-III	0.26	2.1%	Dirty	A-1
ED S-III-6	S-III	0.26	2.1%	Dirty	A-1
ED S-IV-1	S-IV	4.02	4.9%	Clear/Dirty	A-2
ED S-IV-2	S-IV	1.95	9.1%	Clear	A-2
ED S-IV-3	S-IV	0.34	3.3%	Clear	A-2
ED S-IV-4	S-IV	0.17	1.0%	Clear	A-2
ED S-IV-5	S-IV	1.16	7.7%	Clear	A-2
ED S-IV-6	S-IV	0.62	15.4%	Clear	A-3
ED S-IV-7	S-IV	0.82	10.0%	Clear	A-2
ED S-V-1	S-V	1.16	8.3%	Clear	A-2
ED S-V-2	S-V	0.36	4.6%	Clear	A-2
ED S-V-3	S-V	0.12	5.0%	Dirty	A-2



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
225 Schilling Circle, Suite 400, Hunt Valley, Maryland 21031

Temporary Gabion/Stone Outlet Structure Schedule

By: SCL
 Date: 11/18/2020
 Check: _____
 Date: _____
 Sheet: 1 of 2

Project: Gude Landfill
 Job Number: 1564601
 Maryland County: Montgomery
 Study Area Limits: N/A
 Study Area Designator: N/A

Temporary Gabion Outlet Structure Schedule						
ID	Phase	Drainage Area (AC.)	Volume Required	Volume Provided	Channel Bottom Elevation	Weir Elevation
TGOS S-I-1	S-I	1.15	2,070	2,465	465	468
TGOS S-I-2	S-I	1.49	2,682	7,785	465	467
TGOS S-I-3	S-I	1.42	2,556	2,560	467	469
TGOS S-I-4	S-I	1.34	2,412	2,798	468	470
TGOS S-II-1	S-II	1.31	2,358	4,753	459	461
TGOS S-II-2	S-II	0.91	1,638	2,414	452	454
TGOS S-II-3	S-II	1.07	1,926	2,664	466.5	467.5
TGOS S-II-4	S-II	2.25	4,050	4,500	459.5	462
TGOS S-III-1	S-III	0.44	792	4,538	451	454
TGOS S-III-2	S-III	1.46	2,628	3,371	451	454
TGOS S-III-3	S-III	1.5	2,700	2,850	463.5	464.8
TGOS S-VI-1	S-VI	1.15	2,070	3,019	451	452.5



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
225 Schilling Circle, Suite 400, Hunt Valley, Maryland 21031

Temporary Gabion/Stone Outlet Structure Schedule

By: SCL
 Date: 6/26/2020
 Check: _____
 Date: _____
 Sheet: 2 of 2

Project: Gude Landfill
 Job Number: 1564601
 Maryland County: Montgomery
 Study Area Limits: N/A
 Study Area Designator: N/A

Temporary Stone Outlet Structure Schedule						
ID	Phase	Drainage Area (AC.)	Volume Required	Volume Provided	Channel Bottom Elevation	Weir Elevation
TSOS S-II-1	S-II	0.46	828	1,018	463	464.5



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
225 Schilling Circle, Suite 400, Hunt Valley, Maryland 21031

By: SCL
 Date: 11/18/2020
 Check: _____
 Date: _____
 Sheet: 1 of 2

Project: Gude Landfill
 Job Number: 1564601
 Maryland County: Montgomery
 Study Area Limits: N/A
 Study Area N/A

Subgrade Clearwater Diversion (CWD) Pipe Schedule

ID	Phase	Drainage Area (AC.)	Pipe Size	Pipe Length (ft.)	Min. Pipe Slope (%)	2-yr Flow (cfs)	2-Yr Velocity (fps)	Pipe Depth of Flow (ft.)	CWD Rock Outlet Protection				
									L (ft)	W (ft)	T (in)	d50 (ft.)	Class
CWD S-IV-1	S-IV	6.54	24"	338	4.7	7.8	11.34	0.54	12	14	19	0.5	I
CWD S-IV-2	S-IV	12.96	24"	498	2.2	15.84	10.43	0.97	12	14	19	0.6	I
CWD S-IV-3	S-IV	10.61	24"	584	2.1	12.49	9.6	0.86	12	14	19	0.5	I
CWD S-IV-4	S-IV	0.99	18"	145	2.2	-	-	-	12	14	19	0.5	I
CWD S-IV-5	S-IV	10.8	24"	260	3.3	14.5	11.76	0.83	12	14	19	0.6	I
CWD S-IV-6	S-IV	0.2	12"	141	2.0	-	-	-	12	14	19	0.5	I
CWD S-IV-7	S-IV	0.68	18"	41	2.0	-	-	-	12	14	19	0.5	I
CWD S-IV-8	S-IV	0.93	18"	68	1.5	-	-	-	12	14	19	0.5	I
CWD S-V-1	S-V	1.62	24"	190	1.1	-	-	-	12	14	19	0.5	I
CWD S-V-2	S-V	0.97	18"	175	2.3	-	-	-	12	14	19	0.5	I
CWD S-V-3	S-V	4.92	24"	120	1.8	5.81	7.32	0.6	12	14	19	0.5	I
CWD S-V-4	S-V	18.85	24"	331	2.1	22.11	11.1	1.21	14	16	19	0.6	I
CWD S-V-5	S-V	5.09	24"	150	3.1	5.85	8.91	0.52	12	14	19	0.5	I
CWD S-V-6	S-V	3.22	24"	161	3.5	-	-	-	12	14	19	0.5	I
CWD S-VI-1	S-VI	1.08	18"	55	1.4	-	-	-	12	14	19	0.5	I
CWD S-VI-2	S-VI	2.74	24"	140	1.9	-	-	-	12	14	19	0.5	I
CWD S-VI-3	S-VI	0.36	12"	46	2.5	-	-	-	12	14	19	0.5	I
CWD S-VI-4	S-VI	11.44	24"	128	2.0	12.96	9.28	0.83	12	14	19	0.5	I
CWD S-VII-1	S-VII	10.57	24"	161	1.5	12.25	8.51	0.93	12	14	19	0.5	I



EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC
225 Schilling Circle, Suite 400, Hunt Valley, Maryland 21031

By: SCL
 Date: 11/18/2020
 Check: _____
 Date: _____
 Sheet: 2 of 2

Project: Gude Landfill
 Job Number: 1564601
 Maryland County: Montgomery
 Study Area Limits: N/A
 Study Area: N/A

Final Grade Clearwater Diversion (CWD) Pipe Schedule													
ID	Phase	Drainage Area (AC.)	Pipe Size	Pipe Length	Min. Pipe Slope (%)	2-yr Flow	2-Yr Velocity	Pipe Depth of	CWD Rock Outlet Protection				
									L (ft)	W (ft)	T (in)	d50 (ft.)	Class
CWD F-III-1	F-III	14.07	24"	150	2.0	17.04	10.27	1.04	12	14	19	0.6	I
CWD F-III-2	F-III	10.95	24"	168	3.3	12.97	11.61	0.77	12	14	19	0.6	I
CWD F-III-3	F-III	2.15	24"	68	1.5	-	-	-	12	14	19	0.5	I
CWD F-IV-1	F-IV	15.81	24"	150	3.3	17.96	12.65	0.92	12	14	19	0.7	I
CWD F-IV-2	F-IV	10.95	24"	168	3.3	12.97	11.61	0.77	12	14	19	0.6	I
CWD F-IV-3	F-IV	2.15	24"	68	1.5	-	-	-	12	14	19	0.5	I
CWD F-V-1	F-IV	2.15	24"	68	1.5	-	-	-	12	14	19	0.5	I
CWD F-VI-1	F-VI	10.95	24"	168	3.3	12.97	11.61	0.77	12	14	19	0.6	I
CWD F-VI-2	F-VI	14.07	24"	170	2.0	17.04	10.27	1.04	12	14	19	0.6	I
CWD F-VI-3	F-VI	37.8	30"	451	1.5	45.78	11.55	1.88	14	16	19	0.8	I

WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: CWD S-IV-1 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\CWD S-IV-1.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD S-IV-1		Outlet	6.54	80	.318

Total area: 6.54 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-IV-1
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-IV-1
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD S-IV-1	7.80
REACHES	
OUTLET	7.80

EA

Gude
CWD S-IV-1
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD S-IV-1	7.80 12.25
------------	---------------

REACHES

OUTLET	7.80
--------	------

EA

Gude
CWD S-IV-1
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD S-IV-1	6.54	0.318	80	Outlet	
Total Area:		6.54 (ac)			

EA

Gude
CWD S-IV-1
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
CWD S-IV-1							
SHEET	100	0.0250	0.240				0.220
SHALLOW	1003	0.0310	0.050				0.098
						Time of Concentration	.318
							=====

EA

Gude
CWD S-IV-1
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD S-IV-1Dirt	(w/ right-of-way)	D	.05	89
	Pasture, grassland or range	(good) D	6.49	80
	Total Area / Weighted Curve Number		6.54	80
			====	==

Channel Report

CWD S-IV-1

Circular

Diameter (ft) = 2.00

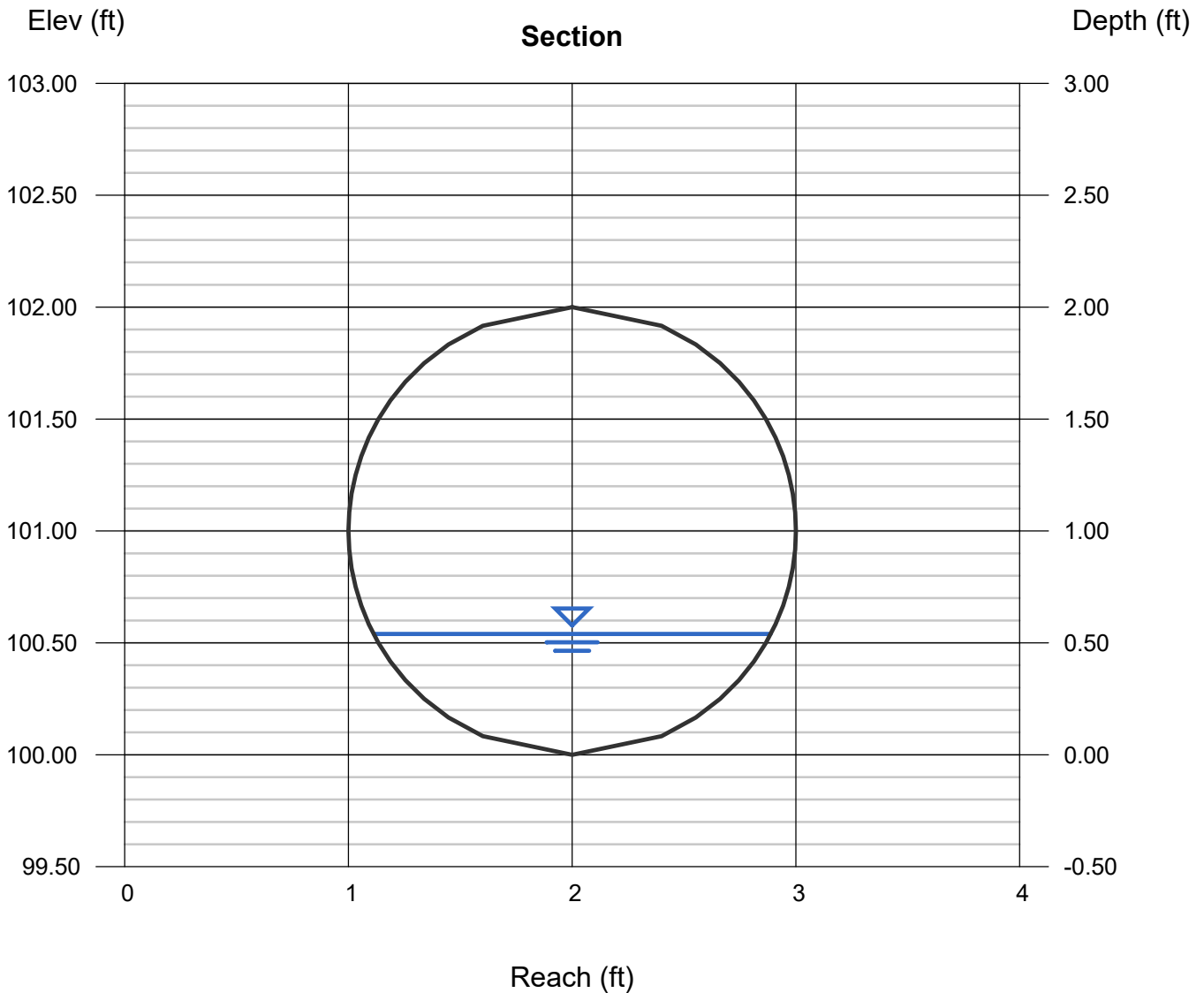
Invert Elev (ft) = 100.00
Slope (%) = 4.70
N-Value = 0.013

Highlighted

Depth (ft) = 0.54
Q (cfs) = 7.800
Area (sqft) = 0.69
Velocity (ft/s) = 11.34
Wetted Perim (ft) = 2.19
Crit Depth, Yc (ft) = 0.99
Top Width (ft) = 1.78
EGL (ft) = 2.54

Calculations

Compute by: Known Q
Known Q (cfs) = 7.80



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: DA-1A Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\slemasters\Desktop\CWD S-IV-2 (DA-1A).w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1A EX		Outlet	12.96	80	.302

Total area: 12.96 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
DA-1A EX	15.84
REACHES	
OUTLET	15.84

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

DA-1A EX	15.84 12.24
----------	----------------

REACHES

OUTLET	15.84
--------	-------

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-1A EX	12.96	0.302	80	Outlet	
Total Area:		12.96 (ac)			

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-1A EX	Dirt (w/ right-of-way)	D	.559	89
	Pasture, grassland or range	(good) D	12.4	80
	Total Area / Weighted Curve Number		12.96	80
			=====	==

EA

Gude
CWD S-IV-3
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD S-IV-3Dirt	(w/ right-of-way)	D	.509	89
	Pasture, grassland or range	(good) D	10.1	80
	Total Area / Weighted Curve Number		10.61	80
			=====	==

Channel Report

CWD S-IV-2

Circular

Diameter (ft) = 2.00

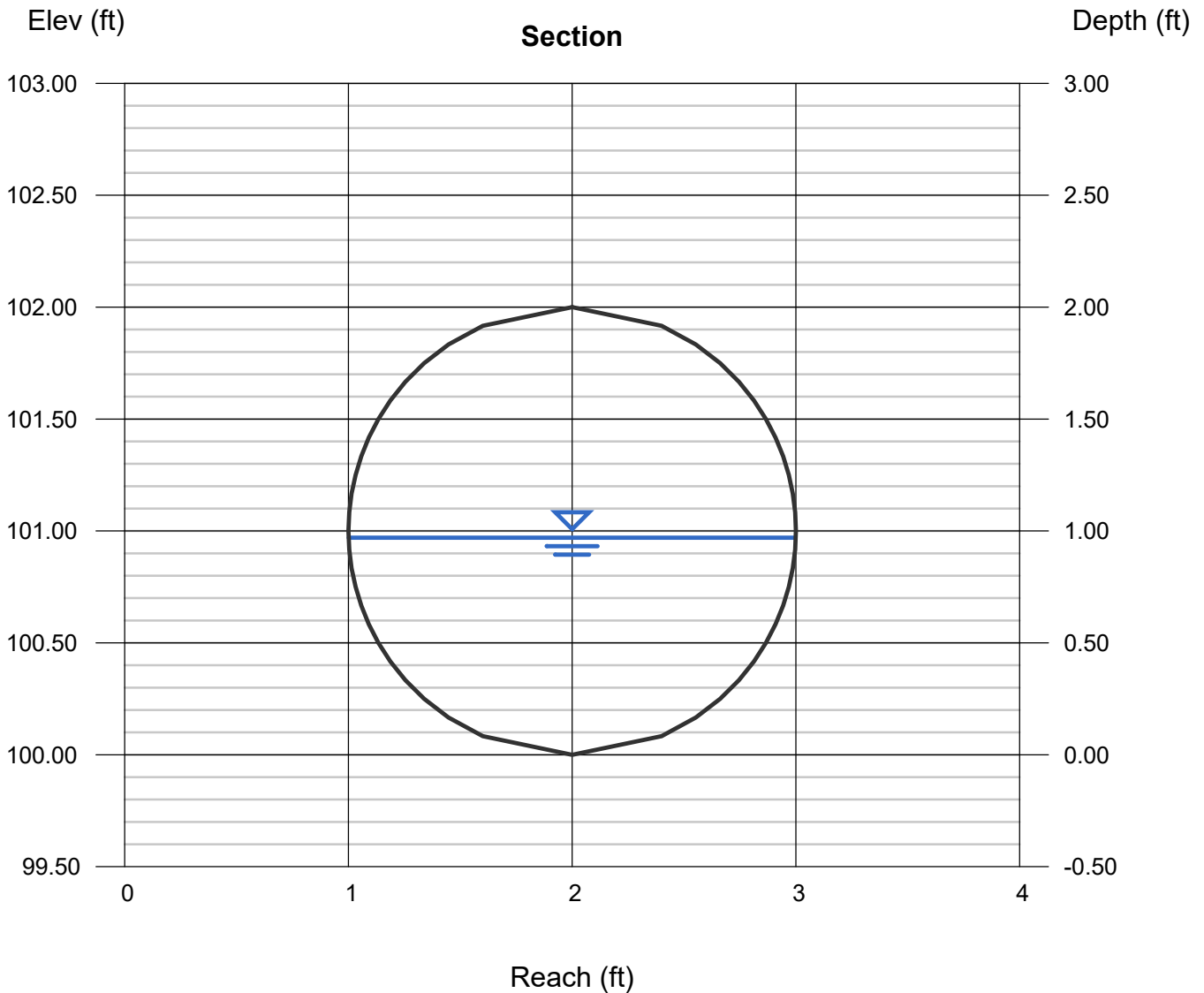
Invert Elev (ft) = 100.00
Slope (%) = 2.20
N-Value = 0.013

Highlighted

Depth (ft) = 0.97
Q (cfs) = 15.84
Area (sqft) = 1.52
Velocity (ft/s) = 10.43
Wetted Perim (ft) = 3.09
Crit Depth, Yc (ft) = 1.44
Top Width (ft) = 2.00
EGL (ft) = 2.66

Calculations

Compute by: Known Q
Known Q (cfs) = 15.84



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: CWD S-IV-3 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\CWD S-IV-3.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD S-IV-3		Outlet	10.61	80	.327

Total area: 10.61 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-IV-3
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-IV-3
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD S-IV-3	12.49
REACHES	
OUTLET	12.49

EA

Gude
CWD S-IV-3
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD S-IV-3	12.49 12.24
------------	----------------

REACHES

OUTLET	12.49
--------	-------

EA

Gude
CWD S-IV-3
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD S-IV-3	10.61	0.327	80	Outlet	
Total Area:	10.61 (ac)				

EA

Gude
CWD S-IV-3
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
CWD S-IV-3							
SHEET	100	0.0200	0.240				0.240
SHALLOW	536	0.0187	0.050				0.067
CHANNEL	880	0.0300	0.013	3.12	6.28	12.222	0.020
						Time of Concentration	.327
							=====

Channel Report

CWD S-IV-3

Circular

Diameter (ft) = 2.00

Invert Elev (ft) = 100.00

Slope (%) = 2.10

N-Value = 0.013

Calculations

Compute by: Known Q

Known Q (cfs) = 12.49

Highlighted

Depth (ft) = 0.86

Q (cfs) = 12.49

Area (sqft) = 1.30

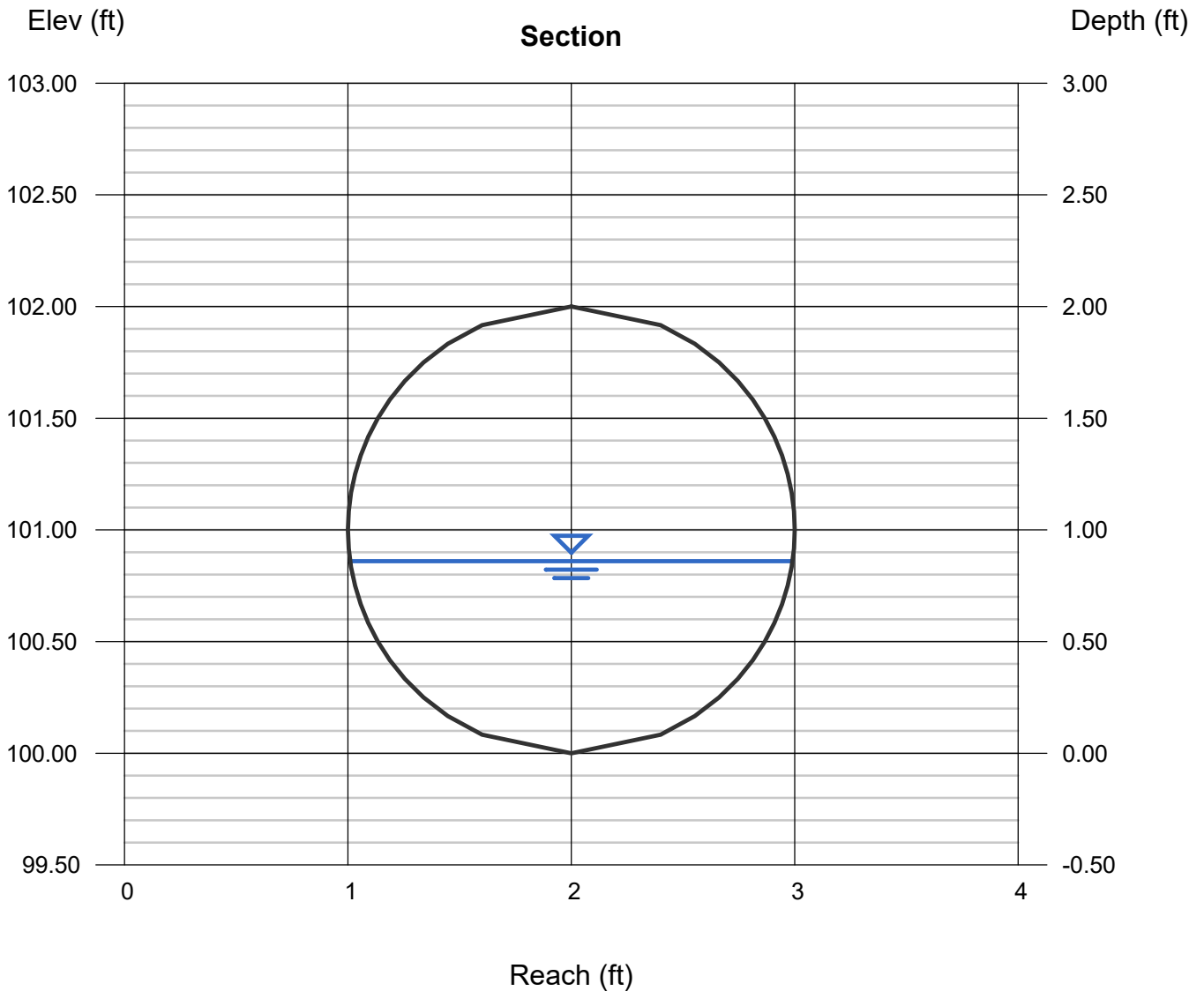
Velocity (ft/s) = 9.60

Wetted Perim (ft) = 2.87

Crit Depth, Yc (ft) = 1.28

Top Width (ft) = 1.98

EGL (ft) = 2.29



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/3/2020
 Project: Gude Units: English
 SubTitle: DA-1B Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: \\oceanpines\Projects\Docs\1564601 - Gude Landfill\Calcs - Uploaded to OneDrive\CWD S-IV-5 (DA-1

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DA-1B EX		Outlet	10.8	80	.244

Total area: 10.80 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)
------------------------------------	--

SUBAREAS
DA-1B EX

14.50

REACHES

OUTLET

14.50

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

DA-1B EX	14.50 12.20
----------	----------------

REACHES

OUTLET	14.50
--------	-------

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DA-1B EX	10.80	0.244	80	Outlet	

Total Area:	10.80 (ac)				

EA

Gude
DA-1B
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DA-1B EX	Dirt (w/ right-of-way)	D	.459	89
	Pasture, grassland or range	(good) D	10.343	80
	Total Area / Weighted Curve Number		10.8	80
			====	==

Channel Report

CWD S-IV-5

Circular

Diameter (ft) = 2.00

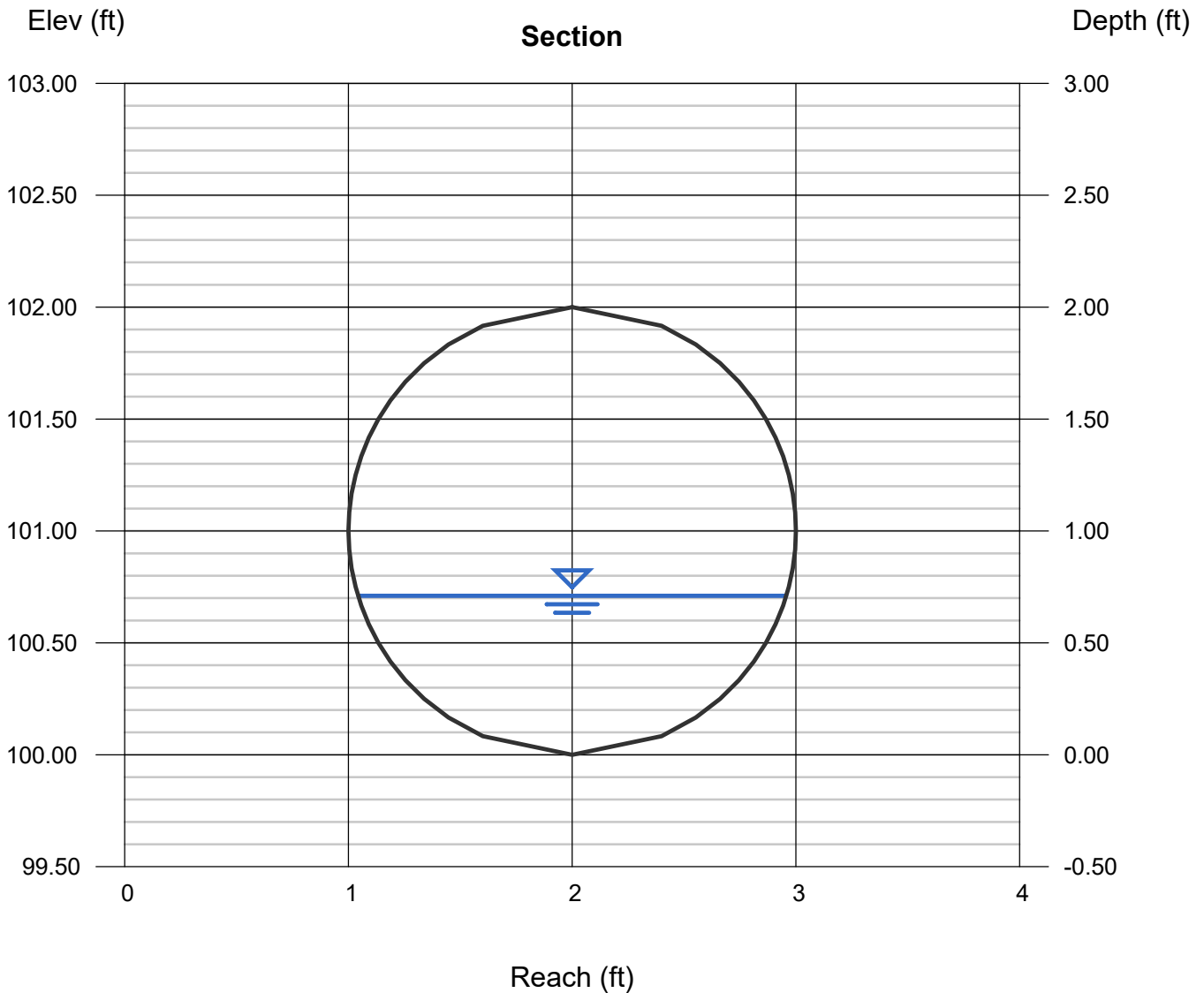
Invert Elev (ft) = 100.00
Slope (%) = 5.70
N-Value = 0.013

Highlighted

Depth (ft) = 0.71
Q (cfs) = 14.50
Area (sqft) = 1.01
Velocity (ft/s) = 14.42
Wetted Perim (ft) = 2.56
Crit Depth, Yc (ft) = 1.38
Top Width (ft) = 1.92
EGL (ft) = 3.94

Calculations

Compute by: Known Q
Known Q (cfs) = 14.50



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: CWD S-V-4 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\slemasters\Desktop\CWD S-V-3.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD S-V-4		Outlet	4.92	81	.363

Total area: 4.92 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD S-V-4	5.81
REACHES	
OUTLET	5.81

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD S-V-4	5.81 12.28
-----------	---------------

REACHES

OUTLET	5.81
--------	------

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD S-V-4	4.92	0.363	81	Outlet	

Total Area:	4.92 (ac)				

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
CWD S-V-4							
SHEET	100	0.0150	0.240				0.269
SHALLOW	950	0.0300	0.050				0.094
						Time of Concentration	.363
							=====

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD S-V-4	Gravel (w/ right-of-way)	D	.29	91
	Pasture, grassland or range	(good) D	4.63	80
	Total Area / Weighted Curve Number		4.92	81
			====	==

Channel Report

CWD S-V-4

Circular

Diameter (ft) = 2.00

Invert Elev (ft) = 100.00

Slope (%) = 1.75

N-Value = 0.013

Calculations

Compute by: Known Q

Known Q (cfs) = 5.81

Highlighted

Depth (ft) = 0.60

Q (cfs) = 5.810

Area (sqft) = 0.79

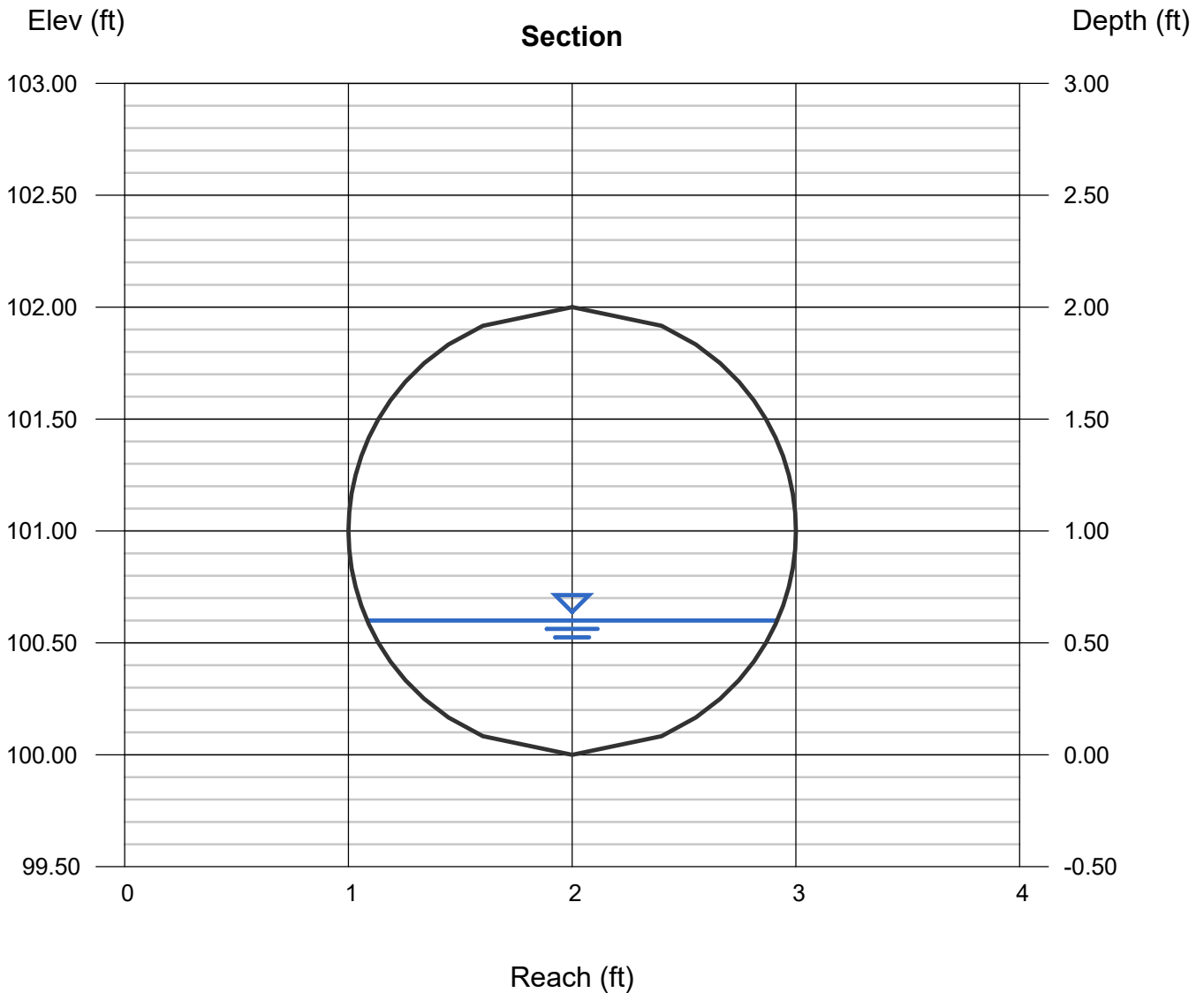
Velocity (ft/s) = 7.32

Wetted Perim (ft) = 2.32

Crit Depth, Y_c (ft) = 0.85

Top Width (ft) = 1.83

EGL (ft) = 1.43



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: CWD S-V-4 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\CWD S-V-4.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD S-V-4		Outlet	18.85	80	.329

Total area: 18.85 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD S-V-4	22.11
REACHES	
OUTLET	22.11

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD S-V-4	22.11 12.26
-----------	----------------

REACHES

OUTLET	22.11
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EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD S-V-4	18.85	0.329	80	Outlet	
Total Area:		18.85 (ac)			

EA

Gude
CWD S-V-4
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD S-V-4	Dirt (w/ right-of-way)	D	.62	89
	Pasture, grassland or range	(good) D	18.23	80
	Total Area / Weighted Curve Number		18.85	80
			=====	==

Channel Report

CWD S-V-4

Circular

Diameter (ft) = 2.00

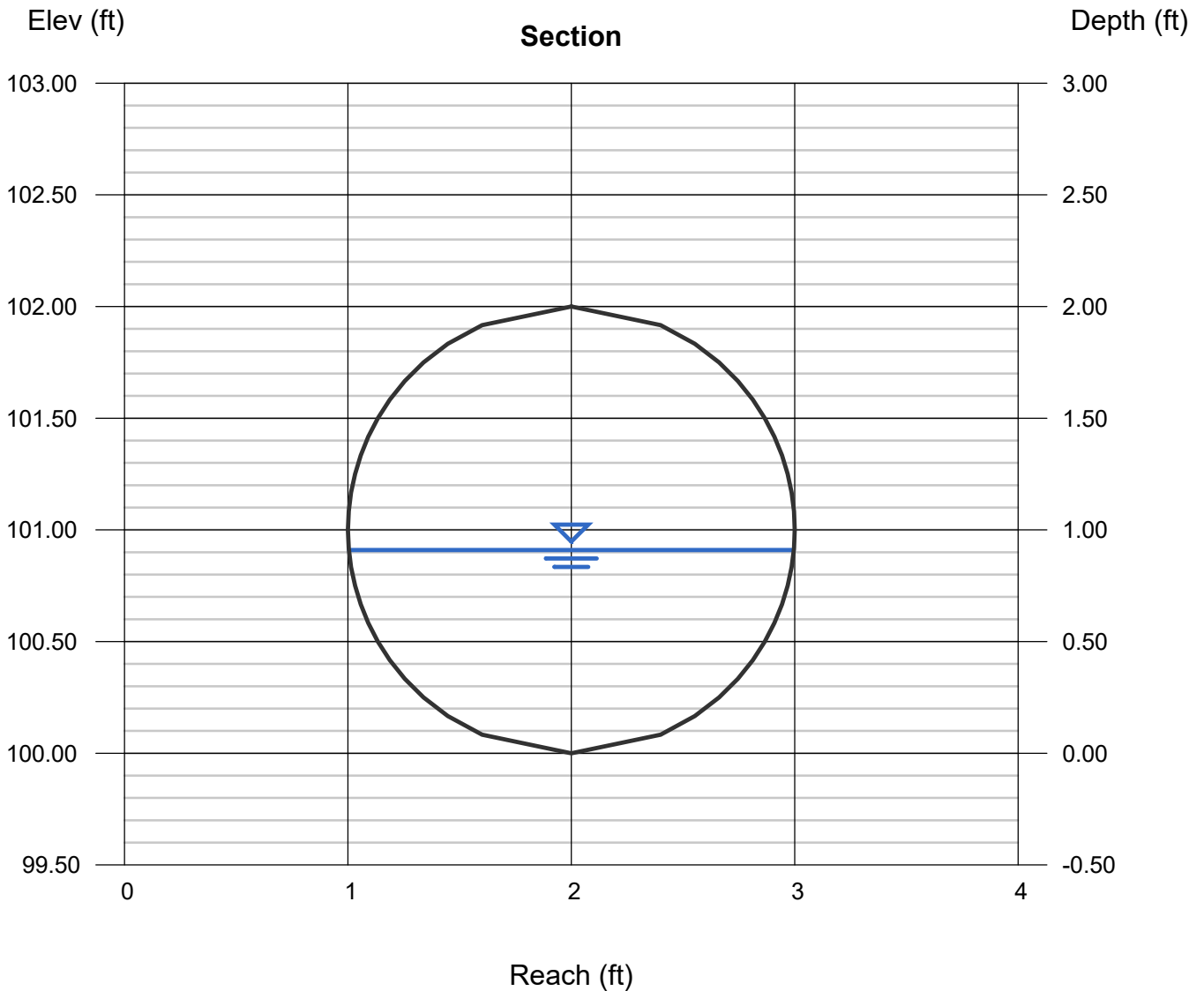
Invert Elev (ft) = 100.00
Slope (%) = 5.40
N-Value = 0.013

Highlighted

Depth (ft) = 0.91
Q (cfs) = 22.11
Area (sqft) = 1.40
Velocity (ft/s) = 15.80
Wetted Perim (ft) = 2.97
Crit Depth, Yc (ft) = 1.68
Top Width (ft) = 1.99
EGL (ft) = 4.79

Calculations

Compute by: Known Q
Known Q (cfs) = 22.11



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: CWD S-V-5 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\CWD S-V-5.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD S-V-5		Outlet	5.09	80	.344

Total area: 5.09 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-V-5
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-V-5
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD S-V-5	5.85
REACHES	
OUTLET	5.85

EA

Gude
CWD S-V-5
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
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SUBAREAS

CWD S-V-5	5.85 12.26
-----------	---------------

REACHES

OUTLET	5.85
--------	------

EA

Gude
CWD S-V-5
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD S-V-5	5.09	0.344	80	Outlet	

Total Area:	5.09 (ac)				

EA

Gude
CWD S-V-5
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD S-V-5	Gravel (w/ right-of-way)	D	.2	91
	Pasture, grassland or range	(good) D	4.89	80
	Total Area / Weighted Curve Number		5.09	80
			====	==

Channel Report

CWD S-V-5

Circular

Diameter (ft) = 2.00

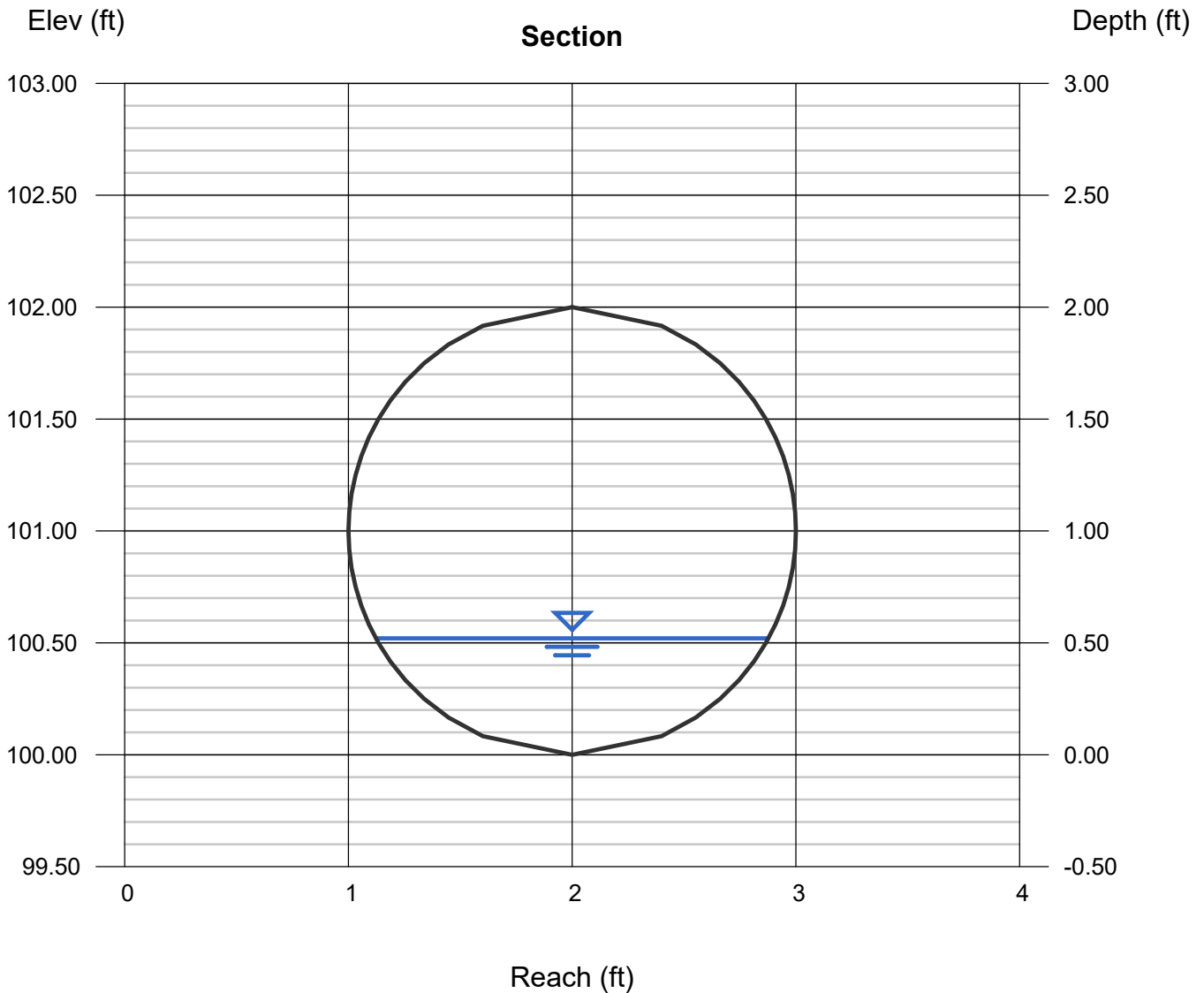
Invert Elev (ft) = 100.00
Slope (%) = 3.10
N-Value = 0.013

Highlighted

Depth (ft) = 0.52
Q (cfs) = 5.850
Area (sqft) = 0.66
Velocity (ft/s) = 8.91
Wetted Perim (ft) = 2.15
Crit Depth, Yc (ft) = 0.86
Top Width (ft) = 1.76
EGL (ft) = 1.75

Calculations

Compute by: Known Q
Known Q (cfs) = 5.85



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/7/2020
Project: Gude Units: English
SubTitle: CWD S-VI-4 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\DA-1A.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD S-VI-4		Outlet	11.44	80	.355

Total area: 11.44 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-VI-4
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-VI-4
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD S-VI-4	12.96
REACHES	
OUTLET	12.96

EA

Gude
CWD S-VI-4
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
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SUBAREAS

CWD S-VI-4	12.96 12.26
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REACHES

OUTLET	12.96
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EA

Gude
CWD S-VI-4
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD S-VI-4	11.44	0.355	80	Outlet	

Total Area:	11.44 (ac)				

EA

Gude
CWD S-VI-4
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
CWD S-VI-4							
SHEET	100	0.0150	0.240				0.269
SHALLOW	422	0.0200	0.050				0.051
CHANNEL	900	0.0200	0.030	14.04	13.90	7.143	0.035
						Time of Concentration	.355
							=====

EA

Gude
CWD S-VI-4
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD S-VI-4	Gravel (w/ right-of-way)	D	.318	91
	Pasture, grassland or range	(good) D	11.12	80
	Total Area / Weighted Curve Number		11.44	80
			=====	==

Channel Report

CWD S-VI-4

Circular

Diameter (ft) = 2.00

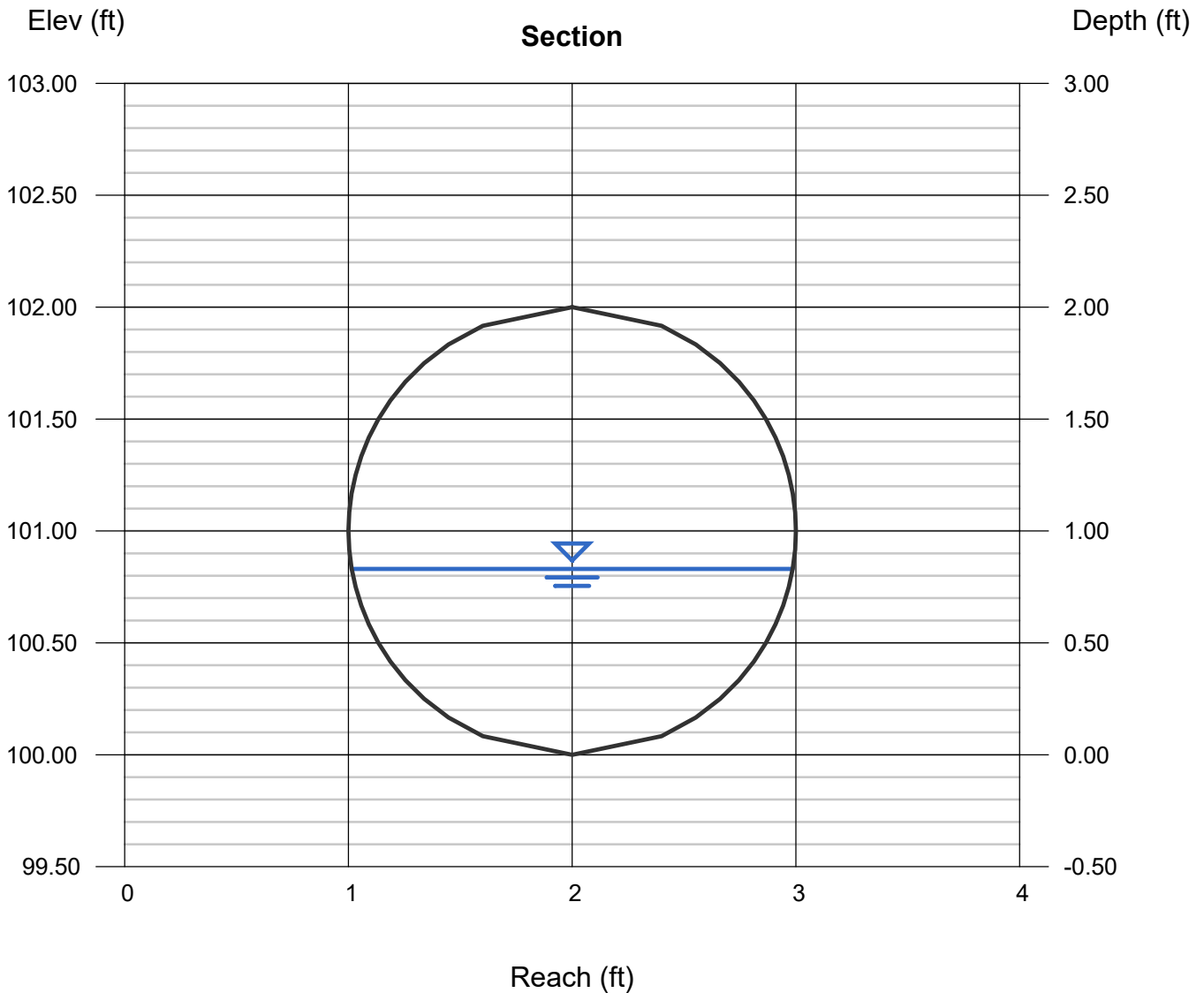
Invert Elev (ft) = 100.00
Slope (%) = 2.00
N-Value = 0.013

Highlighted

Depth (ft) = 0.83
Q (cfs) = 11.44
Area (sqft) = 1.23
Velocity (ft/s) = 9.28
Wetted Perim (ft) = 2.80
Crit Depth, Yc (ft) = 1.22
Top Width (ft) = 1.97
EGL (ft) = 2.17

Calculations

Compute by: Known Q
Known Q (cfs) = 11.44



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/7/2020
Project: Gude Units: English
SubTitle: CWD S-VII-1 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\CWD S-VII-1.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD S-VII-		Outlet	10.57	80	.323

Total area: 10.57 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-VII-1
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD S-VII-1
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD S-VII-	12.52
REACHES	
OUTLET	12.52

EA

Gude
CWD S-VII-1
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD S-VII-	12.52
	12.25

REACHES

OUTLET	12.52
--------	-------

EA

Gude
CWD S-VII-1
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD S-VII-	10.57	0.323	80	Outlet	

Total Area:	10.57 (ac)				

EA

Gude
CWD S-VII-1
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
CWD S-VII-							
SHEET	100	0.0150	0.240				0.269
SHALLOW	300	0.0250	0.050				0.033
CHANNEL	1260	0.0300	0.013	9.71	12.38	16.667	0.021
						Time of Concentration	.323
							=====

EA

Gude
CWD S-VII-1
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD S-VII-Gravel (w/ right-of-way)		D	.322	91
	Pasture, grassland or range	(good) D	10.25	80
	Total Area / Weighted Curve Number		10.57	80
			=====	==

Channel Report

CWD S-VII-1

Circular

Diameter (ft) = 2.00

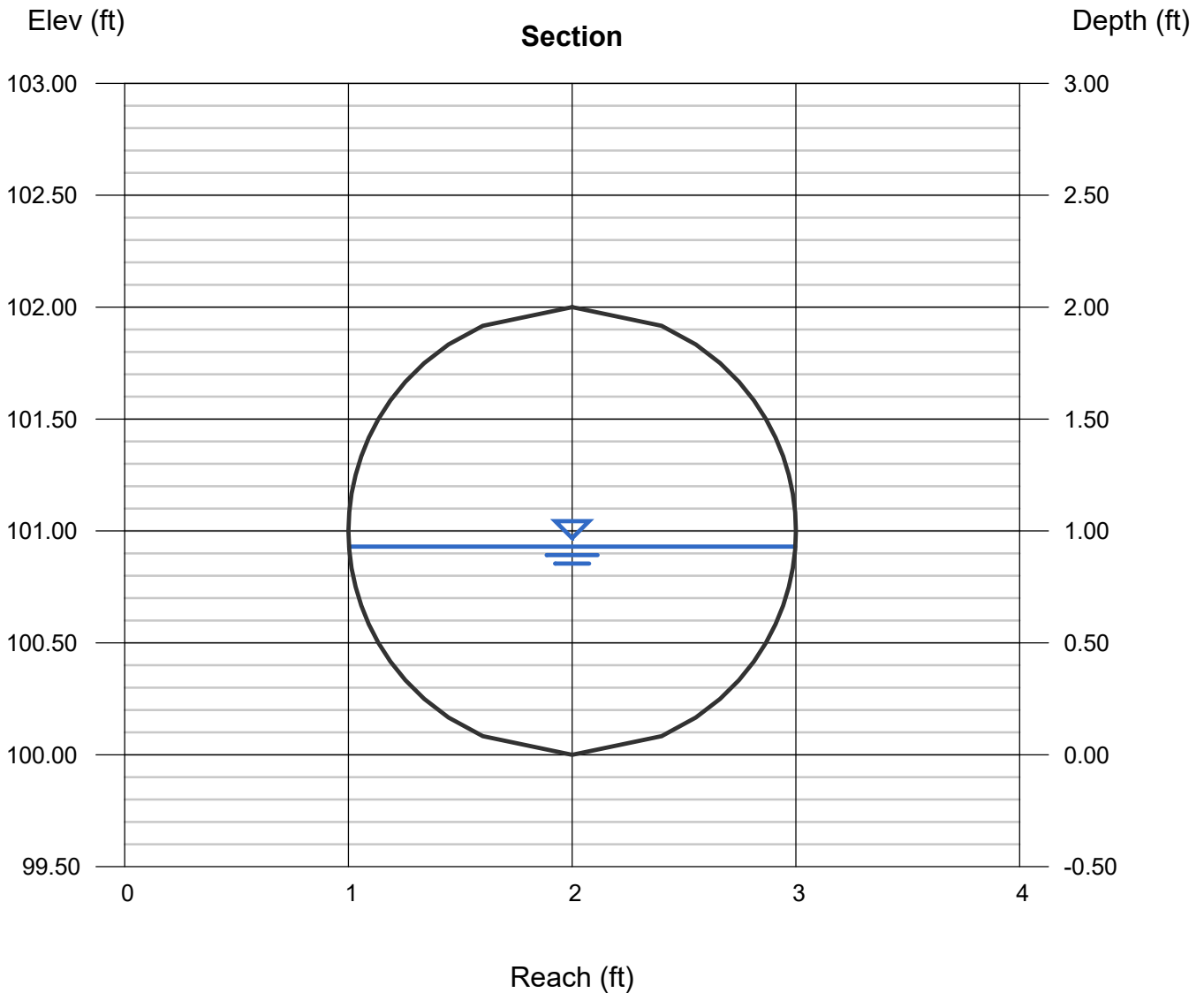
Invert Elev (ft) = 100.00
Slope (%) = 1.50
N-Value = 0.013

Highlighted

Depth (ft) = 0.93
Q (cfs) = 12.25
Area (sqft) = 1.44
Velocity (ft/s) = 8.51
Wetted Perim (ft) = 3.01
Crit Depth, Yc (ft) = 1.26
Top Width (ft) = 2.00
EGL (ft) = 2.06

Calculations

Compute by: Known Q
Known Q (cfs) = 12.25



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: CWD F-III-2 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\CWD F-III-1.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD F-III-	2	Outlet	14.07	80	.307

Total area: 14.07 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)
------------------------------------	--

SUBAREAS	
CWD F-III-	17.04

REACHES

OUTLET	17.04
--------	-------

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD F-III-	17.04
	12.24

REACHES

OUTLET	17.04
--------	-------

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD F-III-	14.07	0.307	80	Outlet	2

Total Area:	14.07 (ac)				

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
CWD F-III-SHEET	100	0.0150	0.240				0.269
SHALLOW	178	0.0250	0.050				0.019
CHANNEL	1154	0.0300	0.013	9.71	12.38	16.871	0.019
						Time of Concentration	.307
							=====

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD F-III-Gravel (w/ right-of-way)		D	.19	91
	Pasture, grassland or range	(good) D	13.88	80
	Total Area / Weighted Curve Number		14.07	80
			====	==

Channel Report

CWD F-III-1

Circular

Diameter (ft) = 2.00

Invert Elev (ft) = 100.00

Slope (%) = 2.00

N-Value = 0.013

Calculations

Compute by: Known Q

Known Q (cfs) = 17.04

Highlighted

Depth (ft) = 1.04

Q (cfs) = 17.04

Area (sqft) = 1.66

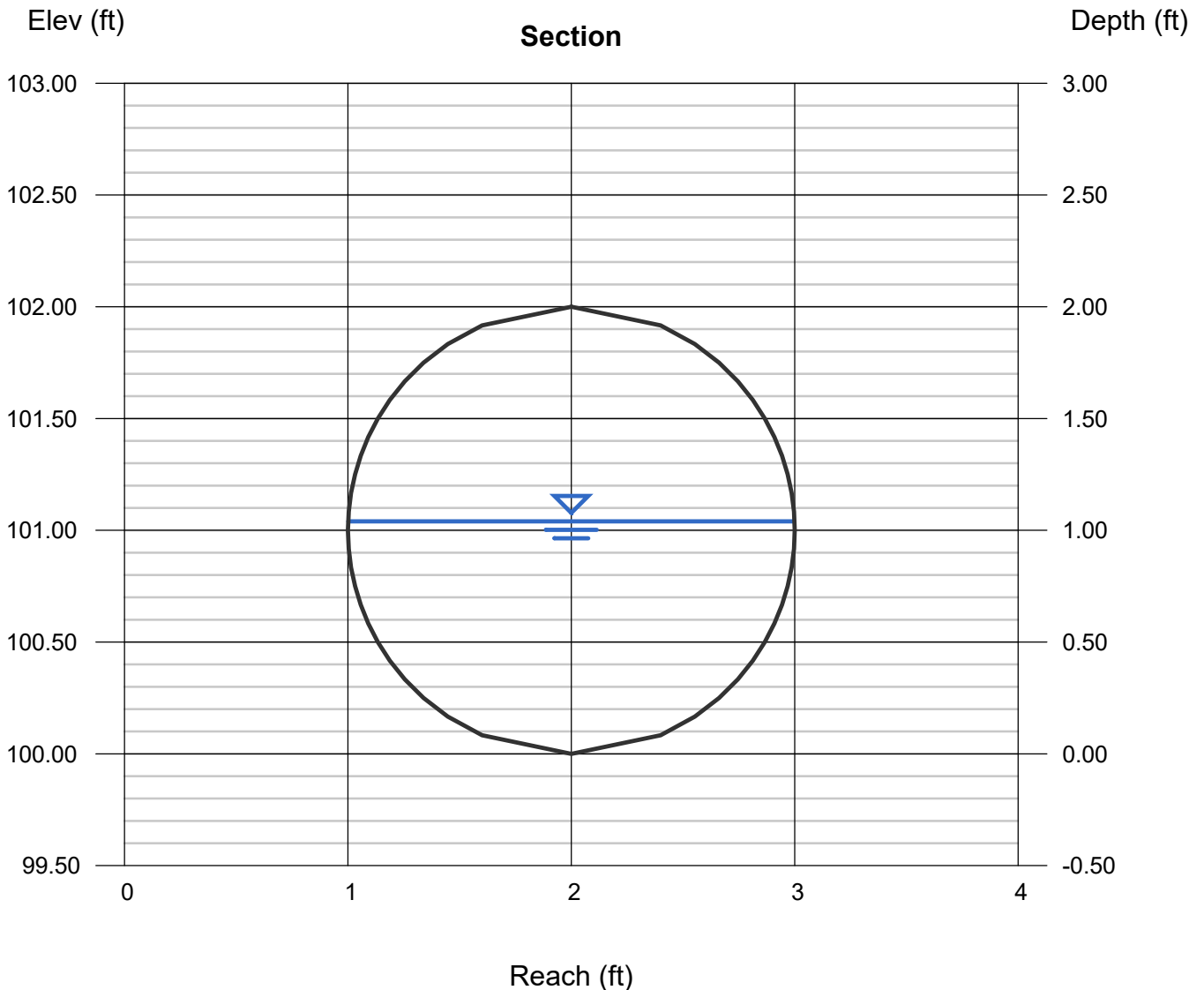
Velocity (ft/s) = 10.27

Wetted Perim (ft) = 3.23

Crit Depth, Y_c (ft) = 1.49

Top Width (ft) = 2.00

EGL (ft) = 2.68



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
 Project: Gude Units: English
 SubTitle: CWD F-III-2 Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: C:\Users\slemasters\Desktop\DA-1B.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD F-III-	2	Outlet	10.95	80	.323

Total area: 10.95 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: NOAA_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD F-III-	12.97
REACHES	
OUTLET	12.97

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD F-III-	12.97
	12.25

REACHES

OUTLET	12.97
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EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD F-III-	10.95	0.323	80	Outlet	2

Total Area:	10.95 (ac)				

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
CWD F-III-SHEET	100	0.0150	0.240				0.269
SHALLOW	300	0.0250	0.050				0.033
CHANNEL	1260	0.0300	0.013	9.71	12.38	16.667	0.021
						Time of Concentration	.323
							=====

EA

Gude
CWD F-III-2
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD F-III-Gravel (w/ right-of-way)		D	.09	91
	Pasture, grassland or range	(good) D	10.86	80
	Total Area / Weighted Curve Number		10.95	80
			=====	==

Channel Report

CWD F-III-2

Circular

Diameter (ft) = 2.00

Invert Elev (ft) = 100.00

Slope (%) = 3.33

N-Value = 0.013

Calculations

Compute by: Known Q

Known Q (cfs) = 12.97

Highlighted

Depth (ft) = 0.77

Q (cfs) = 12.97

Area (sqft) = 1.12

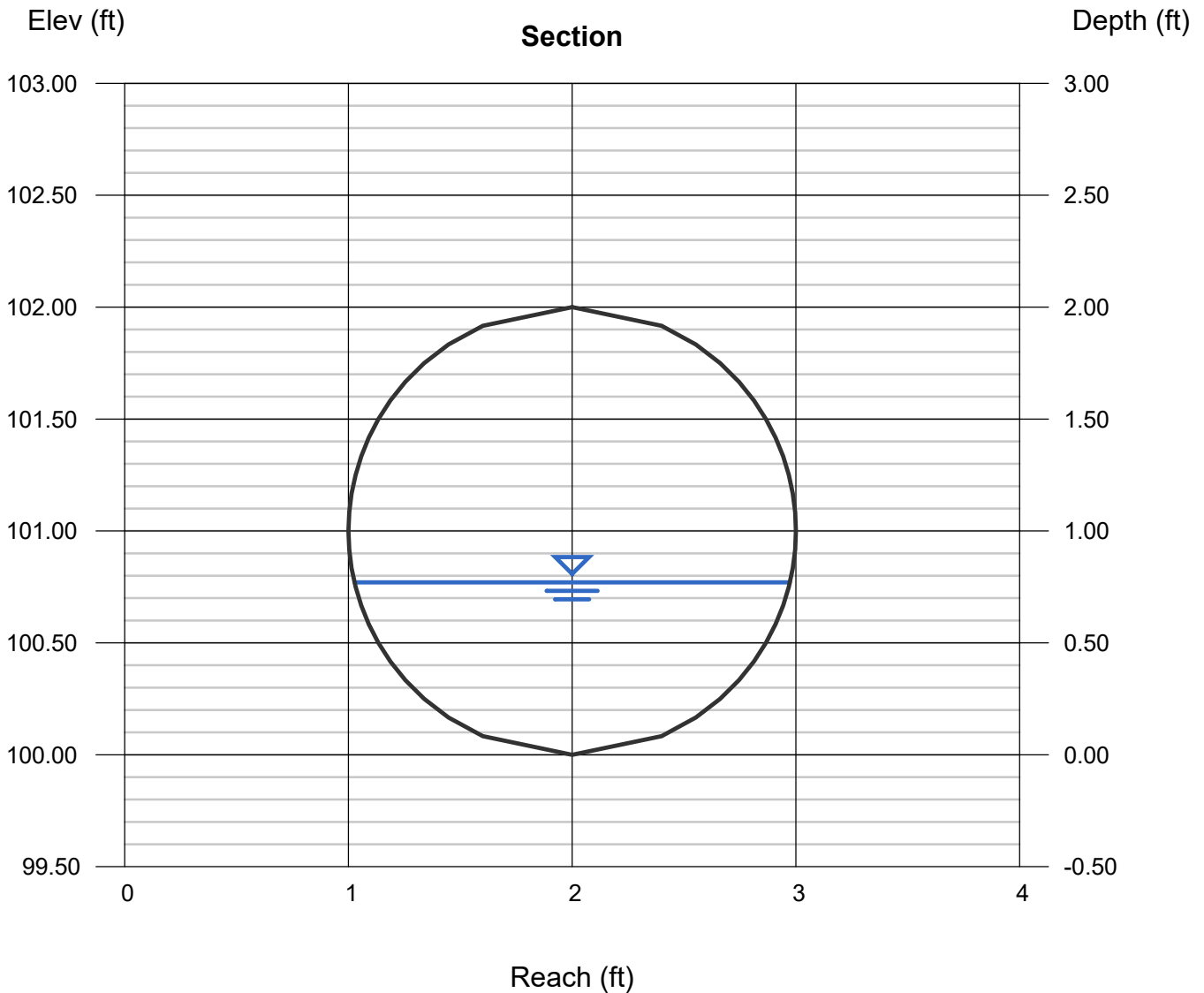
Velocity (ft/s) = 11.61

Wetted Perim (ft) = 2.68

Crit Depth, Y_c (ft) = 1.30

Top Width (ft) = 1.95

EGL (ft) = 2.87



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/24/2020
Project: Gude Units: English
SubTitle: CWD F-IV-1 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\DA-1A.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD F-IV-1		Outlet	15.81	80	.353

Total area: 15.81 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-IV-1
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-IV-1
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD F-IV-1	17.96
REACHES	
OUTLET	17.96

EA

Gude
CWD F-IV-1
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD F-IV-1	17.96 12.27
------------	----------------

REACHES

OUTLET	17.96
--------	-------

EA

Gude
CWD F-IV-1
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD F-IV-1	15.81	0.353	80	Outlet	

Total Area:	15.81 (ac)				

EA

Gude
CWD F-IV-1
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD F-IV-1	Gravel (w/ right-of-way)	D	.48	91
	Pasture, grassland or range	(good) D	15.33	80
	Total Area / Weighted Curve Number		15.81	80
			=====	==

Channel Report

CWD F-IV-1

Circular

Diameter (ft) = 2.00

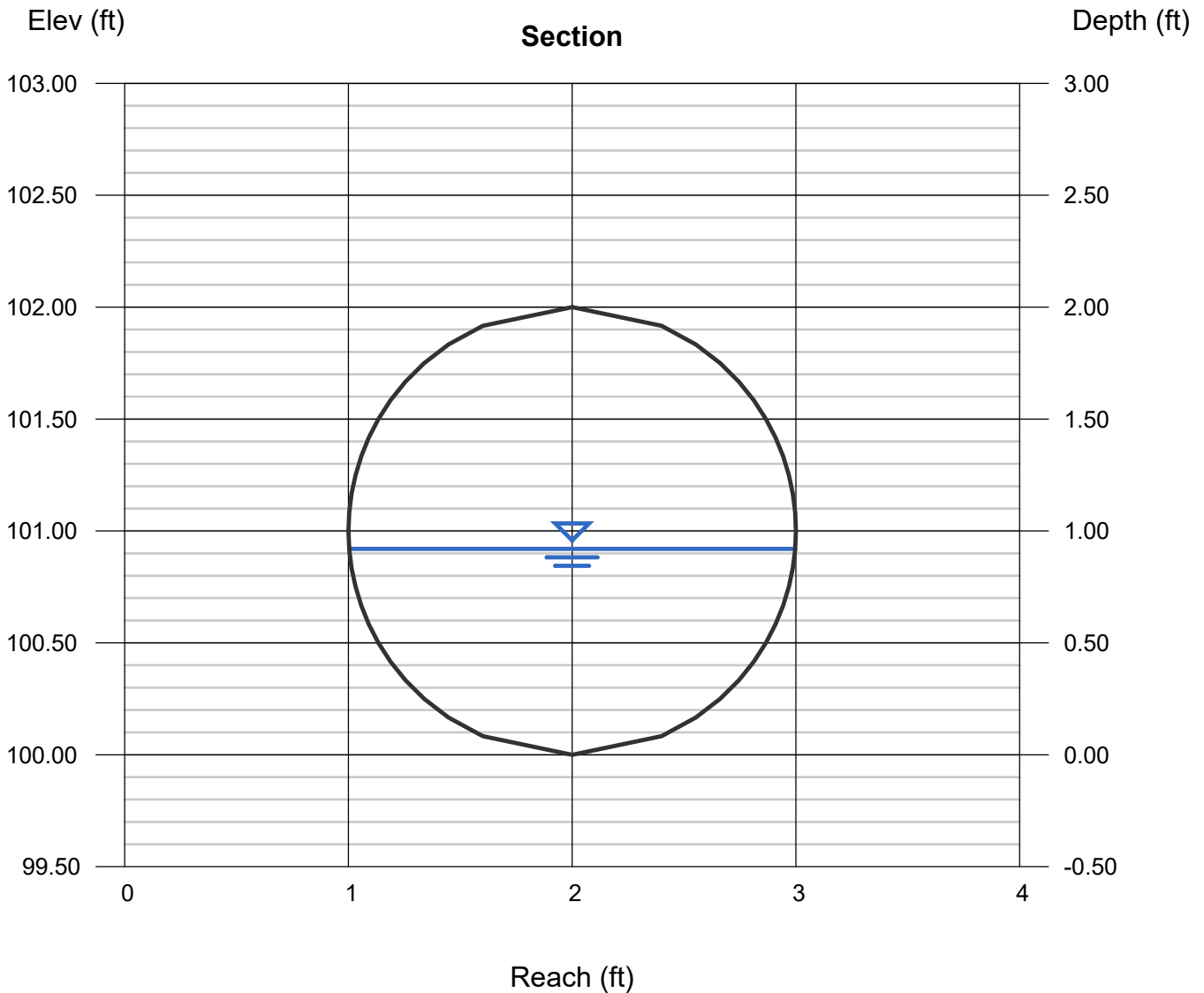
Invert Elev (ft) = 100.00
Slope (%) = 3.33
N-Value = 0.013

Highlighted

Depth (ft) = 0.92
Q (cfs) = 17.96
Area (sqft) = 1.42
Velocity (ft/s) = 12.65
Wetted Perim (ft) = 2.99
Crit Depth, Yc (ft) = 1.53
Top Width (ft) = 1.99
EGL (ft) = 3.41

Calculations

Compute by: Known Q
Known Q (cfs) = 17.96



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 12/7/2020
Project: Gude Units: English
SubTitle: CWD F-VI-3 Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Desktop\CWD F-III-1.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
CWD F-VI-3		Outlet	37.8	80	0.307

Total area: 37.80 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-VI-3
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
CWD F-VI-3
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 2-Yr (cfs)

SUBAREAS	
CWD F-VI-3	45.78
REACHES	
OUTLET	45.78

EA

Gude
CWD F-VI-3
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr)
------------------------------------	---

SUBAREAS

CWD F-VI-3	45.78 12.24
------------	----------------

REACHES

OUTLET	45.78
--------	-------

EA

Gude
CWD F-VI-3
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
CWD F-VI-3	37.80	0.307	80	Outlet	

Total Area:	37.80 (ac)				

EA

Gude
CWD F-VI-3
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

CWD F-VI-3							
SHEET	100	0.0150	0.240				0.269
SHALLOW	178	0.0250	0.050				0.019
CHANNEL	1154	0.0300	0.013	9.71	12.38	16.871	0.019
				Time of Concentration			0.307
							=====

EA

Gude
CWD F-VI-3
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
CWD F-VI-3	Gravel (w/ right-of-way)	D	1.22	91
	Pasture, grassland or range	(good) D	36.58	80
	Total Area / Weighted Curve Number		37.8	80
			====	==

Channel Report

CWD F-VI-3

Circular

Diameter (ft) = 2.50

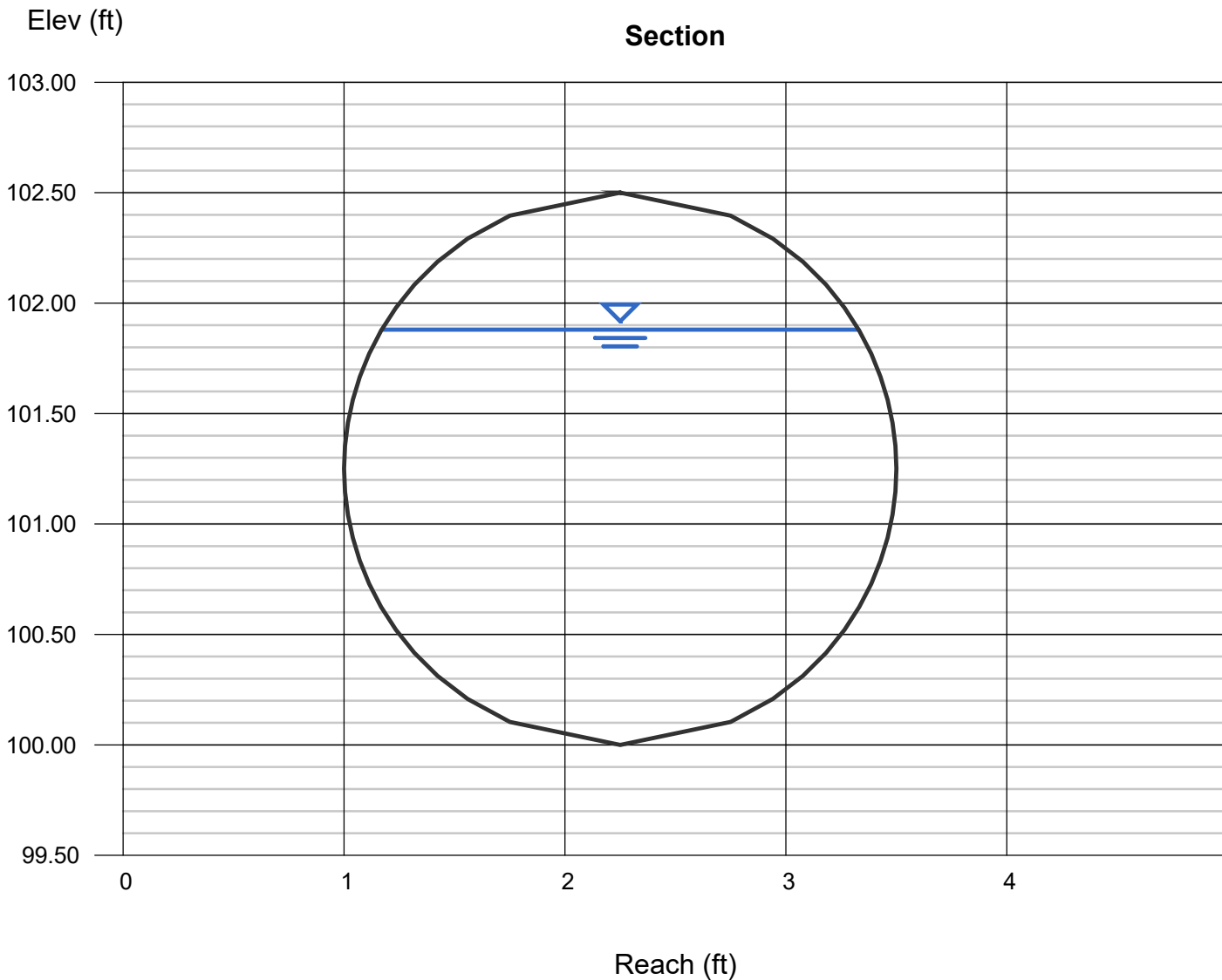
Invert Elev (ft) = 100.00
Slope (%) = 1.50
N-Value = 0.013

Highlighted

Depth (ft) = 1.88
Q (cfs) = 45.78
Area (sqft) = 3.96
Velocity (ft/s) = 11.55
Wetted Perim (ft) = 5.25
Crit Depth, Yc (ft) = 2.24
Top Width (ft) = 2.16
EGL (ft) = 3.96

Calculations

Compute by: Known Q
Known Q (cfs) = 45.78

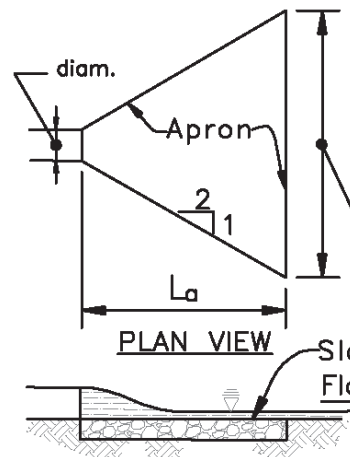


Standard ROP for
CWD - Based on
CWD S-V-3

DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION ($T_w < 0.5$ diam.)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.



$W = \text{diam.} + L_a$

$L=12$

NOTE: DO NOT
EXTRAPOLATE
LENGTH OF
CURVES.

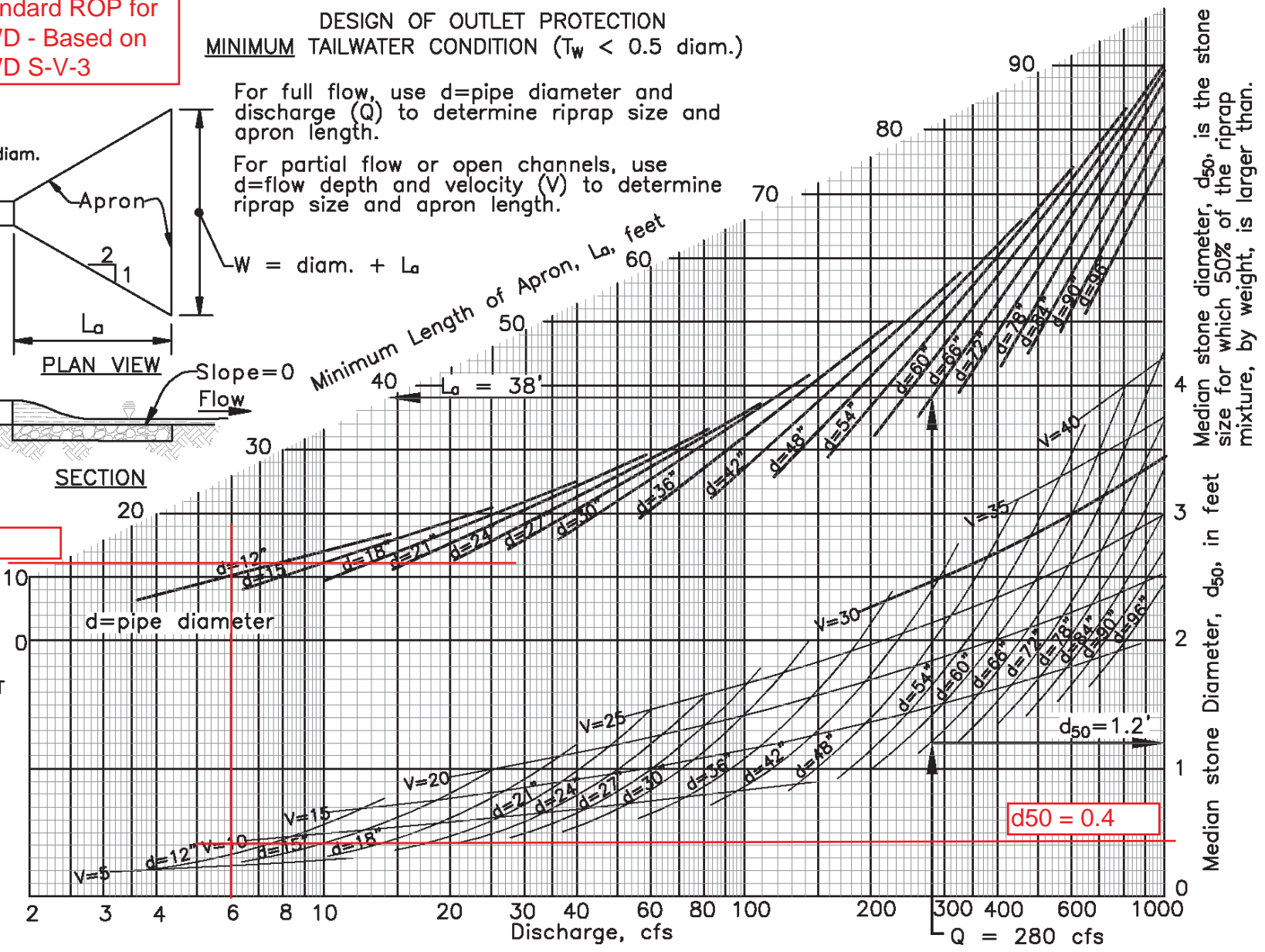
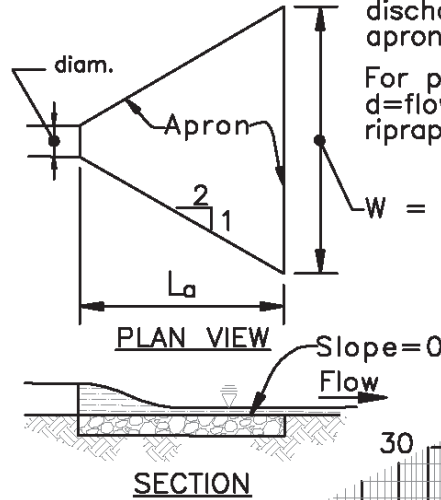


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.



$L=12$

$d = \text{pipe diameter}$

NOTE: DO NOT
 EXTRAPOLATE
 LENGTH OF
 CURVES.

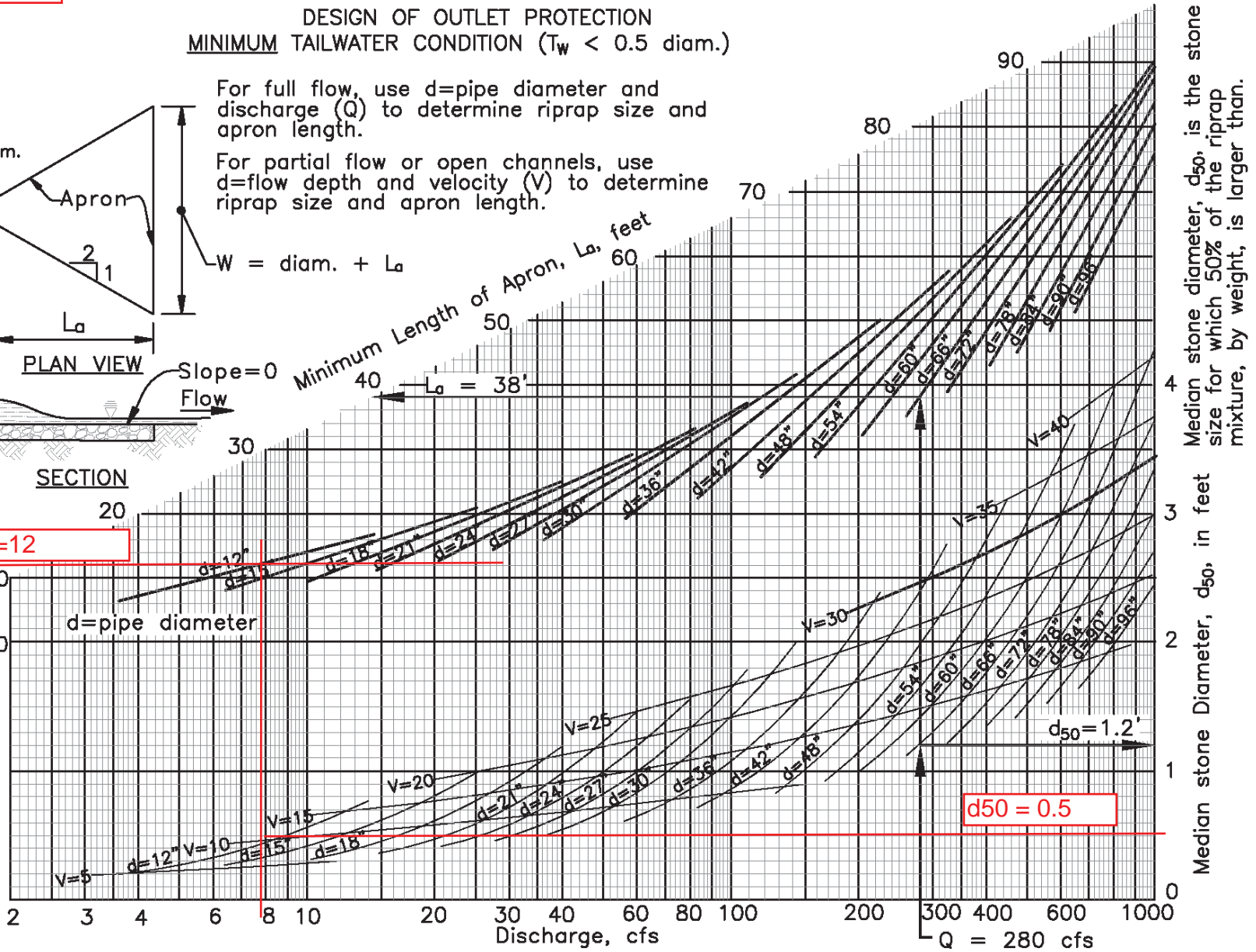
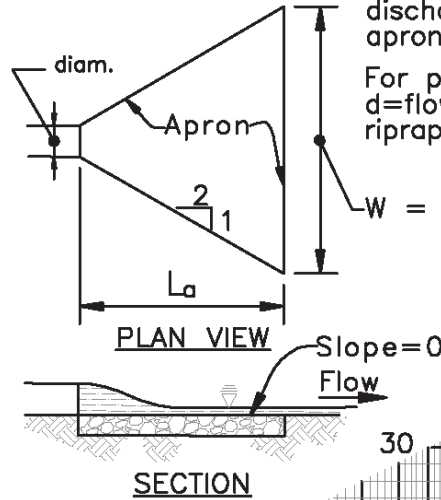


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.



L=12

NOTE: DO NOT
 EXTRAPOLATE
 LENGTH OF
 CURVES.

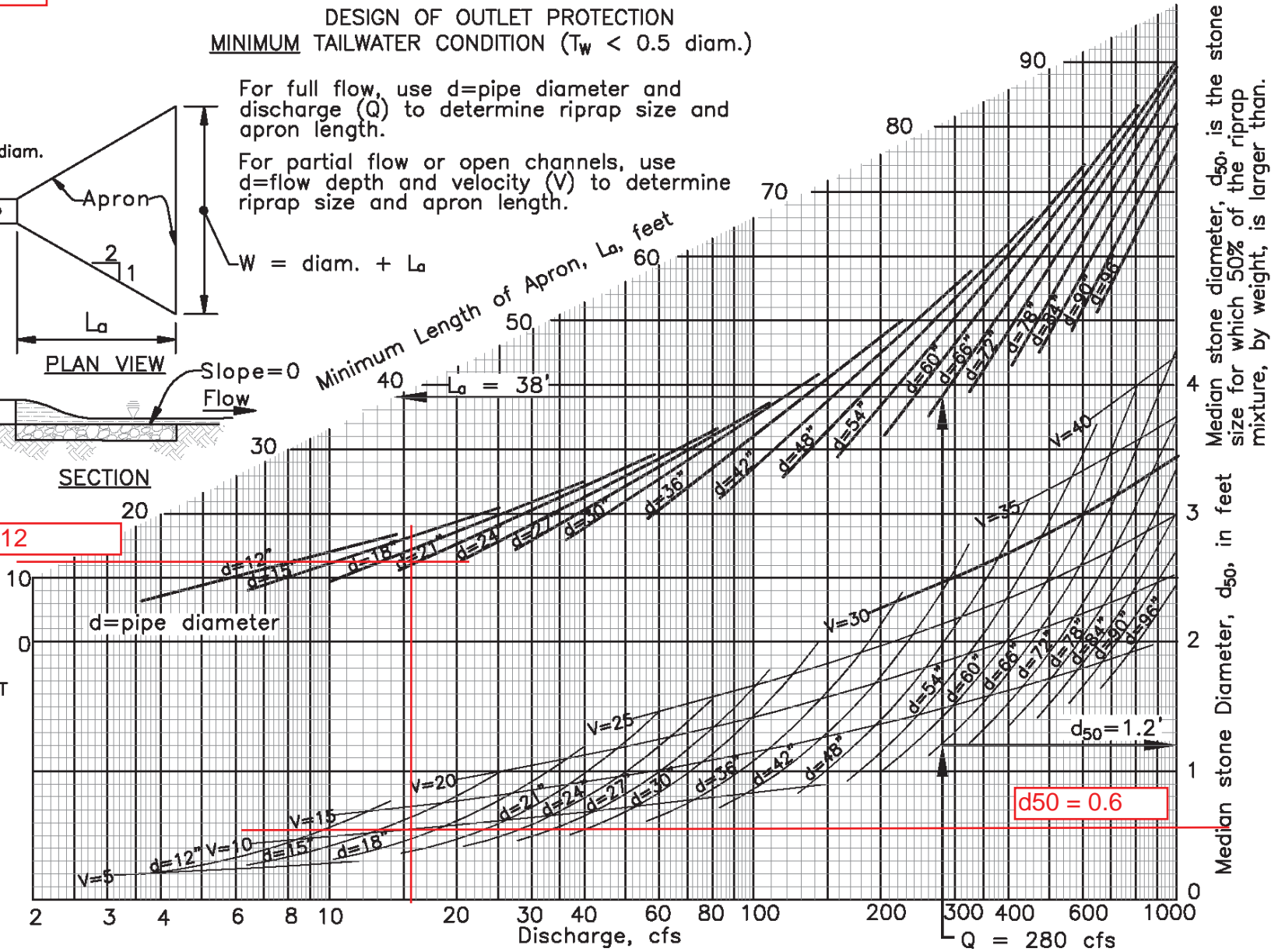


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

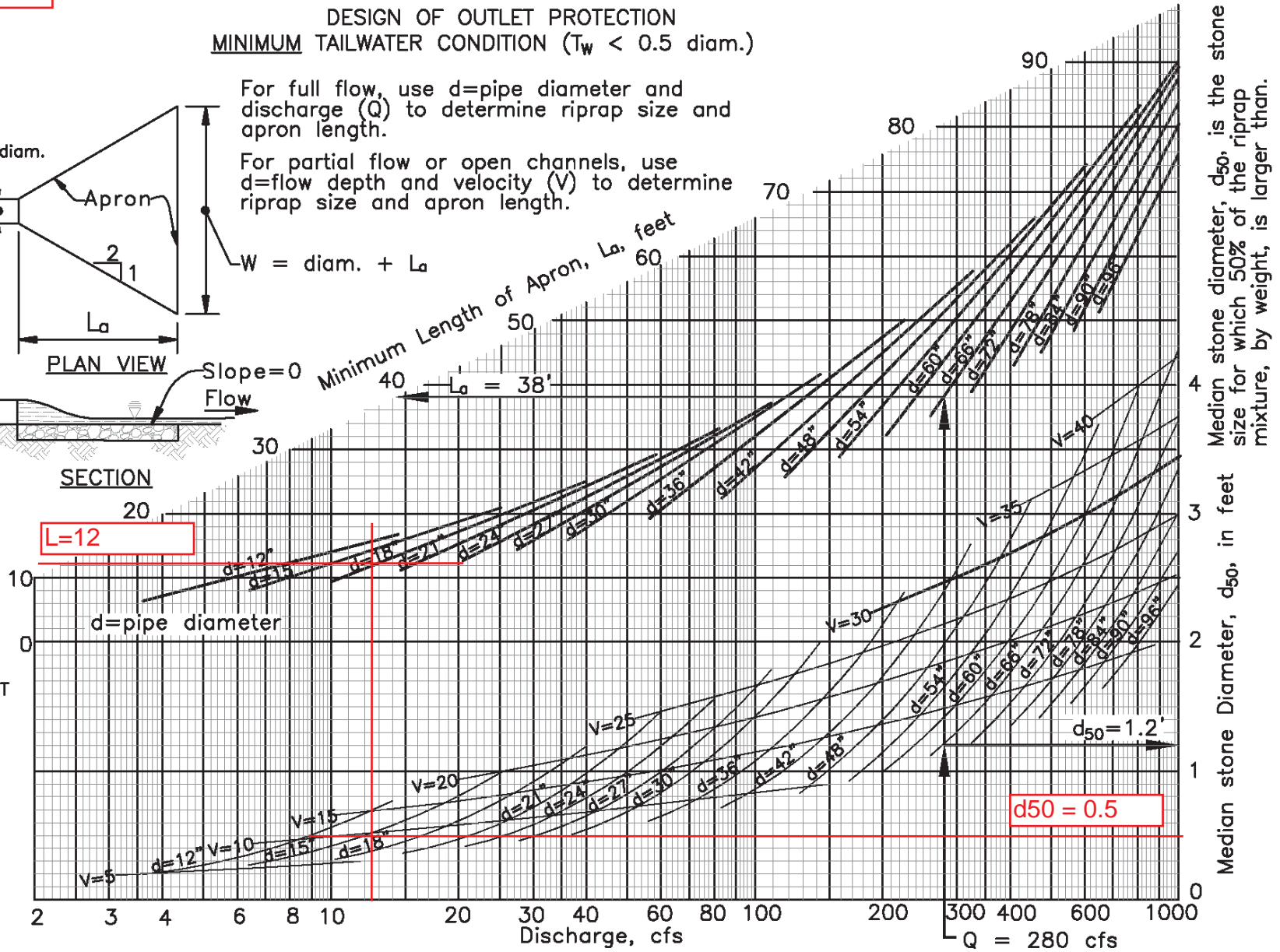
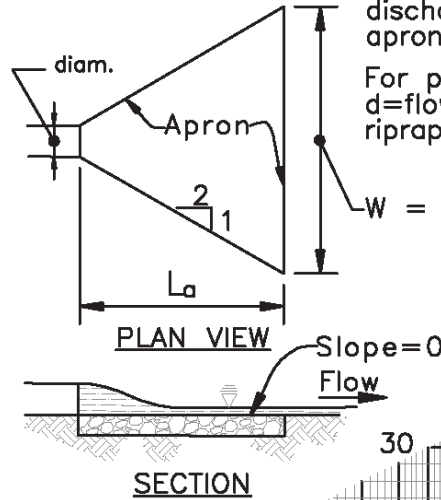
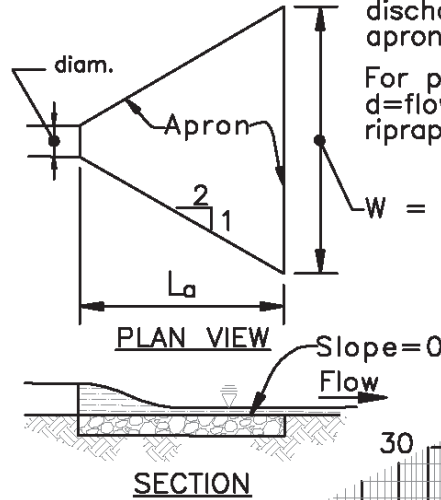


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.



$L=12$

d =pipe diameter

NOTE: DO NOT
 EXTRAPOLATE
 LENGTH OF
 CURVES.

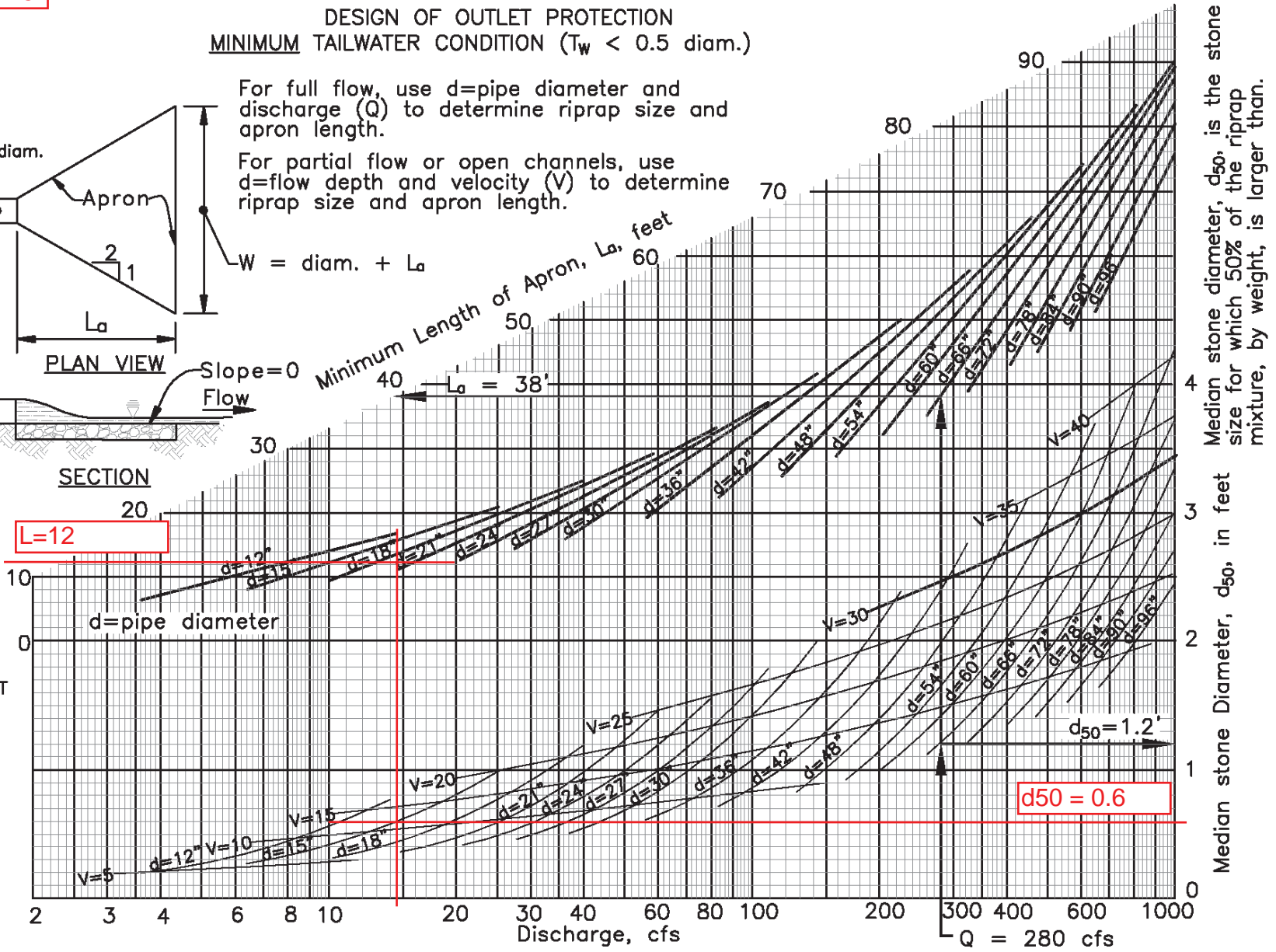
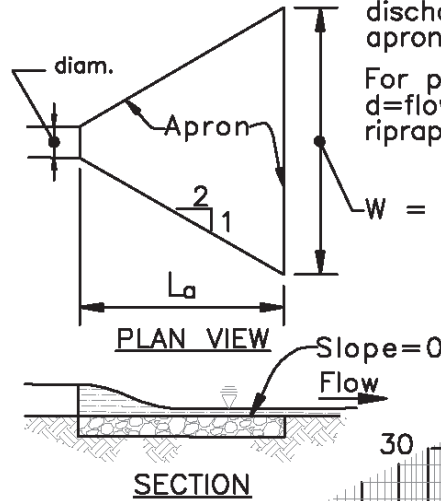


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.



$L=12$

NOTE: DO NOT
 EXTRAPOLATE
 LENGTH OF
 CURVES.

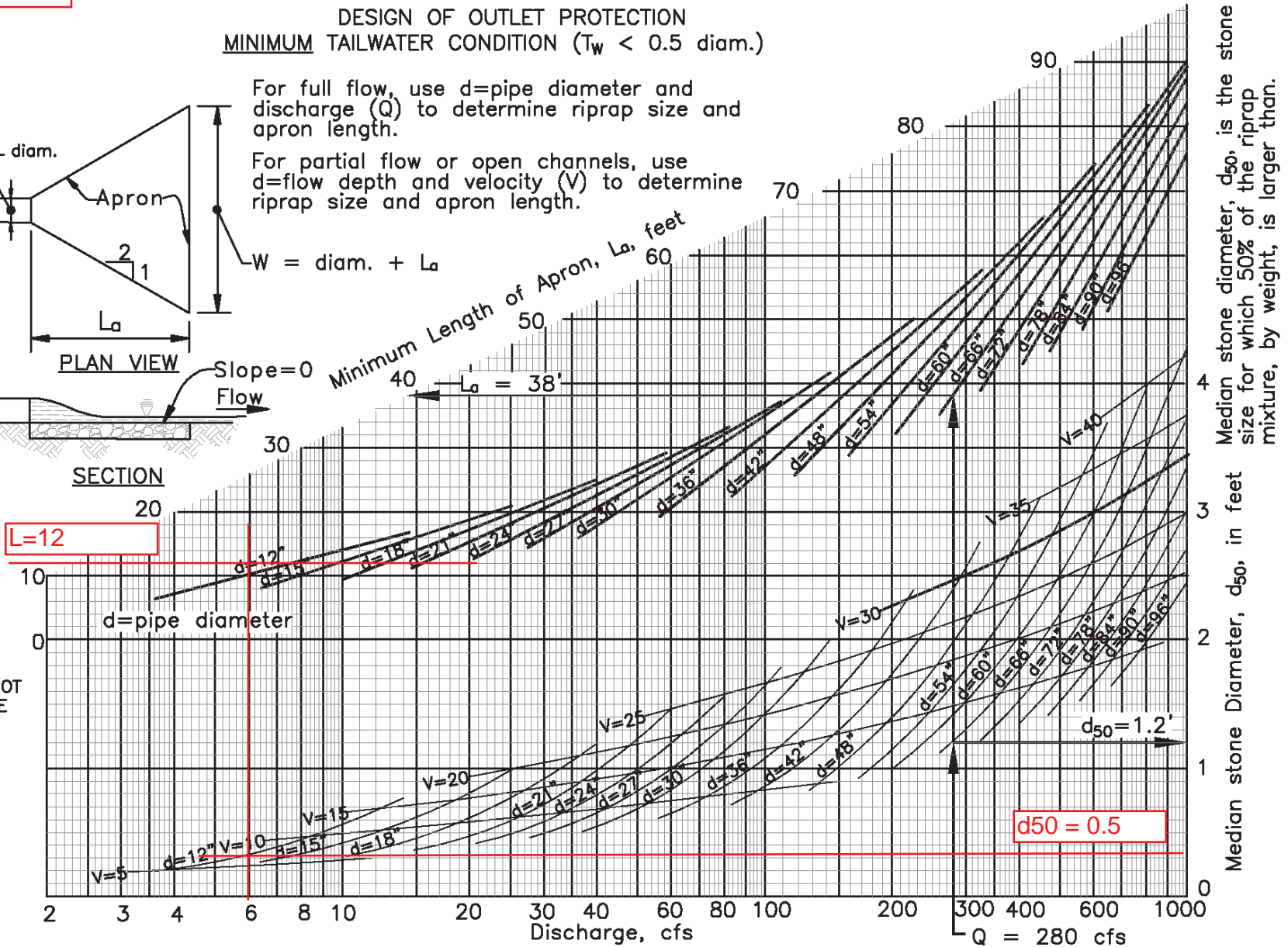
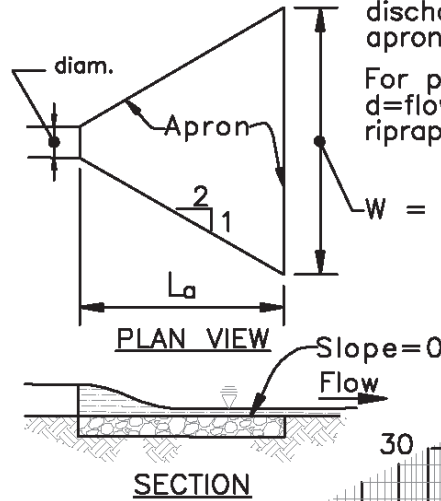


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

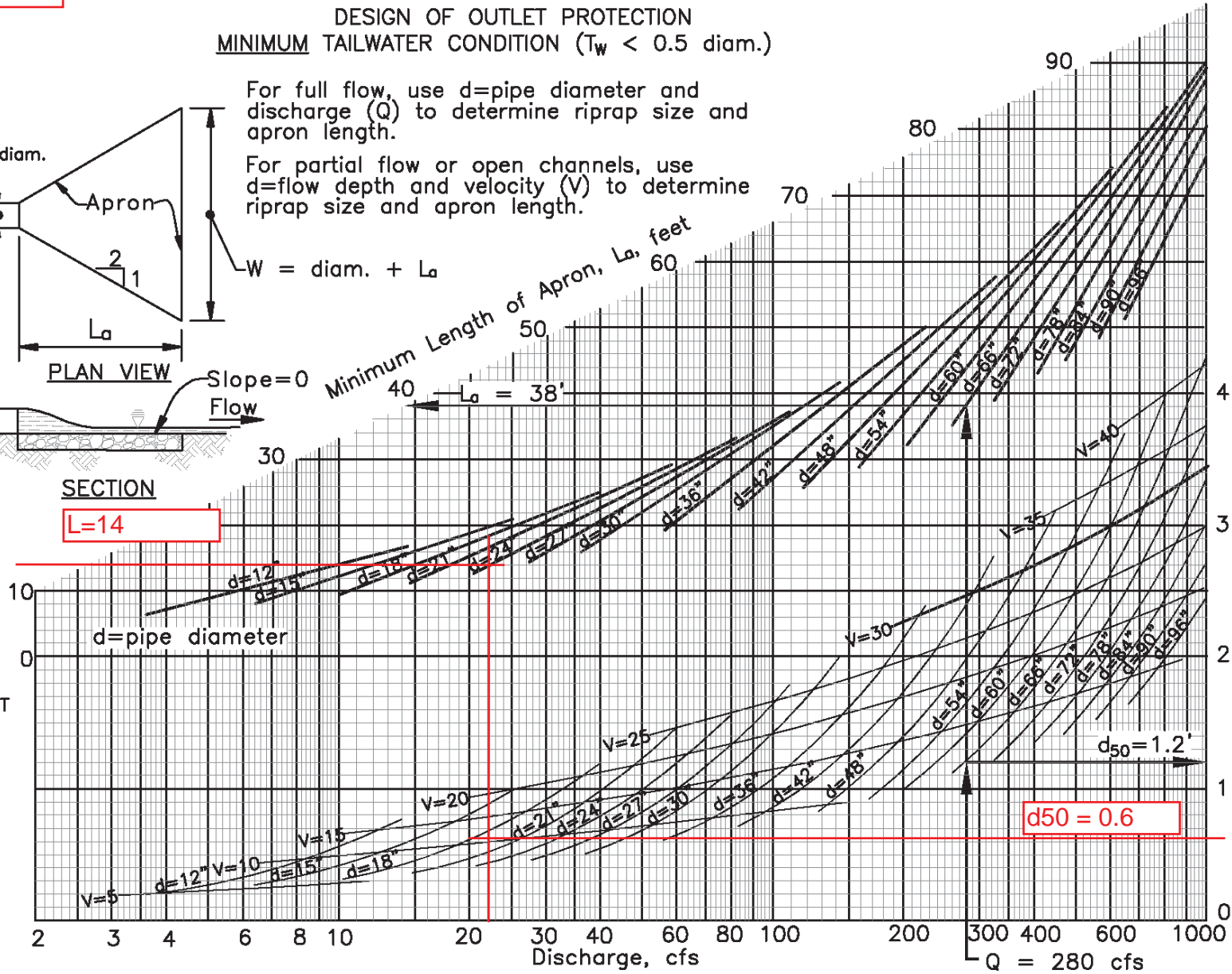


Minimum Length of Apron, L_a , feet

$L=14$

d =pipe diameter

NOTE: DO NOT EXTRAPOLATE LENGTH OF CURVES.



Median stone diameter, d_{50} , is the stone size for which 50% of the riprap mixture, by weight, is larger than.

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

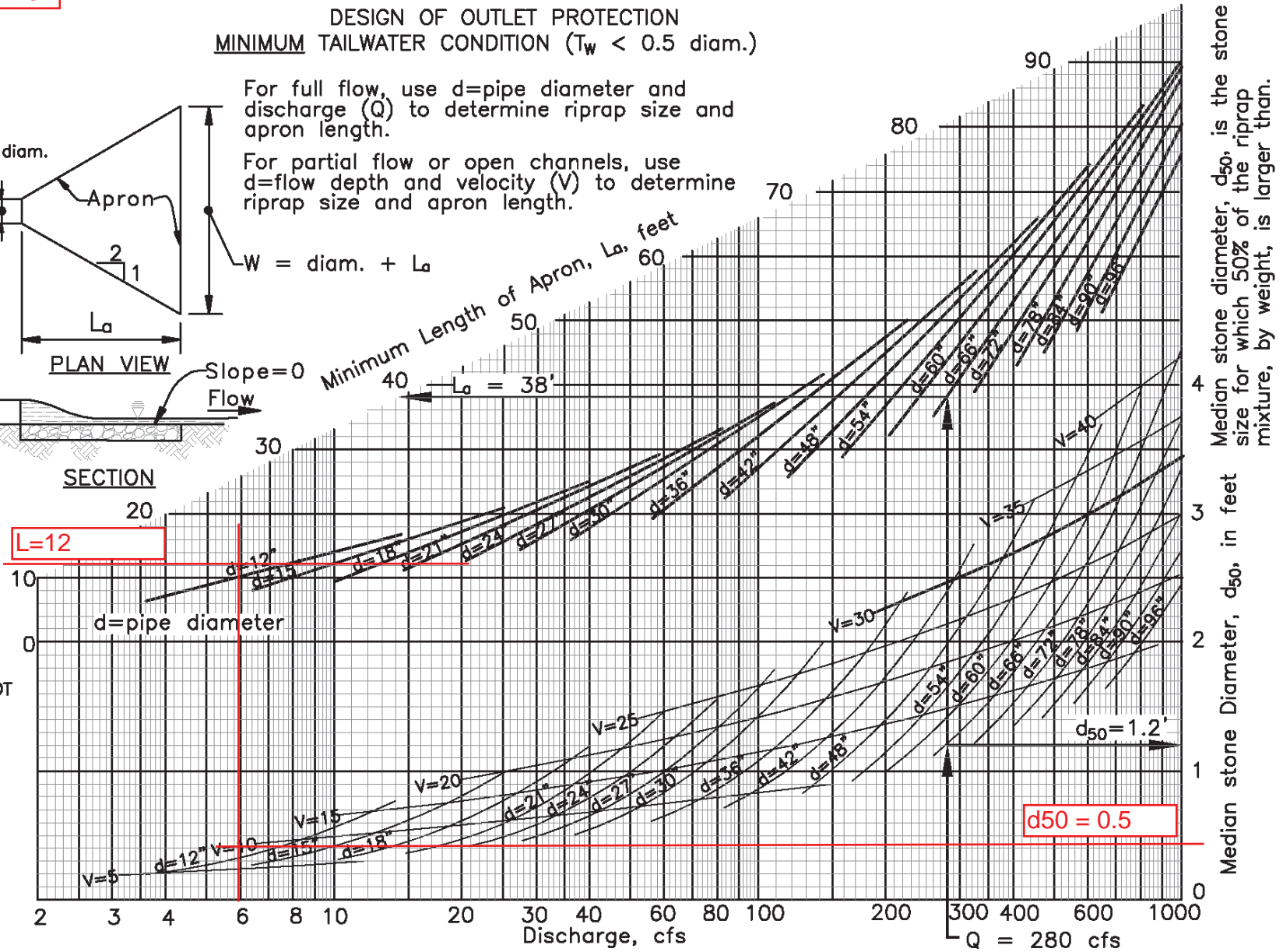
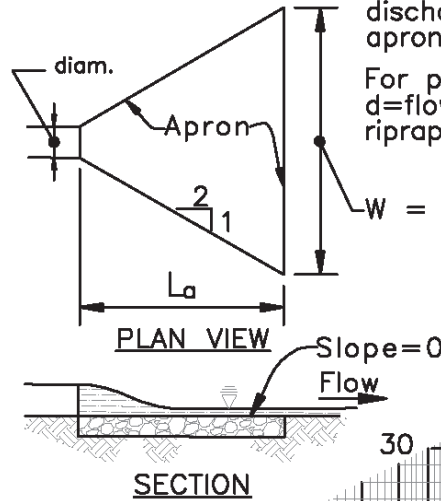


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

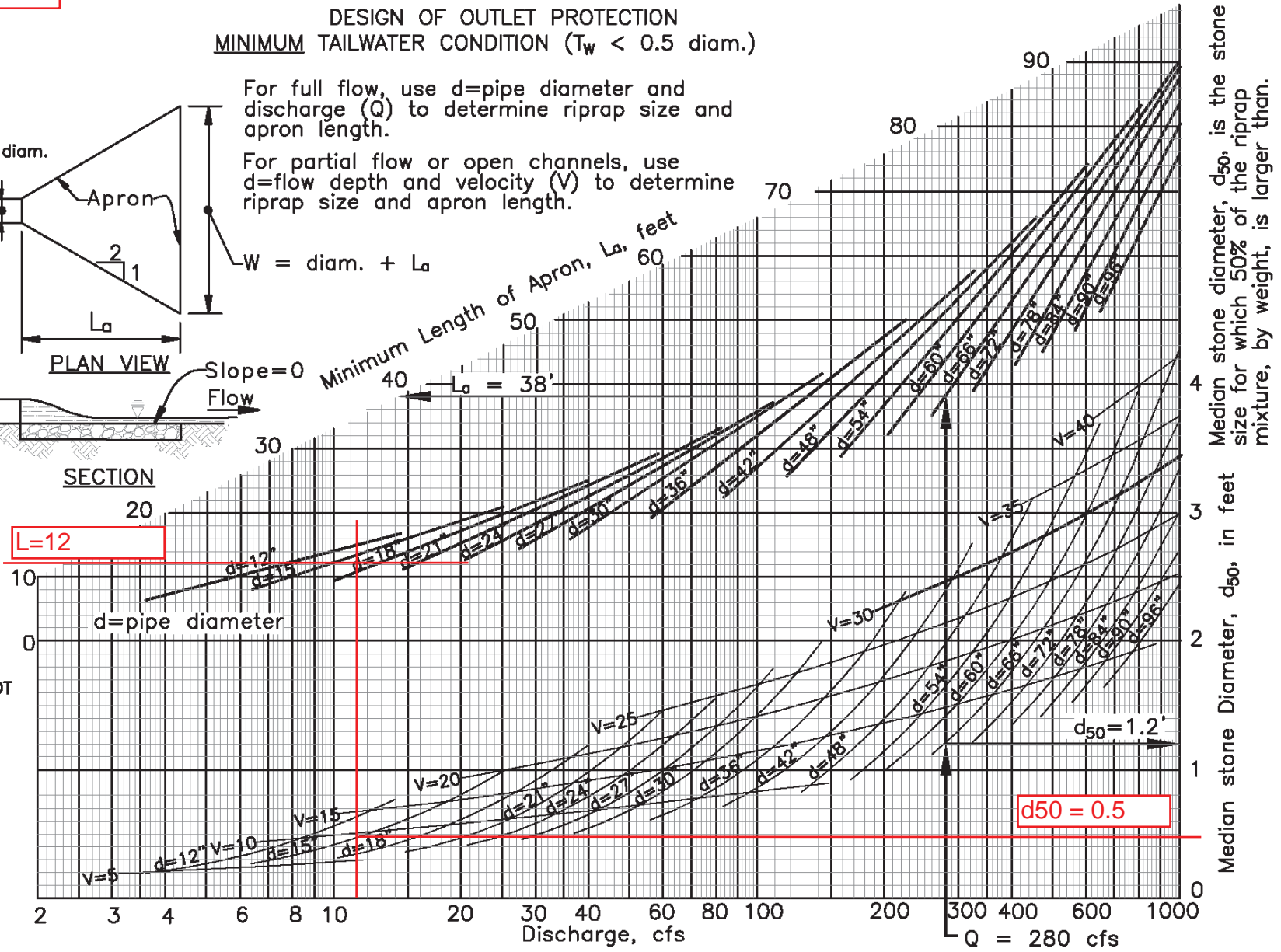
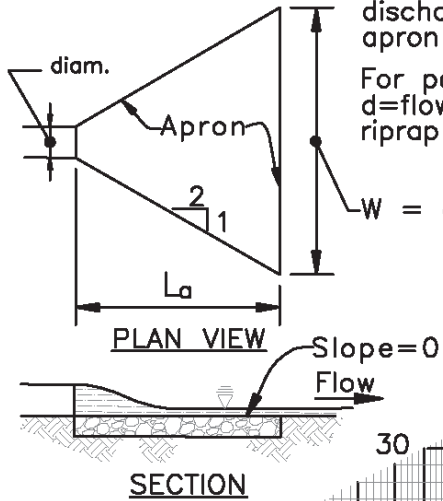
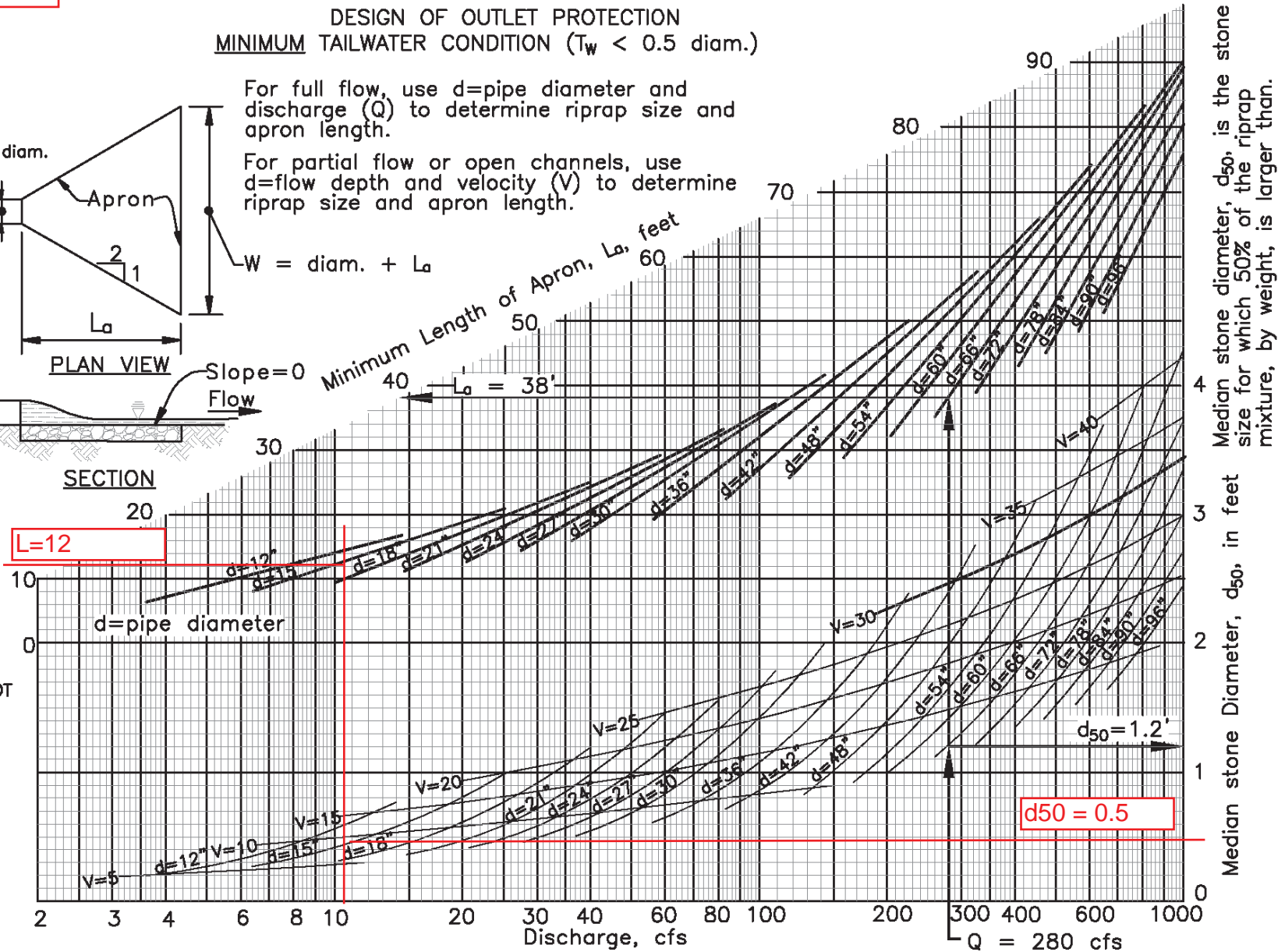
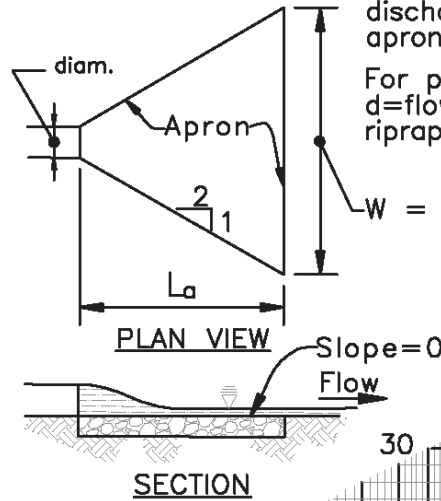


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.



NOTE: DO NOT
 EXTRAPOLATE
 LENGTH OF
 CURVES.

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

CWD F-III-1
& F-VI-2

DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

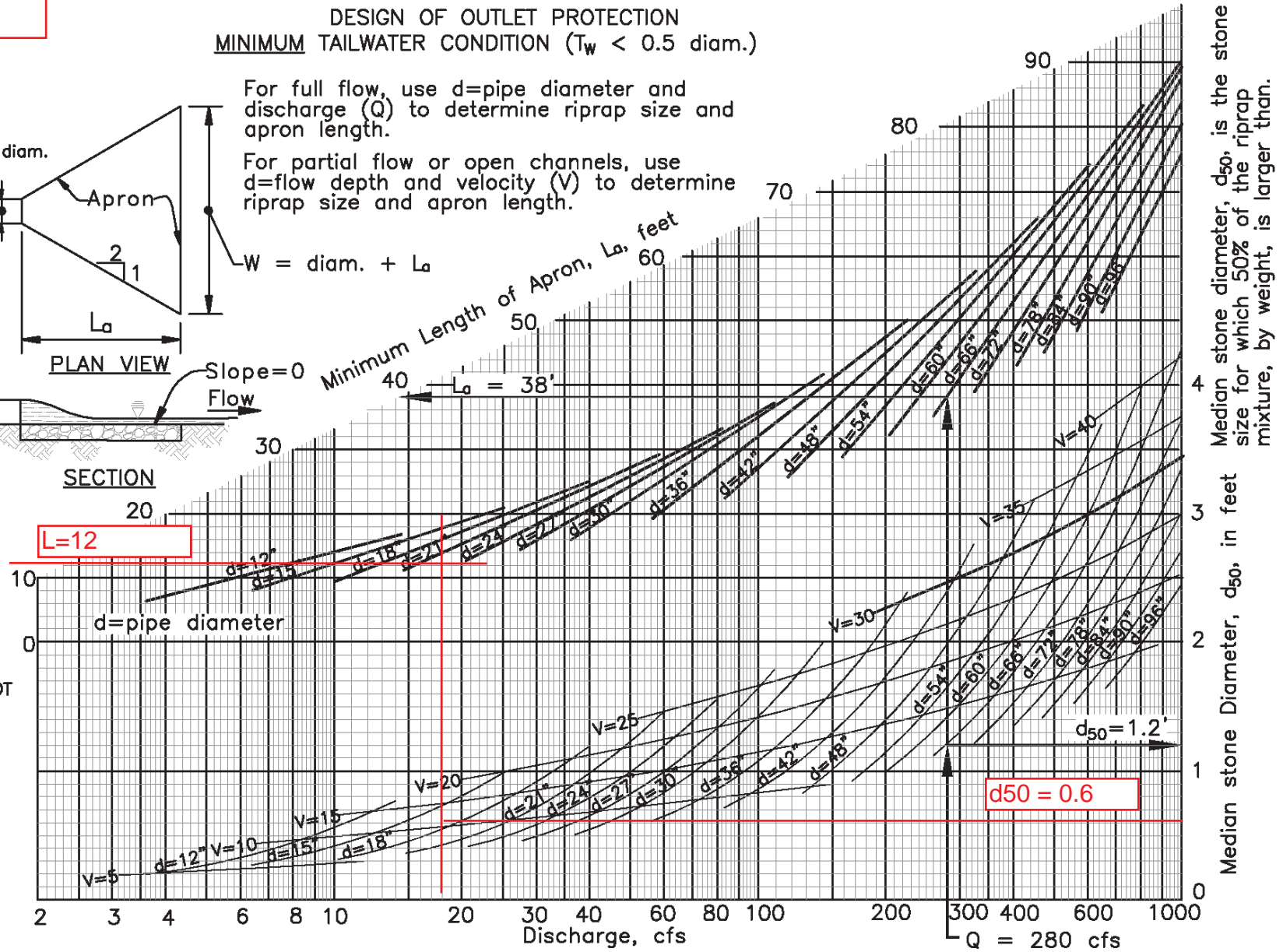
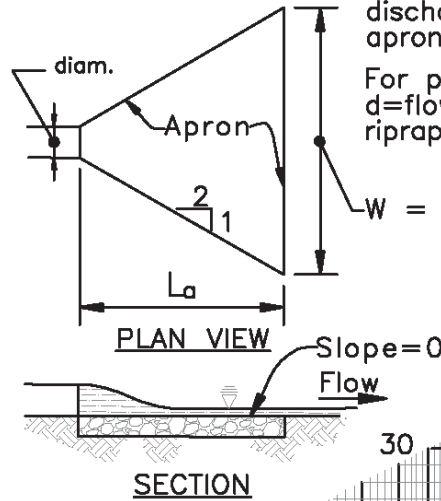


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

CWD F-III-2,
F-IV-2 & F-VI-1

DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

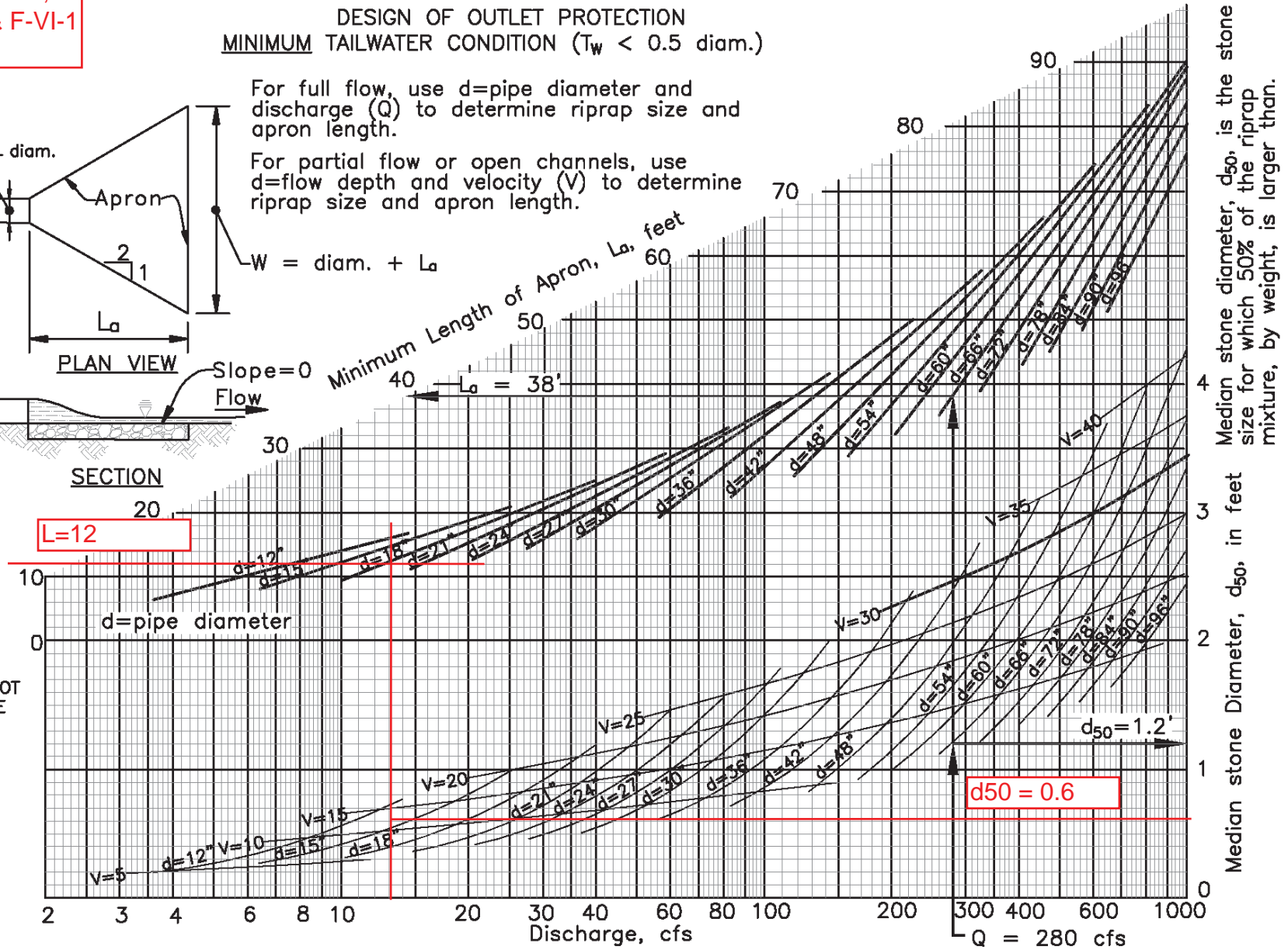
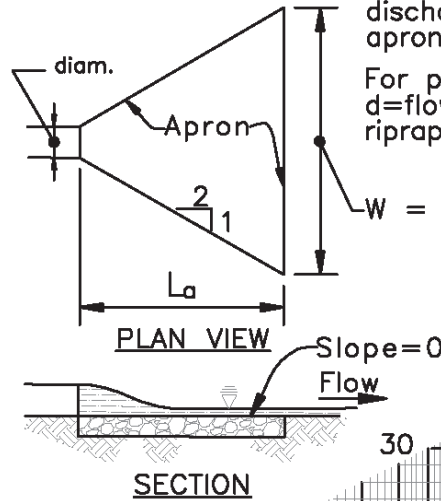


Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

CWD F-III-3, F-IV-3, & F-V-1

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

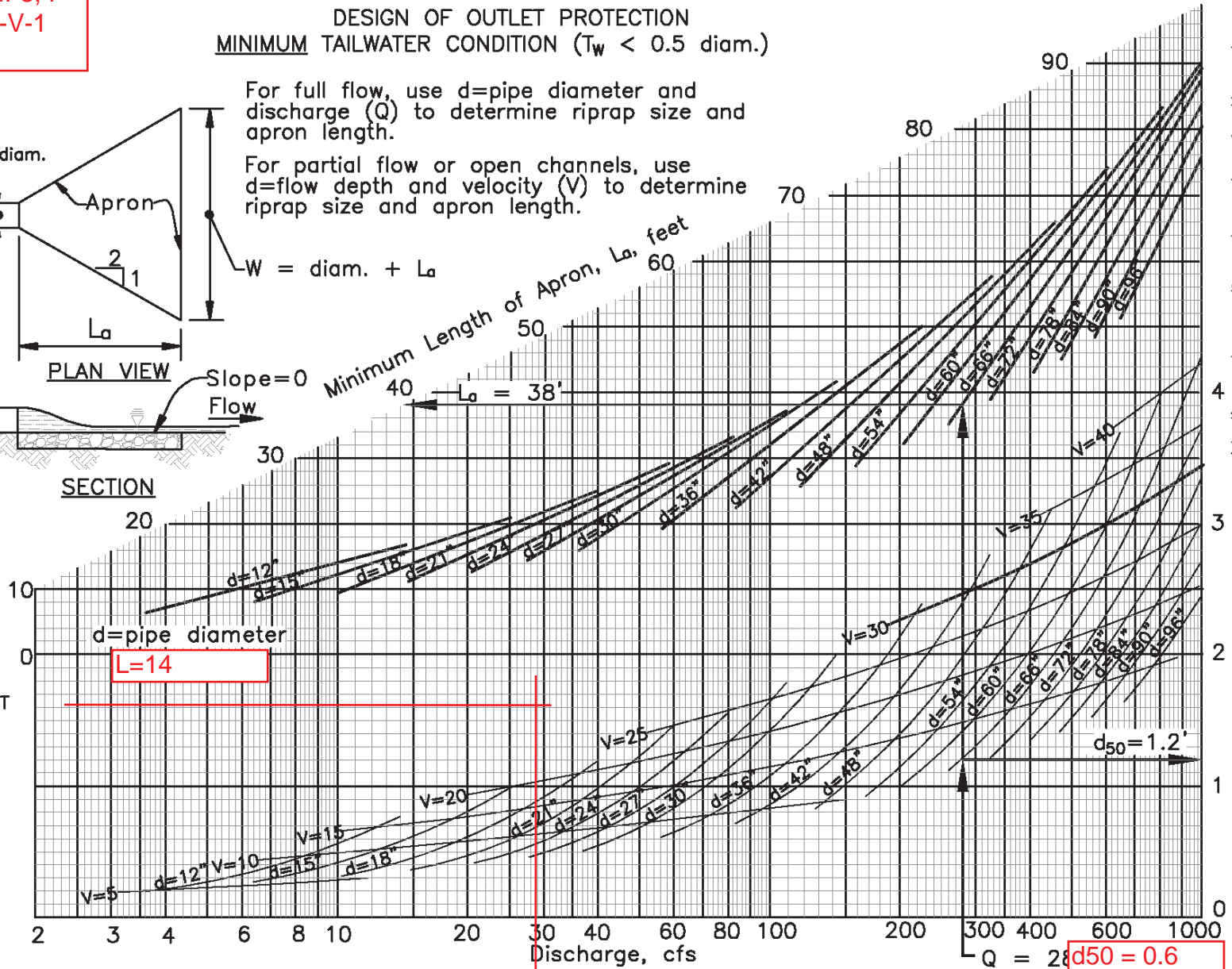
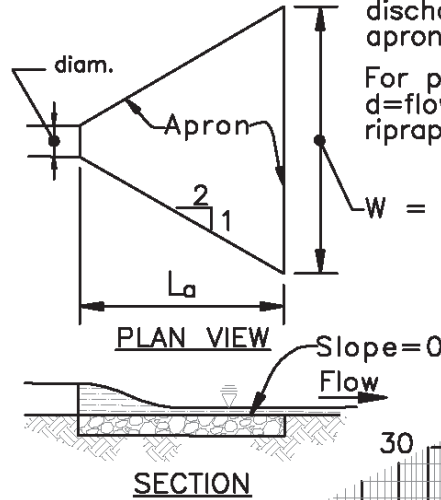


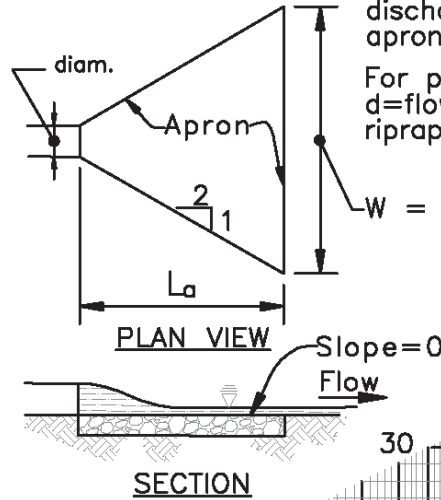
Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

CWD F-IV-1

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.



$W = \text{diam.} + L_a$

Minimum Length of Apron, L_a , feet

$L=12$

NOTE: DO NOT EXTRAPOLATE LENGTH OF CURVES.

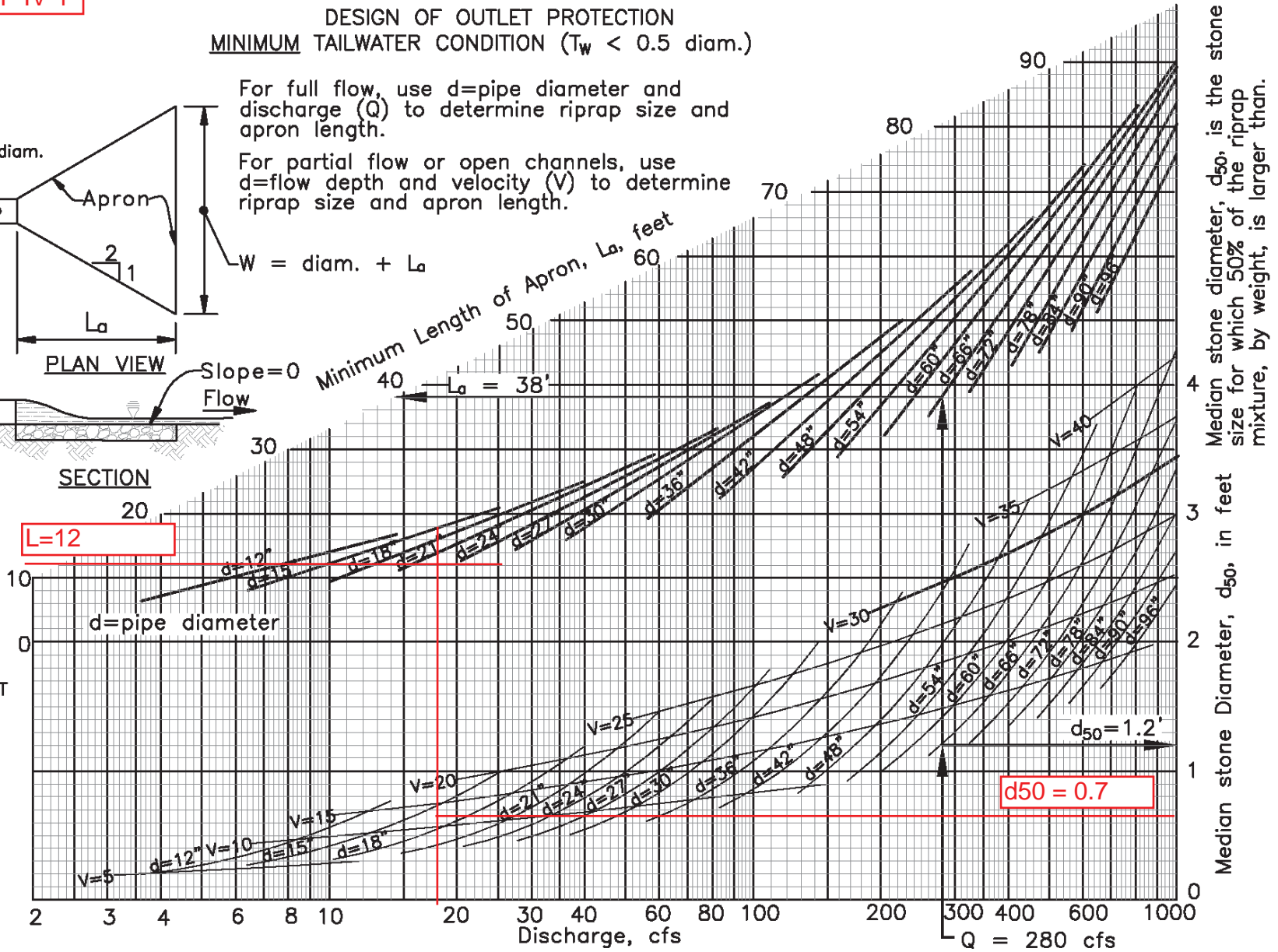


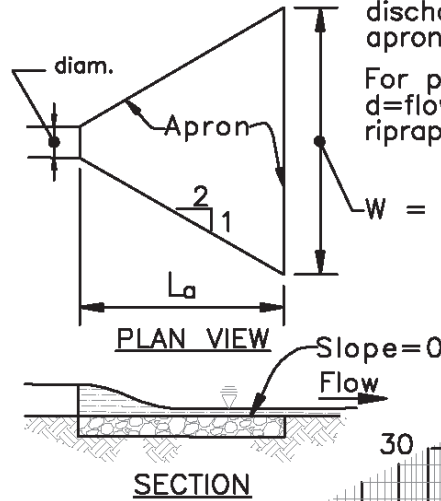
Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

CWD F-VI-3

DESIGN OF OUTLET PROTECTION
 MINIMUM TAILWATER CONDITION ($T_w < 0.5 \text{ diam.}$)

For full flow, use d =pipe diameter and discharge (Q) to determine riprap size and apron length.

For partial flow or open channels, use d =flow depth and velocity (V) to determine riprap size and apron length.

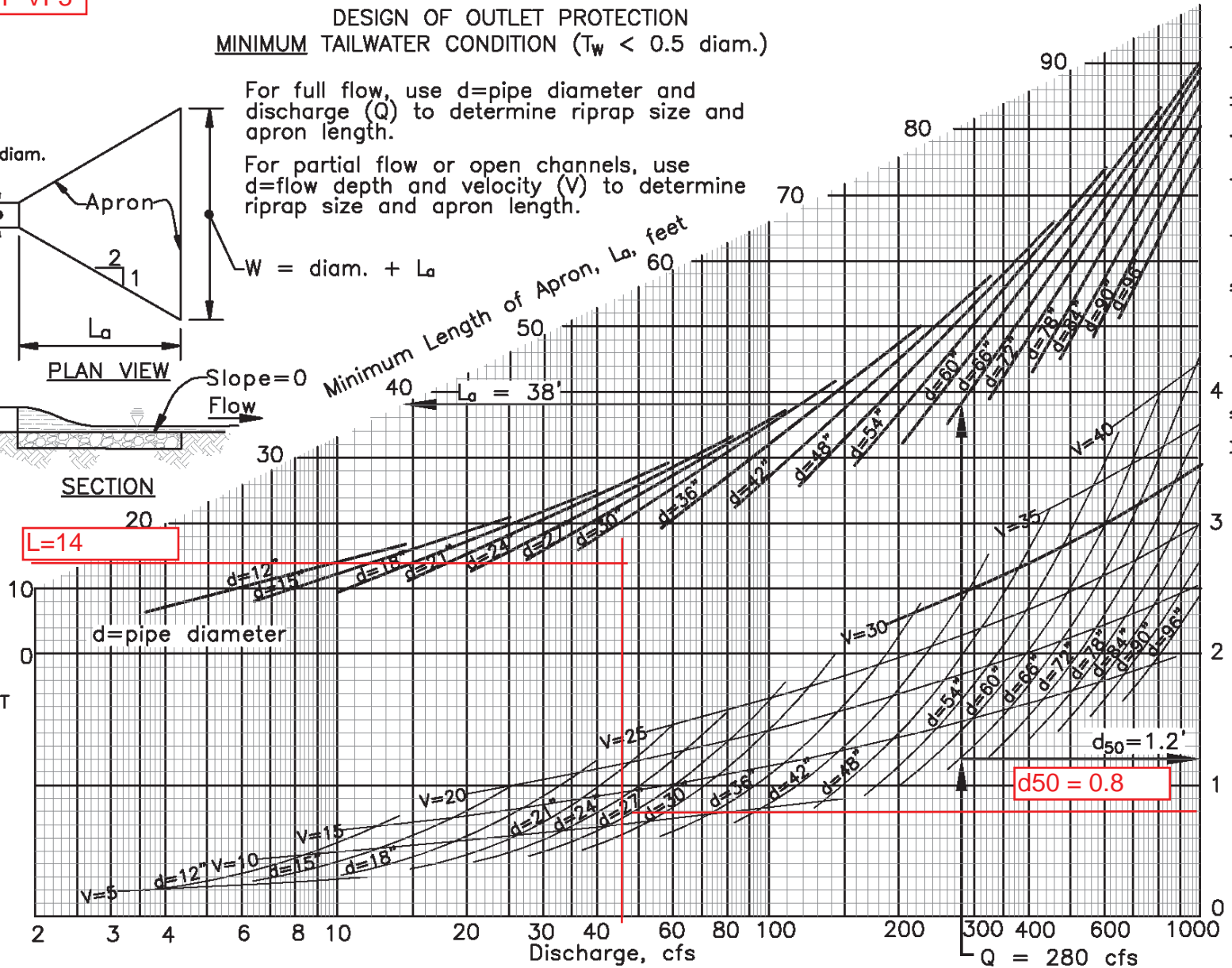


Minimum Length of Apron, L_a , feet

$L=14$

d =pipe diameter

NOTE: DO NOT EXTRAPOLATE LENGTH OF CURVES.



Median stone diameter, d_{50} , is the stone size for which 50% of the riprap mixture, by weight, is larger than.

Figure D.2: Design of Outlet Protection – Minimum Tailwater Condition

Appendix B

Sediment Basin No. 1 Calculations

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WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 11/25/2020
Project: Gude Units: English
SubTitle: DA-1A Areal Units: Acres
State: Maryland
County: Montgomery NOAA-C
Filename: C:\Users\slemasters\Downloads\Maximum Sediment Basin Drainage Area.w55

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
DS-BS-1	Maximum Sediment Basin	Outlet	44.8	86	.371

Total area: 44.80 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
3.14	4.13	4.82	6.19	7.1	8.32	2.6

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: NOAA_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period			
	2-Yr (cfs)	10-Yr (cfs)	25-Yr (cfs)	100-Yr (cfs)

SUBAREAS				
DS-BS-1	66.09	121.06	166.13	236.36
REACHES				
OUTLET	66.09	121.06	166.13	236.36

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area or Reach Identifier	Peak Flow and Peak Time (hr) by Rainfall Return Period			
	2-Yr (cfs) (hr)	10-Yr (cfs) (hr)	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)

SUBAREAS

DS-BS-1	66.09	121.06	166.13	236.36
	12.26	12.26	12.27	12.26

REACHES

OUTLET	66.09	121.06	166.13	236.36
--------	-------	--------	--------	--------

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
DS-BS-1	44.80	0.371	86	Outlet	Maximum Sediment Basin
Total Area:		44.80 (ac)			

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
DS-BS-1							
SHEET	100	0.0120	0.240				0.295
SHALLOW	369	0.0380	0.050				0.033
CHANNEL	900	0.0200	0.030	14.04	13.90	7.143	0.035
CHANNEL	418	0.0600	0.030	20.12	15.83	14.514	0.008
						Time of Concentration	.371
							=====

EA

Gude
DA-1A
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
DS-BS-1	Newly graded area (pervious only)	B	44.8	86
Total Area / Weighted Curve Number			44.8	86
			====	==

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WinTR-20: version 3.20 0 0 .1 0
 Gude Landfill
 Pond 3 - Proposed Conditions

SUB-AREA:
 DA-SB-1 Pond 3 .07 86. .371

STREAM REACH:
 Pond 3 Outlet Pond 3 YY

STORM ANALYSIS:
 2-YR 3.14 TYPE NO_C 2 3.14
 10-YR 4.82 TYPE NO_C 2 3.14
 100-YR 8.32 TYPE NO_C 2 3.14

STRUCTURE RATING:
 Pond 3 398.7
 398.7 0. 4.44
 399. 26.3 4.88
 399.5 74.4 5.33
 400. 131.7 5.8
 400.5 139.4 6.28
 401. 146.1 6.77
 401.5 152.7 7.29
 402. 159.3 7.81

GLOBAL OUTPUT:
 1 .1 .1 YY Y YY Y

WinTR-20 Printed Page File End of Input Data List

Gude Landfill
 Pond 3 - Proposed Conditions

Name of printed page file:
 C:\Users\slemasters\Desktop\Sed Basin 1_scl 48-in lower slope pipe.out

STORM 2-YR

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
DA-SB-1	0.070		1.782		12.26	66.1	944.10

Line Start Time (hr)	Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	Flow (cfs)	Flow (csm)
7.900	0.0	0.1	0.1	0.2	0.2	0.3
8.600	0.3	0.3	0.4	0.4	0.5	0.6
9.300	0.6	0.7	0.8	0.8	0.9	1.1
10.000	1.2	1.3	1.4	1.5	1.7	1.9
10.700	2.1	2.4	2.7	3.1	3.5	4.7
11.400	5.5	6.3	7.5	9.5	12.2	23.7
12.100	39.0	60.0	65.2	54.1	40.8	24.9
12.800	19.8	16.4	14.2	12.4	11.0	8.9
13.500	8.2	7.5	6.8	6.3	5.9	5.5
14.200	5.3	5.1	4.9	4.8	4.6	4.2

14.900	4.1	3.9	3.7	3.6	3.4	3.3	3.3
15.600	3.2	3.2	3.1	3.1	3.0	3.0	2.9
16.300	2.9	2.8	2.8	2.7	2.7	2.7	2.6
17.000	2.6	2.5	2.5	2.4	2.4	2.3	2.3
17.700	2.2	2.2	2.1	2.1	2.1	2.0	2.0
18.400	1.9	1.9	1.9	1.9	1.9	1.9	1.9
19.100	1.9	1.8	1.8	1.8	1.8	1.8	1.8
19.800	1.8	1.8	1.8	1.7	1.7	1.7	1.7
20.500	1.7	1.7	1.7	1.7	1.6	1.6	1.6
21.200	1.6	1.6	1.6	1.6	1.6	1.6	1.5
21.900	1.5	1.5	1.5	1.5	1.5	1.5	1.5
22.600	1.4	1.4	1.4	1.4	1.4	1.4	1.4
23.300	1.4	1.4	1.3	1.3	1.3	1.3	1.3
24.000	1.3	1.3	1.0	0.6	0.3	0.1	0.0

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Pond 3	0.070	Upstream	1.782		12.26	66.1	944.10

Line Start Time (hr)	----- Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	----- (cfs)	(cfs)	(cfs)
7.900	0.0	0.1	0.1	0.2	0.2	0.2	0.3
8.600	0.3	0.3	0.4	0.4	0.5	0.5	0.6
9.300	0.6	0.7	0.8	0.8	0.9	1.0	1.1
10.000	1.2	1.3	1.4	1.5	1.7	1.8	1.9
10.700	2.1	2.4	2.7	3.1	3.5	4.1	4.7

Pond 3 - Proposed Conditions

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.400	5.5	6.3	7.5	9.5	12.2	16.3	23.7
12.100	39.0	60.0	65.2	54.1	40.8	31.7	24.9
12.800	19.8	16.4	14.2	12.4	11.0	9.8	8.9
13.500	8.2	7.5	6.8	6.3	5.9	5.7	5.5
14.200	5.3	5.1	4.9	4.8	4.6	4.4	4.2
14.900	4.1	3.9	3.7	3.6	3.4	3.3	3.3
15.600	3.2	3.2	3.1	3.1	3.0	3.0	2.9
16.300	2.9	2.8	2.8	2.7	2.7	2.7	2.6
17.000	2.6	2.5	2.5	2.4	2.4	2.3	2.3
17.700	2.2	2.2	2.1	2.1	2.1	2.0	2.0
18.400	1.9	1.9	1.9	1.9	1.9	1.9	1.9
19.100	1.9	1.8	1.8	1.8	1.8	1.8	1.8
19.800	1.8	1.8	1.8	1.7	1.7	1.7	1.7
20.500	1.7	1.7	1.7	1.7	1.6	1.6	1.6
21.200	1.6	1.6	1.6	1.6	1.6	1.6	1.5
21.900	1.5	1.5	1.5	1.5	1.5	1.5	1.5
22.600	1.4	1.4	1.4	1.4	1.4	1.4	1.4
23.300	1.4	1.4	1.3	1.3	1.3	1.3	1.3
24.000	1.3	1.3	1.0	0.6	0.3	0.1	0.0

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Pond 3	0.070	Downstream	1.782	399.32	12.38	57.2	817.75

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.200	0.685E-01	0.1	0.2	0.2	0.2	0.3	0.3
8.900	0.3	0.4	0.4	0.5	0.5	0.6	0.6
9.600	0.7	0.8	0.8	0.9	1.0	1.1	1.2
10.300	1.3	1.4	1.6	1.7	1.8	2.0	2.2
11.000	2.5	2.8	3.2	3.7	4.2	4.9	5.7
11.700	6.8	8.4	10.7	14.3	20.9	36.4	53.1
12.400	56.9	50.6	41.6	33.5	26.6	23.1	20.0
13.100	17.3	15.1	13.2	11.7	10.5	9.4	8.5
13.800	7.7	7.1	6.6	6.2	5.9	5.6	5.4
14.500	5.2	5.0	4.8	4.6	4.4	4.3	4.1
15.200	3.9	3.7	3.6	3.5	3.4	3.3	3.2
15.900	3.2	3.1	3.1	3.0	3.0	2.9	2.9
16.600	2.8	2.8	2.7	2.7	2.7	2.6	2.6
17.300	2.5	2.5	2.4	2.4	2.3	2.3	2.2
18.000	2.2	2.1	2.1	2.1	2.0	2.0	2.0
18.700	1.9	1.9	1.9	1.9	1.9	1.9	1.9
19.400	1.8	1.8	1.8	1.8	1.8	1.8	1.8
20.100	1.8	1.8	1.7	1.7	1.7	1.7	1.7
20.800	1.7	1.7	1.7	1.6	1.6	1.6	1.6
21.500	1.6	1.6	1.6	1.6	1.6	1.5	1.5
22.200	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Pond 3 - Proposed Conditions

Line Start Time (hr)	----- (cfs)	Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	----- (cfs)	(cfs)
22.900	1.4	1.4	1.4	1.4	1.4	1.4	1.4
23.600	1.4	1.3	1.3	1.3	1.3	1.3	1.2
24.300	1.1	0.8	0.6	0.4	0.2	0.1	0.0

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Elevation (ft)	Peak Time (hr)	Flow Rate (cfs)	----- Rate (csm)
OUTLET	0.070		1.782		12.38	57.2	817.75

Line Start Time (hr)	----- (cfs)	Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	----- (cfs)	(cfs)
8.200	0.685E-01	0.1	0.2	0.2	0.2	0.3	0.3
8.900	0.3	0.4	0.4	0.5	0.5	0.6	0.6
9.600	0.7	0.8	0.8	0.9	1.0	1.1	1.2
10.300	1.3	1.4	1.6	1.7	1.8	2.0	2.2
11.000	2.5	2.8	3.2	3.7	4.2	4.9	5.7
11.700	6.8	8.4	10.7	14.3	20.9	36.4	53.1
12.400	56.9	50.6	41.6	33.5	26.6	23.1	20.0
13.100	17.3	15.1	13.2	11.7	10.5	9.4	8.5
13.800	7.7	7.1	6.6	6.2	5.9	5.6	5.4
14.500	5.2	5.0	4.8	4.6	4.4	4.3	4.1
15.200	3.9	3.7	3.6	3.5	3.4	3.3	3.2
15.900	3.2	3.1	3.1	3.0	3.0	2.9	2.9
16.600	2.8	2.8	2.7	2.7	2.7	2.6	2.6
17.300	2.5	2.5	2.4	2.4	2.3	2.3	2.2
18.000	2.2	2.1	2.1	2.1	2.0	2.0	2.0
18.700	1.9	1.9	1.9	1.9	1.9	1.9	1.9
19.400	1.8	1.8	1.8	1.8	1.8	1.8	1.8
20.100	1.8	1.8	1.7	1.7	1.7	1.7	1.7
20.800	1.7	1.7	1.7	1.6	1.6	1.6	1.6
21.500	1.6	1.6	1.6	1.6	1.6	1.5	1.5
22.200	1.5	1.5	1.5	1.5	1.5	1.5	1.5
22.900	1.4	1.4	1.4	1.4	1.4	1.4	1.4
23.600	1.4	1.3	1.3	1.3	1.3	1.3	1.2
24.300	1.1	0.8	0.6	0.4	0.2	0.1	0.0

STORM 10-YR

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Elevation (ft)	Peak Time (hr)	Flow Rate (cfs)	----- Rate (csm)
DA-SB-1	0.070		3.299		12.26	121.1	1729.49

Pond 3 - Proposed Conditions

Line Start Time (hr)	----- (cfs)	Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	----- (cfs)	(cfs)
5.800	0.0	0.1	0.1	0.2	0.2	0.2	0.3
6.500	0.3	0.4	0.4	0.4	0.5	0.5	0.6
7.200	0.6	0.7	0.8	0.8	0.9	0.9	1.0
7.900	1.1	1.1	1.2	1.3	1.3	1.4	1.5
8.600	1.5	1.6	1.7	1.8	1.9	1.9	2.1
9.300	2.2	2.4	2.5	2.7	2.9	3.1	3.3
10.000	3.5	3.8	4.0	4.3	4.5	4.8	5.1
10.700	5.5	6.1	6.8	7.5	8.4	9.5	10.8
11.400	12.3	14.0	16.2	20.2	25.5	33.2	47.0
12.100	74.6	111.4	118.7	97.0	72.3	55.8	43.4
12.800	34.3	28.3	24.3	21.3	18.7	16.7	15.2
13.500	13.9	12.7	11.6	10.7	10.0	9.6	9.2
14.200	8.9	8.6	8.3	8.0	7.7	7.4	7.1
14.900	6.8	6.6	6.3	6.0	5.8	5.6	5.5
15.600	5.4	5.3	5.2	5.1	5.0	5.0	4.9
16.300	4.8	4.7	4.7	4.6	4.5	4.4	4.4
17.000	4.3	4.2	4.1	4.0	4.0	3.9	3.8
17.700	3.7	3.7	3.6	3.5	3.4	3.3	3.3
18.400	3.2	3.2	3.2	3.2	3.1	3.1	3.1
19.100	3.1	3.1	3.0	3.0	3.0	3.0	3.0
19.800	2.9	2.9	2.9	2.9	2.9	2.8	2.8
20.500	2.8	2.8	2.8	2.8	2.7	2.7	2.7
21.200	2.7	2.6	2.6	2.6	2.6	2.6	2.6
21.900	2.5	2.5	2.5	2.5	2.5	2.4	2.4
22.600	2.4	2.4	2.4	2.3	2.3	2.3	2.3
23.300	2.3	2.2	2.2	2.2	2.2	2.2	2.1
24.000	2.1	2.1	1.6	0.9	0.5	0.2	0.1
24.700	0.0						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Elevation (ft)	Peak Flow Time (hr)	----- Rate (cfs)	----- Rate (csm)
Pond 3	0.070	Upstream	3.299		12.26	121.1	1729.49

Line Start Time (hr)	----- (cfs)	Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	----- (cfs)	(cfs)
5.800	0.0	0.1	0.1	0.2	0.2	0.2	0.3
6.500	0.3	0.4	0.4	0.4	0.5	0.5	0.6
7.200	0.6	0.7	0.8	0.8	0.9	0.9	1.0
7.900	1.1	1.1	1.2	1.3	1.3	1.4	1.5
8.600	1.5	1.6	1.7	1.8	1.9	1.9	2.1
9.300	2.2	2.4	2.5	2.7	2.9	3.1	3.3
10.000	3.5	3.8	4.0	4.3	4.5	4.8	5.1
10.700	5.5	6.1	6.8	7.5	8.4	9.5	10.8
11.400	12.3	14.0	16.2	20.2	25.5	33.2	47.0
12.100	74.6	111.4	118.7	97.0	72.3	55.8	43.4
12.800	34.3	28.3	24.3	21.3	18.7	16.7	15.2
13.500	13.9	12.7	11.6	10.7	10.0	9.6	9.2

Pond 3 - Proposed Conditions

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
14.200	8.9	8.6	8.3	8.0	7.7	7.4	7.1
14.900	6.8	6.6	6.3	6.0	5.8	5.6	5.5
15.600	5.4	5.3	5.2	5.1	5.0	5.0	4.9
16.300	4.8	4.7	4.7	4.6	4.5	4.4	4.4
17.000	4.3	4.2	4.1	4.0	4.0	3.9	3.8
17.700	3.7	3.7	3.6	3.5	3.4	3.3	3.3
18.400	3.2	3.2	3.2	3.2	3.1	3.1	3.1
19.100	3.1	3.1	3.0	3.0	3.0	3.0	3.0
19.800	2.9	2.9	2.9	2.9	2.9	2.8	2.8
20.500	2.8	2.8	2.8	2.8	2.7	2.7	2.7
21.200	2.7	2.6	2.6	2.6	2.6	2.6	2.6
21.900	2.5	2.5	2.5	2.5	2.5	2.4	2.4
22.600	2.4	2.4	2.4	2.3	2.3	2.3	2.3
23.300	2.3	2.2	2.2	2.2	2.2	2.2	2.1
24.000	2.1	2.1	1.6	0.9	0.5	0.2	0.1
24.700	0.0						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Pond 3	0.070	Downstream	3.298	399.79	12.36	108.1	1544.19

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
6.100	0.0	0.1	0.2	0.2	0.2	0.3	0.3
6.800	0.4	0.4	0.4	0.5	0.5	0.6	0.6
7.500	0.7	0.8	0.8	0.9	0.9	1.0	1.1
8.200	1.1	1.2	1.3	1.3	1.4	1.5	1.5
8.900	1.6	1.7	1.8	1.9	2.0	2.1	2.2
9.600	2.4	2.6	2.7	2.9	3.1	3.3	3.6
10.300	3.8	4.0	4.3	4.5	4.8	5.2	5.7
11.000	6.3	6.9	7.7	8.7	9.8	11.2	12.7
11.700	14.8	18.0	22.5	31.3	48.9	77.0	103.6
12.400	106.0	90.7	72.8	58.5	46.5	37.2	30.6
13.100	26.1	23.6	21.3	19.2	17.3	15.7	14.3
13.800	13.0	12.0	11.1	10.5	9.9	9.5	9.1
14.500	8.7	8.4	8.1	7.8	7.5	7.2	6.9
15.200	6.6	6.3	6.0	5.8	5.7	5.5	5.4
15.900	5.3	5.2	5.1	5.1	5.0	4.9	4.8
16.600	4.7	4.7	4.6	4.5	4.4	4.4	4.3
17.300	4.2	4.1	4.0	4.0	3.9	3.8	3.7
18.000	3.7	3.6	3.5	3.4	3.4	3.3	3.3
18.700	3.2	3.2	3.2	3.1	3.1	3.1	3.1
19.400	3.1	3.0	3.0	3.0	3.0	3.0	2.9
20.100	2.9	2.9	2.9	2.9	2.8	2.8	2.8
20.800	2.8	2.8	2.7	2.7	2.7	2.7	2.7
21.500	2.7	2.6	2.6	2.6	2.6	2.6	2.5
22.200	2.5	2.5	2.5	2.5	2.4	2.4	2.4

Pond 3 - Proposed Conditions

Line Start Time (hr)	----- Flow Values @ time increment of 0.100 hr -----						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
22.900	2.4	2.4	2.3	2.3	2.3	2.3	2.3
23.600	2.2	2.2	2.2	2.2	2.2	2.2	2.0
24.300	1.7	1.3	0.9	0.6	0.4	0.2	0.1
25.000	0.0						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Peak Flow -----			
				Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.070		3.298		12.36	108.1	1544.19

Line Start Time (hr)	----- Flow Values @ time increment of 0.100 hr -----						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
6.100	0.0	0.1	0.2	0.2	0.2	0.3	0.3
6.800	0.4	0.4	0.4	0.5	0.5	0.6	0.6
7.500	0.7	0.8	0.8	0.9	0.9	1.0	1.1
8.200	1.1	1.2	1.3	1.3	1.4	1.5	1.5
8.900	1.6	1.7	1.8	1.9	2.0	2.1	2.2
9.600	2.4	2.6	2.7	2.9	3.1	3.3	3.6
10.300	3.8	4.0	4.3	4.5	4.8	5.2	5.7
11.000	6.3	6.9	7.7	8.7	9.8	11.2	12.7
11.700	14.8	18.0	22.5	31.3	48.9	77.0	103.6
12.400	106.0	90.7	72.8	58.5	46.5	37.2	30.6
13.100	26.1	23.6	21.3	19.2	17.3	15.7	14.3
13.800	13.0	12.0	11.1	10.5	9.9	9.5	9.1
14.500	8.7	8.4	8.1	7.8	7.5	7.2	6.9
15.200	6.6	6.3	6.0	5.8	5.7	5.5	5.4
15.900	5.3	5.2	5.1	5.1	5.0	4.9	4.8
16.600	4.7	4.7	4.6	4.5	4.4	4.4	4.3
17.300	4.2	4.1	4.0	4.0	3.9	3.8	3.7
18.000	3.7	3.6	3.5	3.4	3.4	3.3	3.3
18.700	3.2	3.2	3.2	3.1	3.1	3.1	3.1
19.400	3.1	3.0	3.0	3.0	3.0	3.0	2.9
20.100	2.9	2.9	2.9	2.9	2.8	2.8	2.8
20.800	2.8	2.8	2.7	2.7	2.7	2.7	2.7
21.500	2.7	2.6	2.6	2.6	2.6	2.6	2.5
22.200	2.5	2.5	2.5	2.5	2.4	2.4	2.4
22.900	2.4	2.4	2.3	2.3	2.3	2.3	2.3
23.600	2.2	2.2	2.2	2.2	2.2	2.2	2.0
24.300	1.7	1.3	0.9	0.6	0.4	0.2	0.1
25.000	0.0						

STORM 100-YR

Pond 3 - Proposed Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Elevation (ft)	Peak Flow Time (hr)	----- Rate (cfs)	----- Rate (csm)
DA-SB-1	0.070		6.641		12.26	236.4	3376.59

Line Start Time (hr)	----- (cfs)	Flow Values @ time increment of 0.100 hr (cfs)	----- (cfs)	----- (cfs)	----- (cfs)	----- (cfs)	----- (cfs)
3.700	0.547E-01	0.2	0.2	0.3	0.4	0.4	0.5
4.400	0.6	0.6	0.7	0.8	0.9	0.9	1.0
5.100	1.1	1.1	1.2	1.3	1.3	1.4	1.5
5.800	1.6	1.6	1.7	1.8	1.8	1.9	2.0
6.500	2.1	2.3	2.4	2.5	2.6	2.7	2.9
7.200	3.0	3.1	3.3	3.4	3.5	3.7	3.8
7.900	4.0	4.1	4.3	4.4	4.6	4.7	4.9
8.600	5.0	5.2	5.4	5.5	5.7	5.9	6.1
9.300	6.4	6.8	7.2	7.6	8.1	8.6	9.0
10.000	9.5	10.0	10.5	11.0	11.6	12.1	12.7
10.700	13.6	14.9	16.4	18.1	19.9	22.2	25.0
11.400	28.2	31.6	36.1	44.2	55.0	70.4	97.4
12.100	150.7	219.7	230.7	186.6	137.9	105.6	81.7
12.800	64.2	52.7	45.2	39.4	34.6	30.9	28.0
13.500	25.5	23.3	21.3	19.6	18.5	17.6	16.9
14.200	16.3	15.8	15.2	14.7	14.1	13.6	13.1
14.900	12.5	12.0	11.4	10.9	10.5	10.2	10.0
15.600	9.8	9.7	9.5	9.3	9.2	9.1	8.9
16.300	8.8	8.6	8.5	8.3	8.2	8.1	7.9
17.000	7.8	7.6	7.5	7.4	7.2	7.1	6.9
17.700	6.8	6.6	6.5	6.3	6.2	6.1	6.0
18.400	5.9	5.8	5.8	5.7	5.7	5.7	5.6
19.100	5.6	5.5	5.5	5.5	5.4	5.4	5.4
19.800	5.3	5.3	5.3	5.2	5.2	5.2	5.1
20.500	5.1	5.0	5.0	5.0	4.9	4.9	4.9
21.200	4.8	4.8	4.8	4.7	4.7	4.6	4.6
21.900	4.6	4.5	4.5	4.5	4.4	4.4	4.4
22.600	4.3	4.3	4.3	4.2	4.2	4.1	4.1
23.300	4.1	4.0	4.0	4.0	3.9	3.9	3.9
24.000	3.9	3.8	2.9	1.7	0.8	0.4	0.2
24.700	0.0						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Elevation (ft)	Peak Flow Time (hr)	----- Rate (cfs)	----- Rate (csm)
Pond 3	0.070	Upstream	6.641		12.26	236.4	3376.59

Line Start Time (hr)	----- (cfs)	Flow Values @ time increment of 0.100 hr (cfs)	----- (cfs)	----- (cfs)	----- (cfs)	----- (cfs)	----- (cfs)
3.700	0.547E-01	0.2	0.2	0.3	0.4	0.4	0.5
4.400	0.6	0.6	0.7	0.8	0.9	0.9	1.0
5.100	1.1	1.1	1.2	1.3	1.3	1.4	1.5

Pond 3 - Proposed Conditions

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
5.800	1.6	1.6	1.7	1.8	1.8	1.9	2.0
6.500	2.1	2.3	2.4	2.5	2.6	2.7	2.9
7.200	3.0	3.1	3.3	3.4	3.5	3.7	3.8
7.900	4.0	4.1	4.3	4.4	4.6	4.7	4.9
8.600	5.0	5.2	5.4	5.5	5.7	5.9	6.1
9.300	6.4	6.8	7.2	7.6	8.1	8.6	9.0
10.000	9.5	10.0	10.5	11.0	11.6	12.1	12.7
10.700	13.6	14.9	16.4	18.1	19.9	22.2	25.0
11.400	28.2	31.6	36.1	44.2	55.0	70.4	97.4
12.100	150.7	219.7	230.7	186.6	137.9	105.6	81.7
12.800	64.2	52.7	45.2	39.4	34.6	30.9	28.0
13.500	25.5	23.3	21.3	19.6	18.5	17.6	16.9
14.200	16.3	15.8	15.2	14.7	14.1	13.6	13.1
14.900	12.5	12.0	11.4	10.9	10.5	10.2	10.0
15.600	9.8	9.7	9.5	9.3	9.2	9.1	8.9
16.300	8.8	8.6	8.5	8.3	8.2	8.1	7.9
17.000	7.8	7.6	7.5	7.4	7.2	7.1	6.9
17.700	6.8	6.6	6.5	6.3	6.2	6.1	6.0
18.400	5.9	5.8	5.8	5.7	5.7	5.7	5.6
19.100	5.6	5.5	5.5	5.5	5.4	5.4	5.4
19.800	5.3	5.3	5.3	5.2	5.2	5.2	5.1
20.500	5.1	5.0	5.0	5.0	4.9	4.9	4.9
21.200	4.8	4.8	4.8	4.7	4.7	4.6	4.6
21.900	4.6	4.5	4.5	4.5	4.4	4.4	4.4
22.600	4.3	4.3	4.3	4.2	4.2	4.1	4.1
23.300	4.1	4.0	4.0	4.0	3.9	3.9	3.9
24.000	3.9	3.8	2.9	1.7	0.8	0.4	0.2
24.700	0.0						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Pond 3	0.070	Downstream	6.641	401.62	12.45	154.3	2204.45

Line Start Time (hr)	Flow Values @ time increment of 0.100 hr						
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
3.800	0.0	0.1	0.2	0.2	0.3	0.4	0.4
4.500	0.5	0.6	0.6	0.7	0.8	0.9	0.9
5.200	1.0	1.1	1.1	1.2	1.3	1.3	1.4
5.900	1.5	1.5	1.6	1.7	1.8	1.9	1.9
6.600	2.0	2.1	2.3	2.4	2.5	2.6	2.7
7.300	2.9	3.0	3.1	3.3	3.4	3.5	3.7
8.000	3.8	4.0	4.1	4.3	4.4	4.6	4.7
8.700	4.9	5.0	5.2	5.4	5.5	5.7	5.9
9.400	6.2	6.5	6.9	7.3	7.7	8.1	8.6
10.100	9.1	9.5	10.0	10.5	11.0	11.6	12.2
10.800	13.0	14.0	15.3	16.8	18.5	20.5	22.9
11.500	25.7	30.3	36.3	44.5	55.5	72.5	106.1

Pond 3 - Proposed Conditions

Line Start Time (hr)	----- (cfs)	Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	----- (cfs)	(cfs)
12.200	136.4	146.9	153.3	154.0	150.7	144.8	136.7
12.900	102.0	68.5	52.8	43.3	36.9	32.4	29.0
13.600	26.2	24.7	23.0	21.4	20.1	19.0	18.1
14.300	17.3	16.6	15.9	15.3	14.7	14.2	13.6
15.000	13.1	12.5	12.0	11.5	11.0	10.7	10.4
15.700	10.1	9.9	9.7	9.5	9.4	9.2	9.1
16.400	8.9	8.8	8.6	8.5	8.4	8.2	8.1
17.100	7.9	7.8	7.6	7.5	7.4	7.2	7.1
17.800	6.9	6.8	6.6	6.5	6.3	6.2	6.1
18.500	6.0	5.9	5.8	5.8	5.7	5.7	5.7
19.200	5.6	5.6	5.5	5.5	5.5	5.4	5.4
19.900	5.4	5.3	5.3	5.3	5.2	5.2	5.2
20.600	5.1	5.1	5.0	5.0	5.0	4.9	4.9
21.300	4.9	4.8	4.8	4.8	4.7	4.7	4.7
22.000	4.6	4.6	4.5	4.5	4.5	4.4	4.4
22.700	4.4	4.3	4.3	4.3	4.2	4.2	4.1
23.400	4.1	4.1	4.0	4.0	4.0	3.9	3.9
24.100	3.9	3.7	3.1	2.4	1.7	1.1	0.7
24.800	0.4	0.3	0.2	0.1	0.0		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	----- Elevation (ft)	Peak Flow Time (hr)	----- Rate (cfs)	----- Rate (csm)
OUTLET	0.070		6.641		12.45	154.3	2204.45

Line Start Time (hr)	----- (cfs)	Flow (cfs)	Values @ time (cfs)	increment (cfs)	of 0.100 hr (cfs)	----- (cfs)	(cfs)
3.800	0.0	0.1	0.2	0.2	0.3	0.4	0.4
4.500	0.5	0.6	0.6	0.7	0.8	0.9	0.9
5.200	1.0	1.1	1.1	1.2	1.3	1.3	1.4
5.900	1.5	1.5	1.6	1.7	1.8	1.9	1.9
6.600	2.0	2.1	2.3	2.4	2.5	2.6	2.7
7.300	2.9	3.0	3.1	3.3	3.4	3.5	3.7
8.000	3.8	4.0	4.1	4.3	4.4	4.6	4.7
8.700	4.9	5.0	5.2	5.4	5.5	5.7	5.9
9.400	6.2	6.5	6.9	7.3	7.7	8.1	8.6
10.100	9.1	9.5	10.0	10.5	11.0	11.6	12.2
10.800	13.0	14.0	15.3	16.8	18.5	20.5	22.9
11.500	25.7	30.3	36.3	44.5	55.5	72.5	106.1
12.200	136.4	146.9	153.3	154.0	150.7	144.8	136.7
12.900	102.0	68.5	52.8	43.3	36.9	32.4	29.0
13.600	26.2	24.7	23.0	21.4	20.1	19.0	18.1
14.300	17.3	16.6	15.9	15.3	14.7	14.2	13.6
15.000	13.1	12.5	12.0	11.5	11.0	10.7	10.4
15.700	10.1	9.9	9.7	9.5	9.4	9.2	9.1
16.400	8.9	8.8	8.6	8.5	8.4	8.2	8.1
17.100	7.9	7.8	7.6	7.5	7.4	7.2	7.1
17.800	6.9	6.8	6.6	6.5	6.3	6.2	6.1

Pond 3 - Proposed Conditions

Line Start Time (hr)	----- (cfs)	Flow Values @ time (cfs)	increment (cfs)	of (cfs)	0.100 hr (cfs)	----- (cfs)	(cfs)
18.500	6.0	5.9	5.8	5.8	5.7	5.7	5.7
19.200	5.6	5.6	5.5	5.5	5.5	5.4	5.4
19.900	5.4	5.3	5.3	5.3	5.2	5.2	5.2
20.600	5.1	5.1	5.0	5.0	5.0	4.9	4.9
21.300	4.9	4.8	4.8	4.8	4.7	4.7	4.7
22.000	4.6	4.6	4.5	4.5	4.5	4.4	4.4
22.700	4.4	4.3	4.3	4.3	4.2	4.2	4.1
23.400	4.1	4.1	4.0	4.0	4.0	3.9	3.9
24.100	3.9	3.7	3.1	2.4	1.7	1.1	0.7
24.800	0.4	0.3	0.2	0.0			

Pond 3 - Proposed Conditions

Area or Reach Identifier	Drainage Area (sq mi)	----- Peak Flow by Storm -----				
		2-YR (cfs)	10-YR (cfs)	100-YR (cfs)	(cfs)	(cfs)
DA-SB-1	0.070	66.1	121.1	236.4		
Pond 3	0.070	66.1	121.1	236.4		
DOWNSTREAM		57.2	108.1	154.3		
OUTLET	0.070	57.2	108.1	154.3		

GUDE LANDFILL REMEDIATION
Sediment Basin No. 1
Stage-Storage Table and Related Design Criteria

Elevation (ft)	Area (sq ft)	Average End Area (sq ft)	Change in Elevation (ft)	Volume (cu ft)	Cumulative Volume (cu ft)	Cumulative Volume (acre-ft)
392.0	22,725				0	0.00
392.5	23,732	23,229	0.5	11,615	11,615	0.27
393.0	24,752	24,242	0.5	12,121	23,736	0.54
393.5	25,798	25,275	0.5	12,638	36,373	0.84
394.0	26,866	26,332	0.5	13,166	49,539	1.14
394.5	27,996	27,431	0.5	13,716	63,255	1.45
395.0	29,067	28,532	0.5	14,266	77,521	1.78
395.2	29,518	29,293	0.2	5,859	83,379	1.91
395.5	30,201	29,634	0.5	14,817	92,338	2.12
396.0	31,354	30,778	0.5	15,389	107,727	2.47
396.5	32,526	31,940	0.5	15,970	123,697	2.84
397.0	33,718	33,122	0.5	16,561	140,258	3.22
397.5	34,930	34,324	0.5	17,162	157,420	3.61
397.7	35,420	35,175	0.2	7,035	164,455	3.78
398.0	36,154	35,787	0.3	10,736	175,191	4.02
398.5	37,404	36,779	0.5	18,390	193,580	4.44
399.0	38,669	38,037	0.5	19,019	212,599	4.88
399.5	39,947	39,308	0.5	19,654	232,253	5.33
400.0	41,242	40,595	0.5	20,298	252,550	5.80
400.5	42,550	41,896	0.5	20,948	273,498	6.28
401.0	43,873	43,212	0.5	21,606	295,104	6.77
401.5	45,221	44,547	0.5	22,274	317,378	7.29
402.0	46,561	45,891	0.5	22,946	340,323	7.81

Principal Spillway Elevation = 398.7 feet
Storage to Principal Spillway = 201,187 cu ft
Drainage Area Capacity = 55.9 acres

Draw-Down Device Invert = 395.2 feet
Wet Storage Volume = 83,379 cu ft
Dry Storage Volume = 117,808 cu ft

Basin Cleanout Elevation = 393.70 feet
Riser Crest to Cleanout = 5.0 feet

Basin Surface Area (at Wet Storage EI) = 0.69 acres

GUDE LANDFILL REMEDIATION
Sediment Basin No. 1

Stage (ft)	Storage (acre-ft)	Discharge (cfs) (cfs)
392.0	0.00	0.0
392.5	0.27	0.0
393.0	0.54	0.0
393.5	0.84	0.0
394.0	1.14	0.0
394.5	1.45	0.0
395.0	1.78	0.0
395.2	1.91	0.0
395.5	2.12	0.0
396.0	2.47	0.0
396.5	2.84	0.0
397.0	3.22	0.0
397.5	3.61	0.0
397.7	3.78	0.0
398.0	4.02	0.0
398.5	4.44	0.0
399.0	4.88	12.2
399.5	5.33	53.2
400.0	5.80	110.3
400.5	6.28	139.4
401.0	6.77	146.1
401.5	7.29	152.7
402.0	7.81	159.3

Low-Flow Orifice Information:

Low-Flow Orifice Invert Elevation =	395.2 ft	where:	$Q = CA \sqrt{2gH}$
Low-Flow Orifice Diameter =	0.8 in	Q = discharge (cfs)	
Low-Flow Orifice Coefficient =	0.6	C = orifice coefficient	
Dewatering Pipe Diameter	48.0 in		
Height of Riser =	3.5 ft		
Number of Low-Flow Orifices Per Row =	50	A = orifice area (ft ²)	
Number of Low-Flow Orifice Rows =	15	g = gravity = 32.2 ft/sec ²	
Spacing Between Low-Flow Orifice Rows =	3.0 in	H = head (ft) = stage - orifice centerline elevation	
Permittivity of geotextile wrap =	0 s ⁻¹	(use "0" for no wrap)	
Percent clogging of orifices =	0%		

Principal Spillway Information:

Top of Riser Elevation =	398.7 ft	see next sheet for calculations
Riser Crest Length =	24 ft	
Weir Coefficient, C =	3.1	
Riser Area, A =	36 ft ²	
Barrel Diameter =	4 ft	
Barrel Length =	70 ft	
Manning's Coefficient =	0.013	RCP
K _m =	1	Assume only entrance loss
K _p =	0.003	
Tailwater Elevation =	0	Estimated based on assumed capacity of pipe

Emergency Spillway Information:

Spillway Weir Crest Elevation =	0.0 ft	$Q = CLH^{\frac{3}{2}}$
Spillway Weir Length =	0.0 ft	where:
Spillway Weir Coefficient =	3.0	Q = discharge (cfs)
		C = weir coefficient
		L = weir length (ft)
		H = head (ft) = stage - crest elev.

Principal Spillway

Stage (ft)	Low Flow Dewatering (Assume Blocked)	Riser (Weir Flow)	Riser (Orifice Flow)	Max Riser Flow (Includes Low Flow Orifice)	48-in. Barrel (HY-8)	Actual	Control Type
392.0	0.000	0.00	0.00	0.00	0.00	0.00	
392.5	0.000	0.00	0.00	0.00	0.00	0.00	
393.0	0.000	0.00	0.00	0.00	0.00	0.00	
393.5	0.000	0.00	0.00	0.00	0.00	0.00	
394.0	0.000	0.00	0.00	0.00	0.00	0.00	
394.5	0.000	0.00	0.00	0.00	0.00	0.00	
395.0	0.000	0.00	0.00	0.00	0.00	0.00	
395.2	0.000	0.00	0.00	0.00	0.00	0.00	
395.5	0.000	0.00	0.00	0.00	1.00	0.00	
396.0	0.000	0.00	0.00	0.00	47.00	0.00	
396.5	0.000	0.00	0.00	0.00	59.92	0.00	
397.0	0.000	0.00	0.00	0.00	72.85	0.00	
397.5	0.000	0.00	0.00	0.00	85.07	0.00	
397.7	0.000	0.00	0.00	0.00	89.54	0.00	
398.0	0.407	0.00	0.00	0.41	96.25	0.00	
398.5	0.664	0.00	0.00	0.66	106.21	0.00	
399.0	0.847	12.23	94.94	13.07	115.42	12.23	Riser (Weir Flow)
399.5	0.996	53.24	155.04	54.23	123.95	53.24	Riser (Weir Flow)
400.0	1.126	110.28	197.64	111.40	131.66	110.28	Riser (Weir Flow)
400.5	1.242	179.67	232.56	180.92	139.37	139.37	48-in. Barrel (HY-8)
401.0	1.349	259.52	262.88	260.87	146.10	146.10	48-in. Barrel (HY-8)
401.5	1.447	348.59	290.05	291.50	152.69	152.69	48-in. Barrel (HY-8)
402.0	1.540	446.01	314.89	316.43	159.28	159.28	48-in. Barrel (HY-8)

Riser (Weir Flow) Discharge

$$Q = CLH^{1.5}$$

where: Q = discharge (cfs)

L = riser crest length (ft)

H = head (ft) = stage - top of riser elevation

Riser (Orifice Flow) Discharge

$$Q = CA \sqrt{2gH}$$

where: Q = discharge (cfs)

C = orifice coefficient

A = cross-sectional area of the riser

g = gravity = 32.2 ft/sec²

H = head (ft) = stage - top of riser elevation

GUDE LANDFILL REMEDIATION
Sediment Basin No. 1

Stage (ft)	Storage (cu ft)	Dewatering Device Discharge (cfs)	Time to Dewater			CUMULATIVE Time to Dewater		
			(min)	(hr)	(days)	(min)	(hr)	(days)
395.2	83,379	0.00	NA	NA	NA	NA	NA	NA
395.3	86,365	0.23	212	3.53	0.15	212	3.53	0.15
395.4	89,351	0.33	150	2.50	0.10	362	6.03	0.25
395.5	92,338	0.57	90	1.49	0.06	451	7.52	0.31
395.6	95,415	0.76	68	1.13	0.05	519	8.65	0.36
395.7	98,493	0.90	57	0.95	0.04	576	9.61	0.40
395.8	101,571	1.25	41	0.68	0.03	617	10.29	0.43
395.9	104,649	1.45	35	0.59	0.02	653	10.88	0.45
396.0	107,727	1.79	30	0.50	0.02	683	11.38	0.47
396.1	110,921	2.06	26	0.43	0.02	708	11.81	0.49
396.2	114,115	2.28	23	0.39	0.02	732	12.20	0.51
396.3	117,309	2.71	20	0.33	0.01	751	12.52	0.52
396.4	120,503	2.99	18	0.30	0.01	769	12.82	0.53
396.5	123,697	3.40	16	0.27	0.01	785	13.09	0.55
396.6	127,009	3.74	15	0.25	0.01	800	13.34	0.56
396.7	130,321	4.02	14	0.23	0.01	814	13.57	0.57
396.8	133,633	4.51	12	0.20	0.01	826	13.77	0.57
396.9	136,945	4.85	11	0.19	0.01	838	13.96	0.58
397.0	140,258	5.32	11	0.18	0.01	848	14.14	0.59
397.1	143,690	5.71	10	0.17	0.01	858	14.31	0.60
397.2	147,122	6.05	9	0.16	0.01	868	14.46	0.60
397.3	150,555	6.60	9	0.14	0.01	876	14.61	0.61
397.4	153,987	6.99	8	0.14	0.01	885	14.74	0.61
397.5	157,420	7.50	8	0.13	0.01	892	14.87	0.62
397.6	160,937	7.95	7	0.12	0.01	900	15.00	0.62
397.7	164,455	8.34	7	0.12	0.00	907	15.12	0.63
397.8	168,033	8.94	7	0.11	0.00	914	15.23	0.63
397.9	171,612	9.37	6	0.11	0.00	920	15.33	0.64
398.0	175,191	9.93	6	0.10	0.00	926	15.44	0.64
398.1	178,869	10.42	6	0.10	0.00	932	15.53	0.65
398.2	182,546	10.86	6	0.09	0.00	938	15.63	0.65
398.3	186,224	11.50	5	0.09	0.00	943	15.72	0.65
398.4	189,902	11.97	5	0.09	0.00	948	15.80	0.66
398.5	193,580	12.41	5	0.09	0.00	953	15.89	0.66
398.6	197,384	12.82	5	0.08	0.00	958	15.97	0.67
398.7	201,188	13.22	5	0.08	0.00	963	16.05	0.67

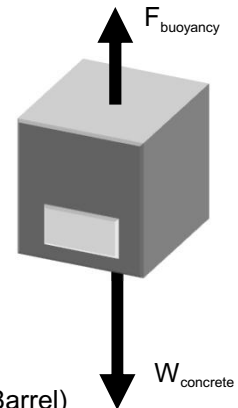
**Gude Landfill
Sediment Basin No. 1**

RISER STRUCTURE FLOTATION COMPUTATIONS

$$W_{concrete} \geq 1.2 \times F_{buoyancy}$$

$$W_{concrete} = V_{concrete} \times \gamma_{concrete}$$

	H/W/radius	L	Thickness		
$V_{concrete} =$	<u>9.00</u>	x <u>9.00</u>	x <u>1.50</u>	= 121.50	Bottom slab
+	<u>8.70</u>	x <u>7.33</u>	x <u>0.67</u>	= 42.73	Back wall 54" Opening(48" Barrel)
-	<u>2.25</u>	x	x <u>0.67</u>	= 10.66	
-		x	x	= 0.00	
+	<u>8.70</u>	x <u>7.33</u>	x <u>0.67</u>	= 42.73	Front wall
-		x	x	= 0.00	
-	<u>0.59</u>	x	x <u>0.67</u>	= 0.72	14" Opening (10" orifice)
+	<u>8.70</u>	x <u>7.33</u>	x <u>0.67</u>	= 42.73	
		x	x	= 0.00	Side wall
+	<u>8.70</u>	x <u>7.33</u>	x <u>0.67</u>	= 42.73	
-		x	x	= 0.00	Side wall
+		x	x	= 0.00	
-		x	x	= 0.00	
+		x	x	= 0.00	
=				<u>281.03</u>	ft ³



Refer to riser detail in plans for dimensions

$$W_{concrete} = V_{concrete} \times \gamma_{concrete}$$

$$W_{concrete} = 281.03 \text{ ft}^3 \times 150 \text{ lb/ft}^3$$

$$W_{concrete} = 42,154.51 \text{ lb}$$

$$F_{buoyancy} = V_{riser} \times \gamma_w$$

$$V_{riser} = \frac{8.70}{12} \times \frac{7.33}{12} \times \frac{7.33}{12} = \frac{467.44}{12^3} \text{ Box}$$

$$V_{riser-foot} = \frac{467.44}{12^3} \text{ ft}^3$$

$$F_{buoyancy} = V_{riser} \times \gamma_w$$

$$F_{buoyancy} = 467.44 \text{ ft}^3 \times 62.4 \text{ lb/ft}^3$$

$$F_{buoyancy} = 29,168.35 \text{ lb}$$

$$W_{concrete} \geq 1.2 \times F_{buoyancy}$$

$$42,154.51 \geq 1.2 \times 29,168.35$$

$$42,154.51 \geq 35,002.01$$

OK

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Table G.6: Temporary Sediment Basin Design Data Sheet
(Refer to instructions on pages G.27 through G.29)

Computed by: SCL Date: 6/25/2020 Checked by: _____ Date: _____
 Project name: Gude Landfill Remediation Basin #: Sediment Basin No. 1
 Location: 600 E Gude Drive

Design Volumes and Elevations

1. Total area draining to basin = 44.80 acres (ac)
2. Required total storage volume = $3600 \text{ ft}^3/\text{ac} \times \frac{44.80}{44.80}$ acre drainage area = 161280 ft^3
3. Required wet storage volume = $1800 \text{ ft}^3/\text{ac} \times \frac{44.80}{44.80}$ acre drainage area = 80640 ft^3
4. Required dry storage volume = $1800 \text{ ft}^3/\text{ac} \times \frac{44.80}{44.80}$ acre drainage area = 80640 ft^3
5. Basin bottom elevation = 392 ft
6. Riser or weir crest (total storage) elevation = 398.7 ft
7. Provided total storage volume = 175191 ft^3
8. Wet storage (permanent pool/draw-down) elevation = 395.2 ft
9. Provided wet storage volume = 83,528 ft^3
10. Provided dry storage volume = 117808 ft^3
11. Basin cleanout elevation (located at 1/2 wet storage depth) = 393.7 ft
12. Distance from riser crest elevation to cleanout elevation = 5.0 ft

Surface Area Design

13. $Q_{10} = \frac{108.1}{108.1}$ cfs (peak inflow from 10-yr, 24-hr storm event; attach computations)
14. Minimum basin surface area $\geq 0.0035 \times Q_{10} = \frac{0.38}{\text{required}}$ ac $\leq \frac{.68}{\text{provided}}$ ac

Principal Spillway (Q_{ps})
(See Figure G.1)

15. Design Q_{ps} for barrel = 108.1 cfs (min. 10% of Q_{10})
16. Barrel head, H = 5.66 ft; Barrel length, L = 53 ft
17. Barrel dia. = 48 in (min. 10 inch); $Q_{ps} = \frac{147}{147}$ (Q from Table G.7 or G.8) $\times \frac{1.03}{1.03}$ (length correction factor) = 151 cfs. **Note: Q_{ps} must equal or exceed Design Q_{ps}**
18. Riser dia. = 72x72 in; Riser height = 6.7 ft; Riser head (h) = 1.09 ft
19. Trash rack dia. = 74x74 in; Trash rack height = 37 in

See Calculation Sheets for Custom Riser, Stage-Storage-Discharge, and TR-20 analysis.

Emergency Spillway (Q_{es})
(See Figures G.3 and G.4)

20. Emergency spillway capacity $Q_{es} = Q_{10} - Q_{ps} = \underline{\hspace{1cm}} - \underline{\hspace{1cm}} = \underline{\hspace{1cm}}$ cfs
21. Width, b = ft; $H_p = \underline{\hspace{1cm}}$ ft
22. Exit channel slope %
23. Emergency Spillway Crest = ft
24. Design High Water = ft
25. Settled top of embankment elevation = ft

100-yr containment is provided in sediment basin, conveyed with principle spillway.

Table G.6: Temporary Sediment Basin Design Data Sheet (continued)

Anti-Seep Collar Design (If Required)
(See Figures G.5 and G.6)

26. $y = \underline{5.7}$ ft; $z = \underline{3}$:1; pipe slope = $\underline{1.87}$ %; $L_s = \underline{52}$ ft 52ft. determined graphically
27. Use $\underline{2}$ collars, $\underline{9}$ ft - $\underline{0}$ in. square; projection = $\underline{2}$ ft

Draw-Down Device
(See Table G.10 and Details G-2-6 and G-2-7)

28. $Q_{d-d} = \underline{2.25}$ cfs
29. Calculated $A_o = \underline{.27}$ ft²
30. Calculated $d_o = \underline{.58}$ in
31. Maximum diameter from Table G.10 = $\underline{10}$ in
32. Design d_o = smaller of line 30 or line 31 = $\underline{.58}$ in
33. Draw-down device pipe diameter = $\underline{48}$ in
34. Minimum A_t = total area of perforations = $4A_o = \underline{1.07}$ ft²
35. Perforation diameter = $\underline{0.75}$ in Perforation size Per Montgomery County Modified Dewatering Device Detail
36. Minimum number of perforations = $\underline{356}$
37. Number of longitudinal rows = $\underline{25}$ Based on Montgomery Co. perforation spacing = 6"
38. Perforated pipe length = $\underline{3}$ ft
39. Actual $A_t = (0.0055 \text{ ft}^2) \times (\text{line 37} \div 0.5 \text{ ft}) \times (\text{line 38}) = \underline{0.45}$ ft² (must be \geq line 34)

See Calculation Sheet for Dewatering Calculations
 - Modification to perforation internals proposed

Baffle Board Design
(See Detail G-2-4)

40. A = surface area at wet storage elevation = $\underline{29.518}$ ft²
41. Effective width, $W_e = (A/2)^{1/2} = \underline{121.5}$ ft $W_e * 2 = 243'$ (min.)
42. Flow length from inflow point to outlet = _____ ft 186ft, 179ft, 85ft (west to east inflow points)
43. If line 42 is less than $W_e \times 2$, provide baffle boards to lengthen flow path
44. Effective flow length, $L_e = L_1 + L_2 + L_3 =$ _____ ft (must be $\geq W_e \times 2 =$ _____ ft)
248ft, 288ft, 425ft (west to east inflow points)

Attachment K4
Floodplain Study

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**Gude Landfill Remediation Design
Montgomery County, Maryland**

Floodplain Analysis Report

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

July 2020
Version: DRAFT
EA Project No. 15646.01

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**Gude Landfill Remediation Design
Montgomery County, Maryland**

Floodplain Analysis Report

Prepared for

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2	Soil Map Units and Soil Hydrologic Groups
3	Water Surface Elevations

LIST OF ACRONYMS AND ABBREVIATIONS

HSG	Hydrologic soil group
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
the Landfill	Gude Landfill
M-NCPPC	Maryland-National Capital Park and Planning Commission
NRCS	Natural Resources Conservation Service
T _c	Time of concentration

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1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has been contracted to provide engineering, permitting, and support services for developing a remediation design to address the remedial action objectives at the Gude Landfill (“the Landfill”) in order to achieve compliance with the consent order for the Landfill.

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. Refer to **Figure 1** for a vicinity and location map. The site is accessed at two locations: East Gude Drive from the south-southwest and Southlawn Lane from the east-southeast.

The Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. An additional 17 acres of waste disposal area were delineated in 2009 on Maryland-National Capital Park and Planning Commission (M-NCPPC) property, beyond the northeastern property boundary of the Landfill. A land exchange between the County and M-NCPPC on October 21, 2014, transferred ownership of this additional waste disposal area to the County in exchange for a similar area of land without waste, which was transferred to M-NCPPC.

Landfill capping was selected as a corrective measure for the upper surface of the Landfill, as well as portions of the side-slopes of the Landfill where placement of a closure capping system is feasible. EA’s design includes the following major elements as part of the corrective measure:

- Erosion and sediment control,
- Existing waste reconfiguration and subgrade establishment,
- Landfill closure cap construction,
- Landfill gas management, and
- Stormwater management.

A stormwater management concept report was submitted to the Montgomery County Department of Permitting Services (DPS), which documented the stormwater management design associated with the remediation design in accordance with the *2000 Maryland Stormwater Design Manual* and design requirements based on Chapter 19 of the Montgomery County Code. The stormwater management concept plan was approved by DPS on March 10, 2020.

The design and the approved stormwater management concept plan include changes to the existing drainage areas at the site. The existing drainage area to the eastern side of the site is approximately 96 acres and the proposed drainage area will be approximately 99 acres. This change will require a Floodplain District Permit from DPS and this Floodplain Analysis Report.

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2. FLOODPLAIN ANALYSIS

EA met with DPS on February 18, 2020, to discuss the floodplain requirements for this project. Based on the discussion, EA understood an approximate floodplain delineation is appropriate for this project. The methodology presented herein is based on our understanding of those requirements, comments received on the initial floodplain submittal dated 30 April 2020, and our professional judgement.

The floodplain analysis methodology includes:

1. Perform existing and proposed hydrologic analysis
 - a. Delineate existing and proposed drainage areas to the point of investigation where the site discharges to the adjacent 100-year floodplain.
 - b. Determine hydrologic soil groups (HSGs) and land use within the drainage areas.
 - c. Calculate the times of concentration (T_c) for the existing and proposed drainage areas.
 - d. Utilize TR-55 to calculate the existing and proposed discharges for the 100-year storm intensity with the duration equal to the time of concentration.
2. Estimate the water surface elevation in the receiving stream based on discharge from the site in existing and proposed conditions. Compare the existing and proposed water surface elevations to the 100-year floodplain elevations.

2.1 EXISTING AND PROPOSED HYDROLOGIC ANALYSIS

2.1.1 Drainage Areas

The Landfill has been divided into 13 drainage areas (DAs), shown on the Drainage Area Map – Existing Conditions (Drawing C-103) and the Drainage Area Map – Proposed Conditions (Drawing C-104). **Table 1** summarizes the eight existing and proposed drainage areas of the Landfill that drain to the east to Southlawn Branch. **Figure 2** is a simple line diagram that demonstrate the routing for each of the drainage areas to Southlawn Branch. These drainage areas cover the limit of disturbance of the project and reflect the additional 3 acres of drainage from the existing to the proposed condition. The overall/combined drainage areas are shown on the Floodplain Drainage Area Map – Existing Conditions (Drawing C-105) and the Floodplain Drainage Area Map – Proposed Conditions (Drawing C-106).

Table 1 Drainage Area Summary

Drainage Area Name	Existing Area (acres)	Proposed Area (acres)	Discharge Point
DA-1A	36.95	33.36	Pond 3 Bypass
DA-1B	16.07	29.57	Pond 3
DA-2	28.63	21.88	Pond 1
DA-8	3.88	4.06	Southlawn Branch
DA-9	8.10	8.51	Southlawn Branch
DA-10	1.53	0.84	Southlawn Branch
DA-11	0.38	0.38	Southlawn Branch
DA-12	0.47	0.47	Southlawn Branch
TOTAL	96.01	99.07	Southlawn Branch – Xsec 3.3

2.1.2 Hydrologic Soil Groups and Land Use

The Web Soil Survey was used to determine the soils onsite, and in the vicinity, and their properties. The Natural Resources Conservation Service (NRCS) Web Soil Survey report is included in **Appendix A**. The soils found throughout the project and in the vicinity have also been summarized in **Table 2**.

Table 2 Soil Map Units and Soil Hydrologic Groups

Map Symbol	Soils Series	Hydrologic Soil Group
1B	Gaila silt loam, 3 to 8 percent slopes	B
1C	Gaila silt loam, 8 to 15 percent slopes	B
2B	Glenelg silt loam, 3 to 8 percent slopes	B
4B	Eliok silt loam, 3 to 8 percent slopes	C
5A	Glenville silt loam, 0 to 3 percent slopes	C
5B	Glenville silt loam, 3 to 8 percent slopes	C/D
6A	Baile silt loam, 0 to 3 percent slopes	C/D
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	C
17C	Ococoquan loam, 8 to 15 percent slopes	B
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B/D
100	Dumps, refuse	Not rated
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	D
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	D

There is no HSG rating for the soil within the footprint of the Landfill. HSG D was utilized for soils for the existing and proposed analyses throughout the site. HSG D is typically utilized for landfill projects where surficial soils are disturbed and compacted.

Land uses were determined based on the existing and proposed ground surfaces within the drainage areas and are listed in the TR-55 output in **Appendix B**. The land use is predominantly pasture and woods (~95 percent) along with some gravel and asphalt access roads (~5 percent).

2.1.3 Times of Concentration

T_c was calculated for the overall floodplain drainage areas of 96 acres (existing) and 99 acres (proposed). The T_c paths are shown on the Floodplain Drainage Area Map – Existing Conditions (Drawing C-105) and the Floodplain Drainage Area Map – Proposed Conditions (Drawing C-106). T_c for existing conditions is 0.392 hour (~24 minutes) and T_c for proposed conditions is 0.385 hour (~23 minutes).

2.1.4 TR-55

The hydrologic analyses are based upon the methods outlined in the NRCS TR-55 Manual and WinTR-55 software. The inputs described in previous sections were used in the model along with the rainfall amount of 2.25 inches, which was taken from the NOAA Atlas 14 for Rockville, Maryland for a 100-year, 30-minute duration storm. The 30-minute duration storm was selected because it is the closest, published duration to T_c and is not lower than T_c , resulting in a conservative estimate of peak flow. Supporting calculations are included in **Appendix B**.

The TR-55 model indicates peak discharges of 52.8 and 55.0 cubic feet per second in existing and proposed conditions, respectively.

In addition to the 30-minute duration, the 100-yr 24-hour storm distribution was analyzed to determine the peak flow for a full 8.32-inch 24-hr rainfall event. The rainfall amount of 8.32-in. was taken from the NOAA Atlas 14 for Rockville, Maryland. The TR-55 model indicates a peak discharge of 450.9 and 469.2 cubic feet per second in existing and proposed conditions, respectively.

2.2 WATER SURFACE ELEVATION CALCULATION

Manning's equation was utilized to calculate the water surface elevations in Southlawn Branch for the existing and proposed peak discharges calculated by TR-55 for both analyzed storm events. Manning's equation calculations were performed in Hydraflow Express Extension for Autodesk AutoCAD Civil 3D and are included in **Appendix B**. The elevations are calculated at cross-section 3.3 identified in the M-NCPPC floodplain study included in **Appendix B**.

The water surface elevation at cross-section 3.3 is 0.02 foot higher in the proposed condition compared to the existing condition for the 30-minute storm and 0.06 feet higher for the 24-hour storm. Both analyzed conditions are well below the 100-year floodplain elevation reported in the M-NCPPC study (334.50 feet). The results are summarized in **Table 3**.

Table 3 Water Surface Elevations

Elevation Description	Elevation in Existing Conditions (feet)	Elevation in Proposed Conditions (feet)
Channel Invert	325.00	325.00
Calculated Water Surface based on 100-year, 30-minute storm	326.78	326.80
Calculated Water Surface based on 100-year, 24-hour storm	328.96	329.02
100-year floodplain elevation (M-NCPPC)	334.50	334.50

The calculated water surface elevation for the proposed drainage area is less than the existing 100-year floodplain elevation from the M-NCPPC study; therefore, the proposed project does not change the existing 100-year floodplain.

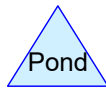
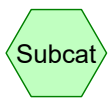
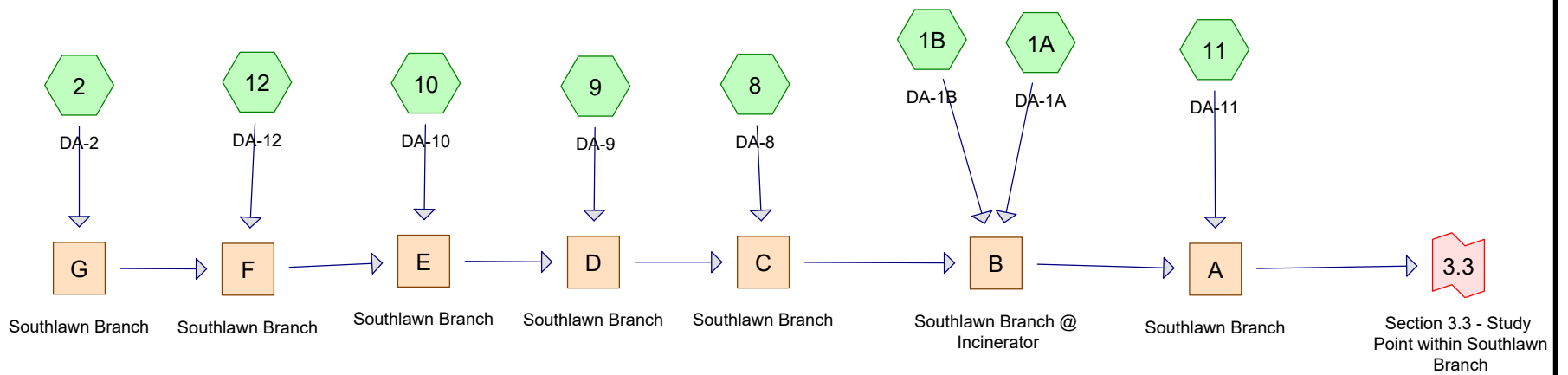
3. SUMMARY

The Gude Landfill Remediation Project will alter the drainage characteristics, grading, and drainage areas at the site. This will result in an increased peak discharge of approximately 5 percent to Southlawn Branch, east of the Landfill; however, the project will not affect the 100-year floodplain as previously mapped by M-NCPPC.

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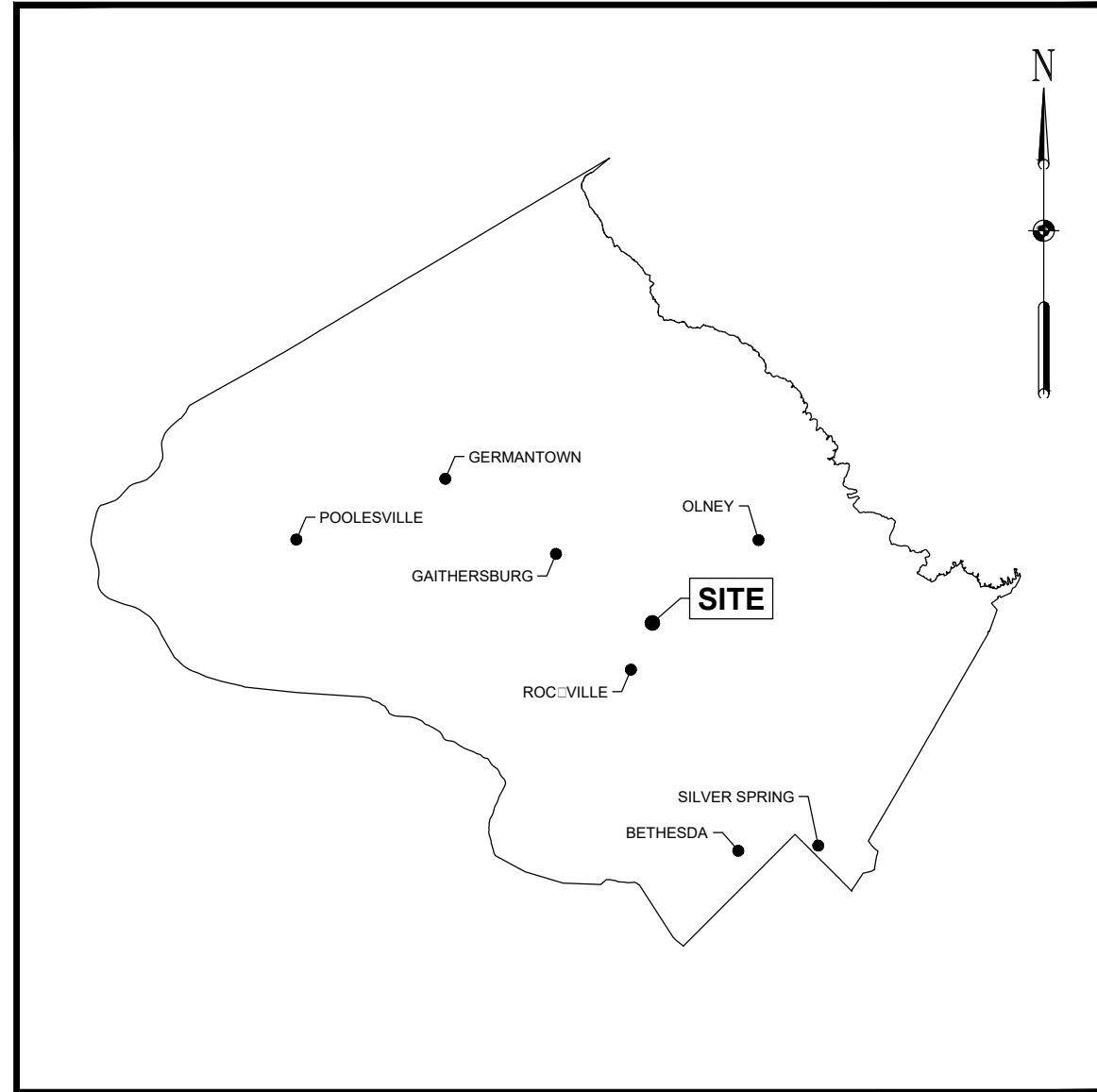
Figures

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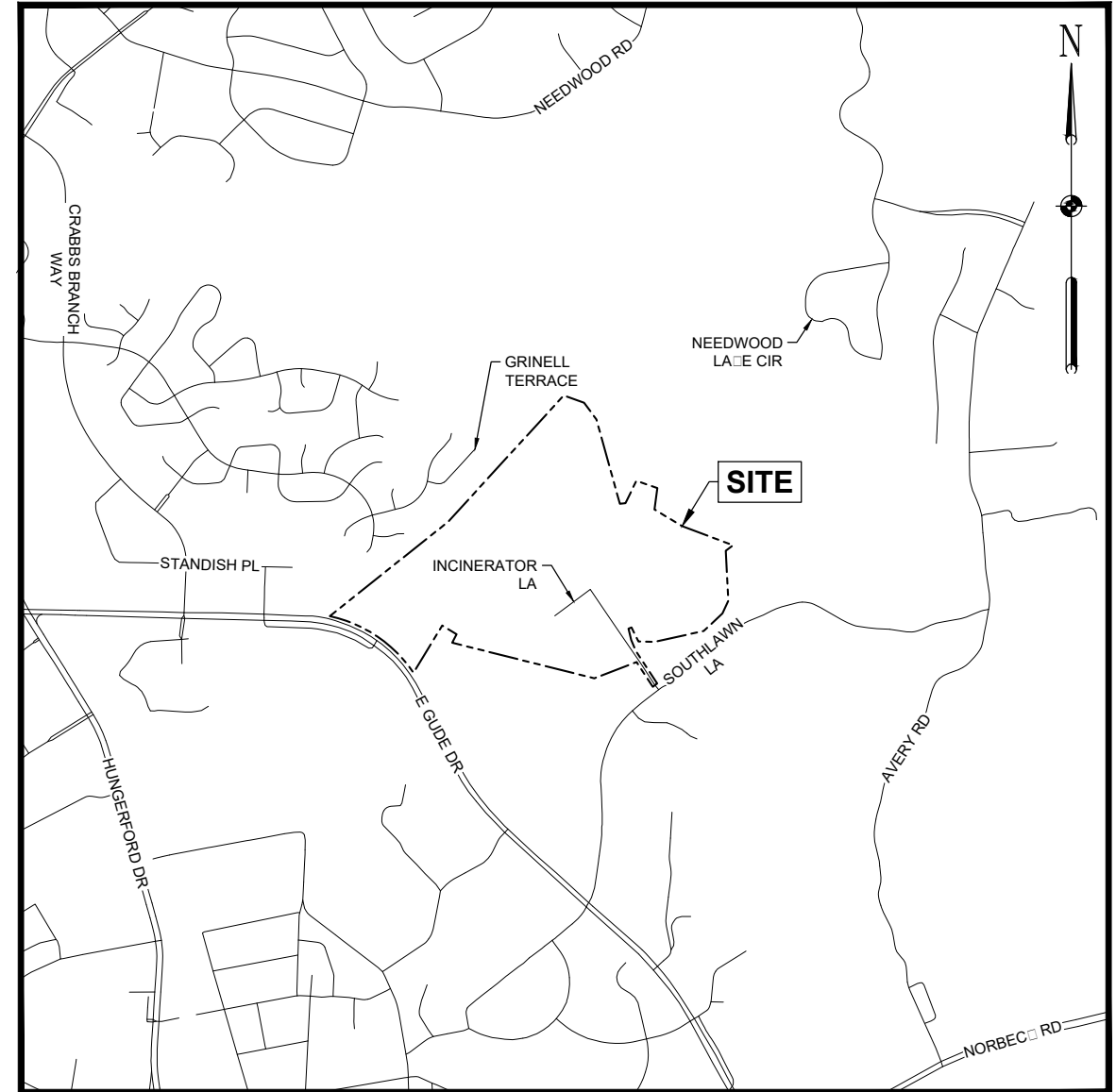


Routing Diagram for Gude FP Study -Ex. Line Diagram
 Prepared by EA Engineering, Printed 7/20/2020
 HydroCAD® 10.00-13 s/n 08838 © 2014 HydroCAD Software Solutions LLC

FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\WM\FIGURE 1 - VICINITY AND LOCATION MAP.DWG (FIGURE 1) 4/30/19



LOCATION MAP - MONTGOMERY COUNTY, MARYLAND
NOT TO SCALE



VICINITY MAP
SCALE: 1" = 2,000'



EA Engineering, Science, and Technology, Inc., PBC
Hunt Valley Center
225 Schilling Circle, Suite 400
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(410) 584-7000

PROJECT NUMBER:
1564601
DATE:
DECEMBER 2019

DESIGNED BY:
EF/SMB
CHECKED BY:
LJO

DRAWN BY:
SMB
PROJECT MGR.:
MJG

FIGURE:
1
SHEET NUMBER:
1 OF 1

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
MONTGOMERY COUNTY, MARYLAND

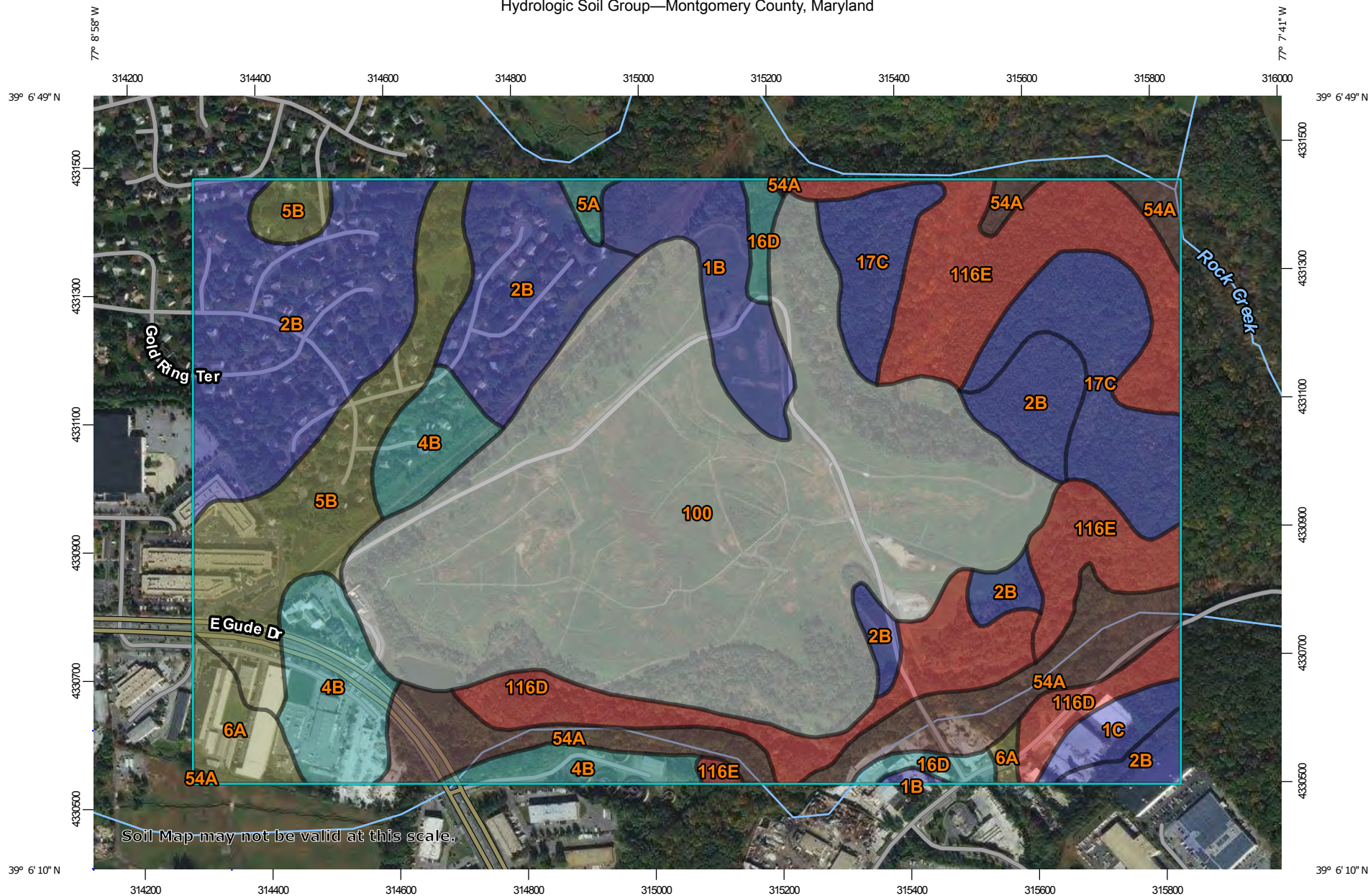
FIGURE 1 - LOCATION AND VICINITY MAP

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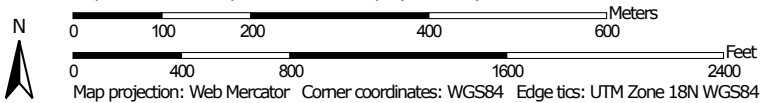
Appendix A
Web Soil Survey

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Hydrologic Soil Group—Montgomery County, Maryland




Map Scale: 1:8,500 if printed on A landscape (11" x 8.5") sheet.



MAP LEGEND

Area of Interest (AOI)









 Area of Interest (AOI)

Soils

Soil Rating Polygons





 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Lines


 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Points






 A
 A/D
 B
 B/D

 C
 C/D
 D
 Not rated or not available

Water Features

 Streams and Canals

Transportation

 Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Montgomery County, Maryland
 Survey Area Data: Version 13, Sep 18, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 3, 2015—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Gaila silt loam, 3 to 8 percent slopes	B	12.9	3.6%
1C	Gaila silt loam, 8 to 15 percent slopes	B	3.9	1.1%
2B	Glenelg silt loam, 3 to 8 percent slopes	B	61.9	17.1%
4B	Elioak silt loam, 3 to 8 percent slopes	C	22.3	6.2%
5A	Glenville silt loam, 0 to 3 percent slopes	C	1.2	0.3%
5B	Glenville silt loam, 3 to 8 percent slopes	C/D	27.1	7.5%
6A	Baile silt loam, 0 to 3 percent slopes	C/D	6.5	1.8%
16D	Brinklow-Blocktown channery silt loams, 15 to 25 percent slopes	C	3.8	1.0%
17C	Occoquan loam, 8 to 15 percent slopes	B	23.8	6.6%
54A	Hatboro silt loam, 0 to 3 percent slopes, frequently flooded	B/D	24.9	6.9%
100	Dumps, refuse		121.9	33.7%
116D	Blocktown channery silt loam, 15 to 25 percent slopes, very rocky	D	19.9	5.5%
116E	Blocktown channery silt loam, 25 to 45 percent slopes, very rocky	D	31.6	8.7%
Totals for Area of Interest			361.8	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix B

Hydrologic and Hydraulic Calculations

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NOAA Atlas 14, Volume 2, Version 3
 Location name: Rockville, Maryland, USA*
 Latitude: 39.1076°, Longitude: -77.1365°
 Elevation: 435.95 ft**
 * source: ESRI Maps
 ** source: USGS



POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

[PF_tabular](#) | [PF_graphical](#) | [Maps_&_aerials](#)

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.345 (0.313-0.381)	0.413 (0.374-0.455)	0.491 (0.444-0.542)	0.549 (0.496-0.605)	0.622 (0.557-0.686)	0.677 (0.603-0.747)	0.731 (0.648-0.808)	0.783 (0.689-0.868)	0.850 (0.741-0.948)	0.903 (0.781-1.01)
10-min	0.551 (0.499-0.608)	0.660 (0.599-0.728)	0.787 (0.711-0.868)	0.878 (0.793-0.968)	0.992 (0.888-1.09)	1.08 (0.961-1.19)	1.16 (1.03-1.28)	1.24 (1.09-1.38)	1.35 (1.17-1.50)	1.42 (1.23-1.59)
15-min	0.689 (0.624-0.760)	0.830 (0.752-0.915)	0.995 (0.900-1.10)	1.11 (1.00-1.22)	1.26 (1.13-1.39)	1.37 (1.22-1.51)	1.47 (1.30-1.62)	1.57 (1.38-1.74)	1.69 (1.48-1.89)	1.78 (1.54-2.00)
30-min	0.944 (0.856-1.04)	1.15 (1.04-1.26)	1.41 (1.28-1.56)	1.61 (1.45-1.77)	1.86 (1.67-2.05)	2.06 (1.83-2.27)	2.25 (1.99-2.48)	2.44 (2.15-2.70)	2.69 (2.35-3.00)	2.89 (2.50-3.23)
60-min	1.18 (1.07-1.30)	1.44 (1.30-1.59)	1.81 (1.64-2.00)	2.10 (1.89-2.31)	2.48 (2.22-2.73)	2.79 (2.48-3.07)	3.10 (2.75-3.42)	3.42 (3.01-3.79)	3.87 (3.37-4.31)	4.22 (3.65-4.72)
2-hr	1.39 (1.26-1.54)	1.70 (1.54-1.87)	2.15 (1.95-2.37)	2.51 (2.26-2.76)	3.01 (2.70-3.31)	3.43 (3.05-3.77)	3.87 (3.42-4.26)	4.33 (3.80-4.79)	5.00 (4.33-5.55)	5.54 (4.76-6.19)
3-hr	1.50 (1.36-1.66)	1.82 (1.65-2.02)	2.31 (2.09-2.55)	2.70 (2.43-2.98)	3.26 (2.91-3.60)	3.72 (3.31-4.11)	4.22 (3.71-4.66)	4.74 (4.14-5.26)	5.51 (4.74-6.14)	6.15 (5.23-6.89)
6-hr	1.85 (1.68-2.06)	2.24 (2.03-2.49)	2.83 (2.56-3.14)	3.32 (2.99-3.68)	4.04 (3.60-4.47)	4.66 (4.12-5.16)	5.33 (4.67-5.91)	6.06 (5.25-6.73)	7.14 (6.09-7.99)	8.06 (6.78-9.06)
12-hr	2.26 (2.03-2.54)	2.72 (2.45-3.06)	3.46 (3.10-3.88)	4.09 (3.64-4.58)	5.05 (4.45-5.65)	5.89 (5.15-6.60)	6.83 (5.90-7.67)	7.89 (6.71-8.87)	9.50 (7.92-10.7)	10.9 (8.93-12.4)
24-hr	2.60 (2.37-2.88)	3.14 (2.87-3.48)	4.03 (3.68-4.46)	4.82 (4.38-5.32)	6.03 (5.44-6.62)	7.10 (6.35-7.77)	8.32 (7.36-9.07)	9.71 (8.48-10.6)	11.8 (10.2-12.8)	13.7 (11.6-14.8)
2-day	3.01 (2.75-3.34)	3.65 (3.33-4.04)	4.67 (4.26-5.17)	5.55 (5.04-6.14)	6.88 (6.20-7.58)	8.03 (7.20-8.83)	9.32 (8.28-10.2)	10.8 (9.47-11.8)	12.9 (11.2-14.1)	14.8 (12.7-16.2)
3-day	3.19 (2.91-3.53)	3.85 (3.52-4.27)	4.93 (4.50-5.45)	5.85 (5.32-6.47)	7.24 (6.54-7.98)	8.45 (7.58-9.29)	9.80 (8.71-10.8)	11.3 (9.95-12.4)	13.6 (11.8-14.9)	15.5 (13.3-17.0)
4-day	3.36 (3.07-3.72)	4.06 (3.72-4.50)	5.18 (4.74-5.73)	6.15 (5.61-6.80)	7.61 (6.88-8.38)	8.88 (7.97-9.76)	10.3 (9.15-11.3)	11.9 (10.4-13.0)	14.2 (12.3-15.6)	16.2 (13.9-17.9)
7-day	3.89 (3.58-4.27)	4.68 (4.31-5.14)	5.92 (5.44-6.49)	6.98 (6.39-7.64)	8.56 (7.79-9.35)	9.93 (8.98-10.8)	11.4 (10.3-12.5)	13.1 (11.7-14.3)	15.6 (13.7-17.0)	17.7 (15.4-19.4)
10-day	4.44 (4.09-4.87)	5.34 (4.92-5.85)	6.66 (6.13-7.29)	7.77 (7.12-8.50)	9.39 (8.56-10.2)	10.7 (9.75-11.7)	12.2 (11.0-13.3)	13.8 (12.3-15.0)	16.1 (14.2-17.6)	18.1 (15.8-19.7)
20-day	6.01 (5.58-6.51)	7.15 (6.64-7.74)	8.64 (8.02-9.35)	9.85 (9.13-10.6)	11.5 (10.7-12.4)	12.9 (11.9-13.9)	14.3 (13.1-15.4)	15.8 (14.4-17.0)	17.8 (16.1-19.2)	19.5 (17.5-21.0)
30-day	7.40 (6.91-7.94)	8.76 (8.18-9.40)	10.4 (9.72-11.2)	11.8 (10.9-12.6)	13.6 (12.6-14.6)	15.1 (13.9-16.1)	16.6 (15.3-17.7)	18.1 (16.6-19.4)	20.2 (18.4-21.7)	21.8 (19.8-23.5)
45-day	9.30 (8.73-9.92)	11.0 (10.3-11.7)	12.8 (12.0-13.6)	14.2 (13.4-15.2)	16.1 (15.1-17.1)	17.5 (16.4-18.7)	18.9 (17.7-20.2)	20.3 (18.9-21.6)	22.1 (20.5-23.6)	23.4 (21.6-25.0)
60-day	11.1 (10.4-11.8)	13.0 (12.3-13.8)	15.0 (14.2-15.9)	16.6 (15.6-17.6)	18.6 (17.4-19.7)	20.0 (18.8-21.2)	21.5 (20.1-22.7)	22.8 (21.3-24.2)	24.5 (22.8-26.0)	25.8 (23.9-27.4)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

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Channel Report

Gude Floodplain XS - Postdevelopment 8.32in 24-hr Distribution

User-defined

Invert Elev (ft) = 325.00
Slope (%) = 1.00
N-Value = 0.040

Highlighted

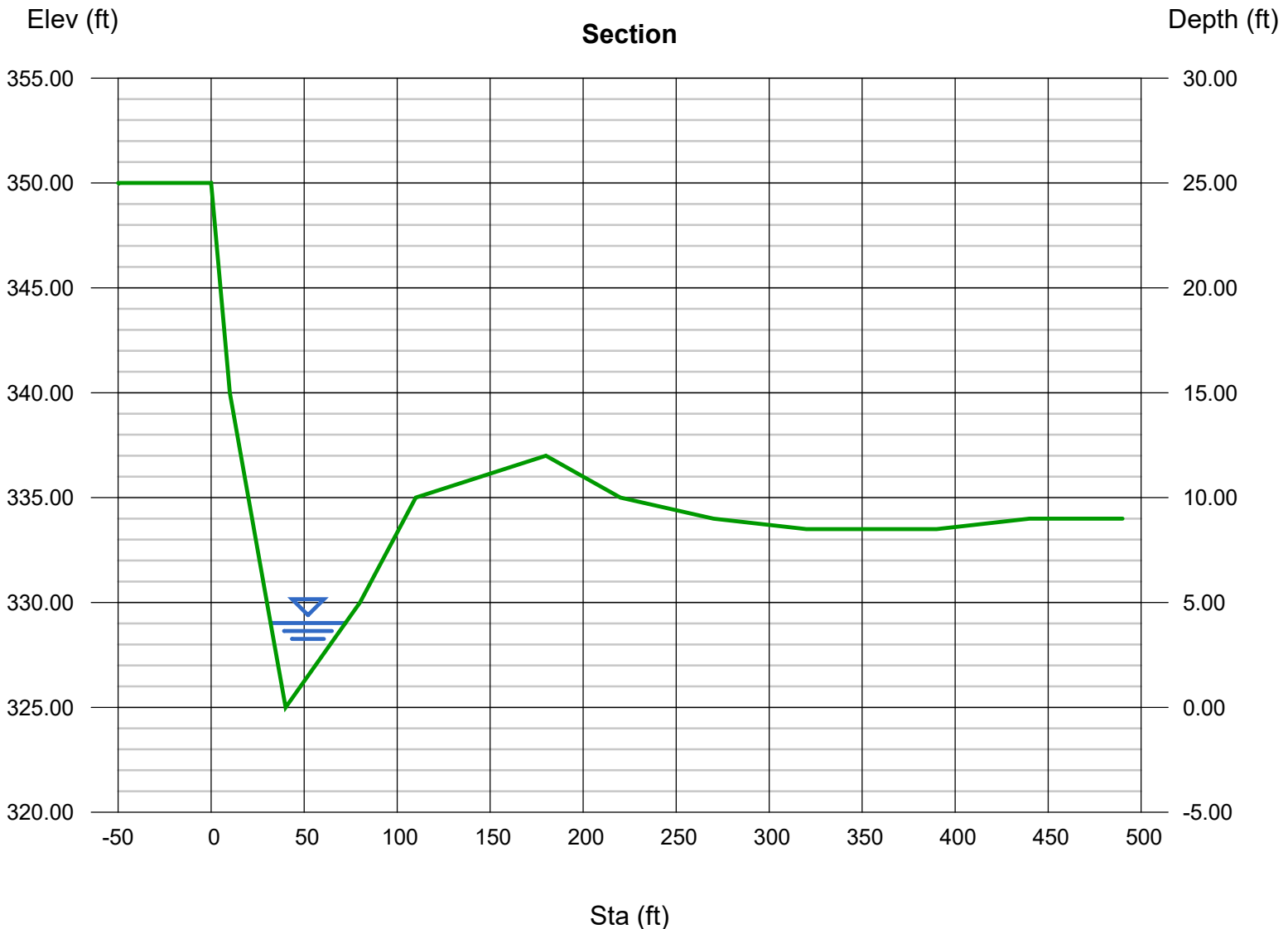
Depth (ft) = 4.02
Q (cfs) = 469.15
Area (sqft) = 80.80
Velocity (ft/s) = 5.81
Wetted Perim (ft) = 41.40
Crit Depth, Yc (ft) = 3.53
Top Width (ft) = 40.20
EGL (ft) = 4.54

Calculations

Compute by: Known Q
Known Q (cfs) = 469.15

(Sta, El, n)-(Sta, El, n)...

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-(220.00, 335.00, 0.100)-(270.00, 334.00, 0.100)-(320.00, 333.50, 0.100)-(390.00, 333.50, 0.100)-(440.00, 334.00, 0.100)



Channel Report

Gude Floodplain XS - Predevelopment 8.32-inch 24-hr Distribution

User-defined

Invert Elev (ft) = 325.00
Slope (%) = 1.00
N-Value = 0.040

Highlighted

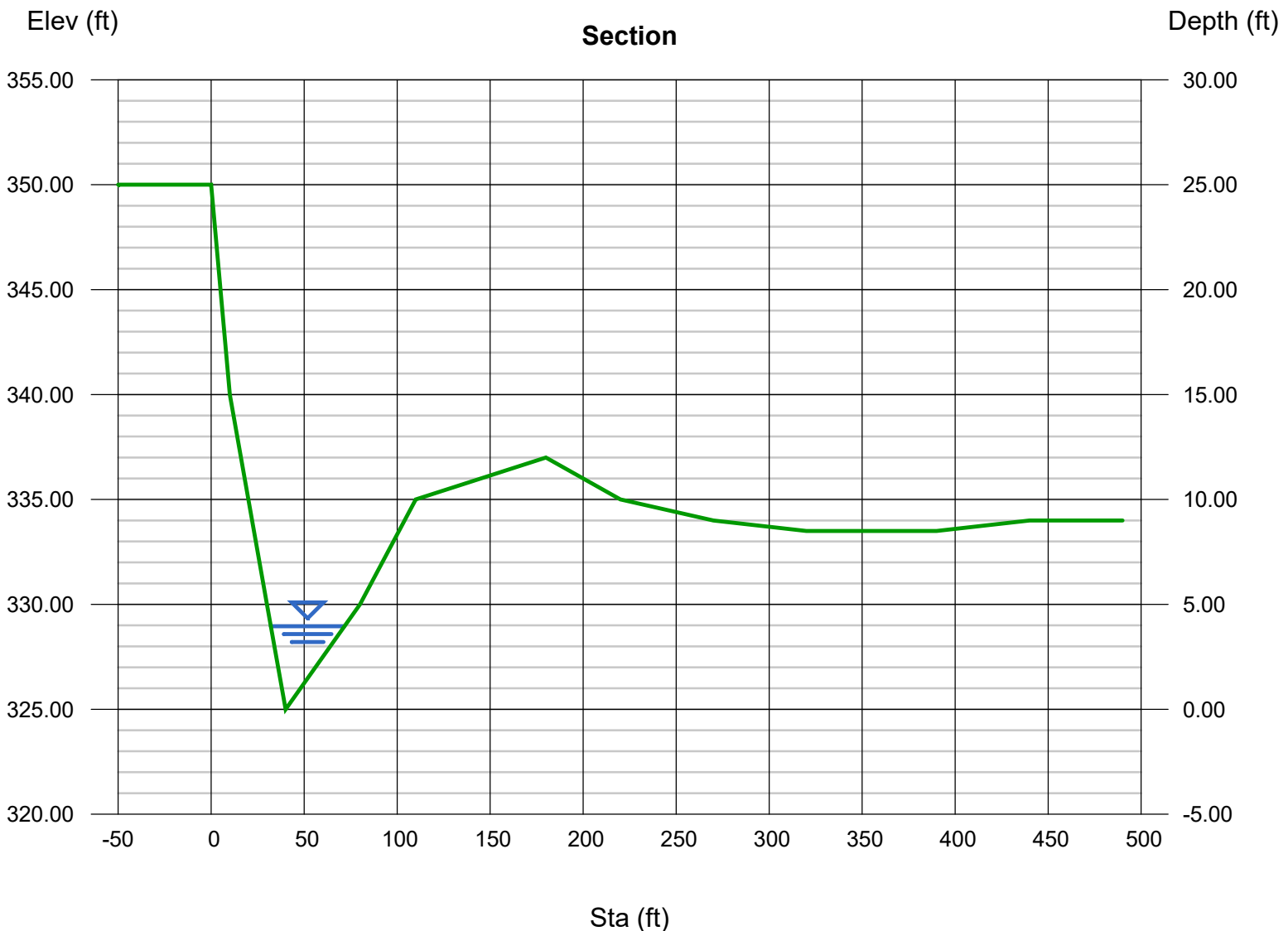
Depth (ft) = 3.96
Q (cfs) = 450.92
Area (sqft) = 78.41
Velocity (ft/s) = 5.75
Wetted Perim (ft) = 40.78
Crit Depth, Yc (ft) = 3.48
Top Width (ft) = 39.60
EGL (ft) = 4.47

Calculations

Compute by: Known Q
Known Q (cfs) = 450.92

(Sta, El, n)-(Sta, El, n)...

(0.00, 350.00)-(10.00, 340.00, 0.100)-(30.00, 330.00, 0.040)-(40.00, 325.00, 0.040)-(80.00, 330.00, 0.040)-(110.00, 335.00, 0.100)-(180.00, 337.00, 0.100)
-(220.00, 335.00, 0.100)-(270.00, 334.00, 0.100)-(320.00, 333.50, 0.100)-(390.00, 333.50, 0.100)-(440.00, 334.00, 0.100)



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 7/20/2020
 Project: Gude Units: English
 SubTitle: FPS Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: \\lovetonfp\projects\State & Local\State\NMWDA\1564601 Gude LF Design\Task 4 - Permitting and Ri

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
FPS-EX		Outlet	96.01	80	.392
FPS-PR		Outlet	99.07	80	.385

Total area: 195.08 (ac)

--- Storm Data ---

Rainfall Depth by Rainfall Return Period

2-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	100-Yr (in)	-Yr (in)
3.1	.0	.0	.0	.0	8.32	.0

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: Type NO_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	100-Yr (in)	-Yr (in)
3.1	.0	.0	.0	.0	8.32	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type NO_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 100-Yr (cfs)
------------------------------------	--

SUBAREAS

FPS-EX 450.92

FPS-PR 469.15

REACHES

OUTLET 919.60

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 100-Yr
Identifier (cfs)
 (hr)

SUBAREAS

FPS-EX 450.92
 12.27

FPS-PR 469.15
 12.28

REACHES

OUTLET 919.60

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
FPS-EX	96.01	0.392	80	Outlet	
FPS-PR	99.07	0.385	80	Outlet	

Total Area:	195.08 (ac)				

EA

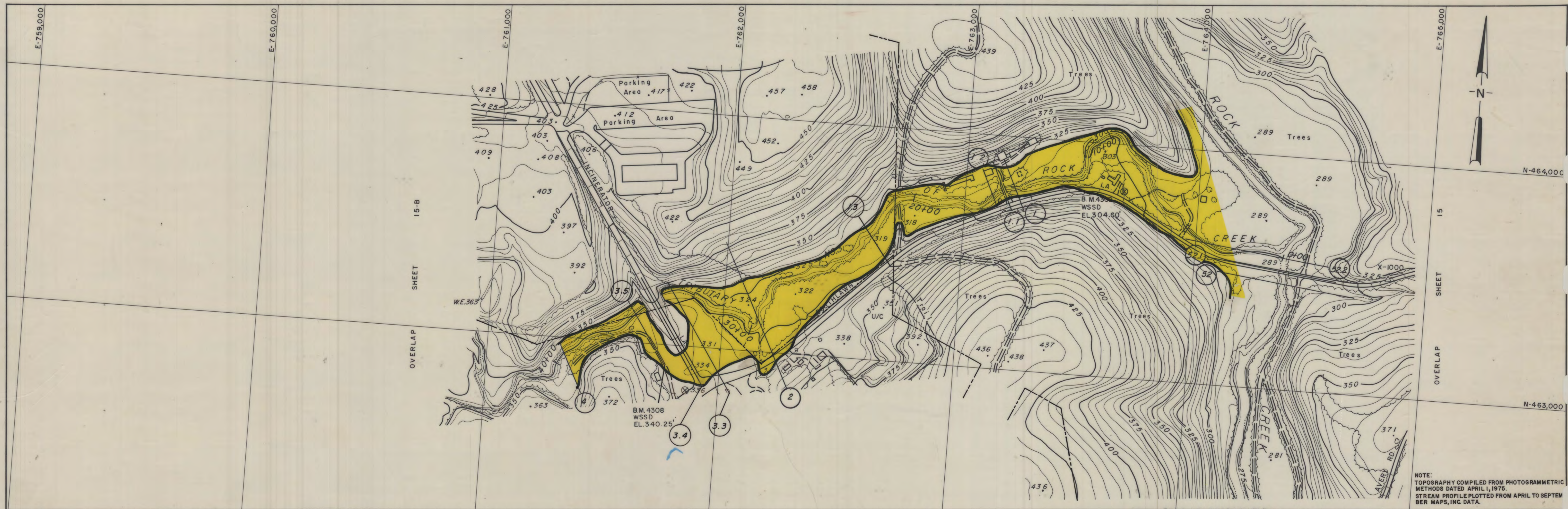
Gude
FPS
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

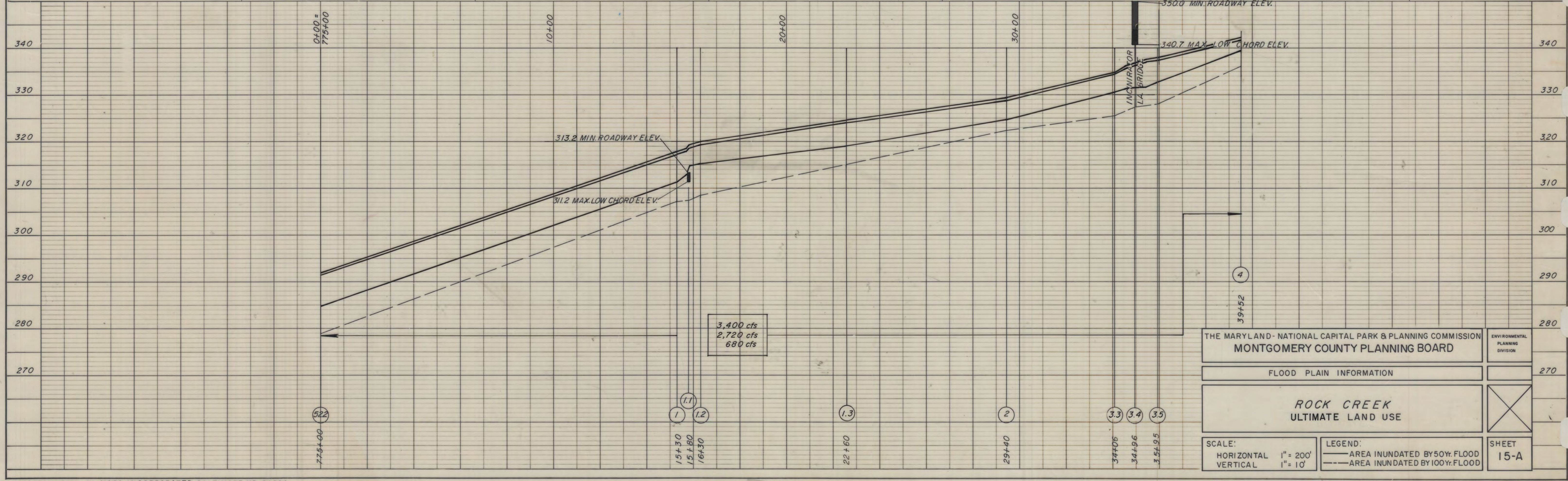
Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
FPS-EX	Paved parking lots, roofs, driveways	D	.18	98
	Gravel (w/ right-of-way)	D	3.44	91
	Dirt (w/ right-of-way)	D	.12	89
	Pasture, grassland or range (good)	D	83.13	80
	Woods (good)	D	9.14	77
	Total Area / Weighted Curve Number		96.01	80
			=====	==
FPS-PR	Paved parking lots, roofs, driveways	D	.14	98
	Gravel (w/ right-of-way)	D	4.5	91
	Dirt (w/ right-of-way)	D	.09	89
	Pasture, grassland or range (good)	D	85.83	80
	Woods - grass combination (good)	D	8.51	79
	Total Area / Weighted Curve Number		99.07	80
			=====	==

PLAN
 SURVEYED: _____
 PLOTTED: _____
 NOTE BOOK No. _____
 ALIGNMENT CHECKED: _____
 RT. OF WAY CHECKED: _____

PROFILE
 SURVEYED: _____
 PLOTTED: _____
 NOTE BOOK No. _____
 GRADES CHECKED: _____
 STRUCTURE NOTATIONS CHECKED: _____



NOTE:
 TOPOGRAPHY COMPILED FROM PHOTOGRAMMETRIC METHODS DATED APRIL 1, 1975.
 STREAM PROFILE PLOTTED FROM APRIL TO SEPTEMBER MAPS, INC. DATA.



THE MARYLAND - NATIONAL CAPITAL PARK & PLANNING COMMISSION
 MONTGOMERY COUNTY PLANNING BOARD

FLOOD PLAIN INFORMATION

ROCK CREEK
 ULTIMATE LAND USE

SCALE:
 HORIZONTAL 1" = 200'
 VERTICAL 1" = 10'

LEGEND:
 — AREA INUNDATED BY 50yr. FLOOD
 - - - AREA INUNDATED BY 100yr. FLOOD

ENVIRONMENTAL PLANNING DIVISION
 SHEET 15-A

Channel Report

Gude Floodplain XS - Postdevelopment

User-defined

Invert Elev (ft) = 325.00
Slope (%) = 1.00
N-Value = 0.040

Highlighted

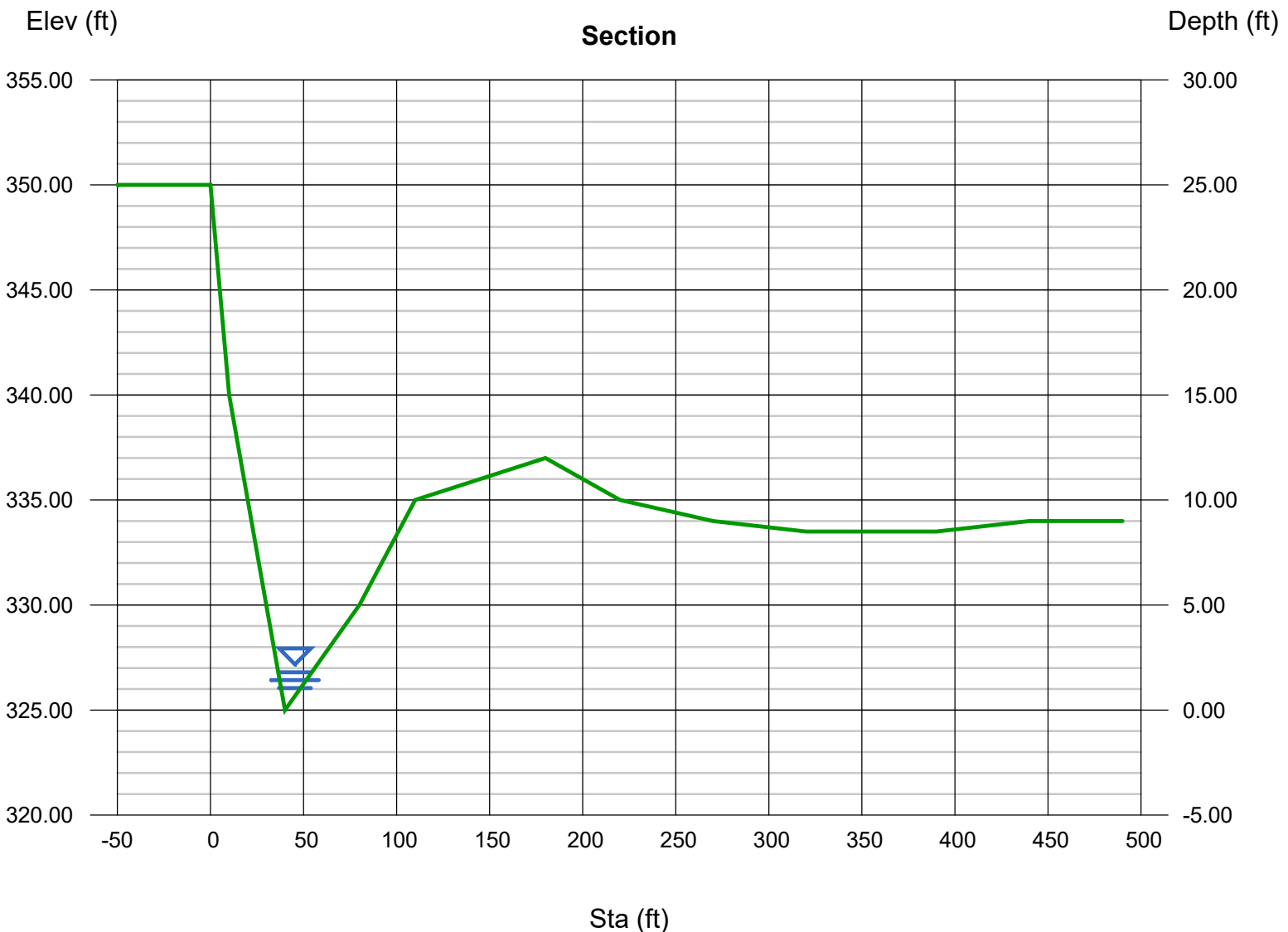
Depth (ft) = 1.80
Q (cfs) = 55.00
Area (sqft) = 16.20
Velocity (ft/s) = 3.40
Wetted Perim (ft) = 18.54
Crit Depth, Yc (ft) = 1.50
Top Width (ft) = 18.00
EGL (ft) = 1.98

Calculations

Compute by: Known Q
Known Q (cfs) = 55.00

(Sta, El, n)-(Sta, El, n)...

(0.00, 350.00)-(10.00, 340.00, 0.100)-(30.00, 330.00, 0.040)-(40.00, 325.00, 0.040)-(80.00, 330.00, 0.040)-(110.00, 335.00, 0.100)-(180.00, 337.00, 0.100)
-(220.00, 335.00, 0.100)-(270.00, 334.00, 0.100)-(320.00, 333.50, 0.100)-(390.00, 333.50, 0.100)-(440.00, 334.00, 0.100)



Channel Report

Gude Floodplain XS - Predevelopment

User-defined

Invert Elev (ft) = 325.00
Slope (%) = 1.00
N-Value = 0.040

Highlighted

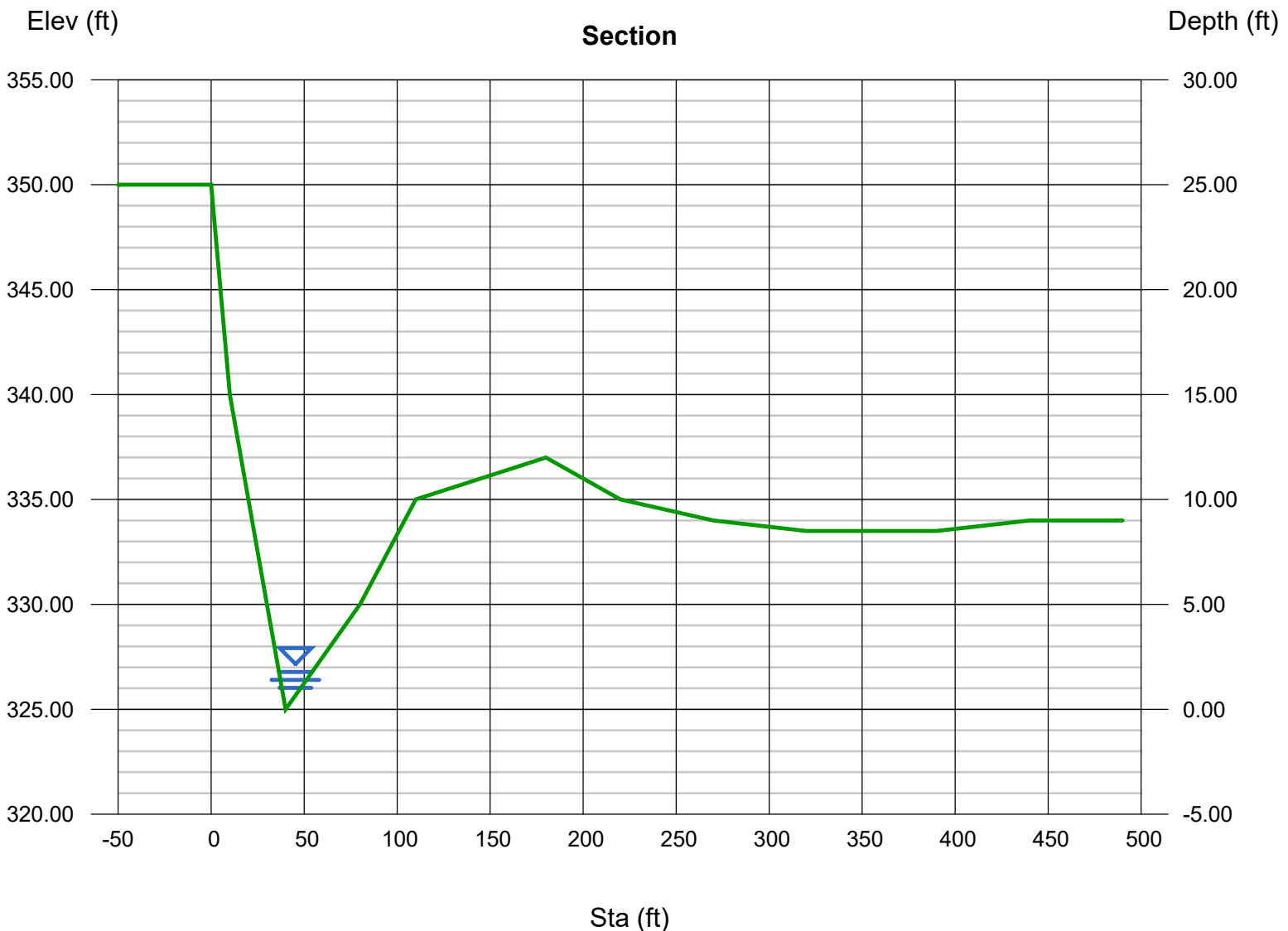
Depth (ft) = 1.78
Q (cfs) = 52.80
Area (sqft) = 15.84
Velocity (ft/s) = 3.33
Wetted Perim (ft) = 18.33
Crit Depth, Yc (ft) = 1.48
Top Width (ft) = 17.80
EGL (ft) = 1.95

Calculations

Compute by: Known Q
Known Q (cfs) = 52.80

(Sta, El, n)-(Sta, El, n)...

(0.00, 350.00)-(10.00, 340.00, 0.100)-(30.00, 330.00, 0.040)-(40.00, 325.00, 0.040)-(80.00, 330.00, 0.040)-(110.00, 335.00, 0.100)-(180.00, 337.00, 0.100)
-(220.00, 335.00, 0.100)-(270.00, 334.00, 0.100)-(320.00, 333.50, 0.100)-(390.00, 333.50, 0.100)-(440.00, 334.00, 0.100)



WinTR-55 Current Data Description

--- Identification Data ---

User: EA Date: 3/26/2020
 Project: Gude Units: English
 SubTitle: FPS Areal Units: Acres
 State: Maryland
 County: Montgomery NOAA-C
 Filename: P:\State & Local\State\NMWDA\1564601 Gude LF Design\Task 4 - Permitting and Right-of-Entry Servi

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
FPS-EX		Outlet	96.01	80	.392
FPS-PR		Outlet	99.07	80	.385

Total area: 195.08 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	100-Yr (in)	-Yr (in)
3.1	.0	.0	.0	.0	2.25	.0

Storm Data Source: User-provided custom storm data
 Rainfall Distribution Type: Type NO_C
 Dimensionless Unit Hydrograph: <standard>

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	-Yr (in)	100-Yr (in)	-Yr (in)
3.1	.0	.0	.0	.0	2.25	.0

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type NO_C
Dimensionless Unit Hydrograph: <standard>

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 100-Yr (cfs)
------------------------------------	--

SUBAREAS

FPS-EX 52.82

FPS-PR 54.98

REACHES

OUTLET 107.71

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Hydrograph Peak/Peak Time Table

Sub-Area Peak Flow and Peak Time (hr) by Rainfall Return Period
or Reach 100-Yr
Identifier (cfs)
 (hr)

SUBAREAS

FPS-EX 52.82
 12.30

FPS-PR 54.98
 12.30

REACHES

OUTLET 107.71

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
FPS-EX	96.01	0.392	80	Outlet	
FPS-PR	99.07	0.385	80	Outlet	

Total Area:	195.08 (ac)				

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)

FPS-EX							
SHEET	100	0.0180	0.240				0.252
SHALLOW	1122	0.0220	0.050				0.130
CHANNEL	402	0.0779	0.013	3.14	6.28	18.611	0.006
CHANNEL	265	0.0400	0.013	7.07	9.42	18.403	0.004
						Time of Concentration	.392
							=====
FPS-PR							
SHEET	100	0.0120	0.240				0.296
SHALLOW	369	0.0380	0.050				0.033
CHANNEL	1218	0.0200	0.030	14.04	13.90	7.049	0.048
CHANNEL	418	0.0600	0.030	20.12	15.83	14.514	0.008
						Time of Concentration	.385
							=====

EA

Gude
FPS
Montgomery NOAA-C County, Maryland

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use	Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
FPS-EX	Paved parking lots, roofs, driveways	D	.18	98
	Gravel (w/ right-of-way)	D	3.44	91
	Dirt (w/ right-of-way)	D	.12	89
	Pasture, grassland or range (good)	D	83.13	80
	Woods (good)	D	9.14	77
	Total Area / Weighted Curve Number		96.01	80
			=====	==
FPS-PR	Paved parking lots, roofs, driveways	D	.14	98
	Gravel (w/ right-of-way)	D	4.5	91
	Dirt (w/ right-of-way)	D	.09	89
	Pasture, grassland or range (good)	D	85.83	80
	Woods - grass combination (good)	D	8.51	79
	Total Area / Weighted Curve Number		99.07	80
			=====	==

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Attachment L

Geosynthetics Calculations

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Project Gude Landfill Remediation Design Project No. 15646.01
Subject Vegetative Support Soil Requirements Sheet No. 1 of 1
Based on Geotextile Filter Drawing No. _____
Computed by KEF Date 1/6/2020 Checked by EAT Date 1/7/2020

OBJECTIVE:

Determine the requirements for the vegetative support soil material based on the apparent opening size (AOS) of the geotextile component of the geocomposite drainage collection layer. Specify a vegetative support soil material which will minimize clogging of the geotextile and piping into the drainage layer.

PROCEDURE:

Use Carroll's criteria to determine the smallest acceptable d_{85} for the vegetative support soil.

$$d_{85} \geq \frac{O_{95}}{2}$$

where:

O_{95} = apparent opening size of geotextile (AOS)

d_{85} = grain size which 85% of the barrier protection soil is smaller than (mm)

$$d_{85} \geq \frac{O_{95}}{2} \geq \frac{0.177 \text{ mm}}{2} \geq 0.089 \text{ mm}$$

RESULTS:

Therefore, the d_{85} of the vegetative support soil must be > 0.089 mm.

Koerner, R.M. (1998).
Designing With Geosynthetics, Fourth Edition. Prentice Hall. Upper Saddle River, NJ.

Carroll, R.G., Jr. (1983).
"Geotextile Filter Criteria,"
Engineering Fabrics in Transportation Construction. TRR 916, TBR, Washington, D.C.

GSE FabriNet HF



Project Gude Landfill Remediation Design Project No. 15646.01
Subject Geocomposite Capacity Sheet No. 1 of 5
Drawing No. _____
Computed by KEF Date 12/10/2020 Checked by GAT Date 12/10/20

OBJECTIVE:

Determine the required transmissivity and thickness of the geocomposite drainage layer based on the maximum rainfall intensity and maximum permeability of the vegetative support soil. Consider combinations of geocomposites and vegetative support soil permeabilities to optimize the design.

Evaluate three scenarios. Refer to the attached figure for the locations. Scenario A represents the longest length possible (90 horizontal feet) of the steepest slope (3H:1V) on the landfill. Scenario B represents a longer length (100 horizontal feet) of a slightly less steep slope (4H:1V) on the landfill. Scenario C represents a two-slope scenario on the northwest slope of the landfill. Drainage from the geocomposites will be conveyed to downchutes at benches.

PROCEDURE:

Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", Geosynthetics International, Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.

1) Utilize the design method developed by Giroud et al. to evaluate the multiple slope configurations on the west side of the landfill. The multiple slope analysis considers flow through a flatter slope before reaching a steeper slope. For a single slope scenarios, use the equation for the upper slope only.

The design method calculates the maximum liquid thickness in the upper and lower slopes. If the liquid thickness is contained within the geocomposite, there is no head in the overlying soil material and the design is acceptable.

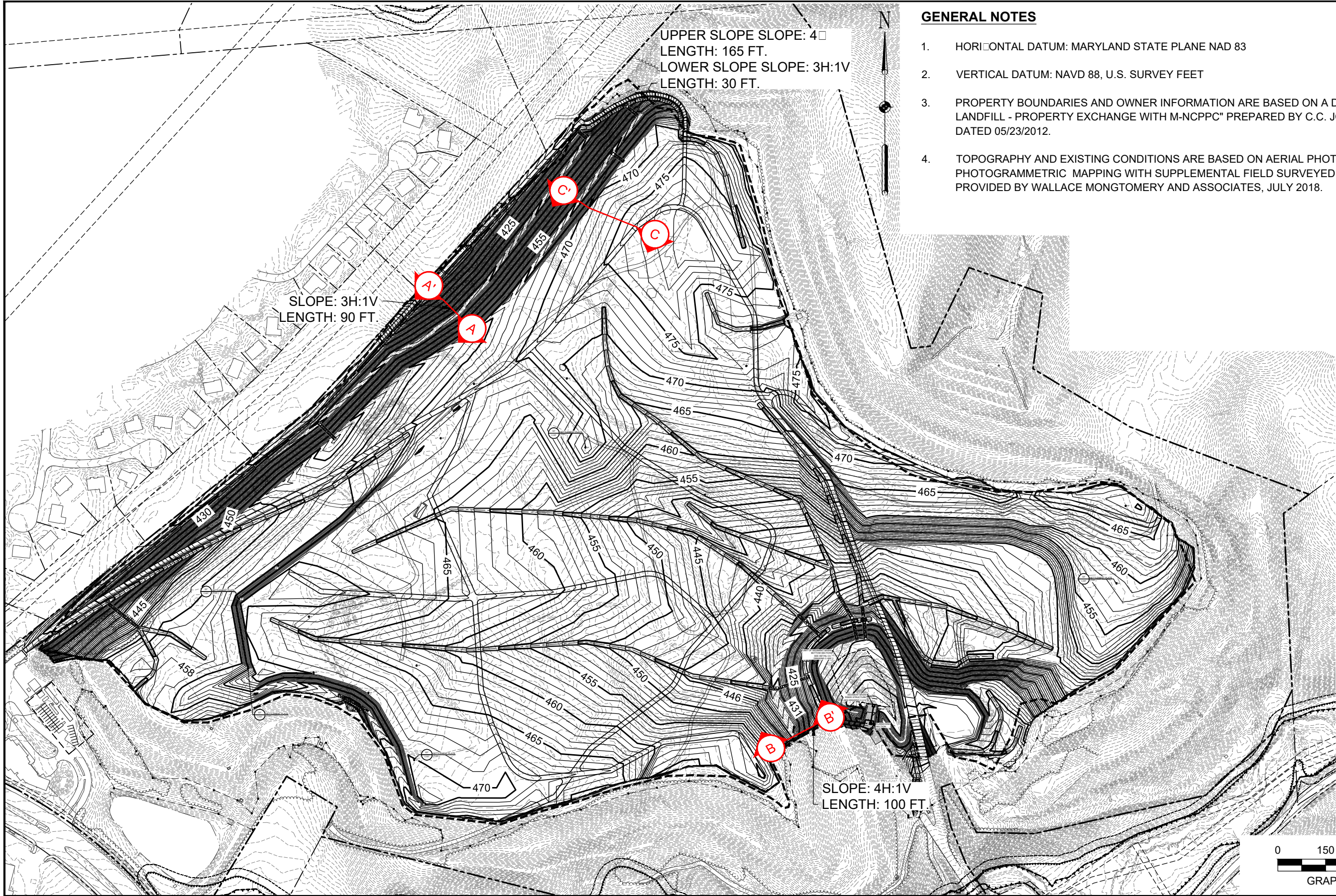
Both the standard and the alternate closure cap section are based on a drainage layer providing a minimum $7.5 \times 10^{-4} \text{ m}^2/\text{sec}$ transmittivity.

2) Calculations are shown on the attached sheet, which also further describes the equations. A design factor of safety of 1.5 was used.

CONCLUSION:

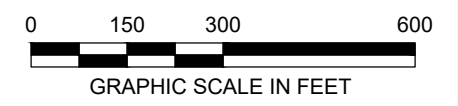
A 300-mil or thicker geocomposite or the 50 mil LLDPE Agru MicroDrain geomembrane (or equivalent) with a minimum ultimate transmissivity of $7.0 \times 10^{-4} \text{ m}^2/\text{sec}$ is adequate if the vegetative support soil has a maximum permeability of $1 \times 10^{-4} \text{ cm}/\text{sec}$.

FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\1564601 - GEOCOMPOSITE CAPACITY CALC FIGURE.DWG [02] 11/6/18



GENERAL NOTES

1. HORIZONTAL DATUM: MARYLAND STATE PLANE NAD 83
2. VERTICAL DATUM: NAVD 88, U.S. SURVEY FEET
3. PROPERTY BOUNDARIES AND OWNER INFORMATION ARE BASED ON A DRAWING ENTITLED "GUDE LANDFILL - PROPERTY EXCHANGE WITH M-NCPPC" PREPARED BY C.C. JOHNSON & MALHOTRA, P.C., DATED 05/23/2012.
4. TOPOGRAPHY AND EXISTING CONDITIONS ARE BASED ON AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRIC MAPPING WITH SUPPLEMENTAL FIELD SURVEYED INFORMATION AND WERE PROVIDED BY WALLACE MONTGOMERY AND ASSOCIATES, JULY 2018.



EA Engineering, Science, and Technology, Inc., PBC
 Hunt Valley Center
 225 Schilling Circle, Suite 400
 Hunt Valley, Maryland 21031
 (410) 584-7000

PROJECT NUMBER: 1564601	DESIGNED BY: EF	DRAWN BY: SMB	FIGURE: 1
DATE: DECEMBER 2020	CHECKED BY: GAT	PROJECT MGR.: MJG	SHEET NUMBER: -

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
BASIS OF DESIGN REPORT
 MONTGOMERY COUNTY, MARYLAND

FIGURE 1 GEOCOMPOSITE CALCULATION FIGURE

GUDE LANDFILL REMEDIATION DESIGN

GEOCOMPOSITE CAPACITY ANALYSIS Scenario A: One Slope Scenario: 3:1 Slope

liquid impingement rate, $q_h = 1.0E-04$ cm/sec (min of design storm or barrier layer permeability)

GEOCOMPOSITE PROPERTIES

ultimate transmissivity, $\Theta =$	7.5E-04 m ² /sec	
geocomposite thickness, $t =$	300 mil	RF Ranges for Landfill Caps
reduction factor for elastic deformation, $RF_{in} =$	1.1	1.0 to 1.2
reduction factor for creep deformation, $RF_{cr} =$	1.3	1.1 to 1.4
reduction factor for chemical clogging $RF_{cc} =$	1.1	1.0 to 1.2
reduction factor for biological clogging $RF_{bc} =$	1.4	1.2 to 1.5
reduction factor for root penetration, $RF_{rp} =$	1.0	--
design factor of safety, $FS =$	1.5	
allowable hydraulic conductivity, $k =$	3.0E+00 cm/sec	

CALCULATION

slope, $z =$	3 H:1V	
slope, $\beta =$	18.43 °	
length of slope, $L =$	90 ft	
characteristic parameter, $\lambda =$	0.000302	
modifying factor, $j =$	0.998363	
max. liquid thickness, $t_{max} =$	0.11 in	
max. liquid thickness, $t_{max} =$	114.62 mil	Acceptable - liquid thickness is less than geocomposite thickness

MAX. LIQUID THICKNESS IN SLOPE:

$$t_{max} = \frac{q_h L_{up}}{k \sin \beta}$$

WHERE:

t_{max} = maximum liquid thickness

q_h = liquid impingement rate

L_{up} = length of slope

k = hydraulic conductivity of geocomposite

β = slope

REFERENCE: Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", *Geosynthetics International*, Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.

GUIDE LANDFILL REMEDIATION DESIGN

GEOCOMPOSITE CAPACITY ANALYSIS Scenario B: One Slope Scenario: 4:1 Slope

liquid impingement rate, $q_h = 1.0E-04$ cm/sec (min of design storm or barrier layer permeability)

GEOCOMPOSITE PROPERTIES

ultimate transmissivity, $\Theta =$	7.5E-04 m ² /sec	
geocomposite thickness, $t =$	300 mil	RF Ranges for Landfill Caps
reduction factor for elastic deformation, $RF_{in} =$	1.1	1.0 to 1.2
reduction factor for creep deformation, $RF_{cr} =$	1.3	1.1 to 1.4
reduction factor for chemical clogging $RF_{cc} =$	1.1	1.0 to 1.2
reduction factor for biological clogging $RF_{bc} =$	1.4	1.2 to 1.5
reduction factor for root penetration, $RF_{rp} =$	1.0	--
design factor of safety, $FS =$	1.5	
allowable hydraulic conductivity, $k =$	3.0E+00 cm/sec	

CALCULATION

slope, $z =$	4 H:1V	
slope, $\beta =$	14.04 °	
length of slope, $L =$	100 ft	
characteristic parameter, $\lambda =$	0.000537	
modifying factor, $j =$	0.996948	
max. liquid thickness, $t_{max} =$	0.17 in	
max. liquid thickness, $t_{max} =$	166.05 mil	Acceptable - liquid thickness is less than geocomposite thickness

MAX. LIQUID THICKNESS IN SLOPE:

$$t_{max} = \frac{q_h L_{up}}{k \sin \beta}$$

WHERE:

t_{max} = maximum liquid thickness

q_h = liquid impingement rate

L_{up} = length of slope

k = hydraulic conductivity of geocomposite

β = slope

REFERENCE: Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", *Geosynthetics International*, Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.

GUIDE LANDFILL REMEDIATION DESIGN

GEOCOMPOSITE CAPACITY ANALYSIS

Scenario C: Two Slope Scenario

liquid impingement rate, $q_h = 1.0E-04$ cm/sec (min of design storm or barrier layer permeability)

GEOCOMPOSITE PROPERTIES

ultimate transmissivity, $\Theta =$	7.5E-04 m ² /sec	
geocomposite thickness, $t =$	300 mil	RF Ranges for Landfill Caps
reduction factor for elastic deformation, $RF_{in} =$	1.1	1.0 to 1.2
reduction factor for creep deformation, $RF_{cr} =$	1.3	1.1 to 1.4
reduction factor for chemical clogging $RF_{cc} =$	1.1	1.0 to 1.2
reduction factor for biological clogging $RF_{bc} =$	1.4	1.2 to 1.5
reduction factor for root penetration, $RF_{rp} =$	1.0	--
design factor of safety, $FS =$	1.5	
allowable hydraulic conductivity, $k =$	3.0E+00 cm/sec	

UPPER SLOPE (FLATTER)

slope, $z =$	4 %
slope, $\beta =$	2.29 °
length of slope, $L =$	165 ft

characteristic parameter, $\lambda = 0.020976$
 modifying factor, $j = 0.948653$

max. liquid thickness, $t_{max} = 1.66$ in
 max. liquid thickness, $t_{max} = 1662.62$ mil

LOWER SLOPE (STEEPER)

slope, $z =$	3 H:1V
slope, $\beta =$	18.43 °
length of slope, $L =$	30 ft

characteristic parameter, $\lambda = 0.000302$
 modifying factor, $j = 0.998363$

max. liquid thickness, $t_{max} = 0.25$ in
 max. liquid thickness, $t_{max} = 248.35$ mil

MAX. LIQUID THICKNESS IN UPPER SLOPE:

$$t_{max} = \frac{q_h L_{up}}{k \sin \beta}$$

WHERE:

- t_{max} = maximum liquid thickness
- q_h = liquid impingement rate
- L_{up} = length of upper slope
- k = hydraulic conductivity of geocomposite
- β = upper slope

MAX. LIQUID THICKNESS IN LOWER SLOPE:

$$t_{max} = \frac{q_h (L_{up} + L_{down})}{k \sin \beta}$$

WHERE:

- t_{max} = maximum liquid thickness
- q_h = liquid impingement rate
- L_{up} = length of upper slope
- L_{down} = length of lower slope
- k = hydraulic conductivity of geocomposite
- β = lower slope

REFERENCE: Giroud, J.P., J.G. Zornberg, and J.F. Beech, 2000, "Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers Comprising Two Different Slopes", *Geosynthetics International*, Special Issue on Liquid Collection Systems, Vol. 7, Nos. 4-6, pp 453-489.



Project Gude Landfill Remediation Design Project No. 15646.01
 Subject Geomembrane Puncture Resistance Sheet No. 1 of 3
 Drawing No. _____
 Computed by KEF 12/04/2019 Checked by CGAT Date 1/7/2020

OBJECTIVE:

Determine the required mass per unit area of the cushion geotextile to provide a minimum factor of safety of 3.0 for the puncture resistance of the proposed geomembrane liner for the Gude Landfill closure cap. It is imperative that the geomembrane not be punctured when installing the closure cap as this will cause unacceptable material transfer between the landfill and the exterior environment.

PROCEDURE:

The required mass per unit area is calculated using the method presented in Koerner and is based on a 1.0 mm thick (40 mil) LLDPE geomembrane. The method uses the design by function approach.

$$FS = \frac{P_{allow}}{P_{act}}$$

$$P_{allow} = \left(50 + 0.00045 \frac{M}{H^2} \right) \left[\frac{1}{MF_s * MF_{PD} * MF_A} \right] \left[\frac{1}{RF_{CR} * RF_{CBD}} \right]$$

$$P_{act} = \gamma * d + P_{eqp}$$

Koerner, R.M. (2012),
Designing with Geosynthetics,
 6th Edition, Prentice Hall
 Publishing Co., Englewood
 Cliffs, NJ.

Where:

- FS = Factor of safety against geomembrane puncture
- P_{allow} = Allowable pressure based on geotextile and site specific conditions (kPa)
- P_{act} = Actual pressure due to the landfill contents or surface (kPa)
- M = Geotextile mass per unit area (g/m²)
- H = Height of the protrusion above the liner (m)
- MF_s = Modification factor for protrusion shape
- MF_{PD} = Modification factor for packing density
- MF_A = Modification factor for arching in solids
- RF_{CR} = Reduction factor for long-term creep
- RF_{CBD} = Reduction factor for long-term chemical/biological degradation
- γ = Unit weight of material on top of geomembrane (kN/m³)
- d = depth of material on top of geomembrane (m)
- P_{eqp} = Pressure from equipment (kPa)



Project Gude Landfill Remediation Design Project No. 15646.01
Subject Geomembrane Puncture Resistance Sheet No. 2 of 3
Drawing No. _____
Computed by KEF 12/04/2019 Checked by _____ Date _____

Assumptions / Inputs:

M = 8 oz/sy (271 g/m²)
H = 0.025 m
MF_S = 0.5 (subrounded)
MF_{PD} = 0.67 (Dense, 25mm)
MF_A = 0.75 (Geostatic, shallow)
RF_{CR} = 1.5 (maximum reduction factor)
RF_{CBD} = 1.1 (mild leachate)
γ = 120 lb/ft³ (18.85 kN/m³)
d = 2 ft (0.6096 m)
P_{eqp} = 8 psi (55.2 kPa)

Solved:

$$FS = \frac{P_{allow}}{P_{act}} = 10.3$$

CONCLUSIONS:

A 8 oz/sy geotextile will provide a factor of safety greater than 3.0 against puncturing the geomembrane. The load proposed to be applied to the geomembrane does not subject the geomembrane to puncture risk.

**GUDE LANDFILL REMEDIATION DESIGN
GEOMEMBRANE PUNCTURE RESISTANCE**

This calculation apply to geotextiles placed under geomembranes.

$$FS = \frac{p_{allow}}{p_{act}} \quad p_{allow} = \left(50 + 0.00045 \frac{M}{H^2} \right) \left[\frac{1}{MF_S \times MF_{PD} \times MF_A} \right] \left[\frac{1}{RF_{CR} \times RF_{CBD}} \right]$$

geotextile mass per unit area, M =	8 oz/sy	
	271 g/m ²	
protrusion height, H =	1 in	
	0.025 m	
modification factor for protrusion shape, MF _S =	0.5	subrounded
modification factor for packing density, MF _{PD} =	0.67	dense, 25mm
modification factor for arching in solids, MF _A =	0.75	geostatic, shallow
reduction factor for long-term creep, RF _{CR} =	1.5	
reduction factor for long-term degradation, RF _{CBD} =	1.1	mild leachate
allowable pressure, p _{allow} =	577 kPa	
	84 psi	
unit weight of material on top of geomembrane, γ =	120 pcf	
depth of material on top of geomembrane, d =	2 ft	
pressure from equipment, P _{eqp} =	8 psi	assume 8 psi ground pressure from equipme
actual pressure, p _{act} =	8.14 psi	
factor of safety for puncture, FS =	10.28	

Reference: Koerner, R., Designing with Geosynthetics, Sixth Edition (Equations 5.33 and 5.34).

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Attachment M

**Condensate Quantity and Quality Evaluation
Technical Memorandum**

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14 November 2019

TECHNICAL MEMORANDUM

TO: Northeast Maryland Waste Disposal Authority and the Montgomery County
Department of Environmental Protection, Recycling and Resource Management
Division

FROM: Laura Jo Oakes, P.E., BCEE, EA Project Engineer

SUBJECT: Remediation Design – Condensate Quantity and Quality Evaluation
Gude Landfill, Montgomery County, Maryland
EA Project No. 15646.01

1. INTRODUCTION

EA Engineering, Science, and Technology, Inc., PBC (EA) has evaluated the quantity and characterized the quality of existing condensate generated at Gude Landfill (the Landfill), as part of the design for the Maryland Department of the Environment-approved corrective measure alternative, toupee capping and additional landfill gas (LFG) collection. This Technical Memorandum presents the summary of the quality and estimated quantity of condensate generated from the Landfill as part of the redesign and improvements to the LFG management system.

2. BACKGROUND

Gude Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. The site is located at 600 East Gude Drive in Rockville, Maryland. The site is bordered to the east by industrial operations, to the south by Gude Drive, to the west by the community of Derwood, and to the north by Maryland-National Capital Park and Planning Commission land.

2.1 EXISTING CONDENSATE MANAGEMENT

As LFG is extracted from the Landfill and transported through the LFG collection system, it gradually cools and condensate is formed. The LFG condensate primarily consists of water and typically contains minimal quantities of volatile and miscible compounds. LFG condensate can have similar composition to leachate. Condensate sumps within the system are utilized for the collection of condensate, which are periodically pumped out, as necessary. It is EA's understanding that condensate is currently managed with the use of three sumps, several condensate traps, and at least one self-draining condensate trap that currently drains back to the Landfill. Additionally, there is a condensate knockout located at the blower skid that drains

to a below-grade condensate sump within the fenced area for the enclosed flares. A site plan depicting the existing condensate sumps is included as **Figure 1**.

Based on information provided by APTIM (previously CB&I) and reviewed as-built documentation, the following sumps are utilized to manage condensate:

1. Flare Sump – is located close to the plant where the condensate drains to the sump by gravity from the flare and knockout.
2. Inlet Sump – a sump is located at the inlet to the LFG plant that is below grade with a pneumatic pump.
3. Sump A – located between the Inlet Sump and Sump B, has an estimated depth of 16.5 feet. Based on APTIM's inspections throughout the years, this sump has historically not contained condensate.
4. Sump B – is located near the center of the existing well field with an estimated depth of 12 feet. APTIM noted that the connections to the sump are below grade and include a valve with an extended stem for operations.

2.2 PROPOSED CONDENSATE MANAGEMENT

As part of the improvements to the LFG collection system, the existing condensate sumps, traps, and drains are to be disconnected and abandoned along with the existing above-grade LFG collection system; however, a condensate sump located at the LFG blower skid will remain. Based on the slope of the finished grade, condensate drains are proposed to be installed at the potential low points of the proposed LFG collection system. The proposed condensate drains would increase the overall efficiency and reliability of the LFG collection system since there would be less chance of condensate accumulation in the LFG collection piping. Moreover, there would be less likelihood for system downtime for maintenance and/or other issues associated with pumping stations that would be required throughout the Landfill. Since this facility is adjacent to a residential community, minimal interruptions to operation of the LFG collection system is a priority to the County. Condensate sumps with conveyance pumps within the Landfill are not proposed due to the frequency of low spots and overall management that would be required via a series of below grade sumps with conveyance pumps and piping under the toupee cap at an unmanned landfill. Additionally, settlement across the Landfill may vary and would significantly impact the infrastructure associated with condensate sumps and the associated electrical service that would need to be installed across the site. Design and operational considerations for electrical requirements of the pumps would also be required. Currently there is no electrical service planned for the site and the addition of a permanent electrical service and transmission of electric across the site would be significant in relation to both cost and design. Another consideration is that due to the average estimated depth of waste (50 feet) according to the temporary piezometers (installed in the Landfill as part of the Assessment of Corrective Measures [ACM]) construction logs, it is anticipated that due to the capped condition, condensate from the proposed drains would likely percolate slowly and may

become perched within the existing waste mass. The detail drawing of the proposed condensate drains and a schedule will be provided as part of the 60% design submittal.

3. CONDENSATE QUANTITY

3.1 CONDENSATE GENERATION

As part of the condensate quantity determination, EA performed the calculation of condensate generation using Antoine's equation. The calculation is provided in **Attachment A**. To estimate LFG production to be used for condensate generation calculation, EA used the U.S. Environmental Protection Agency (EPA) LFG Emissions Model (LandGEM) and compared that to recent data. The average LFG collection observed from November 2017 to April 2018 was 507 standard cubic feet per minute. The average LFG volume collected from the Landfill was estimated to be 485 standard cubic feet per minute according to the LandGEM model for the years 2017 and 2018 based on 75% collection efficiency. Since the LandGEM model confirmed the most recent landfill gas volume data, an LFG production value of 507 standard cubic feet per minute was utilized for the design basis. Based on the estimated total LFG production from the Landfill, the total volume of condensate produced per minute is estimated to be 0.264 gallon per minute or 380 gallons per day (**Attachment A**). Currently, the volume of condensate removed from the existing sumps varies, but during the period of January through April 2019 the monthly volume pumped out for disposal ranged from 700 to 2,200 gallons.

3.2 LEACHATE GENERATION COMPARISON

The Hydrologic Evaluation of Landfill Performance (HELP) model was used as part of the ACM report preparation to estimate the average annual leachate generation volume which infiltrates (percolates) through the bottom of the waste as leachate (ACM 2016). The average annual leachate volume was calculated over the entire 140 acres of original Landfill footprint, including portions of the Landfill that will remain uncapped. Based on the estimated volume of condensate generation and leachate generation, it appears that the total volume of condensate generated comprises only 0.9% of the total leachate generation from the Landfill. Additionally, a portion of the total condensate generated will still be collected and managed at the blower skid. Therefore, based on the volume of condensate generated, the percolation of condensate via drains back into the waste mass is not a significant potential source of contamination to the groundwater and is an appropriate approach to minimize the maintenance associated with the installation of sumps within the proposed toupee cap. For further information, refer to the HELP model results included as **Attachment B**.

4. CONDENSATE QUALITY

In order to evaluate and characterize the quality of condensate, EA performed a condensate sample collection event on March 5, 2019. During the sampling event, two condensate samples were collected from condensate sumps located at the Flare facility and within the Landfill (Sump B) and analyzed for general water quality parameters, total metals, and volatile organic compounds (VOCs).

4.1 SAMPLE COLLECTION

Condensate samples from two condensate sumps were obtained during the sampling event and analyzed in accordance with the parameters identified in the Landfill's Groundwater and Surface Water Monitoring Plan.

Samples were collected from each condensate sump using grab sampling methodology. Each sample was obtained using a clean and non-preserved long-handled polytetrafluoroethylene dip sampler, which was used to collect the sample from the sampling location and then transfer it into the proper sample container. The first sample aliquot was used to fill the volatile organics parameter vials. Samples for volatile organics were collected in a manner that minimized aeration and the containers were free of bubbles and headspace. The remaining sample was transferred to the sample containers. Containers that held preservative were not filled to overflowing and were mixed after filling by upending. Each pre-labeled container was then placed in a cooler containing ice and a sample entry made on the chain-of-custody form.

During the sampling event, a trip blank was prepared and delivered to the laboratory accompanying the field samples. The trip blank was analyzed for VOCs. The trip blank was prepared prior to field sampling by the laboratory, sealed and labeled, and never opened during any sampling activities. Trip blanks were collected to identify potential contamination during shipping and handling of samples.

4.2 SAMPLE ANALYSIS

The samples were analyzed by Maryland Spectral Services, Inc. located in Baltimore, Maryland. The laboratory performed the following methods: EPA 9045D, EPA 180.1, EPA 8260B, EPA 3010A/6020A, EPA 410.4, USGS I-3765-85, and SM 2320B. All analytical results below practical quantitation limits are reported with a "J" qualifier, and non-detect analytical results are identified with a "U" qualifier. Laboratory reports are included as **Attachment C**.

4.3 CONDENSATE ANALYTICAL RESULTS

A complete summary of detected analytes of the condensate samples, as well as the range of results from the most recent groundwater sampling event for comparison, is presented in **Table 1**.

As shown in **Table 1**, none of the measured general water quality parameters had maximum contaminant level (MCL) exceedances at any of the condensate sump locations. Additionally, all general water quality parameters at both condensate sumps were within the range of Fall 2018 groundwater water quality parameters with one exception—the pH value of the condensate collected from Sump B.

There was an MCL exceedance for antimony reported at both condensate sumps during the sampling event. Antimony exceeded the MCL at concentrations of 0.0317 and 0.0796 milligram per liter (mg/L) in the Flare Sump, which had a pH of 7.05, and Sump B, which had a pH of 7.76, respectively. All other metals remained within the range of Fall 2018 groundwater metal results.

Antimony is a natural constituent of soil and also comes from anthropogenic sources such as municipal waste. In the neutral pH range, antimony is retained in soil through the process of adsorption and can also sorb onto clay minerals, oxides, and hydroxides in the soil (Agency for Toxic Substances and Disease Registry 2017). Since, antimony is not typically found in groundwater at the site it can be assumed that it is not mobile in groundwater at the site and, therefore, the presence of it within the condensate is not a concern.

No VOCs were detected above the MCLs for the samples collected from both condensate sumps. Four VOCs were detected above practical quantitation limits in both condensate sumps: 1,4-dichlorobenzene was detected at concentrations of 2.2 and 5.5 micrograms per liter ($\mu\text{g/L}$) in the Flare Sump and Sump B, respectively; acetone was detected at concentrations of 82.4 and 621 $\mu\text{g/L}$ in the Flare Sump and Sump B, respectively; m&p-xylene was detected at concentrations of 1.9 and 5.7 $\mu\text{g/L}$ in the Flare Sump and Sump B, respectively; o-xylene was detected at concentrations of 1.1 and 2.6 $\mu\text{g/L}$ in the Flare Sump and Sump B, respectively. Cis-1,2-dichloroethene was detected only in the Flare Sump at a concentration of 1.0 $\mu\text{g/L}$. 2-Butanone, 2-hexanone, 4-methyl-2-pentanone, and ethylbenzene were detected only in Sump B at concentrations of 727, 5.4, 29.0, and 1.1 $\mu\text{g/L}$, respectively. Among the VOCs detected at the condensate sumps, acetone, m&p-xylene, and o-xylene exceeded the range of Fall 2018 groundwater VOC results. In addition, the condensate sample collected from Sump B exceeded the groundwater range for 2-butanone, 2-hexanone, and 4-methyl-2-pentanone. Based on the analytical results, the range of VOC concentrations are unlikely to significantly impact groundwater.

Table 1 Summary of Condensate and Groundwater Analytical Results

Sampling Location			Flare Sump	Sump B (Field Sump)	Groundwater Results
Sampling date			3/5/2019	3/5/2019	Fall 2018
Parameters	Units	MCL	Results	Results	Range (min-max)
General Parameters					
Alkalinity	mg/L	--	112	196	8.8–1,050
Ammonia Nitrogen	mg/L	--	0.95	3.07	0.202–23.7
Chemical Oxygen Demand	mg/L	--	37.8	67.2	10.2–142
Chloride	mg/L	--	157	154	2.51–607
Hardness	mg/L	--	130	586	11.8–832
Nitrate	mg/L	10	1.1	0.4	0.205–5.81
pH	SU	--	7.05	7.76	4.84–7.36
Specific Conductivity	$\mu\text{S/cm}$	--	782	1240	31.4–2,710
Sulfate, total	mg/L	--	28.5	63.1	2.6–240
Total Dissolved Solids	mg/L	--	432	756	26–1,840
Total Suspended Solids	mg/L	--	4.3	3.5	--
Turbidity	NTU	--	8.69	17.4	0.0–149.8
Inorganics					
Antimony, total	mg/L	0.006	0.0317	0.0796	0.002U–0.005U
Arsenic, total	mg/L	0.01	0.00331	0.00422	0.00201–0.035
Barium, total	mg/L	2	0.0242	0.0608	0.00381–0.605
Calcium, total	mg/L	--	34.8	119	2.54–178
Chromium, total	mg/L	0.1	0.00527	0.001 U	0.00205–0.0276
Cobalt, total	mg/L	--	0.001 U	0.0146	0.00223–0.786
Copper, total	mg/L	--	0.011	0.001 U	0.00211–0.0488
Iron, total	mg/L	--	1.09	1.48	0.0645–91.2
Magnesium, total	mg/L	--	10.5	69.9	1.32–116

Table 1 Summary of Condensate and Groundwater Analytical Results

Sampling Location			Flare Sump	Sump B (Field Sump)	Groundwater Results
Sampling date			3/5/2019	3/5/2019	Fall 2018
Parameters	Units	MCL	Results	Results	Range (min–max)
Manganese, total	mg/L	--	0.0459	12.9	0.00686–24
Nickel, total	mg/L	--	0.00805	0.00608	0.00223–0.0875
Potassium, total	mg/L	--	3.69	0.278	0.675–58.4
Sodium, total	mg/L	--	99.7	20.5	3.36–462
VOCs					
1,4-Dichlorobenzene	µg/L	75	2.2	5.5	1.01–17.7
2-Butanone	µg/L	--	5 U	727	5U
2-Hexanone	µg/L	--	5 U	5.4	5U
4-Methyl-2-Pentanone	µg/L	--	5 U	29.0	5U
Acetone	µg/L	--	82.4	621	5U–14.5
cis-1,2-Dichloroethene	µg/L	70	1.0	1 U	1.29–80
Ethylbenzene	µg/L	700	1 U	1.1	1U
m&p-Xylene	µg/L	10,000	1.9	5.7	2U
o-Xylene	µg/L	10,000	1.1	2.6	1U
Toluene	µg/L	1,000	1 U	2.2	1.74–12.4
Note: µS/cm = Microsiemens per centimeter. NTU = Nephelometric turbidity units. SU = Standard Units. U = The compound was analyzed for but not detected. The associated value is the compound reporting limit.					

5. CONCLUSIONS

Based on the condensate quantity and quality analyses performed, the following can be concluded:

- In comparison to the total leachate volume estimated to be generated following installation of the toupee cap, the volume of condensate generated is estimated as approximately 0.9% of the total combined volume.
- The quality of the condensate generated from the Landfill had no MCL exceedances except for antimony and is generally within the range of the groundwater results observed during the most recent sampling event.
- The volume of condensate generated can be appropriately managed by the proposed condensate drains and the sump located at the blower skid.

6. REFERENCES

Agency for Toxic Substances and Disease Registry. 2017. *Toxicological Profile for Antimony and Compounds*. Draft for Public Comment. April.
<https://www.atsdr.cdc.gov/toxprofiles/tp23.pdf>. Accessed on 13 April 2019.

Figure

- 1 Location of Existing Condensate Sumps

Table

- 1 Summary of Condensate and Groundwater Analytical Results

Attachments

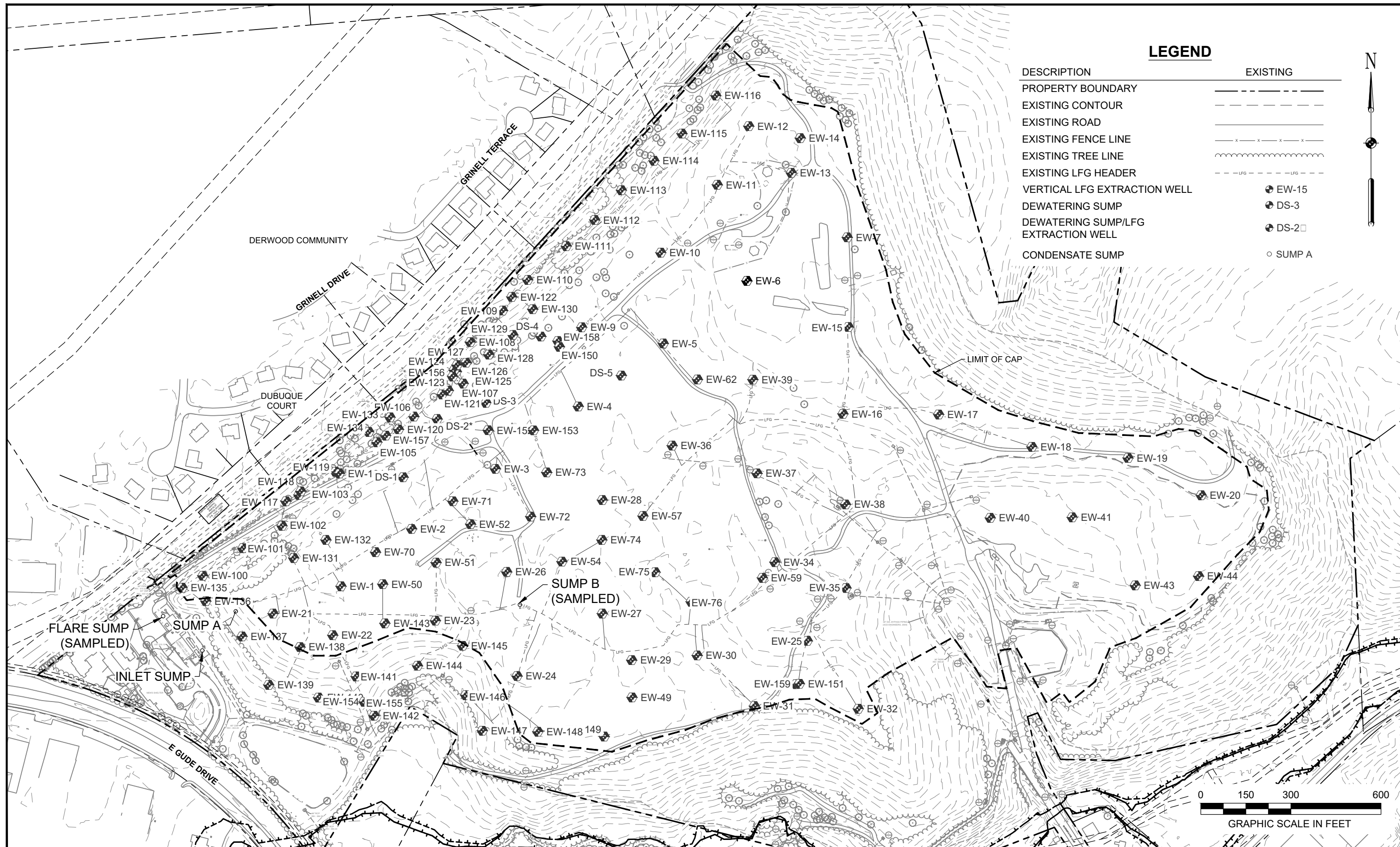
- A Condensate Quantity Calculation
- B HELP Model Results (ACM 2016)
- C Laboratory Reports

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Figure

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FILE PATH: Q:\PROJECTS\1564601 - GUDE LF DESIGN\CAD\PRODUCTION\FIGURES\LANDFILL GAS\1564601 - FIGURE CONDENSATE SUMP LOCATION TM.DWG [11X17 CONDENSATE TM] 12/20/16



EA Engineering, Science, and Technology, Inc., PBC
 Hunt Valley Center
 225 Schilling Circle, Suite 400
 Hunt Valley, Maryland 21031
 (410) 584-7000

PROJECT NUMBER:
1564601
 DATE:
APRIL 2019

DESIGNED BY:
-
 CHECKED BY:
GAT

DRAWN BY:
SS
 PROJECT MGR.:
MJG

FIGURE:
1
 SHEET NUMBER:
-

GUDE LANDFILL REMEDIATION DESIGN
NORTHEAST MARYLAND WASTE DISPOSAL AUTHORITY
 MONTGOMERY COUNTY, MARYLAND

FIGURE 1 LOCATION OF EXISTING CONDENSATE SUMPS

Attachment A

Condensate Quantity Calculation

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References:

LANDTEC. Landfill Gas
 System Engineering Design:
 A Practical Approach. 1994

LFG Extraction Wells
 Operational Data, APTIM,
 March 2019

CONDENSATE ESTIMATION

OBJECTIVE:

Estimate the quantity of condensate production in the LFG collection system.

PROCEDURE:

Use Antoine’s Equation to determine a conservative estimate of condensate produced within the system.

A. Antoine’s Equation—Use Antoine’s equation to provide a conservative estimate for LFG production.

$$V_{cond} = 5,694 * 10^{\beta} / P_s$$

where:

- V_{cond} = Volume of condensate (water) produced (gallons per million cubic foot of LFG)
- β = $6.32 - (3081 / (T + 385))$
- T = Maximum gas temperature (degrees Fahrenheit [°F]) =
Assume average initial temperature of gas at 110 °F
- P_{atm} = Atmospheric pressure (in. w.c.)
- P_{vac} = Vacuum pressure (in. w.c.)
= 30 in. w.c (based on the operational data)
- P_s = System pressure (psia)
= $(P_{atm} - P_{vac}) / 27.7$
= 13.671 psia

$$V_{cond} = 521.3 \frac{gal}{MMcfLFG}$$

Solution: Total gas production from the landfill is estimated at 507 scfm; therefore, the Total Volume of condensate produced per minute is estimated at 0.264 gallon per minute or 380 gallons per day.

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Attachment B

HELP Model Results (ACM 2016)

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Appendix B

Infiltration Testing Summary Report and HELP Model Results – 2016

Contents:

Infiltration Testing Summary Report

HELP Model Results

Infiltration Testing Summary Report



Soil and Land Use Technology, Inc. (SaLUT-TLB)

530 McCormick Drive, Suite S • Glen Burnie, MD 21061

(443) 577-1600
www.SaLUTinc.com

November 20, 2015

Ms. Laura Jo Oakes, PE
EA Engineering, Science and Technology, Inc.
225 Schilling Circle, Suite 400
Hunt Valley, MD 21031

Re: Gude Landfill Double Ring Infiltration Testing
Montgomery County, MD.
SaLUT Summary Report

Dear Ms. Oakes,

In accordance with our proposal dated October 15, 2015, Soil and Land Use Technology, Inc. (SaLUT) has completed the double ring infiltration testing at the Gude Landfill located in Montgomery County, Maryland as shown in Figure A-1 in Appendix A. The purpose of this testing was to evaluate the infiltration rate in the top two (2) feet of the existing soil cover. The specific scope of our services on this project consisted of preparing the surface at six (6) test locations, installing double rings below the surface, providing water and obtaining water level readings for up to 8 hours, and submitting our findings in a summary report.

The field exploration consisted of six (6) double ring infiltration tests, conducted on November 5, 2015 through November 10, 2015. A test location plan showing all six (6) test locations and a sketch of each individual location is included in Appendix A. The ground surface at each test location was prepared by clearing away any grass or vegetation using a skid loader. The infiltration test locations were located just outside of previously disturbed areas as observed by new growth of grass and straw mulch, and as shown on test location sketch in Appendix A. Approximate dimensions from the existing well and edge of the access road are shown on the location sketches. After the ground surface was prepared, the double infiltration test rings were installed at each location to a maximum depth of 6-inches below the ground surface. The diameter of the inner and outer rings were 12-inches and 24-inches, respectfully. Several double ring infiltration test were conducted simultaneously at various locations. Water was brought to the site and was manually added during the infiltration test using a graduated cylinder. Water level readings were recorded at 15 minute intervals for the first hour, 30 minute intervals for the second hour and one hour intervals for the following 6 hours, totaling 8 hours. All six (6) double ring infiltration test were terminated after 8 hours. After the test was completed, the double rings were removed from the test locations.



The incremental infiltration velocity was calculated for the inner ring and annular space in accordance with ASTM D 3385. Results of the infiltration testing are summarized in Table-1. The infiltration test logs are included in Appendix B.

Test Location	Inner Ring ($V_{IR, AVG}$) (in/hr)	Annular Space ($V_{A, AVG}$) (in/hr)
I-1	0.34	0.35
I-2	0	0.13
I-3	0.04	0.19
I-4	0	0
I-5	0.41	0.67
I-6	0.44	0.59

As requested, the vertical hydraulic conductivity was estimated from the double ring infiltration test data. Per ASTM D 3385, the double-ring infiltration test method “cannot be used directly to determine the hydraulic conductivity of the soil.” Therefore, assuming a constant-rate-test method and unit hydraulic gradient, the vertical hydraulic conductivity was estimated by dividing the flow rate by the area of the inner ring. Table 2 below summarizes the vertical hydraulic gradient for the average flow rate at each test location.

Test Location	Average Flow Rate (in³/min)	K_{est} (in/min)	K_{est} (cm/s)
I - 1	0.65	5.74E-3	2.43E-4
I - 2	0.00	0	0
I - 3	0.07	6.35E-4	2.69E-5
I - 4	0.00	0	0
I - 5	0.78	6.88E-3	2.91E-4
I - 6	0.84	7.39E-3	3.13E-4

We appreciate the opportunity working with you and if you have any questions, please contact us.

Soil and Land Use Technology Inc.

Edward H. Dalton, PE
Vice President



Appendix A

Contents:

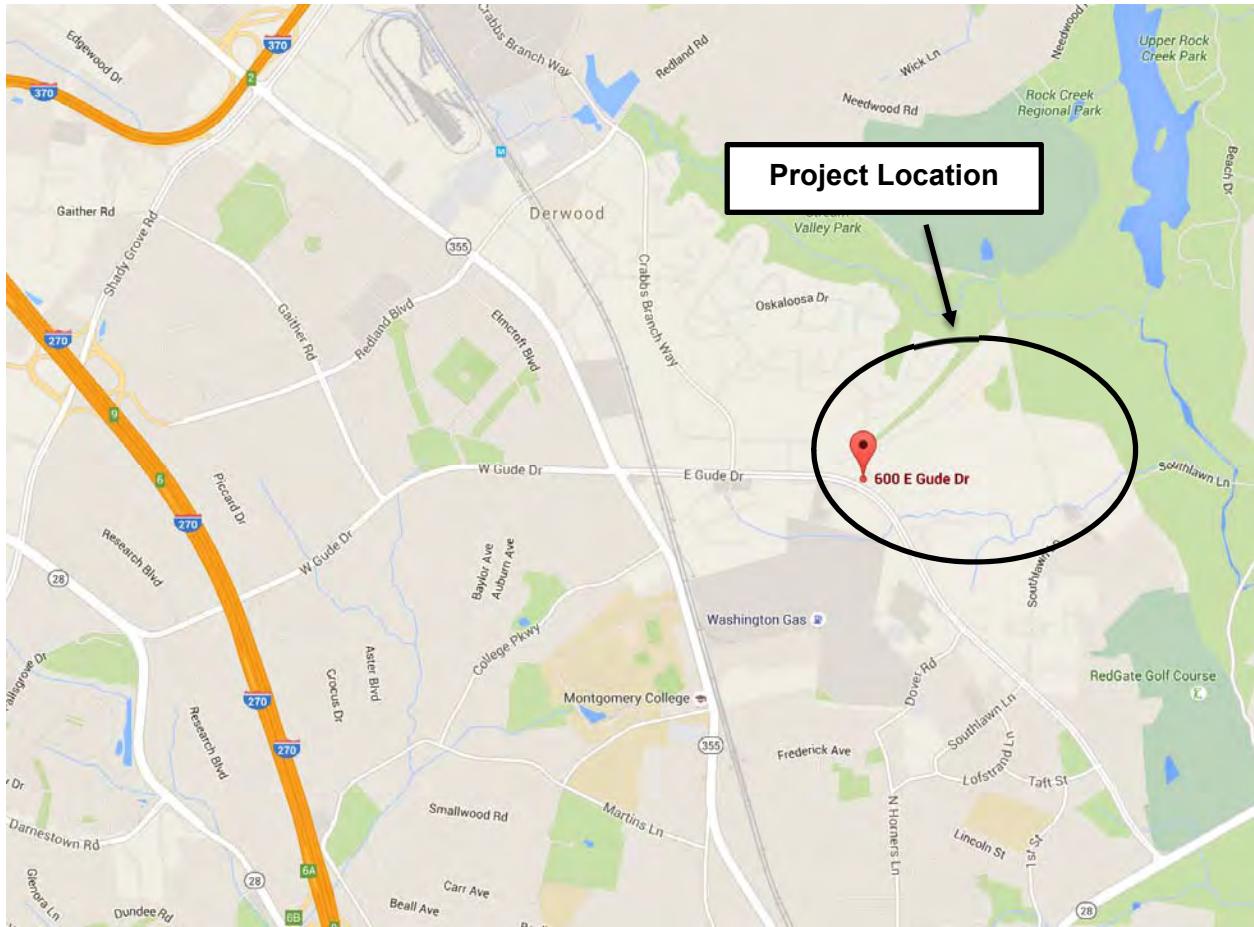
Project Location Map

Infiltration Test Location Plan

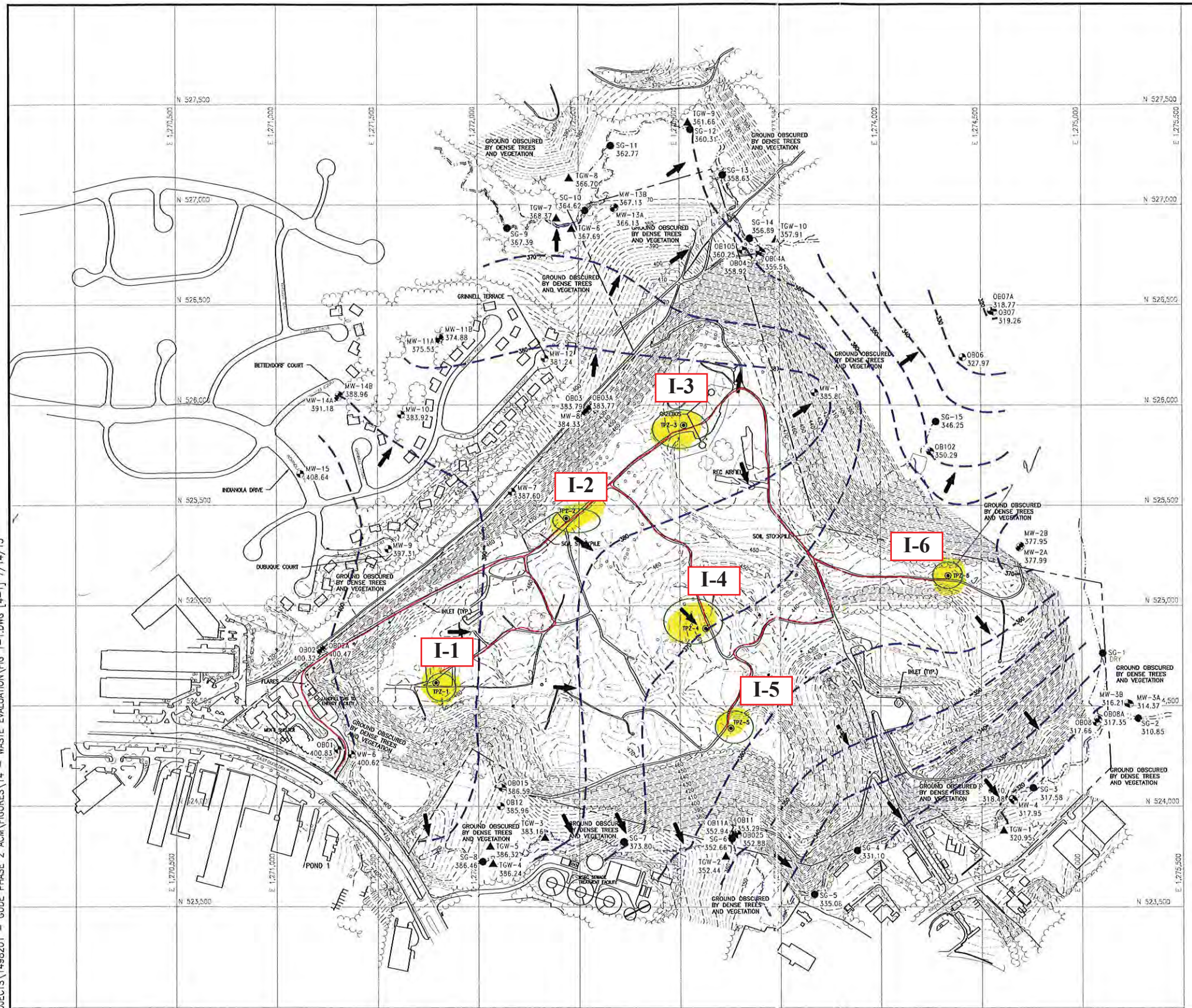
Infiltration Test Location Sketch



Figure A-1: Project Location Map



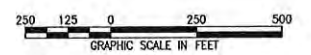
FILE PATH: Q:\PROJECTS\1498201 - GUDE PHASE 2 ACM\FIGURES\14 - WASTE EVALUATION\FIG 1-1.DWG [4-1] 7/14/15



- NOTES:
1. TOPOGRAPHY COMPILED BY APPLIED MAPPING SOLUTIONS, INC. USING PHOTOGRAMMETRIC METHODS WITH PHOTOGRAPHY DATED 06/24/09 AND SUPPLEMENTED WITH FIELD SURVEY PERFORMED BY C.C. JOHNSON & MALHOTRA, P.C., OCTOBER 2009.
 2. SURVEY OF STREAMS TAKEN FROM 2007 PHOTOGRAMMETRY BY AXIS GEOSPATIAL, LLC.
 3. HORIZONTAL DATUM IS NORTH AMERICAN DATUM OF 1983/91 (NAD-83/91). COORDINATE SYSTEM IS MARYLAND STATE PLANE, U.S. SURVEY FEET. VERTICAL DATUM IS NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD-88) WITH ELEVATIONS SHOWN IN FEET.
 4. TOPOGRAPHY IS APPROXIMATE IN AREAS NOTED "GROUND OBSCURED BY DENSE TREES AND VEGETATION".
 5. FIELD SURVEY OF MW-14A, MW-14B, & MW-15, TEMPORARY GROUNDWATER MONITORING LOCATIONS, AND STREAM GAUGE LOCATIONS PERFORMED BY C.C. JOHNSON & MALHOTRA, P.C., AUGUST 2011.
 6. GROUNDWATER ELEVATION DATA FOR OB102 (350.19') NOT USED IN CONTOURING BECAUSE IT IS INCONSISTENT WITH SURROUNDING DATA.

LEGEND

	10-FT ELEVATION CONTOUR
	2-FT ELEVATION CONTOUR
	PROPERTY BOUNDARY
	STREAM
	GROUNDWATER CONTOUR INTERVAL (10 FEET)
	TEMPORARY STREAM GAUGE LOCATION (2011)
	EXISTING GROUNDWATER MONITORING WELL
	TEMPORARY GROUNDWATER MONITORING LOCATION (2011)
	GROUNDWATER ELEVATION (FT. MSL.)
	INFERRED GROUNDWATER FLOW
	TEMPORARY PIEZOMETER LOCATION
	APPROVED ROUTES OF TRAVEL FOR DRILL RIG



GUDE LANDFILL
ASSESSMENT OF CORRECTIVE MEASURES
MONTGOMERY COUNTY, MARYLAND

FIGURE A-2
Infiltration Test Location Plan

DESIGNED BY PL/LJO	DRAWN BY TJP	DATE JULY 2015	PROJECT NO. 14982.01
CHECKED BY PC	PROJECT MGR. JK	DRAWING NO. -	FIGURE A-2

Soil and Land Use Technology Inc. (SaLUT)

Geotechnical Engineers

530 McCormick Drive, Suite S

Glen Burnie, MD. 21061

443-577-1600

Job: bude Landfill Double-Ring Infiltrometer

Job No: 15-00047 Sheet No. 1 of 4

Calculated By: OMO Date: 11/19/15

Checked By: _____ Date: _____

Subject: Infiltration Test Location Sketch

1:20 scale

Location I-1

Well # MD-15-0185



I-1



44'

Disturbed Area

ACCESS Rd.

Legend:



: Well



: Double-ring Infiltration Test Location



: Disturbed Area

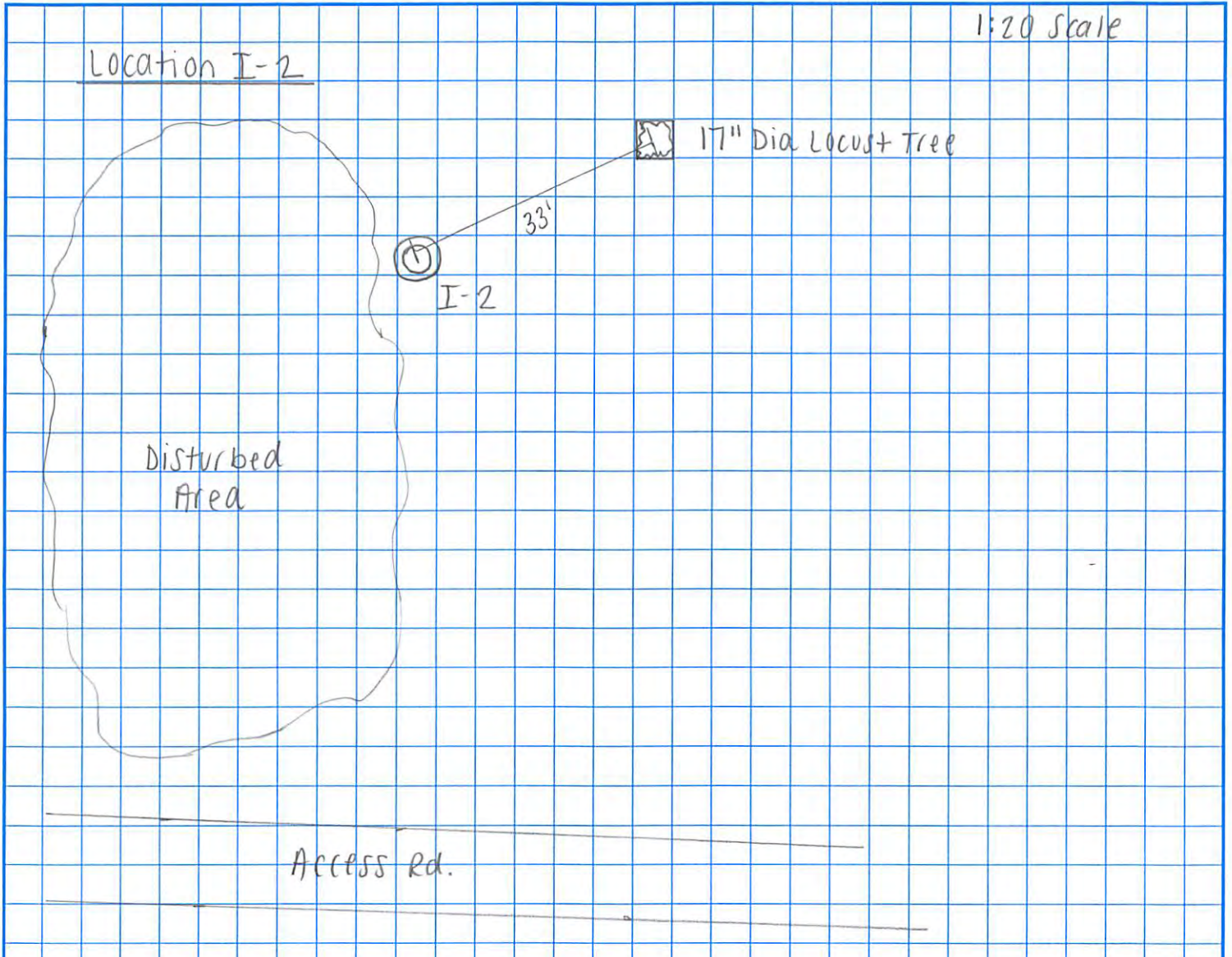


: Locust Tree

Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers

530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: Gude Landfill Double-Ring Infiltrometer
Job No: 15-00047 Sheet No. 2 of 4
Calculated By: OMO Date: 11/19/15
Checked By: _____ Date: _____
Subject: Infiltration Test Location Sketch



Soil and Land Use Technology Inc. (SaLUT)

Geotechnical Engineers

530 McCormick Drive, Suite S

Glen Burnie, MD. 21061

443-577-1600

Job: Bude Landfill Double-Ring Infiltrometer

Job No: 15-00047 Sheet No. 3 of 4

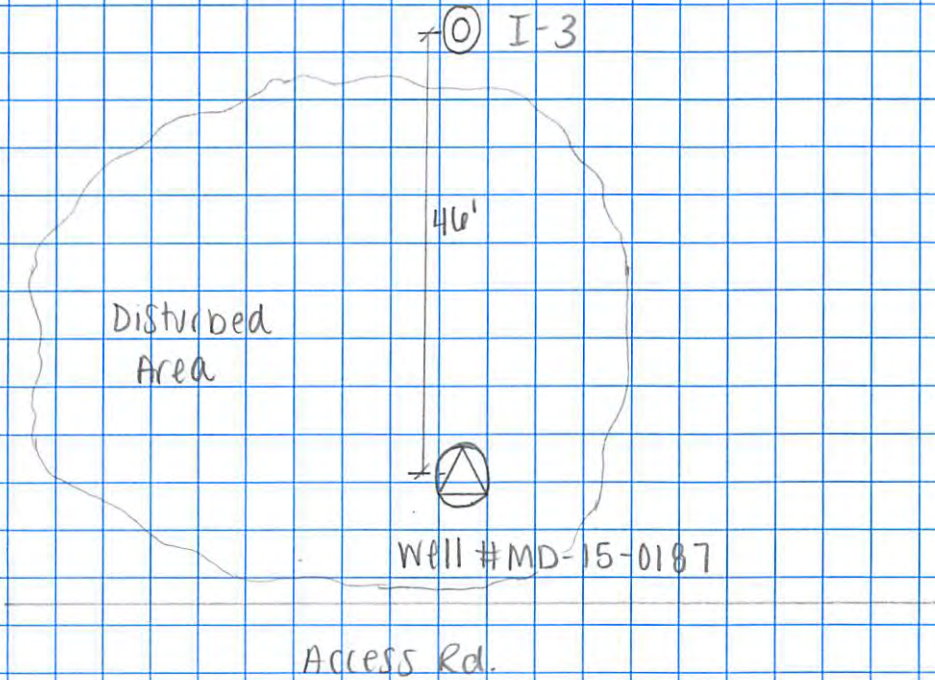
Calculated By: OMB Date: 11/19/15

Checked By: _____ Date: _____

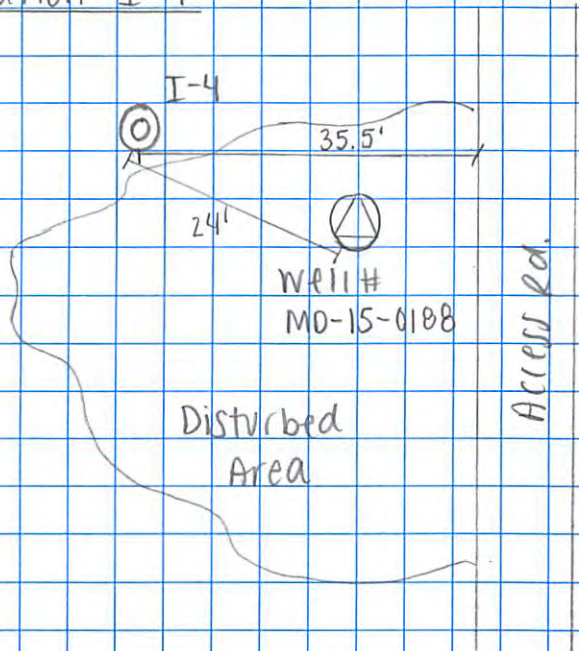
Subject: Infiltration Test Location Sketch

1:20 Scale

Location I-3



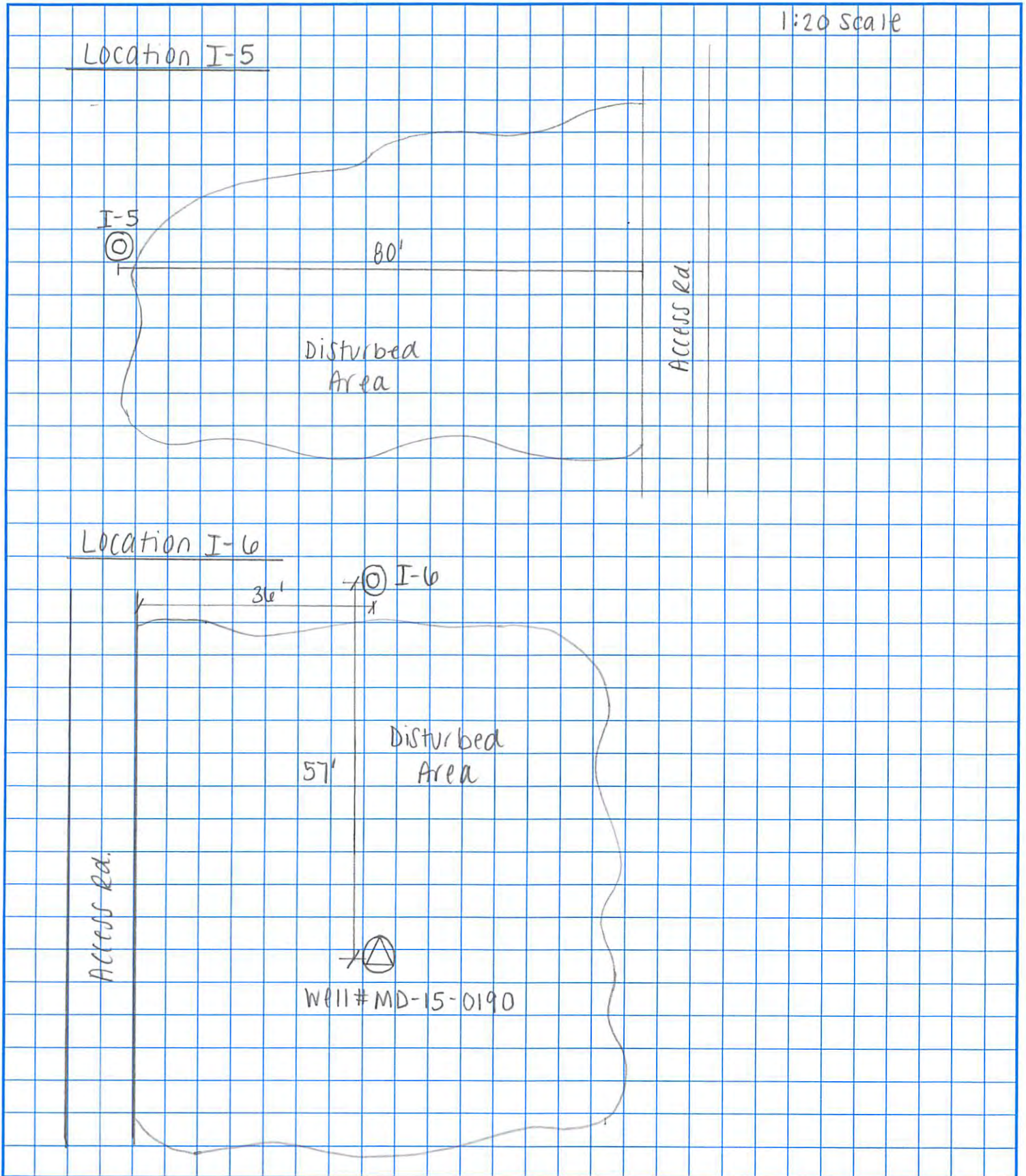
Location I-4



Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers

530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: Gude Landfill Double-Ring Infiltrometer
Job No: 15-00047 Sheet No. 4 of 4
Calculated By: OMD Date: 11/19/15
Checked By: _____ Date: _____
Subject: Infiltration Test Location Sketch





Appendix B

Contents:

Infiltration Test Logs



Project: Gude Landfill Double-Ring Infiltration Testing
 Location: 600 Gude Drive, Rockville MD
 Tested By: Dan and Wade
 Inner Ring Diameter = 12 in
 Outer Ring Diameter = 24 in
 Ring Thickness = 0.125 in

Job No: 15-00047
 Client: EA Engineering
 Contact: Laura Oakes
 Depth of Water = 8 in
 Embedment Depth of Rings = 4 in

Ring No. : 3

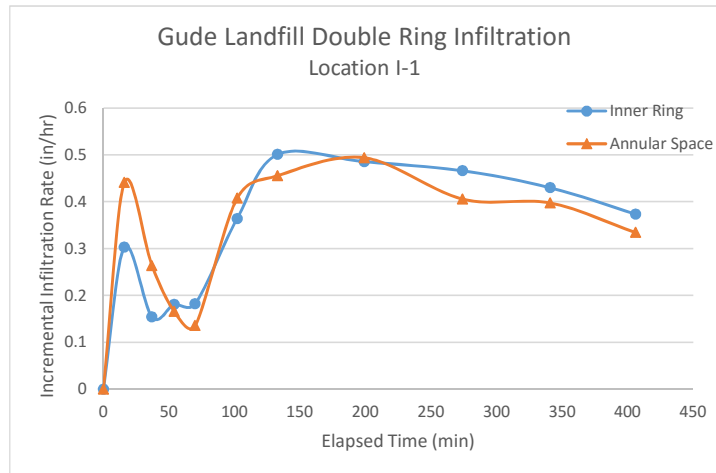
Location: I-1

$A_{IR} = 113.1 \text{ in}^2$
 $A_A = 336.9 \text{ in}^2$

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added				Water Temp ($^{\circ}\text{F}$)	V_{IR} (in/hr)	V_A (in/hr)
						Inner Ring, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in ³)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_A (in ³)			
1	11/5/2015	8:34 AM	0	0	0					65	0	0
2	11/5/2015	8:50 AM	16	16	0.27	150	9.15	650	39.67	65	0.30	0.44
3	11/5/2015	9:11 AM	21	37	0.35	100	6.10	510	31.12	65	0.15	0.26
4	11/5/2015	9:28 AM	17	54	0.28	95	5.80	260	15.87	65	0.18	0.17
5	11/5/2015	9:44 AM	16	70	0.27	90	5.49	200	12.20	65	0.18	0.14
6	11/5/2015	10:16 AM	32	102	0.53	360	21.97	1200	73.23	65	0.36	0.41
7	11/5/2015	10:47 AM	31	133	0.52	480	29.29	1300	79.33	65	0.50	0.46
8	11/5/2015	11:53 AM	66	199	1.10	990	60.41	3000	183.07	65	0.49	0.49
9	11/5/2015	1:08 PM	75	274	1.25	1080	65.91	2800	170.87	65	0.47	0.41
10	11/5/2015	2:15 PM	67	341	1.12	890	54.31	2450	149.51	65	0.43	0.40
11	11/5/2015	3:20 PM	65	406	1.08	750	45.77	2000	122.05	65	0.37	0.33

Average

0.34 0.35



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:

V_{IR} = inner ring incremental infiltration velocity (in/hr)
 ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in³)
 A_{IR} = internal area of inner ring (in²)
 Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:

V_A = annular space incremental infiltration velocity (in/hr)
 ΔV_A = volume of liquid used during time interval to maintain constant head in the annular space between the two rings (in³)
 A_A = area of annular space between the rings (in²)
 Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

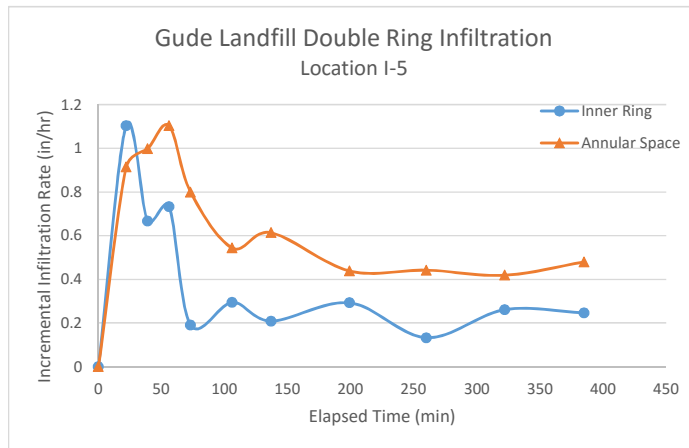


Project: Gude Landfill Double-Ring Infiltration Testing
 Location: 600 Gude Drive, Rockville MD
 Tested By: Dan and Terry
 Inner Ring Diameter = 12 in
 Outer Ring Diameter = 24 in
 Ring Thickness = 0.125 in

Job No: 15-00047
 Client: EA Engineering
 Contact: Laura Oakes
 Depth of Water = 8 in
 Embedment Depth of Rings = 3.75 in
 $A_{IR} = 113.1 \text{ in}^2$
 $A_A = 336.9 \text{ in}^2$

Ring No. : 2 Location: I-5

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added				Water Temp (°F)	V_{IR} (in/hr)	V_A (in/hr)
						Inner Ring, ΔV_{IR} (mL)	Inner Ring, ΔV_{IR} (in ³)	Annular Space, ΔV_A (mL)	Annular Space, ΔV_A (in ³)			
1	11/7/2015	9:13 AM	0	0	0					67	0	0
2	11/7/2015	9:35 AM	22	22	0.37	750	45.77	1850	112.89	67	1.10	0.91
3	11/7/2015	9:52 AM	17	39	0.28	350	21.36	1560	95.20	67	0.67	1.00
4	11/7/2015	10:09 AM	17	56	0.28	385	23.49	1725	105.27	67	0.73	1.10
5	11/7/2015	10:26 AM	17	73	0.28	185	6.10	1250	76.28	67	0.19	0.80
6	11/7/2015	10:59 AM	33	106	0.55	300	18.31	1650	100.69	63	0.29	0.54
7	11/7/2015	11:30 AM	31	137	0.52	200	12.20	1750	106.79	63	0.21	0.61
8	11/7/2015	12:32 PM	62	199	1.03	560	34.17	2500	152.56	60	0.29	0.44
9	11/7/2015	1:33 PM	61	260	1.02	250	15.26	2480	151.34	60	0.13	0.44
10	11/7/2015	2:35 PM	62	322	1.03	500	30.51	2390	145.85	60	0.26	0.42
11	11/7/2015	3:38 PM	63	385	1.05	480	29.29	2780	169.65	60	0.25	0.48
Average											0.41	0.67



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
 V_{IR} = inner ring incremental infiltration velocity (in/hr)
 ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in³)
 A_{IR} = internal area of inner ring (in²)
 Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
 V_A = annular space incremental infiltration velocity (in/hr)
 ΔV_A = volume of liquid used during time interval to maintain constant head in the annular space between the two rings (in³)
 A_A = area of annular space between the rings (in²)
 Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

HELP Model Results



Project Gude Landfill – Assessment of Corrective Measures Project No. 14982.01.0012
Subject Average Annual Leachate Infiltration Sheet No. 1 of 2
Drawing No. _____
Computed by BTT Date 4/8/16 Checked by [Signature] Date 4/8/16

REFERENCES:

EA Engineering, Science, and Technology, Inc., PBC (EA). 2015. *Waste Evaluation: Temporary Piezometer Installation Summary, Gude Landfill, Montgomery County, Maryland*. Technical Memorandum. 19 November.

EA. 2016. *Stormwater Engineering Evaluation*. Technical Memorandum. 4 April.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3," EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Schroeder, P. R., Dozier, T.S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/R-94/168b, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

OBJECTIVE:

Estimate the average annual leachate generation volume which infiltrates (percolates) through the bottom of the landfill. Compare the average annual leachate generation volume with and without an engineered geosynthetic cap over the existing landfill cover soil.

PROCEDURE:

Using the Hydrologic Evaluation of Landfill Performance (HELP) Model (Version 3.07, November 1997), determine the average annual leachate volume (generated by precipitation percolating through the landfill) which infiltrates through the bottom layer of the landfill.

The HELP Model rainfall was synthetically generated over a 30-year period using HELP Model data for the Washington, DC area. The estimated annual rainfall is approximately 38 in. (see attached HELP Model output). The volume of leachate generated from the rainfall was averaged over the same 30-year period.

The average annual leachate volume was calculated over the entire landfill, including portions of the landfill that will remain uncapped. The landfill layer properties were estimated using averages of the soil properties based on the information obtained during drilling for the four temporary piezometers TPZ-1, TPZ-3, TPZ-4, and TPZ-6 (EA 2015). Hydraulic conductivity for the existing cover soil was estimated using the results of double ring infiltration testing (Soil and Land Use Technology, Inc. 2015).

The calculation for leachate volume produced from the uncapped side slopes were performed separately and added to the leachate volume produced by the remaining portions of the landfill with and without a geosynthetic cap. The capping scenario assumed a geocomposite drainage layer and a geosynthetic cap will be installed over the existing cover soil to promote drainage off of the landfill.

It was assumed that that 99.5% of the landfill allows runoff without a cap and 100% of the landfill area allows runoff with a cap. The runoff percent without a cap was calculated using the results of a Stormwater Engineering Evaluation (EA 2016).



Project Gude Landfill – Assessment of Corrective Measures Project No. 14982.01.0012
 Subject Average Annual Leachate Infiltration Sheet No. 2 of 2
 Drawing No. _____
 Computed by BTT Date 4/8/16 Checked by [Signature] Date 4/8/16

REFERENCES (continued):

Soil and Land Use Technology, Inc. (SaLUT-TLB). 2015. Re: Gude Landfill Double Ring Infiltration Testing; Montgomery County, MD.; SaLUT Summary Report. Letter from Edward H. Dalton, Soil and Land Use Technology, Inc. to Laura Jo Oakes, EA Engineering, Science, and Technology, Inc., PBC. 20 November.

CONCLUSION:

The total leachate volume produced over the Landfill with and without a geosynthetic cap is shown in the table below (identified as percolation/leakage in the HELP Model). With the installation of a toupee cap, leachate volume decreased by approximately 65% over the entire landfill.

	Annual Percolation (cft) - no cap	Annual Percolation (cft) - with cap	Percent Decrease in Infiltration
Top and West Side Slopes	5,581,584	43,687	99
Uncapped Side Slopes	2,982,499	2,982,499	0
Total	8,565,787	2,085,978	65

GUDESSLO

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS = 57.00 INCHES
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.0020 VOL/VOL
WILTING POINT = 0.0010 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.5010 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.146000006000E-03 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS = 30.00 INCHES
POROSITY = 0.4630 VOL/VOL
FIELD CAPACITY = 0.2320 VOL/VOL
WILTING POINT = 0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3003 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS = 495.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3010 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS = 93.00 INCHES
POROSITY = 0.4530 VOL/VOL
FIELD CAPACITY = 0.1900 VOL/VOL
WILTING POINT = 0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2554 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.720000011000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-
Page 2

GUDESSLO
 SPECIFIED CURVE NUMBER OF 70.0, A SURFACE SLOPE
 OF 24. % AND A SLOPE LENGTH OF 167. FEET.

SCS RUNOFF CURVE NUMBER	=	73.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	49.080	ACRES
EVAPORATIVE ZONE DEPTH	=	4.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.855	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	1.812	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.340	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	211.184	INCHES
TOTAL INITIAL WATER	=	211.184	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
 WASHINGTON DISTRICT OF COLUMBIA

STATION LATITUDE	=	38.90	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	104	
END OF GROWING SEASON (JULIAN DATE)	=	296	
EVAPORATIVE ZONE DEPTH	=	4.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	62.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	65.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
2.76	2.62	3.46	2.93	3.48	3.35
3.88	4.40	3.22	2.90	2.82	3.18

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.40	33.60	42.40	53.30	62.40	70.70
75.50	74.30	67.40	55.30	44.80	35.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

GUDESSLO
AND STATION LATITUDE = 38.90 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.55 4.10	2.78 3.32	3.17 2.85	3.03 3.25	3.40 2.62	3.79 2.90
STD. DEVIATIONS	1.38 2.25	1.13 1.65	1.46 1.98	1.38 2.21	2.11 1.10	1.86 1.63
RUNOFF						
TOTALS	0.345 0.008	1.287 0.010	0.453 0.026	0.000 0.022	0.012 0.002	0.022 0.079
STD. DEVIATIONS	0.604 0.023	1.402 0.045	0.789 0.091	0.002 0.050	0.037 0.012	0.049 0.330
EVAPOTRANSPIRATION						
TOTALS	0.876 2.533	0.833 2.051	1.745 1.536	1.780 1.195	1.986 1.095	2.375 0.938
STD. DEVIATIONS	0.304 0.979	0.410 0.917	0.435 0.808	0.689 0.494	0.901 0.418	0.931 0.213
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.9875 1.4923	0.6654 1.3257	1.7116 1.2554	1.1888 1.9576	1.4860 1.4363	1.4725 1.5940
STD. DEVIATIONS	1.1129 1.5175	0.7931 1.0179	1.0903 1.3344	0.7819 1.8606	1.4536 0.9343	1.2536 1.4222
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	1.6592 1.3224	1.3607 1.5223	1.7790 1.2737	1.3540 1.4857	1.1891 1.3190	1.2390 1.2365
STD. DEVIATIONS	0.8982 0.6514	0.6758 0.6621	0.8034 0.7585	0.6511 0.7165	0.6308 0.7502	0.6924 0.6910

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0192	0.0186	0.0394	0.0231	0.0297	0.0311
----------	--------	--------	--------	--------	--------	--------

	GUDESSLO					
	0.0305	0.0245	0.0260	0.0367	0.0290	0.0271
STD. DEVIATIONS	0.0225	0.0223	0.0242	0.0175	0.0317	0.0297
	0.0354	0.0214	0.0284	0.0391	0.0218	0.0265

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	37.77	(5.959)	6729058.0	100.00
RUNOFF	2.268	(1.4899)	404004.06	6.004
EVAPOTRANSPIRATION	18.944	(2.9354)	3375101.25	50.157
PERCOLATION/LEAKAGE THROUGH LAYER 2	16.57330	(3.78598)	2952706.000	43.87993
AVERAGE HEAD ON TOP OF LAYER 2	0.028	(0.006)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	16.74053	(4.04880)	2982499.000	44.32268
CHANGE IN WATER STORAGE	-0.183	(3.4512)	-32544.67	-0.484

♀

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.34	595055.750
RUNOFF	2.193	390710.0620
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.551147	454513.40600
AVERAGE HEAD ON TOP OF LAYER 2	1.789	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.195620	34851.67970
SNOW WATER	3.40	605259.6870
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4528
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.0850

GUDESSLO

0

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	0.3917	0.0979
2	28.5570	0.5010
3	8.7480	0.2916
4	145.5473	0.2940
5	22.4598	0.2415
SNOW WATER	0.000	

WOCAPUT

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS = 57.00 INCHES
POROSITY = 0.5010 VOL/VOL
FIELD CAPACITY = 0.0020 VOL/VOL
WILTING POINT = 0.0010 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.5010 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.146000006000E-03 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS = 30.00 INCHES
POROSITY = 0.4630 VOL/VOL
FIELD CAPACITY = 0.2320 VOL/VOL
WILTING POINT = 0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2994 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS = 495.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.3012 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS = 93.00 INCHES
POROSITY = 0.4530 VOL/VOL
FIELD CAPACITY = 0.1900 VOL/VOL
WILTING POINT = 0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2550 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.720000011000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-
Page 2

WOCAPOUT
 SPECIFIED CURVE NUMBER OF 71.0, A SURFACE SLOPE
 OF 2. % AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER	=	69.30	
FRACTION OF AREA ALLOWING RUNOFF	=	99.5	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	91.350	ACRES
EVAPORATIVE ZONE DEPTH	=	4.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.855	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	1.812	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.340	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	211.216	INCHES
TOTAL INITIAL WATER	=	211.216	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
 WASHINGTON DISTRICT OF COLUMBIA

STATION LATITUDE	=	38.90	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	104	
END OF GROWING SEASON (JULIAN DATE)	=	296	
EVAPORATIVE ZONE DEPTH	=	4.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	62.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	65.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
2.76	2.62	3.46	2.93	3.48	3.35
3.88	4.40	3.22	2.90	2.82	3.18

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
31.40	33.60	42.40	53.30	62.40	70.70
75.50	74.30	67.40	55.30	44.80	35.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
 COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

WOCAPOUT
AND STATION LATITUDE = 38.90 DEGREES

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.55 4.10	2.78 3.32	3.17 2.85	3.03 3.25	3.40 2.62	3.79 2.90
STD. DEVIATIONS	1.38 2.25	1.13 1.65	1.46 1.98	1.38 2.21	2.11 1.10	1.86 1.63
RUNOFF						
TOTALS	0.344 0.001	1.283 0.004	0.450 0.009	0.000 0.008	0.003 0.000	0.007 0.073
STD. DEVIATIONS	0.602 0.006	1.397 0.024	0.784 0.035	0.000 0.022	0.012 0.002	0.021 0.327
EVAPOTRANSPIRATION						
TOTALS	0.878 2.535	0.834 2.050	1.747 1.537	1.780 1.192	1.985 1.092	2.371 0.937
STD. DEVIATIONS	0.304 0.980	0.410 0.921	0.436 0.809	0.690 0.494	0.901 0.419	0.935 0.212
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.9754 1.4959	0.6700 1.3345	1.7137 1.2703	1.1903 1.9778	1.4960 1.4381	1.4910 1.6123
STD. DEVIATIONS	1.0999 1.5203	0.7955 1.0263	1.0892 1.3757	0.7834 1.8803	1.4744 0.9363	1.2746 1.4490
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	1.6628 1.3220	1.3726 1.5249	1.7890 1.2914	1.3617 1.4929	1.1957 1.3310	1.2398 1.2485
STD. DEVIATIONS	0.9012 0.6539	0.6817 0.6683	0.8052 0.7743	0.6515 0.7189	0.6293 0.7532	0.6927 0.6979

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0186	0.0188	0.0392	0.0233	0.0297	0.0318
----------	--------	--------	--------	--------	--------	--------

	WOCAPOUT					
	0.0309	0.0252	0.0262	0.0387	0.0285	0.0280
STD. DEVIATIONS	0.0223	0.0227	0.0240	0.0171	0.0319	0.0305
	0.0351	0.0219	0.0297	0.0412	0.0220	0.0281

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	37.77	(5.959)	12524438.0	100.00
RUNOFF	2.184	(1.4619)	724125.81	5.782
EVAPOTRANSPIRATION	18.936	(2.9482)	6279219.00	50.136
PERCOLATION/LEAKAGE THROUGH LAYER 2	16.66524	(3.80584)	5526200.500	44.12334
AVERAGE HEAD ON TOP OF LAYER 2	0.028	(0.006)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	16.83225	(4.06800)	5581584.000	44.56554
CHANGE IN WATER STORAGE	-0.182	(3.4667)	-60488.99	-0.483

♀

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.34	1107545.620
RUNOFF	2.183	723971.3120
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.520311	835736.37500
AVERAGE HEAD ON TOP OF LAYER 2	1.783	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.196413	65130.56250
SNOW WATER	3.40	1126537.6200
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4500
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.0850

WOCAPOUT

0

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	0.3936	0.0984
2	28.5570	0.5010
3	8.7484	0.2916
4	145.5685	0.2941
5	22.4758	0.2417
SNOW WATER	0.000	

WCAPOUT

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2105	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.000000000	CM/SEC
SLOPE	=	4.00	PERCENT
DRAINAGE LENGTH	=	1000.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	10.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3	- GOOD

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 6

THICKNESS	=	4.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2102	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 0

THICKNESS	=	57.00	INCHES
POROSITY	=	0.5010	VOL/VOL
FIELD CAPACITY	=	0.2840	VOL/VOL
WILTING POINT	=	0.1350	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2846	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.146000006000E-03	CM/SEC

WCAPOUT
LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8
THICKNESS = 30.00 INCHES
POROSITY = 0.4630 VOL/VOL
FIELD CAPACITY = 0.2320 VOL/VOL
WILTING POINT = 0.1160 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2320 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.369999994000E-03 CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18
THICKNESS = 495.00 INCHES
POROSITY = 0.6710 VOL/VOL
FIELD CAPACITY = 0.2920 VOL/VOL
WILTING POINT = 0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.100000005000E-02 CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6
THICKNESS = 93.00 INCHES
POROSITY = 0.4530 VOL/VOL
FIELD CAPACITY = 0.1900 VOL/VOL
WILTING POINT = 0.0850 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.1900 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.720000011000E-03 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-SPECIFIED CURVE NUMBER OF 71.0, A SURFACE SLOPE OF 4. % AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER = 69.80
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 91.350 ACRES
EVAPORATIVE ZONE DEPTH = 10.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE = 2.343 INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE = 4.530 INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE = 0.850 INCHES
INITIAL SNOW WATER = 0.000 INCHES
INITIAL WATER IN LAYER MATERIALS = 192.186 INCHES
TOTAL INITIAL WATER = 192.186 INCHES

WCAPOUT

 PRECIPITATION

TOTALS	2.55 4.10	2.78 3.32	3.17 2.85	3.03 3.25	3.40 2.62	3.79 2.90
STD. DEVIATIONS	1.38 2.25	1.13 1.65	1.46 1.98	1.38 2.21	2.11 1.10	1.86 1.63

 RUNOFF

TOTALS	0.231 0.002	0.972 0.002	0.321 0.009	0.000 0.009	0.004 0.002	0.004 0.054
STD. DEVIATIONS	0.420 0.008	1.178 0.009	0.581 0.036	0.000 0.031	0.020 0.008	0.014 0.255

 EVAPOTRANSPIRATION

TOTALS	0.944 3.272	0.922 2.864	2.334 2.026	2.535 1.400	2.902 1.297	3.224 1.017
STD. DEVIATIONS	0.368 1.371	0.491 1.185	0.466 1.072	0.883 0.444	1.107 0.353	1.329 0.182

 LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	1.1878 0.5717	0.8607 0.5986	1.7002 0.5606	0.6985 1.2947	0.8250 1.1587	0.6237 1.2389
STD. DEVIATIONS	0.8557 0.7315	0.8771 0.6480	0.8414 0.7825	0.7193 1.4524	1.0662 1.0477	0.6719 1.1715

 PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0087 0.0043	0.0091 0.0038	0.0212 0.0127	0.0051 0.0219	0.0089 0.0118	0.0047 0.0160
STD. DEVIATIONS	0.0108 0.0108	0.0168 0.0051	0.0230 0.0426	0.0100 0.0426	0.0246 0.0226	0.0083 0.0327

 PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0131 0.0051	0.0106 0.0045	0.0138 0.0033	0.0173 0.0060	0.0207 0.0088	0.0135 0.0151
STD. DEVIATIONS	0.0139 0.0108	0.0122 0.0096	0.0148 0.0087	0.0162 0.0119	0.0267 0.0104	0.0192 0.0146

 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

 DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0656 0.0295	0.0860 0.0226	0.2015 0.1344	0.0345 0.2227	0.0766 0.1068	0.0339 0.1495
STD. DEVIATIONS	0.1149 0.1159	0.1979 0.0467	0.2571 0.5061	0.1084 0.4779	0.2721 0.2578	0.0871 0.3676

WCAPOUT

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	37.77	(5.959)	12524438.0	100.00
RUNOFF	1.611	(1.2442)	534291.81	4.266
EVAPOTRANSPIRATION	24.737	(3.4278)	8202647.00	65.493
LATERAL DRAINAGE COLLECTED FROM LAYER 2	11.31905	(3.66468)	3753401.500	29.96862
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.12807	(0.09013)	42467.023	0.33907
AVERAGE HEAD ON TOP OF LAYER 3	0.097	(0.085)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.13175	(0.08414)	43687.285	0.34882
CHANGE IN WATER STORAGE	-0.029	(1.1838)	-9586.85	-0.077

♀

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.34	1107545.620
RUNOFF	1.980	656660.1870
DRAINAGE COLLECTED FROM LAYER 2	0.44825	148639.28100
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.044864	14876.79390
AVERAGE HEAD ON TOP OF LAYER 3	15.952	
MAXIMUM HEAD ON TOP OF LAYER 3	27.743	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	129.1 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.005176	1716.27661
SNOW WATER	3.40	1126537.6200
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.4066

MINIMUM VEG. SOIL WATER (VOL/VOL) WCAPOUT 0.0850

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

♀

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	5.1823	0.2159
2	0.0216	0.1096
3	0.0000	0.0000
4	0.7600	0.1900
5	16.1873	0.2840
6	6.9597	0.2320
7	144.5277	0.2920
8	17.6797	0.1901
SNOW WATER	0.000	

Attachment C

Laboratory Reports

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14 March 2019

Laura Oakes
EA Engineering
225 Schilling Circle, STE 400
Hunt Valley, MD 21031
RE: GUDE LANDFILL

Enclosed are the results of analyses for samples received by the laboratory on 03/05/19 15:54.

Maryland Spectral Services, Inc. is a TNI 2009 Standard accredited laboratory and as such, all analyses performed at Maryland Spectral Services included in this report are 2009 TNI certified except as indicated at the end of this report. Please visit our website at www.mdspectral.com for a complete listing of our TNI 2009 Standard accreditations.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,



Will Brewington
President

Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

Reported:

03/14/19 13:26

Client Sample ID	Alternate Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
FLARE SUMP		9030516-01	Nonpotable Water	03/05/19 09:53	03/05/19 15:54
FIELD SUMP		9030516-02	Nonpotable Water	03/05/19 10:29	03/05/19 15:54
TRIP BLANK		9030516-03	Nonpotable Water	03/05/19 00:00	03/05/19 15:54



Will Brewington, President

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

FLARE SUMP

9030516-01 (Nonpotable Water)
Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
pH MEASUREMENT BY EPA 9045D									O-04, O-05
pH	7.05		pH Units			1	03/07/19	03/07/19 19:29	VVD
TURBIDITY BY EPA 180.1									
Turbidity	8.69		NTU	0.500	0.500	1	03/06/19	03/06/19 20:25	VVD
VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS)									
Acetone	82.4		ug/L	5.0	5.0	1	03/12/19	03/12/19 13:13	GM
Acrylonitrile	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 13:13	GM
Allyl chloride (3-Chloropropylene)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Benzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Bromochloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Bromodichloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Bromoform	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Bromomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
2-Butanone (MEK)	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 13:13	GM
Carbon disulfide	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Carbon tetrachloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Chlorobenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Chloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Chloroform	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Chloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Chloroprene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Dibromochloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,2-Dibromo-3-chloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,2-Dibromoethane (EDB)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Dibromomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,2-Dichlorobenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,4-Dichlorobenzene	2.2		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
trans-1,4-Dichloro-2-butene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,1-Dichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,2-Dichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,1-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
cis-1,2-Dichloroethene	1.0		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
trans-1,2-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,2-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM

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Will Brewington, President

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

FLARE SUMP

9030516-01 (Nonpotable Water)
Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS) (continued)									
1,3-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
2,2-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,1-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
cis-1,3-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
trans-1,3-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Ethyl methacrylate	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 13:13	GM
Ethylbenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
2-Hexanone	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 13:13	GM
Isobutanol	ND		ug/L	100	100	1	03/12/19	03/12/19 13:13	GM
Iodomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Methyl tert-butyl ether (MTBE)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
4-Methyl-2-pentanone	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 13:13	GM
Methylene chloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Methyl methacrylate	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 13:13	GM
Styrene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,1,1,2-Tetrachloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,1,2,2-Tetrachloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Tetrachloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Toluene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,1,1-Trichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,1,2-Trichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Trichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Trichlorofluoromethane (Freon 11)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
1,2,3-Trichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Vinyl acetate	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
Vinyl chloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
o-Xylene	1.1		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
m- & p-Xylenes	1.9		ug/L	1.0	1.0	1	03/12/19	03/12/19 13:13	GM
<i>Surrogate: 1,2-Dichloroethane-d4</i>			<i>80-120</i>	<i>99 %</i>	<i>03/12/19</i>		<i>03/12/19 13:13</i>		
<i>Surrogate: Toluene-d8</i>			<i>88-110</i>	<i>94 %</i>	<i>03/12/19</i>		<i>03/12/19 13:13</i>		
<i>Surrogate: 4-Bromofluorobenzene</i>			<i>86-115</i>	<i>102 %</i>	<i>03/12/19</i>		<i>03/12/19 13:13</i>		

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

Reported:

03/14/19 13:26

FLARE SUMP

9030516-01 (Nonpotable Water)

Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
TOTAL METALS ANALYSIS BY EPA 3010A/6020A									
Hardness as CaCO3	130000		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Antimony	31.7		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Arsenic	3.31		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Barium	24.2		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Beryllium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Cadmium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Calcium	34800		ug/L	80.0	80.0	1	03/06/19	03/08/19 01:14	VVD
Chromium	5.27		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Cobalt	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Copper	11.0		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Iron	1090		ug/L	100	100	1	03/06/19	03/08/19 01:14	VVD
Lead	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Magnesium	10500		ug/L	100	100	1	03/06/19	03/08/19 01:14	VVD
Manganese	45.9		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Mercury	ND		ug/L	0.100	0.100	1	03/06/19	03/08/19 01:14	VVD
Nickel	8.05		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Potassium	3690		ug/L	100	100	1	03/06/19	03/08/19 01:14	VVD
Selenium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Silver	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Sodium	99700		ug/L	100	100	1	03/06/19	03/08/19 01:14	VVD
Thallium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Vanadium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:14	VVD
Zinc	36.7		ug/L	4.00	4.00	1	03/06/19	03/08/19 01:14	VVD
CHEMICAL OXYGEN DEMAND BY EPA 410.4									
COD	37.8		mg/L	20.0	20.0	1	03/12/19	03/12/19 16:26	VVD

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

FLARE SUMP

9030516-01 (Nonpotable Water)
Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
TOTAL SUSPENDED SOLIDS BY USGS I-3765-85									
Solids, Suspended	4.3		mg/L	2.7	2.7	1	03/11/19	03/11/19 17:32	AM
Wet Chemistry Performed at Enviro-Chem									
Ammonia Nitrogen	0.95		mg/L	0.10	0.05	1	03/08/19	03/08/19 14:13	FRD
Chloride	157		mg/L	5.0	5.0	10	03/07/19	03/07/19 21:44	SES
Conductivity	782		us/Cm	1.00	1.00	1	03/09/19	03/09/19 16:30	SES
Dissolved Solids	432		mg/L	5.0	5.0	1	03/09/19	03/09/19 11:50	SES
Nitrate (as N)	1.1		mg/L	0.2	0.1	1	03/06/19	03/06/19 18:32	SES
Sulfate	28.5		mg/L	1.0	0.5	1	03/06/19	03/06/19 18:32	SES
Alkalinity SM2320B Performed at Enviro-Chem									
Alkalinity as CaCO3	112		mg/L	1.0	1.0	1	03/08/19	03/08/19 16:30	SES



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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

FIELD SUMP

9030516-02 (Nonpotable Water)
Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
pH MEASUREMENT BY EPA 9045D									O-04, O-05
pH	7.76		pH Units			1	03/07/19	03/07/19 19:29	VVD
TURBIDITY BY EPA 180.1									
Turbidity	17.4		NTU	0.500	0.500	1	03/06/19	03/06/19 20:28	VVD
VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS)									
Acetone	621	Ea	ug/L	5.0	5.0	1	03/12/19	03/12/19 12:47	GM
Acrylonitrile	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:47	GM
Allyl chloride (3-Chloropropylene)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Benzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Bromochloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Bromodichloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Bromoform	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Bromomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
2-Butanone (MEK)	727	Ea	ug/L	5.0	5.0	1	03/12/19	03/12/19 12:47	GM
Carbon disulfide	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Carbon tetrachloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Chlorobenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Chloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Chloroform	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Chloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Chloroprene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Dibromochloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,2-Dibromo-3-chloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,2-Dibromoethane (EDB)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Dibromomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,2-Dichlorobenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,4-Dichlorobenzene	5.5		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
trans-1,4-Dichloro-2-butene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,1-Dichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,2-Dichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,1-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
cis-1,2-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
trans-1,2-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,2-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM

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Will Brewington, President

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

FIELD SUMP

9030516-02 (Nonpotable Water)
Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS) (continued)									
1,3-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
2,2-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,1-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
cis-1,3-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
trans-1,3-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Ethyl methacrylate	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:47	GM
Ethylbenzene	1.1		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
2-Hexanone	5.4		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:47	GM
Isobutanol	ND		ug/L	100	100	1	03/12/19	03/12/19 12:47	GM
Iodomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Methyl tert-butyl ether (MTBE)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
4-Methyl-2-pentanone	29.0		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:47	GM
Methylene chloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Methyl methacrylate	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:47	GM
Styrene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,1,1,2-Tetrachloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,1,2,2-Tetrachloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Tetrachloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Toluene	2.2		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,1,1-Trichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,1,2-Trichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Trichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Trichlorofluoromethane (Freon 11)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
1,2,3-Trichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Vinyl acetate	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
Vinyl chloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
o-Xylene	2.6		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
m- & p-Xylenes	5.7		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:47	GM
<i>Surrogate: 1,2-Dichloroethane-d4</i>			80-120	100 %	03/12/19		03/12/19 12:47		
<i>Surrogate: Toluene-d8</i>			88-110	93 %	03/12/19		03/12/19 12:47		
<i>Surrogate: 4-Bromofluorobenzene</i>			86-115	103 %	03/12/19		03/12/19 12:47		

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

Reported:

03/14/19 13:26

FIELD SUMP

9030516-02 (Nonpotable Water)

Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
TOTAL METALS ANALYSIS BY EPA 3010A/6020A									
Hardness as CaCO ₃	586000		ug/L	20.0	20.0	20	03/06/19	03/11/19 13:14	VVD
Antimony	79.6		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Arsenic	4.22		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Barium	60.8		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Beryllium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Cadmium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Calcium	119000		ug/L	1600	1600	20	03/06/19	03/11/19 13:14	VVD
Chromium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Cobalt	14.6		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Copper	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Iron	1480		ug/L	100	100	1	03/06/19	03/08/19 01:20	VVD
Lead	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Magnesium	69900		ug/L	2000	2000	20	03/06/19	03/11/19 13:14	VVD
Manganese	12900		ug/L	20.0	20.0	20	03/06/19	03/11/19 13:14	VVD
Mercury	ND		ug/L	0.100	0.100	1	03/06/19	03/08/19 01:20	VVD
Nickel	6.08		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Potassium	278		ug/L	100	100	1	03/06/19	03/08/19 01:20	VVD
Selenium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Silver	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Sodium	20500		ug/L	100	100	1	03/06/19	03/08/19 01:20	VVD
Thallium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Vanadium	ND		ug/L	1.00	1.00	1	03/06/19	03/08/19 01:20	VVD
Zinc	ND		ug/L	4.00	4.00	1	03/06/19	03/08/19 01:20	VVD
CHEMICAL OXYGEN DEMAND BY EPA 410.4									
COD	67.2		mg/L	20.0	20.0	1	03/12/19	03/12/19 16:27	VVD



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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

Reported:

03/14/19 13:26

FIELD SUMP

9030516-02 (Nonpotable Water)

Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
TOTAL SUSPENDED SOLIDS BY USGS I-3765-85									
Solids, Suspended	3.5		mg/L	3.1	3.1	1	03/11/19	03/11/19 17:32	AM
Wet Chemistry Performed at Enviro-Chem									
Ammonia Nitrogen	3.07		mg/L	0.10	0.05	1	03/08/19	03/08/19 14:16	FRD
Chloride	154		mg/L	5.0	5.0	10	03/07/19	03/07/19 22:02	SES
Conductivity	1240		us/Cm	1.00	1.00	1	03/09/19	03/09/19 16:30	SES
Dissolved Solids	756		mg/L	5.0	5.0	1	03/09/19	03/09/19 11:50	SES
Nitrate (as N)	0.4		mg/L	0.2	0.1	1	03/06/19	03/06/19 18:50	SES
Sulfate	63.1		mg/L	1.0	0.5	1	03/06/19	03/06/19 18:50	SES
Alkalinity SM2320B Performed at Enviro-Chem									
Alkalinity as CaCO3	196		mg/L	1.0	1.0	1	03/08/19	03/08/19 16:30	SES

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

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9030516-03 (Nonpotable Water)
Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS)									
Acetone	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:22	GM
Acrylonitrile	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:22	GM
Allyl chloride (3-Chloropropylene)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Benzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Bromochloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Bromodichloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Bromoform	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Bromomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
2-Butanone (MEK)	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:22	GM
Carbon disulfide	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Carbon tetrachloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Chlorobenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Chloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Chloroform	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Chloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Chloroprene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Dibromochloromethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,2-Dibromo-3-chloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,2-Dibromoethane (EDB)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Dibromomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,2-Dichlorobenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,4-Dichlorobenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
trans-1,4-Dichloro-2-butene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,1-Dichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,2-Dichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,1-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
cis-1,2-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
trans-1,2-Dichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,2-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,3-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
2,2-Dichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,1-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
cis-1,3-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

TRIP BLANK

9030516-03 (Nonpotable Water)
Sample Date: 03/05/19

Analyte	Result	Notes	Units	Reporting Limit (MRL)	Quantitation Limit (LOQ)	Dilution	Prepared	Analyzed	Analyst
VOLATILE ORGANICS BY EPA METHOD 8260B (GC/MS) (continued)									
trans-1,3-Dichloropropene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Ethyl methacrylate	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:22	GM
Ethylbenzene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
2-Hexanone	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:22	GM
Isobutanol	ND		ug/L	100	100	1	03/12/19	03/12/19 12:22	GM
Iodomethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Methyl tert-butyl ether (MTBE)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
4-Methyl-2-pentanone	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:22	GM
Methylene chloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Methyl methacrylate	ND		ug/L	5.0	5.0	1	03/12/19	03/12/19 12:22	GM
Styrene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,1,1,2-Tetrachloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,1,2,2-Tetrachloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Tetrachloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Toluene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,1,1-Trichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,1,2-Trichloroethane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Trichloroethene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Trichlorofluoromethane (Freon 11)	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
1,2,3-Trichloropropane	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Vinyl acetate	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Vinyl chloride	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
o-Xylene	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
m- & p-Xylenes	ND		ug/L	1.0	1.0	1	03/12/19	03/12/19 12:22	GM
Surrogate: 1,2-Dichloroethane-d4			80-120	100 %	03/12/19		03/12/19 12:22		
Surrogate: Toluene-d8			88-110	94 %	03/12/19		03/12/19 12:22		
Surrogate: 4-Bromofluorobenzene			86-115	101 %	03/12/19		03/12/19 12:22		

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001
Project Manager: Laura Oakes

Reported:
03/14/19 13:26

Maryland Spectral Services does not maintain certification for the following analytical parameters:

Enviro-Chem

Matrix , Method , Analyte

Water | TDS | Dissolved Solids	Water | SO4-IC | Sulfate
Water | NO3-IC | Nitrate (as N)	Water | NH3 | Ammonia Nitrogen
Water | COND | Conductivity	Water | CL-IC | Chloride
Water | ALK | Alkalinity as CaCO3	

Maryland Spectral Services

Matrix , Method , Analyte

Soil | pH (pH Meter) | pH

Matrix , Method , Analyte

Water | Turbidity | Turbidity	Water | COD | COD
Water | 8260 (Low Level) | Acrylonitrile	Water | 8260 (Low Level) | Allyl chloride (3-Chloropropylene)
Water | 8260 (Low Level) | Chloroprene	Water | 8260 (Low Level) | trans-1,4-Dichloro-2-butene
Water | 8260 (Low Level) | Ethyl methacrylate	Water | 8260 (Low Level) | Isobutanol
Water | 8260 (Low Level) | Iodomethane	Water | 8260 (Low Level) | Methyl methacrylate
Water | 8260 (Low Level) | Vinyl acetate	Water | 6020 (MDE Landfill Table-II) | Hardness as CaCO3
Water | 6020 (MDE Landfill Table-II) | Antimony	Water | 6020 (MDE Landfill Table-II) | Arsenic
Water | 6020 (MDE Landfill Table-II) | Barium	Water | 6020 (MDE Landfill Table-II) | Beryllium
Water | 6020 (MDE Landfill Table-II) | Cadmium	Water | 6020 (MDE Landfill Table-II) | Calcium
Water | 6020 (MDE Landfill Table-II) | Chromium	Water | 6020 (MDE Landfill Table-II) | Cobalt
Water | 6020 (MDE Landfill Table-II) | Copper	Water | 6020 (MDE Landfill Table-II) | Iron
Water | 6020 (MDE Landfill Table-II) | Lead	Water | 6020 (MDE Landfill Table-II) | Magnesium
Water | 6020 (MDE Landfill Table-II) | Manganese	Water | 6020 (MDE Landfill Table-II) | Mercury
Water | 6020 (MDE Landfill Table-II) | Nickel	Water | 6020 (MDE Landfill Table-II) | Potassium
Water | 6020 (MDE Landfill Table-II) | Selenium	Water | 6020 (MDE Landfill Table-II) | Silver
Water | 6020 (MDE Landfill Table-II) | Sodium	Water | 6020 (MDE Landfill Table-II) | Thallium
Water 6020 (MDE Landfill Table-II) Vanadium	Water 6020 (MDE Landfill Table-II) Zinc

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Analytical Results

Project: GUDE LANDFILL

Project Number: 1556404.0008.0001

Project Manager: Laura Oakes

Reported:

03/14/19 13:26

Notes and Definitions

- O-05 This sample was prepared outside of the EPA recommended holding time.
- O-04 This sample was analyzed outside the EPA recommended holding time.
- Ea The concentration indicated for this analyte is an estimated value above the calibration range of the instrument. This value is considered an estimate (CLP E-flag).
- E Over Calibration Estimated Result
- DET Analyte DETECTED
- ND Analyte NOT DETECTED at or above the reporting limit
- NR Not Reported
- dry Sample results reported on a dry weight basis
- RPD Relative Percent Difference
- %-Solids Percent Solids is a supportive test and as such does not require accreditation



Will Brewington, President

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SUBCONTRACT ORDER
Maryland Spectral Services

9030516

SENDING LABORATORY:

Maryland Spectral Services
1500 Caton Center Dr. Suite G
Halethorpe, MD 21227
Phone: 410.247.7600
Project Manager: Cory Koons

RECEIVING LABORATORY:

Enviro-Chem Laboratories, Inc
47 Loveton Circle, Suite K
Sparks, MD 21152
Phone : (410) 472-1112
Fax: (410) 472-1116

Reports Email: Reporting@mdspectral.com

Due 4:00 PM 03/14/19

Laboratory ID

Comments

Sample ID: 9030516-01 FLARE SUMP Water Sampled: 03/05/19 09:53

Alkalinity Chloride Conductance
Nitrogen, Nitrate Solids (Total Dissolved) Sulfate

Nitrogen, Ammonia

Containers Supplied:

Plastic, 0.050L None (D) Plastic, 0.050L None (E) Plastic, 0.050L None (F)

Sample ID: 9030516-02 FIELD SUMP Water Sampled: 03/05/19 10:29

Alkalinity Chloride Conductance
Nitrogen, Nitrate Solids (Total Dissolved) Sulfate

Nitrogen, Ammonia

Containers Supplied:

Plastic, 0.050L None (D) Plastic, 0.050L None (E) Plastic, 0.050L None (F)

908 2.6 °C

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Attachment N

Landfill Gas Calculations

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Project Gude Landfill Remediation Design Project No. 1564601
 Subject Landfill Gas Collection System Sheet No. 1 of 4
Header Pipes - Strength Calculations Drawing No. _____
 Computed by SS Date 6/17/19 Checked by CAAT Date 7/2/2020

Plastics Pipe Institute,
 Handbook of PE Pipe,
 Second Edition (Equation 3-10).

OBJECTIVE:

Calculate the deflection of the underground landfill gas collection header pipes, Standard Dimension Ratio (SDR) 17, HDPE pipe due to the embedment and landfill loads.

PROCEDURE:

Use the standard formulas below to determine the safety factors against ring deflection, wall crushing, and wall buckling.

A. Ring Deflection - Ring deflection is the change in vertical diameter of the pipe as the pipe-bedding layer / aggregate system deforms under the external vertical pressure. The actual ring deflection of the pipe must be less than the allowable ring deflection of the pipe. According to the Plastics Pipe Institute, the allowable ring deflection may be assumed to be 7.5%. The pipe ring deflection may be estimated as equal to the strain of the soil backfill around the pipe, which is calculated by the following equation.

$$\frac{\Delta X}{D_M} = \frac{1}{144} \left(\frac{K_{BED} L_{DL} P_E + K_{BED} P_L}{\frac{2E}{3} \left(\frac{1}{DR - 1} \right)^3 + 0.061 F_S E'} \right)$$

Where:

- K_{BED} = Bedding factor (assume 0.1)
- L_{DL} = Deflection lag factor (assume 1.25)
- γ = Unit weight of cover soil, lb/ft² (assume 70)
- H = Thickness of cover soil, ft (1.5)
- P_E = Vertical soil pressure due to earth load, lb/ft²
- P_L = Vertical soil pressure due to live load, lb/ft² (assume 1900)
- E = Apparent modulus of elasticity of pipe, lb/in² (27,000)
- DR = Pipe dimension ratio (17)
- F_S = Soil support factor (assume 1.1)
- E' = Modulus of soil reaction, lb/in² (assume 1000)
- D_M = Mean pipe diameter, in



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Vertical soil pressure due to earth load is calculated by:

$$P_E = \gamma \times H$$

Where:

- γ = Unit weight of cover soil, lb/ft³ (assume 70)
- H = Thickness of cover soil, ft (1.5)
- P_E = Vertical soil pressure due to earth load, lb/ft²

Assuming, PE pipe material designation as PE 3408 and duration of sustained loading of 100 years, apparent modulus of elasticity of pipe was obtained as 27,000 psi using Table B.1.1 of Chapter 3.

Solved:

$$\frac{\Delta X}{D_M} = \frac{1}{144} \left(\frac{(0.1 \times 1.25 \times 105) + (0.1 \times 1900)}{\frac{2 \times 27,000}{3} \left(\frac{1}{17-1} \right)^3 + 0.061 \times 1.1 \times 1000} \right)$$

$$\frac{\Delta X}{D_M} = 2.0\%$$

2.0% < 7.5% allowable ring deflection.

B. Pipe Wall Crushing -Wall crushing occurs when the stress in the pipe wall, due to external, vertical pressure, exceeds the compressive strength of the pipe material. Pipe wall compressive stress is calculated by the following equation.

$$S = \frac{(P_E + P_L)DR}{288}$$

- P_E = Vertical soil pressure due to earth load, lb/ft²
- P_L = Vertical soil pressure due to live load, lb/ft² (assume 1900)
- DR = Pipe dimension ratio (17)

Solved:

$$S = \frac{(105 + 1900) \times 17}{288}$$

$$= 118 \text{ lb/in}^2$$

Plastics Pipe Institute,
 Handbook of PE Pipe,
 Second Edition (Equation 3-13).



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Allowable Compressive Stress for HDPE is 118 lb/in² which is less than allowable compressive stress, 1000 lb/in².

C. Wall Buckling - Wall buckling is a failure along the longitudinal plane of the pipe wall. Buckling can occur when the external vertical pressure exceeds the critical buckling pressure of the pipe/bedding aggregate system. Allowable constrained buckling pressure is calculated by the following equation.

$$P_{wc} = \frac{5.65}{N} \sqrt{RB'E' \frac{E}{12(DR - 1)^3}}$$

Where:

- P_{WC} = Allowable constrained buckling pressure, lb/in²
- N = Safety factor (assume 1)
- R = Buoyancy reduction factor
- B' = Soil support factor
- E' = Modulus of soil reaction, lb/in² (assume 1000)
- E = Apparent modulus of elasticity of pipe, lb/in² (27,000)
- DR = Pipe dimension ratio (17)

Plastics Pipe Institute,
 Handbook of PE Pipe,
 Second Edition (Equations
 3-15, 3-17, 3-18).

Buoyancy reduction factor is calculated by:

$$R = 1 - 0.33 \frac{H_{GW}}{H}$$

Where:

- H_{GW} = Height of liquid above pipe (0 ft)
- H = Depth of cover, ft

Soil support factor is calculated by:

$$B' = \frac{1}{1 + 4e^{(-0.065H)}}$$

Solved:

Buoyancy reduction factor and soil support factors are calculated as 1.0 and 0.216, respectively using above mentioned equations.



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Header Pipes - Strength Calculations Drawing No. _____
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$$P_{WC} = \frac{5.65}{1} \sqrt{(1 \times 0.216 \times 1000) \frac{27000}{12(17 - 1)^3}}$$
$$P_{WC} = 61.55 \text{ psi}$$

Therefore, the factor of safety against buckling is:

$$F.O.S = \frac{61.55 \times 144}{(105 + 1900)}$$
$$F.O.S = 4.4$$

Factor of safety > 2 is acceptable.

CONCLUSIONS:

A conservative factor of safety against crushing and buckling is 2 to 1. Calculated pipe wall compressive stress for the SDR17 pipe in this application is less than the acceptable allowable stress. The pipe also provides a factor of safety of 4.4 against buckling which is above the design minimum. The percent ring deflection allowed in the SDR17 pipe is 7.5% and in this application, the maximum ring deflection is determined to be less of 2.0%. **Therefore, the SDR17 pipe will provide sufficient strength against the crushing, buckling, and ring deflection under the maximum load.**



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 Subject Landfill Gas System Pipe Sizing Sheet No. 1 of 10
 Drawing No. _____
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References:

LANDTEC. Landfill Gas System Engineering Design: A Practical Approach. 1994

Waste placement 1964 through 1982 based on historical tonnage report provided to EA.

Gude Landfill Remediation Design, Basis of Design 100% Submission. 2020

PART 1 – PIPE SIZING AND PRESSURE DROP

OBJECTIVE:

To determine which pipe diameters will be used to convey landfill gas (LFG). The pipeline diameter will be calculated using the Darcy-Weisbach Equation of Pressure Loss to ensure that there is adequate pressure flow to convey the gas along each length of pipe in the network. An 8-in. pipe is to be considered for use for the LFG header and a 6-in. pipe is to be used for the LFG laterals.

PROCEDURE:

Use the Continuity Equation, Reynolds Number, and Darcy-Weisbach Equation to determine Piping Pressure Drop to size the pipelines. Assume fully turbulent flow.

A. Continuity—This analysis will be used to calculate the velocity of the gas in each length of pipe based on the inner diameter of a trial pipe size and estimated gas flow.

$$v = \frac{Q}{\left(\frac{\pi d^2}{4}\right)}$$

where:

- Q = Flowrate of gas (cubic feet per minute [ft³/min]) = 507 ft³/min total or 4.83 ft³/min-well for 105 LFG wells (Based on the average LFG collection observed from November 2017 to April 2018).
- d = Inner diameter of pipe (feet [ft])
- v = Mean flow velocity (feet per second [ft/s]).

B. Reynolds Number—Calculate the Reynolds number to estimate friction factor for use in the Darcy-Weisbach Equation. Assume absolute viscosity is 8.0x10⁻⁶ pound-mass (lb_m)/ft s and density is 0.061 lb_m/ft³.

$$Re = \frac{d * v * \rho}{\mu}$$

where:

- d = Inner diameter of pipe (ft)
- v = Mean flow velocity (ft/s)



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ρ = Density of LFG (lb_m/ft^3) = $0.061 \text{ lb}_m/\text{ft}^3$
 μ = Absolute viscosity ($\text{lb}_m/\text{ft}\cdot\text{s}$) = $8.0 \times 10^{-6} \text{ lb}_m/\text{ft}\cdot\text{s}$
Re = Reynolds Number.

C. Darcy Friction Factor—Friction factor is found by calculating the relative roughness in which the absolute roughness was assumed to be 7×10^{-5} ft for high-density polyethylene (HDPE). Using a Moody diagram, relative roughness, and Reynolds number, the friction factor can be determined.

$$\text{relative roughness} = \frac{\varepsilon}{d}$$

where:

d = Inner diameter of pipe (ft)
 ε = Absolute Roughness (ft) = 7×10^{-5} ft.

D. Darcy-Weisbach Equation—This analysis will be used to calculate the change in pressure over the length of the pipe. Gravity is assumed to be $32.2 \text{ (lb}_m/\text{ft}\cdot\text{pound-force [lb}_f\text{]}/\text{s}^2)$. A conversion of 27.7 is used to convert a pressure of pounds per square inch (psi) to inches of water column. Using an 8-in. pipe for the LFG header and 6-in. for the laterals, the change in pressure through each pipe is calculated using the following equations:

$$\Delta P = \frac{\rho * f * L * v^2}{144 * d * 2g} * 27.7$$

where:

ΔP = Pressure drop (inches [in.] of water column [w.c.])
 ρ = Density of LFG (lb_m/ft^3)
f = Darcy friction factor
L = Length of piping (ft)
v = Mean flow velocity (ft/s)
d = Inner diameter of pipe (ft)
g = Gravitational constant ($(\text{lb}_m/\text{ft}\cdot\text{lb}_f)/\text{s}^2$) = $32.2 \text{ (lb}_m/\text{ft}\cdot\text{lb}_f)\text{s}^2$.

Solution: The computed analysis using Excel is presented in the attached table.



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CONCLUSION:

An 8-in. nominal diameter pipe will be effective for the LFG extraction design for the header pipes and 6-in. nominal diameter pipe for the lateral piping. In addition, EA has verified that there is sufficient vacuum pressure available at the existing blower, considering pressure losses from the proposed LFG collection system.

PART 2 – CONDENSATE ESTIMATION AND PIPE SIZING

OBJECTIVE:

Estimate the quantity of condensate production in the LFG collection system to determine the appropriate line size and frequency of condensate traps required to remove condensate from the LFG collection system.

PROCEDURE:

Use Antoine's Equation to determine a conservative estimate of condensate produced within the system and then use Manning's Equation to verify maximum flow capacity.

A. Antoine's Equation—Use Antoine's equation to provide a conservative estimate for LFG production.

$$V_{cond} = 5,694 * 10^{\beta} / P_s$$

where:

V_{cond} = Volume of condensate (water) produced (gallons per million cubic foot of LFG)

β = $6.32 - (3081/T + 385)$

T = Maximum gas temperature (degrees Fahrenheit [°F]) =
Assume average initial temperature of gas at 110 °F

P_s = System pressure (psia) = Assume 13.617 @ 30 in. w.c. vacuum (average).

$$V_{cond} = 521.3 \frac{gal}{MMcfLFG}$$

Solution: Total gas production from the landfill is estimated at 507 cfm (waste placement 1964 through 1982 based on historical tonnage report provided to EA); therefore, the Total Volume of condensate produced per



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minute is estimated at 0.264 gallon per minute (gpm). If assumed condensate production is uniform across all 105 LFG wells, the total condensate production per well is estimated at = 0.0025 gpm.

B. Manning's Equation—The system has been designed to drain condensate by gravity and utilize common collection lines with the LFG collection system. Using the Manning's equation, a maximum flow capacity was calculated for both 6-in.- and 8-in.-diameter piping.

$$Q = (1.486/n)(AR^{2/3})(S^{1/2})$$

$$R = A/(2 * \pi r)$$

where:

- Q = Flow (cubic feet per second [cfs]); 1 cfs = 448.8 gpm
- n = Manning's coefficient, assume 0.010 for HDPE
- A = Area of pipe, 0.20 ft² for 6-in. and 0.35 ft² for 8-in.
- R = Hydraulic Radius as calculated above
- S = Slope, assume minimum 0.03.

Solution: Using the Manning's Equation above at slope 0.03, the flow capacity of a 6-in. pipe was calculated to be 0.90 cfs (404 gpm) and 1.9 cfs (853 gpm) for 8-in. pipe. The small pipe sizes are more likely to be affected by landfill settlement; therefore, pipe installation at higher slope is important for these pipe runs. For shorter piping runs at 0.06 slope, the flow capacity was calculated to be 1.28 cfs (574 gpm) for 6-in. pipe and 2.7 cfs (1212 gpm) for 8-in. pipe.

CONCLUSION:

The contribution of 0.0025 gpm condensate across the entire LFG collection system relative to the significantly larger capacity of the LFG collection piping was determined to be negligible in pipe sizing. However, as good design practice to accommodate future landfill settlement, multiple condensate traps were designed for placement throughout the collection header within the landfill to allow for condensate drainage back into the landfill.

Pressure Loss Through Pipes and Fittings

Segment	Start	Start Elevation (ft)	Finish	Finish Elevation (ft)	Horizontal Pipe Length (ft)	Pipe Slope (ft/ft)	Actual Pipe Length (+20%) (ft)	Vapor Density (lb _m /ft ³)	Vacuum Pressure (psi)	Absolute Viscosity (lb _m /ft*s)	Wells Added	Flow Added (cfm)	Flow (cfm)	Nominal Size (in)	ID (in)	ID Area (ft ²)	Velocity (ft/s)	Reynolds Number	Absolute Factor	Relative Roughness (in)	Darcy friction Factor	Pressure Loss (in WC)
EAST LOOP (EAST OF MIDDLE HEADER)																						
L1	EW-111	421.23	EB	464.81	164	0.030	204	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00108
LEB.EC	EB	464.81	EC	466.60	120	0.030	144	0.061	20.000	0.000008	0	0.00	4.83	8	7.45	0.30	0.265844	1240.88	0.00007	0.0001128	0.07262	0.00022
L2	EW-112	425.03	EC	466.30	159	0.030	197	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00104
LEC.ED	EC	466.30	ED	467.53	77	0.030	92	0.061	20.000	0.000008	0	0.00	9.66	8	7.45	0.30	0.531689	2481.76	0.00007	0.0001128	0.05877	0.00045
L3	EW-10	470.72	ED	467.53	76	0.030	91	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00048
LED.EE	ED	467.53	EE	468.35	59	0.030	71	0.061	20.000	0.000008	0	0.00	14.49	8	7.45	0.30	0.797533	3722.64	0.00007	0.0001128	0.05204	0.00069
L4	EW-113	427.86	EE	468.35	157	0.030	195	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00103
LEE.EF	EE	468.35	EF	469.26	21	0.030	26	0.061	20.000	0.000008	0	0.00	19.31	8	7.45	0.30	1.063377	4963.52	0.00007	0.0001128	0.04778	0.00041
L5	EW-114	427.86	EF	469.26	112	0.030	143	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00076
LEE.EF	EF	469.26	EF	469.26	21	0.030	26	0.061	20.000	0.000008	0	0.00	24.14	8	7.45	0.30	1.329222	6204.40	0.00007	0.0001128	0.04475	0.00060
L6	EW-172	474.35	EF	469.26	348	0.030	418	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00221
LEF.EG	EF	469.26	EG	471.07	203	0.030	244	0.061	20.000	0.000008	0	0.00	24.14	8	7.45	0.30	1.329222	6204.40	0.00007	0.0001128	0.04475	0.00567
L7	EW-177	475.63	EG	471.07	111	0.030	133	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00070
LEG.EH	EG	471.07	EH	471.15	8	0.030	10	0.061	20.000	0.000008	0	0.00	28.97	8	7.45	0.30	1.595066	7445.28	0.00007	0.0001128	0.04244	0.00031
L8	EW-170	433	EH	471.15	139	0.030	173	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00091
LEH.EH1	EH	471.15	EH1	471.48	33	0.030	40	0.061	20.000	0.000008	0	0.00	33.80	8	7.45	0.30	1.860911	8686.15	0.00007	0.0001128	0.04059	0.00164
LEH1.EH2	EH1	471.48	EH2	468.57	127	0.030	152	0.061	20.000	0.000008	0	0.00	33.80	8	7.45	0.30	1.860911	8686.15	0.00007	0.0001128	0.04059	0.00631
LEH2.EI	EH2	468.57	EI	468.91	49	0.030	59	0.061	20.000	0.000008	0	0.00	33.80	8	7.45	0.30	1.860911	8686.15	0.00007	0.0001128	0.04059	0.00243
L9	EW-175	441.73	EI	468.91	114	0.030	141	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00074
LEI.EJ	EI	468.91	EJ	469.18	10	0.030	12	0.061	20.000	0.000008	0	0.00	38.63	8	7.45	0.30	2.126755	9927.03	0.00007	0.0001128	0.03906	0.00062
L10	EW-176	470.54	EJ	469.18	32	0.030	38	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00020
LEJ.EJ1	EJ	469.18	EJ1	469.90	35	0.030	42	0.061	20.000	0.000008	0	0.00	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00267
LEJ1.EJ2	EJ1	469.9	EJ2	473.30	76	0.030	91	0.061	20.000	0.000008	0	0.00	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00581
LEJ2.EJ3	EJ2	473.3	EJ3	472.82	28	0.030	34	0.061	20.000	0.000008	0	0.00	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00214
LEJ3.EJ4	EJ3	472.82	EJ4	473.82	10	0.030	12	0.061	20.000	0.000008	0	0.00	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00077
LEJ4.EJ5	EJ4	473.82	EJ5	472.35	35	0.030	42	0.061	20.000	0.000008	0	0.00	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00268
LEJ5.EK	EJ5	472.35	EK	474.69	41	0.030	49	0.061	20.000	0.000008	0	0.00	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00314
L11	EW-174	475.22	EK	474.69	17	0.030	21	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00011
LEK.EK1	EK	474.69	EK1	475.00	118	0.030	142	0.061	20.000	0.000008	0	0.00	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.01080
L12	EW-189	475.09	EK1	475.00	100	0.030	120	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00063
LEK1.EK2	EK1	472.35	EK2	476.00	175	0.030	210	0.061	20.000	0.000008	0	0.00	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.01602
LEK2.EK3	EK2	474.69	EL	476.45	100	0.030	120	0.061	20.000	0.000008	0	0.00	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.00915
L13	EW-173	475.09	EL	476.45	32	0.030	38	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00020
LEL.EL1	EL	476.45	EL1	474.17	89	0.030	107	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.00962
LEL1.EL2	EL1	474.17	EL2	471.78	57	0.030	68	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.00615
L14	EW-189	475.09	EL2	471.78	268	0.030	322	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00170
LEL2.EL3	EL2	471.78	EL3	469.68	76	0.030	91	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.00820
LEL3.EM	EL3	469.68	EM	472.26	79	0.030	95	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.00852
L15	EW-15	472.54	EM	471.96	79	0.030	95	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00050
LEM.EM1	EM	471.96	EM1	469.93	52	0.030	62	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.00652
LEM1.EM2	EM1	469.93	EM2	470.97	20	0.030	24	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.00251
L16	EW-187	466.96	EM2	470.97	100	0.030	120	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00063
LEM2.EM3	EM2	470.97	EM3	467.69	246	0.030	295	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.03080
LEM3.EN	EM3	467.69	EN	462.00	52	0.030	63	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.00655
L17	EW-17	466.96	EN	462.00	38	0.030	46	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00024
LEN.EN1	EN	462.00	EN1	463.46	84	0.030	101	0.061	20.000	0.000008	0	0.00	62.77	8	7.45	0.30	3.455977	16131.43	0.00007	0.0001128	0.03404	0.01207
LEN1.EO	EN1																					

Pressure Loss Through Pipes and Fittings

Segment	Start	Start Elevation (ft)	Finish	Finish Elevation (ft)	Horizontal Pipe Length (ft)	Pipe Slope (ft/ft)	Actual Pipe Length (+20%) (ft)	Vapor Density (lb _m /ft ³)	Vacuum Pressure (psi)	Absolute Viscosity (lb _m /ft*s)	Wells Added	Flow Added (cfm)	Flow (cfm)	Nominal Size (in)	ID (in)	ID Area (ft ²)	Velocity (ft/s)	Reynolds Number	Absolute Factor	Relative Roughness (in)	Darcy friction Factor	Pressure Loss (in WC)
L23	EW-166	463.58	ER	457.25	211	0.030	253	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00134
LER.ER1	ER	457.25	ER1	452.98	39	0.030	47	0.061	20.000	0.000008	0	0.00	82.09	8	7.45	0.30	4.519354	21094.95	0.00007	0.0001128	0.03160	0.00899
LER1.ER2	ER1	452.98	ER2	452.18	7	0.030	8	0.061	20.000	0.000008	0	0.00	82.09	8	7.45	0.30	4.519354	21094.95	0.00007	0.0001128	0.03160	0.00154
LER2.ES	ER2	452.18	ES	453.75	66	0.030	79	0.061	20.000	0.000008	0	0.00	82.09	8	7.45	0.30	4.519354	21094.95	0.00007	0.0001128	0.03160	0.01503
L24	EW-165	463.58	ES	453.75	211	0.030	253	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00134
LES.ES1	ES	453.75	ES1	451.95	32	0.030	38	0.061	20.000	0.000008	0	0.00	86.91	8	7.45	0.30	4.785199	22335.83	0.00007	0.0001128	0.03111	0.00807
LES1.ES2	ES1	453.75	ES2	450.79	36	0.030	43	0.061	20.000	0.000008	0	0.00	86.91	8	7.45	0.30	4.785199	22335.83	0.00007	0.0001128	0.03111	0.00909
LES2.ES3	ES2	453.75	ES3	445.00	100	0.030	120	0.061	20.000	0.000008	0	0.00	86.91	8	7.45	0.30	4.785199	22335.83	0.00007	0.0001128	0.03111	0.02527
LES3.ET	ES3	451.95	ET	443.81	102	0.030	123	0.061	20.000	0.000008	0	0.00	86.91	8	7.45	0.30	4.785199	22335.83	0.00007	0.0001128	0.03111	0.02576
L25	EW-169	433.69	ET	443.81	46	0.030	57	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00030
LET.ET1	ET	443.81	ET1	443.65	57	0.030	68	0.061	20.000	0.000008	0	0.00	91.74	8	7.45	0.30	5.051043	23576.71	0.00007	0.0001128	0.03065	0.01575
L26	EW-184	463.58	ET1	443.65	100	0.030	122	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00065
LET1.ET2	ET1	443.65	ET2	439.92	52	0.030	63	0.061	20.000	0.000008	0	0.00	91.74	8	7.45	0.30	5.051043	23576.71	0.00007	0.0001128	0.03065	0.01441
LET2.EU	ET2	439.92	EU	439.50	85	0.030	102	0.061	20.000	0.000008	0	0.00	91.74	8	7.45	0.30	5.051043	23576.71	0.00007	0.0001128	0.03065	0.02349
L27	EW-164	415.50	EU	439.20	95	0.030	117	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00062
LEU.EU1	EU	439.50	EU1	434.68	39	0.030	47	0.061	20.000	0.000008	0	0.00	96.57	8	7.45	0.30	5.316887	24817.58	0.00007	0.0001128	0.03023	0.01186
LEU1.EU2	EU1	439.20	EU2	419.31	155	0.030	188	0.061	20.000	0.000008	0	0.00	96.57	8	7.45	0.30	5.316887	24817.58	0.00007	0.0001128	0.03023	0.04718
LEU2.EU3	EU2	434.68	EU3	430.20	119	0.030	143	0.061	20.000	0.000008	0	0.00	96.57	8	7.45	0.30	5.316887	24817.58	0.00007	0.0001128	0.03023	0.03595
LEU3.EV	EU3	430.20	EV	429.30	119	0.030	143	0.061	20.000	0.000008	0	0.00	96.57	8	7.45	0.30	5.316887	24817.58	0.00007	0.0001128	0.03023	0.03593
L28	EW-163	429.87	EV	429.30	6	0.030	7	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00004
LEV.EV1	EV	429.30	EV1	429.00	82	0.030	98	0.061	20.000	0.000008	0	0.00	101.40	8	7.45	0.30	5.582732	26058.46	0.00007	0.0001128	0.02983	0.02693
L29	EW-182	463.58	EV1	429.00	100	0.030	127	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00067
LEV1.EV2	EV1	429.00	EV2	433.56	73	0.030	88	0.061	20.000	0.000008	0	0.00	101.40	8	7.45	0.30	5.582732	26058.46	0.00007	0.0001128	0.02983	0.02403
LEV2.EV3	EV2	433.56	EV3	434.58	18	0.030	22	0.061	20.000	0.000008	0	0.00	101.40	8	7.45	0.30	5.582732	26058.46	0.00007	0.0001128	0.02983	0.00592
LEV3.EW	EV3	434.58	EW	435.53	17	0.030	20	0.061	20.000	0.000008	0	0.00	101.40	8	7.45	0.30	5.582732	26058.46	0.00007	0.0001128	0.02983	0.00559
L30	EW-16	457.51	EWL1	454.43	195	0.030	234	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00124
LEWL1.EWL2	EWL1	454.43	EWL2	448.13	130	0.030	156	0.061	20.000	0.000008	0	0.00	106.23	8	7.45	0.30	5.848576	27299.34	0.00007	0.0001128	0.02945	0.04633
L31	EW-162	445.00	EWL2	448.13	33	0.030	40	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00021
LEWL2.EW	EWL2	448.13	EW	435.00	130	0.030	156	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28540.22	0.00007	0.0001128	0.02910	0.05004
LEW.EW1	EW	435.00	EW1	435.50	54	0.030	65	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28540.22	0.00007	0.0001128	0.02910	0.02076
LEW1.EW2	EW1	435.50	EW2	437.00	50	0.030	60	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28540.22	0.00007	0.0001128	0.02910	0.01923
LEW1.EX	EW2	437.00	EX	437.50	45	0.030	54	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28540.22	0.00007	0.0001128	0.02910	0.01730
L32	EW-161	441.10	EX	437.50	10	0.030	13	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00007
LEX.EY	EX	437.50	EY	437.70	26	0.030	31	0.061	20.000	0.000008	0	0.00	115.89	8	7.45	0.30	6.380265	29781.10	0.00007	0.0001128	0.02877	0.01076
L33	EW-38	443.63	EY	437.3	222	0.030	266	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00141
LEY.EZ	EY	437.50	EZ	437.30	30	0.030	36	0.061	20.000	0.000008	0	0.00	120.71	8	7.45	0.30	6.646109	31021.98	0.00007	0.0001128	0.02845	0.01332
L34	EW-37	447.99	EZ	437.30	237	0.030	285	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00151
LEZ.EZA	EY	437.30	EZA	438.28	76	0.030	91	0.061	20.000	0.000008	0	0.00	125.54	8	7.45	0.30	6.911954	32262.86	0.00007	0.0001128	0.02816	0.03613
L35	EW-160	402.00	EZA	438.28	134	0.030	167	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00088
LEZA.EZA1	EZA	438.28	EZA1	438.50	39	0.030	47	0.061	20.000	0.000008	0	0.00	130.37	8	7.45	0.30	7.177798	33503.74	0.00007	0.0001128	0.02787	0.01979
LEZA1.EZA2	EZA1	438.50	EZA2	438.50	31	0.030	37	0.061	20.000	0.000008	0	0.00	130.37	8	7.45	0.30	7.177798	33503.74	0.00007	0.0001128	0.02787	0.01573
LEZA2.EZB	EZA2	438.50	EZB	440.63	16	0.030	19	0.061	20.000	0.000008	0	0.00	130.37	8	7.45	0.30	7.177798	33503.74	0.00007	0.0001128	0.02787	0.00819
L36	EW-35	441.08	EZA2	438.50	20	0.030	24	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00013
L37	EW-35	441.08	EZB	440.63	20	0.030	24	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00013
L38	EW-179	464.23	EZB	438.50	195	0.030	159	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00084
LEZB.EZC	EZB	440.63	EZC	440.93	30	0.030	36	0.061	20.000	0.000008	0	0.00	135.20	8	7.45	0.30	7.443642	34744.62	0.00007	0.0001128	0.02760	0.01621
L39	EW-34	445.46	EZC	440.93	274	0.030	329	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00174
LEZC.EZC1	EZC	440.93	EZC1	445.31	66	0.030	79	0.061	20.000	0.000008	0	0.00	140.03	8	7.45	0.30	7.709487	35985.50	0.00007	0.0001128	0.02735	0.03799
LEZC1.EZC2	EZC1	445.31	EZC2	443.30	10	0.030	12	0.061	20.000	0.000008	0	0.00	140.03	8	7.45	0.30	7.709487	35985.50	0.00007	0.0001128	0.02735	0.00586
LEZC2.EZC3	EZC2	443.30	MH	448.00	450	0.030	540	0.061	20.000	0.000008	0	0.00	140.03	8	7.45	0.30	7.709487	35985.50	0.00007	0.0001128	0.02735	0.25845
SPLIT MIDDLE HEADER CONNECTION																						
L1	EW-111	421.23	EB	464.81	164	0.030	204	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.8				

Pressure Loss Through Pipes and Fittings

Segment	Start	Start Elevation (ft)	Finish	Finish Elevation (ft)	Horizontal Pipe Length (ft)	Pipe Slope (ft/ft)	Actual Pipe Length (+20%) (ft)	Vapor Density (lb _m /ft ³)	Vacuum Pressure (psi)	Absolute Viscosity (lb _m /ft*s)	Wells Added	Flow Added (cfm)	Flow (cfm)	Nominal Size (in)	ID (in)	ID Area (ft ²)	Velocity (ft/s)	Reynolds Number	Absolute Factor	Relative Roughness (in)	Darcy friction Factor	Pressure Loss (in WC)
L44	EW-73	465.45	MH5	461.45	266	0.030	319	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00169
LMH5.MH6	MH5	461.45	MH6	460.87	108	0.030	130	0.061	20.000	0.000008	0	0.00	24.14	8	7.45	0.30	1.329222	6204.40	0.00007	0.0001128	0.04475	0.00302
L45	EW-39	462.16	MH7	458.99	74	0.030	89	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00047
LMH7.MH8	MH7	458.99	MH8	458.02	330	0.030	396	0.061	20.000	0.000008	0	0.00	28.97	8	7.45	0.30	1.595066	7445.28	0.00007	0.0001128	0.04244	0.01259
L46	EW-36	459.61	MH8	458.02	20	0.030	159	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00084
L47	EW-57	464.23	MH10	458.02	195	0.030	159	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00084
LMH8.MH6	MH8	458.02	MH6	460.87	229	0.030	275	0.061	20.000	0.000008	0	0.00	38.63	8	7.45	0.30	2.126755	9927.03	0.00007	0.0001128	0.03906	0.01430
L48	EW-71	469.56	MH9	468.36	72	0.030	86	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00046
L49	EW-52	470.05	MH9	468.36	68	0.030	82	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00043
LMH9.MH10	MH9	468.36	MH10	464.11	189	0.030	227	0.061	20.000	0.000008	0	0.00	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.01730
LMH10.MH11	MH10	464.11	MH11	467.00	151	0.030	181	0.061	20.000	0.000008	0	0.00	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.01384
L50	EW-72	467.58	MH15	467.00	50	0.030	60	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00032
LMH11.MH12	MH11	467	MH12	462.78	186	0.030	223	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.02006
L51	EW-168	463.12	MH12	462.78	50	0.030	60	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00032
LMH12.MH6	MH10	464.11	MH6	460.69	87	0.030	104	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.00939
LMH6.MH13	MH6	460.69	MH13	459.99	210	0.030	252	0.061	20.000	0.000008	0	0.00	96.57	8	7.45	0.30	5.316887	24817.58	0.00007	0.0001128	0.03023	0.06340
L52	EW-70	471.47	MH14	467.00	193	0.030	232	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00122
L53	EW-2	471.47	MH14	467.00	85	0.030	102	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00054
L54	EW-51	467.74	MH14	467.00	15	0.030	18	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00010
LMH14.MH15	MH14	467.00	MH15	463.26	241	0.030	289	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.02598
L55	EW-26	463.80	MH15	463.26	15	0.030	18	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00010
LMH15.MH16	MH15	463.26	MH16	461.76	200	0.030	240	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.02504
L56	EW-54	462.82	MH16	461.76	20	0.030	24	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00013
LMH16.MH17	MH16	461.76	MH17	459.87	155	0.030	186	0.061	20.000	0.000008	0	0.00	149.69	8	7.45	0.30	8.241176	38467.26	0.00007	0.0001128	0.02687	0.09994
LMH17.MH13	MH17	459.87	MH13	459.99	145	0.030	174	0.061	20.000	0.000008	0	0.00	101.40	8	7.45	0.30	5.582732	26058.46	0.00007	0.0001128	0.02983	0.04763
LMH13.MH18	MH13	459.99	MH18	454.85	95	0.030	114	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.01191
L57	EW-75	455.25	MH18	454.85	68	0.030	82	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00043
L58	EW-188	464.23	MH19	454.85	100	0.030	159	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00084
LMH18.MH19	MH18	454.85	MH19	460.17	118	0.030	142	0.061	20.000	0.000008	0	0.00	9.66	8	7.45	0.30	0.531689	2481.76	0.00007	0.0001128	0.05877	0.00069
L59	EW-27	460.61	MH19	453.08	314	0.030	377	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00199
LMH12.MH6	MH12	462.78	MH6	460.69	87	0.030	104	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.01090
L60	EW-76	460.96	MH19	453.08	20	0.030	26	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00014
LMH19.MH20	MH19	453.08	MH20	460.17	60	0.030	73	0.061	20.000	0.000008	0	0.00	62.77	8	7.45	0.30	3.455977	16131.43	0.00007	0.0001128	0.03404	0.00868
L61	EW-186	464.23	MH20	453.08	100	0.030	159	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00084
L62	EW-29	468.25	MH21	464.49	205	0.030	246	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00130
LMH19.MH20	MH19	464.49	MH20	460.17	60	0.030	72	0.061	20.000	0.000008	0	0.00	9.66	8	7.45	0.30	0.531689	2481.76	0.00007	0.0001128	0.05877	0.00035
L63	EW-30	463.00	MH21	464.49	61	0.030	73	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00039
LMH21.MH20	MH21	464.49	MH20	460.17	128	0.030	154	0.061	20.000	0.000008	0	0.00	72.43	8	7.45	0.30	3.987666	18613.19	0.00007	0.0001128	0.03271	0.02354
L64	EW-185	464.23	MH20	460.17	100	0.030	159	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00084
LMH20.MH22	MH17	460.17	MH19	455.30	172	0.030	206	0.061	20.000	0.000008	0	0.00	72.43	8	7.45	0.30	3.987666	18613.19	0.00007	0.0001128	0.03271	0.03163
LMH22.MH23	MH22	455.3	MH23	448.19	172	0.030	207	0.061	20.000	0.000008	0	0.00	72.43	8	7.45	0.30	3.987666	18613.19	0.00007	0.0001128	0.03271	0.03164
L65	EW-25	450.74	MH23	448.19	20	0.030	24	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00013
LMH23.MH	MH23	448.19	MH	447.06	90	0.030	108	0.061	20.000	0.000008	0	0.00	77.26	8	7.45	0.30	4.25351	19854.07	0.00007	0.0001128	0.03214	0.01849
NORTHWEST OF MIDDLE HEADER TO BLOWER-FLARE FACILITY																						
L1	EW-191	441.00	EA1	463.52	100	0.225	123	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00065
LEB.EA	EA1	463.52	EA	468.36	32	0.151	39	0.061	20.000	0.000008	0	0.00	4.83	8	7.45	0.30	0.265844	1240.88	0.00007	0.0001128	0.07262	0.00006
LEA.WA	EA	468.36	WA	462.58	150	0.039	180	0.061	20.000	0.000008	0	0.00	4.83	8	7.45	0.30	0.265844	1240.88	0.00007	0.0001128	0.07262	0.00027
L66	EW-158	425.18	WA	462.58	50	0.748	75	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00040
LWA.WB	WA	462.58	WB	468.36	50	0.116	60	0.061	20.000	0.000008	0	0.00	9.66	8	7.45	0.30	0.531689	2481.76	0.00007	0.0001128	0.05877	0.00030
L67	EW-130	465.19	WB	468.36	67	0.047	80	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00043
LWB.WB1	WB	468.36	WB1	462.58	20	0.289	25	0.061	20.000	0.000008	0	0.00	14.49	8	7.45	0.30	0.797533	3722.64	0.00007	0.0001128	0.05204	0.00024
L68	EW-110	465.19	WB1	462.58	165	0.016	198	0.061	20.000	0.00000												

Pressure Loss Through Pipes and Fittings

Segment	Start	Start Elevation (ft)	Finish	Finish Elevation (ft)	Horizontal Pipe Length (ft)	Pipe Slope (ft/ft)	Actual Pipe Length (+20%) (ft)	Vapor Density (lb _m /ft ³)	Vacuum Pressure (psi)	Absolute Viscosity (lb _m /ft*s)	Wells Added	Flow Added (cfm)	Flow (cfm)	Nominal Size (in)	ID (in)	ID Area (ft ²)	Velocity (ft/s)	Reynolds Number	Absolute Factor	Relative Roughness (in)	Darcy friction Factor	Pressure Loss (in WC)
LWC3.WC4	WC3	438.87	WC4	456.19	116	0.149	141	0.061	20.000	0.000008	0	0.00	33.80	8	7.45	0.30	1.860911	8686.15	0.00007	0.0001128	0.04059	0.00582
L72	EW-128	437.20	WC4	456.19	23	0.826	36	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00019
LWC4.WD	WC4	456.19	WD	454.52	25	0.068	29	0.061	20.000	0.000008	0	0.00	38.63	8	7.45	0.30	2.126755	9927.03	0.00007	0.0001128	0.03906	0.00153
L73	EW-108	437.15	WD	454.52	93	0.187	114	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00060
LWD.WD1	WD	454.52	WD1	454.78	80	0.003	96	0.061	20.000	0.000008	0	0.00	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00613
L74	EW-156	441.19	WD1	454.78	10	1.431	20	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00011
L75	EW-126	444.13	WD1	454.78	2	5.325	13	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00007
LWD1.WE	WD1	454.78	WE	455.72	18	0.052	22	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.00194
L76	EW-152	459.74	WE	455.72	135	0.030	162	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00086
LWE.WE1	WE	455.72	WE1	453.52	95	0.023	114	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.01190
LWE1.WE2	WE1	453.52	WE2	455.47	47	0.041	56	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.00589
LWE2.WF	WE2	455.47	WF	446.84	88	0.098	106	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.01107
L77	EW-171	452.00	WH	446.84	16	0.323	20	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00011
LWF.WF1	WF	446.84	WF1	445.68	29	0.040	35	0.061	20.000	0.000008	0	0.00	62.77	8	7.45	0.30	3.455977	16131.43	0.00007	0.0001128	0.03404	0.00417
LWF1.WF2	WF1	445.68	WF2	444.74	28	0.034	34	0.061	20.000	0.000008	0	0.00	62.77	8	7.45	0.30	3.455977	16131.43	0.00007	0.0001128	0.03404	0.00403
LWF2.WG	WF2	444.74	WG	440.82	71	0.055	85	0.061	20.000	0.000008	0	0.00	62.77	8	7.45	0.30	3.455977	16131.43	0.00007	0.0001128	0.03404	0.01022
L78	EW-157	449.15	WG	440.82	26	0.320	33	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00017
LWG.WH	WG	440.82	WH	439.02	40	0.045	48	0.061	20.000	0.000008	0	0.00	67.60	8	7.45	0.30	3.721821	17372.31	0.00007	0.0001128	0.03335	0.00654
L79	EW-105	447.96	WH	439.02	27	0.331	34	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00018
LWH.WH1	WH	439.02	WH1	433.90	116	0.044	139	0.061	20.000	0.000008	0	0.00	72.43	8	7.45	0.30	3.987666	18613.19	0.00007	0.0001128	0.03271	0.02134
LWH1.WH2	WH1	433.90	WH2	436.34	16	0.153	19	0.061	20.000	0.000008	0	0.00	72.43	8	7.45	0.30	3.987666	18613.19	0.00007	0.0001128	0.03271	0.00297
LWH2.WI	WH2	436.34	WI	437.76	47	0.030	56	0.061	20.000	0.000008	0	0.00	72.43	8	7.45	0.30	3.987666	18613.19	0.00007	0.0001128	0.03271	0.00862
L80	EW-104	445.33	WI	437.76	26	0.291	32	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00017
LWI.WJ	WI	437.76	WJ	437.49	16	0.017	19	0.061	20.000	0.000008	0	0.00	77.26	8	7.45	0.30	4.25351	19854.07	0.00007	0.0001128	0.03214	0.00329
L81	EW-119	445.27	WJ	437.76	15	0.501	20	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00011
LWJ.WJ1	WJ	437.76	WJ1	436.66	35	0.031	42	0.061	20.000	0.000008	0	0.00	82.09	8	7.45	0.30	4.519354	21026.01	0.00007	0.0001128	0.03163	0.00797
LWJ1.WJ2	WJ1	436.66	WJ2	435.05	40	0.040	48	0.061	20.000	0.000008	0	0.00	82.09	8	7.45	0.30	4.519354	21026.01	0.00007	0.0001128	0.03163	0.00911
LWJ2.WK	WJ2	435.05	WK	431.97	66	0.047	79	0.061	20.000	0.000008	0	0.00	82.09	8	7.45	0.30	4.519354	21026.01	0.00007	0.0001128	0.03163	0.01503
L82	EW-103	436.27	WK	431.97	56	0.076	68	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00036
LWK.WK1	WL	431.97	WL1	437.24	67	0.078	81	0.061	20.000	0.000008	0	0.00	86.91	8	7.45	0.30	4.785199	22262.83	0.00007	0.0001128	0.03114	0.01695
LWK1.WL	WK1	431.97	WL	427.28	113	0.042	136	0.061	20.000	0.000008	0	0.00	86.91	8	7.45	0.30	4.785199	22262.83	0.00007	0.0001128	0.03114	0.02840
L83	EW-1	458.00	WL1	455.55	128	0.019	154	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00081
LWL1.WL2	WL1	455.55	WL2	454.00	59	0.026	71	0.061	20.000	0.000008	0	0.00	91.74	8	7.45	0.30	5.051043	23499.66	0.00007	0.0001128	0.03068	0.01627
L84	EW-132	454.96	WL2	454.00	43	0.022	52	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00027
LWL2.WL3	WL2	454.00	WL3	437.26	122	0.137	148	0.061	20.000	0.000008	0	0.00	96.57	8	7.45	0.30	5.316887	24736.48	0.00007	0.0001128	0.03025	0.03709
L85	EW-102	438.8	WL3	437.26	15	0.103	18	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00010
LWL3.WL	WL3	437.26	WL	427.28	55	0.181	67	0.061	20.000	0.000008	0	0.00	101.40	8	7.45	0.30	5.582732	25973.31	0.00007	0.0001128	0.02985	0.01832
LWL.WM	WL	437.26	WM	422.02	165	0.092	199	0.061	20.000	0.000008	0	0.00	101.40	8	7.45	0.30	5.582732	25973.31	0.00007	0.0001128	0.02985	0.05430
L86	EW-101	429.38	WN	427.28	5	0.420	7	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00003
LWN.WN1	WN	424.31	WN1	425.45	52	0.022	62	0.061	20.000	0.000008	0	0.00	106.23	8	7.45	0.30	5.848576	27210.13	0.00007	0.0001128	0.02948	0.01847
LWN1.WO	WN1	425.45	WO	431.48	79	0.076	95	0.061	20.000	0.000008	0	0.00	106.23	8	7.45	0.30	5.848576	27210.13	0.00007	0.0001128	0.02948	0.02814
L87	EW-100	425.39	WO	431.48	25	0.244	31	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00016
LWO.WP	WO	431.48	WP	439.91	37	0.228	46	0.061	20.000	0.000008	0	0.00	106.23	8	7.45	0.30	5.848576	27210.13	0.00007	0.0001128	0.02948	0.01348
L88	EW-192	457.59	WP	439.91	198	0.089	239	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00126
LWP.WP1	WP	439.91	WP1	447.07	33	0.217	41	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28446.95	0.00007	0.0001128	0.02913	0.01295
LWP1.WP2	WP1	447.07	WP2	450.23	22	0.141	27	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28446.95	0.00007	0.0001128	0.02913	0.00868
LWP2.WP3	WP2	450.23	WP3	454.96	48	0.099	58	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28446.95	0.00007	0.0001128	0.02913	0.01850
LWP3.WP4	WP3	421.33	WP4	456.23	20	1.745	48	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28446.95	0.00007	0.0001128	0.02913	0.01543
LWP4.BF	WP4	456.23	WO2	425.95	27	1.121	49	0.061	20.000	0.000008	0	0.00	111.06	8	7.45	0.30	6.114421	28446.95	0.00007	0.0001128	0.02913	0.01556
Southwest of Middle Header to Blower-Flare Facility																						
LMH.SA	MH	448.00	SA	457.02	145	0.030	174	0.061	20.000	0.000008	0	4.83	4.83	8	7.45	0.30	0.265844	1240.88	0.00007	0.0001128	0.07262	0.00026
L89	EW-32	459.36	SA1	458.63	56	0.030	67	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00

Pressure Loss Through Pipes and Fittings

Segment	Start	Start Elevation (ft)	Finish	Finish Elevation (ft)	Horizontal Pipe Length (ft)	Pipe Slope (ft/ft)	Actual Pipe Length (+20%) (ft)	Vapor Density (lb _m /ft ³)	Vacuum Pressure (psi)	Absolute Viscosity (lb _m /ft*s)	Wells Added	Flow Added (cfm)	Flow (cfm)	Nominal Size (in)	ID (in)	ID Area (ft ²)	Velocity (ft/s)	Reynolds Number	Absolute Factor	Relative Roughness (in)	Darcy friction Factor	Pressure Loss (in WC)
LSD.SE	SD	466.85	SE	466.91	232	0.030	278	0.061	20.000	0.000008	0	0.00	19.31	8	7.45	0.30	1.063377	4963.52	0.00007	0.0001128	0.04778	0.00443
LSE.SF	SE	466.91	SF	460.91	200	0.030	240	0.061	20.000	0.000008	0	0.00	19.31	8	7.45	0.30	1.063377	4963.52	0.00007	0.0001128	0.04778	0.00382
L94	EW-24	467.80	SF	460.91	24	0.030	30	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00016
LSF.SG	SF	460.91	SG	460.34	15	0.030	18	0.061	20.000	0.000008	0	0.00	24.14	8	7.45	0.30	1.329222	6204.40	0.00007	0.0001128	0.04475	0.00043
L95	EW-146	428.57	SG	460.34	164	0.030	200	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00106
LSG.SG1	SG	460.34	SG1	456.88	130	0.030	156	0.061	20.000	0.000008	0	4.83	28.97	8	7.45	0.30	1.595066	7445.28	0.00007	0.0001128	0.04244	0.00496
LSG1.SH	SG1	456.88	SH	456.42	73	0.030	88	0.061	20.000	0.000008	0	4.83	28.97	8	7.45	0.30	1.595066	7445.28	0.00007	0.0001128	0.04244	0.00278
L96	EW-145	450.58	SH	456.42	50	0.030	60	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00032
LSH.SH1	SH	456.42	SH1	458.65	72	0.030	86	0.061	20.000	0.000008	0	4.83	33.80	8	7.45	0.30	1.860911	8686.15	0.00007	0.0001128	0.04059	0.00358
LSH1.SI	SH1	458.65	SI	459.31	50	0.030	60	0.061	20.000	0.000008	0	4.83	33.80	8	7.45	0.30	1.860911	8686.15	0.00007	0.0001128	0.04059	0.00248
L97	EW-23	428.57	SI	459.31	15	0.030	41	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00022
LSI.SJ	SI	459.31	SJ	460.13	51	0.030	61	0.061	20.000	0.000008	0	4.83	38.63	8	7.45	0.30	2.126755	9927.03	0.00007	0.0001128	0.03906	0.00318
L98	EW-144	432.37	SJ	460.13	144	0.030	176	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00093
LSJ.SJ1	SJ	460.13	SJ1	460.13	51	0.030	61	0.061	20.000	0.000008	0	4.83	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00390
LSJ1.SJ2	SJ1	460.13	SJ2	460.13	51	0.030	61	0.061	20.000	0.000008	0	4.83	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00390
L99	EW-50	432.37	SJ2	460.13	140	0.030	171	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00090
LSJ.SJ1	SJ	460.13	SJ1	460.13	51	0.030	61	0.061	20.000	0.000008	0	4.83	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.00467
LSJ2.SK	SJ2	460.13	SK	463.57	25	0.030	30	0.061	20.000	0.000008	0	4.83	43.46	8	7.45	0.30	2.392599	11167.91	0.00007	0.0001128	0.03777	0.00193
L100	EW-143	464.55	SK	463.57	15	0.030	18	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00010
LSK.SL	SK	463.57	SL	458.60	29	0.030	35	0.061	20.000	0.000008	0	0.00	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.00269
LSL.SM	SL	458.6	SM	456.98	78	0.030	94	0.061	20.000	0.000008	0	0.00	48.29	8	7.45	0.30	2.658444	12408.79	0.00007	0.0001128	0.03665	0.00714
L101	EW-22	460.19	SM	456.98	50	0.030	60	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00031
LSM.SN	SM	456.98	SN	459.19	54	0.030	65	0.061	20.000	0.000008	0	0.00	53.11	8	7.45	0.30	2.924288	13649.67	0.00007	0.0001128	0.03568	0.00580
L102	EW-140	461.81	SN	457.83	170	0.030	204	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00108
LSN.SN1	SN	457.83	SN1	458.63	50	0.030	60	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.00626
LSN1.SO	SN1	458.63	SO	459.95	30	0.030	36	0.061	20.000	0.000008	0	0.00	57.94	8	7.45	0.30	3.190132	14890.55	0.00007	0.0001128	0.03482	0.00376
L103	EW-138	459.11	SO	457.89	15	0.030	18	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00010
LSO.SP	SO	457.89	SP	457.89	58	0.030	70	0.061	20.000	0.000008	0	0.00	62.77	8	7.45	0.30	3.455977	16131.43	0.00007	0.0001128	0.03404	0.00833
L104	EW-139	430.49	SP	457.89	167	0.030	203	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00107
LSP.SP1	SP	457.89	SP1	455.84	50	0.030	60	0.061	20.000	0.000008	0	0.00	67.60	8	7.45	0.30	3.721821	17372.31	0.00007	0.0001128	0.03335	0.00817
LSP1.SQ	SP1	455.84	SQ	457.86	10	0.030	12	0.061	20.000	0.000008	0	0.00	72.43	8	7.45	0.30	3.987666	18613.19	0.00007	0.0001128	0.03271	0.00188
L105	EW-21	430.49	SQ	457.86	22	0.030	42	0.061	20.000	0.000008	1	4.83	4.83	6	5.80	0.18	0.438616	1593.89	0.00007	0.0001448	0.07262	0.00022
LSQ.BF	SQ	457.86	BF	457.10	68	0.030	82	0.061	20.000	0.000008	0	0.00	77.26	8	7.45	0.30	4.25351	19854.07	0.00007	0.0001128	0.03214	0.01397
CONVERGE AT OUTLET																						
LBF.BF1	BF	457.10	BF1	451.25	45	0.129	55	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.02830
LBF1.BF2	BF1	451.25	BF2	434.93	72	0.228	88	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.04557
LBF2.BF3	BF2	434.93	BF3	417.37	134	0.131	162	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.08369
LBF3.BF4	BF3	417.37	Skid	413.25	23	0.181	28	0.061	20.000	0.000008	0	0.00	507.00	12	11.50	0.72	11.71477	84406.76	0.00007	7.304E-05	0.01973	0.01436

Summary of Pressure Loss Through Pipes and Fittings

Path 1	East of Middle Header to Blower-Flare Station	1.59049 in WC
Path 2	Middle Header to Blower-Flare Station	0.80509 in WC
Path 3	West of Middle Header to Blower-Flare Station	0.63502 in WC

Pressure Loss through Valves and Fittings

Valve Number	Darcy Friction Factor	K'	d	Cv	density	# of wells	Q	Delta P	Delta P (in w.c.)
1	0.07262	40	7.45	262.394	0.065	19	91.74	0.007	2.57E-04
2	0.07262	40	5.80	159.037	0.065	3	275.23	0.175	6.30E-03
3	0.07262	40	7.45	262.394	0.065	21	101.40	0.009	3.14E-04
4	0.07262	40	5.80	159.037	0.065	4	19.31	0.001	3.10E-05
5	0.07262	40	5.80	159.037	0.065	5	24.14	0.001	4.85E-05
6	0.07262	40	5.80	159.037	0.065	2	9.66	0.000	7.76E-06
7	0.07262	40	5.80	159.037	0.065	2	9.66	0.000	7.76E-06
8	0.07262	40	5.80	159.037	0.065	3	14.49	0.000	1.75E-05
9	0.07262	40	7.45	262.394	0.065	21	101.40	0.009	3.14E-04
10	0.07262	40	5.80	159.037	0.065	2	9.66	0.000	7.76E-06
11	0.07262	40	5.80	159.037	0.065	2	9.66	0.000	7.76E-06
12	0.07262	40	5.80	159.037	0.065	2	9.66	0.000	7.76E-06
13	0.07262	40	7.45	262.394	0.065	15	72.43	0.004	1.60E-04
Skid	0.07262	40	11.50	625.226	0.065	105	507.00	0.038	1.38E-03
Elbows (standard sizes)	0.07262	1.5	7.45	1354.996	0.065	53	253.50	0.002	7.36E-05

Total 8.94E-03 in WC

TOTAL HEAD LOSS THROUGH PIPES, FITTINGS, AND VALVES 1.60

Reserve 10

Total 11.60 in WC



Project Gude Landfill Remediation Design Project No. 1564601
 Subject LFG Extraction Well Spacing Sheet No. 1 of 3
 Drawing No. _____
 Computed by SS 12/07/20 Checked by GAT Date 12/10/20

Reference:

NSPS Background Information Document (BID). Appendix E. 1991

U.S. EPA. 1991. Air Emissions from Municipal Solid Waste Landfills: Background Information for Proposed Standards and Guidelines, EPA-450/3-90-011a (NTIS PB91-197061), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March.

OBJECTIVE:

To determine the spacing between landfill gas extraction wells. This will be calculated using the EPA method.

PROCEDURE:

Well spacing is determined by finding the radius of influence using the EPA method and using this radius to determine the spacing.

A. EPA Method – This analysis will be used to calculate the radius of influence of the landfill gas extraction wells.

$$R \left(\frac{Q_w DC}{\pi L \rho Q_{gen} \eta} \right)^{1/2}$$

Where:

- R = Radius of Influence (ft)
- Q_w = Well Flow (scfm)
- DC = Design Capacity (5.16x10⁶ lbs; waste placement 1964 through 1982 based on historical tonnage report)
- L = Length of Perforations (feet; varies per well)
- ρ = Waste Density (assumed 1400 lb/cyd)
- Q_{gen} = LFG generation rate (507 scfm; based on observed gas flow November 2017 through April 2018)
- η = Extraction Efficiency (75 percent)

B. Spacing – Well spacing is found from the radius of influence:

$$spacing = R\sqrt{3}$$

Where:

- R = Radius of Influence (ft)
- Spacing = spacing of wells (ft)

Solution:

Due to heterogeneity of landfills not every well is going to be the same depth. Minimally, it is assumed that 507 scfm total for Q_w is divided among the 105 extraction wells, therefore the Q_w is 4.83 scfm per well. DC of the landfill is estimated as 5.16x10⁶ tons or 1.03x10¹⁰ lbs and ρ is 1400 lb/cyd or 51.85 lb/ft³. A sample calculation is provided for EW-



Project Gude Landfill Remediation Design Project No. 1564601
Subject LFG Extraction Well Spacing Sheet No. 2 of 3
Drawing No. _____
Computed by SS 12/07/20 Checked by GAT Date 12/19/20

130. Total well depth for this well is 45 ft and slotted screen length is 30ft. Completing this calculation yields:

$$R = 131.1 \left(\frac{4.83 * 1.03E10}{\pi * 30 * 51.85 * 507 * 0.75} \right)^{1/2}$$

$$R = 164 \text{ ft}$$

Using the above-mentioned parameters, radius of influence has been calculated for each of the existing and proposed LFG extraction wells. Based on the calculation, radius of influence ranged between 136 ft and 536 ft for the existing extraction wells and between 147 ft and 256 ft for the proposed extraction wells. Well spacing ranged from 235 ft to 928 ft for the existing extraction wells and between 254 ft and 444 ft for the proposed extraction wells. The radius of influence was selected as 150 ft as a conservative estimate to ensure maximum LFG collection coverage. Based on the selected radius of influence, the well spacing yields:

$$\text{spacing} = 150 * \sqrt{3}$$
$$\text{spacing} = 260 \text{ ft}$$

CONCLUSION:

Recognizing that there will be $Q_{w \text{ total}} = 507$ scfm over the entire area of the landfill it can be concluded that the calculation for radius of influence and minimum required well placement distance overestimates the spacing. Therefore, the wells are conservatively spaced at approximately 260 ft to balance the landfill gas extraction capacity with the cost of the system.

Attachment O

Environmental Assessment Report

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Gude Landfill Remediation Design Environmental Assessment Montgomery County, Maryland

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031
(410) 584-7000

December 2020
EA Project No. 15646.01

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**Gude Landfill Remediation Design
Environmental Assessment
Montgomery County, Maryland**

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
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4	Landfill and Surrounding Area
5	Construction Staging and Routing of Traffic
6	Derwood Station Vegetated Buffer Improvement Plan

LIST OF TABLES

<u>Number</u>	<u>Title</u>
1	Summary of Potential Environmental Effects

LIST OF ACRONYMS AND ABBREVIATIONS

ACM	Assessment of Corrective Measures
CMA	Corrective Measure Alternative
COMAR the County	Code of Maryland Regulations Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
dba	A-weighted decibels
DPS	Montgomery County Department of Permitting Services
EA	EA Engineering, Science, and Technology, Inc., PBC
the Landfill	Gude Landfill
MDE	Maryland Department of the Environment
NSP	Noise Suppression Plan
RAOs	Remedial Action Objectives

1. INTRODUCTION

In 2013, the Maryland Department of the Environment (MDE) and Montgomery County negotiated a consent order to address negative environmental impacts associated with Gude Landfill (the Landfill). EA Engineering, Science, and Technology, Inc., PBC (EA) has been contracted to provide services to achieve compliance with the consent order, which outlines Remedial Action Objectives (RAOs) for the Landfill. After investigation of the site and environmental monitoring data, EA developed a remediation design that involves multiple phases of construction at the Landfill. As part of this work, an Environmental Assessment has been prepared to discuss potential beneficial and adverse effects of these construction activities on the surrounding area and communities. In general, the long-term benefits of the remediation project will result in short-term effects to the community during construction of the project.

This report summarizes the findings of the Environmental Assessment, and includes the identification of potentially impacted communities, identification and quantification of construction phase (temporary) and long-term effects (permanent) of the remediation project, and discussion of potential measures to minimize and mitigate potential adverse effects.

1.1 GUDE LANDFILL REMEDIATION

This section provides background on Gude Landfill and the Gude Landfill Remediation project, including necessary construction activities and expected long-term benefits of the remediation design.

1.1.1 Background

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. The site is accessed at two locations: East Gude Drive from the south-southwest and Southlawn Lane from the east-southeast. The Landfill is currently owned and maintained by the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County). The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres and was constructed and operated prior to current U.S. Environmental Protection Agency standards for the design, management, and closure of solid waste disposal facilities. Since 1982, Montgomery County has implemented and maintained Best Management Practices for pre-regulatory era landfills to ensure compliance with Code of Maryland Regulations (COMAR) requirements. Montgomery County currently maintains an active landfill gas collection system including flares, gas extraction wells, and conveyance piping. A network of onsite and offsite groundwater monitoring wells, a network of onsite landfill gas monitoring wells, and environmental monitoring programs for groundwater, surface water, landfill gas, and stormwater are also maintained for the Landfill site.

Due to concerns about the impacts of the Landfill on the environment and human health, the Montgomery County Department of Environmental Protection was required by MDE as part of the 2013 consent order to perform an Assessment of Corrective Measures (ACM) to address

specific RAOs (MDE and Montgomery County 2013). The consent order for the Landfill establishes the following RAOs:

- No exceedances of maximum contaminant levels, established by the U.S. Environmental Protection Agency as limits for drinking water, in the groundwater at the Landfill property boundary or between the Landfill and adjacent streams;
- No lower explosive limit exceedances for methane gas at the Landfill property boundary; and
- No non-stormwater discharges (e.g., leachate) to the waters of the State.

To meet these RAOs, EA developed an ACM Report (EA 2016) to identify a recommended Corrective Measure Alternative (CMA), or remediation design, for the County. The CMA was designed to meet regulatory compliance requirements at the Landfill, as discussed in the next section.

1.1.2 Remediation Design

As discussed in the previous section, EA developed the ACM Report (EA 2016) to identify a CMA for the County that would meet the provided RAOs. MDE approved the CMA recommended by EA, which includes the following components:

- Construction of a closure cap over the top of the Landfill as well as the west and northwest Landfill side-slopes; and
- Construction of additional landfill gas collection and conveyance.

The Landfill will be capped on its upper surface and portions of the side-slopes, as outlined in **Figure 1**. According to the design for the CMA developed by EA, the closure cap will include layers of geosynthetic liner material, soil to sustain vegetation, and seeded vegetation. Gravel access roads will also be installed on the upper surface of the closure cap. In order to achieve the grading necessary for the closure cap and future site maintenance, waste will be excavated from the northwest slope and placed on the top surface of the Landfill.

The design also details modifications to the existing landfill gas collection system. Based on spacing requirements, the remediation design includes new landfill gas extraction wells to be installed in addition to some of the existing wells which will remain. New underground landfill gas collection and conveyance piping will be installed.

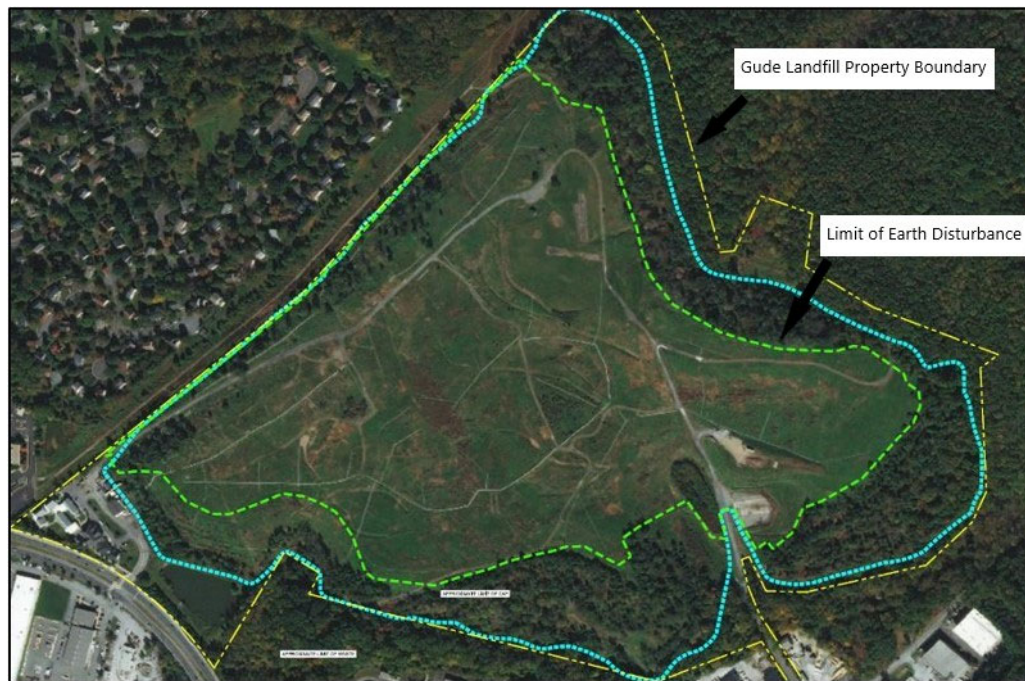


Figure 1 Boundaries of the Landfill and Closure Cap.

1.1.3 Remediation Benefits

The overall objective of the Landfill remediation design is to minimize the impact of the Landfill on the surrounding environment to the greatest extent possible. The design for the CMA was developed by EA to address the RAOs discussed previously, including minimizing maximum contaminant level exceedances in groundwater, non-stormwater discharges (e.g., leachate seeps), and landfill gas migration. Landfill capping will minimize the infiltration of stormwater through the waste and thus reduce the potential for impacts to groundwater and release of non-stormwater discharges. Landfill capping and modifications to the existing landfill gas collection system will minimize the potential for migration of landfill gas off site.

The remediation design will also have benefits for the environment and surrounding community through the development of passive recreational land (parkland) on the upper surface of the capped Landfill. This beneficial land use is expected to include improved site access, new vegetation and wildlife habitat, as well as recreational amenities for the public. In the long-term, this remediation project is intended and expected to benefit the surrounding community.

1.1.4 Construction Activities

This section will discuss construction activities necessary for the closure cap and improvements to the landfill gas collection system. Landfill capping is expected to involve construction activities including:

- Existing vegetation removal;

- Excavation, hauling, and relocation of existing waste from the northwest slope of the Landfill to the top of the Landfill;
- Installation of a geosynthetic closure cap, landfill gas collection system, and cover soil;
- Installation of drainage structures;
- Establishment of a meadow and grassed areas on the closure cap;
- Installation of gravel access roads; and
- Construction of recreational amenities.

The Landfill capping design includes a phased construction approach, with grading limited to 20-acre areas based on the limit imposed by the 2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control. Two series of phases have been developed for closure cap construction. The first series of phases is for subgrade construction, which includes waste excavation and relocation and covering the waste with a compacted layer of soil that serves as a stable base for the closure cap. The second series of phases is for placement of the geosynthetic closure cap, soil cover, and establishing vegetation.

Subgrade construction has been divided into seven phases (S-I through S-VII) as shown on **Figure 2**. The construction of the closure cap itself has been divided into six phases (F-I through F-VI) as shown on **Figure 3**. The phase boundaries shown in these figures are approximate and may change with future design iterations.

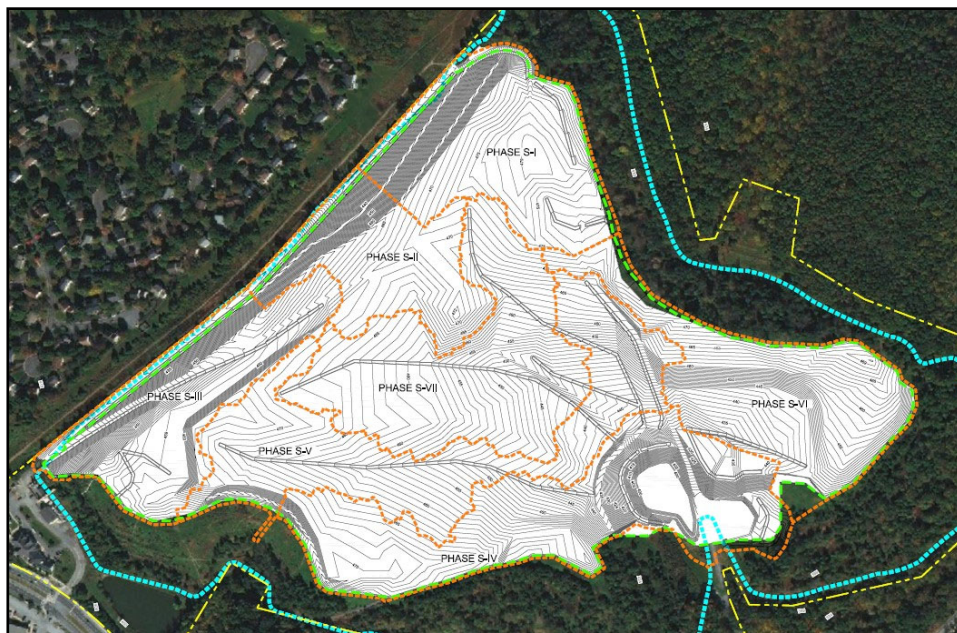


Figure 2 Subgrade Construction Phasing

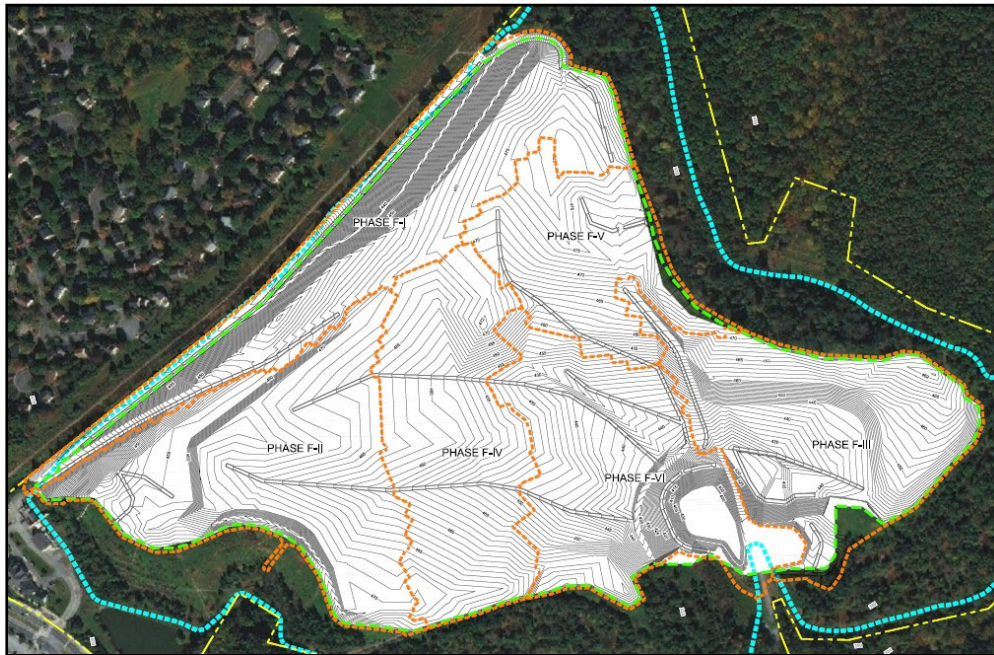


Figure 3 Closure Cap Final Construction Phasing

The landfill gas collection system modifications will also occur in phases so there will be minimal disruption to landfill gas collection during construction.

The construction duration is anticipated to be approximately 4 years. In order to minimize the impact to nearby residential communities, phases of work on the northwest slope will be performed first, and this area will be capped and completed before moving work east.

1.2 SURROUNDING AREA AND COMMUNITY

The surrounding area and properties adjacent to the Landfill have mixed uses including parkland, industrial property, and residential development (**Figure 4**). Communities that may be potentially impacted by remediation activities at the Landfill are expected to include:

- Nearby residential communities including Derwood Station,
- Montgomery County 600 East Gude Drive Campus users,
- Nearby commercial and industrial businesses, and
- Recreational users.

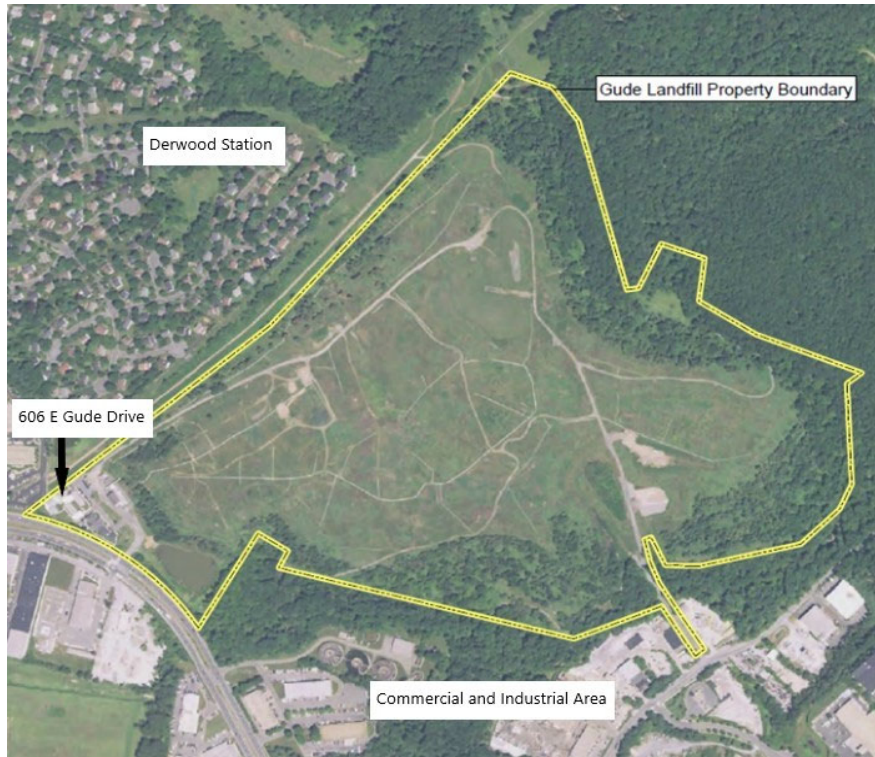


Figure 4 Landfill and Surrounding Area

2. ENVIRONMENTAL EFFECTS

This section describes the construction phase and long-term effects of the remediation project on the surrounding environment and communities. Construction phase effects are temporary and only occur during construction activities. Long-term effects occur post-construction as a result of the completed remediation project. The remediation design meets applicable federal, state, and local regulations to mitigate and minimize construction phase effects. Potential effects and measures to eliminate, minimize, and mitigate these effects are summarized in **Table 1** and are discussed in detail in the following sections.

In general, construction phase nuisances will include changes in traffic, dust, noise, odor, and aesthetics at and around the Landfill site and will only be temporary. However, long-term beneficial effects are expected for groundwater quality, landfill gas migration control, stormwater runoff, site access, habitat and natural resources, recreation, and site aesthetics.

Table 1 Summary of Potential Environmental Effects

Topic	Long-Term Effect*	Environmental Effects	Construction Phase Mitigation Measures
Traffic	0	<ul style="list-style-type: none"> Traffic in and out of the site will increase during construction After construction, traffic levels will return to pre-construction conditions 	<ul style="list-style-type: none"> Heavy construction traffic will be routed to Southlawn Lane site entrance away from residential areas
Dust	0	<ul style="list-style-type: none"> Dust will be generated by construction activities After construction, dust generation will return to pre-construction levels 	<ul style="list-style-type: none"> Heavy construction traffic will be routed to Southlawn Lane site entrance away from residential areas Stabilized construction entrances will be installed to minimize tracking at Southlawn Lane and East Gude Drive site entrances Onsite speed limit will be set Access roads will be watered Dump trucks will be covered
Noise	0	<ul style="list-style-type: none"> Noise will be generated by construction activities After construction, noise levels will return to pre-construction levels 	<ul style="list-style-type: none"> Work will be limited to weekday, daylight hours Vehicles and equipment will have mufflers Montgomery County Noise Control Law will be followed Noise Suppression Plan will be developed
Odor	+	<ul style="list-style-type: none"> Odors may be released during waste excavation Long-term odor levels may be less than pre-construction levels due to closure cap and improved landfill gas collection 	<ul style="list-style-type: none"> Area of exposed waste will be limited Odor control measures such as foam over the waste or misting to eliminate odor will be employed if needed
Landfill Gas	+	<ul style="list-style-type: none"> Landfill gas capture will be less effective during construction Modified landfill gas collection system and closure cap will improve control of landfill gas after construction 	<ul style="list-style-type: none"> Disruption to landfill gas collection will be limited by phasing of work Landfill gas concentrations will be monitored
Leachate (Non-Stormwater Discharges)	+	<ul style="list-style-type: none"> Leachate generation and migration may change during construction activities Completed closure cap and new vegetation will decrease generation and migration of leachate after construction 	<ul style="list-style-type: none"> Area of exposed waste will be limited Any leachate encountered will be controlled Vegetation removal will be limited at any one time Exposed waste will be covered at the end of each workday
Hazardous Waste	+	<ul style="list-style-type: none"> Hazardous waste could potentially be encountered during waste excavation Any hazardous waste excavated and removed will reduce the Landfill's impact on the environment 	<ul style="list-style-type: none"> Any hazardous waste will be handled and disposed of according to state and federal regulations

Topic	Long-Term Effect*	Environmental Effects	Construction Phase Mitigation Measures
Stormwater Runoff	+	<ul style="list-style-type: none"> More stormwater runoff with sediment may occur during construction Completed closure cap, new vegetation, and new stormwater management systems will improve stormwater runoff conditions after construction 	<ul style="list-style-type: none"> Area of exposed waste will be limited Vegetation removal will be limited at any one time Sediment controls that meet MDE and County requirements will limit sediment in the runoff
Fuel Storage	0	<ul style="list-style-type: none"> Fuel may be stored at the site during construction Any fuel storage facility will be removed at the end of construction 	<ul style="list-style-type: none"> Fuel will be stored according to local, state, and federal regulations Spill Prevention, Control, and Countermeasure Plan will be developed
Site Access, Safety, and Security	+	<ul style="list-style-type: none"> Site access will be restricted during construction for safety reasons After construction, site access will be improved by new public entrances and walking paths 	<ul style="list-style-type: none"> Site-Specific Health and Safety Plan will be developed to protect construction workers Construction fencing and clear signage will be implemented to limit access to the site Closed-circuit television surveillance system will be installed and monitored by the County
Habitat and Natural Resources	+	<ul style="list-style-type: none"> Vegetation removal during construction will temporarily reduce habitat Habitat and natural resources will be improved after construction by planting native species and installing butterfly and bird nesting boxes 	<ul style="list-style-type: none"> Vegetation removal will be limited at any one time Native meadow will be seeded as construction is completed in each phase across the site
Recreation	+	<ul style="list-style-type: none"> There are currently no recreational opportunities on the Landfill Recreation will be improved by landscaping the closure cap for recreational use, with features such as walking paths, dog park, mulched play area, and disc golf course 	<ul style="list-style-type: none"> Access to the Gude Trail will be maintained and no impacts are anticipated
Site Aesthetics	+	<ul style="list-style-type: none"> Construction activities and vehicles will be visible from the surrounding area during construction After construction, site aesthetics will be improved by the vegetated and landscaped closure cap 	<ul style="list-style-type: none"> Exposed waste will be covered at the end of each workday Vegetated buffer between Derwood Station and the Landfill will be improved prior to construction
<p>Note: * + = Positive effect. 0 = No effect.</p>			

2.1 TRAFFIC

2.1.1 Construction Phase

Construction associated with the Landfill remediation project will increase vehicle traffic onto the Landfill site. There are two entrances to the Landfill site: (1) East Gude Drive from the south-southwest; and (2) Southlawn Lane at Incinerator Lane from the east-southeast. All construction vehicle traffic will enter and exit the site via the intersection of Southlawn Lane and Incinerator Lane, while the entrance from East Gude Drive will be used only as an administrative entrance that will include parking for construction workers. This traffic pattern is shown in **Figure 5**.

A Traffic Impact Study was performed by T3 Design Corporation to determine the additional traffic generated during construction and its potential impact on the adjacent roadways and intersections. The study indicated all nearby intersections are expected to continue to operate at acceptable levels-of-service (T3 Design Corporation 2019).

Traffic mitigation measures during construction will include limiting the use of the East Gude Drive entrance as an administrative entrance and area and requiring all construction traffic to use the Southlawn Lane/Incinerator Lane entrance to the Landfill. This plan diverts heavy construction traffic from East Gude Drive and acts as a mitigation measure for overall traffic impacts.

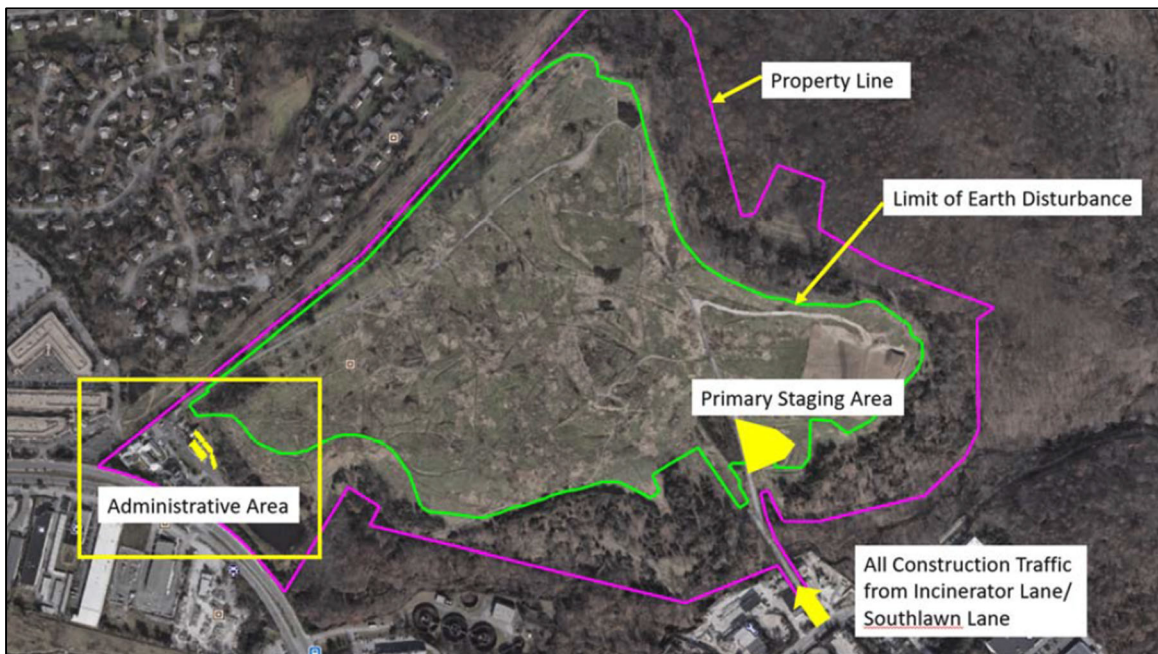


Figure 5 Construction Staging and Routing of Traffic

2.1.2 Long-Term

Long-term traffic patterns are expected to return to pre-construction levels after remediation is complete and construction vehicle traffic is no longer affecting surrounding roadways and intersections.

2.2 DUST

2.2.1 Construction Phase

Construction activities and onsite traffic may generate airborne particulate matter or dust, which could potentially migrate to the surrounding community if not controlled on site. The extent of this migration is dependent on wind speed and direction. Dust, if not mitigated, may negatively affect visibility and air quality in the surrounding community during the construction phase of remediation.

Measures will be implemented during construction to minimize the generation and migration of dust to protect surrounding communities and adhere to requirements outlined in the Montgomery County Department of Environmental Protection Air Quality Ordinance and COMAR 26.11.06.03 Part D: Particulate Matter from Materials Handling and Construction. These regulations require reasonable precautionary measures be taken during construction activities that have the potential to generate dust. These actions include covering open-bodied vehicles transporting materials that could create dust; applying water, foam, or suitable chemicals to roads, open earth, and material stockpiles; and using tarping or other means to cover soil and other construction materials. The contractor for the Landfill remediation project will be required to employ these measures as necessary to control dust on site. Additionally, the contractor will restrict heavy construction vehicle traffic to the Southlawn Lane/Incinerator Lane site entrance, which is further removed from residential communities than the East Gude Drive entrance. The contractor will also limit the speed of onsite traffic in order to minimize dust generation. Stabilized construction entrances will be installed to reduce tracking of dust and other materials during ingress and egress. One stabilized construction entrance will be installed at the entrance to the northwest slope access road from the administrative area located at the East Gude Drive site entrance. A second stabilized construction entrance will be installed at the entrance to the Landfill access road from the construction staging area to be located off of the Southlawn Lane/Incinerator Lane site entrance.

2.2.2 Long-Term

Once construction activities are complete, dust generation will return to pre-construction levels. All exposed soil will be seeded and the site will be stabilized. Traffic will be limited to periodic maintenance activities.

2.3 NOISE

2.3.1 Construction Phase

Noise is expected to be generated by construction vehicles and heavy equipment used during construction, potentially increasing noise levels in the surrounding community.

Measures will be taken to minimize and mitigate construction noise in order to limit the nuisance to the surrounding community and adhere to requirements and guidelines outlined in the Montgomery County Noise Control Law. This law outlines the maximum allowable noise levels

measured at the receiving location as 75 A-weighted decibels (dBA) from 7 AM to 5 PM on weekdays, 65 dBA during other daytime hours, and 55 dBA during all nighttime hours. As part of these regulations, the development of a Noise Suppression Plan (NSP) by the contractor will be required. The NSP allows an increased maximum noise level of 85 dBA from 7 AM to 5 PM on weekdays and includes a description of noise-suppression strategies and equipment. The NSP also includes the requirement for an informational notice on construction noise levels to be distributed to all nearby residences.

The contractor will be required to limit construction activities to weekdays during daylight hours and limit construction traffic to the Southlawn Lane/Incinerator Lane entrance of the Landfill, which will minimize noise on the northwest side of the Landfill closest to residential communities. Other mitigation methods include source control, such as the selection of equipment that will minimize noise generation. This equipment may include adequate mufflers to control engine noise, localized or directional vehicle backup alarms, white noise vehicle backup alarms, or backup alarms that self-adjust to ambient noise levels. Noise levels will be monitored by the County to ensure that requirements of the Montgomery County Noise Control Law are being met during construction.

Additionally, the vegetated corridor between the Derwood Station community and the northwest property line will be supplemented and improved prior to major construction activities, providing noise screening during the construction phase. Planned improvements to this vegetated buffer include the removal of invasive species and the planting of native trees, shrubs, and other plants, as shown in **Figure 6**.



Figure 6 Derwood Station Vegetated Buffer Improvement Plan

2.3.2 Long-Term

Long-term noise levels are expected to return to pre-construction levels after remediation is complete. There may be slight changes in long-term noise levels or patterns dependent on the use of the remediated Landfill site for recreation. Use of the Landfill for recreation after construction is complete will be limited to daylight hours. Additionally, the improved vegetated corridor between the Derwood Station community and the Landfill will provide a long-term noise buffer.

2.4 ODOR

2.4.1 Construction Phase

As part of the Landfill capping activities, waste on the northwest slope of the Landfill will be excavated, relocated, and regraded onto the upper surface of the Landfill. The exposure of excavated waste may release odors above pre-construction levels at the Landfill site. Depending on wind speeds and direction, these odors have the potential to migrate to the surrounding community. The waste being excavated as part of this remediation project has been in the Landfill for at least 40 years and most organic material should be decomposed, limiting the potential odors. Changes in odor on and off site may also occur due to modifications being made to the landfill gas collection system as part of remediation. As portions of the landfill gas system are temporarily disconnected during construction, there is the potential for temporary increases in landfill gas odors.

The mitigation of odor release and migration to the surrounding community will occur through three main potential strategies: (1) selective timing for waste excavation and landfill gas modifications; (2) waste handling/daily cover of waste; and (3) suppression or masking of odor using misting technology.

Selective timing refers to the contractor adjusting construction activities based on weather and other conditional factors that affect odor migration. For example, odor emission and dispersion are lower when temperatures are colder, so odors will be less likely during colder fall or winter months. Additionally, meteorological conditions, specifically wind speed and direction, have a significant effect on odor migration. The contractor will be required to utilize the existing weather station on site to monitor prevailing wind direction and speed, and will be required to adjust waste excavation activities when odors are more significant and when migration to residential communities is more likely based on meteorological conditions.

The remediation design will be phased to limit the amount of waste that can be exposed to an area that can be covered at the end of the work day. This phasing will minimize odor release, as the entire volume of excavated waste will not be exposed at one time.

Lastly, odors may be neutralized or masked using foam or misting products. These misting products may include deodorizers such as plant and essential oil and water blends, which absorb airborne odor molecules when sprayed onto exposed waste or into the air. Misting products may also include masking agents, which cover landfill odors with a more pleasant fragrance. Use of

misters will be a last resort for the project and may be used if odors are significant and the other mitigation measures are not effective.

2.4.2 Long-Term

Long-term odor levels on and off site are expected to be less than pre-construction levels after construction activities are complete. The completed closure cap and improved landfill gas collection system are expected to mitigate the potential release and migration of odors on a long-term basis.

2.5 LANDFILL GAS

2.5.1 Construction Phase

Improvements to the landfill gas collection system will be made as part of the Landfill remediation and will include the installation of new gas extraction wells and new underground collection piping which will connect to the existing landfill gas flare facility. During the abandonment or removal of existing extraction wells and piping, and the installation of new extraction wells and piping, portions of the landfill gas collection system will be temporarily disconnected. This could impact the effectiveness of the landfill gas collection system in controlling the migration and odor of landfill gas during construction activities.

The landfill gas collection system modifications will occur in phases to minimize disruption to landfill gas collection during construction. Existing perimeter landfill gas monitoring wells will be monitored during construction and will be monitored more frequently when portions of the landfill gas system are temporarily disconnected. If landfill gas concentrations exceed 5% by volume in the monitoring wells, the contractor will be required to make adjustments to the system vacuum to reduce migration while modifications are being made to the system.

2.5.2 Long-Term

Long-term effects to the landfill gas collection system are expected to be beneficial. The existing landfill gas collection system is positioned on the surface of the Landfill and has been susceptible to damage by weather and waste settlement. The new collection system piping installed underground within the Landfill closure cap will provide a better solution to landfill gas issues at the site. The revised configuration of gas piping will provide improved flexibility in situations of pipe repair or blockages. New gas extraction wells will also improve the collection and control of landfill gas from the entire site, particularly near the property boundary. The geosynthetic landfill cap will also improve the amount of landfill gas that the system collects, further reducing the amount of gas migrating from the Landfill. Overall, long-term levels of landfill gas migration and odor are expected to be less than pre-construction levels as a result of modifications made during remediation.

2.6 LEACHATE

2.6.1 Construction Phase

Leachate generation and potential for migration off site (non-stormwater discharges) may be impacted by construction activities at the Landfill. Activities of particular concern for leachate effects are the removal of existing vegetation and the exposure of waste during excavation. These activities may lead to stormwater being able to infiltrate into waste more readily, generating increased leachate with the potential for migration during the construction period. Excavating into waste may also expose pockets of existing leachate in the Landfill that must be contained to prevent runoff over the ground surface.

Design aspects and construction measures will minimize and mitigate increased leachate generation and migration at the Landfill. The remediation design includes a closure cap specifically designed so that the heavily vegetated northern, southern, and eastern slopes of the site will not be disturbed, limiting stormwater infiltration and leachate impacts in those areas. Changes in leachate generation in the areas of the site that are being excavated or otherwise disturbed will be largely dependent on waste excavation and handling. The design specifications will require the contractor to cover exposed waste with soil, tarps, or other means at the end of each workday. This will minimize the infiltration of stormwater into areas of disturbance, thus minimizing the generation and migration of leachate during construction. The contractor will also be required to excavate the Landfill in a sump condition, meaning that any existing leachate that is exposed during excavation cannot flow over the ground surface and will be encouraged to drain back into the Landfill or will be pumped from the Landfill and trucked to a leachate treatment facility.

2.6.2 Long-Term

Remediation activities are expected to have a beneficial impact on leachate generation and migration off site in the long term. Installation of the geosynthetic closure cap and new vegetation will reduce the infiltration of stormwater into the waste compared to the existing condition, which will decrease the generation and potential migration of leachate from the Landfill. These remedial actions are expected to ensure that long-term effects of the leachate on the groundwater are beneficial to the site and surrounding community.

2.7 HAZARDOUS WASTE

2.7.1 Construction Phase

The Gude Landfill started accepting waste around 1964 when environmental regulations were minimal. There are no known documents that indicate hazardous waste was placed in the Landfill, but it was not uncommon for some hazardous and industrial wastes to be co-disposed with municipal waste and construction and demolition debris in that era. The remediation design includes requirements for the contractor to stop work if any potential hazardous waste is uncovered based on odor and visual observation and to sample the waste to determine if it is in fact hazardous.

Any hazardous waste excavated will be transported offsite for disposal in accordance with current regulations (COMAR 26.13: Disposal of Controlled Hazardous Substances). Transport and disposal of hazardous waste is heavily regulated to ensure it is performed safely, but there is an increase in potential exposure to the waste compared to it being buried in the Landfill.

2.7.2 Long-Term

In the long-term, the removal of any excavated hazardous waste from the Landfill can only improve groundwater quality and will reduce the Landfill's impact on the environment.

2.8 STORMWATER RUNOFF

2.8.1 Construction Phase

The quantity and quality of stormwater runoff at the Landfill will be potentially impacted by construction activities. Increased generation of stormwater and changes in the quality of that stormwater may occur based on waste excavation and handling, changes in the area of exposed earth, and changes in slopes during the remediation project.

Changes in stormwater runoff quantity and quality will firstly be minimized by the design of the Landfill closure cap, which allows the heavily vegetated northern, southern, and eastern slopes of the site to remain undisturbed, limiting stormwater runoff in those areas to current amounts. During remediation activities, the contractor will take steps to minimize erosion and to control sediment runoff in areas of the site that are being disturbed. The contractor will employ controls during construction as required by the Montgomery County Department of Permitting Services (DPS) and included in MDE's *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. The construction cannot begin until DPS approves the Sediment Control Plan for the project. A DPS inspector will visit the site during construction to ensure the controls are properly installed and maintained as approved in the Sediment Control Plan.

2.8.2 Long-Term

Long-term stormwater runoff from the Landfill site is expected to be equal to or less than pre-construction quantities after construction activities are complete. Pre-construction runoff characteristics will be maintained as nearly as possible. The final ground surface after remediation will be similar to the pre-construction ground surface; however, the remediated ground surface slope on top of the Landfill will be slightly steeper than the pre-construction slopes to promote drainage and minimize the potential for stormwater ponding on the Landfill closure cap. New vegetation will be planted following remediation activities, which will mimic the existing vegetation and maintain similar stormwater runoff from the Landfill surface and slopes. Overall, the installation of the closure cap, vegetation, and new drainage and stormwater management systems on the Landfill is expected to have a beneficial long-term impact, maintaining or decreasing stormwater quantity and maintaining or improving stormwater quality from the site.

2.9 FUEL STORAGE

2.9.1 Construction Phase

The contractor will have the option to install temporary fuel storage at the site for construction vehicles and equipment. This may include temporary aboveground fuel storage tanks and other containers. Any time fuel is being stored, there is a risk for potential effects such as fire, spills, and contamination of nearby materials.

In order to minimize potential effects, the contractor will follow regulations and best practices for managing temporary fuel storage for construction activities. Major requirements are outlined by MDE and the Occupational Safety and Health Administration and refer to the National Fire Protection Association Standard 30, Flammable and Combustible Liquids Code, and Title 29, Parts 1910 and 1926, of the Code of Federal Regulations. These resources outline requirements and best practices for the use of temporary fuel storage, including, but not limited to the employment of approved double-walled tanks or containers with proper venting and emergency features; designated fueling locations a distance from property lines, structures, and sources of physical damage; fire extinguishers of proper size and class; proper signage and labeling; and spill prevention, control, and countermeasure plans in place in the case of a fuel spill. The contractor will coordinate the inspection of temporary fuel storage containers, fire extinguishers, and other equipment.

2.9.2 Long-Term

The increase in fuel storage on the Landfill site will be temporary as needed for construction activities; therefore, no long-term effects to the site or surrounding communities are expected. The contractor will be required to use best practices for preventing and addressing any spills that may potentially occur during construction to minimize long-term effects.

2.10 SITE ACCESS, SAFETY, AND SECURITY

2.10.1 Construction Phase

Site access to the Landfill will be restricted during construction for safety reasons. There will be increased personnel, vehicle traffic, and presence and activity of heavy construction equipment during remediation, which can pose a danger to people in the construction area.

Measures will be employed to restrict site access and improve safety and security during construction, such as requiring the contractor to utilize a closed-circuit television surveillance system to promote security at the site. For safety reasons, the contractor will install temporary construction fencing and display clear signage where necessary to restrict access and protect nearby community members. The existing chain-link fencing along the northwest boundary of the Landfill will be maintained in some form during construction. The contractor will also minimize safety hazards by adhering to Occupational Safety and Health Administration regulations and following a site-specific Health and Safety Plan. The contractor must provide a Site Safety Officer during construction activities.

2.10.2 Long-Term

Site access, safety, and security at the Landfill are expected to return to pre-construction levels or better after remediation is complete. Site access will be improved over pre-construction levels, as recreational users will have access to the remediated site and its walking paths via new public entrances from the existing Gude Trail. Additionally, the improved vegetated corridor between the residential community of Derwood Station and the Landfill (discussed in Section 2.3.1) will provide improved access to the remediated site from Derwood Station via a grass access path to the Gude Trail. To minimize long-term safety and security impacts, the chain-link fencing along the Gude Trail will be maintained following construction and site access will be controlled to two locations where Landfill walking paths will intersect the Gude Trail. Additionally, a closed-circuit television surveillance system will be installed permanently for security.

2.11 HABITAT AND NATURAL RESOURCES

2.11.1 Construction Phase

Construction activities at the Landfill will require the removal of vegetation and disturbance to existing habitat at the site. The typical ground cover across the Landfill site is open grassy fields with patches of brushy vegetation with trees on most side slopes and along the perimeter borders of the Landfill. Vegetation removal and disturbance to existing habitat will particularly occur where waste is excavated from the northwest slope and placed and regraded onto the top of the Landfill.

The remediation design includes a closure cap specifically designed so that the heavily vegetated northern, southern, and eastern slopes of the site will not be disturbed, minimizing the loss of vegetation and habitat in those areas. Additionally, the waste excavation and grading will not occur all at one time, but rather will be phased, allowing for areas of the site to be replanted with stabilizing vegetation, replacing and improving natural resources and habitat as construction proceeds.

2.11.2 Long-Term

Remediation is expected to give long-term benefits to onsite habitat and existing natural resources by increasing vegetated habitat on the closure cap, seeding with native plants, and creating wildlife habitat. The Landfill capping activities include the establishment of a meadow environment, with custom seed mixes to incorporate diverse plant species, including grasses and wildflowers. This meadow habitat is expected to support a variety of wildlife, including butterflies, bees, other insects, and avian species. Added features to the site, such as bird and butterfly nesting boxes and avian perches, are also expected to benefit wildlife by providing additional habitat. A vegetated buffer will also be planted along the northwest property line (adjacent to the existing Gude Trail and residential community of Derwood Station). Plantings will include native trees, shrubs, and other species. These improvements to natural resources, habitat, and biodiversity onsite may potentially see accelerated rebound and growth due to the site's proximity to forested stream valleys, which connect the site to established corridors of movement for a wide variety of species.

2.12 RECREATION

2.12.1 Construction Phase

Recreational use of the Landfill site will be impacted by construction activities. Effects are expected to include restrictions to site access while construction activities are occurring. The Gude Trail, which runs along the northwest side of the Landfill outside of the property boundary, is expected to remain open but may be somewhat impacted by its proximity to the northwest slope of the Landfill, where waste excavation will occur.

Impacts to recreation will be minimized by fencing off construction areas and including clear signage to inform potential recreational users of limited access. The Gude Trail is expected to remain open for recreational use.

2.12.2 Long-Term

Remediation of the Landfill will benefit long-term recreational use of the site. The vegetated closure cap, when completed, will be landscaped for recreational use, and is expected to be open for public use during daylight hours. Entrance for public access to the Landfill will be provided at two gate locations along the northwest property line, accessed from the existing Gude Trail.

Recreational features at the site will potentially include both paved and vegetated walking and running paths, a lookout area, seating areas, a dog park, a disc golf course, a mulched play area, nature play equipment, art installations, and educational signage. Trail markers and informational signage will be installed to direct recreational users of the site.

2.13 SITE AESTHETICS

2.13.1 Construction Phase

Site aesthetics will be impacted during construction activities at the Landfill. Effects to surrounding communities are expected to include disturbance to the existing viewshed by construction fencing and potential views of construction vehicles and remediation activities such as waste excavation, regrading, closure cap installation, and landfill gas system construction.

Measures for mitigating effects to site aesthetics for the surrounding communities include the use of construction fencing, both for safety and aesthetic uses. Excavated waste will be covered at the end of each workday, which will limit the sight of it. Additionally, the improved vegetated buffer between the residential community of Derwood Station and the north side of the existing Gude Trail and Landfill property boundary (discussed in Section 2.3.1) will provide vegetative screening to help block construction activities from view.

2.13.2 Long-Term

Remediation will have long-term benefits to site aesthetics for surrounding communities. The existing viewshed will be improved by the installation of a vegetated closure cap, which will be

landscaped for recreational use. The remediated and landscaped site will include walking and running paths, lawns and meadows, a lookout point, recreational areas, and art installations. Additionally, a vegetated buffer will be located on the Landfill site running the entire length of the base of the slope along the northwest property line and adjacent to the south side of the existing Gude Trail and residential community of Derwood Station. This buffer will include both evergreen and deciduous trees and shrubs and will provide aesthetic screening of the remediated site from the surrounding community. Additionally, the improved vegetated buffer between the Derwood Station community and the north side of the existing Gude Trail and Landfill property boundary (discussed in Section 2.3.1) will provide additional long-term screening.

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Attachment P

Post-Closure Care Plan

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Gude Landfill Remediation Design Post-Closure Care Plan Montgomery County, Maryland

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

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December 2020
EA Project No. 15646.01

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**Gude Landfill Remediation Design
Post-Closure Care Plan
Montgomery County, Maryland**

Prepared for

Northeast Maryland Waste Disposal Authority and
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Recycling and Resource Management Division
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LIST OF ACRONYMS AND ABBREVIATIONS

COMAR	Code of Maryland Regulations
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
the Landfill	Gude Landfill
MDE	Maryland Department of the Environment
M-NCPPC	Maryland-National Capital Park and Planning Commission

1. POST-CLOSURE CARE

1.1 INTRODUCTION

EA Engineering, Science, and Technology, Inc. has prepared this Post-Closure Care Plan for the Montgomery County Department of Environmental Protection, Recycling and Resource Management Division (the County) to document the post-closure care plan for the Gude Landfill (the Landfill) located in Rockville, Maryland. This plan describes activities necessary to satisfy the post-closure criteria identified in the Code of Maryland Annotated Regulations (COMAR) 26.04.07.22.

The Landfill is located at 600 East Gude Drive, Rockville, Maryland 20850. The site has road access at two locations: East Gude Drive and Southlawn Lane.

The Landfill is currently owned and maintained by the County Department of Environmental Protection. The Landfill was used for the disposal of municipal solid waste and incinerator residues from 1964 to 1982. The Landfill property encompasses approximately 162 acres, of which approximately 140 acres were used for waste disposal. An additional 17 acres of waste disposal area were delineated in 2009 on Maryland-National Capital Park and Planning Commission (M-NCPPC) property, beyond the northeastern property boundary of the Landfill. A land exchange between the County and M-NCPPC on October 21, 2014, transferred ownership of this additional waste disposal area to the County in exchange for a similar area of land without waste, which was transferred to M-NCPPC.

The post-closure care period refers to that period of time following the completion of final site closure activities during which the Landfill and the Landfill surroundings will be inspected, monitored, and maintained. Post-closure care for the Landfill is proposed for a minimum 30-year period, after which the need for continued monitoring should be reassessed by the Maryland Department of the Environment (MDE), and a decision should be made to continue, decrease, or cease monitoring activities. The anticipated post-closure care activities at the Landfill include inspections, monitoring, and maintenance.

1.2 POST-CLOSURE CARE

1.2.1 Site Maintenance Plan

Site maintenance during post-closure will consist of semi-annual inspections with irregularities and problems corrected within 30 days and that include at a minimum:

- The integrity of the Landfill cover is maintained,
- Erosion damage and drainage irregularities are repaired,
- Surface expressions of leachate are repaired,
- Monitoring wells are routinely checked, and
- Passive recreational land use elements are maintained.

1.2.2 Post-Closure Activity

Post-closure use of the property will not disturb the integrity of the final cover, liner(s), or other components of the containment system, or the function of the monitoring systems.

Post-closure use of the property will be passive recreational land use. Features of this future land use were selected based on the Northeast Maryland Waste Disposal Authority and County's goals and input from stakeholders. EA's subcontractor, Floura Teeter Landscape Architects, developed the passive recreational land use design, which includes elements such as paved and vegetated walking paths, a lookout area, seating areas, a dog park, a disc golf course, a mulched play area, nature play equipment, art installations, trail markers, and educational signage.

1.3 MONITORING PLAN

1.3.1 Surface Water Management System

The County will monitor surface water during routine monitoring in accordance with the County's *Groundwater and Surface Water Monitoring Plan*, updated June 2020 (EA 2020) and all MDE-approved updates.

1.3.2 Groundwater Monitoring

Groundwater will be monitored during routine monitoring in accordance with the County's *Groundwater and Surface Water Monitoring Plan*, updated June 2020 (EA 2020) and all MDE-approved updates.

1.3.3 Landfill Gas Monitoring System

Landfill gas monitoring around the Landfill perimeter during the post-closure period will be performed in accordance with the County's *Landfill Gas Monitoring Plan* (Montgomery County Department of Environmental Protection 2009) and all MDE-approved updates.

1.3.4 Cover System

Inspections will be performed two times per year during the post-closure period and after major storm events (2-year, 24-hour—3.2 inches). Inspections will be documented in accordance with the example Landfill Site Inspection Checklist included in **Appendix A**.

The inspection will include observation of the cover at the Landfill, notation of any settlement of the Landfill surface, subsidence of slopes, drainage irregularities, signs of cover erosion, burrowing animals, or growth of woody vegetation.

1.4 POST-CLOSURE SECURITY

The Landfill will be utilized for passive recreational uses following closure. The County is planning on providing site access to the public from dawn to dusk. The County will take additional security measures to control the site if vandalism or unintended damage occurs to site.

1.4.1 Site Security

The existing configuration of chain-link fencing and gates will be maintained after site closure. A video surveillance system will be added to the site and monitored by the County. The surveillance system will be a standalone cloud-based system that utilizes cellular connection.

Additional measures to secure the site features include:

- Monitoring well caps will be locked
- The landfill gas blower/flare station is surrounded by chain-link fencing with locked gates
- The landfill gas piping will be buried within the capping soils

1.4.2 Vehicle Entry Control

All vehicles must enter the site through Incinerator Lane or the entrance from East Gude Drive. Both access roads have chain link gates that are locked and only opened for access by County and County contractor vehicles for maintenance.

1.5 POST-CLOSURE MAINTENANCE ACTIVITIES

This section of the plan details the requirements for inspecting, reporting, and implementing corrective actions for any of the Landfill's infrastructure or systems that may need repair. Each of the following subsections is included in the example Landfill Site Inspection Checklist included in **Appendix A**. Corrective action of problems or deficiencies will be documented by the County on the example Landfill Site Maintenance Log included in **Appendix B**.

1.5.1 Repair of Security Devices

The County will repair the fence or access gates as needed to maintain site security.

1.5.2 Vegetation Management

The County will maintain the vegetation over the closure system and may apply fertilizer or spray for noxious weeds, if deemed necessary by the County. The County will remove woody vegetation, which can compromise the Landfill cover system. Mowing should be minimized to promote the benefit of the native grasses.

1.5.3 Repair of Erosion or Cracking of Final Cover

Erosion can be mitigated by spreading straw mulch over the eroded sections until the eroded soil is replaced and the site revegetated. Repair of erosion of the final cover will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

1.5.4 Repair of Settlement Depressions

If significant differential settlement becomes apparent, the County will investigate the integrity of the liner system. If areas of significant settlement are detected (e.g., greater than 2 feet) that impede surface water runoff, the affected area will also be brought back to grade, with depressed areas graded to facilitate drainage.

1.5.5 Maintenance of Landfill Gas Control System

The County will inspect, operate, and maintain the Landfill gas control system in accordance with the Operations and Maintenance Manual (APTIM 2020 or as updated). Key components include the extraction wells, gas collection piping, gas condensate system, blowers, and flares. Required repair of the Landfill gas control system will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

1.5.6 Maintenance of Landfill Gas Monitoring System

The County will inspect and maintain the Landfill gas perimeter monitoring system in accordance with the *Landfill Gas Monitoring Plan*, dated April 2009 (Montgomery County 2009) and all MDE-approved updates. Required repair of the Landfill gas monitoring system will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

1.5.7 Maintenance of Groundwater Monitoring Systems

The County will inspect the groundwater monitoring systems during routine monitoring activities in accordance with the County's *Groundwater and Surface Water Monitoring Plan*, updated June 2020 (EA 2020) and all MDE-approved updates. Required repair of groundwater monitoring systems will be made as soon as possible based on weather conditions and the potential need to procure a contractor to complete the repairs.

1.5.8 Maintenance of the Stormwater Management System

Drainage on the upper surface of the Landfill will be conveyed primarily by a network of open channel swales, box culverts, and storm drains. The County will perform site inspections and perform maintenance of these features as necessary. Maintenance will include the removal of accumulated sediment and repair of visible erosion of the drainage features.

1.5.9 Maintenance of Passive Recreational Land Use Elements

The County will inspect and maintain the passive recreational land use elements as needed. Pet waste bins will be provided and maintained by the County.

1.5.10 Post-Closure Personnel Training

All landfill personnel responsible for post-closure maintenance will be trained in their specific assigned duties. Personnel will be provided with instructions on inspection frequency, forms, and corrective action to ensure the Landfill is maintained in adherence with the applicable post-closure requirements.

1.5.11 Post-Closure Contact

Montgomery County Department of Environmental Protection shall be contacted regarding post-closure activities:

Montgomery County
Department of Environmental Protection
Recycling and Resource Management Division
Attn: Division Chief
101 Monroe Street, 6th Floor
Rockville, Maryland 20850
Phone: (240) 777-0311

1.5.12 Post-Closure Site Use

Montgomery County has no current plans for future development of the Landfill beyond what is currently permitted (passive recreational use). There are no current plans to disturb the final cover system. MDE will be notified for approval should any future development of the site be proposed. Proposed future development on the Landfill cover system will be subject to the post-closure requirements in this plan.

1.5.13 Post-Closure Cost Estimate and Financial Assurance

Montgomery County will maintain inspection and operations of the post-closure system as required to maintain adherence to the COMAR regulations. Post-closure maintenance will be funded through the County's annual operations and maintenance budget.

1.5.14 Post-Closure Reporting and Record Keeping

In accordance with COMAR 26.04.07.22, results of inspections will be submitted to MDE within 60 days of the inspection. Records of the inspections will also be maintained by the County.

2. REFERENCES

Maryland Department of the Environment (MDE). 2011. *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*. Revised January 2012.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2020. *Groundwater and Surface Water Monitoring Plan*. Maryland. March.

Montgomery County. 2009. *Landfill Gas Monitoring Plan*. Maryland.

Appendix A
Site Inspection Checklist

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LANDFILL SITE INSPECTION CHECKLIST

INSPECTOR: _____

DATE/TIME: _____

WEATHER: _____

SITE: _____

		GOOD	FAIR	POOR	N/A
I.	SITE INSPECTION				
	A. Site Security (Condition of Gate/Lock)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	B. Access Road Condition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	C. Landfill Cover Soil/Vegetation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	D. Surface Drainage Control	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	E. Landfill Gas Extraction System	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		YES		NO	
	F. Settlement of Landfill Surface	<input type="checkbox"/>		<input type="checkbox"/>	
	G. Subsidence of Side Slopes	<input type="checkbox"/>		<input type="checkbox"/>	
	H. Erosion of Cover Soil/Vegetation	<input type="checkbox"/>		<input type="checkbox"/>	
	I. Presence of Exposed Waste/Leachate Seeps	<input type="checkbox"/>		<input type="checkbox"/>	
	J. Evidence of Animal Burrowing	<input type="checkbox"/>		<input type="checkbox"/>	
	K. Evidence of Unauthorized Dumping	<input type="checkbox"/>		<input type="checkbox"/>	

II. COMMENTS/RECOMMENDATIONS/ACTION ITEMS

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Appendix B

Landfill Site Maintenance Log

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LANDFILL SITE MAINTENANCE LOG

INSPECTOR: _____

DATE/TIME: _____

WEATHER: _____

SITE: _____

**Date Problem
Identified**

**Date Scheduled for
Corrective Action**

**Date Problem
Corrected**

**1. Landfill Cover/
Vegetation**

Description of Corrective Action _____

Comments _____

**Date Problem
Identified**

**Date Scheduled for
Corrective Action**

**Date Problem
Corrected**

2. Cover Settlement

Description of Corrective Action _____

Comments _____

	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
3. Slope Subsidence	_____	_____	_____

Description of Corrective Action _____

Comments _____

	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
4. Surface Drainage	_____	_____	_____

Description of Corrective Action _____

Comments _____

	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
5. Erosion of Cover Soil/ Vegetation	_____	_____	_____

Description of Corrective Action _____

Comments _____

	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
6. Landfill Gas Extraction System	_____	_____	_____
Description of Corrective Action _____			

Comments _____			

	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
7. Access Road/Site Security	_____	_____	_____
Description of Corrective Action _____			

Comments _____			

	Date Problem Identified	Date Scheduled for Corrective Action	Date Problem Corrected
8. Other	_____	_____	_____
Description of Corrective Action _____			

Comments _____			

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Attachment Q
Construction Schedule

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**ENGINEER'S OPINION OF GUDE LANDFILL REMEDIATION SCHEDULE
BASED ON 100% DESIGN
ASSUMED PRODUCTION RATES AND TASK DURATIONS**

ID	Task	Duration	Phase Area (acres)	Phase Cut/Fill (CY)	Notes/Assumptions
1	NTP	0			
2	Project Planning and Submittals	45			
3	Mobilization	20			
4	Phase S-I		10	36,000	
5	Erosion and Sediment and Other Environmental Controls	20			2 days per acre
6	Clearing and Grubbing	10			1 day per acre
7	Subgrade Preparation/Waste Relocation and LFG Adjustments	34			1500 CY per day plus
8	Vegetative Stabilization	5			0.5 days per acre
9	Phase S-II		9	34,000	
10	Erosion and Sediment and Other Environmental Controls	18			
11	Clearing and Grubbing	9			
12	Subgrade Preparation/Waste Relocation and LFG Adjustments	32			
13	Vegetative Stabilization	5			
14	Phase S-III		14	41,000	
15	Erosion and Sediment and Other Environmental Controls	28			
16	Clearing and Grubbing	14			
17	Subgrade Preparation/Waste Relocation and LFG Adjustments	42			
18	Vegetative Stabilization	7			
19	Phase F-I		15		5 days per acre
20	Closure Cap/LFG/Access Road Construction	75			
21	Vegetative Stabilization	8			
22	Northwest Boundary Tree Planting and Fencing	15			3000 linear feet at
23	Phase S-IV		17	51,000	200 linear feet per day
24	Erosion and Sediment and Other Environmental Controls	34			
25	Sediment Basin No. 3 Construction	25			
26	Clearing and Grubbing	17			
27	Subgrade Preparation/Waste Relocation and LFG Adjustments	51			
28	Vegetative Stabilization	9			
29	Phase S-V		16	57,000	
30	Erosion and Sediment and Other Environmental Controls	32			
31	Clearing and Grubbing	16			
32	Subgrade Preparation/Waste Relocation and LFG Adjustments	54			
33	Vegetative Stabilization	8			
34	Phase S-VI		15	25,000	
35	Erosion and Sediment and Other Environmental Controls	30			
36	Clearing and Grubbing	15			
37	Subgrade Preparation/Waste Relocation and LFG Adjustments	32			
38	Vegetative Stabilization	8			
39	Phase S-VII		13	38,000	
40	Erosion and Sediment and Other Environmental Controls	26			
41	Clearing and Grubbing	13			
42	Subgrade Preparation/Waste Relocation and LFG Adjustments	39			
43	Vegetative Stabilization	7			
44	Phase F-II		11		
45	Closure Cap/LFG/Access Road Construction	55			
46	Vegetative Stabilization	6			
47	Phase F-III		21		
48	Closure Cap/LFG/Access Road Construction	105			
49	Vegetative Stabilization	11			
50	Phase F-IV		14		
51	Closure Cap/LFG/Access Road Construction	70			
52	Vegetative Stabilization	7			
53	Phase F-V		17		
54	Closure Cap/LFG/Access Road Construction	85			
55	Vegetative Stabilization	9			
56	Phase F-VI		20		
57	Closure Cap/LFG/Access Road Construction	100			
58	Vegetative Stabilization	10			
59	Passive Land Uses	40			
60	As-Built Survey	15			
61	Project Closeout and Demobilization	45			
62	Final Acceptance	0			

Potential Schedule Results with Changes in Production Rates

If contractor relocates waste @ 3,000 CY per day, project is 3 months shorter than baseline.
If contractor installs geosynthetic closure cap @ 3 days per acre, project is 9 months shorter than baseline.

Attachment R

Passive Recreation Land Use Basis Of Design

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**Passive Recreation Land Use
At Gude Landfill
Basis of Design
Montgomery County, Maryland**

100% Submission

Prepared for

Northeast Maryland Waste Disposal Authority and
Montgomery County Department of Environmental Protection
Recycling and Resource Management Division
Montgomery County, Maryland

Prepared by

Floura Teeter Landscape Architects, Inc.
800 N. Charles Street, Suite 300
Baltimore, Maryland 21201
(410) 528-8395

Under Contract to

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Hunt Valley, Maryland 21031
(410) 584-7000

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LIST OF ACRONYMS AND ABBREVIATIONS

the Authority	Northeast Maryland Waste Disposal Authority
the County	Montgomery County Department of Environmental Protection, Recycling and Resource Management Division
M-NCPPC	Maryland-National Capital Park and Planning Commission
DEP	Department of Environmental Protection
EA	EA Engineering, Science, and Technology, Inc., PBC
FTLA	Floura Teeter Landscape Architects, Inc.
GLCC	Gude Landfill Concerned Citizens
the Project Team	EA, FTLA, the County
the Design Team	EA, FTLA
the Landfill	Gude Landfill
the Master Plan	Preferred Conceptual Master Plan
the Summary Report	Passive Recreation Land Use Planning Summary Report
the BODR	Passive Recreation Land Use at Gude Landfill Basis of Design Report

1. EXECUTIVE SUMMARY

The Passive Recreation Land Use Basis of Design Report (BODR) provides an overall understanding for the development of the design of the passive recreation land uses for the Gude Landfill (the Landfill). The BODR is not intended to be a technical document, but rather a comprehensive description of the basis of design, design criteria, and guidelines for how passive recreation land uses are integrated into the remediated landfill. The BODR should be read in conjunction with related reports and documents including Construction Documents and Specifications.

Generally, the design development for passive recreation land uses at the Landfill post remediation implements the Preferred Conceptual Master Plan (the Master Plan) developed with stakeholder engagement during the master planning process. An overview of the process and resulting Master Plan are documented in the Passive Recreation Land Use Planning Summary Report (the Summary Report).

The Northeast Maryland Waste Disposal Authority and Montgomery County Department of Environmental Protection, Recycling and Resource Management Division intends to integrate construction and installation of the passive recreation land uses with the construction of the permanent landfill capping system. All elements of the Master Plan are intended for construction concurrent with the landfill capping system except the potential future solar panel array. An area in size, shape, and location identified in the Master Plan will be reserved for potential future design and installation of a solar panel array, at a date to be determined.

The project schedule required the passive recreation land uses to be reviewed as a separate construction document submittal for the 60% milestone. With the current 100% milestone submission, the construction documents and specifications have been consolidated into one overall Landfill remediation construction document submittal.

2. ACCESS

Montgomery County, Maryland, will remain the owner of the site post construction, with responsibility for day to day operations and maintenance.

Post remediation, the Landfill will continue to have sensitive infrastructure in place to monitor and maintain the Landfill over time. In order to minimize risk to the sensitive infrastructure, the Landfill will be secured with a perimeter fence system in high visibility and activity areas including the southeast entrance at Incinerator Lane, southwest entrance at 600 E. Gude Drive, and the length of the northwest property line adjacent to Gude Trail. The County's intention is to provide public access to the site for day use only. Even though public recreation amenities are provided, this site is not part of the Montgomery Parks system. The County may determine the need for temporary closures or adjustments to public access based on available resources.

2.1 COUNTY MAINTENANCE ACCESS

Vehicle access will be restricted to only County employees or County-contractor representatives. Two gates will accommodate vehicle access; one located adjacent to the existing flare station, and one located at Incinerator Lane. Gravel access roads are planned to provide vehicular access for security, site maintenance and routine monitoring of on-site landfill gas extraction wells located throughout the Landfill. The gravel access roads are anticipated to be approximately fifteen feet in width to accommodate maintenance vehicles.

2.2 PUBLIC RECREATION ACCESS & TRAIL NETWORK

Entrance for public access to the Landfill will be provided at two gate locations along the northwest property line, accessed from the existing Gude Trail. Public use of the Landfill is intended to be by pedestrians only; motorized vehicles, bicycles, or horseback will be restricted at this site.

The gravel access roads, in addition to vehicular access for site maintenance, will function as the primary pedestrian circulation and trail network on the Landfill. The proposed gravel access road width of fifteen-feet is adequate to serve a variety of recreation users moving in both directions on the gravel access roads. Areas adjacent to the gravel access roads will be mowed as needed to maintain a short meadow edge condition.

Grass access paths will be incorporated in select locations to extend access to areas of the Landfill not served by gravel access roads or to provide an alternative trail route or shortcut route that is less physically challenging. Serving as secondary circulation, the proposed grass access paths are anticipated to have a width of fifteen feet total.

3. RECREATION AMENITIES

Recreation proposed at the Landfill include a combination of low impact recreation uses, many of which are complementary in nature. Defined recreation destinations are located and sited on the Landfill in conformance with the Master Plan, while recreation activities such as birdwatching are not location specific and occur throughout the Landfill at the users' determination.

Foundations for the passive recreation elements were designed to protect the landfill cap and ensure the amenities are secure. Attachment A includes engineering calculations for determining required size for concrete spread footers and reinforcing steel for various design elements associated with the recreation amenities and signage. Due to the depth limitations of the landfill cap, a typical concrete footer installed below the frost line is not a feasible option.

3.1 HIGHPOINT LOOKOUT

Physically located at the highest elevation of the site, the Highpoint Lookout is a passive use area that affords users a view of the site looking south with the City of Rockville skyline in the distance. Recreational uses envisioned for this destination include walking, dog walking on leash, kite-flying, birdwatching, seating/rest in nature. This area will be maintained as short meadow planting. Seating will be provided.

Site Furnishings /Equipment:

- Chaise lounge chair: wooden slats, fixed in place
- Park bench; custom stump and planed wood bench design
- Trash receptacle

Signage:

- Educational Sign: timeline of site history, section of landfill to describe capping system, graphic of landfill gas extraction wells.

Fencing:

- Guardrail; located along portions of the leading edge of maintained area, at top of graded slope

Plantings:

- Maintained short meadow/turfgrass
- Tall meadow with owl nesting box

3.2 DOG PLAY OFF LEASH

This destination provides a fenced, designated space for supervised off leash dog play and exercise. Design elements include a double gated entrance to minimize conflicts of incoming and outgoing dogs and separate areas for large and small dogs. The fenced area will be maintained as short meadow planting. Seating will be provided.

Site Furnishings /Equipment:

Outside of Fenced Area:

- Park bench; custom stump and planed wood bench design
- Trash receptacle

Inside of Fenced Area:

- Park bench; custom stump and planed wood bench design
- Terraced boulder seating; nested into a sloped grade
- Stump groupings
- Shade structure

Signage:

- Informational Sign; describing rules of use; located outside of the fenced area

Fencing:

- Chain-link fence with wooden posts; five-foot height fence, black powder coated

At Grade Materials:

- Mulched pad inside entrance to large and small dog areas
- Earthen mound; planted with short meadow/turfgrass

Plantings:

- Maintained short meadow/turfgrass

3.3 CHILDREN'S NATURE PLAY

This destination will provide nature inspired play elements and activity areas to foster a connection between children and the natural environment. Nature play spaces encourage creativity and decision-making allowing children to curate their own play experience. Consideration can be given to building play elements and seating from trees removed during the remediation of the Landfill. Signage, bird and butterfly houses, and other educational elements will be incorporated into the design of this destination. A mulched surface will be provided for nature play elements.

Site Furnishings /Equipment:

- Park bench; custom stump and planed wood bench design
- Shade structure
- Balance star; wooden
- Stump climb
- Boulder climb
- Tunnel
- Teeter totter
- Tic-tac-toe; wooden
- Magnifying lens post

- Butterfly box

Fencing:

- Guardrail to define rear edge of amenity area

At Grade Materials:

- Mulched pad surrounding play elements

Plantings:

- Maintained short meadow/turfgrass

3.4 DISC GOLF

A 9-hole disc golf course will be provided. Disc golf is a sport played in groups of two or more where players stand at a tee box and throw a frisbee-like disc toward a target or basket. This area will be maintained as short meadow planting.

Site Furnishings /Equipment:

- Disc golf basket target; galvanized steel

Signage:

- Informational sign /tee post; located at each tee box; identify par and hole number

Fencing:

- Guardrail; located along leading edge of maintained area, at top of graded slope

At Grade Materials:

- Tee box

Plantings:

- Maintained short meadow/turfgrass

3.5 ENVIRONMENTAL ART INSTALLATION

Environmental art will be used to visually highlight the contours of the Landfill. When viewed from a distance, the art may encourage users to explore the landscape. The artwork will be constructed to function as avian perches giving bird populations a vantage point to hunt or rest.

Site Furnishings /Equipment:

- Park bench; custom stump and planed wood bench design
- Environmental art installation; custom metal avian perch poles, finish: powder-coat bright red

Signage:

- Educational sign; avian species

Plantings:

- Maintained short meadow/turfgrass
- Tall meadow with owl nesting box

4. SIGN TYPOLOGY

4.1 WAYFINDING

Waystations are proposed at important trail intersections throughout the site. Waystations will be designed to include a consistent set of elements including a trail marker with directional signage and a site map, educational signage, and seating. Waystations are important as they will function as meeting points and will provide orientation for circulation and navigation of the trail network to site amenities.

Trail Markers will serve as the primary wayfinding features. At a height of 10'-0", the trail markers will be visible from a distance. These are located at trail intersections and decision points along the primary trail network and will indicate trail names, distance to destinations and length of trail, and "you are here" map of the Landfill for general orientation.

Directional Sign Posts will serve as supplemental wayfinding features to be located at intersections of grass access paths with the primary trail network. These will include the trail name and length of trail. Height of directional sign posts will be 4'-6". Directional sign posts will be used to identify areas of the Landfill not intended for recreation use, such as area designated for a potential future solar panel array. Refer to Attachment E for the location of the potential future solar panel array.

4.2 EDUCATIONAL

The history and evolution of the Landfill present opportunities for education on multiple related topics. Integration of educational signage will occur at four waystations and at select locations along the primary trail network. Attachment B includes graphics for educational signage.

Each waystation will have a specific environmental education focus:

Waystation #1 – Evolution of the Landfill; Educational signage will illustrate a timeline of use from landfill to remediation with key facts. Information describing the sensitive infrastructure will be included to illustrate the section of the landfill capping system and a graphic describing the landfill gas extraction wells and capture system.

Waystation #2 – Meteorological Weather Station; A weather station currently located on the Landfill will be relocated to a location accessible to the public to bring awareness to monitoring and data collection. The intent is to coordinate a QR code display that can be scanned with a smart phone for digital access for the public to easily connect to current and historical information collected by the weather station.

Waystation #3 – Avian Habitat; The art installation is an intentional aesthetic intervention in the meadow landscape to punctuate the natural contours of the Landfill. Thirty individual components at a height of 10'-0" and finished with a contrasting red color will be placed to align with and stepping down the contours of the hillside. When viewed from locations of higher elevation throughout the Landfill, such as the Highpoint Lookout, the installation will resemble a

flock of birds in flight. Moreover, the individual components of the installation function as perch posts, a vantage point for birds within a meadow landscape void of trees.

Waystation #4 – Pollinator Habitat; As a restored native meadow habitat, the Landfill will support birdwatching activities and will be an opportunity to bring awareness of important meadow ecologies and how open meadow plant communities are important for specific avian species to thrive. Educational signage will focus on highlighting how the meadow ecosystem functions as a food web where specific meadow plants serve as food or host plants for insect and avian species.

Educational Posts are proposed along a portion of the trail adjacent to the disc golf course, twelve posts total. These posts help to imply an edge to the disc golf course separating it from the trail. Content will be focused on meadow plant species growing onsite and avian species that users are likely to encounter.

4.3 INFORMATIONAL

Informational signage is used in areas to provide guidance or instruction for use or recreation amenities located on the Landfill. Informational signage is proposed in the following locations: two public access entrances to the Landfill from Gude Trail, disc golf course, dog play area, and landfill gas extraction wells located in close proximity to recreation amenities.

Each public access entrance will include signage to list the general rules for use of the park and activities that are restricted such as fire, camping, bicycle riding, or horseback riding. Additional information will be posted that describes the nature of the site, potential risks to users, and contact information in case of an emergency.

The disc golf course will include a tee post at each tee box to identify recommended par and hole number.

The dog play area will include a list of general rules and safety recommendations for using the fenced dog play.

Caution signs notifying the public to avoid tampering with landfill infrastructure will be installed adjacent to landfill gas extraction wells that are in close proximity to passive recreation uses.

5. FENCE TYPOLOGY

5.1 PERIMETER FENCING

A 10'0" height galvanized steel chain-link fence will be installed at the perimeter of the Landfill in high visibility and activity areas. Gates serving pedestrian and vehicles will be incorporated in select locations.

5.2 ENCLOSURE FENCING

The area of the Landfill designated for fenced off-leash dog play will be enclosed with a 5'-0" height black powder coat steel chain-link fence. A double gated entrance will serve pedestrians and pets.

5.3 GUARDRAIL /SAFETY FENCING

A wooden guardrail fence is proposed in select locations where recreation amenity areas are near steeply sloped areas of the Landfill. The guardrail will be 3'-0" in height.

6. LANDSCAPE PLANTINGS & HABITAT CREATION

6.1 MEADOW PLANTINGS

Landscapes are living and continually evolving through both natural processes and human influences. That notion is especially relevant to the Landfill as it progresses through remediation and post closure reuse. Due to the limited soil depth available, a meadow ecology is compatible with the Landfill cap construction. A primary goal of the project is to establish a naturalistic meadow environment encouraging the interaction of avian species with the new flora.

Custom meadow seed mixes were developed for the Landfill incorporating a diversity of native plant species to provide both host plants and food supply supporting a wide variety of butterflies, bees, and other insects, establishing a food web for birds, bats, and beyond. Plant species included in the custom meadow seed mixes respond to needs of both specialist insect species that may rely on only one type of plant species for their diet and generalist insect species that can feed on a wider variety of plant species. The site is bounded on two sides by forested stream valleys, connecting the site to established corridors of movement for a wide variety of species, possibly contributing to an accelerated rebound in biodiversity of species on the post closure Landfill.

Three custom meadow seed mixes are proposed for permanent stabilization of the Landfill. The proposed locations for the various mixes are based on site conditions such as steep slopes or recreation uses. In addition, species selection considers deer tolerance, seed dormancy, and mature height.

Meadow Mix #1- Includes thirty different native wildflower and grass species; overall mix is 30% grass species and 70% wildflower species for use in areas of the site unencumbered by steep slopes.

Meadow Mix #2 – Includes three types of turfgrass species for use in recreation amenity areas, grass access trails, and adjacent to gravel access roads.

Meadow Mix #3 - Includes thirty different native wildflower and grass species; overall mix is 65% grass species and 35% wildflower species for use in areas of the site with steep slopes.

Meadows are dynamic plant communities with each species characteristically having differing durations of seed dormancy. To accommodate for succession in the first year of establishment, the meadow areas will be overseeded with an annual cover crop that will quickly germinate, grow, and provide soil stabilization to buffer the time needed for slower to germinate meadow species. Meadows can take three to five years to become fully established. The first one to three years prominent meadow species will include annuals, biennials, and short-lived perennials. These key indicator species include Black-eyed Susan, Wild Bergamot, and Virginia Wild Rye. As the meadow matures between years three to five, long lived perennials will become more prominent as they out compete annuals and other short-lived species. The meadow will continue to evolve over time in response in large part to variations of annual rainfall.

For any areas of the site that may encounter settlement requiring additional soil and/or grading to maintain positive drainage toward the sides of the Landfill cap, a plant list will be provided identifying appropriate perennial species to be installed as container plantings rather than a seed mix in order to provide fast establishment and soil stabilization. Having a specific group of species for use in these instances create an opportunity to mark a visual record on the site of continued Landfill processes.

Attachment C includes a species list for each meadow mix.

Attachment D includes a schedule for meadow maintenance and invasive species management.

6.2 PERIMETER SCREEN PLANTINGS

A vegetated buffer will be located the entire length of the base of the slope along the northwest property line and adjacent to the existing Gude Trail and residential community of Derwood Station. This will occur on the Landfill site inside the perimeter fence between the fence and the onsite gravel access road. Plantings will include both evergreen and deciduous trees and shrubs.

6.3 NESTING BOXES

To promote a healthy population of breeding pairs of barn owls, *Tyto alba*, nesting boxes will be located within meadow areas of the Landfill. The nesting boxes will be spaced at a maximum density of 1 box per 10 acres.

Nesting box design is an off the shelf model is a molded plastic construction incorporating a double box system which combined with heat reflective pigments and integrated vents reduces heat captured inside the box when located in full sun.

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ATTACHMENT A – PASSIVE RECREATION ELEMENT DESIGN CALCULATIONS

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Project Gude Landfill Remediation Design Project No. 15564.07
Subject Passive Recreation Elements Design Calculations Sheet No. 1 of 3
Drawing No. _____
Computed by CVH Date 10/15/2020 Checked by GAT Date 11/24/2020

OBJECTIVE:

Foundation Design: Determine the required dimensions for concrete foundations for the passive recreation elements included in the Passive Recreation Land Use Design as part of the Gude Landfill Remediation Design. Size concrete foundations to provide a minimum factor of safety of 2.0 for overturning and 1.5 for sliding. Size reinforcing steel based on calculated required area of steel.

Settlement: Estimate the long-term settlement of the landfill waste under the boulder elements to determine the necessary additional subgrade height under these features to maintain cap drainage.

PROCEDURE:

The required concrete foundation dimensions are calculated using the method for wind load presented in ASCE 7 and the methods for overturning and sliding presented in *Principles of Foundation Engineering* (Das, 2011). Long-term settlement under the boulder features is calculated using methods presented in *Geotechnology of Waste Management* (Oweis and Khera, 1998). Detailed procedure for each passive recreation element is provided in the calculation spreadsheets in Attachment A.

Foundation Design:

- 1) Determine the velocity pressure at height of the sign.
 - a. Determine velocity pressure based on local conditions.
 - b. Determine area of sign.
 - c. Determine wind force on sign.
 - d. Determine the design wind pressure for the sign.
- 2) Determine the load on support posts and foundation.
 - a. Calculate live loads from wind force.
 - b. Calculate dead loads from weight of components.
 - c. Calculate load combination.
- 3) Determine loads to support posts to assess adequacy in deflection.

American Society of Civil Engineers (ASCE) (2005). *Standard ASCE 7: Minimum Design Loads for Buildings and Other Structures, 3rd Edition*, American Society of Civil Engineers, Reston, Virginia.

Das, Braja (2011). *Principles of Foundation Engineering, 7th Edition*. Cengage Learning, Stamford, Connecticut.

Oweis, Issa S. and Khera, Raj P. (1998). *Geotechnology of Waste Management, 2nd Edition*. PWS Publishing Co., Boston, MA.



- a. Analyze load on support posts as point load acting at end of post.
 - b. Analyze load on support posts as a uniformly distributed load.
- 4) Analyze the load on the foundation and soil.
- a. Calculate load to foundation and load to soil.
 - b. Compare load to soil with soil bearing capacity to ensure adequacy.
- 5) Determine the area of steel required in the foundation.
- a. Calculate reinforcement ratio and area of steel required.
 - b. Calculate sizing and spacing of rebar required to satisfy area of steel required.
- 6) Perform overturning and sliding analysis.
- a. Calculate passive Rankine force from soil.
 - b. Calculate overturning and stabilizing forces on sign from front and side. Satisfy factor of safety of 2.0.
 - c. Calculate horizontal sliding forces on sign. Satisfy factor of safety of 1.5.
 - d. Calculate maximum pressure on geomembrane liner in overturning case.

Settlement:

- 1) Calculate long-term settlement based on the material properties and changes in stress due to the addition of boulder features.
 - a. Divide the existing waste into sublayers to account for the variation in initial effective stress.
 - b. Calculate the settlement for each layer and sum them to determine the total expected settlement.
 - c. Use an iterative approach to counter the expected settlement due to boulder features with additional subgrade height.



Project Gude Landfill Remediation Design Project No. 15564.07
Subject Passive Recreation Elements Design Calculations Sheet No. 3 of 3
Drawing No. _____
Computed by CVH Date 10/15/2020 Checked by GAT Date 11/24/2020

CONCLUSIONS:

The attached summary table presents foundation and reinforcing steel sizing for the passive recreation elements. All foundations will provide a factor of safety of at least 2.0 against overturning and at least 1.5 against sliding. The loads proposed to be applied to the geomembrane liner do not subject the geomembrane to puncture risk. The subgrade under the boulder elements shall be raised 1.4 ft above surrounding subgrade to counter the effects of long-term settlement.

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PASSIVE RECREATION ELEMENTS CALCULATIONS SUMMARY TABLE

SYMBOL	FEATURE NAME	REINFORCING STEEL	FOUNDATION WIDTH (FEET) (W)	FOUNDATION LENGTH (FEET) (L)	CONCRETE VOLUME PER FOOTING (FT ³)	FOOTING QUANTITY	TOTAL CONCRETE VOLUME (FT ³)	AGGREGATE VOLUME PER FOOTING (FT ³)	TOTAL AGGREGATE VOLUME (FT ³)	GEOTEXTILE PER FOOTING (SF)	TOTAL GEOTEXTILE (SF)
C-3	DOG PLAY FENCE	#5 @ 12" O.C.	3.00	4.00	12.00	116	1392.00	12.00	1392.00	31.50	3654.00
C-6	SHADE STRUCTURE (3) 12' x 8'	#5 @ 6" O.C.	14.08	4.00	56.32	3	168.96	112.64	337.92	147.84	443.52
C-7	ART INSTALLATION	#5 @ 6" O.C.	3.00	5.25	15.75	30	472.50	15.75	472.50	39.00	1170.00
C-13	TEETER TOTTER	#4 @ 12" O.C.	2.75	3.00	8.25	3	24.75	8.25	24.75	23.38	70.13
C-14	BUTTERFLY BOX	#5 @ 12" O.C.	3.25	3.25	10.56	3	31.68	10.56	31.69	29.25	87.75
C-15	MAGNIFYING LENS POST	#4 @ 12" O.C.	2.75	2.75	7.56	2	15.13	7.56	15.13	22.00	44.00
C-16	TRASH RECEPTACLE	#5 @ 12" O.C.	3.00	3.00	9.00	4	36.00	9.00	36.00	25.50	102.00
C-17	WOODEN GUARDRAIL	#4 @ 12" O.C.	3.00	3.00	9.00	203	1827.00	9.00	1827.00	25.50	5176.50
C-18	OWL NESTING BOX	#5 @ 10" O.C.	3.50	3.75	13.13	4	52.52	13.13	52.50	35.00	140.00
C-20	DISC GOLF BASKET TARGET	#5 @ 12" O.C.	3.50	3.50	12.25	9	110.25	12.25	110.25	33.25	299.25
C-21	SLOPED CHASE LOUNGE CHAIR	#5 @ 12" O.C.	3.00	5.00	15.00	10	150.00	15.00	150.00	37.50	375.00
DS	DIRECTIONAL SIGN POST	#5 @ 12" O.C.	3.00	3.25	9.75	8	78.00	9.75	78.00	27.00	216.00
EP	EDUCATIONAL POST	#5 @ 12" O.C.	3.25	3.50	11.38	12	136.56	11.38	136.50	30.88	370.50
ISL	INFORMATION SIGN (LARGE)	#5 @ 10" O.C.	3.00	4.00	12.00	6	72.00	12.00	72.00	31.50	189.00
ISS	INFORMATION SIGN (SMALL)	#5 @ 10" O.C.	3.00	4.25	12.75	15	191.25	12.75	191.25	33.00	495.00
TM	TRAIL MARKER	#5 @ 8" O.C.	3.25	4.25	13.81	4	55.24	13.81	55.25	35.75	143.00
TP	DISC GOLF TEE POST	#4 @ 12" O.C.	2.75	2.75	7.56	9	68.06	7.56	68.06	22.00	198.00

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DOG PLAY FENCE

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Dog Play Fence
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- $q_z =$ velocity pressure at height z. Height (z) = 6 ft
- $k_d =$ wind directional factor, Table 6-4, where $K_d =$ 0.85 for solid sign
- $k_z =$ velocity pressure exposure coefficient, Table 6-3,
 for heights of 0 ft to 15 ft, Exposure C, $K_h =$ 0.85
 for heights of 16 ft to 20 ft, Exposure C, $K_h =$ 0.90
 Use $k_h =$ 0.85
- $k_{zt} =$ topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$
 and K_1, K_2 and K_3 are given in Figure 6-4.
 Assuming general limited changes in topography, no ridge area, escarpment
 or axisymmetrical hill exists. Use $K_{st} =$ 1.0
- $V =$ basic wind speed, from Figure 6-1, where $V =$ 90 mph, for Exposure C
 (3 second wind gust)
 Exposure B consists of urban and suburban areas with closely spaced
 obstructions with heights equivalent to single family homes or larger, where
 $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights
 generally less than 30 feet. Exposure C is most conservative, due to larger
 velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.
- $I =$ importance factor Use $I =$ 1.0

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: $h =$ overall height = 6 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Wire Mes	4.71	10	0.00
2 - Steel Rail	30.33	0.21	6.32
3 - Post	6	0.5	3.00

$A =$ 9.32 ft²

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

$F =$ 14.982 lb/ft² x 9.32 ft² = 139.62 lb (acting at end of post)

$w =$ $\frac{139.62}{6}$ lb = 23.27 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground.
 Neglect q_h for the sign.
- $q_i = q_z = q_h =$ 1.0
- $G =$ gust effect factor, Use $G =$ 0.85
- $C_p =$ external pressure coefficient. From Figure 6-6,
 $C_p =$ 0.80 (windward); $C_p =$ -0.50 (leeward)
- $(G C_{pi}) =$ internal pressure coefficient. From Figure 6-5,
 Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 139.62 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{139.62}{6} \text{ lb/ft} = 23.27 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Area (ft ²)	Unit weight (lb/ft ²)	Weight (lb)
1 - Wire Mesh Fencing		47.08	0.21	9.89
		Length (ft)	Unit weight (lb/ft)	
2- Rails	2.5" Diam. Steel Pipe	30.33	1.2	36.40
Total				46.29

$$\begin{aligned} \text{Sign/Fencing Weight (W}_{\text{sign}}) &= 46.29 \text{ lb} \\ \text{Wt}_{\text{sign}}/\text{ft}^2 &= \frac{46.3}{9.3} \text{ lb/ft}^2 = 4.97 \text{ lb/ft}^2 \end{aligned}$$

$$\text{Uniform Weight @ Sign} = \frac{46.29}{6} \text{ lb/ft} = 7.71 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 7 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 46.29 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{46.29}{6} \text{ lb/ft} = 7.71 \text{ lb/ft} \end{aligned}$$

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight
3 - Post	Western Red Cedar	1.75	23	40.25

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) - 6" \times 6" \times 7" \text{ Western Red Cedar Timber} &= 40.25 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = \text{Wt/ft} &= 6.71 \text{ lb/ft} \end{aligned}$$

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 139.62 \text{ lb} + 1.2 \times (46 \text{ lb} + 40.25 \text{ lb}) \\ P &= 327.24 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 23.27 \text{ lb/ft} + 1.2 \times (7.71 \text{ lb/ft} + 6.71 \text{ lb/ft}) \\ w &= 54.54 \text{ lb/ft} = 4.55 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 54.54 \text{ lb/ft} \times \frac{6}{7} \text{ ft} = 46.75 \text{ lb/ft} = 3.90 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

$$\begin{aligned} \text{Total equivalent Uniform Load } (W_{\text{equil}}) &= 4P \\ W_{\text{equil}} &= 1,309.0 \text{ lb/ft} \\ \text{Axial Load (R) = Shear (V) = P} \\ R = V = P &= 327.2 \text{ lb} \\ M_{\text{maximum}} &= \frac{PL}{2} = 327.2 \frac{\text{lb} \times \text{ft}}{2} = 1,145 \text{ lb ft} \quad (\text{at both ends}) \\ \text{Total Allowable Deflection} &= L/240 = 0.350 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{PL^3}{12EI} \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 76.3 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.016 \text{ inches} \quad (\text{at deflected end}) \\ (\Delta_{\text{max}}) &= 0.016 \text{ inches} < \Delta_{\text{allowable}} = 0.350 \text{ inches, ok} \end{aligned}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

$$\begin{aligned} \text{Total equivalent Uniform Load } (W_{\text{equil}}) &= \frac{8wL}{3} \\ W_{\text{equil}} &= 1,018.1 \text{ lb/ft} = 84.84 \text{ lb/in} \\ \text{Axial Load (R) = Shear (V) = wL} \\ R = V = wL &= 381.8 \text{ lb} \\ M_{\text{maximum}} &= \frac{wL^2}{3} = 890.8 \text{ lb-ft} = 10,690 \text{ lb-in (at fixed end)} \\ \text{Total Allowable Deflection} &= L/240 = 0.350 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{wL^4}{24EI} \quad (\text{at deflected end}) \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 76.3 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.096 \text{ inches} \quad (\text{at deflected end, adjusted over length of post}) \\ (\Delta_{\text{max}}) &= 0.096 \text{ inches} < \Delta_{\text{allowable}} = 0.350 \text{ inches, ok} \end{aligned}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 6-inch x 6-inch Western Red Cedar rectangular columns/posts for the fence supports. Use Simpson Strong-Tie Post Base Model MPBZ or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00 ft =	36	inches
Length of Footing =	4.00 ft =	48	inches
Thickness of Footing (L) =	1.00 ft =	12	inches
Depth of Footing Base =	1.00 ft =	12	inches
Area of Footing (A_{ftg}) =	12.00 ft ²		
Volume of Footing (V_{ftg}) =	12.00 ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,800.00 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	327.2 lb
Uniform Load on Post =	381.8 lb

Load to Soil:

Point Load on Post + W_{ftg} =	2,127.2 lb /	12.00 ft ² =	177.3 lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	2,181.8 lb /	12.00 ft ² =	181.8 lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,800.0 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,800.00 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}} + W_{ftg})$
 $P = 327.24 \text{ lb} + 1.2 (1800.00 \text{ lb}) = 2,487.24 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}} + W_{ftg}/\text{depth of footing})$
 $w = 2,214.54 \text{ lb/ft} = 184.55 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{2,487.2 \text{ lb} \times 7}{2} \text{ ft}$
 $M_{\text{maximum}} = 8,705 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = 36,170.8 \text{ lb ft} = 434,050 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 8,705 \text{ lb ft} = 104,464 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:

$f_y =$	60	ksi
$f_c' =$	3,000	psi
$\rho_{\text{shear}} =$	0.85	
$\rho_{\text{flexure}} =$	0.90	
unit width (w) =	1.0	ft
footing thickness/depth (d_{ftg}) =	1.00	ft

f_y = yield stress or strength of steel
 f_c' = compressive stress or strength of concrete

Coefficient of Resistance (R_u) = $M_u / [\rho_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 67.2 \text{ psi}$

$\rho_{\text{balanced}} = (0.85)^2 (f_c' / f_y) [87,000 / (87,000 + f_y)] = 0.02138$

$\rho_{\text{maximum}} = 0.85 (f_c' / f_y) [1 - (1 - 2R_u / (0.85f_c'))^{1/2}] = 0.01604$

$\rho_{\text{minimum}} = 200 / f_y = 0.00333$

The approximate reinforcement ratio ($\rho_{\text{approx}} = 0.18 (f_c' / f_y) = 0.00900$)

Use $\rho_{\text{approximate}} = 0.00900$

$m = f_y / (0.85f_c') = 23.53$

$R_u = \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}})(m) / 2] = 482.82 \text{ psi}$

$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 20.03 \text{ in}^3$

b = width of stem/web of concrete cross section
 d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

$d =$	9.54	in	Use $d =$	9.50	in
$b =$	5.30	in	Use $b =$	5.25	in

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 = 473.81 \text{ in}^3$

$R_{u \text{ revised}} = M_u / (\rho_{\text{flexure}} bd^2) = 244.97 \text{ psi}$

$\rho_{\text{revised}} = \rho_{\text{approx}} (R_{u \text{ revised}} / R_u) = 0.004566$

$A_{\text{steel required}} = \rho_{\text{revised}} bd = 0.23 \text{ in}^2$

Use minimum #4 bars @ 10 inches O/C +/-, Area_{steel provided} = 0.24 in²,
 or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in².

**Dog Play Fence
Overturning and Sliding Analysis**

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Wire Mesh	47.08	0.00	4.00	0.00	9.89	2.00	19.78	
2 - Steel Rails	6.32	94.68	4.00	378.71	36.40	2.00	72.80	
3 - Post	3.00	44.95	4.00	179.78	40.25	2.00	80.50	
4 - Concrete Foundation	--	0	--	--	1800.00	2.00	3600.00	
6 - Push/Lean	--	200.00	7.00	1400.00	0	--	--	
7 - Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				1958.50			3932.12	2.01 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Wire Mesh	47.08	0.00	9.89
2 - Steel Rails	6.32	94.68	36.40
3 - Post	3.00	44.95	40.25
4 - Concrete Foundation	--	0	1800.00
6 - Push/Lean	--	200.00	0
Total		339.62	1886.54

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation

base ($\delta' = (1/2)\phi'_2$) = 13 degrees

Adhesion between soil and foundation base (c'_a) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	339.62	753.63	2.22 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$

Soil cohesion (c'_2) =

0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) =

26 degrees

Unit weight of soil (γ_2) =

82.8 lbf/ft³

Depth to base of concrete (D) =

1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) =$

2.56

$P_p =$

106.03 lb/ft

Calculate Maximum Pressure on Liner

$q_{max} =$ maximum pressure by foundation on soil at overturning corner = $Q/(B \times L) + 6M/(B \times L^2)$

Total axial/downward load (Q) = 1886.54 lb

Effective length of Foundation (L) = L - 2e = 1.92 ft

Effective Width of Foundation (B) = 3.00 ft

Moment (M) = 1958.50 lb-ft

Eccentricity (e) = M/Q = 1.04 ft

$q_{max} =$ 1005.61 lb/ft²

$q_{max} =$ **6.98 psi**

ART INSTALLATION

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Art Installation
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 10 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_z = 0.85$
for heights of 16 ft to 20 ft, Exposure C, $K_z = 0.90$
Use $k_z = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4.
Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.
- I = importance factor Use $I = 1.0$

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 10 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Bird Sculpture			12
2 - Post	10	0.33	3.33

$$A = 15.33 \text{ ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

$F =$	14.982	lb/ft ² x	15.33	ft ² =	229.72	lb	(acting at end of post)
$w =$	<u>229.72</u>	lb	=	22.97	lb/ft		(acting over surface of sign)
	10	ft					

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground.
- Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- $G =$ gust effect factor, Use $G = 0.85$
- $C_p =$ external pressure coefficient. From Figure 6-6,
 $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi}) =$ internal pressure coefficient. From Figure 6-5,
Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 229.72 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{229.72}{10} \text{ lb/ft} = 22.97 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight (lb)
1 - Bird Sculpture	Galvanized Steel Panel	0.500	487.30	243.65
Total				243.65

$$\begin{aligned} \text{Sign Weight (W}_{\text{sign}}) &= 243.65 \text{ lb} \\ \text{Wt}_{\text{sign}}/\text{ft}^2 &= \frac{243.7}{15.3 \text{ ft}^2} \text{ lb} = 15.89 \text{ lb/ft}^2 \end{aligned}$$

$$\text{Uniform Weight @ Sign} = \frac{243.65}{10} \text{ lb/ft} = 24.37 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 11 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 243.65 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{243.65}{10} \text{ lb/ft} = 24.37 \text{ lb/ft} \end{aligned}$$

Section	Material	Length (ft)	Unit Weight (lb/ft)	Weight (lb)
3 - Post	4" Dia., 1/4" t	11.00	10.81	118.90

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) &= 118.90 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= 11.89 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (Wt_{\text{sign/post}} + Wt_{\text{post@ sign}}) \\ P &= 1.6 \times 229.72 \text{ lb} + 1.2 \times (244 \text{ lb} + 118.90 \text{ lb}) \\ P &= 802.62 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (Wt_{\text{sign/post}} + Wt_{\text{post@ sign}}) \\ w &= 1.6 \times 22.97 \text{ lb/ft} + 1.2 \times (24.37 \text{ lb/ft} + 11.89 \text{ lb/ft}) \\ w &= 80.26 \text{ lb/ft} = 6.69 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 80.26 \text{ lb/ft} \times \frac{10}{11} \text{ ft} = 72.97 \text{ lb/ft} = 6.08 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

$$\begin{aligned}
 \text{Total equivalent Uniform Load } (W_{\text{equil}}) &= 4P \\
 W_{\text{equil}} &= 3,210.5 \text{ lb/ft} \\
 \\
 \text{Axial Load } (R) = \text{Shear } (V) &= P \\
 R = V = P &= 802.6 \text{ lb} \\
 \\
 M_{\text{maximum}} &= \frac{PL}{2} = 802.6 \text{ lb} \times \frac{11}{2} \text{ ft} \\
 M_{\text{maximum}} &= 4,414 \text{ lb ft} \quad (\text{at both ends}) \\
 \\
 \text{Total Allowable Deflection} &= L/240 = 0.550 \text{ inches} \\
 \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{PL^3}{12EI} \\
 E &= 2.9E+07 \text{ lb/in}^2 \\
 I &= 201.1 \text{ in}^4 \\
 (\Delta_{\text{max}}) &= 0.002 \text{ inches} \quad (\text{at deflected end}) \\
 (\Delta_{\text{max}}) &= 0.002 \text{ inches} < \Delta_{\text{allowable}} = 0.550 \text{ inches, ok}
 \end{aligned}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

$$\begin{aligned}
 \text{Total equivalent Uniform Load } (W_{\text{equil}}) &= 8wL \\
 W_{\text{equil}} &= 2,354.3 \text{ lb/ft} = 196.20 \text{ lb/in} \\
 \\
 \text{Axial Load } (R) = \text{Shear } (V) &= wL \\
 R = V = wL &= 882.9 \text{ lb} \\
 \\
 M_{\text{maximum}} &= \frac{wL^2}{3} = 3,237.2 \text{ lb-ft} = 38,847 \text{ lb-in (at fixed end)} \\
 \\
 \text{Total Allowable Deflection} &= L/240 = 0.550 \text{ inches} \\
 \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{wL^4}{24EI} \quad (\text{at deflected end}) \\
 E &= 2.9E+07 \text{ lb/in}^2 \\
 I &= 201.1 \text{ in}^4 \\
 (\Delta_{\text{max}}) &= 0.013 \text{ inches} \quad (\text{at deflected end, adjusted over length of post}) \\
 (\Delta_{\text{max}}) &= 0.013 \text{ inches} < \Delta_{\text{allowable}} = 0.550 \text{ inches, ok}
 \end{aligned}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 4-inch diameter Galvanized Steel posts with 1/4-inch thickness for the supports. Use 3/8-inch square base plate with 3/8-inch diameter, 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00 ft =	36	inches
Length of Footing =	5.25 ft =	63	inches
Thickness of Footing (L) =	1.00 ft =	12	inches
Depth of Footing Base =	1.00 ft =	12	inches
Area of Footing (A_{ftg}) =	15.75 ft ²		
Volume of Footing (V_{ftg}) =	15.75 ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00 \text{ lb/ft}^3$
 $W_{ftg} = 2,362.50 \text{ lb}$

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	802.6 lb
Uniform Load on Post =	882.9 lb

Load to Soil:

Point Load on Post + W_{ftg} =	3,165.1 lb /	15.75 ft ² =	201.0 lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	3,245.4 lb /	15.75 ft ² =	206.1 lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00 \text{ lb/ft}^3$
 $W_{ftg} = 2,362.5 \text{ lb}$
 $W_{ftg}/\text{thickness of footing} = 2,362.50 \text{ lb/ft}$

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@ sign}}} + W_{ftg})$
 $P = 802.62 \text{ lb} + 1.2 (2362.50 \text{ lb}) = 3,637.62 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@ sign}}} + W_{ftg}/\text{depth of footing})$
 $w = 2,915.26 \text{ lb/ft} = 242.94 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{3,637.6 \text{ lb} \times 11 \text{ ft}}{2}$
 $M_{\text{maximum}} = 20,007 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{117,582.2 \text{ lb ft}}{3} = 1,410,987 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 20,007 \text{ lb ft} = 240,083 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$ yield stress or strength of steel
	$f_c =$	3,000 psi	$f_c =$ compressive stress or strength of concrete
	$p_{\text{shear}} =$	0.85	
	$p_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0 ft	
	footing thickness/depth (	1.00 ft	

$$\begin{aligned} \text{Coefficient of Resistance (} R_u \text{)} &= M_u / [p_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 154.4 \text{ psi} \\ p_{\text{balanced}} &= (0.85)^2 (f_c / f_y) [87,000 / (87,000 + f_y)] = 0.02138 \\ p_{\text{maximum}} &= 0.85 (f_c / f_y) [1 - (1 - (2R_u / (0.85 f_c))^{1/2})] = 0.01604 \\ p_{\text{minimum}} &= 200 / f_y = 0.00333 \end{aligned}$$

$$\begin{aligned} \text{The approximate reinforcement ratio (} p_{\text{approx}} \text{)} &= 0.18 (f_c / f_y) = 0.00900 \\ \text{Use } p_{\text{approximate}} &= 0.00900 \end{aligned}$$

$$\begin{aligned} m &= f_y / (0.85 f_c) = 23.53 \\ R_u &= p_{\text{approx}} f_y [1 - (p_{\text{approx}})(m) / 2] = 482.82 \text{ psi} \end{aligned}$$

$$bd^2 = M_u / (p_{\text{flexure}}) (R_u) = 46.04 \text{ in}^3$$

$b =$ width of stem/web of concrete cross section
 $d =$ effective depth from top of reinforced concrete

$$\begin{aligned} \text{Using a } d/b \text{ ratio} &= 1.80 \\ d &= 9.54 \text{ in} & \text{Use } d &= 9.50 \text{ in} \\ b &= 5.30 \text{ in} & \text{Use } b &= 5.25 \text{ in} \end{aligned}$$

checking the d/b ratio = 1.81 , OK

$$\begin{aligned} \text{Revising the reinforcement ratio:} \\ bd^2 &= 473.81 \text{ in}^3 \\ R_u \text{ revised} &= M_u / (p_{\text{flexure}} bd^2) = 563.00 \text{ psi} \\ p_{\text{revised}} &= p_{\text{approx}} (R_u \text{ revised} / R_u) = 0.010495 \\ A_{\text{steel required}} &= p_{\text{revised}} bd = 0.52 \text{ in}^2 \end{aligned}$$

Use minimum #5 bars @ 6 inches O/C +/-, Area_{steel provided} = 0.61 in² ,
or use #6 bars @ 10 inches O/C +/-, Area_{steel provided} = 0.53 in² ,

Art Installation
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Bird Sculpture	12.00	179.78	11.00	1977.59	243.65	2.63	639.58	
3 - Post	3.33	49.94	6.00	299.64	118.90	2.63	312.13	
4 - Concrete Foundation	--	0	--	--	2362.50	2.63	6201.56	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				3477.23			7312.31	2.10 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Bird Sculpture	12.00	0	--	--	243.65	1.50	365.48	
3 - Post	3.33	49.94	6.00	299.64	118.90	1.50	178.36	
4 - Concrete Foundation	15.75	0	--	--	2362.50	1.50	3543.75	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7- Passive Rankine	--	0	--	--	556.65	0.500	278.32	
Total				1499.64			4365.91	2.91 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Bird Sculpture	12.00	179.78	243.65
3 - Post	3.33	49.94	118.90
4 - Concrete Foundation	--	0	2362.50
6 - Push/Lean	--	200.00	0
Total		429.72	2725.05

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation
 base ($\delta' = (1/2)\phi'_2$) = 13 degrees
 Adhesion between soil and foundation base
 (c'_a) = 0 kPa = kN/m²
 Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force		429.72	2.20 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times Y_2 \times D^2) + 2(c'_2) \times v(K_p \times D)$
 Soil cohesion (c'_2) = 0 kPa = kN/m²
 Effective Soil Friction angle (ϕ'_2) = 26 degrees
 Unit weight of soil (γ_s) = 82.8 lb/ft³
 Depth to base of concrete (D) = 1.00 ft
 $K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$
 $P_p = 106.03$ lb/ft

Calculate Maximum Pressure on Liner

$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \cdot L) + 6M/(B \cdot L^2)$
 Total axial/downward load (Q) = 2725.05 lb
 Effective length of Foundation (L) = L - 2e = 2.70 ft
 Effective Width of Foundation (B) = 3.00 ft
 Moment (M) = 3477.23 lb-ft
 Eccentricity (e) = M/Q = 1.28 ft
 $q_{max} = 1195.91$ lb/ft²
 $q_{max} = 8.30$ psi

BUTTERFLY BOX

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Butterfly Box
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 5 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$; for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$; Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 5 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 -Butterfly E	2.00	0.50	1.00
2 -			
3 - Post	3.00	0.125	0.38

$A = 1.38 \text{ ft}^2$

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

$F = 14.982 \text{ lb/ft}^2 \times 1.38 \text{ ft}^2 = 20.60 \text{ lb}$ (acting at end of post)
 $w = \frac{20.60}{5} \text{ lb} = 4.12 \text{ lb/ft}$ (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 20.60 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{20.60}{5} \text{ lb/ft} = 4.12 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Area (ft ²)	Unit Weight (lWeight (lb)
1 - Butterfly Box	Wood		3.50
			0.00
Total			3.50

$$\text{Sign Weight (W}_{\text{sign}}) = 3.50 \text{ lb}$$

$$W_{\text{sign}}/\text{ft}^2 = \frac{3.5 \text{ lb}}{1.4 \text{ ft}^2} = 2.55 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{3.50}{5} \text{ lb/ft} = 0.70 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 4.00 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 3.50 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{3.50}{5} \text{ lb/ft} = 0.70 \text{ lb/ft} \end{aligned}$$

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight
3 - Post	1.5" O.D. Galvanized Steel	0.05	487.30	23.92

$$\begin{aligned} \text{Post Weight (W}_{\text{tpost}}) &= 23.92 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= W_{\text{t}}/\text{ft} = 4.78 \text{ lb/ft} \end{aligned}$$

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{t sign/post}} + W_{\text{t post@ sign}}) \\ P &= 1.6 \times 20.60 \text{ lb} + 1.2 \times (4 \text{ lb} + 23.92 \text{ lb}) \\ P &= 65.86 \text{ lb} \quad \text{(point load at end of post)} \end{aligned}$$

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{t sign/post}} + W_{\text{t post@ sign}}) \\ w &= 1.6 \times 4.12 \text{ lb/ft} + 1.2 \times (0.70 \text{ lb/ft} + 4.78 \text{ lb/ft}) \\ w &= 13.17 \text{ lb/ft} = 1.10 \text{ lb/in} \quad \text{(uniform load over extent of sign on post)} \end{aligned}$$

Adjusting uniform load over entire length of post:

$$w = 13.17 \text{ lb/ft} \times \frac{5.0}{4.0} \text{ ft} = 16.47 \text{ lb/ft} = 1.37 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = $4P$
 $W_{equil} = 263.5 \text{ lb/ft}$

Axial Load (R) = Shear (V) = P
 $R = V = P = 65.9 \text{ lb}$

$M_{maximum} = \frac{PL}{2} = 65.9 \text{ lb} \times \frac{4}{2} \text{ ft}$
 $M_{maximum} = 132 \text{ lb ft}$ (at both ends)

Total Allowable Deflection = $L/240 = 0.200 \text{ inches}$

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

$E = 2.9E+07 \text{ lb/in}^2$
 $I = 0.2 \text{ in}^4$
 $(\Delta_{max}) = 0.009 \text{ inches}$ (at deflected end)
 $(\Delta_{max}) = 0.009 \text{ inches} < \Delta_{allowable} = 0.200 \text{ inches, ok}$

Y = Young's Modulus/Mc
 I = Area Moment of Iner

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $8wL$

$W_{equil} = 140.5 \text{ lb/ft} = 11.71 \text{ lb/in}$

Axial Load (R) = Shear (V) = wL
 $R = V = wL = 52.7 \text{ lb}$

$M_{maximum} = \frac{wL^2}{3} = 70.3 \text{ lb-ft} = 843 \text{ lb-in}$ (at fixed end)

Total Allowable Deflection = $L/240 = 0.200 \text{ inches}$

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

$E = 2.9E+07 \text{ lb/in}^2$
 $I = 0.2 \text{ in}^4$
 $(\Delta_{max}) = 0.052 \text{ inches}$ (at deflected end, adjusted over length of post)
 $(\Delta_{max}) = 0.052 \text{ inches} < \Delta_{allowable} = 0.200 \text{ inches, ok}$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 1.5-inch diameter galvanized steel columns/posts for the supports. Use 3/8-inch square base plate with 3/8-inch diameter, 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.25	ft =	39	inches
Length of Footing =	3.25	ft =	39	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	10.56	ft ²		
Volume of Footing (V_{ftg}) =	10.56	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,584.38 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	65.9	lb
Uniform Load on Post =	52.7	lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,650.2	lb /	10.56	ft ² =	156.2	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	1,637.1	lb /	10.56	ft ² =	155.0	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,584.4 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,584.38 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg})$
 $P = 65.86 \text{ lb} + 1.2 (1584.38 \text{ lb}) = 1,967.11 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg}/\text{depth of footing})$
 $w = 1,914.42 \text{ lb/ft} = 159.54 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{1,967.1 \text{ lb} \times 4}{2} \text{ ft}$
 $M_{\text{maximum}} = 3,934 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{10,210.3 \text{ lb ft}}{3} = 122,523 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 3,934 \text{ lb ft} = 47,211 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$ yield stress or strength of steel
	$f_c =$	3,000 psi	$f_c =$ compressive stress or strength of concrete
	$\rho_{\text{shear}} =$	0.85	
	$\rho_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0 ft	
	footing thickness/depth (d_{ftg}) =	1.00 ft	

Coefficient of Resistance (R_u) = $M_u / [\rho_{\text{flexure}} (w) (d_{\text{ftg}})^2] =$	30.4 psi
$\rho_{\text{balanced}} = (0.85)^2 (f_c' / f_y) [87,000 / (87,000 + f_y)] =$	0.02138
$\rho_{\text{maximum}} = 0.85 (f_c' / f_y) [1 - (1 - (2R_u / (0.85 f_c'))^{1/2})] =$	0.01604
$\rho_{\text{minimum}} = 200 / f_y =$	0.00333

The approximate reinforcement ratio ($\rho_{\text{approx}} = 0.18 (f_c' / f_y) =$	0.00900
Use $\rho_{\text{approximate}} =$	0.00900

$m = f_y / (0.85 f_c') =$	23.53
$R_u = \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}} (m) / 2)] =$	482.82 psi

$bd^2 = M_u / (\rho_{\text{flexure}} (R_u)) =$	9.05 in ³	$b =$ width of stem/web of concrete cross section
		$d =$ effective depth from top of reinforced concrete

Using a d/b ratio =	1.80		
$d =$	9.54 in	Use $d =$	9.50 in
$b =$	5.30 in	Use $b =$	5.25 in
		checking the d/b ratio =	1.81, OK

Revising the reinforcement ratio:	
$bd^2 =$	473.81 in ³
$R_u \text{ revised} = M_u / (\rho_{\text{flexure}} bd^2) =$	110.71 psi
$\rho_{\text{revised}} = \rho_{\text{approx}} (R_u \text{ revised} / R_u) =$	0.002064
$A_{\text{steel required}} = \rho_{\text{revised}} bd =$	0.10 in ²

Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in².
 or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in²,

Butterfly Box
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Butterfly Box	1.00	14.98	5.00	74.91	3.50	1.63	5.69	
3 - Post	0.38	5.62	2.50	14.05	23.92	1.63	38.87	
4 - Concrete Foundation	--	0	--	--	1584.38	1.63	2574.61	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				1288.95			2791.46	2.17 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Butterfly Box	1.00	14.98	5.00	74.91	3.50	1.63	5.69	
3 - Post	0.38	5.62	2.50	14.05	23.92	1.63	38.87	
4 - Concrete Foundation	--	0	--	--	1584.38	1.63	2574.61	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				1288.95			2791.46	2.17 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Butterfly Box	1.00	14.98	3.50
3 - Post	0.38	5.62	23.92
4 - Concrete Foundation	--	0	1584.38
6 - Push/Lean	--	200.00	0
Total		220.60	1611.80

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (δ') = $(1/2)\phi'_s$ = 13 degrees

Adhesion between soil and foundation base (c'_s) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta_s)$ + (length of footing) x c'_s + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	220.60	716.70	3.25 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times \gamma_s \times D^2) + 2(c'_s) \times \sqrt{K_p \times D}$$

Soil cohesion (c'_s) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_s) = 26 degrees

Unit weight of soil (γ_s) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_s/2)) = 2.56$

$P_p = 106.03 \text{ lb/ft}$

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = $Q/(B^*L) + 6M/(B^*L^2)$

Total axial/downward load (Q) = 1611.80 lb

Effective length of Foundation (L') = L - 2e = 1.65 ft

Effective Width of Foundation (B') = 3.25 ft

Moment (M) = 1288.95 lb-ft

Eccentricity (e) = M/Q = 0.80 ft

$q_{max} = 744.05 \text{ lb/ft}^2$

$q_{max} = 5.17 \text{ psi}$

MAGNIFYING LENS POST

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Magnifying Lens Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 3 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$; for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$; Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 4.5 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 -			0.00
2 -			
3 - Post	3.00	0.500	1.50

$A = 1.50 \text{ ft}^2$

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

$F = 14.982 \text{ lb/ft}^2 \times 1.50 \text{ ft}^2 = 22.47 \text{ lb}$ (acting at end of post)
 $w = \frac{22.47}{5} \text{ lb} = 4.99 \text{ lb/ft}$ (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 22.47 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{22.47}{4.5} \text{ lb/ft} = 4.99 \text{ lb/ft} \end{aligned}$$

Dead Loads:

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 4.00 \text{ ft} \end{aligned}$$

Section	Material	Volume (ft3)	Density (lb/ft ³)	Weight
Post	Western Red Cedar	1.00	23	23.00

$$\begin{aligned} \text{Post Weight (W}_{t_{\text{post}}}) - 8" \times 8" \text{ Western Red Cedar} &= 23.00 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = W_t/ft &= 5.11 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@sign}}}) \\ P &= 1.6 \times 22.47 \text{ lb} + 1.2 \times (0 \text{ lb} + 23.00 \text{ lb}) \\ P &= 63.56 \text{ lb} \quad (\text{point load at end of post}) \end{aligned}$$

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@sign}}}) \\ w &= 1.6 \times 4.99 \text{ lb/ft} + 1.2 \times (0.00 \text{ lb/ft} + 5.11 \text{ lb/ft}) \\ w &= 14.12 \text{ lb/ft} = 1.18 \text{ lb/in} \quad (\text{uniform load over extent of sign on post}) \end{aligned}$$

Adjusting uniform load over entire length of post:

$$w = 14.12 \text{ lb/ft} \times \frac{4.5}{4.0} \text{ ft} = 15.89 \text{ lb/ft} = 1.32 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = $4P$

$$W_{equil} = 254.2 \text{ lb/ft}$$

Axial Load (R) = Shear (V) = P

$$R = V = P = 63.6 \text{ lb}$$

$$M_{maximum} = \frac{PL}{2} = 63.6 \text{ lb} \times \frac{4}{2} \text{ ft}$$

$$M_{maximum} = 127 \text{ lb ft} \quad (\text{at both ends})$$

Total Allowable Deflection = $L/240 = 0.200$ inches

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

$$E = 1.1E+06 \text{ lb/in}^2$$

$$I = 76.3 \text{ in}^4$$

$$(\Delta_{max}) = 0.0006 \text{ inches} \quad (\text{at deflected end})$$

$$(\Delta_{max}) = 0.0006 \text{ inches} < \Delta_{allowable} = 0.200 \text{ inches, ok}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8wL}{3}$

$$W_{equil} = 150.7 \text{ lb/ft} = 12.55 \text{ lb/in}$$

Axial Load (R) = Shear (V) = wL

$$R = V = wL = 56.5 \text{ lb}$$

$$M_{maximum} = \frac{wL^2}{3} = 75.3 \text{ lb-ft} = 904 \text{ lb-in} \quad (\text{at fixed end})$$

Total Allowable Deflection = $L/240 = 0.200$ inches

Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

$$E = 1.1E+06 \text{ lb/in}^2$$

$$I = 76.3 \text{ in}^4$$

$$(\Delta_{max}) = 0.003 \text{ inches} \quad (\text{at deflected end, adjusted over length of post})$$

$$(\Delta_{max}) = 0.003 \text{ inches} < \Delta_{allowable} = 0.200 \text{ inches, ok}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 6-inch x 6-inch Western Red Cedar rectangular columns/posts for the sign supports. Use Simpson Strong-Tie Post Base Model MPB66Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	2.75	ft =	33	inches
Length of Footing =	2.75	ft =	33	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	7.56	ft ²		
Volume of Footing (V_{ftg}) =	7.56	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,134.38 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	63.6	lb
Uniform Load on Post =	56.5	lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,197.9	lb /	7.56	ft ² =	158.4	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	1,190.9	lb /	7.56	ft ² =	157.5	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,134.4 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,134.38 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg})$
 $P = 63.56 \text{ lb} + 1.2 (1134.38 \text{ lb}) = 1,424.81 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg}/\text{depth of footing})$
 $w = 1,375.37 \text{ lb/ft} = 114.61 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{1,424.8 \text{ lb} \times 4}{2} \text{ ft}$
 $M_{\text{maximum}} = 2,850 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{7,335.3 \text{ lb ft}}{3} = 88,024 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 2,850 \text{ lb ft} = 34,195 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$ yield stress or strength of steel
	$f_c =$	3,000 psi	$f_c =$ compressive stress or strength of concrete
	$p_{\text{shear}} =$	0.85	
	$p_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0 ft	
	footing thickness/depth (d_{ftg}) =	1.00 ft	

$$\begin{aligned} \text{Coefficient of Resistance (} R_u \text{)} &= M_u / [p_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 22.0 \text{ psi} \\ p_{\text{balanced}} &= (0.85)^2 (f_c' / f_y) [87,000 / (87,000 + f_y)] = 0.02138 \\ p_{\text{maximum}} &= 0.85 (f_c' / f_y) [1 - (1 - (2R_u / (0.85f_c'))^{1/2})] = 0.01604 \\ p_{\text{minimum}} &= 200 / f_y = 0.00333 \end{aligned}$$

$$\begin{aligned} \text{The approximate reinforcement ratio (} p_{\text{approx}} \text{)} &= 0.18 (f_c' / f_y) = 0.00900 \\ \text{Use } p_{\text{approximate}} &= 0.00900 \end{aligned}$$

$$\begin{aligned} m &= f_y / (0.85f_c') = 23.53 \\ R_u &= p_{\text{approx}} f_y [1 - (p_{\text{approx}}) (m) / 2] = 482.82 \text{ psi} \end{aligned}$$

$$\begin{aligned} bd^2 &= M_u / (p_{\text{flexure}}) (R_u) = 6.56 \text{ in}^3 \\ \text{b} &= \text{width of stem/web of concrete cross section} \\ \text{d} &= \text{effective depth from top of reinforced concrete} \end{aligned}$$

$$\begin{aligned} \text{Using a d/b ratio} &= 1.80 \\ \text{d} &= 9.54 \text{ in} & \text{Use d} &= 9.50 \text{ in} \\ \text{b} &= 5.30 \text{ in} & \text{Use b} &= 5.25 \text{ in} \end{aligned}$$

$$\text{checking the d/b ratio} = 1.81, \text{ OK}$$

$$\begin{aligned} \text{Revising the reinforcement ratio:} \\ bd^2 &= 473.81 \text{ in}^3 \\ R_u \text{ revised} &= M_u / (p_{\text{flexure}} bd^2) = 80.19 \text{ psi} \\ p_{\text{revised}} &= p_{\text{approx}} (R_u \text{ revised} / R_u) = 0.001495 \\ A_{\text{steel required}} &= p_{\text{revised}} bd = 0.07 \text{ in}^2 \end{aligned}$$

**Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in²,
or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in²,**

Magnifying Lens Post
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				856.18			1737.18	2.03 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				856.18			1737.18	2.03 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Post	1.50	22.47	23.00
2 - Concrete Foundation	--	0	1134.38
3 - Push/Lean	--	200.00	0
Total		222.47	1157.38

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$\delta' = (1/2)\phi'_2 = 13$ degrees

Adhesion between soil and foundation base (c'_a) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta'_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	222.47	558.78	2.51 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \nu(K_p \times D)$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$

$P_p = 106.03$ lb/ft

Calculate Maximum Pressure on Liner

$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \cdot L) + 6M/(B^2 \cdot L)$

Total axial/downward load (Q) = 1157.38 lb

Effective length of Foundation (L) = L - 2e = 1.27 ft

Effective Width of Foundation (B) = 2.75 ft

Moment (M) = 856.18 lb-ft

Eccentricity (e) = M/Q = 0.74 ft

$q_{max} = 865.93$ lb/ft²

$q_{max} = 6.01$ psi

TRASH RECEPTACLE

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Trash Receptacle
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 4.17 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$
for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$
Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4.
Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.
- I = importance factor Use $I = 1.0$

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 4.1667 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
2 - Receptacle	3.5	1.58	5.54

$$A = 5.54 \text{ ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

$$F = 14.982 \text{ lb/ft}^2 \times 5.54 \text{ ft}^2 = 83.02 \text{ lb} \quad (\text{acting at end of post})$$

$$w = \frac{83.02}{4} \text{ lb} = 19.93 \text{ lb/ft} \quad (\text{acting over surface of sign})$$

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground.
Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6,
 $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5,
Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 83.02 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{83.02 \text{ lb}}{4.1667 \text{ ft}} = 19.93 \text{ lb/ft} \end{aligned}$$

Dead Loads:

$$\begin{aligned} \text{Number of Receptacles/Post} &= 1 \\ \text{Post Length} &= 4.167 \text{ ft} \end{aligned}$$

Section	Material	Weight (lb)
	Receptacle/Post	120.00

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}), 4" \text{ Galvanized Steel Pole} &= 120.00 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \text{Wt/ ft} = 28.80 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}}) \\ P &= 1.6 \times 83.02 \text{ lb} + 1.2 \times (0 \text{ lb} + 120.00 \text{ lb}) \\ P &= 276.84 \text{ lb} \quad (\text{point load at end of post}) \end{aligned}$$

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}}) \\ w &= 1.6 \times 19.93 \text{ lb/ft} + 1.2 \times (0.00 \text{ lb/ft} + 28.80 \text{ lb/ft}) \\ w &= 66.44 \text{ lb/ft} = 5.54 \text{ lb/in} \quad (\text{uniform load over extent of sign on post}) \end{aligned}$$

Adjusting uniform load over entire length of post:

$$w = 66.44 \text{ lb/ft} \times \frac{4}{4} \text{ ft} = 66.44 \text{ lb/ft} = 5.54 \text{ lb/in}$$

Note: Surface mount according to manufacturer specifications.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	3.00	ft =	36	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	9.00	ft ²		
Volume of Footing (V_{ftg}) =	9.00	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 1,350.00$ lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	276.8	lb
Uniform Load on Post =	276.8	lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,626.8	lb /	9.00	ft ² =	180.8	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	1,626.8	lb /	9.00	ft ² =	180.8	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 1,350.0$ lb
 $W_{ftg}/\text{thickness of footing} = 1,350.00$ lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{t \text{ sign/post}} + W_{t \text{ post@ sign}} + W_{ftg})$
 $P = 276.84 \text{ lb} + 1.2 (1350.00 \text{ lb}) = 1,896.84 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{t \text{ sign/post}} + W_{t \text{ post@ sign}} + W_{ftg}/\text{depth of footing})$
 $w = 1,686.44 \text{ lb/ft} = 140.54 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{1,896.8 \text{ lb} \times 4.16667 \text{ ft}}{2}$
 $M_{\text{maximum}} = 3,952 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{9,759.5 \text{ lb ft}}{3} = 117,114 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 3,952 \text{ lb ft} = 47,421 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:

$f_y =$	60	ksi
$f_c =$	3,000	psi
$\rho_{\text{shear}} =$	0.85	
$\rho_{\text{flexure}} =$	0.90	
unit width (w) =	1.0	ft
footing thickness/depth (	1.00	ft

f_y = yield stress or strength of steel
 f_c = compressive stress or strength of concrete

Coefficient of Resistance ($R_u = M_u / [\rho_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 30.5 \text{ psi}$

$\rho_{\text{balanced}} = (0.85)(f_c / f_y) [87,000 / (87,000 + f_y)] = 0.02138$

$\rho_{\text{maximum}} = 0.85(f_c / f_y) [1 - (1 - (2R_u / (0.85f_c))^{1/2})] = 0.01604$

$\rho_{\text{minimum}} = 200 / f_y = 0.00333$

The approximate reinforcement ratio ($\rho_{\text{approx}} = 0.18(f_c / f_y) = 0.00900$

Use $\rho_{\text{approximate}} = 0.00900$

$m = f_y / (0.85f_c) = 23.53$

$R_u = \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}})(m) / 2] = 482.82 \text{ psi}$

$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 9.09 \text{ in}^3$

b = width of stem/web of concrete cross section
 d = effective depth from top of reinforced concrete

Using a d/b ratio = 1.80

$d = 9.54 \text{ in}$ Use $d = 9.50 \text{ in}$

$b = 5.30 \text{ in}$ Use $b = 5.25 \text{ in}$

checking the d/b ratio = 1.81 , OK

Revising the reinforcement ratio:

$bd^2 = 473.81 \text{ in}^3$

$R_{u \text{ revised}} = M_u / (\rho_{\text{flexure}} bd^2) = 111.20 \text{ psi}$

$\rho_{\text{revised}} = \rho_{\text{approx}} (R_{u \text{ revised}} / R_u) = 0.002073$

$A_{\text{steel required}} = \rho_{\text{revised}} bd = 0.10 \text{ in}^2$

Use minimum #4 bars @ 12 inches O/C +/-, $\text{Area}_{\text{steel provided}} = 0.20 \text{ in}^2$,
 or use #5 bars @ 12 inches O/C +/-, $\text{Area}_{\text{steel provided}} = 0.31 \text{ in}^2$,

**Trash Receptacle
Overturning and Sliding Analysis**

Overturning

Section from Side- Wind Force on Front of Receptacle	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Receptacle/Post	5.54	83.02	2.75	228.32	120.00	1.50	180.00	
2 - Concrete Foundation	--	0	--	--	1350.00	1.50	2025.00	
3 - Push/Lean	--	200.00	4.50	900.00	0	--	--	
4- Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				1128.32			2364.04	2.10 acceptable

Overturning

Section from Front - Wind Force on Side of Receptacle	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Receptacle/Post	5.54	83.02	2.75	228.32	120.00	1.50	180.00	
2 - Concrete Foundation	9.00	0	--	--	1350.00	1.50	2025.00	
3 - Push/Lean	--	200.00	4.50	900.00	0	--	--	
4- Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				1128.32			2364.04	2.10 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Receptacle/Post	5.54	83.02	120.00
2 - Concrete Foundation	--	0	1350.00
3 - Push/Lean	--	200.00	0
Total		283.02	1470.00

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation

base ($\delta' = (1/2)\phi'_2$) = 13 degrees

Adhesion between soil and foundation base

(c'_a) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force		283.02	657.46 2.32 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lb/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$

$P_p = 106.03 \text{ lb/ft}$

Calculate Maximum Pressure on Liner

$$q_{\max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B^*L') + 6M/(B'^2 * L')$$

Total axial/downward load (Q) = 1470.00 lb

Effective length of Foundation (L') = L - 2e = 1.46 ft

Effective Width of Foundation (B') = 3.00 ft

Moment (M) = 1128.32 lb-ft

Eccentricity (e) = M/Q = 0.77 ft

$q_{\max} = 848.00 \text{ lb/ft}^2$

$q_{\max} = 5.89 \text{ psi}$

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WOODEN GUARDRAIL

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Wooden Guardrail
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- $q_z =$ velocity pressure at height z. Height (z) = 3 ft
- $k_d =$ wind directional factor, Table 6-4, where $K_d =$ 0.85 for solid sign
- $k_z =$ velocity pressure exposure coefficient, Table 6-3,
 for heights of 0 ft to 15 ft, Exposure C, $K_h =$ 0.85
 for heights of 16 ft to 20 ft, Exposure C, $K_h =$ 0.90
 Use $k_h =$ 0.85
- $k_{zt} =$ topographic factor, where $K_{st} = (1 + K_1 K_2 K_3)^2$
 and K_1, K_2 and K_3 are given in Figure 6-4.
 Assuming general limited changes in topography, no ridge area, escarpment
 or axisymmetrical hill exists. Use $K_{st} =$ 1.0
- $V =$ basic wind speed, from Figure 6-1, where $V =$ 90 mph, for Exposure C
 (3 second wind gust)
 Exposure B consists of urban and suburban areas with closely spaced
 obstructions with heights equivalent to single family homes or larger, where
 $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights
 generally less than 30 feet. Exposure C is most conservative, due to larger
 velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.
- $I =$ importance factor Use $I =$ 1.0

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: $h =$ overall height = 6 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Rail	0.50	8.00	4.00
2 - Post	3	0.6667	2.00

$A =$ 6.00 ft²

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

$F =$ 14.982 lb/ft² x 6.00 ft² = 89.89 lb (acting at end of post)

$w =$ $\frac{89.89}{6}$ lb = 14.98 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground.
 Neglect q_h for the sign.
- $q_i = q_z = q_h =$ 1.0
- $G =$ gust effect factor, Use $G =$ 0.85
- $C_p =$ external pressure coefficient. From Figure 6-6,
 $C_p =$ 0.80 (windward); $C_p =$ -0.50 (leeward)
- $(G C_{pi}) =$ internal pressure coefficient. From Figure 6-5,
 Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 89.89 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{89.89}{6} \text{ lb/ft} = 14.98 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Volume	Density (lb/ft ³)	Weight (lb)
1- Rail	Western Red Cedar	0.67	23	15.33
Total				15.33

$$\text{Sign/Fencing Weight (W}_{\text{sign}}) = 15.33 \text{ lb}$$

$$W_{\text{sign}}/\text{ft}^2 = \frac{15.3 \text{ lb}}{6.0 \text{ ft}^2} = 2.56 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{15.33}{6} \text{ lb/ft} = 2.56 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 4.00 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 15.33 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{15.33}{6} \text{ lb/ft} = 2.56 \text{ lb/ft} \end{aligned}$$

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight
2 - Post	Western Red Cedar	1.78	23	40.89

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) - 6" \times 6" \times 7" \text{ Western Red Cedar Timber} &= 40.89 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = W/\text{ft} &= 6.82 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 89.89 \text{ lb} + 1.2 \times (15 \text{ lb} + 40.89 \text{ lb}) \\ P &= 211.30 \text{ lb} \quad \text{(point load at end of post)} \end{aligned}$$

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 14.98 \text{ lb/ft} + 1.2 \times (2.56 \text{ lb/ft} + 6.82 \text{ lb/ft}) \\ w &= 35.22 \text{ lb/ft} = 2.93 \text{ lb/in} \quad \text{(uniform load over extent of sign on post)} \end{aligned}$$

Adjusting uniform load over entire length of post:

$$w = 35.22 \text{ lb/ft} \times \frac{6}{4} \text{ ft} = 52.82 \text{ lb/ft} = 4.40 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

$$\begin{aligned} \text{Total equivalent Uniform Load } (W_{\text{equil}}) &= 4P \\ W_{\text{equil}} &= 845.2 \text{ lb/ft} \\ \text{Axial Load (R) = Shear (V) = P} \\ R = V = P &= 211.3 \text{ lb} \\ M_{\text{maximum}} &= \frac{PL}{2} = 211.3 \frac{\text{lb} \times 4}{2} \text{ ft} \\ M_{\text{maximum}} &= 423 \text{ lb ft} \quad (\text{at both ends}) \\ \text{Total Allowable Deflection} &= L/240 = 0.200 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{PL^3}{12EI} \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 263.7 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.001 \text{ inches} \quad (\text{at deflected end}) \\ (\Delta_{\text{max}}) &= 0.001 \text{ inches} < \Delta_{\text{allowable}} = 0.200 \text{ inches, ok} \end{aligned}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

$$\begin{aligned} \text{Total equivalent Uniform Load } (W_{\text{equil}}) &= \frac{8wL}{3} \\ W_{\text{equil}} &= 375.6 \text{ lb/ft} = 31.30 \text{ lb/in} \\ \text{Axial Load (R) = Shear (V) = wL} \\ R = V = wL &= 140.9 \text{ lb} \\ M_{\text{maximum}} &= \frac{wL^2}{3} = 187.8 \text{ lb-ft} = 2,254 \text{ lb-in (at fixed end)} \\ \text{Total Allowable Deflection} &= L/240 = 0.200 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{wL^4}{24EI} \quad (\text{at deflected end}) \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 263.7 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.003 \text{ inches} \quad (\text{at deflected end, adjusted over length of post}) \\ (\Delta_{\text{max}}) &= 0.003 \text{ inches} < \Delta_{\text{allowable}} = 0.200 \text{ inches, ok} \end{aligned}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the fence supports. Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	3.00	ft =	36	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	9.00	ft ²		
Volume of Footing (V_{ftg}) =	9.00	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,350.00 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	211.3	lb
Uniform Load on Post =	140.9	lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,561.3	lb /	9.00	ft ² =	173.5	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	1,490.9	lb /	9.00	ft ² =	165.7	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,350.0 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,350.00 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}} + W_{\text{ftg}})$$

$$P = 211.30 \text{ lb} + 1.2 (1350.00 \text{ lb}) = 1,831.30 \text{ lb} \quad (\text{point load at end of post})$$

Analyzing as a uniform load on the post:

$$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}} + W_{\text{ftg}/\text{depth of footing}})$$

$$w = 1,655.22 \text{ lb/ft} = 137.93 \text{ lb/in} \quad (\text{uniform load over extent of sign on post})$$

Recalculated moment for the point loading condition:

$$M_{\text{maximum}} = \frac{PL}{2} = \frac{1,831.3 \text{ lb} \times 4 \text{ ft}}{2} = 3,663 \text{ lb ft} \quad (\text{at fixed end foundation})$$

Moment remains unchanged for the uniformly distributed loading condition:

$$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{8,827.8 \text{ lb ft}}{3} = 105,934 \text{ lb-in} \quad (\text{at fixed end at foundation})$$

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 3,663 \text{ lb ft} = 43,951 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:

$f_y =$	60	ksi
$f'_c =$	3,000	psi
$\rho_{\text{shear}} =$	0.85	
$\rho_{\text{flexure}} =$	0.90	
unit width (w) =	1.0	ft
footing thickness/depth (d_{ftg}) =	1.00	ft

f_y = yield stress or strength of steel
 f'_c = compressive stress or strength of concrete

Coefficient of Resistance (R_u) = $M_u / [\rho_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 28.3 \text{ psi}$

$\rho_{\text{balanced}} = (0.85)^2 (f'_c / f_y) [87,000 / (87,000 + f_y)] = 0.02138$

$\rho_{\text{maximum}} = 0.85 (f'_c / f_y) [1 - (1 - (2R_u / (0.85f'_c))^{1/2})] = 0.01604$

$\rho_{\text{minimum}} = 200 / f_y = 0.00333$

The approximate reinforcement ratio ($\rho_{\text{approx}} = 0.18 (f'_c / f_y) = 0.00900$

Use $\rho_{\text{approximate}} = 0.00900$

$m = f_y / (0.85f'_c) = 23.53$

$R_u = \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}})(m) / 2] = 482.82 \text{ psi}$

$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 8.43 \text{ in}^3$

b = width of stem/web of concrete cross section
 d = effective depth from top of reinforced concrete

Using a d/b ratio =

1.80

$d = 9.54 \text{ in}$

$b = 5.30 \text{ in}$

Use $d = 9.50 \text{ in}$

Use $b = 5.25 \text{ in}$

checking the d/b ratio =

1.81 , OK

Revising the reinforcement ratio:

$bd^2 = 473.81 \text{ in}^3$

$R_{u \text{ revised}} = M_u / (\rho_{\text{flexure}} bd^2) = 103.07 \text{ psi}$

$\rho_{\text{revised}} = \rho_{\text{approx}} (R_{u \text{ revised}} / R_u) = 0.001921$

$A_{\text{steel required}} = \rho_{\text{revised}} bd = 0.10 \text{ in}^2$

Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in²,
 or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in².

**Wooden Guardrail
Overturning and Sliding Analysis**

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Rail	4.00	59.93	3.08	184.78	15.33	1.50	23.00	
2 - Post	2.00	29.97	2.50	74.91	40.89	1.50	61.34	
3 - Concrete Foundation	--	0	--	--	1350.00	1.50	2025.00	
4 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
5- Passive Rankine		0	--	--	318.08	0.500	159.04	
Total				1059.69			2268.38	2.14 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Rail	4.00	59.93	15.33
2 - Post	2.00	29.97	40.89
3 - Concrete Foundation	--	0	1350.00
4 - Push/Lean	--	200.00	0
Total		289.89	1406.23

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base ($\delta' = (1/2)\phi'_2$) = 13 degrees

Adhesion between soil and foundation base (c'_a) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta'_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	289.89	642.74	2.22 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$

$P_p = 106.03 \text{ lb/ft}$

Calculate Maximum Pressure on Liner

$$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B' \cdot L') + 6M/(B'^2 \cdot L')$$

Total axial/downward load (Q) = 1406.23 lb

Effective length of Foundation (L') = L - 2e = 1.49 ft

Effective Width of Foundation (B') = 3.00 ft

Moment (M) = 1059.69 lb-ft

Eccentricity (e) = M/Q = 0.75 ft

$q_{max} = 787.21 \text{ lb/ft}^2$

$q_{max} = 5.47 \text{ psi}$

OWL NESTING BOX

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Owl Nesting Box
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 10.25 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3,
 - for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$
 - for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$
 - Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.

Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 10.25 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 -Owl Nest	2.25	1.46	3.28
2 -			
3 - Post	8.00	0.250	2.00

$A = 5.28 \text{ ft}^2$

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

$F = 14.982 \text{ lb/ft}^2 \times 5.28 \text{ ft}^2 = 79.12 \text{ lb}$ (acting at end of post)

$w = \frac{79.12}{10} \text{ lb} = 7.92 \text{ lb/ft}$ (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6,
 - $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5,
 - Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 79.12 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{79.12}{10.25} \text{ lb} = 7.72 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Area (ft ²)	Unit Weight (lb)
1 - Owl Nest Plastic			12.00
2-			0.00
Total			12.00

$$\text{Sign Weight (W}_{\text{sign}}) = 12.00 \text{ lb}$$

$$W_{\text{sign}}/\text{ft}^2 = \frac{12.0 \text{ lb}}{5.3 \text{ ft}^2} = 2.27 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{12.00}{10.25} \text{ lb} = 1.17 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 9.00 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 12.00 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{12.00}{10.25} \text{ lb} = 1.17 \text{ lb/ft} \end{aligned}$$

Section	Material	Length (ft)	Unit Weight (lb)
3 - Post	1.5" O.D. Galvanized Steel	9.00	3.00
			27.00

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) &= 27.00 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= 2.63 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 79.12 \text{ lb} + 1.2 \times (12 \text{ lb} + 27.00 \text{ lb}) \\ P &= 173.40 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 7.72 \text{ lb/ft} + 1.2 \times (1.17 \text{ lb/ft} + 2.63 \text{ lb/ft}) \\ w &= 16.92 \text{ lb/ft} = 1.41 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 16.92 \text{ lb/ft} \times \frac{10.3}{9.0} \text{ ft} = 19.27 \text{ lb/ft} = 1.61 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = $4P$
 $W_{equil} = 693.6 \text{ lb/ft}$

Axial Load (R) = Shear (V) = P
 $R = V = P = 173.4 \text{ lb}$

$M_{maximum} = \frac{PL}{2} = 173.4 \text{ lb} \times \frac{9}{2} \text{ ft}$
 $M_{maximum} = 780 \text{ lb ft} \quad (\text{at both ends})$

Total Allowable Deflection = $L/240 = 0.450 \text{ inches}$

Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$
 $E = 2.9E+07 \text{ lb/in}^2$
 $I = 3.9 \text{ in}^4$

$(\Delta_{max}) = 0.013 \text{ inches} \quad (\text{at deflected end})$

$(\Delta_{max}) = 0.013 \text{ inches} < \Delta_{allowable} = 0.450 \text{ inches, ok}$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 3-inch diameter galvanized steel columns/posts for the supports. Use 3/8-inch square base plate with 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.50 ft =	42	inches
Length of Footing =	3.75 ft =	45	inches
Thickness of Footing (L) =	1.00 ft =	12	inches
Depth of Footing Base =	1.00 ft =	12	inches
Area of Footing (A_{ftg}) =	13.13 ft ²		
Volume of Footing (V_{ftg}) =	13.13 ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$

where: $p_{concrete} = 150.00 \text{ lb/ft}^3$
 $W_{ftg} = 1,968.75 \text{ lb}$

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	173.4 lb
Uniform Load on Post =	152.3 lb

Load to Soil:

Point Load on Post + W_{ftg} =	2,142.1 lb /	13.13 ft ² =	163.2 lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	2,121.0 lb /	13.13 ft ² =	161.6 lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$

where: $p_{concrete} = 150.00 \text{ lb/ft}^3$
 $W_{ftg} = 1,968.8 \text{ lb}$
 $W_{ftg}/\text{thickness of footing} = 1,968.75 \text{ lb/ft}$

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@sign}}} + W_{ftg})$
 $P = 173.40 \text{ lb} + 1.2 (1968.75 \text{ lb}) = 2,535.90 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@sign}}} + W_{ftg}/\text{depth of footing})$
 $w = 2,379.42 \text{ lb/ft} = 198.28 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{2,535.9 \text{ lb} \times 9 \text{ ft}}{2}$
 $M_{\text{maximum}} = 11,412 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{64,244.3 \text{ lb ft}}{3} = 770,931 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 11,412 \text{ lb ft} = 136,938 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$ yield stress or strength of steel
	$f'_c =$	3,000 psi	$f'_c =$ compressive stress or strength of concrete
	$\rho_{\text{shear}} =$	0.85	
	$\rho_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0 ft	
	footing thickness/depth (d_{fg}) =	1.00 ft	

$$\begin{aligned} \text{Coefficient of Resistance (R}_u) &= M_u / [\rho_{\text{flexure}} (w) (d_{\text{fg}})^2] = 88.1 \text{ psi} \\ \rho_{\text{balanced}} &= (0.85)^2 (f'_c / f_y) [87,000 / (87,000 + f_y)] = 0.02138 \\ \rho_{\text{maximum}} &= 0.85 (f'_c / f_y) [1 - (1 - (2R_u / (0.85f'_c))^{1/2})] = 0.01604 \\ \rho_{\text{minimum}} &= 200 / f_y = 0.00333 \end{aligned}$$

$$\begin{aligned} \text{The approximate reinforcement ratio } (\rho_{\text{approx}}) &= 0.18 (f'_c / f_y) = 0.00900 \\ \text{Use } \rho_{\text{approximate}} &= 0.00900 \end{aligned}$$

$$\begin{aligned} m &= f_y / (0.85f'_c) = 23.53 \\ R_u &= \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}}) (m) / 2] = 482.82 \text{ psi} \end{aligned}$$

$$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 26.26 \text{ in}^3$$

$b =$ width of stem/web of concrete cross section
 $d =$ effective depth from top of reinforced concrete

$$\begin{aligned} \text{Using a d/b ratio} &= 1.80 \\ d &= 9.54 \text{ in} & \text{Use } d &= 9.50 \text{ in} \\ b &= 5.30 \text{ in} & \text{Use } b &= 5.25 \text{ in} \end{aligned}$$

$$\text{checking the d/b ratio} = 1.81, \text{ OK}$$

Revising the reinforcement ratio:

$$\begin{aligned} bd^2 &= 473.81 \text{ in}^3 \\ R_{u \text{ revised}} &= M_u / (\rho_{\text{flexure}} bd^2) = 321.13 \text{ psi} \\ \rho_{\text{revised}} &= \rho_{\text{approx}} (R_{u \text{ revised}} / R_u) = 0.005986 \\ A_{\text{steel required}} &= \rho_{\text{revised}} bd = 0.30 \text{ in}^2 \end{aligned}$$

Use minimum #4 bars @ 6 inches O/C +/-, Area_{steel provided} = 0.39 in².
Or use #5 bars @ 10 inches O/C +/-, Area_{steel provided} = 0.37 in²,

Owl Nesting Box
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Owl Nesting Box	3.28	49.16	10.17	499.80	12.00	1.88	22.50	
3 - Post	1.00	14.98	5.00	74.91	47.84	1.88	89.70	
4 - Concrete Foundation	--	0	--	--	1968.75	1.88	3691.41	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	371.10	0.500	185.55	
Total				1774.71			3989.16	2.25 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Owl Nesting Box	3.28	49.16	10.17	499.80	12.00	1.75	21.00	
3 - Post	1.00	14.98	5.00	74.91	47.84	1.75	83.72	
4 - Concrete Foundation	--	0	--	--	1968.75	1.75	3445.31	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	397.61	0.500	198.80	
Total				1774.71			3748.84	2.11 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Owl Nesting Box	3.28	49.16	12.00
3 - Post	1.00	14.98	47.84
4 - Concrete Foundation	--	0	1968.75
6 - Push/Lean	--	200.00	0
Total		264.14	2028.59

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$$\delta' = (1/2)\phi'_2 = 13 \text{ degrees}$$

Adhesion between soil and foundation base (c'_s)= 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ₂) + (length of footing) x c'_s + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	264.14	839.44	3.18 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times Y_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$$

Soil cohesion (c'₂) = 0 kPa = kN/m²

Effective Soil Friction angle (φ'₂) = 26 degrees

Unit weight of soil (γ₂) = 82.8 lb/ft³

Depth to base of concrete (D) = 1.00 ft

$$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$$

P_p = 106.03 lb/ft

Calculate Maximum Pressure on Liner

$$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \cdot L) + 6M/(B \cdot L^2)$$

Total axial/downward load (Q) = 2028.59 lb

Effective length of Foundation (L') = L - 2e = 2.00 ft

Effective Width of Foundation (B') = 3.50 ft

Moment (M) = 1774.71 lb-ft

Eccentricity (e) = M/Q = 0.87 ft

q_{max} = 724.31 lb/ft²

q_{max} = 5.03 psi

DISC GOLF TARGET BASKET

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Disc Golf Target Basket
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 4.2 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$
for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$
Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 4.2 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1- Disc Golf	3	2	6
2-			
3 - Post	2	0.167	0.333

$A = 6.33 \text{ ft}^2$

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

$F = 14.982 \text{ lb/ft}^2 \times 6.33 \text{ ft}^2 = 94.88 \text{ lb}$ (acting at end of post)
 $w = \frac{94.88}{4} \text{ lb} = 22.77 \text{ lb/ft}$ (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 94.88 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{94.88}{4.167} \text{ lb/ft} = 22.77 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Weight (lb)
1 - Disc Golf Target Basket		20
Total		20

$$\text{Basket Weight (W}_{\text{sign}}) = 20.00 \text{ lb}$$

$$W_{\text{sign/ft}^2} = \frac{20.0 \text{ lb}}{6.3 \text{ ft}^2} = 3.16 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{20.00}{4.167} \text{ lb/ft} = 4.80 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 5 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 20.00 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{20.00}{4.167} \text{ lb/ft} = 4.80 \text{ lb/ft} \end{aligned}$$

Section	Material	Length (ft)	Unit Weight (lWeight (lb)
3 - Post	Galvanized Steel Pipe 2" O.D., 1.5" I.D.	4.00	3.5 14.00

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) - \text{Galvanized Steel Pipe} &= 14.00 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = W_{\text{post}} / \text{ft} &= 3.36 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 94.88 \text{ lb} + 1.2 \times (20 \text{ lb} + 14.00 \text{ lb}) \\ P &= 192.62 \text{ lb} \quad (\text{point load at end of post}) \end{aligned}$$

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 22.77 \text{ lb/ft} + 1.2 \times (4.80 \text{ lb/ft} + 3.36 \text{ lb/ft}) \\ w &= 46.22 \text{ lb/ft} = 3.85 \text{ lb/in} \quad (\text{uniform load over extent of sign on post}) \end{aligned}$$

Adjusting uniform load over entire length of post:

$$w = 46.22 \text{ lb/ft} \times \frac{4.2 \text{ ft}}{5.00 \text{ ft}} = 38.52 \text{ lb/ft} = 3.21 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = $4P$
 $W_{equil} = 770.5 \text{ lb/ft}$

Axial Load (R) = Shear (V) = P
 $R = V = P = 192.6 \text{ lb}$

$M_{maximum} = \frac{PL}{2} = 192.6 \text{ lb} \times \frac{5}{2} \text{ ft}$
 $M_{maximum} = 482 \text{ lb ft}$ (at both ends)

Total Allowable Deflection = $L/240 = 0.250 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

$E = 2.9E+07 \text{ lb/in}^2$
 $I = 0.5 \text{ in}^4$

$(\Delta_{max}) = 0.019 \text{ inches}$ (at deflected end)
 $(\Delta_{max}) = 0.019 \text{ inches} < \Delta_{allowable} = 0.250 \text{ inches, ok}$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8wL}{3}$
 $W_{equil} = 616.3 \text{ lb/ft} = 51.36 \text{ lb/in}$

Axial Load (R) = Shear (V) = wL
 $R = V = wL = 231.1 \text{ lb}$

$M_{maximum} = \frac{wL^2}{3} = 385.2 \text{ lb-ft} = 4,622 \text{ lb-in}$ (at fixed end)

Total Allowable Deflection = $L/240 = 0.250 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

$E = 2.9E+07 \text{ lb/in}^2$
 $I = 0.5 \text{ in}^4$

$(\Delta_{max}) = 0.111 \text{ inches}$ (at deflected end, adjusted over length of post)
 $(\Delta_{max}) = 0.111 \text{ inches} < \Delta_{allowable} = 0.250 \text{ inches, ok}$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 2-inch O.D. 1.5-inch I.D. galvanized steel poles for the supports. Use 3/8-inch square base plate with 3/8-inch diameter, 6-inch length anchor bolts.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.50	ft =	42	inches
Length of Footing =	3.50	ft =	42	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	12.25	ft ²		
Volume of Footing (V_{ftg}) =	12.25	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,837.50 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	192.6	lb
Uniform Load on Post =	231.1	lb

Load to Soil:

Point Load on Post + W_{ftg} =	2,030.1	lb /	12.25	ft ² =	165.7	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	2,068.6	lb /	12.25	ft ² =	168.9	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,837.50 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,837.50 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg})$
 $P = 192.62 \text{ lb} + 1.2 (1837.50 \text{ lb}) = 2,397.62 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg}/\text{depth of footing})$
 $w = 2,251.22 \text{ lb/ft} = 187.60 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{2,397.6 \text{ lb} \times 5}{2} \text{ ft}$
 $M_{\text{maximum}} = 5,994 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{18,760.2 \text{ lb ft}}{3} = 225,122 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 5,994 \text{ lb ft} = 71,928 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60	ksi	$f_y =$	yield stress or strength of steel
	$f_c' =$	3,000	psi	$f_c' =$	compressive stress or strength of concrete
	$\rho_{\text{shear}} =$	0.85			
	$\rho_{\text{flexure}} =$	0.90			
	unit width (w) =	1.0	ft		
	footing thickness/depth (d_{fg}) =	1.00	ft		

$$\begin{aligned} \text{Coefficient of Resistance (} R_u \text{)} &= M_u / [\rho_{\text{flexure}} (w) (d_{\text{fg}})^2] = 46.3 \text{ psi} \\ \rho_{\text{balanced}} &= (0.85)^2 (f_c' / f_y) [87,000 / (87,000 + f_y)] = 0.02138 \\ \rho_{\text{maximum}} &= 0.85 (f_c' / f_y) [1 - (1 - (2R_u / (0.85 f_c'))^{1/2})] = 0.01604 \\ \rho_{\text{minimum}} &= 200 / f_y = 0.00333 \end{aligned}$$

$$\begin{aligned} \text{The approximate reinforcement ratio (} \rho_{\text{approx}} \text{)} &= 0.18 (f_c' / f_y) = 0.00900 \\ \text{Use } \rho_{\text{approximate}} &= 0.00900 \end{aligned}$$

$$\begin{aligned} m &= f_y / (0.85 f_c') = 23.53 \\ R_u &= \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}}) (m) / 2] = 482.82 \text{ psi} \end{aligned}$$

$$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 13.79 \text{ in}^3$$

$b =$ width of stem/web of concrete cross section
 $d =$ effective depth from top of reinforced concrete

$$\begin{aligned} \text{Using a } d/b \text{ ratio} &= 1.80 \\ d &= 9.54 \text{ in} & \text{Use } d &= 9.50 \text{ in} \\ b &= 5.30 \text{ in} & \text{Use } b &= 5.25 \text{ in} \end{aligned}$$

$$\text{checking the } d/b \text{ ratio} = 1.81, \text{ OK}$$

$$\begin{aligned} \text{Revising the reinforcement ratio:} \\ bd^2 &= 473.81 \text{ in}^3 \\ R_u \text{ revised} &= M_u / (\rho_{\text{flexure}} bd^2) = 168.68 \text{ psi} \\ \rho \text{ revised} &= \rho_{\text{approx}} (R_u \text{ revised} / R_u) = 0.003144 \\ A_{\text{steel required}} &= \rho \text{ revised} bd = 0.16 \text{ in}^2 \end{aligned}$$

Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in²,
or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in²,

**Disc Golf Target Basket
Overturning and Sliding Analysis**

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Disc Golf Target Basket	6.00	89.89	4.00	359.56	20.00	1.75	35.00	
3 - Post	0.33	4.99	3.08	15.40	14.00	1.75	24.50	
4 - Concrete Foundation	--	0	--	--	1837.50	1.75	3215.63	
6 - Push/Lean	--	200.00	5.17	1033.40	0	--	--	
7 - Passive Rankine	--	0	--	--	371.10	0.500	185.55	
Total				1408.36			3460.67	2.46 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Disc Golf Target Basket	6.00	89.89	4.00	359.56	20.00	1.75	35.00	
3 - Post	0.33	4.99	3.08	15.40	14.00	1.75	24.50	
4 - Concrete Foundation	--	0	--	--	1837.50	1.75	3215.63	
6 - Push/Lean	--	200.00	5.17	1033.40	0	--	--	
7 - Passive Rankine	--	0	--	--	371.10	0.500	185.55	
Total				1408.36			3460.67	2.46 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Disc Golf Target Basket	6.00	89.89	20.00
3 - Post	0.33	4.99	14.00
4 - Concrete Foundation	--	0	1837.50
6 - Push/Lean	--	200.00	0
Total		294.88	1871.50

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (δ') =

$\delta' = (1/2)\phi'_2 = 13 \text{ degrees}$

Adhesion between soil and foundation base (c'_a) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta'_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	294.88	803.17	2.72 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lb/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$

$P_p = 106.03 \text{ lb/ft}$

Calculate Maximum Pressure on Liner

$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \times L) + 6M/(B \times L^2)$

Total axial/downward load (Q) = 1871.50 lb

Effective length of Foundation (L') = L - 2e = 1.99 ft

Effective Width of Foundation (B') = 3.50 ft

Moment (M) = 1408.36 lb-ft

Eccentricity (e) = M/Q = 0.75 ft

$q_{max} = 613.81 \text{ lb/ft}^2$

$q_{max} = 4.26 \text{ psi}$

SLOPED CHAISE LOUNGE CHAIR

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Sloped Chaise Lounge Chair
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 3.83 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_z = 0.85$ for heights of 16 ft to 20 ft, Exposure C, $K_z = 0.90$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.

Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 3.83 ft

Area A = h x w for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Lounge C	7.5	3	22.5
3 - Posts	1	2	2.0

A = 24.50 ft²

Determine Wind Force on the Sign:

F = P x A = q_z x A

F = 14.982 lb/ft² x 24.50 ft² = 367.05 lb (acting at end of post)

w = 367.05 lb / 4 ft = 91.76 lb/ft (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$

$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 367.05 lb
 Uniform Weight/ Post @ Sign = $\frac{367.05}{3.83}$ lb = 95.84 lb/ft

Dead Loads:

Section	Material	Weight (lb)
1 - Lounge Chair	FSC Hardwood + Galvanized Steel	581.00
2- User		250.00
Total		831.00

Sign Weight (W_{sign}) = 831.00 lb
 $W_{sign}/ft^2 = \frac{831.00}{24.5}$ lb = 33.92 lb/ft²

Uniform Weight @ Sign = $\frac{831.00}{3.83}$ lb = 216.97 lb/ft

Number of Posts = 2
 Post Length = 2 ft

Sign Weight/ Post ($W_{sign/post}$) = 415.50 lb
 Uniform Weight/ Post @ Sign = $\frac{415.50}{3.83}$ lb = 108.49 lb/ft

Section	Material	Area (ft ²)	Density (lb/ft ²)	Weight (lb)
3 - Post	Galvanized Steel	8.00	10	80.00

Post Weight (W_{post}) = 80.00 lb
 Uniform Weight/ Post @ Sign = $W_{post}/ft = 20.89$ lb/ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$P = 1.6 W_{per\ post} + 1.2 (W_{sign/post} + W_{post@sign})$
 $P = 1.6 \times 367.05 \text{ lb} + 1.2 \times (415.50 \text{ lb} + 80.00 \text{ lb})$
 $P = 1,181.88 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{sign/post} + W_{post@sign})$
 $w = 1.6 \times 95.84 \text{ lb/ft} + 1.2 \times (108.49 \text{ lb/ft} + 20.89 \text{ lb/ft})$
 $w = 308.59 \text{ lb/ft} = 25.72 \text{ lb/in}$ (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$w = 308.59 \text{ lb/ft} \times \frac{4}{2} \text{ ft} = 590.94 \text{ lb/ft} = 49.25 \text{ lb/in}$

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	5.00	ft =	60	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	15.00	ft ²		
Volume of Footing (V_{ftg}) =	15.00	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 2,250.00$ lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	1,181.9	lb
Uniform Load on Post =	617.2	lb

Load to Soil:

Point Load on Post + W_{ftg} =	3,431.9	lb /	15.00	ft ² =	228.8	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	2,867.2	lb /	15.00	ft ² =	191.1	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 2,250.00$ lb
 $W_{ftg} / \text{thickness of footing} = 2,250.00$ lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:
 $P = 1.6 W_{per\ post} + 1.2 (W_{t\ sign/post} + W_{t\ post@sign} + W_{ftg})$
 $P = 1,181.88$ lb + $1.2 (2250.00$ lb) = 3,881.88 lb (point load at end of post)

Analyzing as a uniform load on the post:
 $w = 1.6 W + 1.2 (W_{t\ sign/post} + W_{t\ post@sign} + W_{ftg}/\text{depth of footing})$
 $w = 3,008.59$ lb/ft = 250.72 lb/in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2} = \frac{3,881.9\ \text{lb} \times 2}{2}$ ft
 $M_{maximum} = 3,882$ lb ft (at fixed end foundation)

Recalculated moment for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3} = 4,011.4$ lb ft = 48,137 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 3,882 \text{ lb ft} = 46,583 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:

$f_y =$	60	ksi
$f_c =$	3,000	psi
$P_{\text{shear}} =$	0.85	
$P_{\text{flexure}} =$	0.90	
unit width (w) =	1.00	ft
footing thickness/depth (d_{reg}) =	1.00	ft

f_y = yield stress or strength of steel
 f_c = compressive stress or strength of concrete

Coefficient of Resistance (R_u) = $M_u / [P_{\text{flexure}} (w) (d_{\text{reg}})^2] = 30.0 \text{ psi}$

$p_{\text{balanced}} = (0.85)^2 (f_c / f_y) [87,000 / (87,000 + f_y)] =$	0.02138
$p_{\text{maximum}} = 0.85 (f_c / f_y) [1 - (1 - (2R_u / (0.85f_c))^{1/2})] =$	0.01604
$p_{\text{minimum}} = 200 / f_y =$	0.00333

The approximate reinforcement ratio ($p_{\text{approx}} = 0.18 (f_c / f_y) = 0.00900$

Use $p_{\text{approximate}} = 0.00900$

$m = f_y / (0.85f_c) =$	23.53
$R_u = p_{\text{approx}} f_y [1 - (p_{\text{approx}})(m) / 2] =$	482.82 \text{ psi}

$bd^2 = M_u / (p_{\text{flexure}}) (R_u) = 8.93 \text{ in}^3$

b = width of stem/web of concrete cross section
 d = effective depth from top of reinforced concrete

Using a d/b ratio =

$d/b = 1.80$	
$d = 9.54 \text{ in}$	Use $d = 9.50 \text{ in}$
$b = 5.30 \text{ in}$	Use $b = 5.25 \text{ in}$

checking the d/b ratio =

1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$	473.81 \text{ in}^3
$R_u \text{ revised} = M_u / (p_{\text{flexure}} bd^2) =$	109.24 \text{ psi}
$p_{\text{revised}} = p_{\text{approx}} (R_u \text{ revised} / R_u) =$	0.002036
$A_{\text{steel required}} = p_{\text{revised}} bd =$	0.10 \text{ in}^2

Use minimum #4 bars @ 12 inches O/C +/-, $A_{\text{steel provided}} = 0.20 \text{ in}^2$,
 or use minimum #5 bars @ 12 inches O/C +/-, $A_{\text{steel provided}} = 0.31 \text{ in}^2$,

**Sloped Chaise Lounge Chair
Overturning and Sliding Analysis**

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Lounge Chair	22.50	337.09	2.50	842.72	581.00	2.50	1452.50	
3 - Post	2.00	29.96	1.50	44.95	80.00	2.50	200.00	
4 - Concrete Foundation	--	0	--	--	2250.00	2.50	5625.00	
6 - Push/Lean	--	200.00	4.83	966.00	0	--	--	
7 - Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				1853.67			7436.54	4.01 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Lounge Chair	0	0	--	--	581.00	1.50	871.50	
3 - Post	7.66	114.76	1.50	172.14	80.00	1.50	120.00	
4 - Concrete Foundation	--	0	--	--	2250.00	1.50	3375.00	
6 - Push/Lean	--	200.00	4.83	966.00	0	--	--	
7 - Passive Rankine	--	0	--	--	530.14	0.500	265.07	
Total				1138.14			4631.57	4.07 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Lounge Chair	22.50	337.09	581.00
3 - Post	2.00	29.96	80.00
4 - Concrete Foundation	--	0	2250.00
6 - Push/Lean	--	200.00	0
Total		567.05	2911.00

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$$\delta' = (1/2)\phi'_2 = 13 \text{ degrees}$$

Adhesion between soil and foundation base (c'_a) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Sliding Horizontal Force	567.05	990.14	1.75 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$

$P_p = 106.03 \text{ lb/ft}$

Calculate Maximum Pressure on Liner

$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \times L) + 6M/(B \times L^2)$

Total axial/downward load (Q) = 2911.00 lb

Effective length of Foundation (L) = L - 2e = 3.73 ft

Effective Width of Foundation (B) = 3.00 ft

Moment (M) = 1853.67 lb-ft

Eccentricity (e) = M/Q = 0.64 ft

$q_{max} = 592.02 \text{ lb/ft}^2$

$q_{max} = 4.11 \text{ psi}$

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TRAIL MARKER

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Trail Marker
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 10 ft
- k_d = wind directional factor, Table 6-4, where K_d = 0.85 for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3,
 for heights of 0 ft to 15 ft, Exposure C, K_h = 0.85
 for heights of 16 ft to 20 ft, Exposure C, K_h = 0.90
 Use k_h = 0.85
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$
 and K_1, K_2 and K_3 are given in Figure 6-4.
 Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use K_{zt} = 1.0
- V = basic wind speed, from Figure 6-1, where V = 90 mph, for Exposure C (3 second wind gust)

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

- I = importance factor Use I = 1.0

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 10 ft

Area $A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Upper Sign	2	2	4.0
2 - Lower Sign	2	2.5	5.0
3 - Post	6	0.6667	4.0

$$A = 13.00 \text{ ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

$$F = 14.982 \text{ lb/ft}^2 \times 13.00 \text{ ft}^2 = 194.77 \text{ lb} \quad (\text{acting at end of post})$$

$$w = \frac{194.77}{10} = 19.48 \text{ lb/ft} \quad (\text{acting over surface})$$

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground.
 Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6,
 $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5,
 Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 194.77 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{194.77}{10} \text{ lb/ft} = 19.48 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Area (ft ²)	Unit Weight (lb)	Weight (lb)
1 - Upper Sign	Corten Steel	8	5.00	40.00
2 - Lower Sign	Corten Steel	5	5.00	25.00
End Cap	Corten Steel	1.33	5.00	6.67
Total				71.67

$$\text{Sign Weight (W}_{\text{sign}}) = 71.67 \text{ lb}$$

$$W_{\text{sign/ft}^2} = \frac{71.7 \text{ lb}}{13.0 \text{ ft}^2} = 5.51 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{71.67}{10} \text{ lb/ft} = 7.17 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 11 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 71.67 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{71.67}{10} \text{ lb/ft} = 7.17 \text{ lb/ft} \end{aligned}$$

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight (lb)
3 - Post	Western Red Cedar	4.89	23	112.46

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) &= 112.46 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= W/ft = 11.25 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 194.77 \text{ lb} + 1.2 \times (71.67 \text{ lb} + 112.46 \text{ lb}) \\ P &= 532.57 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 19.48 \text{ lb/ft} + 1.2 \times (7.17 \text{ lb/ft} + 11.25 \text{ lb/ft}) \\ w &= 53.26 \text{ lb/ft} = 4.44 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 53.26 \text{ lb/ft} \times \frac{10}{11} \text{ ft} = 48.42 \text{ lb/ft} = 4.03 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

$$\begin{aligned} \text{Total equivalent Uniform Load } (W_{\text{equi}}) &= 4P \\ W_{\text{equi}} &= 2,130.3 \text{ lb/ft} \\ \text{Axial Load } (R) = \text{Shear } (V) &= P \\ R = V = P &= 532.6 \text{ lb} \\ M_{\text{maximum}} &= \frac{PL}{2} = 532.6 \frac{\text{lb} \times 11}{2} \text{ ft} \\ M_{\text{maximum}} &= 2,929 \text{ lb ft} \quad (\text{at both ends}) \\ \text{Total Allowable Deflection} &= L/240 = 0.550 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{PL^3}{12EI} \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 263.7 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.029 \text{ inches} \quad (\text{at deflected end}) \\ (\Delta_{\text{max}}) &= 0.029 \text{ inches} < \Delta_{\text{allowable}} = 0.550 \text{ inches, ok} \end{aligned}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

$$\begin{aligned} \text{Total equivalent Uniform Load } (W_{\text{equi}}) &= 8wL \\ W_{\text{equi}} &= 1,562.2 \text{ lb/ft} = 130.18 \text{ lb/in} \\ \text{Axial Load } (R) = \text{Shear } (V) &= wL \\ R = V = wL &= 585.8 \text{ lb} \\ M_{\text{maximum}} &= \frac{wL^2}{3} = 2,148.0 \text{ lb-ft} = 25,777 \text{ lb-in (at fixed end)} \\ \text{Total Allowable Deflection} &= L/240 = 0.550 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{wL^4}{24EI} \quad (\text{at deflected end}) \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 263.7 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.176 \text{ inches} \quad (\text{at deflected end, adjusted over length of post}) \\ (\Delta_{\text{max}}) &= 0.176 \text{ inches} < \Delta_{\text{allowable}} = 0.550 \text{ inches, ok} \end{aligned}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports. Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.25 ft =	39	inches
Length of Footing =	4.25 ft =	51	inches
Thickness of Footing (L) =	1.00 ft =	12	inches
Depth of Footing Base =	1.00 ft =	12	inches
Area of Footing (A_{ftg}) =	13.81 ft ²		
Volume of Footing (V_{ftg}) =	13.81 ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 2,071.88 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:
 Point Load on Post = 532.6 lb
 Uniform Load on Post = 585.8 lb

Load to Soil:
 Point Load on Post + W_{ftg} = 2,604.4 lb / 13.81 ft² = 188.6 lb/ft² < 2,000 lb/ft², ok
 Uniform Load on Post + W_{ftg} = 2,657.7 lb / 13.81 ft² = 192.4 lb/ft² < 2,000 lb/ft², ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 2,071.9 lb
 $W_{ftg}/\text{thickness of footing}$ = 2,071.88 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{t \text{ sign/post}} + W_{t \text{ post@ sign}} + W_{ftg})$
 $P = 532.57 \text{ lb} + 1.2 (2071.88 \text{ lb}) = 3,018.82 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{t \text{ sign/post}} + W_{t \text{ post@ sign}} + W_{ftg}/\text{depth of footing})$
 $w = 2,539.51 \text{ lb/ft} = 211.63 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{3,018.8 \text{ lb} \times 11}{2} \text{ ft}$
 $M_{\text{maximum}} = 16,604 \text{ lb ft}$ (at fixed end foundation)

Recalculated moment for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = 102,426.8 \text{ lb ft} = 1,229,122 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 16,604 \text{ lb ft} = 199,242 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:

$f_y =$	60 ksi
$f_c =$	3,000 psi
$p_{\text{shear}} =$	0.85
$p_{\text{flexure}} =$	0.90
unit width (w) =	1.00 ft
footing thickness/depth (d_{ftg}) =	1.00 ft

f_y = yield stress or strength of steel
 f_c = compressive stress or strength of concrete

Coefficient of Resistance ($R_u = M_u / [p_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 128.1 \text{ psi}$)

$p_{\text{balanced}} = (0.85)^2 (f_c / f_y) [87,000 / (87,000 + f_y)] =$	0.02138
$p_{\text{maximum}} = 0.85 (f_c / f_y) [1 - (1 - (2R_u / (0.85 f_c'))^{1/2})] =$	0.01604
$p_{\text{minimum}} = 200 / f_y =$	0.00333

The approximate reinforcement ratio ($p_{\text{approx}} = 0.18 (f_c / f_y) = 0.00900$)

Use $p_{\text{approximate}} = 0.00900$

$m = f_y / (0.85 f_c) =$	23.53
$R_u = p_{\text{approx}} f_y [1 - (p_{\text{approx}} (m) / 2)] =$	482.82 psi

$bd^2 = M_u / (p_{\text{flexure}} (R_u)) = 38.21 \text{ in}^3$

b = width of stem/web of concrete cross section
 d = effective depth from top of reinforced concrete

Using a d/b ratio =

$d =$	9.54 in	Use $d =$	9.50 in
$b =$	5.30 in	Use $b =$	5.25 in

checking the d/b ratio =

1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$	473.81 in ³
$R_u \text{ revised} = M_u / (p_{\text{flexure}} bd^2) =$	467.23 psi
$p_{\text{revised}} = p_{\text{approx}} (R_u \text{ revised} / R_u) =$	0.008709
$A_{\text{steel required}} = p_{\text{revised}} bd =$	0.43 in ²

Use minimum #5 bars @ 8 inches O/C +/-, $Area_{\text{steel provided}} = 0.47 \text{ in}^2$,
 or use #6 bars @ 12 inches O/C +/-, $Area_{\text{steel provided}} = 0.44 \text{ in}^2$.

Trail Marker
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Upper Sign	4.00	59.93	9.00	539.34	40.00	2.13	85.00	
2 - Lower Sign	5.00	74.91	4.50	337.09	25.00	2.13	53.13	
3 - Post	4.00	59.93	6.00	359.58	119.12	2.13	253.14	
4 - Concrete Foundation	--	0	--	--	2071.88	2.13	4402.73	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				2436.01			4966.29	2.04 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Upper Sign	0	0	--	--	40.00	1.63	65.00	
2 - Lower Sign	0	0	--	--	25.00	1.63	40.63	
3 - Post	6.67	99.88	6.00	599.30	119.12	1.63	193.57	
4 - Concrete Foundation	--	0	--	--	2071.88	1.63	3366.80	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	450.62	0.500	225.31	
Total				1799.30			3891.31	2.16 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Upper Sign	4.00	59.93	40.00
2 - Lower Sign	5.00	74.91	25.00
3 - Post	4.00	59.93	119.12
4 - Concrete Foundation	--	0	2071.88
6 - Push/Lean	--	200.00	0
Total		394.77	2256.00

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$$\delta' = (1/2)\phi'_2 = 13 \text{ degrees}$$

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ₂) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Sliding Horizontal Force	394.77	865.43	2.19 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times Y_2 \times D^3) + 2(c'_2 \times \sqrt{K_p \times D})$$

Soil cohesion (c'₂) = 0 kPa = kN/m²

Effective Soil Friction angle (φ'₂) = 26 degrees

Unit weight of soil (γ₂) = 82.8 lb/ft³

Depth to base of concrete (D) = 1.00 ft

$$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$$

$$P_p = 106.03 \text{ lb/ft}$$

Calculate Maximum Pressure on Liner

$$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \times L) + 6M/(B^2 \times L)$$

Total axial/downward load (Q) = 2256.00 lb

Effective length of Foundation (L) = L - 2e = 1.70 ft

Effective Width of Foundation (B') = 3.25 ft

Moment (M) = 2436.01 lb-ft

Eccentricity (e) = M/Q = 1.08 ft

$$q_{max} = 1223.78 \text{ lb/ft}^2$$

$$q_{max} = 8.50 \text{ psi}$$

EDUCATIONAL POST

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Educational Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 4.5 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$
for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$
Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 4.5 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Educator	1.00	1.5	1.50
2 -			
3 - Post	3.50	1.50	5.25

$A = 6.75 \text{ ft}^2$

Determine Wind Force on the Sign:

$F = P \times A = q_z \times A$

$F = \frac{14.982}{5} \text{ lb/ft}^2 \times 6.75 \text{ ft}^2 = 101.13 \text{ lb}$ (acting at end of post)
 $w = \frac{101.13}{5} \text{ lb} = 22.47 \text{ lb/ft}$ (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 101.13 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{101.13}{4.5} \text{ lb} = 22.47 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Area (ft ²)	Unit Weight (l Weight (lb)
1 - Educational Sign	Corten Steel	1.50	10.2
Total			15.30

$$\text{Sign Weight (W}_{\text{sign}}), \text{Corten Steel Sign Weight} = 15.30 \text{ lb}$$

$$W_{\text{sign/ft}^2} = \frac{15.3 \text{ lb}}{6.8 \text{ ft}^2} = 2.27 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{15.30}{4.5} \text{ lb} = 3.40 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 5.50 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 15.30 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{15.30}{4.5} \text{ lb} = 3.40 \text{ lb/ft} \end{aligned}$$

Section	Material	Area (ft ²)	Unit Weight (l Weight (lb)
3 - Post	Corten Steel	5.25	10.2
Total			53.55

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) - \text{Corten Steel} &= 53.55 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = W_{\text{t/ft}} &= 11.90 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 101.13 \text{ lb} + 1.2 \times (15 \text{ lb} + 53.55 \text{ lb}) \\ P &= 244.42 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 22.47 \text{ lb/ft} + 1.2 \times (3.40 \text{ lb/ft} + 11.90 \text{ lb/ft}) \\ w &= 54.32 \text{ lb/ft} = 4.53 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 54.32 \text{ lb/ft} \times \frac{4.5}{5.5} \text{ ft} = 44.44 \text{ lb/ft} = 3.70 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equi}) = $4P$

$$W_{equi} = 977.7 \text{ lb/ft}$$

Axial Load (R) = Shear (V) = P

$$R = V = P = 244.4 \text{ lb}$$

$$M_{\text{maximum}} = \frac{PL}{2} = 244.4 \text{ lb} \times \frac{5.5}{2} \text{ ft}$$

$$M_{\text{maximum}} = 672 \text{ lb ft} \quad (\text{at both ends})$$

Total Allowable Deflection = $L/240 = 0.275 \text{ inches}$

$$\text{Maximum Deflection } (\Delta_{\text{max}}) = \frac{PL^3}{12EI}$$

$$E = 3.0E+07 \text{ lb/in}^2$$

$$I = 0.188 \text{ in}^4$$

$$(\Delta_{\text{max}}) = 0.0868 \text{ inches} \quad (\text{at deflected end})$$

$$(\Delta_{\text{max}}) = 0.0868 \text{ inches} < \Delta_{\text{allowable}} = 0.275 \text{ inches, ok}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 1/2 inch Corten Steel for the sign support.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.25 ft =	39 inches
Length of Footing =	3.50 ft =	42 inches
Thickness of Footing (L) =	1.00 ft =	12 inches
Depth of Footing Base =	1.00 ft =	12 inches
Area of Footing (A_{ftg}) =	11.38 ft ²	
Volume of Footing (V_{ftg}) =	11.38 ft ³	

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete} = 150.00 \text{ lb/ft}^3$
 $W_{ftg} = 1,706.25 \text{ lb}$

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	244.4 lb
Uniform Load on Post =	298.7 lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,950.7 lb /	11.38 ft ² =	171.5 lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	2,005.0 lb /	11.38 ft ² =	176.3 lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete} = 150.00 \text{ lb/ft}^3$
 $W_{ftg} = 1,706.3 \text{ lb}$
 $W_{ftg}/\text{thickness of footing} = 1,706.25 \text{ lb/ft}$

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}} + W_{ftg})$
 $P = 244.42 \text{ lb} + 1.2 (1706.25 \text{ lb}) = 2,291.92 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}} + W_{ftg}/\text{depth of footing})$
 $w = 2,101.82 \text{ lb/ft} = 175.15 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{2,291.9 \text{ lb} \times 5.5 \text{ ft}}{2}$
 $M_{\text{maximum}} = 6,303 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = 21,193.3 \text{ lb ft} = 254,320 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 6,303 \text{ lb ft} = 75,633 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$ yield stress or strength of steel
	$f'_c =$	3,000 psi	$f'_c =$ compressive stress or strength of concrete
	$\rho_{\text{shear}} =$	0.85	
	$\rho_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0 ft	
	footing thickness/depth (d_{hg}) =	1.00 ft	

$$\begin{aligned} \text{Coefficient of Resistance (} R_u \text{)} &= M_u / [\rho_{\text{flexure}} (w) (d_{\text{hg}})^2] = 48.6 \text{ psi} \\ \rho_{\text{balanced}} &= (0.85)^2 (f'_c / f_y) [87,000 / (87,000 + f_y)] = 0.02138 \\ \rho_{\text{maximum}} &= 0.85 (f'_c / f_y) [1 - (1 - (2R_u / (0.85f'_c))^{1/2})] = 0.01604 \\ \rho_{\text{minimum}} &= 200 / f_y = 0.00333 \end{aligned}$$

$$\begin{aligned} \text{The approximate reinforcement ratio (} \rho_{\text{approx}} \text{)} &= 0.18 (f'_c / f_y) = 0.00900 \\ \text{Use } \rho_{\text{approximate}} &= 0.00900 \end{aligned}$$

$$\begin{aligned} m &= f_y / (0.85f'_c) = 23.53 \\ R_u &= \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}}) (m) / 2] = 482.82 \text{ psi} \end{aligned}$$

$$bd^2 = M_u / (\rho_{\text{flexure}} (R_u)) = 14.50 \text{ in}^3$$

$b =$ width of stem/web of concrete cross section
 $d =$ effective depth from top of reinforced concrete

$$\begin{aligned} \text{Using a } d/b \text{ ratio} &= 1.80 \\ d &= 9.54 \text{ in} & \text{Use } d &= 9.50 \text{ in} \\ b &= 5.30 \text{ in} & \text{Use } b &= 5.25 \text{ in} \end{aligned}$$

$$\text{checking the } d/b \text{ ratio} = 1.81, \text{ OK}$$

Revising the reinforcement ratio:

$$\begin{aligned} bd^2 &= 473.81 \text{ in}^3 \\ R_u \text{ revised} &= M_u / (\rho_{\text{flexure}} bd^2) = 177.36 \text{ psi} \\ \rho_{\text{revised}} &= \rho_{\text{approx}} (R_u \text{ revised} / R_u) = 0.003306 \\ A_{\text{steel required}} &= \rho_{\text{revised}} bd = 0.16 \text{ in}^2 \end{aligned}$$

**Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in²,
or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in²,**

Educational Post
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Educational Sign	1.50	22.47	5.00	112.36	15.30	1.75	26.78	
3 - Post	5.25	78.65	2.75	216.30	53.55	1.75	93.71	
4 - Concrete Foundation	--	0	--	--	1706.25	1.75	2985.94	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				1428.66			3278.72	2.29 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Educational Sign	1.50	0	--	--	15.30	1.63	24.86	
3 - Post	5.25	78.65	2.75	216.30	53.55	1.63	87.02	
4 - Concrete Foundation	--	0	--	--	1706.25	1.63	2772.66	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine	--	0	--	--	371.10	0.500	185.55	
Total				1316.30			3070.09	2.33 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Educational Sign	1.50	22.47	15.30
3 - Post	5.25	78.65	53.55
4 - Concrete Foundation	--	0	1706.25
6 - Push/Lean	--	200.00	0
Total		301.13	1775.10

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$\delta' = (1/2)\phi'_2 =$ 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	301.13	754.41	2.51 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lb/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) =$ 2.56

$P_p =$ 106.03 lb/ft

Calculate Maximum Pressure on Liner

$q_{max} =$ maximum pressure by foundation on soil at overturning corner = $Q/(B \times L) + 6M/(B \times L^2)$

Total axial/downward load (Q) = 1775.10 lb

Effective length of Foundation (L') = L - 2e = 1.89 ft

Effective Width of Foundation (B') = 3.25 ft

Moment (M) = 1428.66 lb-ft

Eccentricity (e) = M/Q = 0.80 ft

$q_{max} =$ 718.25 lb/ft²

$q_{max} =$ 4.99 psi

INFORMATIONAL SIGN (SMALL)

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Information Sign (Small)

Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} K_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 8.2 ft
- K_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$; for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$; Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.

Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} K_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 8.167 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Info Sign	4.00	2.00	8.00
2 -			
3 - Post	4.17	0.667	2.78

$$A = 10.78 \text{ ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

F =	14.982	lb/ft ² x	10.78	ft ² =	161.47	lb	(acting at end of post)
w =	161.47	lb	=	19.77	lb/ft		(acting over surface)
	8	ft					

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_l (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_l (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 161.47 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{161.47}{8.167} \text{ lb/ft} = 19.77 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Area (ft ²)	Unit Weight (lb/ft ²)	Weight (lb)
1 - Info Sign	Corten Steel	8.00	2.575	20.60
End Cap	Corten Steel	1.33	2.575	3.43
Total				24.03

$$\text{Sign Weight (W}_{\text{sign}}), \text{Corten Steel Sign Weight} = 24.03 \text{ lb}$$

$$W_{\text{sign}}/ft^2 = \frac{24.03 \text{ lb}}{10.8 \text{ ft}^2} = 2.23 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{24.03}{8.167} \text{ lb/ft} = 2.94 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 9.17 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 24.03 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{24.03}{8.167} \text{ lb/ft} = 2.94 \text{ lb/ft} \end{aligned}$$

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight
3 - Post	Western Red Cedar	4.07	23	93.72

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) - 8" \times 8" \text{ Western Red Cedar} &= 93.72 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = W_{\text{t}}/ft &= 11.48 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 161.47 \text{ lb} + 1.2 \times (24 \text{ lb} + 93.72 \text{ lb}) \\ P &= 399.66 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 19.77 \text{ lb/ft} + 1.2 \times (2.94 \text{ lb/ft} + 11.48 \text{ lb/ft}) \\ w &= 48.94 \text{ lb/ft} = 4.08 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 48.94 \text{ lb/ft} \times \frac{8.2}{9.2} \text{ ft} = 43.60 \text{ lb/ft} = 3.63 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

$$\begin{aligned} \text{Total equivalent Uniform Load (W}_{\text{equi}}) &= 4P \\ W_{\text{equi}} &= 1,598.6 \text{ lb/ft} \\ \text{Axial Load (R) = Shear (V) = P} \\ R = V = P &= 399.7 \text{ lb} \\ M_{\text{maximum}} &= \frac{PL}{2} = 399.7 \text{ lb} \times \frac{9.167}{2} \text{ ft} \\ M_{\text{maximum}} &= 1,832 \text{ lb ft} \quad (\text{at both ends}) \\ \text{Total Allowable Deflection} &= L/240 = 0.458 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{PL^3}{12EI} \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 263.7 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.013 \text{ inches} \quad (\text{at deflected end}) \\ (\Delta_{\text{max}}) &= 0.013 \text{ inches} < \Delta_{\text{allowable}} = 0.458 \text{ inches, ok} \end{aligned}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

$$\begin{aligned} \text{Total equivalent Uniform Load (W}_{\text{equi}}) &= \frac{8}{3} wL \\ W_{\text{equi}} &= 1,196.2 \text{ lb/ft} = 99.69 \text{ lb/in} \\ \text{Axial Load (R) = Shear (V) = wL} \\ R = V = wL &= 448.6 \text{ lb} \\ M_{\text{maximum}} &= \frac{wL^2}{3} = 1,370.8 \text{ lb-ft} = 16,449 \text{ lb-in (at fixed end)} \\ \text{Total Allowable Deflection} &= L/240 = 0.458 \text{ inches} \\ \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{wL^4}{24EI} \quad (\text{at deflected end}) \\ E &= 1.1\text{E}+06 \text{ lb/in}^2 \\ I &= 263.7 \text{ in}^4 \\ (\Delta_{\text{max}}) &= 0.076 \text{ inches} \quad (\text{at deflected end, adjusted over length of post}) \\ (\Delta_{\text{max}}) &= 0.076 \text{ inches} < \Delta_{\text{allowable}} = 0.458 \text{ inches, ok} \end{aligned}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports. Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	4.25	ft =	51	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	12.75	ft ²		
Volume of Footing (V_{ftg}) =	12.75	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 1,912.50$ lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post = 399.7 lb
 Uniform Load on Post = 448.6 lb

Load to Soil:

Point Load on Post + W_{ftg} = 2,312.2 lb / 12.75 ft² = 181.3 lb/ft² < 2,000 lb/ft², ok
 Uniform Load on Post + W_{ftg} = 2,361.1 lb / 12.75 ft² = 185.2 lb/ft² < 2,000 lb/ft², ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 1,912.5$ lb
 $W_{ftg}/\text{thickness of footing} = 1,912.50$ lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@sign}}} + W_{ftg})$
 $P = 399.66$ lb + $1.2 (1,912.50$ lb) = 2,694.66 lb (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{t_{\text{sign/post}}} + W_{t_{\text{post@sign}}} + W_{ftg}/\text{depth of footing})$
 $w = 2,343.94$ lb/ft = 195.33 lb/in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{2,694.7 \text{ lb} \times 9.167 \text{ ft}}{2}$
 $M_{\text{maximum}} = 12,351$ lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = 65,656.7$ lb ft = 787,880 lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 12,351 \text{ lb ft} = 148,212 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:

$f_y =$	60	ksi
$f_c =$	3,000	psi
$\rho_{\text{shear}} =$	0.85	
$\rho_{\text{flexure}} =$	0.90	
unit width (w) =	1.0	ft
footing thickness/depth (d_{ftg}) =	1.00	ft

f_y = yield stress or strength of steel
 f_c = compressive stress or strength of concrete

Coefficient of Resistance ($R_u = M_u / [\rho_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 95.3 \text{ psi}$)

$\rho_{\text{balanced}} = (0.85)^2 (f_c / f_y) [87,000 / (87,000 + f_y)] = 0.02138$

$\rho_{\text{maximum}} = 0.85 (f_c / f_y) [1 - (1 - (2R_u / (0.85f_c))^{1/2})] = 0.01604$

$\rho_{\text{minimum}} = 200 / f_y = 0.00333$

The approximate reinforcement ratio ($\rho_{\text{approx}} = 0.18 (f_c / f_y) = 0.00900$)

Use $\rho_{\text{approximate}} = 0.00900$

$m = f_y / (0.85f_c) = 23.53$

$R_u = \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}})(m) / 2] = 482.82 \text{ psi}$

$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 28.42 \text{ in}^3$

b = width of stem/web of concrete cross section
d = effective depth from top of reinforced concrete

Using a d/b ratio =

$d =$	9.54 in	Use d =	9.50 in
$b =$	5.30 in	Use b =	5.25 in

checking the d/b ratio =

1.81, OK

Revising the reinforcement ratio:

$bd^2 = 473.81 \text{ in}^3$

$R_{u \text{ revised}} = M_u / (\rho_{\text{flexure}} bd^2) = 347.56 \text{ psi}$

$\rho_{\text{revised}} = \rho_{\text{approx}} (R_{u \text{ revised}} / R_u) = 0.006479$

$A_{\text{steel required}} = \rho_{\text{revised}} bd = 0.32 \text{ in}^2$

Use minimum #4 bars @ 7 inches O/C +/-, Area_{steel provided} = 0.34 in².
or use #5 bars @ 10 inches O/C +/-, Area_{steel provided} = 0.37 in²,

Information Sign (Small)
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (small)	8.00	119.85	6.00	719.12	20.60	2.13	43.78	
3 - Post	2.78	41.62	5.17	215.05	97.15	2.13	206.44	
4 - Concrete Foundation	--	0	--	--	1912.50	2.13	4064.06	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				2134.17			4473.32	2.10 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (small)	8.00	0	--	--	20.60	1.50	30.90	
3 - Post	2.78	41.62	5.17	215.05	97.15	1.50	145.72	
4 - Concrete Foundation	--	0	--	--	1912.50	1.50	2868.75	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	450.62	0.500	225.31	
Total				1415.05			3270.68	2.31 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Info Sign (small)	8.00	119.85	20.60
3 - Post	2.78	41.62	97.15
4 - Concrete Foundation	--	0	1912.50
6 - Push/Lean	--	200.00	0
Total		361.47	2030.25

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$$\delta' = (1/2)\phi'_2 = 13 \text{ degrees}$$

$$\text{Adhesion between soil and foundation base (c'_a)} = 0 \text{ kPa} = \text{kN/m}^2$$

$$\text{Sum of horizontal resisting forces} = (\text{sum of resisting vertical forces}) \times \tan(\delta_2) + (\text{length of footing}) \times c'_a + P_p$$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	361.47	786.81	2.18 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2 \times \sqrt{K_p \times D})$$

$$\text{Soil cohesion (c'_2)} = 0 \text{ kPa} = \text{kN/m}^2$$

$$\text{Effective Soil Friction angle (\phi'_2)} = 26 \text{ degrees}$$

$$\text{Unit weight of soil (\gamma_2)} = 82.8 \text{ lb/ft}^3$$

$$\text{Depth to base of concrete (D)} = 1.00 \text{ ft}$$

$$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$$

$$P_p = 106.03 \text{ lb/ft}$$

Calculate Maximum Pressure on Liner

$$q_{\text{max}} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \times L) + 6M/(B \times L^2)$$

$$\text{Total axial/downward load (Q)} = 2030.25 \text{ lb}$$

$$\text{Effective length of Foundation (L')} = L - 2e = 2.15 \text{ ft}$$

$$\text{Effective Width of Foundation (B')} = 3.00 \text{ ft}$$

$$\text{Moment (M)} = 2134.17 \text{ lb-ft}$$

$$\text{Eccentricity (e)} = M/Q = 1.05 \text{ ft}$$

$$q_{\text{max}} = 977.61 \text{ lb/ft}^2$$

$$q_{\text{max}} = 6.79 \text{ psi}$$

DIRECTIONAL SIGN POST

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Directional Sign Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

q_z =	velocity pressure at height z. Height (z) =	4.5	ft
k_d =	wind directional factor, Table 6-4, where K_d =	0.85	for solid sign
k_z =	velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, K_h =	0.85	
	for heights of 16 ft to 20 ft, Exposure C, K_h =	0.90	
	Use k_h =	0.85	
k_{zt} =	topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use K_{zt} =	1.0	
V =	basic wind speed, from Figure 6-1, where V =	90	mph, for Exposure C (3 second wind gust)
I =	importance factor	1.0	Use I =

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 4.5 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Direction:	0.667	2	1.33
2 -			
3 - Post	3.83	0.667	2.56

$$A = 3.89 \text{ ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

F =	14.982	lb/ft ² x	3.89	ft ² =	58.26	lb	(acting at end of post)
w =	$\frac{58.26}{5}$	lb =	12.95	lb/ft			(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

q =	q_z	for windward walls at height z above the ground.
q =	q_h	for leeward walls, where sides are at height h above the ground.
		Neglect q_h for the sign.
q_i =	$q_z = q_h$ =	1.0
G =	gust effect factor, Use G =	0.85
C_p =	external pressure coefficient. From Figure 6-6,	
	C_p =	0.80 (windward); C_p = -0.50 (leeward)
$(G C_{pi})$ =	internal pressure coefficient. From Figure 6-5,	
	Use	0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 58.26 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{58.26}{4.5} \text{ lb/ft} = 12.95 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Area (ft ²)	Unit Weight (lb)	Weight (lb)
1 - Upper Sign	Corten Steel	2.67	2.575	6.87
End Cap	Corten Steel	1.33	2.575	3.43
Total				10.30

$$\text{Sign Weight (W}_{\text{sign}}), \text{Corten Steel Sign Weight} = 10.30 \text{ lb}$$

$$W_{\text{sign/ft}^2} = \frac{10.3 \text{ lb}}{3.9 \text{ ft}^2} = 2.65 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{10.30}{4.5} \text{ lb/ft} = 2.29 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 5.5 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 10.30 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{10.30}{4.5} \text{ lb/ft} = 2.29 \text{ lb/ft} \end{aligned}$$

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight
3 - Post	Western Red Cedar	2.44	23	56.23

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) - 8" \times 8" \text{ Western Red Cedar} &= 56.23 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = W_{\text{post}} &= 12.50 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 58.26 \text{ lb} + 1.2 \times (10 \text{ lb} + 56.23 \text{ lb}) \\ P &= 173.06 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 12.95 \text{ lb/ft} + 1.2 \times (2.29 \text{ lb/ft} + 12.50 \text{ lb/ft}) \\ w &= 38.46 \text{ lb/ft} = 3.20 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 38.46 \text{ lb/ft} \times \frac{4.5 \text{ ft}}{5.5 \text{ ft}} = 31.46 \text{ lb/ft} = 2.62 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = $4P$
 $W_{equil} = 692.2 \text{ lb/ft}$

Axial Load (R) = Shear (V) = P
 $R = V = P = 173.1 \text{ lb}$

$M_{maximum} = \frac{PL}{2} = 173.1 \text{ lb} \times \frac{5.5}{2} \text{ ft}$
 $M_{maximum} = 476 \text{ lb ft}$ (at both ends)

Total Allowable Deflection = $L/240 = 0.275 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 263.7 \text{ in}^4$

$(\Delta_{max}) = 0.001 \text{ inches}$ (at deflected end)
 $(\Delta_{max}) = 0.001 \text{ inches} < \Delta_{allowable} = 0.275 \text{ inches, ok}$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8wL}{3}$
 $W_{equil} = 564.0 \text{ lb/ft} = 47.00 \text{ lb/in}$

Axial Load (R) = Shear (V) = wL
 $R = V = wL = 211.5 \text{ lb}$

$M_{maximum} = \frac{wL^2}{3} = 387.8 \text{ lb-ft} = 4,653 \text{ lb-in}$ (at fixed end)

Total Allowable Deflection = $L/240 = 0.275 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 263.7 \text{ in}^4$

$(\Delta_{max}) = 0.007 \text{ inches}$ (at deflected end, adjusted over length of post)
 $(\Delta_{max}) = 0.007 \text{ inches} < \Delta_{allowable} = 0.275 \text{ inches, ok}$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports. Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	3.25	ft =	39	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	9.75	ft ²		
Volume of Footing (V_{ftg}) =	9.75	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,462.50 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	173.1	lb
Uniform Load on Post =	211.5	lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,635.6	lb /	9.75	ft ² =	167.7	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	1,674.0	lb /	9.75	ft ² =	171.7	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,462.5 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,462.50 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg})$
 $P = 173.06 \text{ lb} + 1.2 (1462.50 \text{ lb}) = 1,928.06 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg}/\text{depth of footing})$
 $w = 1,793.46 \text{ lb/ft} = 149.45 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{1,928.1 \text{ lb} \times 5.5 \text{ ft}}{2} = 5,302 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{18,084.0 \text{ lb ft}}{3} = 217,008 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 5,302 \text{ lb ft} = 63,626 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$ yield stress or strength of steel
	$f_c' =$	3,000 psi	$f_c' =$ compressive stress or strength of concrete
	$p_{\text{shear}} =$	0.85	
	$p_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0 ft	
	footing thickness/depth (d_{fg}) =	1.00 ft	

Coefficient of Resistance ($R_u = M_u / [p_{\text{flexure}} (w) (d_{\text{fg}})^2] =$	40.9 psi
$p_{\text{balanced}} = (0.85)^2 (f_c' / f_y) [87,000 / (87,000 + f_y)] =$	0.02138
$p_{\text{maximum}} = 0.85 (f_c' / f_y) [1 - (1 - (2R_u / (0.85 f_c'))^{1/2})] =$	0.01604
$p_{\text{minimum}} = 200 / f_y =$	0.00333

The approximate reinforcement ratio ($p_{\text{approx}} = 0.18 (f_c' / f_y) =$	0.00900
Use $p_{\text{approximate}} =$	0.00900

$m = f_y / (0.85 f_c') =$	23.53
$R_u = p_{\text{approx}} f_y [1 - (p_{\text{approx}} (m) / 2)] =$	482.82 psi

$bd^2 = M_u / (p_{\text{flexure}}) (R_u) =$	12.20 in ³	$b =$ width of stem/web of concrete cross section
		$d =$ effective depth from top of reinforced concrete

Using a d/b ratio =	1.80		
$d =$	9.54 in	Use $d =$	9.50 in
$b =$	5.30 in	Use $b =$	5.25 in

checking the d/b ratio = 1.81, OK

Revising the reinforcement ratio:	
$bd^2 =$	473.81 in ³
$R_u \text{ revised} = M_u / (p_{\text{flexure}} bd^2) =$	149.21 psi
$p_{\text{revised}} = p_{\text{approx}} (R_u \text{ revised} / R_u) =$	0.002781
$A_{\text{steel required}} = p_{\text{revised}} bd =$	0.14 in ²

Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in²,
 or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in²,

Directional Sign Post
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Directional Sign	1.33	19.98	4.17	83.24	6.87	1.63	11.16	
3 - Post	2.56	38.29	3.25	124.44	59.66	1.63	96.95	
4 - Concrete Foundation	--	0	--	--	1462.50	1.63	2376.56	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				1307.68			2643.71	2.02 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Directional Sign	1.33	0	--	--	6.87	1.50	10.30	
3 - Post	2.56	38.29	3.25	124.44	59.66	1.50	89.49	
4 - Concrete Foundation	--	0	--	--	1462.50	1.50	2193.75	
6 - Push/Lean	--	200.00	5.50	1100.00	0	--	--	
7- Passive Rankine	--	0	--	--	344.59	0.500	172.30	
Total				1224.44			2465.84	2.01 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Directional Sign	1.33	19.98	6.87
3 - Post	2.56	38.29	59.66
4 - Concrete Foundation	--	0	1462.50
6 - Push/Lean	--	200.00	0
Total		258.26	1529.03

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$\delta' = (1/2)\phi_2' = 13 \text{ degrees}$

Adhesion between soil and foundation base (c_2')= 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x $c_2' + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	258.26	671.09	2.60 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c_2') \times \sqrt{K_p \times D}$

Soil cohesion (c_2') = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ_2') = 26 degrees

Unit weight of soil (γ_2) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi_2'/2)) = 2.56$

$P_p = 106.03 \text{ lb/ft}$

Calculate Maximum Pressure on Liner

$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \times L) + 6M/(B^2 \times L)$

Total axial/downward load (Q) = 1529.03 lb

Effective length of Foundation (L) = L - 2e = 1.54 ft

Effective Width of Foundation (B) = 3.00 ft

Moment (M) = 1307.68 lb-ft

Eccentricity (e) = M/Q = 0.86 ft

$q_{max} = 897.33 \text{ lb/ft}^2$

$q_{max} = 6.23 \text{ psi}$

INFORMATIONAL SIGN (LARGE)

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Information Sign (Large)
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 8.167 ft
- k_d = wind directional factor, Table 6-4, where K_d = 0.85 for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, K_h = 0.85 for heights of 16 ft to 20 ft, Exposure C, K_h = 0.90 Use k_h = 0.85
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use K_{zt} = 1.0
- V = basic wind speed, from Figure 6-1, where V = 90 mph, for Exposure C (3 second wind gust)
- I = importance factor Use I = 1.0

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 8.167 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Info Sign	4.00	6.33	25.33
2 -			
3 - Post	8.33	0.667	5.56

$A = 30.89 \text{ ft}^2$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

$F = 14.982 \text{ lb/ft}^2 \times 30.89 \text{ ft}^2 = 462.75 \text{ lb}$ (acting at end of post)

$w = \frac{462.75}{8} \text{ lb} = 56.66 \text{ lb/ft}$ (acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 462.75 lb
 Uniform Weight/ Post @ Sign = $\frac{462.75}{8.167} \text{ lb/ft} = 56.66 \text{ lb/ft}$

Dead Loads:

Section	Material	Area (ft ²)	Unit Weight (l/Weight (lb)	
1 - Info Sign	Corten Steel	25.33	2.575	65.23
End Caps	Corten Steel	2.67	2.575	6.87
Total				72.10

Sign Weight (W_{sign}), Corten Steel Sign Weight = 72.10 lb

Wt_{sign}/ft² = $\frac{72.1 \text{ lb}}{30.9 \text{ ft}^2} = 2.33 \text{ lb/ft}^2$

Uniform Weight @ Sign = $\frac{72.10}{8.167} \text{ lb/ft} = 8.83 \text{ lb/ft}$

Number of Posts = 2
 Post Length = 9.17 ft

Sign Weight/ Post (W_{sign/post}) = 36.05 lb
 Uniform Weight/ Post @ Sign = $\frac{36.05}{8.167} \text{ lb/ft} = 4.41 \text{ lb/ft}$

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight
3 - Post	Western Red Cedar	4.07	23	93.72

Post Weight (W_{post}) - Western Red Cedar = 93.72 lb
 Uniform Weight/ Post @ Sign = W_W/ft = 11.48 lb/ft

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

P = 1.6 W_{per post} + 1.2 (W_{sign/post} + W_{post@sign})
 P = 1.6 x 462.75 lb + 1.2 x (36 lb + 93.72 lb)
 P = 896.11 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 (W_{sign/post} + W_{post@sign})
 w = 1.6 x 56.66 lb/ft + 1.2 x (4.41 lb/ft + 11.48 lb/ft)
 w = 109.72 lb/ft = 9.14 lb/in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 109.72 lb/ft x $\frac{8.2}{9.2} \text{ ft} = 97.75 \text{ lb/ft} = 8.15 \text{ lb/in}$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

$$\begin{aligned}
 \text{Total equivalent Uniform Load } (W_{\text{equi}}) &= 4P \\
 W_{\text{equi}} &= 3,584.4 \text{ lb/ft} \\
 \\
 \text{Axial Load (R)} = \text{Shear (V)} &= P \\
 R = V = P &= 896.1 \text{ lb} \\
 \\
 M_{\text{maximum}} &= \frac{PL}{2} = 896.1 \text{ lb} \times \frac{9.167 \text{ ft}}{2} \\
 M_{\text{maximum}} &= 4,107 \text{ lb ft} \quad (\text{at both ends}) \\
 \\
 \text{Total Allowable Deflection} &= L/240 = 0.458 \text{ inches} \\
 \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{PL^3}{12EI} \\
 E &= 1.1\text{E}+06 \text{ lb/in}^2 \\
 I &= 263.7 \text{ in}^4 \\
 (\Delta_{\text{max}}) &= 0.029 \text{ inches} \quad (\text{at deflected end}) \\
 (\Delta_{\text{max}}) &= 0.029 \text{ inches} < \Delta_{\text{allowable}} = 0.458 \text{ inches, ok}
 \end{aligned}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

$$\begin{aligned}
 \text{Total equivalent Uniform Load } (W_{\text{equi}}) &= 8wL \\
 W_{\text{equi}} &= 2,682.2 \text{ lb/ft} = 223.52 \text{ lb/in} \\
 \\
 \text{Axial Load (R)} = \text{Shear (V)} &= wL \\
 R = V = wL &= 1,005.8 \text{ lb} \\
 \\
 M_{\text{maximum}} &= \frac{wL^2}{3} = 3,073.5 \text{ lb-ft} = 36,882 \text{ lb-in (at fixed end)} \\
 \\
 \text{Total Allowable Deflection} &= L/240 = 0.458 \text{ inches} \\
 \text{Maximum Deflection } (\Delta_{\text{max}}) &= \frac{wL^4}{24EI} \quad (\text{at deflected end}) \\
 E &= 1.1\text{E}+06 \text{ lb/in}^2 \\
 I &= 263.7 \text{ in}^4 \\
 (\Delta_{\text{max}}) &= 0.171 \text{ inches} \quad (\text{at deflected end, adjusted over length of post}) \\
 (\Delta_{\text{max}}) &= 0.171 \text{ inches} < \Delta_{\text{allowable}} = 0.458 \text{ inches, ok}
 \end{aligned}$$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the sign supports. Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	3.00	ft =	36	inches
Length of Footing =	4.00	ft =	48	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	12.00	ft ²		
Volume of Footing (V_{ftg}) =	12.00	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 1,800.00$ lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:
 Point Load on Post = 896.1 lb
 Uniform Load on Post = 1,005.8 lb

Load to Soil:
 Point Load on Post + W_{ftg} = 2,696.1 lb / 12.00 ft = 224.7 lb/ft² < 2,000 lb/ft², ok
 Uniform Load on Post + W_{ftg} = 2,805.8 lb / 12.00 ft = 233.8 lb/ft² < 2,000 lb/ft², ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times \rho_{concrete}$
 where: $\rho_{concrete} = 150.00$ lb/ft³
 $W_{ftg} = 1,800.00$ lb
 $W_{ftg}/\text{thickness of footing} = 1,800.00$ lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:
 $P = 1.6 W_{per\ post} + 1.2 (W_{t\ sign/post} + W_{t\ post@sign} + W_{ftg})$
 $P = 896.11$ lb + $1.2 (1800.00$ lb) = 3,056.11 lb (point load at end of post)

Analyzing as a uniform load on the post:
 $w = 1.6 W + 1.2 (W_{t\ sign/post} + W_{t\ post@sign} + W_{ftg}/\text{depth of footing})$
 $w = 2,269.72$ lb/ft = 189.14 lb/in (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{maximum} = \frac{PL}{2} = \frac{3,056.1\ \text{lb} \times 9.167\ \text{ft}}{2} = 14,008$ lb ft (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{maximum} = \frac{wL^2}{3} = \frac{63,577.9\ \text{lb ft}}{3} = 762,935$ lb-in (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 14,008 \text{ lb ft} = 168,092 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60	ksi
	$f_c =$	3,000	psi
	$\rho_{\text{shear}} =$	0.85	
	$\rho_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0	ft
	footing thickness/depth (d_{fg}) =	1.00	ft

f_y = yield stress or strength of steel
 f_c = compressive stress or strength of concrete

$$\text{Coefficient of Resistance (} R_u \text{)} = M_u / [\rho_{\text{flexure}} (w) (d_{\text{fg}})^2] = 108.1 \text{ psi}$$

$$\rho_{\text{balanced}} = (0.85)^2 (f_c / f_y) [87,000 / (87,000 + f_y)] = 0.02138$$

$$\rho_{\text{maximum}} = 0.85 (f_c / f_y) [1 - (1 - (2R_u / (0.85f_c))^{1/2})] = 0.01604$$

$$\rho_{\text{minimum}} = 200 / f_y = 0.00333$$

$$\text{The approximate reinforcement ratio (} \rho_{\text{approx}} \text{)} = 0.18 (f_c / f_y) = 0.00900$$

$$\text{Use } \rho_{\text{approximate}} = 0.00900$$

$$m = f_y / (0.85f_c) = 23.53$$

$$R_u = \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}})(m) / 2] = 482.82 \text{ psi}$$

$$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 32.24 \text{ in}^3$$

b = width of stem/web of concrete cross section
 d = effective depth from top of reinforced concrete

Using a d/b ratio =

$$d = 1.80$$

$$d = 9.54 \text{ in}$$

$$b = 5.30 \text{ in}$$

$$\text{Use } d = 9.50 \text{ in}$$

$$\text{Use } b = 5.25 \text{ in}$$

checking the d/b ratio =

1.81 , OK

Revising the reinforcement ratio:

$$bd^2 = 473.81 \text{ in}^3$$

$$R_u \text{ revised} = M_u / (\rho_{\text{flexure}} bd^2) = 394.18 \text{ psi}$$

$$\rho_{\text{revised}} = \rho_{\text{approx}} (R_u \text{ revised} / R_u) = 0.007348$$

$$A_{\text{steel required}} = \rho_{\text{revised}} bd = 0.37 \text{ in}^2$$

Use minimum #5 bars @ 10 inches O/C +/-, Area_{steel provided} = 0.37 in² ,
or use #6 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.44 in² .

Information Sign (Large)
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (Large)	12.67	189.76	6.00	1138.55	32.61	2.00	65.23	
3 - Posts	2.78	41.61	5.17	215.02	100.58	2.00	201.17	
4 - Concrete Foundation	--	0	--	--	1800.00	2.00	3600.00	
6 - Push/Lean	--	100.00	6.00	600.00	0	--	--	
7 - Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				1953.58			4025.44	2.06 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Info Sign (Large)	12.67	0	--	--	32.61	1.50	48.92	
3 - Posts	2.78	41.61	5.17	215.02	100.58	1.50	150.87	
4 - Concrete Foundation	--	0	--	--	1800.00	1.50	2700.00	
6 - Push/Lean	--	100.00	6.00	600.00	0	--	--	
7 - Passive Rankine	--	0	--	--	424.11	0.500	212.06	
Total				815.02			3111.85	3.82 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Info Sign (Large)	12.67	189.76	65.23
3 - Post	2.78	41.61	100.58
4 - Concrete Foundation	--	0	1800.00
6 - Push/Lean	--	100.00	0
Total		331.37	1965.81

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (δ') = $(1/2)\phi'_2$ = 13 degrees

Adhesion between soil and foundation base (c'_a) = 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x $\tan(\delta'_2)$ + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	331.37	771.93	2.33 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) = 2.56$

$P_p = 106.03 \text{ lb/ft}$

Calculate Maximum Pressure on Liner

$q_{max} = \text{maximum pressure by foundation on soil at overturning corner} = Q/(B \times L) + 6M/(B \times L^2)$

Total axial/downward load (Q) = 1933.20 lb

Effective length of Foundation (L') = L - 2e = 1.98 ft

Effective Width of Foundation (B') = 3.00 ft

Moment (M) = 1953.58 lb-ft

Eccentricity (e) = M/Q = 1.01 ft

$q_{max} = 983.76 \text{ lb/ft}^2$

$q_{max} = 6.83 \text{ psi}$

DISC GOLF TEE POST

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Disc Golf Tee Post
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 3 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$
for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$
Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
 Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 4.5 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Post	3.00	0.500	1.50

$$A = 1.50 \text{ ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

$$F = 14.982 \text{ lb/ft}^2 \times 1.50 \text{ ft}^2 = 22.47 \text{ lb} \quad (\text{acting at end of post})$$

$$w = \frac{22.47}{5} \text{ lb} = 4.49 \text{ lb/ft} \quad (\text{acting over surface})$$

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- $G =$ gust effect factor, Use $G = 0.85$
- $C_p =$ external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi}) =$ internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 22.47 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{22.47}{4.5} \text{ lb/ft} = 4.99 \text{ lb/ft} \end{aligned}$$

Dead Loads:

$$\begin{aligned} \text{Number of Posts} &= 1 \\ \text{Post Length} &= 4.00 \text{ ft} \end{aligned}$$

Section	Material	Volume (ft3)	Density (lb/ft ³)	Weight
1 - Post	Western Red Cedar	1.00	23	23.00

$$\begin{aligned} \text{Post Weight (Wt}_{\text{post}}) - 8" \times 8" \text{ Western Red Cedar} &= 23.00 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = \text{Wt/ ft} &= 5.11 \text{ lb/ft} \end{aligned}$$

Load Combinations: $P = 1.6 \text{ LL} + 1.2 \text{ DL}$

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ P &= 1.6 \times 22.47 \text{ lb} + 1.2 \times (0 \text{ lb} + 23.00 \text{ lb}) \\ P &= 63.56 \text{ lb} \quad (\text{point load at end of post}) \end{aligned}$$

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@sign}}) \\ w &= 1.6 \times 4.99 \text{ lb/ft} + 1.2 \times (0.00 \text{ lb/ft} + 5.11 \text{ lb/ft}) \\ w &= 14.12 \text{ lb/ft} = 1.18 \text{ lb/in} \quad (\text{uniform load over extent of sign on post}) \end{aligned}$$

Adjusting uniform load over entire length of post:

$$w = 14.12 \text{ lb/ft} \times \frac{4.5}{4.0} \text{ ft} = 15.89 \text{ lb/ft} = 1.32 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = $4P$
 $W_{equil} = 254.2 \text{ lb/ft}$

Axial Load (R) = Shear (V) = P
 $R = V = P = 63.6 \text{ lb}$

$M_{maximum} = \frac{PL}{2} = 63.6 \text{ lb} \times \frac{4}{2} \text{ ft}$
 $M_{maximum} = 127 \text{ lb ft}$ (at both ends)

Total Allowable Deflection = $L/240 = 0.200 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 76.3 \text{ in}^4$

$(\Delta_{max}) = 0.0006 \text{ inches}$ (at deflected end)
 $(\Delta_{max}) = 0.0006 \text{ inches} < \Delta_{allowable} = 0.200 \text{ inches, ok}$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $\frac{8wL}{3}$
 $W_{equil} = 150.7 \text{ lb/ft} = 12.55 \text{ lb/in}$

Axial Load (R) = Shear (V) = wL
 $R = V = wL = 56.5 \text{ lb}$

$M_{maximum} = \frac{wL^2}{3} = 75.3 \text{ lb-ft} = 904 \text{ lb-in}$ (at fixed end)

Total Allowable Deflection = $L/240 = 0.200 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 76.3 \text{ in}^4$

$(\Delta_{max}) = 0.003 \text{ inches}$ (at deflected end, adjusted over length of post)
 $(\Delta_{max}) = 0.003 \text{ inches} < \Delta_{allowable} = 0.200 \text{ inches, ok}$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 6-inch x 6-inch Western Red Cedar rectangular columns/posts for the sign supports. Use Simpson Strong-Tie Post Base Model MPB66Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	2.75	ft =	33	inches
Length of Footing =	2.75	ft =	33	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	7.56	ft ²		
Volume of Footing (V_{ftg}) =	7.56	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,134.38 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	63.6	lb
Uniform Load on Post =	56.5	lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,197.9	lb /	7.56	ft ² =	158.4	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	1,190.9	lb /	7.56	ft ² =	157.5	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,134.4 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,134.38 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg})$
 $P = 63.56 \text{ lb} + 1.2 (1134.38 \text{ lb}) = 1,424.81 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{ftg}/\text{depth of footing})$
 $w = 1,375.37 \text{ lb/ft} = 114.61 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{1,424.8 \text{ lb} \times 4}{2} \text{ ft}$
 $M_{\text{maximum}} = 2,850 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{7,335.3 \text{ lb ft}}{3} = 88,024 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 2,850 \text{ lb ft} = 34,195 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$ yield stress or strength of steel
	$f_c =$	3,000 psi	$f_c =$ compressive stress or strength of concrete
	$p_{\text{shear}} =$	0.85	
	$p_{\text{flexure}} =$	0.90	
	unit width (w) =	1.0 ft	
	footing thickness/depth (d_{ftg}) =	1.00 ft	

$$\begin{aligned} \text{Coefficient of Resistance (} R_u \text{)} &= M_u / [p_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 22.0 \text{ psi} \\ p_{\text{balanced}} &= (0.85)^2 (f_c' / f_y) [87,000 / (87,000 + f_y)] = 0.02138 \\ p_{\text{maximum}} &= 0.85 (f_c' / f_y) [1 - (1 - (2R_u / (0.85f_c'))^{1/2})] = 0.01604 \\ p_{\text{minimum}} &= 200 / f_y = 0.00333 \end{aligned}$$

$$\begin{aligned} \text{The approximate reinforcement ratio (} p_{\text{approx}} \text{)} &= 0.18 (f_c' / f_y) = 0.00900 \\ \text{Use } p_{\text{approximate}} &= 0.00900 \end{aligned}$$

$$\begin{aligned} m &= f_y / (0.85f_c') = 23.53 \\ R_u &= p_{\text{approx}} f_y [1 - (p_{\text{approx}}) (m) / 2] = 482.82 \text{ psi} \end{aligned}$$

$$bd^2 = M_u / (p_{\text{flexure}}) (R_u) = 6.56 \text{ in}^3$$

$b =$ width of stem/web of concrete cross section
 $d =$ effective depth from top of reinforced concrete

$$\begin{aligned} \text{Using a } d/b \text{ ratio} &= 1.80 \\ d &= 9.54 \text{ in} & \text{Use } d &= 9.50 \text{ in} \\ b &= 5.30 \text{ in} & \text{Use } b &= 5.25 \text{ in} \end{aligned}$$

$$\text{checking the } d/b \text{ ratio} = 1.81, \text{ OK}$$

$$\begin{aligned} \text{Revising the reinforcement ratio:} \\ bd^2 &= 473.81 \text{ in}^3 \\ R_u \text{ revised} &= M_u / (p_{\text{flexure}} bd^2) = 80.19 \text{ psi} \\ p_{\text{revised}} &= p_{\text{approx}} (R_u \text{ revised} / R_u) = 0.001495 \\ A_{\text{steel required}} &= p_{\text{revised}} bd = 0.07 \text{ in}^2 \end{aligned}$$

**Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in²,
or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in²,**

Disc Golf Tee Post
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				856.18			1737.18	2.03 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Post	1.50	22.47	2.50	56.18	23.00	1.38	31.63	
2 - Concrete Foundation	--	0	--	--	1134.38	1.38	1559.77	
3 - Push/Lean	--	200.00	4.00	800.00	0	--	--	
4- Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				856.18			1737.18	2.03 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Post	1.50	22.47	23.00
2 - Concrete Foundation	--	0	1134.38
3 - Push/Lean	--	200.00	0
Total		222.47	1157.38

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$\delta' = (1/2)\phi'_2 =$ 13 degrees

Adhesion between soil and foundation base (c'_a)= 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ'_2) + (length of footing) x c'_a + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force	222.47	558.78	2.51 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times \sqrt{K_p \times D}$

Soil cohesion (c'_2) = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ'_2) = 26 degrees

Unit weight of soil (γ_2) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi'_2/2)) =$ 2.56

$P_p =$ 106.03 lb/ft

Calculate Maximum Pressure on Liner

$q_{max} =$ maximum pressure by foundation on soil at overturning corner = $Q/(B \times L) + 6M/(B^2 \times L)$

Total axial/downward load (Q) = 1157.38 lb

Effective length of Foundation (L) = L - 2e = 1.27 ft

Effective Width of Foundation (B) = 2.75 ft

Moment (M) = 856.18 lb-ft

Eccentricity (e) = M/Q = 0.74 ft

$q_{max} =$ 865.93 lb/ft²

$q_{max} =$ 6.01 psi

SHADE STRUCTURE

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Shade Structure
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 9.58 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_z = 0.85$ for heights of 16 ft to 20 ft, Exposure C, $K_z = 0.90$ Use $k_z = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.

Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \quad \text{lb/ft}^2$$

Determine area of sign:

where: h = overall height = 9.583 ft

Area $A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)	Effective Area (ft ²)
1 - Overhead can	5.328	12	63.9	39.96
3 - Posts	8.58	1.5	12.9	

$$A = 52.83 \quad \text{ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

$$F = 14.982 \quad \text{lb/ft}^2 \times 52.83 \quad \text{ft}^2 = 791.55 \quad \text{lb} \quad (\text{acting at end of post})$$

$$w = \frac{791.55}{9.58} \quad \text{lb} = 82.60 \quad \text{lb/ft} \quad (\text{acting over surface})$$

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \quad \text{lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \quad \text{lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

Wind Force (W) = 791.55 lb
 Uniform Weight/ Each Post @ Sign = $\frac{791.55}{28.749}$ lb = 27.53 lb/ ft

Dead Loads:

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight (lb)
1- Overhead Canopy	Western Red Cedar	11.31	23	260.13
Total				260.13

Sign Weight (W_{sign}) = 260.13 lb
 W_{sign}/ft² = $\frac{260.1}{52.8}$ lb = 4.92 lb/ft²

Uniform Weight @ Sign = $\frac{260.13}{9.583}$ lb = 27.14 lb/ ft

Number of Posts = 3
 Post Length = 9.58 ft

Sign Weight/ Post (W_{sign/post}) = 86.71 lb
 Uniform Weight/Each Post @ Sign = $\frac{86.71}{28.749}$ lb = 3.02 lb/ ft

Section	Material	Volume (ft ³)	Density (lb/ft ³)	Weight (lb)
2 - Post	Western Red Cedar	2.40	23	55.10

Post Weight (W_{post}) = 55.10 lb per post
 Uniform Weight/ Each Post @ Sign = W/ ft = 5.75 lb/ ft

Load Combinations: P = 1.6 LL + 1.2 DL
 Analyzing as a point load at the end of the post:

P = 1.6 W_{per post} + 1.2 (W_{sign/post} + W_{post@ sign})
 P = 1.6 x 263.85 lb + 1.2 x (86.71 lb + 55.10 lb)
 P = 592.34 lb (point load at end of post)

Analyzing as a uniform load on the post:

w = 1.6 W + 1.2 (W_{sign/post} + W_{post@ sign})
 w = 1.6 x 27.53 lb/ft + 1.2 x (3.02 lb/ft + 5.75 lb/ft)
 w = 54.57 lb/ ft = 4.55 lb/ in (uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

w = 54.57 lb/ ft x $\frac{9.58}{9.58}$ ft = 54.57 lb/ ft = 4.55 lb/ in

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equi}) = $4P$
 $W_{equi} = 2,369.3 \text{ lb/ft}$

Axial Load (R) = Shear (V) = P
 $R = V = P = 592.3 \text{ lb}$

$M_{maximum} = \frac{PL}{2} = 592.3 \text{ lb} \times \frac{9.583}{2} \text{ ft}$
 $M_{maximum} = 2,838 \text{ lb ft}$ (at both ends)

Total Allowable Deflection = $L/240 = 0.479 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 76.3 \text{ in}^4$

$(\Delta_{max}) = 0.075 \text{ inches}$ (at deflected end)
 $(\Delta_{max}) = 0.075 \text{ inches} < \Delta_{allowable} = 0.479 \text{ inches, ok}$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equi}) = $\frac{8wL}{3}$
 $W_{equi} = 1,394.6 \text{ lb/ft} = 116.22 \text{ lb/in}$

Axial Load (R) = Shear (V) = wL
 $R = V = wL = 523.0 \text{ lb}$

$M_{maximum} = \frac{wL^2}{3} = 1,670.5 \text{ lb-ft} = 20,046 \text{ lb-in}$ (at fixed end)

Total Allowable Deflection = $L/240 = 0.479 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 76.3 \text{ in}^4$

$(\Delta_{max}) = 0.395 \text{ inches}$ (at deflected end, adjusted over length of post)
 $(\Delta_{max}) = 0.395 \text{ inches} < \Delta_{allowable} = 0.479 \text{ inches, ok}$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the overhead canopy on the post and adjusted for the length of the support post is adequate in deflection.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	14.08	ft =	169	inches
Length of Footing =	4.00	ft =	48	inches
Thickness of Footing (L) =	1.00	ft =	12	inches
Depth of Footing Base =	1.00	ft =	12	inches
Area of Footing (A_{ftg}) =	56.33	ft ²		
Volume of Footing (V_{ftg}) =	56.33	ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 8,449.80 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	592.3	lb
Uniform Load on Post =	523.0	lb

Load to Soil:

Point Load on Post + W_{ftg} =	9,042.1	lb /	56.33	ft ² =	160.5	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	8,972.8	lb /	56.33	ft ² =	159.3	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 8,449.8 lb
 W_{ftg} /thickness of footing = 8,449.80 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$$P = 1.6 W_{per\ post} + 1.2 (W_{t\ sign/post} + W_{t\ post@sign} + W_{ftg\ per\ post})$$

P = 592.34 lb + 1.2 (2816.60 lb) = 3,972.26 lb (point load at end of each post)

Analyzing as a uniform load on the post:

$$w = 1.6 W + 1.2 (W_{t\ sign/post} + W_{t\ post@sign} + W_{ftg\ per\ post} / \text{depth of footing})$$

w = 3,434.49 lb/ft = 286.21 lb/in (uniform load over extent of canopy on each post)

Recalculated moment for the point loading condition:

$$M_{maximum} = \frac{PL}{2} = \frac{3,972.3\ lb \times 9.583\ ft}{2}$$

$M_{maximum}$ = 19,033 lb ft (at fixed end foundation)

Recalculated moment for the uniformly distributed loading condition:

$$M_{maximum} = \frac{wL^2}{3} = \frac{105,134.3\ lb\ ft}{3} = 1,261,611\ lb\text{-in (at fixed end at foundation)}$$

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 19,033 \text{ lb ft} = 228,397 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:

$f_y =$	60	ksi
$f_c =$	3,000	psi
$\rho_{\text{shear}} =$	0.85	
$\rho_{\text{flexure}} =$	0.90	
unit width (w) =	1.00	ft
footing thickness/depth (d_{fg}) =	1.00	ft

f_y = yield stress or strength of steel
 f_c = compressive stress or strength of concrete

Coefficient of Resistance ($R_u = M_u / (\rho_{\text{flexure}} (w) (d_{\text{fg}})^2) = 146.9 \text{ psi}$

$\rho_{\text{balanced}} = (0.85)^2 (f_c / f_y) [87,000 / (87,000 + f_y)] =$	0.02138
$\rho_{\text{maximum}} = 0.85 (f_c / f_y) [1 - (1 - (2R_u / (0.85 f_c))^{1/2})] =$	0.01604
$\rho_{\text{minimum}} = 200 / f_y =$	0.00333

The approximate reinforcement ratio ($\rho_{\text{approx}} = 0.18 (f_c / f_y) = 0.00900$
 Use $\rho_{\text{approximate}} = 0.00900$

$m = f_y / (0.85 f_c) =$	23.53
$R_u = \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}}) (m) / 2] =$	482.82 \text{ psi}

$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 43.80 \text{ in}^3$

b = width of stem/web of concrete cross section
 d = effective depth from top of reinforced concrete

Using a d/b ratio =

$d/b = 1.80$	
d = 9.54 in	Use d = 9.50 in
b = 5.30 in	Use b = 5.25 in

checking the d/b ratio =

1.81 , OK

Revising the reinforcement ratio:

$bd^2 =$	473.81 in^3
$R_u \text{ revised} = M_u / (\rho_{\text{flexure}} bd^2) =$	535.60 \text{ psi}
$\rho_{\text{revised}} = \rho_{\text{approx}} (R_u \text{ revised} / R_u) =$	0.009984
$A_{\text{steel required}} = \rho_{\text{revised}} bd =$	0.50 in^2

**Use minimum #5 bars @ 6 inches O/C +/-, Area_{steel provided} = 0.61 in²,
 or use minimum #6 bars @ 10 inches O/C +/-, Area_{steel provided} = 0.53 in²,**

Shade Structure
Overturning and Sliding Analysis

Overturning

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Overhead Canopy	39.96	598.67	9.58	5737.07	260.13	2.00	520.25	
3 - Posts	12.87	192.88	5.29	1020.64	165.31	2.00	330.61	
4 - Concrete Foundation	--	0	--	--	8449.80	2.00	16899.60	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	1,493.20	0.500	746.60	
Total				7957.70			18497.07	2.32 acceptable

Overturning

Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Overhead Canopy	0	0	--	--	260.13	7.04	1831.68	
3 - Posts	12.87	192.88	5.29	1020.64	165.31	7.04	1164.01	
4 - Concrete Foundation	--	0	--	--	8449.80	7.04	59499.27	
6 - Push/Lean	--	200.00	6.00	1200.00	0	--	--	
7 - Passive Rankine	--	0	--	--	424.11	0.500	212.06	
Total				2220.64			62707.01	28.24 acceptable

Sliding

Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Overhead Canopy	39.96	598.67	260.13
3 - Posts	12.87	192.88	55.10
4 - Concrete Foundation	--	0	8449.80
6 - Push/Lean	--	200.00	0
Total		991.55	8765.03

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$$\delta' = (1/2)\phi'_2 = 13 \text{ degrees}$$

Adhesion between soil and foundation base (c'_s)= 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_s) + (length of footing) x c'_s + P_p

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Sliding Horizontal Force	991.55	2129.59	2.15 acceptable

Calculate Passive Rankine Force (Soil)

$$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c'_2) \times v(K_p \times D)$$

Soil cohesion (c'₂) = 0 kPa = kN/m²

Effective Soil Friction angle (φ'₂) = 26 degrees

Unit weight of soil (γ₂) = 82.8 lb/ft³

Depth to base of concrete (D) = 1.00 ft

K_p = tan²(45 + (φ'₂/2)) = 2.56

P_p = 106.03 lb/ft

Calculate Maximum Pressure on Liner

q_{max} = maximum pressure by foundation on soil at overturning corner = Q/(B'*L') + 6M/(B'^2*L')

Total axial/downward load (Q) = 8875.23 lb

Effective length of Foundation (L') = L - 2e = 2.21 ft

Effective Width of Foundation (B') = 14.08 ft

Moment (M) = 7957.70 lb-ft

Eccentricity (e) = M/Q = 0.90 ft

q_{max} = 394.67 lb/ft²

q_{max} = 2.74 psi

TEETER TOTTER

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Teeter Totter
Sign Wind Load Analysis in Accordance with UBC

Determine the Velocity Pressure at Height (z) of the Sign:

Using the following equation to determine velocity pressure:

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I \quad (\text{lb/ft}^2)$$

where:

- q_z = velocity pressure at height z. Height (z) = 2.5 ft
- k_d = wind directional factor, Table 6-4, where $K_d = 0.85$ for solid sign
- k_z = velocity pressure exposure coefficient, Table 6-3, for heights of 0 ft to 15 ft, Exposure C, $K_h = 0.85$
for heights of 16 ft to 20 ft, Exposure C, $K_h = 0.90$
Use $k_h = 0.85$
- k_{zt} = topographic factor, where $K_{zt} = (1 + K_1 K_2 K_3)^2$ and K_1, K_2 and K_3 are given in Figure 6-4. Assuming general limited changes in topography, no ridge area, escarpment or axisymmetrical hill exists. Use $K_{zt} = 1.0$
- V = basic wind speed, from Figure 6-1, where $V = 90$ mph, for Exposure C (3 second wind gust)
- I = importance factor Use $I = 1.0$

Exposure B consists of urban and suburban areas with closely spaced obstructions with heights equivalent to single family homes or larger, where $k_z = 0.70$.
Exposure C consists of open terrain with scattered obstruction having heights generally less than 30 feet. Exposure C is most conservative, due to larger velocity pressure exposure coefficients, where $k_z = 0.90$. Use Exposure C.

$$q_z = 0.00256 k_z k_{zt} k_d V^2 I$$

$$q_z = 14.98176 \text{ lb/ft}^2$$

Determine area of sign:

where: h = overall height = 2.5 ft

$A = h \times w$ for all components

Section	Height h (ft)	Width w (ft)	Area (ft ²)
1 - Seat	0.333	8.0	2.67
2 -			
3 - Post	2.50	0.67	1.67

$$A = 4.33 \text{ ft}^2$$

Determine Wind Force on the Sign:

$$F = P \times A = q_z \times A$$

F	=	14.982	lb/ft ² x	4.33	ft ² =	64.92	lb	(acting at end of post)
w	=	$\frac{64.92}{3}$	lb	=	21.97	lb/ft		(acting over surface)

Determine the Design Wind Pressure for the Sign:

Using the following equation to determine wind pressure:

$$p = q G C_p - q_i (G C_{pi}) \quad (\text{lb/ft}^2)$$

where:

- $q = q_z$ for windward walls at height z above the ground.
- $q = q_h$ for leeward walls, where sides are at height h above the ground. Neglect q_h for the sign.
- $q_i = q_z = q_h = 1.0$
- G = gust effect factor, Use $G = 0.85$
- C_p = external pressure coefficient. From Figure 6-6, $C_p = 0.80$ (windward); $C_p = -0.50$ (leeward)
- $(G C_{pi})$ = internal pressure coefficient. From Figure 6-5, Use 0.55 and -0.55 partially enclosed

Wind pressure acting on the windward and leeward sides of the sign:

$$P_{\text{windward}} = q G C_p - q_i (G C_{pi}) = 0.130 \text{ lb/ft}^2$$

$$P_{\text{leeward}} = q G C_p - q_i (G C_{pi}) = 0.125 \text{ lb/ft}^2$$

Note: The wind pressure design for the sign can be neglected. The sign wind load analysis will be based on the velocity pressure.

Determine Load on Support Posts and Foundation:

Live Loads:

$$\begin{aligned} \text{Wind Force (W)} &= 64.92 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{64.92}{2.5} \text{ lb/ft} = 25.97 \text{ lb/ft} \end{aligned}$$

Dead Loads:

Section	Material	Volume (ft3)	Density (lb/ft ³)	Weight (lb)
1 - Seat	Northern White	0.89	22	19.55
2 - Users				500.00
Total				519.55

$$\text{Sign Weight (W}_{\text{sign}}) = 519.55 \text{ lb}$$

$$W_{\text{sign}}/\text{ft}^2 = \frac{519.6 \text{ lb}}{4.3 \text{ ft}^2} = 119.90 \text{ lb/ft}^2$$

$$\text{Uniform Weight @ Sign} = \frac{519.55}{2.5} \text{ lb/ft} = 207.82 \text{ lb/ft}$$

$$\begin{aligned} \text{Number of Posts} &= 2 \\ \text{Post Length} &= 3.5 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{Sign Weight/ Post (W}_{\text{sign/post}}) &= 259.78 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} &= \frac{259.78}{2.5} \text{ lb/ft} = 103.91 \text{ lb/ft} \end{aligned}$$

Section	Material	Volume (ft3)	Density (lb/ft ³)	Weight
3 - Post	Western Red Cedar	1.11	23	25.56

$$\begin{aligned} \text{Post Weight (W}_{\text{post}}) - 8" \times 8" \text{ Western Red Cedar} &= 25.56 \text{ lb} \\ \text{Uniform Weight/ Post @ Sign} = W/\text{ft} &= 10.22 \text{ lb/ft} \end{aligned}$$

Load Combinations: P = 1.6 LL + 1.2 DL

Analyzing as a point load at the end of the post:

$$\begin{aligned} P &= 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}}) \\ P &= 1.6 \times 64.92 \text{ lb} + 1.2 \times (259.78 \text{ lb} + 25.56 \text{ lb}) \\ P &= 446.27 \text{ lb} \end{aligned}$$

(point load at end of post)

Analyzing as a uniform load on the post:

$$\begin{aligned} w &= 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}}) \\ w &= 1.6 \times 25.97 \text{ lb/ft} + 1.2 \times (103.91 \text{ lb/ft} + 10.22 \text{ lb/ft}) \\ w &= 178.51 \text{ lb/ft} = 14.88 \text{ lb/in} \end{aligned}$$

(uniform load over extent of sign on post)

Adjusting uniform load over entire length of post:

$$w = 178.51 \text{ lb/ft} \times \frac{2.5}{3.5} \text{ ft} = 127.51 \text{ lb/ft} = 10.63 \text{ lb/in}$$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with the Concentrated Load at the Deflected End

Total equivalent Uniform Load (W_{equil}) = $4P$
 $W_{equil} = 1,785.1 \text{ lb/ft}$

Axial Load (R) = Shear (V) = P
 $R = V = P = 446.3 \text{ lb}$

$M_{maximum} = \frac{PL}{2} = 446.3 \text{ lb} \times \frac{3.5}{2} \text{ ft}$
 $M_{maximum} = 781 \text{ lb ft}$ (at both ends)

Total Allowable Deflection = $L/240 = 0.175 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{PL^3}{12EI}$

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 263.7 \text{ in}^4$

$(\Delta_{max}) = 0.0008 \text{ inches}$ (at deflected end)
 $(\Delta_{max}) = 0.0008 \text{ inches} < \Delta_{allowable} = 0.175 \text{ inches, ok}$

Determine Loads to Foundation by Analyzing Beam as Fixed at One End, and Free to Deflect Vertically But Not Rotate at the Other End, with a Uniformly Distributed Load

Note: The uniform load is analyzed over the entire length of the post for simplicity and conservatism.

Total equivalent Uniform Load (W_{equil}) = $8wL$
 $W_{equil} = 1,666.1 \text{ lb/ft} = 138.84 \text{ lb/in}$

Axial Load (R) = Shear (V) = wL
 $R = V = wL = 624.8 \text{ lb}$

$M_{maximum} = \frac{wL^2}{3} = 728.9 \text{ lb-ft} = 8,747 \text{ lb-in}$ (at fixed end)

Total Allowable Deflection = $L/240 = 0.175 \text{ inches}$
 Maximum Deflection (Δ_{max}) = $\frac{wL^4}{24EI}$ (at deflected end)

$E = 1.1E+06 \text{ lb/in}^2$
 $I = 263.7 \text{ in}^4$

$(\Delta_{max}) = 0.005 \text{ inches}$ (at deflected end, adjusted over length of post)
 $(\Delta_{max}) = 0.005 \text{ inches} < \Delta_{allowable} = 0.175 \text{ inches, ok}$

Note: Based on the preceding analysis, the load on the post both as a point load acting at the end of the post and as a uniform load acting over the area of the sign on the post and adjusted for the length of the support post is adequate in deflection. Use minimum 8-inch x 8-inch Western Red Cedar rectangular columns/posts for the supports. Use Simpson Strong-Tie Post Base Model MPB88Z or equivalent.

Analyzing the Load on the Foundation and Soil:

Width of Footing =	2.75 ft =	33	inches
Length of Footing =	3.00 ft =	36	inches
Thickness of Footing (L) =	1.00 ft =	12	inches
Depth of Footing Base =	1.00 ft =	12	inches
Area of Footing (A_{ftg}) =	8.25 ft ²		
Volume of Footing (V_{ftg}) =	8.25 ft ³		

Dead Load of Footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,237.50 lb

Soil Bearing Capacity = 2,000 lb/ft²

Load to Foundation:

Point Load on Post =	446.3 lb
Uniform Load on Post =	624.8 lb

Load to Soil:

Point Load on Post + W_{ftg} =	1,683.8 lb /	8.25	ft ² =	204.1	lb/ft ² < 2,000 lb/ft ² , ok
Uniform Load on Post + W_{ftg} =	1,862.3 lb /	8.25	ft ² =	225.7	lb/ft ² < 2,000 lb/ft ² , ok

Determining the Area of Steel Required in Foundation:

Dead load of footing (W_{ftg}) = $A_{ftg} \times L \times p_{concrete}$
 where: $p_{concrete}$ = 150.00 lb/ft³
 W_{ftg} = 1,237.5 lb
 $W_{ftg}/\text{thickness of footing}$ = 1,237.50 lb/ft

Recalculating the moments under concentrated point load and uniformly distributed loads to include the dead load of the post foundation:

Analyzing as a point load at the end of the post with the dead load of the foundation:

$P = 1.6 W_{\text{per post}} + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{\text{ftg}})$
 $P = 446.27 \text{ lb} + 1.2 (1237.50 \text{ lb}) = 1,931.27 \text{ lb}$ (point load at end of post)

Analyzing as a uniform load on the post:

$w = 1.6 W + 1.2 (W_{\text{sign/post}} + W_{\text{post@ sign}} + W_{\text{ftg}/\text{depth of footing}})$
 $w = 1,663.51 \text{ lb/ft} = 138.63 \text{ lb/in}$ (uniform load over extent of sign on post)

Recalculated moment for the point loading condition:

$M_{\text{maximum}} = \frac{PL}{2} = \frac{1,931.3 \text{ lb} \times 3.5 \text{ ft}}{2} = 3,380 \text{ lb ft}$ (at fixed end foundation)

Moment remains unchanged for the uniformly distributed loading condition:

$M_{\text{maximum}} = \frac{wL^2}{3} = \frac{6,792.7 \text{ lb ft}}{3} = 8,151 \text{ lb-in}$ (at fixed end at foundation)

Using the moment for the point loading condition which includes the foundation load and calculating the area of steel required:

$$M_{\text{maximum}} = M_u = 3,380 \text{ lb ft} = 40,557 \text{ lb-in (at fixed end at foundation)}$$

Using the following design parameters:

where:	$f_y =$	60 ksi	$f_y =$	yield stress or strength of steel
	$f_c =$	3,000 psi	$f_c =$	compressive stress or strength of concrete
	$\rho_{\text{shear}} =$	0.85		
	$\rho_{\text{flexure}} =$	0.90		
	unit width (w) =	1.0 ft		
	footing thickness/depth (d_{ftg}) =	1.00 ft		

$$\begin{aligned} \text{Coefficient of Resistance (} R_u \text{)} &= M_u / [\rho_{\text{flexure}} (w) (d_{\text{ftg}})^2] = 26.1 \text{ psi} \\ \rho_{\text{balanced}} &= (0.85)^2 (f_c' / f_y) [87,000 / (87,000 + f_y)] = 0.02138 \\ \rho_{\text{maximum}} &= 0.85 (f_c' / f_y) [1 - (1 - (2R_u / (0.85f_c'))^{1/2})] = 0.01604 \\ \rho_{\text{minimum}} &= 200 / f_y = 0.00333 \end{aligned}$$

$$\begin{aligned} \text{The approximate reinforcement ratio (} \rho_{\text{approx}} \text{)} &= 0.18 (f_c' / f_y) = 0.00900 \\ \text{Use } \rho_{\text{approximate}} &= 0.00900 \end{aligned}$$

$$\begin{aligned} m &= f_y / (0.85f_c') = 23.53 \\ R_u &= \rho_{\text{approx}} f_y [1 - (\rho_{\text{approx}}) (m) / 2] = 482.82 \text{ psi} \end{aligned}$$

$$bd^2 = M_u / (\rho_{\text{flexure}}) (R_u) = 7.78 \text{ in}^3$$

$b =$ width of stem/web of concrete cross section
 $d =$ effective depth from top of reinforced concrete

$$\begin{aligned} \text{Using a } d/b \text{ ratio} &= 1.80 \\ d &= 9.54 \text{ in} & \text{Use } d &= 9.50 \text{ in} \\ b &= 5.30 \text{ in} & \text{Use } b &= 5.25 \text{ in} \end{aligned}$$

$$\text{checking the } d/b \text{ ratio} = 1.81, \text{ OK}$$

$$\begin{aligned} \text{Revising the reinforcement ratio:} \\ bd^2 &= 473.81 \text{ in}^3 \\ R_u \text{ revised} &= M_u / (\rho_{\text{flexure}} bd^2) = 95.11 \text{ psi} \\ \rho_{\text{revised}} &= \rho_{\text{approx}} (R_u \text{ revised} / R_u) = 0.001773 \\ A_{\text{steel required}} &= \rho_{\text{revised}} bd = 0.09 \text{ in}^2 \end{aligned}$$

Use minimum #4 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.20 in²,
or use #5 bars @ 12 inches O/C +/-, Area_{steel provided} = 0.31 in²,

Checking diameter of support rod based on loading:

Analyze seat as a cantilever beam:

F =	540.0 lb	Weight of users plus seat
Length of seat as cantilever beam =	4.0 ft	
Allowable deflection in seat = $L/240$ =	0.2 in	
Maximum deflection in seat = $FL^3/(3EI)$ =	0.15 in	acceptable
E =	8.0E+05 lb/in ²	Modulus of elasticity for Northern White Cedar lumber
I = $bh^3/12$	170.7 in ⁴	

Analyze steel support rod:

Diameter of rod, d =	1.25 in	
Length of rod, L =	28 in	
Length of rod, L =	2.333 ft	
Uniform load over rod, w =	19.29 lb/in	
Moment, M = $wL^2/8$ =	1,890 lb-in	
Section Modulus of rod = $\pi d^3/32$ =	0.2 in ³	
Actual stress to rod = Moment/Section Modulus =	9,856.7 psi	
Allowable stress to rod = 0.6(36,000 psi)	21,600 psi	
Factor of Safety	2.2	
Allowable deflection in rod = $L/240$ =	0.12 in	
Maximum Deflection in rod = $wL^4/(384EI)$ =	0.022 in	Ends fixed, uniform distributed load, acceptable
E =	2.90E+07 lb/in ²	Modulus of Elasticity for galvanized steel
I = $\pi r^4/4$ =	0.05 in ⁴	

Teeter Totter
Overturning and Sliding Analysis

Overturning								
Section from Side- Wind Force on Front of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Seat	2.67	39.95	3.50	139.82	19.55	1.50	29.33	
3 - Post	1.67	24.97	2.25	56.18	25.56	1.50	38.34	
4 - Concrete Foundation	--	0	--	--	1237.50	1.50	1856.25	
6 - Push/Lean	--	200.00	3.50	700.00	0	--	--	
7 - Passive Rankine	--	0	--	--	291.58	0.500	145.79	
Total				896.00			2069.70	2.31 acceptable

Overturning								
Section from Front - Wind Force on Side of Sign	Area (ft ²)	Overturning Force (lb)	Overturning Moment Arm (ft)	Overturning Moment (lb-ft)	Stabilizing Force (lb)	Stabilizing Moment Arm (ft)	Stabilizing Moment (lb-ft)	Factor of Safety (must be > 2)
1 - Seat	2.67	0	--	--	19.55	1.38	26.88	
3 - Post	1.67	24.97	3.25	81.16	25.56	1.38	35.14	
4 - Concrete Foundation	--	0	--	--	1237.50	1.38	1701.56	
6 - Push/Lean	--	200.00	3.50	700.00	0	--	--	
7 - Passive Rankine	--	0	--	--	318.08	0.500	159.04	
Total				781.16			1922.63	2.46 acceptable

Sliding			
Section from Side- Wind Force on Front of Sign	Area (ft ²)	Driving Horizontal Force (lb)	Resisting Vertical Force (lb)
1 - Seat	2.67	39.95	19.55
3 - Post	1.67	24.97	25.56
4 - Concrete Foundation	--	0	1237.50
6 - Push/Lean	--	200.00	0
Total		264.92	1282.61

Convert Resisting Vertical Force to Resisting Horizontal Force:

Angle of friction between soil and foundation base (

$\delta' = (1/2)\phi_2' = 13$ degrees

Adhesion between soil and foundation base (c_2')= 0 kPa = kN/m²

Sum of horizontal resisting forces = (sum of resisting vertical forces) x tan(δ_2) + (length of footing) x $c_2' + P_p$

	Driving Force (lb)	Resisting Force (lb)	Factor of Safety (must be >1.5)
Total Horizontal Force		264.92	587.69
			2.22 acceptable

Calculate Passive Rankine Force (Soil)

$P_p = (0.5 \times K_p \times \gamma_2 \times D^2) + 2(c_2') \times \sqrt{K_p \times D}$

Soil cohesion (c_2') = 0 kPa = kN/m²

Effective Soil Friction angle (ϕ_2') = 26 degrees

Unit weight of soil (γ_2) = 82.8 lbf/ft³

Depth to base of concrete (D) = 1.00 ft

$K_p = \tan^2(45 + (\phi_2'/2)) = 2.56$

$P_p = 106.03$ lb/ft

Calculate Maximum Pressure on Liner

$q_{max} =$ maximum pressure by foundation on soil at overturning corner = $Q/(B \times L) + 6M/(B \times L^2)$

Total axial/downward load (Q) = 1282.61 lb

Effective length of Foundation (L) = L - 2e = 1.60 ft

Effective Width of Foundation (B) = 2.75 ft

Moment (M) = 896.00 lb-ft

Eccentricity (e) = M/Q = 0.70 ft

$q_{max} = 734.49$ lb/ft²

$q_{max} = 5.10$ psi

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BOULDER AND TERRACED BOULDER SEATING

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GUDE LANDFILL
Estimate of Long-Term Settlement of the Landfill Cap Under Boulder and Terraced Boulder Seating

Layer Geometry				Layer Stresses			Material Properties				Settlement		
Layer	Top of Layer (ft)	Bottom of Layer (ft)	Center of Layer (ft)	Layer Thickness H, (ft)	In-situ Effective Stress P_{o_i} (psf)	Change in Stress ΔP_i (psf)	Final Effective Stress P_{f_i} (psf)	Preconsolidation Pressure P_{p_i} (psf)	Initial Void Ratio e_o	Recompression Index C_r	Compression Index C_c	Settlement Equation	Settlement (ft)
Waste	0.0	10.0	5.00	10.0	575.0	821.0	1396.0	575.0	2.00	0.05	0.50	1	0.64
	10.0	20.0	15.00	10.0	1725.0	821.0	2546.0	1725.0	2.00	0.05	0.50	1	0.28
	20.0	30.0	25.00	10.0	2875.0	821.0	3696.0	2875.0	2.00	0.05	0.50	1	0.18
	30.0	40.0	35.00	10.0	4025.0	821.0	4846.0	4025.0	2.00	0.05	0.50	1	0.13
	40.0	50.0	45.00	10.0	5175.0	821.0	5996.0	5175.0	2.00	0.05	0.50	1	0.11
													1.35

unit weight of existing waste $g_w =$ 115 pcf
unit weight of boulder load, $g =$ 165 pcf
boulder load thickness = 4 ft
unit weight of supplemental soil = 115 pcf
supplemental soil thickness = 1.4 ft

Settlement Equations:

$$1: \text{Settlement} = H \frac{C_c}{1 + e_o} \log \left(\frac{P_f}{P_o} \right)$$

$$2: \text{Settlement} = H \frac{C_r}{1 + e_o} \log \left(\frac{P_f}{P_o} \right)$$

$$3: \text{Settlement} = H \frac{C_c}{1 + e_o} \log \left(\frac{P_f}{P_o} \right) + H \frac{C_r}{1 + e_o} \log \left(\frac{P_p}{P_o} \right)$$

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ATTACHMENT B – SIGNAGE TEXT & GRAPHICS

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Informational Sign (Small) – Dog Play Area

DOG PLAY

OPEN DAILY FROM DAWN TO DUSK

USE AT YOUR OWN RISK – DOG PLAY AREA FOR DOGS
AND HANDLERS ONLY

- Dogs with registration and current vaccinations only.
- Handlers are legally responsible for the behavior of their dog(s) at all times.
- Children under the age of 13 must be accompanied by an adult and supervised at all times.
- Dogs must be leashed while entering and exiting the park.
- Dogs must wear a collar with identification at all times.
- Handlers are responsible for providing their own water.
- Waste must be cleaned up by pet owners immediately.
- Owners must be within the confines of the Dog Play Area and supervising their dog with leash readily available.
- Aggressive dogs must be removed immediately.

PROHIBITED

- Human Food
- Dog Food or Treats
- Glass Containers
- Dogs in Heat
- Sick Dogs
- Aggressive Dogs
- Puppies
(Under 4 months in age)

RESPONSIBILITY

- Any person bringing dogs into this park assumes the legal responsibility, jointly and individually, with the owner of the dog(s) for any damage, disease or injury to persons, other dogs, or property, caused by the dog(s).
- Failure to comply with these rules may result in you and your dog(s) being asked to leave the facility.
- By entering the facility, all persons agree to indemnify and hold harmless Montgomery County, it's officers and agents from claims resulting from use.

IN CASE OF EMERGENCY CALL 911
FOR NON- EMERGENCIES CALL 311

Informational Sign (Small) – Landfill Gas Extraction Wells

CAUTION


**LANDFILL GAS
EXTRACTION WELL**

**LANDFILL GAS IS
EXPLOSIVE AND MAY
RESULT IN BODILY HARM.
DO NOT TOUCH OR
TAMPER WITH WELL.**

**VIOLATORS WILL BE
PROSECUTED.**

**IN CASE OF EMERGENCY
CALL 911
FOR NON EMERGENCIES
CALL 311**

Educational Post #1 – Barn Owl



BARN OWLS HAVE EXCEPTIONAL VISION AND HEARING WHICH ALLOWS THEM TO HUNT AT NIGHT.

AS THEIR NAME SUGGESTS, BARN OWLS WILL OFTEN ROOST IN OLD BARN. LOOK FOR NESTING BOXES INSTALLED THROUGHOUT THE MEADOW TO ATTRACT THIS BIRD SPECIES.


BARN OWLS REQUIRE LARGE AREAS OF OPEN LAND OVER WHICH TO HUNT, FLYING LOW, BACK AND FORTH OVER OPEN HABITATS, SEARCHING FOR SMALL RODENTS.

DISTINGUISHING FEATURES:

- WHITE HEART-SHAPED FACE WITH DARK COLORED EYES.
- WHITE UNDERWING, CHEST, AND BELLY WITH SMALL GREY SPOTTING.
- ORANGE-BROWN COLORING ABOVE.

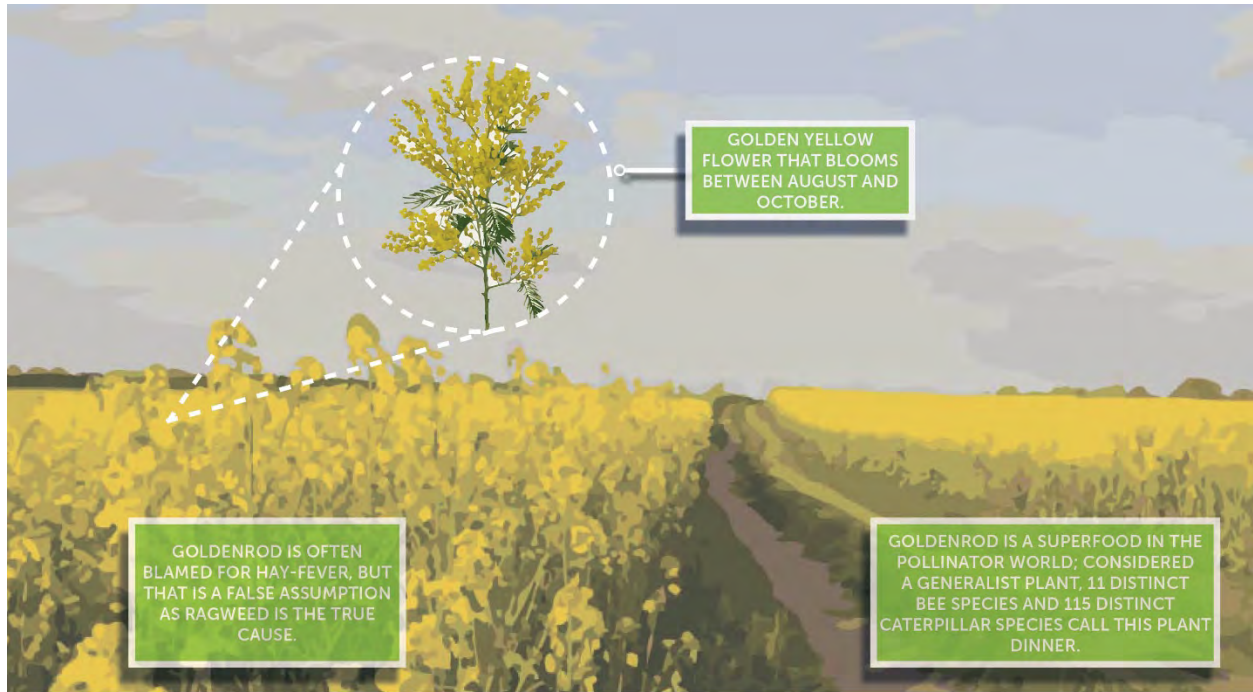
BARN OWL
Tyto alba

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MONTGOMERY COUNTY • MARYLAND



SCAN ME

Educational Post #2 – Goldenrod



GOLDENROD IS OFTEN BLAMED FOR HAY-FEVER, BUT THAT IS A FALSE ASSUMPTION AS RAGWEED IS THE TRUE CAUSE.

GOLDEN YELLOW FLOWER THAT BLOOMS BETWEEN AUGUST AND OCTOBER.

GOLDENROD IS A SUPERFOOD IN THE POLLINATOR WORLD; CONSIDERED A GENERALIST PLANT, 11 DISTINCT BEE SPECIES AND 115 DISTINCT CATERPILLAR SPECIES CALL THIS PLANT DINNER.

GOLDENROD
Solidago rugosa

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Educational Post #3 – Bald Eagle




SCAN ME

BALD EAGLE
Haliaeetus leucocephalus

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Educational Post #4 – Little Bluestem



DISTINGUISHING FEATURES:

- DURING SUMMER MONTHS GRASS STEMS ARE BLUE-GREEN.
- THE LEAVES AND STEMS CHANGE COLOR WITH THE FIRST FROST TO A DEEP RED-BRONZE.
- WHITE FLUFFY SEED HEADS EMERGE IN THE FALL.

LITTLE BLUESTEM IS A PERENNIAL BUNCHGRASS GROWING TO A HEIGHT OF 3 FEET.

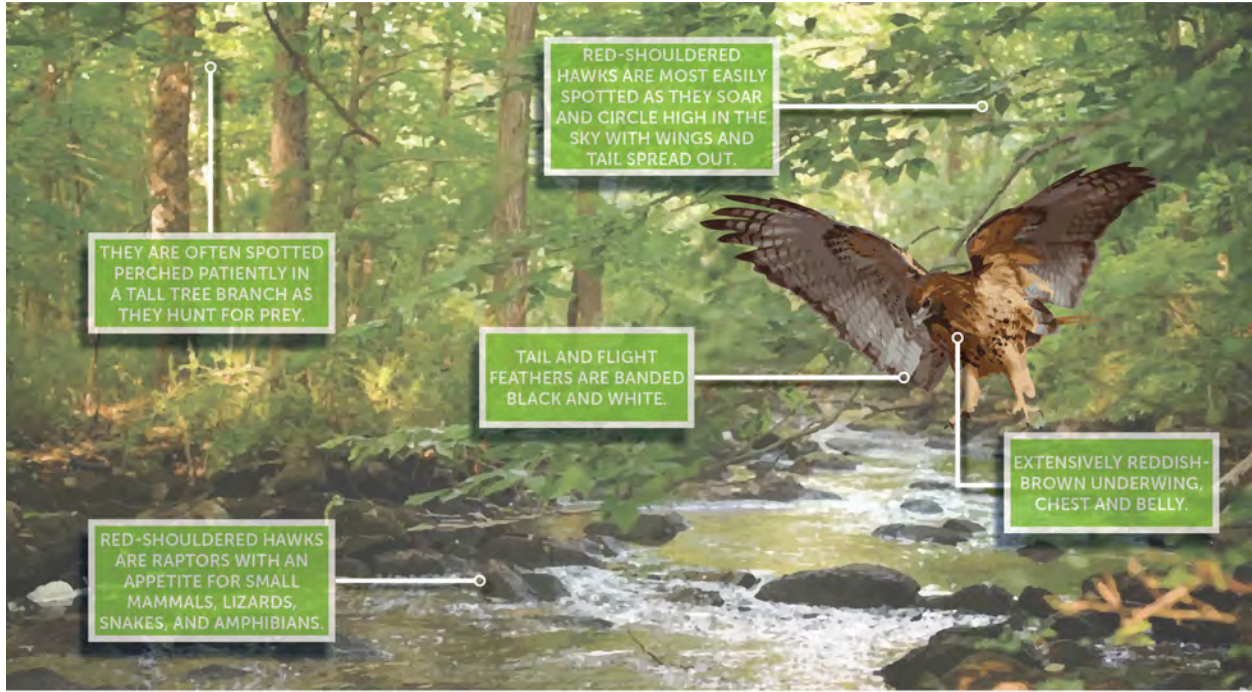
SONGBIRDS EAT THE SEEDS OF THIS GRASS AS WELL AS THE CATERPILLARS THIS PLANT SUPPORTS.

LITTLE BLUESTEM SUPPORTS CATERPILLARS THAT FEED ON ITS FOLIAGE, INCLUDING DUSTED SKIPPER, COBWEB SKIPPER, OTTOE SKIPPER, INDIAN SKIPPER, SWARTHY SKIPPER, AND THE CROSSLINE SKIPPER.

LITTLE BLUESTEM
Schizachyrium scoparium

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Educational Post #5 – Red-shouldered Hawk



SCAN ME

RED-SHOULDERED HAWK
Buteo lineatus

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Educational Post #6 – Blackeyed Susan



BLACKEYED SUSAN
Rudbeckia fulgida

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Educational Post #7 – Cedar Waxwing

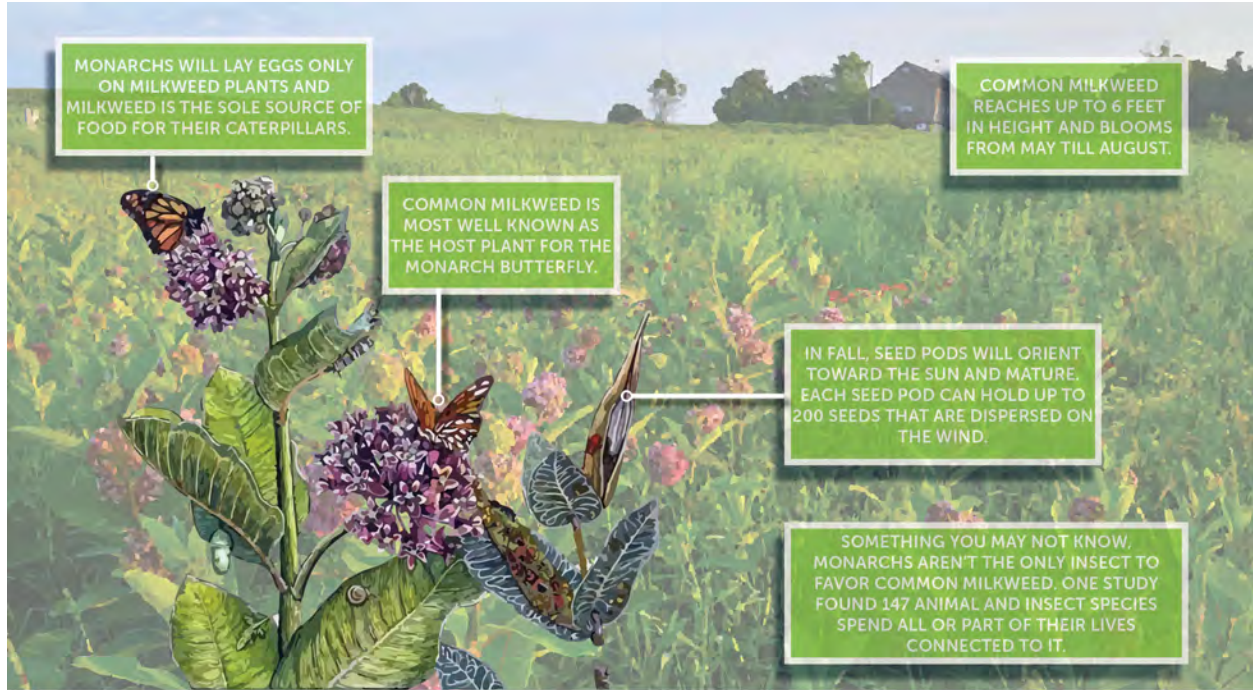


SCAN ME

CEDAR WAXWING
Bombycilla cedrorum

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Educational Post #8 – Common Milkweed



COMMON MILKWEED
Asclepias syriaca

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Educational Post #9 – Field Sparrow




A photograph of a Field Sparrow perched on a branch in a grassy meadow. The bird has a brown head, a white throat, and a plain face. The background shows a line of trees under a clear sky.

SHARP DECLINES IN POPULATION HAVE BEEN OBSERVED OVER THE PAST 50 YEARS UNDERSCORING THE IMPORTANCE OF TRANSFORMING THE LANDFILL AS RESTORED HABITAT.

DISTINGUISHING FEATURES:

- SMALL SPARROW CAN BE EITHER GRAY OR BUFFY OVERALL.
- LOOK FOR A PLAIN FACE WITH A SMALL PINK BILL AND THIN WHITE EYERING.

THE FIELD SPARROW WILL BUILD ITS NEST IN OPEN MEADOWS AND GRASSLANDS AND AVOID HUMAN DOMINATED LANDSCAPES.

 **FIELD SPARROW**
Spizella pusilla

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Educational Post #10 – Virginia Wild Rye



VIRGINIA WILD RYE REACHES 4 FEET IN HEIGHT AND HAS A BRISTLY WHEAT-LIKE SPIKEY FLOWER WITH HAIR FORM IN LATE SPRING.

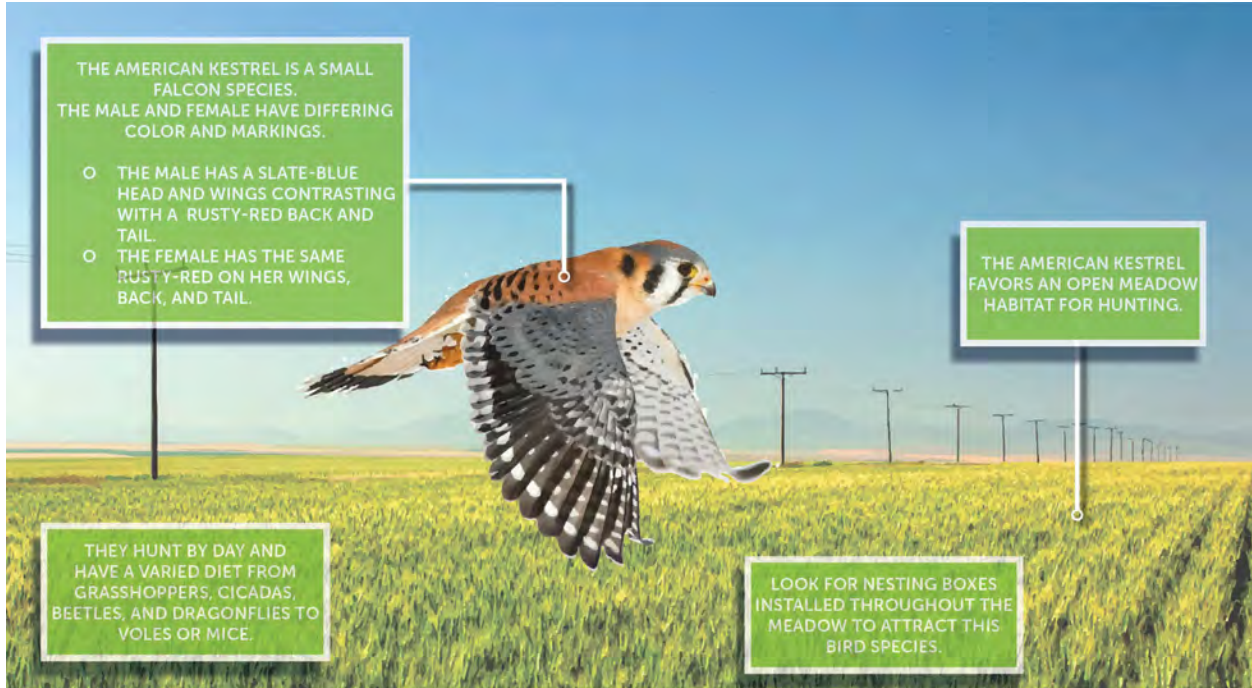
IT IS AN IMPORTANT SPECIES FOR ITS ABILITY TO STABILIZE SOILS QUICKLY TO REDUCE SOIL EROSION.

SERVES AS A HOST PLANT FOR CATERpillARS OF SEVERAL SPECIES OF BRANDED SKIPPERS, SATYRS AND SEVERAL TYPES OF MOTHS, AND PROVIDES SEED TO BIRDS AND SMALL RODENTS.

VIRGINIA WILD RYE
Elymus virginicus

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Educational Post #11 – American Kestrel



The American Kestrel is a small falcon species. The male and female have differing color and markings.

- THE MALE HAS A SLATE-BLUE HEAD AND WINGS CONTRASTING WITH A RUSTY-RED BACK AND TAIL.
- THE FEMALE HAS THE SAME RUSTY-RED ON HER WINGS, BACK, AND TAIL.


THE AMERICAN KESTREL FAVORS AN OPEN MEADOW HABITAT FOR HUNTING.

THEY HUNT BY DAY AND HAVE A VARIED DIET FROM GRASSHOPPERS, CICADAS, BEETLES, AND DRAGONFLIES TO VOLES OR MICE.

LOOK FOR NESTING BOXES INSTALLED THROUGHOUT THE MEADOW TO ATTRACT THIS BIRD SPECIES.

AMERICAN KESTREL
Falco sparverius

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SCAN ME

Educational Post #12 – Tall Boneset



TALL BONESET HAS A FAN-SHAPED CLUSTER OF WHITE BLOOMS AND IS EASILY SPOTTED IN THE MEADOW AUGUST THROUGH OCTOBER.

THE FLOWERS ATTRACT BUTTERFLIES, NATIVE BEES, POLLINATING FLIES, WASPS AND BEETLES. MOTHS OF SEVERAL CATERPILLARS FEED ON THE FOLIAGE.

HISTORICALLY, THIS PLANT WAS USED FOR MEDICINAL PURPOSES BY EARLY AMERICANS.

TALL BONESET
Eupatorium seratinum

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Educational Sign (Large) /Waystation #1 - Evolution of the Landfill

EVOLUTION OF THE LANDFILL

4.8 MILLION TONS OF MUNICIPAL WASTE COLLECTED OVER 18 YEARS

MEADOW HABITAT + RECREATIONAL AMENITIES

VEGETATIVE SUPPORT SOIL - 2 FEET DEPTH

GEO-SYNTHETICS - 3 INDEPENDENT LAYERS

SUB-SOIL CAP - 2 FEET DEPTH

REGRADED EXISTING WASTE AND COVER SOIL

METHANE GAS IS PRODUCED AS A BI-PRODUCT OF DECOMPOSITION OF THE WASTE. THE GAS IS COLLECTED IN A NETWORK OF UNDERGROUND PIPES AND TRANSPORTED TO A FLARE STATION THAT BURNS THE EXCESS METHANE.

LANDFILL GAS MONITORING WELLS ARE LOCATED THROUGHOUT THE SITE

THE PERMANENT LANDFILL CAPPING SYSTEM INCLUDES A LAYER OF SOIL WITH A TYPICAL DEPTH OF TWO FEET.

EXCESS SOIL WAS SOURCED FROM LOCAL CONSTRUCTION PROJECTS INCLUDING THE PURPLE LINE TRANSIT LINE.

VARIES 55' - 100'

PRE - LANDFILL PERIOD
 PRIOR TO DEVELOPMENT AS A LANDFILL, THE PROPERTY WAS OWNED BY ASHLAND HOLDINGS, MANUFACTURING, INC. IN ADELPHI, OHIO. IN 1950, A PRIVATE RAILROAD WITH A 2,000 FOOT RAMPWAY WAS CONSTRUCTED IN THE 1950S.

1965

ACTIVE LANDFILL PERIOD
 GUDE LANDFILL IS THE OLDEST FORMAL LANDFILL IN MONTGOMERY COUNTY. THE LANDFILL LINED WITH A 100-MILL FOOTPRINT.

1982

POST CLOSURE CARE PERIOD
 UPON CLOSURE, A THIRTY-YEAR PERIOD IS REQUIRED TO MONITOR AND MAINTAIN THE EFFECTIVENESS AND INTEGRITY OF WASTE CONTAINMENT SYSTEMS.

2020

RESTORED LANDSCAPE PERIOD
 INSTALLATION OF THE PERMANENT LANDFILL CAP ALLOWS FOR REUSE OF THE PROPERTY AS A PASSIVE RECREATION PARK AND PLAYGROUND. THE REVISION FOR THE PARK WAS ACTIVELY DEVELOPED THROUGH WORKSHOPS WITH THE GUDE LANDFILL COMMUNITY CHILDREN'S COMMITTEE.

GUDE LANDFILL RECREATION PARK
 DEPARTMENT OF ENVIRONMENTAL PROTECTION
 MONTGOMERY COUNTY, MARYLAND

Educational Sign (Large) /Waystation #2 – Meteorological Weather Station

METEOROLOGICAL WEATHER STATION



TELEMETRY

SENDS DATA TO THE ONLINE DATABASE THAT IS ACCESSIBLE TO GOVERNMENT OFFICIALS, SCIENTISTS AND THE PUBLIC.



SOLAR RADIATION SENSOR

MEASURES SOLAR RADIATION FOR EVAPOTRANSPIRATION AND TEMPERATURE / HUMIDITY / SUN / WIND INDEX.



TEMPERATURE + HUMIDITY

USING A CAPACITIVE HUMIDITY SENSOR OR HYGROMETER IT LOGS THE AVERAGE DAILY HURIDITY PERCENTAGE BY PASSING THE CHANGES OF ELECTRICAL CHARGES OR TEMPERATURE IN THE AIR. IT ALSO LOGS WIND DIRECTION AND WIND SPEED. TEMPERATURE USING A BUILT IN THERMOMETER.



DATA LOGGER

DATA LOGGER IS AN ELECTRONIC INSTRUMENT THAT RECORDS MEASUREMENTS. IT STORES IN FLASH OVER TIME. IT ALSO STORES THE BATTERY MICRO-PROCESSOR AND DATA STORAGE OF THE SENSORS.



WIND SENSOR



PHYSICAL DEVICE THAT COLLECTS DIRECTION OF THE WIND BY THE HORIZONTAL ROTATION OF THE WINDMILL. COLLECTS THE WIND SPEED. IT ALSO LOGS WIND DIRECTION. IT ALSO LOGS WIND SPEED. IT ALSO LOGS WIND DIRECTION.

SOLAR PANEL



PHOTO-VOLTAGE CELL THAT GENERATE ELECTRICITY BY ABSORBING SUNLIGHT. THE ENERGY IS STORED IN A BATTERY LOCATED IN THE DATA LOGGER.

RAIN GAUGE



WHEN IT RAINS, WATER COLLECTS IN THE GAUGE GOING THROUGH A FINE MESH. AFTER A PREDETERMINED AMOUNT IS COLLECTED, IT DRIPS INTO A LEAD SINKING'S GAL TO THE DATA LOG.

METEOROLOGICAL WEATHER STATION

LATITUDE: 39°6.17' N
 LONGITUDE: 77°8.42' W
 SITE ELEVATION: 400 FEET (MSL)
 TOWER HEIGHT: 3 METERS (10 FEET)
 SYSTEM ID: 70630-001
 SYSTEM TYPE: M-DAS / C-IMATRON CS / WM283

FOR DAILY WEATHER
 DATA SCAN QR CODE



GUDE LANDFILL RECREATION PARK

DEPARTMENT OF
 ENVIRONMENTAL
 PROTECTION
 MONTGOMERY COUNTY, MARYLAND

Educational Sign (Large) /Waystation #3 – Avian Habitat

AVIAN HABITAT

OPEN MEADOW IS A VITAL HABITAT FOR MANY AVIAN SPECIES. ALLOWING SPACE FOR HUNTING SMALL GROUND MAMMALS, SUCH AS RABBITS, RATS, SNAKES, ALONG WITH PRECIOUS GROUND HABITAT FOR GROUND NESTING BIRDS. MEADOW HABITAT IS SCARCE BY IN THE URBAN LAND USE AND DENSITY OF MONTGOMERY COUNTY.

OVER 200+ BIRD SPECIES HAVE BEEN IDENTIFIED IN THE VICINITY.

EBIRD IS AN INTERACTIVE TOOL THAT ALLOWS YOU AND OTHERS TO CROWD-SOURCE INFORMATION ABOUT BIRDS YOU SEE ANYWHERE OVER TIME. IT CREATES A GREAT POOL OF DATA OF TRACKING WHAT BIRDS ARE IN THE AREA. IT IS ACCESSIBLE ON YOUR PHONE AND COMPUTER.

DOWNLOAD THE APP TODAY TO BEGIN THE COUNT!



BALD EAGLE
Haliaeetus leucocephalus



AMERICAN KESTREL
Falco sparverius



BARN OWL
Tyto alba



BROWN-HEADED COWBIRD
Molothrus ater



RED-SHOULDERED HAWK
Buteo lineatus



COMMON GRACKLE
Quiscalus quiscula



BLACK-HEADED ORIOLE
Oriolus larvatus



DARK-EYED JUNCO
Junco hyemalis

ART INSTALLATION PROVIDES A VISUAL OF A FLOCK OF BIRDS TRAVERSING THE MEADOW REPRESENTING THE HAVEN THIS PARK IS FOR NUMEROUS SPECIES. IT ALSO ACTS AS A PERCH FOR MANY RAPTOR SPECIES TO HUNT ON OR A PLACE TO REST ON THEIR JOURNEY. IT ALSO ACTS AS AN INTRIGUING WAYFINDING DEVICE WITHIN THE PARK.

GUDE LANDFILL RECREATION PARK

DEPARTMENT OF ENVIRONMENTAL PROTECTION
MONTGOMERY COUNTY, MARYLAND

Educational Sign (Large) /Waystation #4 – Pollinator Habitat

POLLINATOR HABITAT



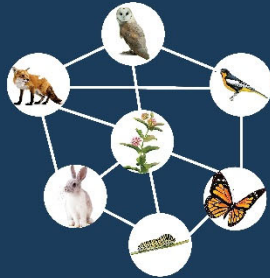
CORRIDOR HABITATS

CONNECTING GREEN SPACE CORRIDORS ALLOW FOR THE MOVEMENT OF ORGANISMS WITHIN THE HABITATS CREATED BY THE BUILDINGS AND DISTRICTS. AS ROADS BUILD OUT, THE EXPANSION OF URBAN DEVELOPMENT OFTEN RESULTS IN FRAGMENTATION OF CORRIDORS AND ISOLATION OF CRITICAL HABITAT. GUDE LANDFILL RECREATION PARK IS LOCATED CLOSE TO OTHER CORRIDOR HABITATS WHICH BRING PLANTS THE OPPORTUNITY FOR JOURNEYS OF SPECIES

FOOD NETWORK

GUDE LANDFILL RECREATION PARK IS AN OPEN MEADOW HABITAT CONTRASTING WITH THE PREDOMINANTLY FORESTED CORRIDORS THAT FOLLOW THE STREAM VALLEYS OF CRABBS BRANCH AND ROCK CREEK. THE MEADOW IS COMPOSED OF OVER 50 DISTINCT NATIVE GRASSES AND HERBACEOUS PLANTS. LIST OF PLANTS AND NESTING SITES FOR BIRDS, CATERPILLARS AND BUTTERFLIES, AND GRASS TOPPERS TO NAME A FEW.

WHY IS THIS IMPORTANT? THE MEADOW FUNCTIONS AS THE BASE OF THE FOOD WEB THAT SUPPORTS MANY SPECIES.



FOOD WEB DIAGRAM REPRESENTS ONE OF THE SPECIES SUPPORTED BY COMMON MILKWEED, A NATIVE PREFERRED PLANT SPECIES.

IN SOME INSTANCES, SPECIES LIKE THE MONARCH BUTTERFLY ARE SPECIALLY ADAPTED TO ONLY FEED ON ONE PLANT TO SERVE AS BOTH PLANT AND FOOD FOR THE CATERPILLAR. MONARCH BUTTERFLIES LAY EGGS ONLY ON THE MILKWEED PLANT.

GUDE LANDFILL RECREATION PARK DEPARTMENT OF ENVIRONMENTAL PROTECTION MARYLAND

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ATTACHMENT C – MEADOW MIX SPECIES LIST

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Meadow Mix #1 – Custom Upland Deer Tolerant Meadow Mix

% of Mix	Latin Name	Common Name	Cultivar/ Ecotype
1.3	<i>Asclepias tuberosa</i>	Butterfly Milkweed	Any
1.3	<i>Aster oblongifolius</i>	Aromatic Aster	PA
1.3	<i>Aster prenanthoides</i>	Zig Zag Aster	PA
0.3	<i>Baptisia tinctoria</i>	Wild Indigo	PA
4.0	<i>Chamaecrista fasciculata</i>	Partridge Pea	PA
4.0	<i>Coreopsis lanceolata</i>	Lance Leaf Coreopsis	Any
8.6	<i>Echinacea purpurea</i>	Purple Coneflower	Any
20.0	<i>Elymus virginicus</i>	Virginia Wildrye	PA
0.3	<i>Eragrostis spectabilis</i>	Purple Lovegrass	PA
0.7	<i>Eupatorium coelestinum</i>	Mistflower	VA
0.2	<i>Geum canadense</i>	White Avens	PA
2.6	<i>Heliopsis helianthoides</i>	Ox-Eye Sunflower	PA
0.5	<i>Liatris spicata</i>	Spiked Gayfeather	PA or any
1.0	<i>Liatris squarrosa</i>	Scaly Blazing Star	VA
0.4	<i>Monarda fistulosa</i>	Wild Bergamot	FIG (PA)
0.3	<i>Monarda punctata</i>	Dotted Mint	MD or APB
0.3	<i>Oenothera fruticosa</i>	Sundrops	PA
19.0	<i>Panicum anceps</i>	Beaked Panicgrass	MD
3.0	<i>Panicum sphaerocarpon</i>	Roundseeded Panicgrass	PA
0.4	<i>Penstemon canescens</i>	Grayhairy Beardtongue	WV
0.7	<i>Penstemon digitalis</i>	Tall White Beardtongue	PA
0.4	<i>Penstemon hirsutus</i>	Hairy Beardtongue	PA
0.9	<i>Pycnanthemum tenuifolium</i>	Narrow Leaved Mountain Mint	PA
0.7	<i>Rudbeckia fulgida</i>	Orange Coneflower	VA
4.0	<i>Rudbeckia hirta</i>	Black Eyed Susan	PA or any
20.0	<i>Schizachyrium scoparium</i>	Little Bluestem	PA or Camper
1.0	<i>Senna hebecarpa</i>	Wild Senna	WV
0.6	<i>Solidago nemoralis</i>	Gray Goldenrod	PA
0.2	<i>Solidago odora</i>	Licorice Scented Goldenrod	PA
1.5	<i>Tradescantia ohiensis</i>	Ohio Spiderwort	PA
0.5	<i>Zizia aurea</i>	Golden Alexanders	PA
100	<i>Total</i>		

By seed count this mix has approximately 357,000 seeds/lb and is 28.1% grasses and 71.9% wildflowers. If an item in this mix is not available, add its percentage to a member of the same genera in the mix or to *Schizachyrium scoparium*. Apply this mix at 10 lbs PLS or 15 bulk lbs/acre along with a cover crop.

For a cover crop use one of the following: Grain Oats, *Avena sativa*, (1 Jan to 30 Apr; 30 lbs/acre), Brown Top Millet, *Brachiaria ramosa*, (1 May to 31 Aug; 10 lbs/acre), or Grain Rye, *Secale cereale*, (1 Sep to 31 Dec; 30 lbs/acre).

Meadow Mix #2 – Three-way Tall Fescue Mix (ERNMX-136 or equivalent)

% of Mix	Latin Name	Common Name	Cultivar/ Ecotype
34.0	<i>Festuca arundinacea</i> <i>'Firecracker SLS'</i>	Tall Fescue, 'Firecracker SLS'	Any
33.0	<i>Festuca arundinacea</i> <i>'Ninja III'</i>	Tall Fescue, 'Ninja III'	Any
33.0	<i>Festuca arundinacea</i> <i>'Valkyrie LS'</i>	Tall Fescue, 'Valkyrie LS'	Any
100	<i>Total</i>		

Apply this mix at 43.5 bulk lbs/acre.

Meadow Mix #3 – Custom Upland Deer Tolerant Slope Meadow Mix

% of Mix	Latin Name	Common Name	Cultivar/ Ecotype
0.2	<i>Asclepias tuberosa</i>	Butterfly Milkweed	Any
0.2	<i>Aster oblongifolius</i>	Aromatic Aster	PA
0.2	<i>Aster prenanthoides</i>	Zig Zag Aster	PA
1.6	<i>Chamaecrista fasciculata</i>	Partridge Pea	PA
1.3	<i>Coreopsis lanceolata</i>	Lance Leaf Coreopsis	Any
2.8	<i>Echinacea purpurea</i>	Purple Coneflower	Any
22.2	<i>Elymus virginicus</i>	Virginia Wildrye	PA
0.1	<i>Eragrostis spectabilis</i>	Purple Lovegrass	PA
0.1	<i>Eupatorium coelestinum</i>	Mistflower	VA
0.1	<i>Geum canadense</i>	White Avens	PA
0.9	<i>Heliopsis helianthoides</i>	Ox-Eye Sunflower	PA
0.1	<i>Liatris spicata</i>	Spiked Gayfeather	PA or any
0.1	<i>Liatris squarrosa</i>	Scaly Blazing Star	VA
0.2	<i>Monarda fistulosa</i>	Wild Bergamot	FIG (PA)
0.2	<i>Monarda punctata</i>	Dotted Mint	MD or APB
0.1	<i>Oenothera fruticosa</i>	Sundrops	PA
31.1	<i>Panicum anceps</i>	Beaked Panicgrass	MD
4.4	<i>Panicum sphaerocarpon</i>	Roundseeded Panicgrass	PA
0.1	<i>Penstemon canescens</i>	Grayhairy Beardtongue	WV
0.2	<i>Penstemon digitalis</i>	Tall White Beardtongue	PA
0.1	<i>Penstemon hirsutus</i>	Hairy Beardtongue	PA
0.2	<i>Pycnanthemum tenuifolium</i>	Narrow Leaved Mountain Mint	PA
0.1	<i>Rudbeckia fulgida</i>	Orange Coneflower	VA
1.3	<i>Rudbeckia hirta</i>	Black Eyed Susan	PA or any
31.1	<i>Schizachyrium scoparium</i>	Little Bluestem	PA or Camper
0.4	<i>Senna hebecarpa</i>	Wild Senna	WV
0.1	<i>Solidago nemoralis</i>	Gray Goldenrod	PA
0.1	<i>Solidago odora</i>	Licorice Scented Goldenrod	PA
0.3	<i>Tradescantia ohiensis</i>	Ohio Spiderwort	PA
0.1	<i>Zizia aurea</i>	Golden Alexanders	PA
100	<i>Total</i>		

By seed count this mix has approximately 234,000 seeds/lb and is 63.7% grasses and 36.3% wildflowers. If an item in this mix is not available, add its percentage to a member of the same genera in the mix or to *Schizachyrium scoparium*. Apply this mix at 45 bulk lbs/acre along with a cover crop and an erosion control blanket.

For a cover crop use one of the following: Grain Oats, *Avena sativa*, (1 Jan to 30 Apr; 30 lbs/acre), Brown Top Millet, *Brachiaria ramosa*, (1 May to 31 Aug; 10 lbs/acre), or Grain Rye, *Secale cereale*, (1 Sep to 31 Dec; 30 lbs/acre).

Supplemental Perennial Planting Species List

After meadow installation and establishment, there may be areas of the site that encounter settlement requiring additional soil and/or grading to maintain positive drainage toward the sides of the Landfill cap. For these areas, it is recommended to replant with container sized plants to minimize duration needed to reestablish meadow coverage of the disturbed area. Use the following species list for planting if this condition arises.

% of Mix	Latin Name	Common Name	Container Size	Spacing
25%	<i>Helianthus maximiliani</i>	Maximilian Sunflower	DP40 / SP4	30" O.C.
40%	<i>Vernonia noveboracensis</i>	New York Ironweed	DP40 / SP4	30" O.C.
35%	<i>Schizachyrium scoparium</i>	Little Bluestem	DP40 / SP4	30" O.C.

ATTACHMENT D – MEADOW MAINTENANCE SCHEDULE

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Meadow Maintenance & Invasive Species Management Schedule												
	Growing Season (April.15 –Nov. 15)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year One												
Meadow Seed Installation												
<i>Installation</i>												
Watering												
<i>Water weekly for 2 months after install (Assume 8)</i>												
<i>Water every 10 days in drought (Assume 4)</i>												
Mowing/Bush-Hogging												
<i>Mowing (Assume 3)</i>												
Inspection/ Application Foliar Treatment to Control Invasive Species												
<i>Inspection</i>												
<i>Application</i>												
Year Two												
Reseeding												
<i>Reseed, if required</i>												
Watering												
<i>Water every 10 days in drought (Assume 4)</i>												
Mowing/Bush-Hogging												
<i>Annual Spring Mowing</i>												
<i>Mowing Invasive Control (Assume 1)</i>												
Inspection/ Application Foliar Treatment to Control Invasive Species												
<i>Inspection</i>												
<i>Application</i>												
Year Three												
Watering												
<i>Water every 10 days in drought (Assume 4)</i>												
Mowing/Bush-Hogging												
<i>Annual Spring Mowing</i>												
<i>Mowing (Assume 1)</i>												
Inspection/ Application Foliar Treatment to Control Invasive Species												
<i>Inspection</i>												
<i>Application</i>												
Meadow Installation Estimated Costs / Acre												

Activity/Item	Mix #1 (48 ac)	Mix #2 (14.25 ac)	Mix #3/4 (25.5 ac)	
Bulk Seed	\$8,70	\$1,175	\$1,395	Quoted Price from ERNST
Install (seed and ssm/straw mulch)	\$9,600 *(Straw)	\$5,000 *(Straw)	\$9,600 *(SSM)	(Assumes 3 workers/4 8hr days @ \$100)
Watering – 2 months (Assume 8)	\$1,400	\$1,400	\$1,400	1 gallon/SF x \$.0004
Total / acre	\$11,870	\$7,375	\$12,395	
Total /site	\$569,760	\$105,094	\$316,072	= \$990,926
*Straw and SSM calculated as separate pay item.				
Meadow Establishment/Maintenance & Invasive Species Control				
Estimated Costs / Year (Entire Site)				
Activity/Item	Year 1	Year 2	Year 3	
Annual Spring Mowing		\$10,000 / 100 acres	\$10,000 / 100 acres	(Assumes 2 workers/6 8hr days @ \$50)
Mowing Invasive Control	\$10,000 / 100 acres x 3 = \$30,000	\$10,000 / 100 acres	\$10,000 / 100 acres	(Assumes 2 workers/6 8hr days @ \$50)
Watering	\$17,500 / 100 acres x 4 = 70,000	\$17,500 / 100 acres x 4 = \$70,000	\$17,500 / 100 acres x 4 = \$70,000	1 gallon/SF x \$.0004
Inspection	\$3,500 / 100 acres x 2 = \$7,000	\$3,500 / 100 acres x 2 = \$7,000	\$3,500 / 100 acres x 2 = \$7,000	(Assumes 1 workers/4 8hr days @ \$100)
Herbicide Application	\$5,500 / 100 acres x 2 = \$11,000	\$5500 / 100 acres x 2 = \$11,000	\$5,500 / 100 acres x 2 = \$11,000	(Assumes 2 workers/4 8hr days @ \$80)
Reseeding – Assume 5% (5 acres)		\$6,2000		
Watering Reseeded areas		\$7,000		
Total	\$118,000	\$177,000	\$55,500	= \$350,500

ATTACHMENT E – POTENTIAL FUTURE SOLAR PANEL ARRAY EXHIBIT

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