Appendix B – Hydraulic Calculations

- Normal Depth Calculations - Proposed Conditions Street Sections
- Normal Depth Calculations – Onsite Sections
- Trench Drain Calculations

Worksheet for ST1.5

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.41 %
Discharge	2,540.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+15.67	2,110.93
0+15.67	2,106.93
0+25.67	2,106.73
0+26.17	2,106.23
0+27.72	2,106.36
0+46.41	2,106.81
0+67.42	2,106.20
0+67.46	2,106.66
0+71.50	2,107.12
0+81.85	2,102.45
0+87.55	2,102.45
0+98.18	2,108.42

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+15.67, 2,110.93)	(0+26.17, 2,106.23)	0.013
(0+26.17, 2,106.23)	(0+67.42, 2,106.20)	0.016
(0+67.42, 2,106.20)	(0+71.50, 2,107.12)	0.013
(0+71.50, 2,107.12)	(0+87.55, 2,102.45)	0.025
(0+87.55, 2,102.45)	(0+98.18, 2,108.42)	0.038

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	6.84 ft
Roughness Coefficient	0.022
Elevation	2,109.29 ft
Elevation Range	2,102.45 to 2,110.93 ft
Flow Area	276.1 ft²

Worksheet for ST1.5

Results	
Wetted Perimeter	88.98 ft
Hydraulic Radius	3.10 ft
Top Width	82.51 ft
Normal Depth	6.84 ft
Critical Depth	6.58 ft
Critical Slope	0.53 %
Velocity	9.20 ft/s
Velocity Head	1.32 ft
Specific Energy	8.15 ft
Froude Number	0.887
Flow Type	Subcritical

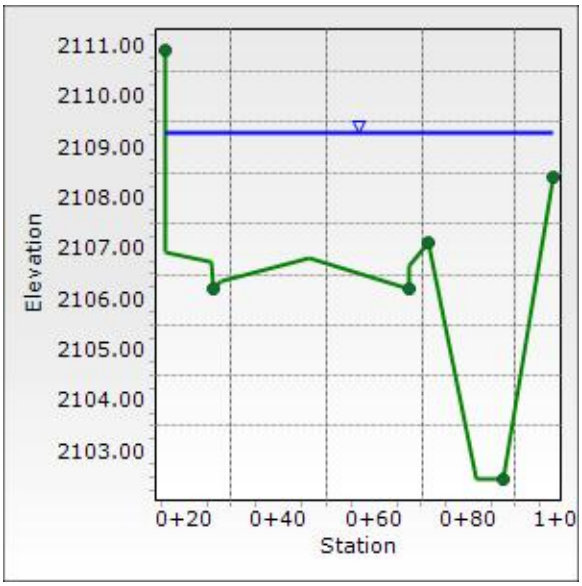
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	6.84 ft
Critical Depth	6.58 ft
Channel Slope	0.41 %
Critical Slope	0.53 %

Cross Section for ST1.5

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.41 %
Normal Depth	6.84 ft
Discharge	2,540.00 cfs



Worksheet for ST2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.90 %
Discharge	2,541.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+19.77	2,110.44
0+19.77	2,106.44
0+29.77	2,106.23
0+29.79	2,105.77
0+29.86	2,105.79
0+31.15	2,105.89
0+49.46	2,106.26
0+68.88	2,105.84
0+70.33	2,105.69
0+74.31	2,106.76
0+84.72	2,102.72
0+86.09	2,101.71
0+91.96	2,101.71
1+07.91	2,108.66

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+19.77, 2,110.44)	(0+29.79, 2,105.77)	0.013
(0+29.79, 2,105.77)	(0+70.33, 2,105.69)	0.016
(0+70.33, 2,105.69)	(0+74.31, 2,106.76)	0.013
(0+74.31, 2,106.76)	(0+86.09, 2,101.71)	0.025
(0+86.09, 2,101.71)	(1+07.91, 2,108.66)	0.038

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	6.35 ft
Roughness Coefficient	0.024
Elevation	2,108.06 ft

Worksheet for ST2

Results	
Elevation Range	2,101.71 to 2,110.44 ft
Flow Area	232.2 ft²
Wetted Perimeter	91.39 ft
Hydraulic Radius	2.54 ft
Top Width	86.76 ft
Normal Depth	6.35 ft
Critical Depth	6.67 ft
Critical Slope	0.63 %
Velocity	10.94 ft/s
Velocity Head	1.86 ft
Specific Energy	8.21 ft
Froude Number	1.179
Flow Type	Supercritical

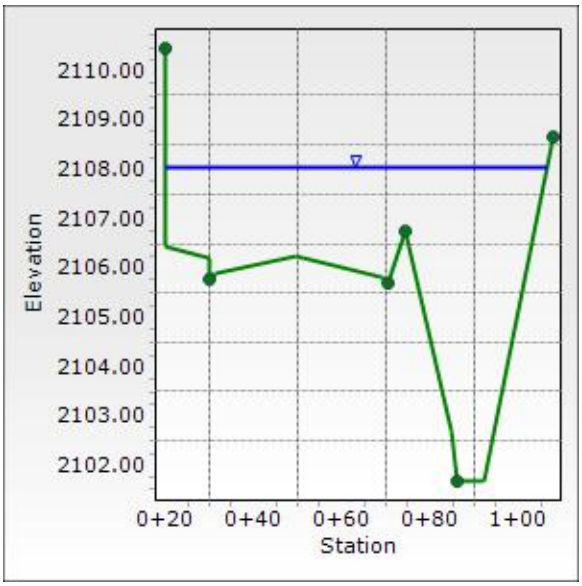
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	6.35 ft
Critical Depth	6.67 ft
Channel Slope	0.90 %
Critical Slope	0.63 %

Cross Section for ST2

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.90 %
Normal Depth	6.35 ft
Discharge	2,541.00 cfs



Worksheet for ST2.5

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.90 %
Discharge	2,543.00 cfs

Section Definitions

Station (ft)	Elevation (ft)
0+18.30	2,106.55
0+18.95	2,105.98
0+29.66	2,105.82
0+30.11	2,105.73
0+34.39	2,105.83
0+56.65	2,105.77
0+69.15	2,105.51
0+70.63	2,105.38
0+70.73	2,105.78
0+73.69	2,105.79
0+74.24	2,105.85
0+83.89	2,101.62
0+88.99	2,101.29
0+90.71	2,101.18
1+06.66	2,115.13

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+18.30, 2,106.55)	(0+30.11, 2,105.73)	0.013
(0+30.11, 2,105.73)	(0+70.63, 2,105.38)	0.016
(0+70.63, 2,105.38)	(0+73.69, 2,105.79)	0.013
(0+73.69, 2,105.79)	(0+90.71, 2,101.18)	0.025
(0+90.71, 2,101.18)	(1+06.66, 2,115.13)	0.038

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	6.48 ft
Roughness Coefficient	0.021
Elevation	2,107.66 ft

Worksheet for ST2.5

Results	
Elevation Range	2,101.18 to 2,115.13 ft
Flow Area	210.1 ft²
Wetted Perimeter	84.82 ft
Hydraulic Radius	2.48 ft
Top Width	79.82 ft
Normal Depth	6.48 ft
Critical Depth	7.02 ft
Critical Slope	0.50 %
Velocity	12.10 ft/s
Velocity Head	2.28 ft
Specific Energy	8.76 ft
Froude Number	1.315
Flow Type	Supercritical

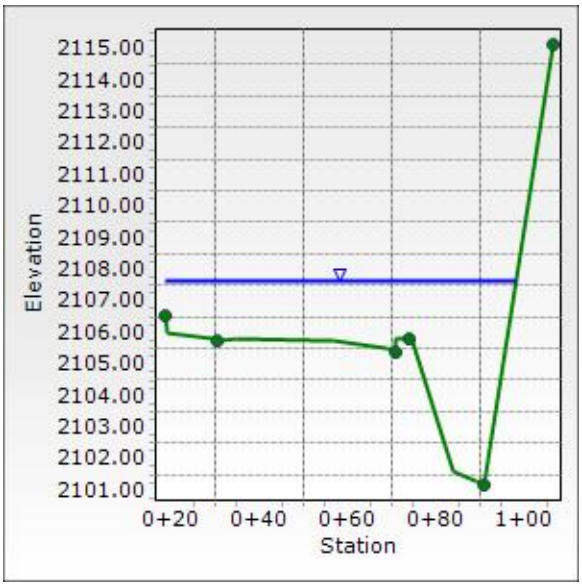
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	6.48 ft
Critical Depth	7.02 ft
Channel Slope	0.90 %
Critical Slope	0.50 %

Cross Section for ST2.5

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.90 %
Normal Depth	6.48 ft
Discharge	2,543.00 cfs



Worksheet for ONG2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.80	%
Discharge	1.00	cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00.00	0.65
0+42.00	0.00
0+42.50	0.00
0+75.20	0.43

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.00, 0.65)	(0+75.20, 0.43)	0.013

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.10	ft
Roughness Coefficient	0.013	
Elevation	0.10	ft
Elevation Range	0.00 to 0.65	ft
Flow Area	0.7	ft²
Wetted Perimeter	14.22	ft
Hydraulic Radius	0.05	ft
Top Width	14.21	ft
Normal Depth	0.10	ft
Critical Depth	0.10	ft
Critical Slope	0.66	%
Velocity	1.39	ft/s
Velocity Head	0.03	ft
Specific Energy	0.13	ft
Froude Number	1.094	
Flow Type	Supercritical	

Worksheet for ONG2

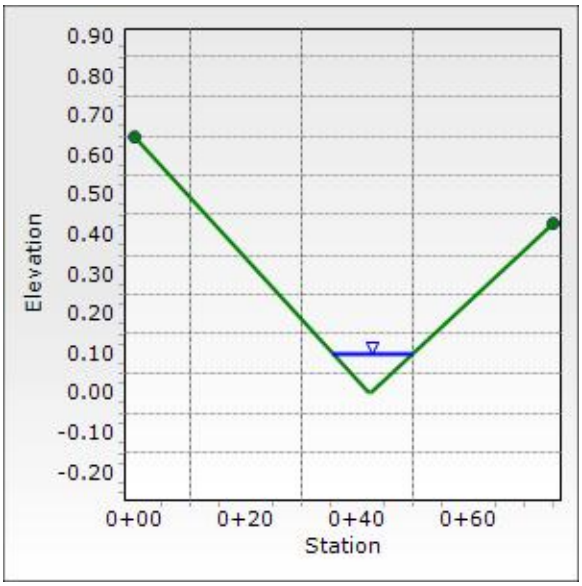
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.10 ft
Critical Depth	0.10 ft
Channel Slope	0.80 %
Critical Slope	0.66 %

Cross Section for ONG2

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.80 %
Normal Depth	0.10 ft
Discharge	1.00 cfs



Worksheet for ONG3N

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	0.10	%
Discharge	1.00	cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00.00	4.00
0+00.00	0.00
0+77.70	1.24

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.00, 4.00)	(0+77.70, 1.24)	0.013

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.20	ft
Roughness Coefficient	0.013	
Elevation	0.20	ft
Elevation Range	0.00 to 4.00	ft
Flow Area	1.3	ft²
Wetted Perimeter	12.90	ft
Hydraulic Radius	0.10	ft
Top Width	12.70	ft
Normal Depth	0.20	ft
Critical Depth	0.14	ft
Critical Slope	0.60	%
Velocity	0.78	ft/s
Velocity Head	0.01	ft
Specific Energy	0.21	ft
Froude Number	0.430	
Flow Type	Subcritical	

GVF Input Data

Worksheet for ONG3N

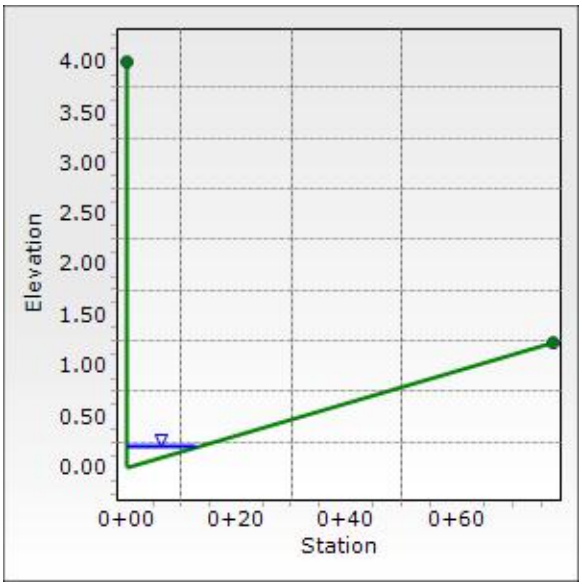
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.20 ft
Critical Depth	0.14 ft
Channel Slope	0.10 %
Critical Slope	0.60 %

Cross Section for ONG3N

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	0.10 %
Normal Depth	0.20 ft
Discharge	1.00 cfs



Worksheet for ONG3S

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Channel Slope	3.02	%
Discharge	1.00	cfs

Section Definitions

Station (ft)	Elevation (ft)
0+00.00	0.19
0+09.30	0.00
0+09.80	0.00
0+09.80	4.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00.00, 0.19)	(0+09.80, 4.00)	0.013

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Normal Depth	0.11	ft
Roughness Coefficient	0.013	
Elevation	0.11	ft
Elevation Range	0.00 to 4.00	ft
Flow Area	0.3	ft²
Wetted Perimeter	5.89	ft
Hydraulic Radius	0.06	ft
Top Width	5.78	ft
Normal Depth	0.11	ft
Critical Depth	0.15	ft
Critical Slope	0.59	%
Velocity	2.95	ft/s
Velocity Head	0.14	ft
Specific Energy	0.24	ft
Froude Number	2.149	
Flow Type	Supercritical	

Worksheet for ONG3S

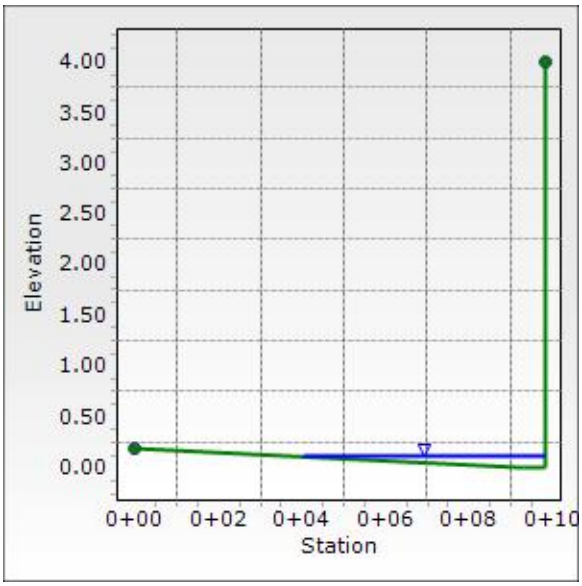
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.11 ft
Critical Depth	0.15 ft
Channel Slope	3.02 %
Critical Slope	0.59 %

Cross Section for ONG3S

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Channel Slope	3.02 %
Normal Depth	0.11 ft
Discharge	1.00 cfs



Grate Inlet Headwater Depth Calculation

4.5-in by 20-ft Trench Drain OND1 #1

Known:

Q=	Flow (cfs)	1.0
W=	Width of Grate (ft)	0.375
L=	Length of Grate (ft)	20.0
D=	Diameter of Circle (in)	
Cf=	Clogging Factor (%)	50

Weir Conditions:

$Hw=(Q/(Cw*P))^{2/3}$

Cw=	Weir Coefficient	2.7
P=	Perimeter of grate (ft)	40.8
Pc=	Perimeter (w/clogging) (ft)	20.4
Hw=	Headwater depth (ft)	0.07

Orifice Conditions:

$Hw=(Q/(Co*Ac))^{2}/2*g$

Co=	Orifice Coefficient	0.67
Ag=	Grate Area (ft^2)	7.5
Gf=	Grate Opening Factor	0.25
Ac=	Grate Open Area (w/ clogging) (ft^2)	0.9
Hw=	Headwater depth (ft)	0.04

Worst Case Scenario Occurs Under Weir Conditions

Headwater Depth (ft) = 0.07

Grate Inlet Headwater Depth Calculation

4.5-in by 122-ft Trench Drain ONE3 #2

Known:

Q=	Flow (cfs)	1.0
W=	Width of Grate (ft)	0.375
L=	Length of Grate (ft)	122.0
D=	Diameter of Circle (in)	
Cf=	Clogging Factor (%)	50

Weir Conditions:

$Hw=(Q/(Cw*P))^{2/3}$

Cw=	Weir Coefficient	2.7
P=	Perimeter of grate (ft)	244.8
Pc=	Perimeter (w/clogging) (ft)	122.4
Hw=	Headwater depth (ft)	0.02

Orifice Conditions:

$Hw=(Q/(Co*Ac))^{2}/2*g$

Co=	Orifice Coefficient	0.67
Ag=	Grate Area (ft^2)	45.8
Gf=	Grate Opening Factor	0.25
Ac=	Grate Open Area (w/ clogging) (ft^2)	5.7
Hw=	Headwater depth (ft)	0.00

Worst Case Scenario Occurs Under Weir Conditions

Headwater Depth (ft) = 0.02