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Coal Combustion Residuals
Run-on and Run-off Control System Plan

Dominion Energy Virginia
Curley Hollow Solid Waste Management Facility
Wise County, Virginia

GAI Project Number: C131883.02, Task 005

October 2016

Revised October 2021

Prepared by: GAI Consultants, Inc.
Pittsburgh Office
385 East Waterfront Drive
Homestead, Pennsylvania 15120-5005

Prepared for: Dominion Energy Virginia
600 East Canal Street
Richmond, Virginia 23219-3852

Coal Combustion Residuals
Run-on and Run-off Control System Plan

Dominion Energy Virginia
Curley Hollow Solid Waste Management Facility
Wise County, Virginia

GAI Project Number: C160523.00

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Prepared for:
Dominion Energy Virginia
600 East Canal Street
Richmond, Virginia 23219-3852

Prepared by:
GAI Consultants, Inc.
Pittsburgh Office
385 East Waterfront Drive
Homestead, Pennsylvania 15120-5005

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Certification/Statement of Professional Opinion

The Coal Combustion Residuals Run-on and Run-off Control System Plan (Plan) for the Curley Hollow Solid Waste Management Facility (CHSWMF) was prepared by GAI Consultants, Inc. (GAI). The Plan was based on certain information that, other than for information GAI originally prepared, GAI has relied on but not independently verified. This Certification/Statement of Professional Opinion is therefore limited to the information available to GAI at the time the Plan was written. On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that the Plan has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances at the same time and in the same locale. It is my professional opinion that the Plan meets the requirements of the United States Environmental Protection Agency's "Disposal of Coal Combustion Residuals From Electric Utilities," published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (40 Code of Federal Regulations § 257 Subpart D).

The use of the words "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty or legal opinion.

GAI Consultants, Inc.

James F. Shields, PE
Assistant Manager, Engineering

Date: 10/7/2021

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Acronyms

CCR	Coal Combustion Residuals
CCR Rule	"Disposal of Coal Combustion Residuals from Electric Utilities" 40 CFR § 257 Subpart D (2015)
CFR	Code of Federal Regulations
CHSWMF	Curley Hollow Solid Waste Management Facility
Dominion	Dominion Energy Virginia
USEPA	United States Environmental Protection Agency
GAI	GAI Consultants, Inc.
Plan	Run-on and Run-off Control System Plan
VA	Virginia
VCHEC	Virginia City Hybrid Energy Center

1.0 Introduction

The Virginia City Hybrid Energy Center (VCHEC) is owned by Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion) and is located in Saint Paul, Virginia (VA). The station includes the Curley Hollow Solid Waste Management Facility (CHSWMF), which is used for the long-term storage of coal combustion residuals (CCRs).

The CHSWMF is located on Dominion property at the VCHEC in Wise County, VA (36°55'48"N 82°20'24"W) and is bounded by Singapura Road on the south, Hughes Hollow Road on the east, Meade Creek on the west, and open mountain ranges on the north.

The CHSWMF is regulated as an existing landfill under the United States Environmental Protection Agency's (USEPA's) "Disposal of Coal Combustion Residuals from Electric Utilities" published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (CCR Rule).

2.0 Purpose

The CHSWMF is a landfill permitted to receive CCR material from VCHEC operations. The CHSWMF is designed to be constructed in six stages. During each stage of operation, run-on channels (sediment and diversion channels) minimize stormwater from flowing onto the active portion of the landfill, and run-off channels (leachate channels) collect and control stormwater that has contacted the active portion of the landfill. Run-on and run-off are collected in separate ponds and treated before being discharged.

Title 40 of the Code of Federal Regulations (CFR) § 257.81 requires that the run-on control system for CCR landfills be designed, constructed, operated, and maintained to prevent flow onto the active portion of the landfill during peak discharge of a 25-year, 24-hour storm. Similarly, the run-off control system must be designed, constructed, operated, and maintained to collect and control the water volume resulting from a 25-year, 24-hour storm.

This Run-on and Run-off Control System Plan (Plan) is prepared pursuant to the requirements in the USEPA's "Disposal of Coal Combustion Residuals From Electric Utilities" published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (CCR Rule), § 257.81(c). This Plan revision is being made to comply with § 257.81(c)(4) which requires the original Plan to be revised every five years.

3.0 Plan

As required by 40 CFR § 257.81(c), this Plan includes the following:

- documentation of how the run-on and run-off control systems have been designed to meet the applicable requirements of § 257.81; and
- supporting engineering calculations (see the Part B Permit Application and Appendix A).

3.1 Run-on Controls

The run-on control system consists of a series of sediment and diversion channels that minimize stormwater contact with CCR. The sediment channels, culverts, and sedimentation control pond are designed and constructed to control the peak flow from at least the 25-year, 24-hour storm event. The run-on control system meets the applicable requirements of 40 CFR § 257.81.

3.2 Sediment Channels

Sediment channels are constructed along the edge of the CHSWMF and on the non-active portions of the CHSWMF to direct non-contact water away from active portions of the CHSWMF. The sediment channels were designed to be lined with vegetation/turf reinforcement, fabric-formed concrete, or concrete, depending on the location, flow velocities, and channel slopes. The sediment channels along

the edge of the CHSWMF also serve as diversion channels for the hillsides around the CHSWMF. The sediment channel capacities control at least the 25-year, 24-hour storm during all phases of construction of the CHSWMF. The sediment channels discharge non-contact water directly, and through a series of culverts and drop boxes, to the sedimentation control pond.

3.3 Sediment Culverts and Drop Boxes

Sediment culverts and drop boxes control run-on from the sediment channels. The culverts and drop boxes were designed to control at least the 25-year, 24-hour storm. The sediment culverts and drop boxes discharge to the sedimentation control pond.

3.3.1 Sedimentation Control Pond

The sedimentation control pond controls run-on from the sediment channels and will continue functioning as a long-term stormwater management pond after the CHSWMF is permanently closed. The sedimentation control pond was designed to control and discharge the peak flow from a 100-year, 24-hour storm. The primary spillway is a riser and discharge pipe that controls flow during normal operation. The emergency spillway is capable of passing the 100-year peak discharge without overtopping the crest of the pond. Both the primary and emergency spillways discharge to the combined spillway channel, and eventually to Meade Creek.

The sedimentation control pond is maintained by cleaning out sediment as necessary when the wet storage area is reduced below a set volume.

3.3.2 Diversion Channels

Three diversion channels were constructed upgradient of the sedimentation pond and final leachate pond. Diversion Channel 1 is a fabricform-lined channel along the edge of the sedimentation pond. Diversion Channel 2 is a concrete-lined channel constructed along the edge of the final leachate pond. Diversion Channel 3 is a grouted rip-rap (upper section) and rock-excavated (lower section) channel constructed north of the final leachate pond. Diversion Channel 3 controls run-on from the hilltop above the sedimentation and final leachate pond, and discharges into a section of gabion baskets in Diversion Channel 2. The gabion baskets serve to break up the flow from Diversion Channel 3 and direct it to its receiving channel and help control the stormwater due to the limited space availability. The channels serve two functions:

- minimize non-contact stormwater run-on from entering the CHSWMF through the ponds; and
- reduce hydraulic loading on the ponds.

The channel capacities control at least the 25-year, 24-hour storm. Diversion Channels 1 and 2 discharge through separate culverts.

3.3.3 Diversion Culverts and Drop Inlets

Diversion culverts and drop inlets control run-on from the diversion channels. The culverts were designed to control at least the 25-year, 24-hour storm. Diversion Channel 1 discharges through a drop inlet and culvert to the combined spillway channel. Diversion Channel 2 discharges through a drop inlet and culvert into Meade Creek.

3.3.4 Combined Spillway Channel

The combined spillway channel receives discharges from Diversion Channel 1, the sedimentation control pond, and the final leachate pond (see Section 3.4.4). The combined spillway channel discharges into Meade Creek. The sedimentation pond emergency spillway is constructed with an articulated concrete block channel and combines with the leachate pond emergency spillway constructed with gabion baskets. Its capacity controls the 100-year, 24-hour storm discharge from Diversion Channel 1 and the ponds.

3.3.5 Bench Capacity

The intermediate and final cap benches were designed to control peak flows resulting from at least the 25-year, 24-hour storm event. Stormwater that contacts these benches is directed towards the sediment channels. Slope drains are installed periodically to control flow from benches to sediment channels and to prevent overloading of bench capacity.

3.4 Run-off Control System

The run-off control system consists of a series of leachate channels that collect and control CCR contact water. The CHSWMF benches, leachate channels, culverts, and final leachate pond were designed to control the peak flow from at least the 25-year, 24-hour storm event. The run-off control system meets the applicable requirements of 40 CFR § 257.81.

3.4.1 Bench Capacity

The waste development benches were designed to control peak flows resulting from at least the 25-year, 24-hour storm event. Stormwater that contacts these benches is directed toward the leachate channels.

3.4.2 Leachate Channels

Leachate channels are constructed on the active portions of the CHSWMF to direct CCR contact water from the active area and the haul road to the final leachate pond. The leachate channels were designed to be lined, either with fabric-formed concrete or concrete, and constructed with a geomembrane liner beneath. The leachate channels control at least the 25-year, 24-hour storm. The leachate channels discharge to the final leachate pond through a series of drop boxes and culverts.

3.4.3 Leachate Culverts and Drop Boxes

Leachate culverts and drop boxes control run-off from the leachate channels. The culverts and drop boxes were designed to control at least the 25-year, 24-hour storm. The leachate culverts and drop boxes discharge through a 90-inch culvert to the final leachate pond.

3.4.4 Final Leachate Pond

The final leachate pond receives flow from the leachate piping above the liner system and receives and controls flow from the leachate channels of the construction stages. The leachate channels do not discharge directly to the final leachate pond, and instead discharge to a series of drop boxes and culverts which collect and direct the leachate through a 90-inch culvert. The 90-inch culvert discharges the leachate to the final leachate pond. The final leachate pond is designed and constructed to control and discharge the peak flow from at least the 100-year, 24-hour storm. During normal operations, the final leachate pond is pumped through a leachate conveyance pipeline to the VCHEC where the water is reused. The emergency overflow discharges to the combined spillway channel (see Section 3.3.4).

4.0 References

Dominion. *Construction Stormwater Pollution Prevention and Erosion and Sediment Control Plan*; April, 2016.

GAI Consultants, Inc. 2015. *Solid Waste Facility Permit Number 608, Curley Hollow Solid Waste Management Facility Industrial Landfill*. January 2015.

GAI Consultants, Inc. 2014. *Stage 2A and 2B Development Construction Drawings*. August 2014.

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GAI Consultants, Inc. 2008. *Curley Hollow SWMF, Leachate Pond Diversion*. March 2008.

GAI Consultants, Inc. 2008. *Hydrologic and Hydraulic Analyses.*

United States Environmental Protection Agency. 2015. 40 CFR Parts 257 and 261, *Hazardous and Solid Waste Management Disposal System; Disposal of Coal Combustion Residual from Electric Utilities, Final Rule*. April 2015.

APPENDIX A
Hydraulics and Hydrology Calculations

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HYDRAULICS AND HYDROLOGY CALCULATIONS

DRAWINGS

EAST PERM B
DA=16.34 AC

EAST PERM A
DA=1.97 AC

WEST PERM A
DA=2.26 AC

1A-4
DA=4.6 AC

1A-1A
DA=14.0 AC

1A-1B-1/2
DA=19.13 AC

S1A-2A/B
DA=6.07 AC

S2-3
DA=13.13 AC

STAGE 2 WEST
RAINCOVER
DA=15.38 AC

EAST PERIMETER C
DA=2.55 AC

STAGE 2 EAST
RAINCOVER
DA=30.09 AC

S2-1/S2-2
DA=119 AC

WEST PERM C/D
DA=9.35 AC

EAST PERM D
DA=10.32 AC

CHANNEL HAUL ROAD 1A
CHANNEL 1B-1
CHANNEL 1B-2
CONTINUE CHANNEL 1A-3
CONTINUE CHANNEL EAST PERIMETER B
CULVERT EAST PERIMETER C
BEGIN CHANNEL EAST PERIMETER C
ACCESS ROAD
CHANNEL S2-2
CHANNEL S2-3
BEGIN WEST PERIMETER CHANNEL SEGMENT C
BEGIN WEST PERIMETER CHANNEL SEGMENT D
LEACHATE POND DIVERSION CHANNEL 2
LEACHATE RECIRCULATION
STAGE 2A DEVELOPMENT
STOCKPILE AREA 1
SEDIMENT TRAP 2-1
CHANNEL 2-6
STOCKPILE AREA 6
EAST PERIMETER CHANNEL SEGMENT D
CHSWMF FACILITY BOU
DROP BOX 6
DROP BOX 3
DROP BOX 4
DROP BOX 7
CULVERT HAUL ROAD 2
HAUL ROAD CHANNEL 1B
CULVERT S2-1
LEACHATE JUNCTION
CULVERT WEST PERIMETER D
CULVERT LD-1
FINAL LEACHATE POND DIVERSION CHANNEL 1
EXISTING SEDIMENTATION POND

BY: MBO DATE: 03/18/2013
CHECKED: ____ DATE: _____

CURLEY HOLLOW SOLID WASTE MANAGEMENT FACILITY
STAGE 2 SEDIMENT POND WITH RAINCOVER
DRAINAGE AREA MAP

SCALE: 1" = 400'
400 0 400 800

N

N3524000
N3523500
N3523000
N3522500
N3522000
N3521500
N3521000
N3520500
N3520000
N3519500
N3519000
N3518500
N3518000
N3517500

E10362000
E10361500
E10361000
E10360500
E10360000
E10359500
E10359000
E10358500
E10358000

CHANNEL HAUL ROAD 1A
CHANNEL 1B-1
CHANNEL 1B-2
CONTINUE CHANNEL 1A-3
CONTINUE CHANNEL EAST PERIMETER B
CULVERT EAST PERIMETER C
BEGIN CHANNEL EAST PERIMETER C
S2-2
DA=150.63 AC
ACCESS ROAD
STAGE 2A DEVELOPMENT
STOCKPILE AREA 1
CHANNEL S2-2
CHANNEL S2-3
BEGIN WEST PERIMETER CHANNEL SEGMENT C
SEDIMENT TRAP 2-1
CHANNEL 2-6
STOCKPILE AREA 6
EAST PERIMETER CHANNEL SEGMENT D
CHSWMF FACILITY BOUNDARY
DROP BOX 6
DROP BOX 3
DROP BOX 4
DROP BOX 7
CULVERT HAUL ROAD 2
HAUL ROAD CHANNEL 1B
CULVERT S2-1
LEACHATE CONVEYANCE JUNCTION MANHOLE
CULVERT WEST PERIMETER D
BEGIN WEST PERIMETER CHANNEL SEGMENT D
LEACHATE POND DIVERSION CHANNEL 2
LEACHATE RECIRCULATION
LEACHATE POND
DA=8.04 AC
CULVERT LD-1
CULVERT S2-1
FINAL LEACHATE POND DIVERSION CHANNEL 1
EXISTING SEDIMENTATION POND
FINAL LEACHATE POND EMERGENCY SPILLWAY
STOCKPILE AREA 8
STOCKPILE AREA 7
SILT FENCE

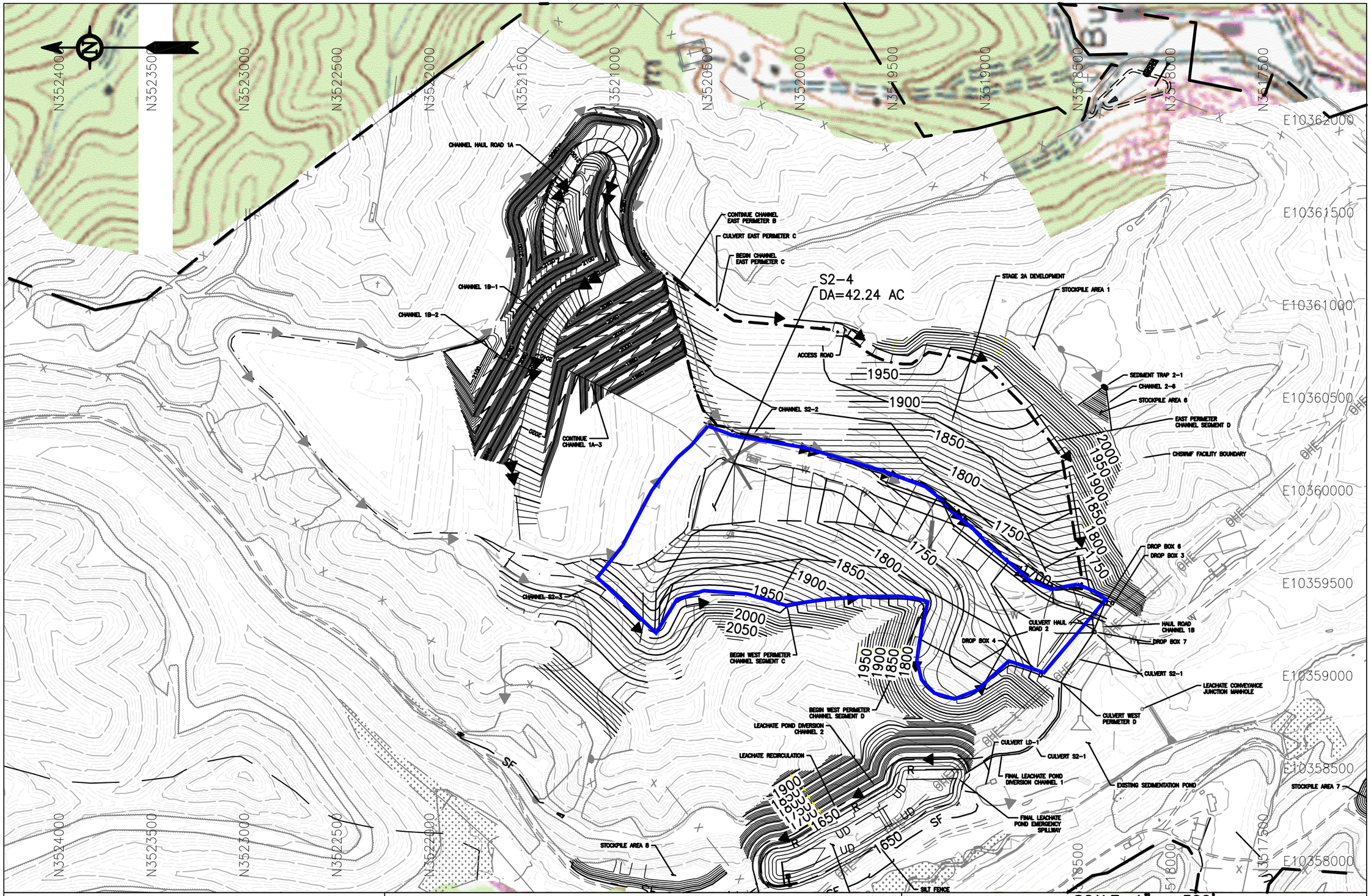
1950
1900
1850
1800
1750
1700
2000
2050
1650

BY: MBO DATE: 03/14/2013
CHECKED: ____ DATE: _____

CURLEY HOLLOW SOLID WASTE MANAGEMENT FACILITY
STAGE 2 LEACHATE POND (S2-2) WITH RAINCOVER
DRAINAGE AREA MAP

SCALE: 1" = 500'

500 0 500 1000



BY: MBO DATE: 03/14/2013
CHECKED: ____ DATE: _____

CURLEY HOLLOW SOLID WASTE MANAGEMENT FACILITY
STAGE 2 LEACHATE POND (S2-4) WITH RAINCOVER
DRAINAGE AREA MAP

SCALE: 1" = 500'

500 0 500 1000

CHANNELS

Calculation package includes:

1. Curley Hollow SWMF Hydrologic and Hydraulic Calculations Summary
   Pages 1-22 and 42-54 omitted due to off-site calculations not applicable to the landfill channel design

2. Curley Hollow SWMF Gabion Channel Design

3. Superelevation Drawings and Summary

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CHANNEL DESIGN

S1A-3A					
	25-Year	100-Year		25-Year	100-Year
Channel	S1A-3A	S1A-3A		S1A-3A	S1A-3A
Condition	Constant Slope	Constant Slope		Constant Slope	Constant Slope
Protective Lining	2.2" FPM	2.2" FPM		Concrete	Concrete
Channel Top Width (ft)	8	5		7.5	3.5
Channel Width at Flow Depth (ft)	3.728	4.052		2.82	3.064
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	2	2		1.5	1.5
Flow Depth (ft)	0.432	0.513		0.33	0.391
Bottom Width:Depth (12:1 max)	4.6	3.9		4.5	3.8
Area (square feet)	1.2	1.6		0.7	0.9
Wetted Perimeter (ft)	3.9	4.3		3.0	3.2
Hydraulic Radius (ft)	0.31	0.36		0.24	0.27
Slope	0.220	0.220		0.220	0.220
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.025	0.025		0.012	0.012
Velocity at Flow Depth (ft/s)	12.93	14.19		22.46	24.61
Flow at Flow Depth (cfs)	16.0	22.0		16.0	22.0
Required Capacity (cfs)	16.0	22.0		16.0	22.0
Minimum Required Freeboard (ft)	1.00	N/A		1.00	N/A
Total Depth Required (ft)	1.43	0.51		1.33	0.39
Actual Depth (ft)	1.50	0.75		1.50	0.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	12.93	14.19		22.46	24.61
Shear Stress at Flow Depth (lb /sf)	7.12	8.45		4.53	5.37
Max. Allowable Shear Stress (lb/sf)	11.00	11.00		N/A	N/A
Froude Number	3.96	4.04		7.87	8.04

SUBJECT CURLEY HOLLOW SWMF

HYDROLOGIC AND HYDRAULIC CALCULATIONS SUMMARY

BY KMB2 DATE 4/1/2013 PROJ. NO. C060702.52

CHKD. BY AA DATE 4/1/2013 SHEET NO. 24 OF 54

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S1A-3B				
	25-Year	25-Year	100-Year	100-Year
Channel	S1A-3B	S1A-3B	S1A-3B	S1A-3B
Condition	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	4" USM	4" USM	4" USM	4" USM
Channel Top Width (ft)	16.5	12.5	13.5	8.5
Channel Width at Flow Depth (ft)	12.328	7.86	13.148	8.248
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	4.5	4.5	4.5	4.5
Flow Depth (ft)	1.957	0.84	2.162	0.937
Bottom Width:Depth (12:1 max)	2.3	5.4	2.1	4.8
Area (square feet)	16.5	5.2	19.1	6.0
Wetted Perimeter (ft)	13.3	8.3	14.2	8.7
Hydraulic Radius (ft)	1.24	0.63	1.35	0.69
Slope	0.010	0.250	0.010	0.250
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015	0.015	0.015
Velocity at Flow Depth (ft/s)	11.48	36.45	12.11	38.68
Flow at Flow Depth (cfs)	189.0	189.2	231.1	231.0
Required Capacity (cfs)	189.0	189.0	231.0	231.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.96	1.84	2.16	0.94
Actual Depth (ft)	3.00	2.00	2.25	1.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	11.48	36.45	12.11	38.68
Shear Stress at Flow Depth (lb /sf)	1.47	15.72	1.62	17.54
Max. Allowable Shear Stress (lb/sf)	18.00	18.00	18.00	18.00
Froude Number	1.75	7.90	1.77	8.01

S1A-3B				
	25-Year	25-Year	100-Year	100-Year
Channel	S1A-3B	S1A-3B	S1A-3B	S1A-3B
Condition	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	15.5	11.5	12.5	7.5
Channel Width at Flow Depth (ft)	11.088	6.832	11.856	7.208
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	3.5	3.5	3.5	3.5
Flow Depth (ft)	1.897	0.833	2.089	0.927
Bottom Width:Depth (12:1 max)	1.8	4.2	1.7	3.8
Area (square feet)	13.8	4.3	16.0	5.0
Wetted Perimeter (ft)	12.0	7.2	12.8	7.6
Hydraulic Radius (ft)	1.15	0.60	1.25	0.65
Slope	0.010	0.250	0.010	0.250
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	13.67	43.95	14.40	46.54
Flow at Flow Depth (cfs)	189.1	189.1	231.0	231.0
Required Capacity (cfs)	189.0	189.0	231.0	231.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.90	1.83	2.09	0.93
Actual Depth (ft)	3.00	2.00	2.25	1.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	13.67	43.95	14.40	46.54
Shear Stress at Flow Depth (lb /sf)	1.18	12.99	1.30	14.46
Max. Allowable Shear Stress (lb/sf)	N/A	N/A	N/A	N/A
Froude Number	2.16	9.76	2.18	9.88

SUBJECT CURLEY HOLLOW SWMF

HYDROLOGIC AND HYDRAULIC CALCULATIONS SUMMARY

BY KMB2 DATE 4/1/2013 PROJ. NO. C060702.52

CHKD. BY AA DATE 4/1/2013 SHEET NO. 25 OF 54

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1A-1A				
	25-Year	100-Year	25-Year	100-Year
Channel	1A-1A	1A-1A	1A-1A	1A-1A
Condition	Constant Slope	Constant Slope	Constant Slope	Constant Slope
Protective Lining	3" USM	3" USM	Concrete	Concrete
Channel Top Width (ft)	9.5	6.5	9.5	6.5
Channel Width at Flow Depth (ft)	5.436	5.904	5.112	5.532
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	2.5	2.5	2.5	2.5
Flow Depth (ft)	0.734	0.851	0.653	0.758
Bottom Width:Depth (12:1 max)	3.4	2.9	3.8	3.3
Area (square feet)	2.9	3.6	2.5	3.0
Wetted Perimeter (ft)	5.8	6.3	5.4	5.9
Hydraulic Radius (ft)	0.50	0.57	0.46	0.52
Slope	0.090	0.090	0.090	0.090
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015	0.012	0.012
Velocity at Flow Depth (ft/s)	18.86	20.42	22.15	23.99
Flow at Flow Depth (cfs)	54.9	73.0	55.0	73.0
Required Capacity (cfs)	55.0	73.0	55.0	73.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A
Total Depth Required (ft)	1.73	0.85	1.65	0.76
Actual Depth (ft)	1.75	1.00	1.75	1.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	18.86	20.42	22.15	23.99
Shear Stress at Flow Depth (lb /sf)	4.95	5.74	3.67	4.26
Max. Allowable Shear Stress (lb/sf)	14.00	14.00	N/A	N/A
Froude Number	4.54	4.62	5.60	5.70

1A-1B				
	25-Year	100-Year	25-Year	100-Year
Channel	1A-1B	1A-1B	1A-1B	1A-1B
Condition	Constant Slope	Constant Slope	Constant Slope	Constant Slope
Protective Lining	3" USM	3" USM	Concrete	Concrete
Channel Top Width (ft)	12.5	9.5	12	8
Channel Width at Flow Depth (ft)	8.096	8.584	7.34	7.792
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	3.5	3.5	3	3
Flow Depth (ft)	1.149	1.271	1.085	1.198
Bottom Width:Depth (12:1 max)	3.0	2.8	2.8	2.5
Area (square feet)	6.7	7.7	5.6	6.5
Wetted Perimeter (ft)	8.6	9.2	7.9	8.4
Hydraulic Radius (ft)	0.77	0.84	0.71	0.77
Slope	0.090	0.090	0.090	0.090
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015	0.012	0.012
Velocity at Flow Depth (ft/s)	25.06	26.45	29.77	31.39
Flow at Flow Depth (cfs)	167.0	203.1	167.0	202.9
Required Capacity (cfs)	167.0	203.0	167.0	203.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A
Total Depth Required (ft)	2.15	1.27	2.09	1.20
Actual Depth (ft)	2.25	1.50	2.25	1.25
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	25.06	26.45	29.77	31.39
Shear Stress at Flow Depth (lb /sf)	7.74	8.57	6.09	6.73
Max. Allowable Shear Stress (lb/sf)	14.00	14.00	N/A	N/A
Froude Number	4.87	4.93	6.00	6.07

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1B-1					
	25-Year	25-Year		100-Year	100-Year
Channel	1B-1	1B-1		1B-1	1B-1
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	3" USM	3" USM		3" USM	3" USM
Channel Top Width (ft)	13	11		10	7
Channel Width at Flow Depth (ft)	8.6	6.452		9.364	6.952
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	3	3		3	3
Flow Depth (ft)	1.4	0.863		1.591	0.988
Bottom Width:Depth (12:1 max)	2.1	3.5		1.9	3.0
Area (square feet)	8.1	4.1		9.8	4.9
Wetted Perimeter (ft)	9.3	6.9		10.1	7.4
Hydraulic Radius (ft)	0.88	0.59		0.97	0.66
Slope	0.012	0.080		0.012	0.080
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.015	0.015		0.015	0.015
Velocity at Flow Depth (ft/s)	9.97	19.87		10.68	21.36
Flow at Flow Depth (cfs)	80.9	81.0		105.0	105.0
Required Capacity (cfs)	81.0	81.0		105.0	105.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	2.40	1.86		1.59	0.99
Actual Depth (ft)	2.50	2.00		1.75	1.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	9.97	19.87		10.68	21.36
Shear Stress at Flow Depth (lb /sf)	1.26	5.17		1.43	5.92
Max. Allowable Shear Stress (lb/sf)	14.00	14.00		14.00	14.00
Froude Number	1.81	4.40		1.84	4.48

1B-1					
	25-Year	25-Year		100-Year	100-Year
Channel	1B-1	1B-1		1B-1	1B-1
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	Concrete	Concrete		Concrete	Concrete
Channel Top Width (ft)	13	11		9	7
Channel Width at Flow Depth (ft)	8.012	6.068		8.704	6.52
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	3	3		3	3
Flow Depth (ft)	1.253	0.767		1.426	0.88
Bottom Width:Depth (12:1 max)	2.4	3.9		2.1	3.4
Area (square feet)	6.9	3.5		8.3	4.2
Wetted Perimeter (ft)	8.6	6.4		9.4	6.9
Hydraulic Radius (ft)	0.80	0.54		0.89	0.60
Slope	0.012	0.080		0.012	0.080
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.012	0.012		0.012	0.012
Velocity at Flow Depth (ft/s)	11.74	23.31		12.58	25.09
Flow at Flow Depth (cfs)	81.0	81.1		105.0	105.1
Required Capacity (cfs)	81.0	81.0		105.0	105.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	2.25	1.77		1.43	0.88
Actual Depth (ft)	2.50	2.00		1.50	1.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	11.74	23.31		12.58	25.09
Shear Stress at Flow Depth (lb /sf)	0.94	3.83		1.07	4.39
Max. Allowable Shear Stress (lb/sf)	N/A	N/A		N/A	N/A
Froude Number	2.23	5.43		2.26	5.52

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1A-3				
	25-Year	25-Year	100-Year	100-Year
Channel	1A-3	1A-3	1A-3	1A-3
Condition	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	4" FPM	4" FPM	4" FPM	4" FPM
Channel Top Width (ft)	12	10	9	6
Channel Width at Flow Depth (ft)	7.944	5.368	8.768	5.8
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	3	3	3	3
Flow Depth (ft)	1.236	0.592	1.442	0.7
Bottom Width:Depth (12:1 max)	2.4	5.1	2.1	4.3
Area (square feet)	6.8	2.5	8.5	3.1
Wetted Perimeter (ft)	8.5	5.6	9.4	6.1
Hydraulic Radius (ft)	0.79	0.44	0.90	0.50
Slope	0.020	0.330	0.020	0.330
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.026	0.026	0.026	0.026
Velocity at Flow Depth (ft/s)	6.94	19.00	7.54	20.81
Flow at Flow Depth (cfs)	47.0	47.1	64.0	64.1
Required Capacity (cfs)	47.0	47.0	64.0	64.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.24	1.59	1.44	0.70
Actual Depth (ft)	2.25	1.75	1.50	0.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	6.94	19.00	7.54	20.81
Shear Stress at Flow Depth (lb /sf)	1.85	14.63	2.16	17.30
Max. Allowable Shear Stress (lb/sf)	20.00	20.00	20.00	20.00
Froude Number	1.33	4.93	1.35	5.03

1A-3				
	25-Year	25-Year	100-Year	100-Year
Channel	1A-3	1A-3	1A-3	1A-3
Condition	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	10.5	8.5	7.5	5.5
Channel Width at Flow Depth (ft)	6.064	4.184	6.668	4.496
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	2.5	2.5	2.5	2.5
Flow Depth (ft)	0.891	0.421	1.042	0.499
Bottom Width:Depth (12:1 max)	2.8	5.9	2.4	5.0
Area (square feet)	3.8	1.4	4.8	1.7
Wetted Perimeter (ft)	6.5	4.4	7.2	4.7
Hydraulic Radius (ft)	0.59	0.32	0.67	0.37
Slope	0.020	0.330	0.020	0.330
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	12.33	33.44	13.41	36.69
Flow at Flow Depth (cfs)	47.0	47.1	64.0	64.0
Required Capacity (cfs)	47.0	47.0	64.0	64.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A
Total Depth Required (ft)	1.89	1.42	1.04	0.50
Actual Depth (ft)	2.00	1.50	1.25	0.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	12.33	33.44	13.41	36.69
Shear Stress at Flow Depth (lb /sf)	1.11	8.67	1.30	10.28
Max. Allowable Shear Stress (lb/sf)	N/A	N/A	N/A	N/A
Froude Number	2.74	10.16	2.79	10.38

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1A-4				
	25-Year	25-Year	100-Year	100-Year
Channel	1A-4	1A-4	1A-4	1A-4
Condition	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	2.2" FPM	2.2" FPM	2.2" FPM	2.2" FPM
Channel Top Width (ft)	10	9	7	5
Channel Width at Flow Depth (ft)	5.856	4.308	6.352	4.556
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	3	3	3	3
Flow Depth (ft)	0.714	0.327	0.838	0.389
Bottom Width:Depth (12:1 max)	4.2	9.2	3.6	7.7
Area (square feet)	3.2	1.2	3.9	1.5
Wetted Perimeter (ft)	6.2	4.5	6.7	4.7
Hydraulic Radius (ft)	0.51	0.27	0.58	0.31
Slope	0.020	0.330	0.020	0.330
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.025	0.025	0.025	0.025
Velocity at Flow Depth (ft/s)	5.38	14.22	5.87	15.68
Flow at Flow Depth (cfs)	17.0	17.0	23.0	23.1
Required Capacity (cfs)	17.0	17.0	23.0	23.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A
Total Depth Required (ft)	1.71	1.33	0.84	0.39
Actual Depth (ft)	1.75	1.50	1.00	0.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	5.38	14.22	5.87	15.68
Shear Stress at Flow Depth (lb /sf)	1.07	8.08	1.25	9.61
Max. Allowable Shear Stress (lb/sf)	11.00	11.00	11.00	11.00
Froude Number	1.29	4.76	1.32	4.87

1A-4				
	25-Year	25-Year	100-Year	100-Year
Channel	1A-4	1A-4	1A-4	1A-4
Condition	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	9.5	7.5	5.5	4.5
Channel Width at Flow Depth (ft)	4.58	3.444	4.948	3.624
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	2.5	2.5	2.5	2.5
Flow Depth (ft)	0.52	0.236	0.612	0.281
Bottom Width:Depth (12:1 max)	4.8	10.6	4.1	8.9
Area (square feet)	1.8	0.7	2.3	0.9
Wetted Perimeter (ft)	4.8	3.6	5.2	3.8
Hydraulic Radius (ft)	0.38	0.20	0.44	0.23
Slope	0.020	0.330	0.020	0.330
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	9.24	24.17	10.08	26.70
Flow at Flow Depth (cfs)	17.0	17.0	23.0	23.0
Required Capacity (cfs)	17.0	17.0	23.0	23.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A
Total Depth Required (ft)	1.52	1.24	0.61	0.28
Actual Depth (ft)	1.75	1.25	0.75	0.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	9.24	24.17	10.08	26.70
Shear Stress at Flow Depth (lb /sf)	0.65	4.86	0.76	5.79
Max. Allowable Shear Stress (lb/sf)	N/A	N/A	N/A	N/A
Froude Number	2.57	9.44	2.62	9.66

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1A-5					
	25-Year	25-Year		100-Year	100-Year
Channel	1A-5	1A-5		1A-5	1A-5
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	3" USM	3" USM		3" USM	3" USM
Channel Top Width (ft)	10	9		7	5
Channel Width at Flow Depth (ft)	5.636	4.5		6.144	4.868
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	2	2		2	2
Flow Depth (ft)	0.909	0.625		1.036	0.717
Bottom Width:Depth (12:1 max)	2.2	3.2		1.9	2.8
Area (square feet)	3.5	2.0		4.2	2.5
Wetted Perimeter (ft)	6.1	4.8		6.6	5.2
Hydraulic Radius (ft)	0.57	0.42		0.64	0.47
Slope	0.023	0.100		0.023	0.100
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.015	0.015		0.015	0.015
Velocity at Flow Depth (ft/s)	10.38	17.72		11.14	19.07
Flow at Flow Depth (cfs)	36.0	36.0		47.0	46.9
Required Capacity (cfs)	36.0	36.0		47.0	47.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	1.91	1.63		1.04	0.72
Actual Depth (ft)	2.00	1.75		1.25	0.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	10.38	17.72		11.14	19.07
Shear Stress at Flow Depth (lb /sf)	1.57	4.68		1.78	5.37
Max. Allowable Shear Stress (lb/sf)	14.00	14.00		14.00	14.00
Froude Number	2.33	4.65		2.37	4.72

1A-5					
	25-Year	25-Year		100-Year	100-Year
Channel	1A-5	1A-5		1A-5	1A-5
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	Concrete	Concrete		Concrete	Concrete
Channel Top Width (ft)	10	9		6	5
Channel Width at Flow Depth (ft)	5.252	4.224		5.712	4.556
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	2	2		2	2
Flow Depth (ft)	0.813	0.556		0.928	0.639
Bottom Width:Depth (12:1 max)	2.5	3.6		2.2	3.1
Area (square feet)	2.9	1.7		3.6	2.1
Wetted Perimeter (ft)	5.6	4.5		6.2	4.9
Hydraulic Radius (ft)	0.52	0.39		0.58	0.43
Slope	0.023	0.100		0.023	0.100
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.012	0.012		0.012	0.012
Velocity at Flow Depth (ft/s)	12.22	20.80		13.12	22.41
Flow at Flow Depth (cfs)	36.0	36.0		47.0	46.9
Required Capacity (cfs)	36.0	36.0		47.0	47.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	1.81	1.56		0.93	0.64
Actual Depth (ft)	2.00	1.75		1.00	0.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	12.22	20.80		13.12	22.41
Shear Stress at Flow Depth (lb /sf)	1.17	3.47		1.33	3.99
Max. Allowable Shear Stress (lb/sf)	N/A	N/A		N/A	N/A
Froude Number	2.88	5.73		2.92	5.82

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East Perimeter B				
	25-Year	100-Year	25-Year	100-Year
Channel	E.P. B	E.P. B	E.P. B	E.P. B
Condition	Constant Slope	Constant Slope	Constant Slope	Constant Slope
Protective Lining	2.2" FPM	2.2" FPM	Concrete	Concrete
Channel Top Width (ft)	16.5	13.5	13.5	10.5
Channel Width at Flow Depth (ft)	12.172	13.28	9.28	10.12
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	4.5	4.5	3.5	3.5
Flow Depth (ft)	1.918	2.195	1.445	1.655
Bottom Width:Depth (12:1 max)	2.3	2.1	2.4	2.1
Area (square feet)	16.0	19.5	9.2	11.3
Wetted Perimeter (ft)	13.1	14.3	10.0	10.9
Hydraulic Radius (ft)	1.22	1.36	0.93	1.03
Slope	0.010	0.010	0.010	0.010
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.025	0.025	0.012	0.012
Velocity at Flow Depth (ft/s)	6.81	7.33	11.80	12.70
Flow at Flow Depth (cfs)	109.0	143.0	109.0	143.1
Required Capacity (cfs)	109.0	143.0	109.0	143.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A
Total Depth Required (ft)	2.92	2.20	2.45	1.66
Actual Depth (ft)	3.00	2.25	2.50	1.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	6.81	7.33	11.80	12.70
Shear Stress at Flow Depth (lb /sf)	1.44	1.64	0.90	1.03
Max. Allowable Shear Stress (lb/sf)	11.00	11.00	N/A	N/A
Froude Number	1.05	1.07	2.09	2.12

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1B-2					
	25-Year	25-Year		100-Year	100-Year
Channel	1B-1	1B-1		1B-1	1B-1
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	3" USM	3" USM		3" USM	3" USM
Channel Top Width (ft)	9	8		6	4
Channel Width at Flow Depth (ft)	4.796	3.32		5.964	3.928
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	2	2		2	2
Flow Depth (ft)	0.699	0.33		0.991	0.482
Bottom Width:Depth (12:1 max)	2.9	6.1		2.0	4.1
Area (square feet)	2.4	0.9		3.9	1.4
Wetted Perimeter (ft)	5.1	3.5		6.4	4.2
Hydraulic Radius (ft)	0.46	0.25		0.61	0.34
Slope	0.020	0.330		0.020	0.330
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.015	0.015		0.015	0.015
Velocity at Flow Depth (ft/s)	8.41	22.80		10.14	28.00
Flow at Flow Depth (cfs)	20.0	20.0		40.0	40.0
Required Capacity (cfs)	20.0	20.0		40.0	40.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	1.70	1.33		0.99	0.48
Actual Depth (ft)	1.75	1.50		1.00	0.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	8.41	22.80		10.14	28.00
Shear Stress at Flow Depth (lb /sf)	1.05	8.15		1.48	11.91
Max. Allowable Shear Stress (lb/sf)	14.00	14.00		14.00	14.00
Froude Number	2.11	7.81		2.20	8.18

1B-2					
	25-Year	25-Year		100-Year	100-Year
Channel	1B-1	1B-1		1B-1	1B-1
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	Concrete	Concrete		Concrete	Concrete
Channel Top Width (ft)	9	8		6	4
Channel Width at Flow Depth (ft)	4.492	3.164		5.548	3.708
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	2	2		2	2
Flow Depth (ft)	0.623	0.291		0.887	0.427
Bottom Width:Depth (12:1 max)	3.2	6.9		2.3	4.7
Area (square feet)	2.0	0.8		3.3	1.2
Wetted Perimeter (ft)	4.8	3.3		6.0	3.9
Hydraulic Radius (ft)	0.42	0.23		0.56	0.31
Slope	0.020	0.330		0.020	0.330
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.012	0.012		0.012	0.012
Velocity at Flow Depth (ft/s)	9.89	26.59		11.94	32.79
Flow at Flow Depth (cfs)	20.0	20.0		40.0	40.0
Required Capacity (cfs)	20.0	20.0		40.0	40.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	1.62	1.29		0.89	0.43
Actual Depth (ft)	1.75	1.50		1.00	0.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	9.89	26.59		11.94	32.79
Shear Stress at Flow Depth (lb /sf)	0.78	5.99		1.11	8.79
Max. Allowable Shear Stress (lb/sf)	N/A	N/A		N/A	N/A
Froude Number	2.60	9.62		2.71	10.08

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West Perimeter C				
	25-Year	100-Year	25-Year	100-Year
Channel	W.P. C	W.P. C	W.P. C	W.P. C
Condition	Const. Slope	Const. Slope	Const. Slope	Const. Slope
Protective Lining	6" FPM	6" FPM	Concrete	Concrete
Channel Top Width (ft)	15	12	12	9
Channel Width at Flow Depth (ft)	10.8288	11.652	7.65	8.28
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	5	5	3	3
Flow Depth (ft)	1.457	1.663	1.163	1.32
Bottom Width:Depth (12:1 max)	3.4	3.0	2.6	2.3
Area (square feet)	11.5	13.8	6.2	7.4
Wetted Perimeter (ft)	11.5	12.4	8.2	8.9
Hydraulic Radius (ft)	1.00	1.11	0.76	0.84
Slope	0.200	0.200	0.200	0.200
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.027	0.027	0.012	0.012
Velocity at Flow Depth (ft/s)	24.70	26.51	46.04	49.29
Flow at Flow Depth (cfs)	284.9	367.1	285.0	366.9
Required Capacity (cfs)	285.0	367.0	285.0	367.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A
Total Depth Required (ft)	2.46	1.66	2.16	1.32
Actual Depth (ft)	2.50	1.75	2.25	1.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	24.70	26.51	46.04	49.29
Shear Stress at Flow Depth (lb /sf)	21.82	24.91	14.51	16.47
Max. Allowable Shear Stress (lb/sf)	30.00	30.00	N/A	N/A
Froude Number	4.22	4.29	9.02	9.16

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East Perimeter C					
	25-Year	25-Year		100-Year	100-Year
Channel	E.P. C	E.P. C		E.P. C	E.P. C
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	4" FPM	4" FPM		4" FPM	4" FPM
Channel Top Width (ft)	17.5	16.5		14.5	12.5
Channel Width at Flow Depth (ft)	13.204	11.568		14.324	12.476
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	5.5	5.5		5.5	5.5
Flow Depth (ft)	1.926	1.517		2.206	1.744
Bottom Width:Depth (12:1 max)	2.9	3.6		2.5	3.2
Area (square feet)	18.0	12.9		21.9	15.7
Wetted Perimeter (ft)	14.1	12.3		15.4	13.3
Hydraulic Radius (ft)	1.28	1.05		1.42	1.18
Slope	0.040	0.100		0.040	0.100
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.026	0.026		0.026	0.026
Velocity at Flow Depth (ft/s)	13.49	18.77		14.50	20.22
Flow at Flow Depth (cfs)	242.9	243.0		317.1	317.0
Required Capacity (cfs)	243.0	243.0		317.0	317.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	2.93	2.52		2.21	1.74
Actual Depth (ft)	3.00	2.75		2.25	1.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	13.49	18.77		14.50	20.22
Shear Stress at Flow Depth (lb /sf)	5.77	11.36		6.61	13.06
Max. Allowable Shear Stress (lb/sf)	20.00	20.00		20.00	20.00
Froude Number	2.03	3.13		2.07	3.18

East Perimeter C					
	25-Year	25-Year		100-Year	100-Year
Channel	E.P. C	E.P. C		E.P. C	E.P. C
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	Concrete	Concrete		Concrete	Concrete
Channel Top Width (ft)	14	13		11	10
Channel Width at Flow Depth (ft)	9.828	8.596		10.668	9.2768
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	4	4		4	4
Flow Depth (ft)	1.457	1.149		1.667	1.3192
Bottom Width:Depth (12:1 max)	2.7	3.5		2.4	3.0
Area (square feet)	10.1	7.2		12.2	8.8
Wetted Perimeter (ft)	10.5	9.1		11.5	9.9
Hydraulic Radius (ft)	0.96	0.79		1.07	0.88
Slope	0.040	0.100		0.040	0.100
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.012	0.012		0.012	0.012
Velocity at Flow Depth (ft/s)	24.13	33.61		25.94	36.18
Flow at Flow Depth (cfs)	243.1	243.2		317.1	316.9
Required Capacity (cfs)	243.0	243.0		317.0	317.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	2.46	2.15		1.67	1.32
Actual Depth (ft)	2.50	2.25		1.75	1.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	24.13	33.61		25.94	36.18
Shear Stress at Flow Depth (lb /sf)	3.64	7.17		4.16	8.23
Max. Allowable Shear Stress (lb/sf)	N/A	N/A		N/A	N/A
Froude Number	4.20	6.46		4.27	6.56

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West Perimeter D					
	25-Year	25-Year		100-Year	100-Year
Channel	W.P. D	W.P. D		W.P. D	W.P. D
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	6" FPM	6" FPM		6" FPM	6" FPM
Channel Top Width (ft)	18	16		15	13
Channel Width at Flow Depth (ft)	13.796	11.14		14.964	11.9488
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	6	6		6	6
Flow Depth (ft)	1.949	1.285		2.241	1.487
Bottom Width:Depth (12:1 max)	3.1	4.7		2.7	4.0
Area (square feet)	19.3	11.0		23.5	13.3
Wetted Perimeter (ft)	14.7	11.7		16.0	12.7
Hydraulic Radius (ft)	1.31	0.94		1.47	1.05
Slope	0.050	0.240		0.050	0.240
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.027	0.027		0.027	0.027
Velocity at Flow Depth (ft/s)	14.78	25.90		15.93	28.02
Flow at Flow Depth (cfs)	285.1	285.2		374.1	373.9
Required Capacity (cfs)	285.0	285.0		374.0	374.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	2.95	2.29		2.24	1.49
Actual Depth (ft)	3.00	2.50		2.25	1.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	14.78	25.90		15.93	28.02
Shear Stress at Flow Depth (lb /sf)	7.30	23.09		8.39	26.73
Max. Allowable Shear Stress (lb/sf)	30.00	30.00		30.00	30.00
Froude Number	2.20	4.59		2.24	4.67

West Perimeter D					
	25-Year	25-Year		100-Year	100-Year
Channel	W.P. D	W.P. D		W.P. D	W.P. D
Condition	Min Slope	Max Slope		Min Slope	Max Slope
Protective Lining	Concrete	Concrete		Concrete	Concrete
Channel Top Width (ft)	14	12		11	9
Channel Width at Flow Depth (ft)	9.972	7.964		10.85	8.58
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	4	4		4	4
Flow Depth (ft)	1.493	0.991		1.713	1.145
Bottom Width:Depth (12:1 max)	2.7	4.0		2.3	3.5
Area (square feet)	10.4	5.9		12.7	7.2
Wetted Perimeter (ft)	10.7	8.4		11.7	9.1
Hydraulic Radius (ft)	0.98	0.70		1.09	0.79
Slope	0.050	0.240		0.050	0.240
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.012	0.012		0.012	0.012
Velocity at Flow Depth (ft/s)	27.33	48.10		29.42	51.97
Flow at Flow Depth (cfs)	285.1	285.1		374.1	374.3
Required Capacity (cfs)	285.0	285.0		374.0	374.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A
Total Depth Required (ft)	2.49	1.99		1.71	1.15
Actual Depth (ft)	2.50	2.00		1.75	1.25
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	27.33	48.10		29.42	51.97
Shear Stress at Flow Depth (lb /sf)	4.66	14.84		5.34	17.15
Max. Allowable Shear Stress (lb/sf)	N/A	N/A		N/A	N/A
Froude Number	4.71	9.82		4.79	10.00

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East Perimeter D									
	25-Year	25-Year	100-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D
Condition	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	6" FPM	6" FPM	6" FPM	6" FPM	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	16.5	14.5	13.5	11.5	13.5	12.5	10.5	9.5
Channel Width at Flow Depth (ft)	12.296	10.456	13.3	11.216	9.312	7.9884	10.032	8.532
Channel Side Slopes (H:V)	2	2	2	2	2	2	2	2
Channel Bottom Width (ft)	5.5	5.5	5.5	5.5	4.5	4.5	4.5	4.5
Flow Depth (ft)	1.699	1.239	1.95	1.429	1.203	0.872	1.383	1.008
Bottom Width:Depth (12:1 max)	3.2	4.4	2.8	3.8	3.7	5.2	3.3	4.5
Area (square feet)	15.1	9.9	18.3	11.9	8.3	5.4	10.0	6.6
Wetted Perimeter (ft)	13.1	11.0	14.2	11.9	9.9	8.4	10.7	9.0
Hydraulic Radius (ft)	1.15	0.90	1.29	1.00	0.84	0.65	0.94	0.73
Slope	0.070	0.230	0.070	0.230	0.070	0.230	0.070	0.230
Vegetative Lining Retardance	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manning's n	0.027	0.027	0.027	0.027	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	16.07	24.58	17.29	26.54	29.27	44.60	31.53	48.24
Flow at Flow Depth (cfs)	242.9	243.0	317.0	317.0	243.1	242.9	316.9	316.9
Required Capacity (cfs)	243.0	243.0	317.0	317.0	243.0	243.0	317.0	317.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.70	2.24	1.95	1.43	2.20	1.87	1.38	1.01
Actual Depth (ft)	2.75	2.25	2.00	1.50	2.25	2.00	1.50	1.25
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	16.07	24.58	17.29	26.54	29.27	44.60	31.53	48.24
Shear Stress at Flow Depth (lb /sf)	8.91	21.34	10.22	24.61	5.25	12.52	6.04	14.47
Max. Allowable Shear Stress (lb/sf)	30.00	30.00	30.00	30.00	N/A	N/A	N/A	N/A
Froude Number	2.55	4.46	2.60	4.53	5.46	9.52	5.55	9.69

East Perimeter D								
	25-Year	25-Year	100-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D	E.P. D
Condition	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	6" FPM	6" FPM	6" FPM	6" FPM	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	12.5	11.5	11	10	10	9.5	8.5	7.5
Channel Width at Flow Depth (ft)	10.338	9.354	10.892	9.754	7.878	7.1746	8.276	7.46
Channel Side Slopes (H:V)	1	1	1	1	1	1	1	1
Channel Bottom Width (ft)	7	7	7	7	5.5	5.5	5.5	5.5
Flow Depth (ft)	1.669	1.177	1.95	1.377	1.189	0.837	1.388	0.98
Bottom Width:Depth (12:1 max)	4.2	5.9	3.6	5.1	4.6	6.6	4.0	5.6
Area (square feet)	14.5	9.6	17.4	11.5	8.0	5.3	9.6	6.4
Wetted Perimeter (ft)	11.7	10.3	12.5	10.9	8.9	7.9	9.4	8.3
Hydraulic Radius (ft)	1.23	0.93	1.39	1.06	0.90	0.67	1.01	0.77
Slope	0.070	0.230	0.070	0.230	0.070	0.230	0.070	0.230
Vegetative Lining Retardance	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manning's n	0.027	0.027	0.027	0.027	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	16.80	25.25	18.20	27.49	30.56	45.79	33.16	49.93
Flow at Flow Depth (cfs)	243.1	243.0	316.9	317.1	243.1	243.0	317.1	317.1
Required Capacity (cfs)	243.0	243.0	317.0	317.0	243.0	243.0	317.0	317.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.67	2.18	1.95	1.38	2.19	1.84	1.39	0.98
Actual Depth (ft)	2.75	2.25	2.00	1.50	2.25	2.00	1.50	1.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	16.80	25.25	18.20	27.49	30.56	45.79	33.16	49.93
Shear Stress at Flow Depth (lb /sf)	8.75	20.27	10.20	23.72	5.19	12.02	6.06	14.06
Max. Allowable Shear Stress (lb/sf)	30.00	30.00	30.00	30.00	N/A	N/A	N/A	N/A
Froude Number	2.50	4.39	2.54	4.46	5.36	9.38	5.44	9.54

Note: East Perimeter D was analyzed using 1H:1V side slopes to account for the modification of the channel to enter Drop Box 3.

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S2-2								
	25-Year	25-Year	100-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	S2-2	S2-2	S2-2	S2-2	S2-2	S2-2	S2-2	S2-2
Condition	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	4" USM	4" USM	4" USM	4" USM	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	20	18	18	15	19	14	16	14
Channel Width at Flow Depth (ft)	15.888	13.824	17.044	14.768	14.832	12.964	15.88	13.816
Channel Side Slopes (H:V)	2	2	2	2	2	2	2	2
Channel Bottom Width (ft)	6	6	6	6	6	6	6	6
Flow Depth (ft)	2.472	1.956	2.761	2.192	2.208	1.741	2.47	1.954
Bottom Width:Depth (12:1 max)	2.4	3.1	2.2	2.7	2.7	3.4	2.4	3.1
Area (square feet)	27.1	19.4	31.8	22.8	23.0	16.5	27.0	19.4
Wetted Perimeter (ft)	17.1	14.7	18.3	15.8	15.9	13.8	17.0	14.7
Hydraulic Radius (ft)	1.59	1.31	1.73	1.44	1.45	1.20	1.59	1.31
Slope	0.040	0.100	0.040	0.100	0.040	0.100	0.040	0.100
Vegetative Lining Retardance	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015	0.015	0.015	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	27.02	37.70	28.67	40.06	31.80	44.28	33.76	47.10
Flow at Flow Depth (cfs)	731.0	730.9	912.1	911.9	731.3	730.9	912.3	911.8
Required Capacity (cfs)	731.0	731.0	912.0	912.0	731.0	731.0	912.0	912.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	3.47	2.96	2.76	2.19	3.21	2.74	2.47	1.95
Actual Depth (ft)	3.50	3.00	3.00	2.25	3.25	2.00	2.50	2.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	27.02	37.70	28.67	40.06	31.80	44.28	33.76	47.10
Shear Stress at Flow Depth (lb /sf)	7.40	14.65	8.27	16.41	5.51	10.86	6.17	12.19
Max. Allowable Shear Stress (lb/sf)	18.00	18.00	18.00	18.00	N/A	N/A	N/A	N/A
Froude Number	3.65	5.61	3.70	5.69	4.50	6.91	4.56	7.01

S2-2								
	25-Year	25-Year	100-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	S2-2	S2-2	S2-2	S2-2	S2-2	S2-2	S2-2	S2-2
Condition	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	4" USM	4" USM	4" USM	4" USM	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	15	14	14	12.5	14	13	13	11.5
Channel Width at Flow Depth (ft)	12.909	11.768	13.568	12.284	11.97	10.929	12.57	11.4
Channel Side Slopes (H:V)	1	1	1	1	1	1	1	1
Channel Bottom Width (ft)	8	8	8	8	7.5	7.5	7.5	7.5
Flow Depth (ft)	2.455	1.884	2.784	2.142	2.235	1.715	2.535	1.95
Bottom Width:Depth (12:1 max)	3.3	4.2	2.9	3.7	3.4	4.4	3.0	3.8
Area (square feet)	25.7	18.6	30.0	21.7	21.8	15.8	25.4	18.4
Wetted Perimeter (ft)	14.9	13.3	15.9	14.1	13.8	12.3	14.7	13.0
Hydraulic Radius (ft)	1.72	1.40	1.89	1.55	1.57	1.28	1.73	1.42
Slope	0.040	0.100	0.040	0.100	0.040	0.100	0.040	0.100
Vegetative Lining Retardance	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015	0.015	0.015	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	28.49	39.26	30.38	41.99	33.61	46.27	35.84	49.51
Flow at Flow Depth (cfs)	731.1	731.0	912.2	912.1	731.2	731.0	911.8	912.3
Required Capacity (cfs)	731.0	731.0	912.0	912.0	731.0	731.0	912.0	912.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	3.45	2.88	2.78	2.14	3.24	2.71	2.54	1.95
Actual Depth (ft)	3.50	3.00	3.00	2.25	3.25	2.75	2.75	2.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	28.49	39.26	30.38	41.99	33.61	46.27	35.84	49.51
Shear Stress at Flow Depth (lb /sf)	7.35	14.11	8.34	16.04	5.58	10.70	6.33	12.17
Max. Allowable Shear Stress (lb/sf)	18.00	18.00	18.00	18.00	N/A	N/A	N/A	N/A
Froude Number	3.56	5.50	3.60	5.56	4.39	6.78	4.44	6.86

Note: S2-2 was analyzed using 1H:1V side slopes to account for the modification of the channel to enter Drop Box 6.

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S2-3					
	25-Year	100-Year		25-Year	100-Year
Channel	S2-3	S2-3		S2-3	S2-3
Condition	Const. Slope	Const. Slope		Const. Slope	Const. Slope
Protective Lining	2.2" FPM	2.2" FPM		Concrete	Concrete
Channel Top Width (ft)	20	18		16.5	13.5
Channel Width at Flow Depth (ft)	15.864	17.308		12.324	13.396
Channel Side Slopes (H:V)	2	2		2	2
Channel Bottom Width (ft)	5	5		4.5	4.5
Flow Depth (ft)	2.716	3.077		1.956	2.224
Bottom Width:Depth (12:1 max)	1.8	1.6		2.3	2.0
Area (square feet)	28.3	34.3		16.5	19.9
Wetted Perimeter (ft)	17.1	18.8		13.2	14.4
Hydraulic Radius (ft)	1.65	1.83		1.24	1.38
Slope	0.010	0.010		0.010	0.010
Vegetative Lining Retardance	N/A	N/A		N/A	N/A
Manning's n	0.025	0.025		0.012	0.012
Velocity at Flow Depth (ft/s)	8.33	8.91		14.35	15.37
Flow at Flow Depth (cfs)	236.0	306.0		236.1	305.9
Required Capacity (cfs)	236.0	306.0		236.0	306.0
Minimum Required Freeboard (ft)	1.00	N/A		1.00	N/A
Total Depth Required (ft)	3.72	3.08		2.96	2.22
Actual Depth (ft)	3.75	3.25		3.00	2.25
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A
Actual Velocity (ft/s)	8.33	8.91		14.35	15.37
Shear Stress at Flow Depth (lb /sf)	2.03	2.30		1.22	1.39
Max. Allowable Shear Stress (lb/sf)	11.00	11.00		N/A	N/A
Froude Number	1.10	1.12		2.19	2.22

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S2-4		
	25-Year	100-Year
Channel	S2-4	S2-4
Condition	Const. Slope	Const. Slope
Protective Lining	Concrete	Concrete
Channel Top Width (ft)	10	7.5
Channel Width at Flow Depth (ft)	6.88	7.308
Channel Side Slopes (H:V)	1	1
Channel Bottom Width (ft)	3	3
Flow Depth (ft)	1.94	2.154
Bottom Width:Depth (12:1 max)	1.5	1.4
Area (square feet)	9.6	11.1
Wetted Perimeter (ft)	8.5	9.1
Hydraulic Radius (ft)	1.13	1.22
Slope	0.040	0.040
Vegetative Lining Retardance	N/A	N/A
Manning's n	0.012	0.012
Velocity at Flow Depth (ft/s)	26.93	28.37
Flow at Flow Depth (cfs)	258.1	314.9
Required Capacity (cfs)	258.0	315.0
Minimum Required Freeboard (ft)	1.00	N/A
Total Depth Required (ft)	2.94	2.15
Actual Depth (ft)	3.50	2.25
Design method for lining: Permis. Vel. Or Shear Stress	S	S
Allowable Velocity (ft/s)	N/A	N/A
Actual Velocity (ft/s)	26.93	28.37
Shear Stress at Flow Depth (lb /sf)	4.84	5.38
Max. Allowable Shear Stress (lb/sf)	N/A	N/A
Froude Number	4.02	4.06

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Final Leachate Diversion 1

	25-Year	100-Year	25-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	F.L.D. 1	F.L.D. 1	F.L.D. 1	F.L.D. 1	F.L.D. 1	F.L.D. 1	F.L.D. 1	F.L.D. 1
Condition	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope
Protective Lining	2.2" FPM	2.2" FPM	Concrete	Concrete	C350 (U)	C350 (V)	C350 (U)	C350 (V)
Channel Top Width (ft)	10	7	9	5	10.5	12.5	7.5	8.5
Channel Width at Flow Depth (ft)	5.728	6.08	4.568	4.824	6.288	7.628	6.656	8.1
Channel Side Slopes (H:V)	2	2	2	2	2	2	2	2
Channel Bottom Width (ft)	2	2	2	2	2.5	2.5	2.5	2.5
Flow Depth (ft)	0.932	1.02	0.642	0.706	0.947	1.282	1.039	1.400
Bottom Width:Depth (12:1 max)	2.1	2.0	3.1	2.8	2.6	2.0	2.4	1.8
Area (square feet)	3.6	4.1	2.1	2.4	4.2	6.5	4.8	7.4
Wetted Perimeter (ft)	6.2	6.6	4.9	5.2	6.7	8.2	7.1	8.8
Hydraulic Radius (ft)	0.58	0.63	0.43	0.47	0.62	0.79	0.67	0.85
Slope	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Vegetative Lining Retardance	N/A	N/A	N/A	N/A	C	C	C	C
Manning's n	0.025	0.025	0.012	0.012	0.03	0.055	0.03	0.055
Velocity at Flow Depth (ft/s)	4.16	4.37	7.10	7.47	3.60	2.31	3.79	2.43
Flow at Flow Depth (cfs)	15.0	18.0	15.0	18.0	15.0	15.0	18.0	18.0
Required Capacity (cfs)	15.0	18.0	15.0	18.0	15.0	15.0	18.0	18.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	1.93	1.02	1.64	0.71	1.95	2.28	1.04	1.40
Actual Depth (ft)	2.00	1.25	1.75	0.75	2.00	2.50	1.25	1.50
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A	10.50	20.00	10.50	20.00
Actual Velocity (ft/s)	4.16	4.37	7.10	7.47	3.60	2.31	3.79	2.43
Shear Stress at Flow Depth (lb /sf)	0.70	0.76	0.40	0.44	0.59	0.80	0.65	0.87
Max. Allowable Shear Stress (lb/sf)	11.00	11.00	N/A	N/A	3.00	10.00	3.00	10.00
Froude Number	0.93	0.94	1.84	1.86	0.78	0.44	0.79	0.45

Final Leachate Diversion 2

	25-Year	100-Year	25-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	F.L.D. 2	F.L.D. 2	F.L.D. 2	F.L.D. 2	F.L.D. 2	F.L.D. 2	F.L.D. 2	F.L.D. 2
Condition	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope	Const. Slope
Protective Lining	2.2" FPM	2.2" FPM	Concrete	Concrete	C350 (U)	C350 (V)	C350 (U)	C350 (V)
Channel Top Width (ft)	15	12	12	9	14	18	11	15
Channel Width at Flow Depth (ft)	10.836	11.856	7.84	8.648	9.948	13.36	10.628	14.844
Channel Side Slopes (H:V)	2	2	2	2	2	2	2	2
Channel Bottom Width (ft)	5	5	3	3	4	4	4	4
Flow Depth (ft)	1.459	1.71	1.21	1.412	1.487	2.34	1.657	2.711
Bottom Width:Depth (12:1 max)	3.4	2.9	2.5	2.1	2.7	1.7	2.4	1.5
Area (square feet)	11.6	14.4	6.6	8.2	10.4	20.3	12.1	25.5
Wetted Perimeter (ft)	11.5	12.7	8.4	9.3	10.7	14.5	11.4	16.1
Hydraulic Radius (ft)	1.00	1.14	0.78	0.88	0.97	1.40	1.06	1.58
Slope	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Vegetative Lining Retardance	N/A	N/A	N/A	N/A	C	C	C	C
Manning's n	0.025	0.025	0.012	0.012	0.022	0.055	0.02	0.055
Velocity at Flow Depth (ft/s)	5.97	6.51	10.52	11.43	6.65	3.40	7.76	3.68
Flow at Flow Depth (cfs)	69.0	94.0	69.0	94.0	69.0	69.0	94.0	94.0
Required Capacity (cfs)	69.0	94.0	69.0	94.0	69.0	69.0	94.0	94.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.46	1.71	2.21	1.41	2.49	3.34	1.66	2.71
Actual Depth (ft)	2.50	1.75	2.25	1.50	2.50	3.50	1.75	2.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A	10.50	20.00	10.50	20.00
Actual Velocity (ft/s)	5.97	6.51	10.52	11.43	6.65	3.40	7.76	3.68
Shear Stress at Flow Depth (lb /sf)	1.09	1.28	0.76	0.88	0.93	1.46	1.03	1.69
Max. Allowable Shear Stress (lb/sf)	11.00	11.00	N/A	N/A	3.00	10.00	3.00	10.00
Froude Number	1.02	1.04	2.03	2.07	1.15	0.49	1.28	0.49

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Haul Road 1A									
	25-Year	25-Year		100-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	H.R. 1A	H.R. 1A		H.R. 1A	H.R. 1A	H.R. 1A	H.R. 1A	H.R. 1A	H.R. 1A
Condition	Min Slope	Max Slope		Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	3" USM	3" USM		3" USM	3" USM	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	14	12		11	9	13.5	11.5	10.5	8.5
Channel Width at Flow Depth (ft)	9.8	7.36		10.76	8.012	9.308	7.152	10.164	7.724
Channel Side Slopes (H:V)	2	2		2	2	2	2	2	2
Channel Bottom Width (ft)	3	3		3	3	3.5	3.5	3.5	3.5
Flow Depth (ft)	1.7	1.09		1.94	1.253	1.452	0.913	1.666	1.056
Bottom Width:Depth (12:1 max)	1.8	2.8		1.5	2.4	2.4	3.8	2.1	3.3
Area (square feet)	10.9	5.6		13.3	6.9	9.3	4.9	11.4	5.9
Wetted Perimeter (ft)	10.6	7.9		11.7	8.6	10.0	7.6	11.0	8.2
Hydraulic Radius (ft)	1.03	0.72		1.14	0.80	0.93	0.64	1.04	0.72
Slope	0.010	0.060		0.010	0.060	0.010	0.060	0.010	0.060
Vegetative Lining Retardance	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015		0.015	0.015	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	10.11	19.49		10.86	21.00	11.83	22.62	12.74	24.45
Flow at Flow Depth (cfs)	110.0	110.1		144.9	144.9	110.0	110.0	145.0	144.9
Required Capacity (cfs)	110.0	110.0		145.0	145.0	110.0	110.0	145.0	145.0
Minimum Required Freeboard (ft)	1.00	1.00		N/A	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.70	2.09		1.94	1.25	2.45	1.91	1.67	1.06
Actual Depth (ft)	2.75	2.25		2.00	1.50	2.50	2.00	1.75	1.25
Design method for lining: Permis. Vel. Or Shear Stress	S	S		S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	10.11	19.49		10.86	21.00	11.83	22.62	12.74	24.45
Shear Stress at Flow Depth (lb /sf)	1.27	4.90		1.45	5.63	0.91	3.42	1.04	3.95
Max. Allowable Shear Stress (lb/sf)	14.00	14.00		14.00	14.00	N/A	N/A	N/A	N/A
Froude Number	1.69	3.92		1.72	3.99	2.09	4.83	2.12	4.92

Haul Road 1B				
	25-Year	100-Year	25-Year	100-Year
Channel	H.R. 1B	H.R. 1B	H.R. 1B	H.R. 1B
Condition	Const. Slope	Const. Slope	Const. Slope	Const. Slope
Protective Lining	3" USM	3" USM	Concrete	Concrete
Channel Top Width (ft)	15.5	12.5	15	12
Channel Width at Flow Depth (ft)	11.412	12.244	10.4328	11.204
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	4.5	4.5	4	4
Flow Depth (ft)	1.728	1.936	1.608	1.801
Bottom Width:Depth (12:1 max)	2.6	2.3	2.5	2.2
Area (square feet)	13.7	16.2	11.6	13.7
Wetted Perimeter (ft)	12.2	13.2	11.2	12.1
Hydraulic Radius (ft)	1.12	1.23	1.04	1.14
Slope	0.090	0.090	0.090	0.090
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015	0.012	0.012
Velocity at Flow Depth (ft/s)	32.22	34.24	38.16	40.55
Flow at Flow Depth (cfs)	443.0	555.0	442.9	555.2
Required Capacity (cfs)	443.0	555.0	443.0	555.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A
Total Depth Required (ft)	2.73	1.94	2.61	1.80
Actual Depth (ft)	2.75	2.00	2.75	2.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	32.22	34.24	38.16	40.55
Shear Stress at Flow Depth (lb /sf)	11.65	13.05	9.03	10.11
Max. Allowable Shear Stress (lb/sf)	14.00	14.00	N/A	N/A
Froude Number	5.17	5.24	6.38	6.46

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Haul Road 2				
	25-Year	100-Year	25-Year	100-Year
Channel	H.R. 2	H.R. 2	H.R. 2	H.R. 2
Condition	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	3" USM	3" USM	Concrete	Concrete
Channel Top Width (ft)	9.5	5.5	9.5	5.5
Channel Width at Flow Depth (ft)	4.956	4.912	4.676	4.64
Channel Side Slopes (H:V)	2	2	2	2
Channel Bottom Width (ft)	2.5	2.5	2.5	2.5
Flow Depth (ft)	0.614	0.603	0.544	0.535
Bottom Width:Depth (12:1 max)	4.1	4.1	4.6	4.7
Area (square feet)	2.3	2.2	2.0	1.9
Wetted Perimeter (ft)	5.2	5.2	4.9	4.9
Hydraulic Radius (ft)	0.44	0.43	0.40	0.39
Slope	0.060	0.100	0.060	0.100
Vegetative Lining Retardance	N/A	N/A	N/A	N/A
Manning's n	0.015	0.015	0.012	0.012
Velocity at Flow Depth (ft/s)	14.00	17.90	16.39	20.97
Flow at Flow Depth (cfs)	32.0	40.0	32.0	40.1
Required Capacity (cfs)	32.0	40.0	32.0	40.0
Minimum Required Freeboard (ft)	1.00	N/A	1.00	N/A
Total Depth Required (ft)	1.61	0.60	1.54	0.54
Actual Depth (ft)	1.75	0.75	1.75	0.75
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	14.00	17.90	16.39	20.97
Shear Stress at Flow Depth (lb /sf)	2.76	4.52	2.04	3.34
Max. Allowable Shear Stress (lb/sf)	14.00	14.00	N/A	N/A
Froude Number	3.63	4.68	4.47	5.76

West Perimeter B								
	25-Year	25-Year	100-Year	100-Year	25-Year	25-Year	100-Year	100-Year
Channel	W.P. B	W.P. B	W.P. B	W.P. B	W.P. B	W.P. B	W.P. B	W.P. B
Condition	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope	Min Slope	Max Slope
Protective Lining	4" FPM	4" FPM	4" FPM	4" FPM	Concrete	Concrete	Concrete	Concrete
Channel Top Width (ft)	17.5	13.5	14.5	10.5	14	11	11	8
Channel Width at Flow Depth (ft)	13.188	9.116	14.42	9.748	9.816	6.744	10.74	7.2208
Channel Side Slopes (H:V)	2	2	2	2	2	2	2	2
Channel Bottom Width (ft)	5.5	5.5	5.5	5.5	4	4	4	4
Flow Depth (ft)	1.922	0.904	2.23	1.062	1.454	0.686	1.685	0.805
Bottom Width:Depth (12:1 max)	2.9	6.1	2.5	5.2	2.8	5.8	2.4	5.0
Area (square feet)	18.0	6.6	22.2	8.1	10.0	3.7	12.4	4.5
Wetted Perimeter (ft)	14.1	9.5	15.5	10.2	10.5	7.1	11.5	7.6
Hydraulic Radius (ft)	1.27	0.69	1.44	0.79	0.96	0.52	1.08	0.59
Slope	0.010	0.167	0.010	0.167	0.010	0.167	0.010	0.167
Vegetative Lining Retardance	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manning's n	0.026	0.026	0.026	0.026	0.012	0.012	0.012	0.012
Velocity at Flow Depth (ft/s)	6.74	18.31	7.29	19.99	12.05	32.84	13.04	35.83
Flow at Flow Depth (cfs)	121.0	121.0	162.0	161.9	121.1	121.0	162.0	161.9
Required Capacity (cfs)	121.0	121.0	162.0	162.0	121.0	121.0	162.0	162.0
Minimum Required Freeboard (ft)	1.00	1.00	N/A	N/A	1.00	1.00	N/A	N/A
Total Depth Required (ft)	2.92	1.90	2.23	1.06	2.45	1.69	1.69	0.81
Actual Depth (ft)	3.00	2.00	2.25	1.25	2.50	1.75	1.75	1.00
Design method for lining: Permis. Vel. Or Shear Stress	S	S	S	S	S	S	S	S
Allowable Velocity (ft/s)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Actual Velocity (ft/s)	6.74	18.31	7.29	19.99	12.05	32.84	13.04	35.83
Shear Stress at Flow Depth (lb /sf)	1.44	11.28	1.67	13.25	0.91	7.13	1.05	8.37
Max. Allowable Shear Stress (lb/sf)	20.00	20.00	20.00	20.00	N/A	N/A	N/A	N/A
Froude Number	1.02	3.79	1.04	3.87	2.10	7.83	2.14	7.98

SUBJECT CURLEY HOLLOW SWMF

GABION CHANNEL DESIGN

BY KMB *REV KMB2* DATE 3/24/08 *REV* 4/12/13 PROJ. NO. C060702.52

CHKD. BY KMB DATE 4/1/13 SHEET NO. 1 OF 6

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INTRODUCTION

Gabion channels will be used at one location within the Curley Hollow Solid Waste Facility. This calculation will evaluate required size of the channel and the rock size and filter needed to convey the desired flow.

CHANNEL LOCATIONS

The gabion channel will be used at the following location:

- Channel carrying the combined flows from the Sedimentation Pond and Final Leachate Pond emergency spillways, as well as the flow from Channel Leachate Diversion 1. Sedimentation Pond phasing analyses show the peak 100-year discharge to be 827 cfs, the Final Lechate Pond 100-year peak discharge is 0 cfs, and Leachate Diversion 1 100-yr peak discharge is 18 cfs. The combined flow will be 845 cfs.

The channel is minimally sloped (1% for the combined spillway channel). Gabions are being utilized to contain flows within a rectangular cross section, minimizing the space required for a channel given the limited space available at these locations.

DESIGN METHODOLOGY

Design will follow procedures included in “Maccaferri Gabions Channeling Works”.

Manning’s roughness coefficient for gabion linings is presented in Table 5 of the Maccaferri documents. From the table (see next page):

use Manning’s n = 0.0222

SUBJECT CURLEY HOLLOW SWMF

GABION CHANNEL DESIGN

BY KMB *REV KMB2* DATE 3/24/08 *REV* 4/12/13 PROJ. NO. C060702.52

CHKD. BY KMB DATE 4/1/13 SHEET NO. 2 OF 6

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Design Methodology continued

***Tab. 5** - Roughness coefficients* ***Tab. 5** - Coefficients de rugosité* ***Tab. 5** - Coeficiente de rugosidad*

Type Type Tipo	Bank characteristics Nature des berges Naturaleza de las paredes	γ ($m^{1/2}$)	c ($m^{1/3}/s$)	n ($s/m^{1/3}$)
1	Lined with Reno mattresses and gabions sealed up to saturation point with sand asphalt mastic, taking special care to obtain a levelled and smooth surface when pouring. *Canaux revêtus en matelas Reno parfaitement colmatés à l'aide du mastic de bitume hydraulique afin d'obtenir une surface plane et lisse.* Canales revestidos en colchones Reno sellados perfectemente hasta rechazo con almáciga bituminosa hidráulica al fin de obtener una superficie plana y bien lisa.	0.36	63	0.0158
2	Lined with Reno mattresses filled with carefully sorted stones and then positioned very carefully. *Canaux revêtus en matelas Reno remplis avec matériaux de sélection et mise en oeuvre soignée.* Canales revestidos en colchones Reno rellenados con material bien seleccionado y puestos en obra con mucho cuidado.	1.00	45	0.0222
3	Unlined - badly maintained: dense growth on bed and banks or irregular deposit of boulders or gravel, or deep and irregular areas of erosion. Also earth lined, excavated by machine and not maintained. *Canaux en terre en mauvaises conditions d'entretien; végétation au fond et sur les berges ou dépôts irréguliers de pierres et gravier ou profondes érosions. Même canaux en terre creusés avec engins mécaniques et entretien négligé.* Canales en tierra en malas condiciones de mantenimiento: presencia de vegetación en el fondo y las en orillas, o depósitos irregulares de piedras y de grava, o profundas erosiones irregulares. Canales en tierra realizados con excavadores y sin mantenimiento.	1.75	33	0.0303

VDOT specifications (section 610) will be used for the gabion size and rock filling.

SUBJECT CURLEY HOLLOW SWMF

GABION CHANNEL DESIGN

BY KMB *REV KMB2* DATE 3/24/08 *REV* 4/12/13 PROJ. NO. C060702.52

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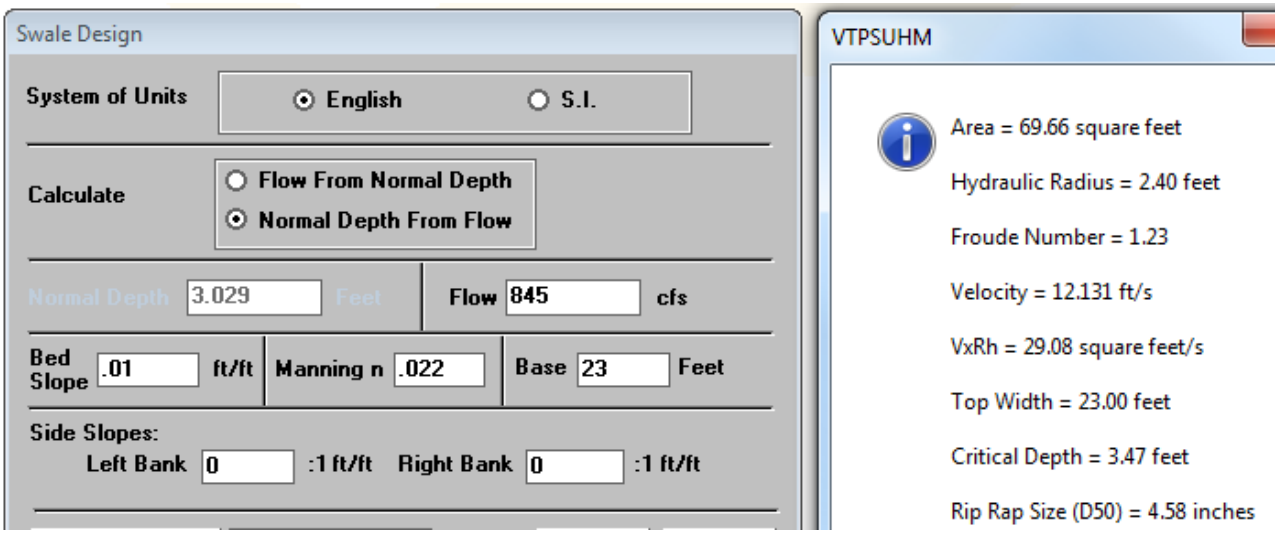
COMBINED SPILLWAY CHANNEL DESIGN

The combined spillway channel will be sized to maintain a rectangular channel with a 3.6-foot depth at a 1% slope. Design flow = 892 cfs

The computer program VT-PSUHM will be used to estimate flow depth.



STRUCTURAL DESIGN

Use the VDOT specification 610 for gabion basket size. From the specification, baskets shall have a uniform horizontal width of 36 inches. Determine average rock sizes for use in filter design:

- Min. size = 4 pounds

  2.6 specific gravity - rock
  62.4 pounds per cubic foot - water
  162.24 pounds per cubic foot - rock

  4 pounds
  Calculate the volume of a blocky rock at given rock unit weight:
  Assume width = height = d; length = 2d
  0.0247 cubic feet
  42.6 cubic inches
  2.77 = d = standard dimension of rock

- Max. size = 30 pounds

  2.6 specific gravity - rock
  62.4 pounds per cubic foot - water
  162.24 pounds per cubic foot - rock

  30 pounds
  Calculate the volume of a blocky rock at given rock unit weight:
  Assume width = height = d; length = 2d
  0.1849 cubic feet
  319.5 cubic inches
  5.43 = d = standard dimension of rock

- Median size = 10 pounds

  2.6 specific gravity - rock
  62.4 pounds per cubic foot - water
  162.24 pounds per cubic foot - rock

  10 pounds
  Calculate the volume of a blocky rock at given rock unit weight:
  Assume width = height = d; length = 2d
  0.0616 cubic feet
  106.5 cubic inches
  3.76 = d = standard dimension of rock

SUBJECT CURLEY HOLLOW SWMF

GABION CHANNEL DESIGN

BY KMB *REV KMB2* DATE 3/24/08 *REV* 4/12/13 PROJ. NO. C060702.52

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Structural Design continued

Use the combined spillway channel to design the filter based on the above rock dimensions.

Calculate the "residual velocity on the bed", v_b, which is the velocity at the mattress/filter interface.

$$v_b = \frac{1}{n}\left(\frac{d_m}{2}\right)^{\frac{2}{3}} i^{\frac{1}{2}}$$ (Maccaferri Manual, pages 32 and 35)

where v_b= residual velocity in m/s
n = Manning's roughness at the interface; n = 0.02 for soil, 0.025 for gravel filter
d_m = average diameter of rock in mm = 95.5 (3.76 inches)
i = average bed gradient = 0.01 max

v_b= residual velocity in m/s		
n =	0.025	
d_m = average diameter of rock in m =	0.0955	(3.76 inches)
i = average bed gradient =	0.01	max

v_b=	0.5 m/s	1.73 ft/s

SUBJECT CURLEY HOLLOW SWMF

GABION CHANNEL DESIGN

BY KMB *REV KMB2* DATE 3/24/08 *REV* 4/12/13 PROJ. NO. C060702.52

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Structural Design continued

From an assessment of the gabion rock size and standard Virginia aggregate designations, a Virginia #357 coarse aggregate can be considered applicable as a filter (maximum aggregate size is equivalent to the minimum gabion rock size):

TABLE II-3
Sizes of Open-Graded Coarse Aggregates

Va. Size	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Weight)													
No.	4 in.	3 1/2 in.	3 in.	2 1/2 in.	2 in.	1 1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 100
1	Min. 100	90–100		25–60		Max. 15		Max. 5							
2			Min. 100	90–100	35–70	Max. 15		Max. 5							
3				Min. 100	90–100	35–70	0–15		Max. 5						
357				Min. 100	95–100		35–70		10–30		Max. 5				
5						Min. 100	90–100	20–55	Max. 10	Max. 5					
56						Min. 100	90–100	40–85	10–40	Max. 15	Max. 5				
57						Min. 100	95–100		25–60		Max. 10	Max. 5			
67							Min. 100	90–100		20–55	Max. 10	Max. 5			
68							Min. 100	90–100		30–65	5–25	Max. 10	Max. 5		
7								Min. 100	90–100	40–70	Max. 15	Max. 5			
78								Min. 100	90–100	40–75	5–25	Max. 10	Max. 5		
8									Min. 100	85–100	10–30	Max. 10	Max. 5		
8P									Min. 100	75–100	5–30	Max. 5			
9										Min. 100	85–100	10–40	Max. 10	Max. 5	
10										Min. 100	85–100				10–30

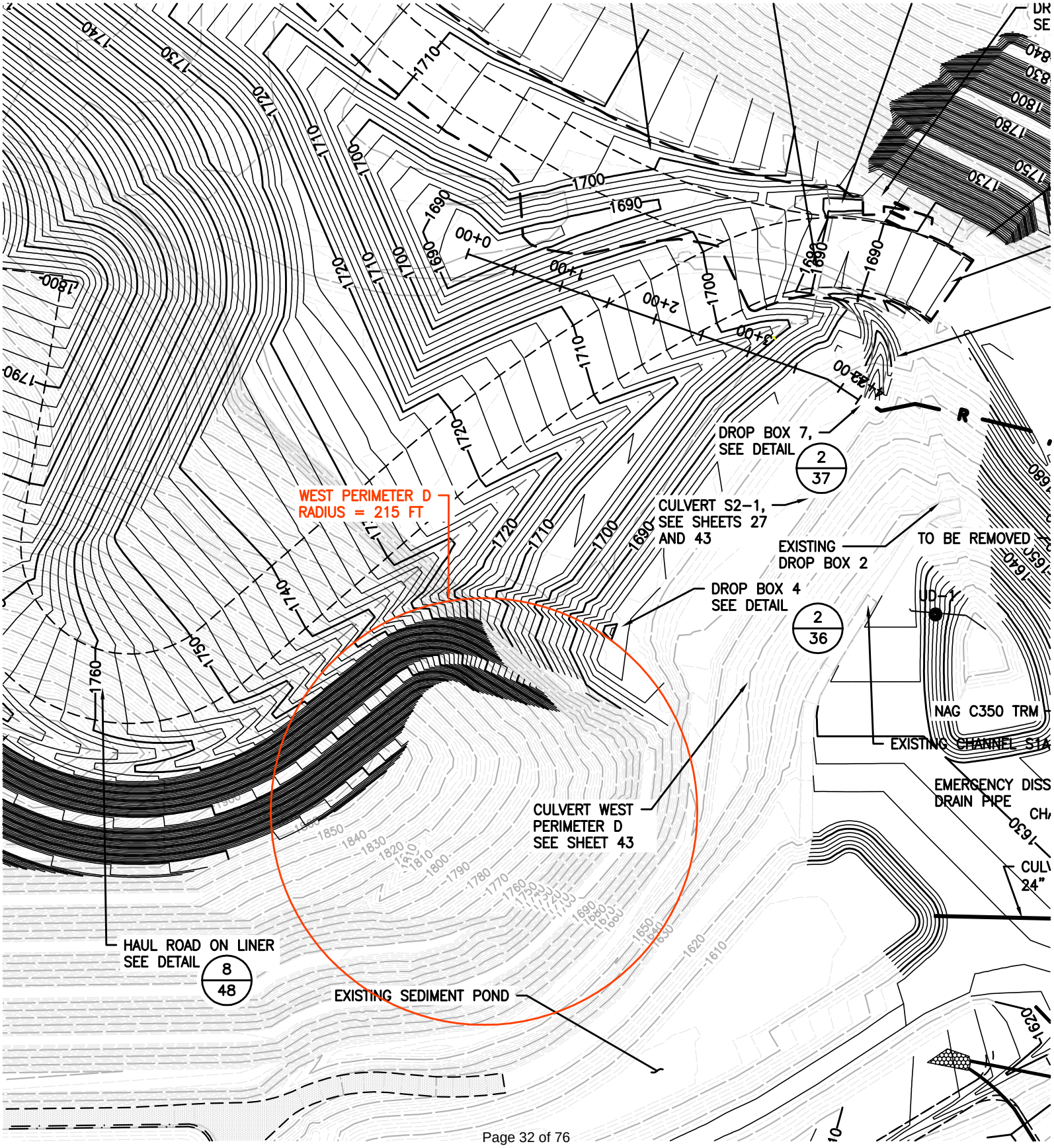
Using methods in the Maccaferri manual, assess the 357 aggregate against the residual velocity.

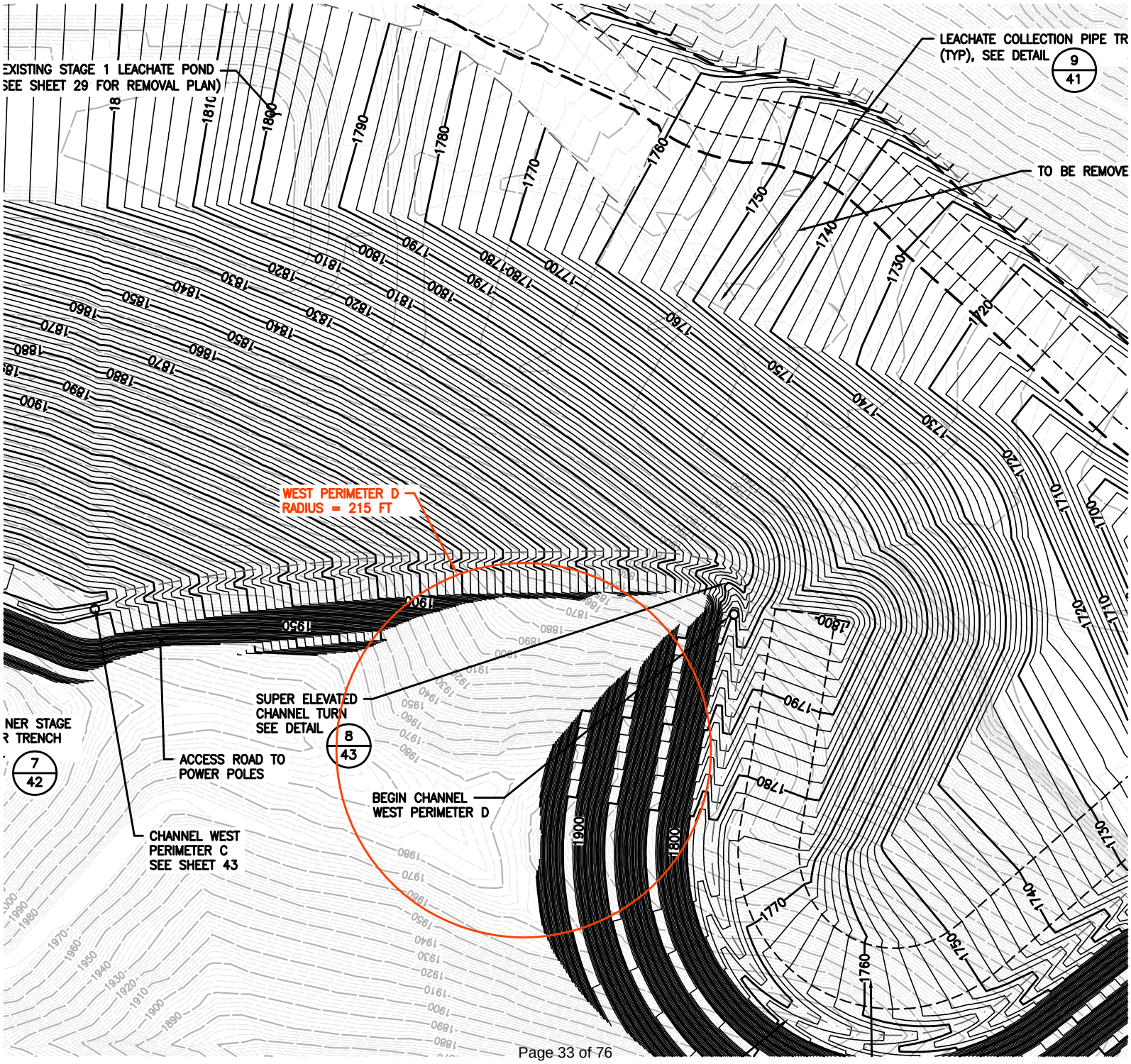
From page 32 of the manual,

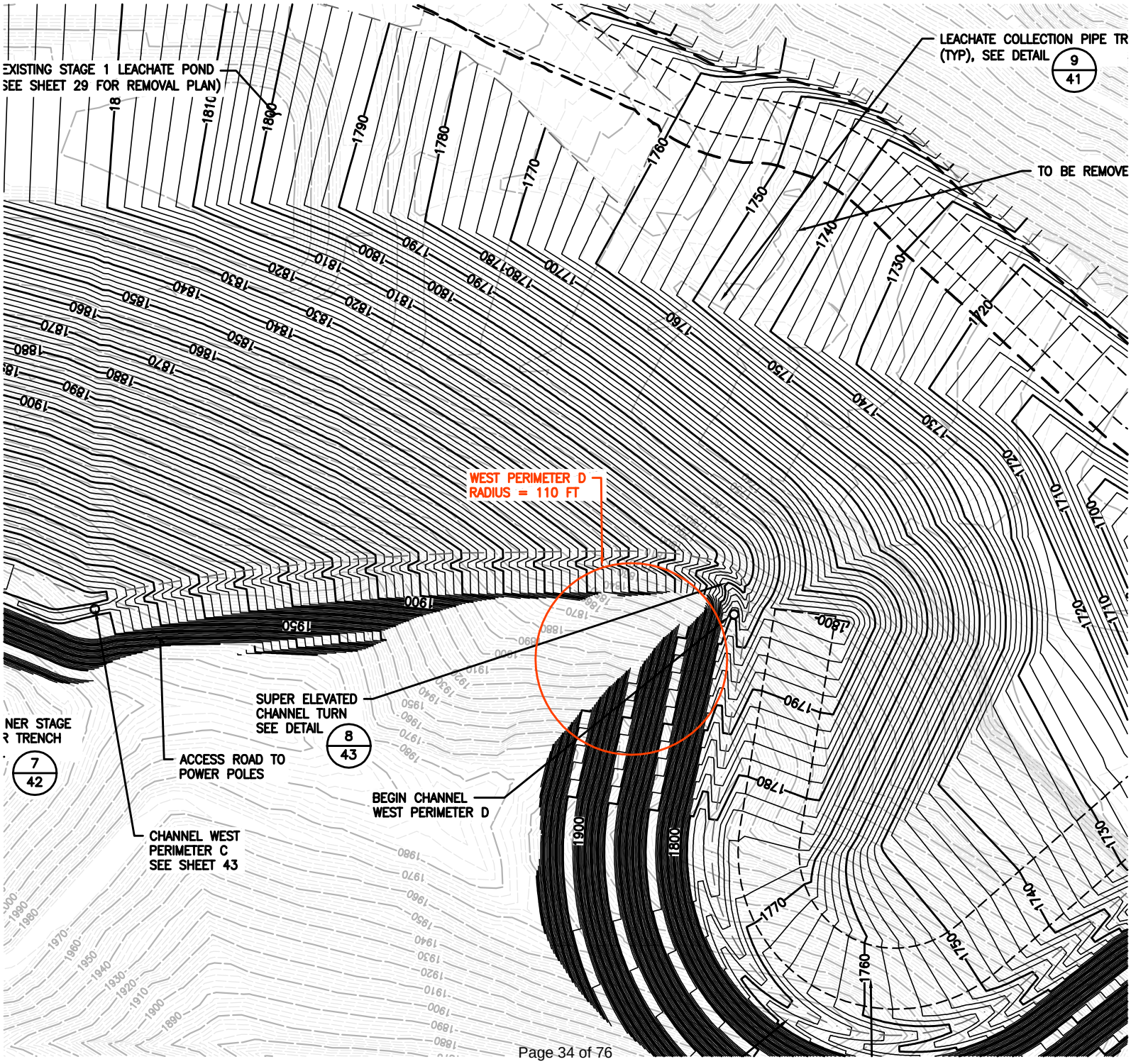
$v_e = 16.1 d^{\frac{1}{2}}$

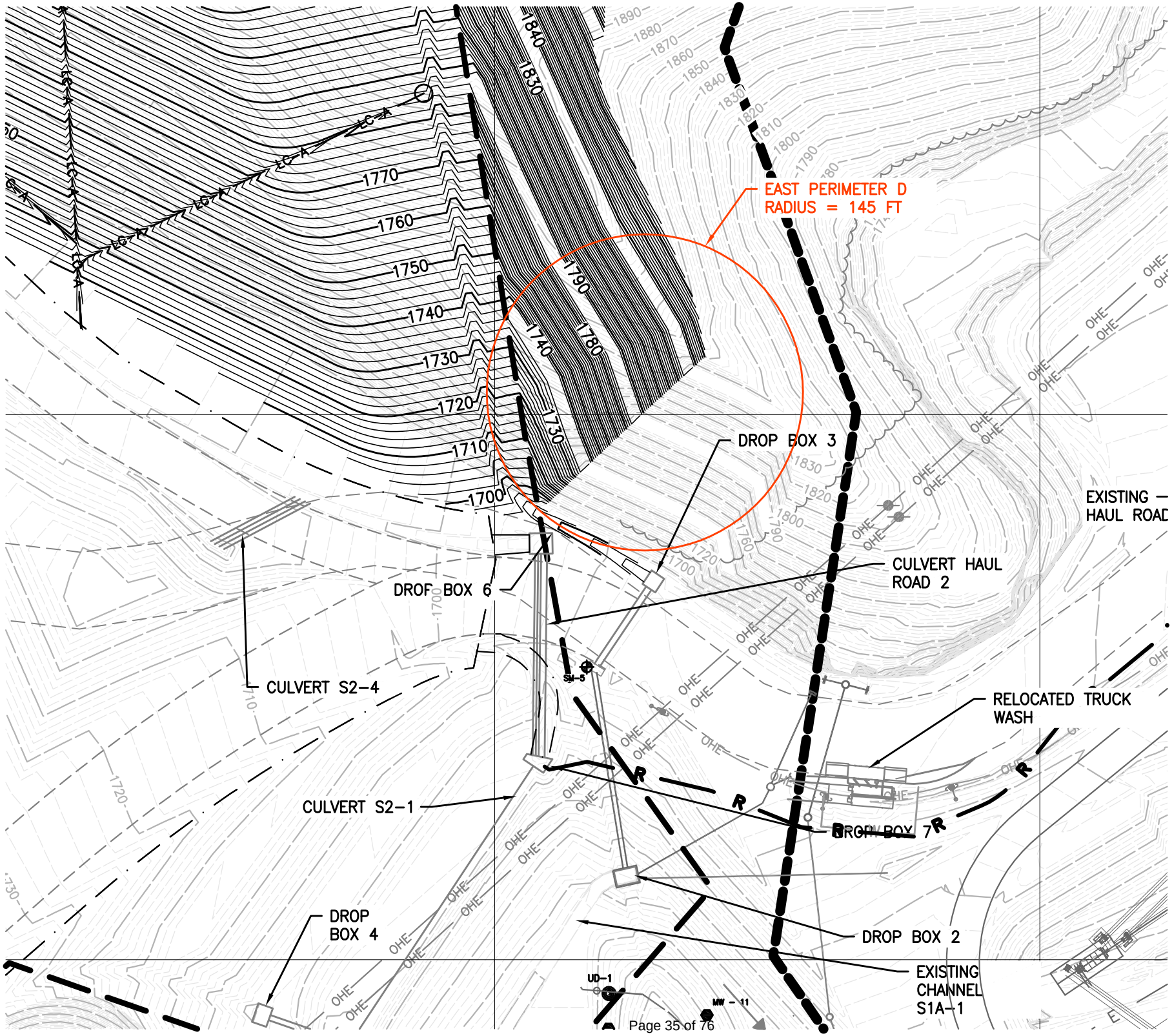
Using d= 1 inch = 0.0254 meter, v_e = 2.56 m/s = 8.4 feet/second > 1.73 ft/s

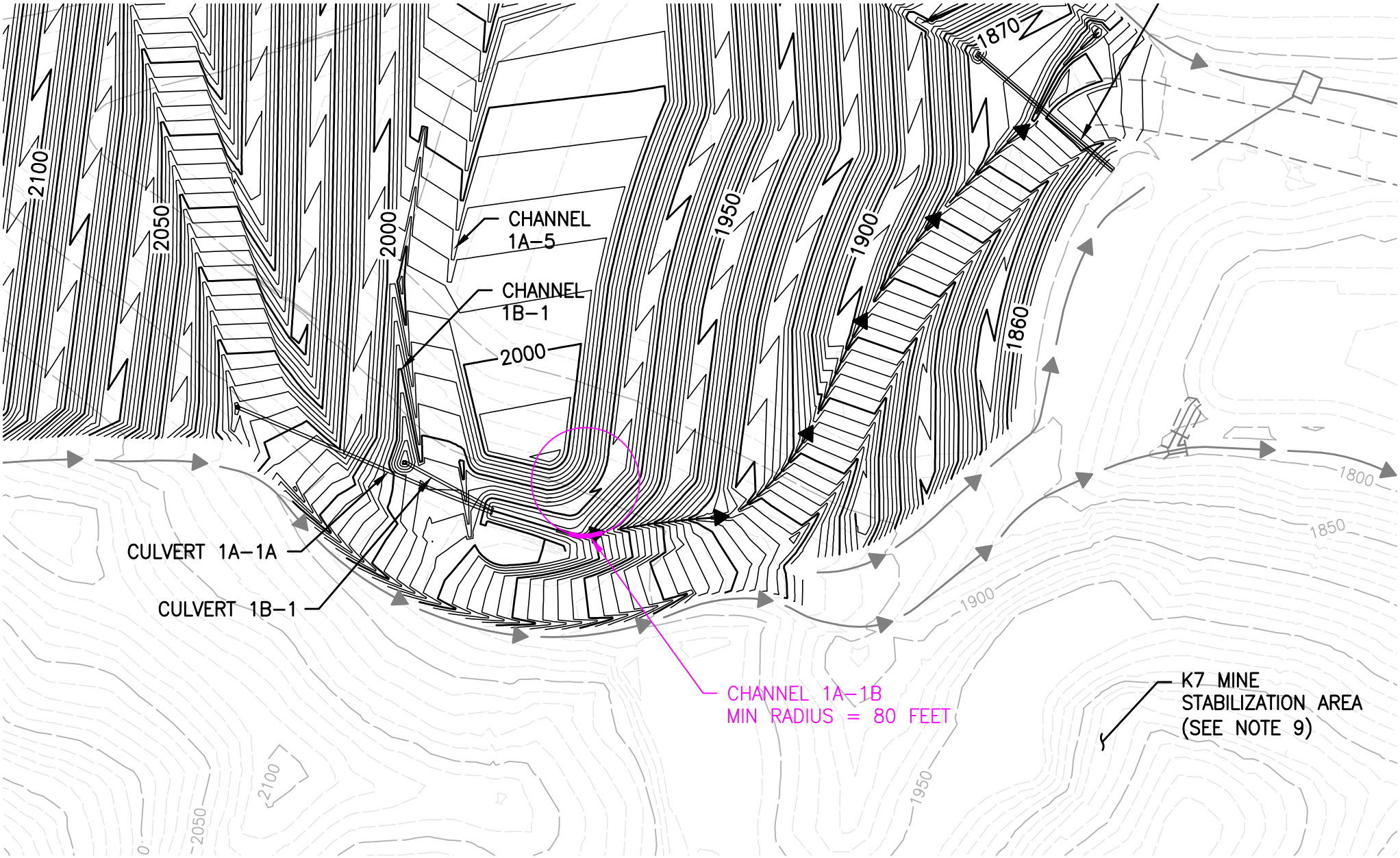
The #357 filter will be adequate. Use a 6” layer, which is 2.4 times the maximum rock thickness in the layer.

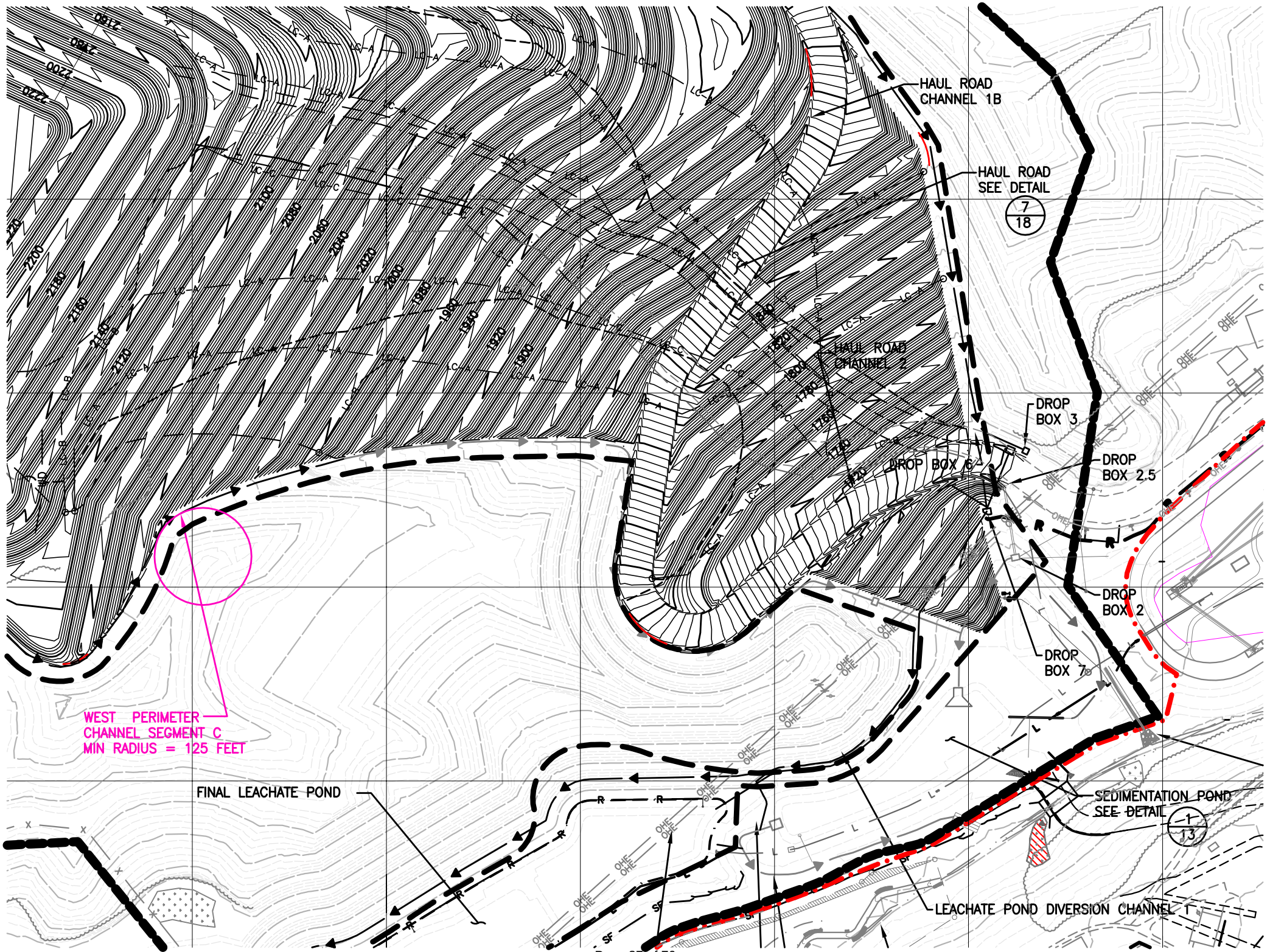

WEST PERIMETER D
RADIUS = 215 FT
DROP BOX 7,
SEE DETAIL
2
37
CULVERT S2-1,
SEE SHEETS 27
AND 43
EXISTING
DROP BOX 2
TO BE REMOVED
DROP BOX 4
SEE DETAIL
2
36
NAG C350 TRM
EXISTING CHANNEL S1A
EMERGENCY DISS
DRAIN PIPE
CULVERT WEST
PERIMETER D
SEE SHEET 43
HAUL ROAD ON LINER
SEE DETAIL
8
48
EXISTING SEDIMENT POND


EXISTING STAGE 1 LEACHATE POND
SEE SHEET 29 FOR REMOVAL PLAN)
LEACHATE COLLECTION PIPE TR
(TYP), SEE DETAIL
9
41
TO BE REMOVE
WEST PERIMETER D
RADIUS = 215 FT
SUPER ELEVATED
CHANNEL TURN
SEE DETAIL
8
43
ACCESS ROAD TO
POWER POLES
BEGIN CHANNEL
WEST PERIMETER D
CHANNEL WEST
PERIMETER C
SEE SHEET 43
NER STAGE
R TRENCH
7
42


EXISTING STAGE 1 LEACHATE POND
(SEE SHEET 29 FOR REMOVAL PLAN)
LEACHATE COLLECTION PIPE TR
(TYP), SEE DETAIL
9
41
TO BE REMOVE
WEST PERIMETER D
RADIUS = 110 FT
SUPER ELEVATED
CHANNEL TURN
SEE DETAIL
8
43
ACCESS ROAD TO
POWER POLES
BEGIN CHANNEL
WEST PERIMETER D
CHANNEL WEST
PERIMETER C
SEE SHEET 43
NER STAGE
R TRENCH
7
42


EAST PERIMETER D
RADIUS = 145 FT
DROP BOX 3
DROP BOX 6
CULVERT HAUL
ROAD 2
EXISTING
HAUL ROAD
CULVERT S2-4
RELOCATED TRUCK
WASH
CULVERT S2-1
DROP BOX 7
DROP
BOX 4
DROP BOX 2
EXISTING
CHANNEL
S1A-1
SM-5
UD-1
MW - 11


2100
2050
2000
1950
1900
1870
1860
1800
1850
CHANNEL
1A–5
CHANNEL
1B–1
2000
CULVERT 1A–1A
CULVERT 1B–1
CHANNEL 1A–1B
MIN RADIUS = 80 FEET
K7 MINE
STABILIZATION AREA
(SEE NOTE 9)


HAUL ROAD
CHANNEL 1B
HAUL ROAD
SEE DETAIL
7
18
HAUL ROAD
CHANNEL 2
DROP
BOX 3
DROP
BOX 6
DROP
BOX 2.5
DROP
BOX 2
DROP
BOX 7
WEST PERIMETER
CHANNEL SEGMENT C
MIN RADIUS = 125 FEET
FINAL LEACHATE POND
SEDIMENTATION POND
SEE DETAIL
1
13
LEACHATE POND DIVERSION CHANNEL 1

SUMMARY

Channel	Radius	Design Depth	Superelevation Depth
S1A3B UPPER	38	2.5	4.00
1A1B UPPER	58	2.25	3.03
1A1B UPPER MIN RAD	80	2.25	2.19
WEST PERIMETER C LOWER	52	2.25	4.35
WEST PERIMETER C LOWER MIN RAD	105	2.25	2.16
WEST PERIMETER D (ABOVE ROAD)	38	2	5.96
WEST PERIMETER D (ABOVE ROAD, 110 FT)	110	2	3.85
WEST PERIMETER D ABOVE ROAD, MIN RAD	215	2	1.97
WEST PERIMETER D LOWER	160	2	2.65
WEST PERIMETER D LOWER, MIN RAD	215	2	1.97
EAST PERIMETER D	76	2.25	4.27
EAST PERIMETER D MIN RAD	145	2.25	2.24

Note: Channels were constructed to meet the superelevation depth calculated here.

CULVERTS

Calculation package includes:

1. Curley Hollow SWMF Culvert Calculations Summary
   Pages 17-26 omitted due to off-site calculations not applicable to the landfill culvert design

2. Curley Hollow SWMF Culvert S2-1 Assessment

SUBJECT CURLEY HOLLOW SWMF

CULVERT CALCULATIONS SUMMARY

BY KMB2 DATE 4/10/2013 PROJ. NO. C060702.52

CHKD. BY AA DATE 4/11/2013 SHEET NO. 1 OF 26

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INTRODUCTION:

At various phases of construction and operation of the Curley Hollow SWMF, sediment and leachate water will be required to be culverted beneath roads, under active areas, and into the treatment ponds. These culverts must be designed to sufficiently pass the 100-year flow of the upstream channels. Culverts located at fill areas (Culverts 310-A1, 310-A3, 310-A Diversion, 310-B3, and 310-B4) are designed using the 10-yr peak flow, based on Virginia Erosion and Sediment Control Handbook requirements.

This calculation set will size culverts based on peak flows determined from the Site Hydrology Calculations. Analysis will utilize the Federal Highway Administration program, HY-8.
Refer to the E&S drawings contained in this package for the location of the culverts.

METHODOLOGY:

The approximate locations of culverts are included on the plan drawings provided with this permit package. From these locations, estimates were made as to the ground surface elevations at culvert inlet and outlet locations. These elevations, in conjunction with the required cover over the culvert to maintain structural integrity, the pipe diameter, and the requirements of headwater and tailwater depths, were used to provide estimates of inlet and outlet invert elevations.

In some instances, the required inlet and outlet elevations necessitate special structures or construction measures in order to meet the elevations of inlet or outlet points. These measures might include the steepening of the upstream channel in order to provide extra headwater depth at the culvert, or the installation of drop boxes. Drop box details can be found in the drop box calculations set.

REQUIREMENTS / ASSUMPTIONS:

- Minimum cover above culverts is 2 ft
- All culverts will be thick wall, smooth interior HDPE.
- Square edge with headwall will be used as the inlet edge condition in all cases. This produces conservative results, and is realistic based on the thickness of the HDPE pipe.

ORGANIZATION:

This calculation set includes the design of most on site culverts. A separate calculation set is included that details the design of Culvert S2-1, which conveys collected runoff from Drop Box 7 to the Final Leachate Pond.

For each culvert, the HY-8 report will be displayed, which documents the input values, as well as the program output.

Culvert S1A-3A

Channel S1A-3A breaks away from channel S1A-3B during placement of waste in Stage 1A. This is done to prevent the clean water from entering the active landfill surface. The Culvert will be constructed as waste is placed. It will run under the haul road that extends to Stage 1B, and discharge into slope drain channel 1A-3 on a landfill bench.

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)
0	0	1969	0	0	0-NF	0	0	1.24	1.24	0	0
2.2	2.2	1969.61	0.605	0.0*	1-JS1t	0.277	0.458	1.24	1.24	0.797	0
4.4	4.4	1969.87	0.871	0.0*	1-JS1t	0.366	0.652	1.24	1.24	1.593	0
6.6	6.6	1970.08	1.082	0.0*	1-S2n	0.455	0.805	0.455	1.24	9.54	0
8.8	8.8	1970.26	1.258	0.0*	1-S2n	0.543	0.932	0.543	1.24	10.074	0
11	11	1970.42	1.418	0.0*	1-S2n	0.598	1.049	0.598	1.24	10.89	0
13.2	13.2	1970.58	1.581	0.0*	1-S2n	0.652	1.152	0.652	1.24	11.522	0
15.4	15.4	1970.75	1.747	0.0*	1-S2n	0.706	1.249	0.729	1.24	11.515	0
17.6	17.6	1970.9	1.901	0.0*	1-S2n	0.76	1.342	0.76	1.24	12.423	0
19.8	19.8	1971.05	2.047	0.0*	1-S2n	0.814	1.428	0.814	1.24	12.756	0
22	22	1971.19	2.185	0.0*	1-S2n	0.856	1.508	0.856	1.24	13.279	0

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

Crest Elevation: 1974.00 Culvert Slope: 0.0287

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1969.00 ft

Outlet Station: 397.00 ft

Outlet Elevation: 1957.60 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1958.84 ft*
*1958.84 ft. represents the elevation of the 100-yr flow depth in the receiving channel (1A-3).

Culvert 1A-3

Channel S1A-3, which is a slope drain down the face of the waste, must be culverted under the haul road in Stage 1A. This culvert will be in use until waste placement in Stage 2 reaches the outlet elevation. Flow from this culvert discharges into channel S1A-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)
0	0	1863.35	0	0	0-NF	0	0	0	0	0	0
6.4	6.4	1864.08	0.733	0.0*	1-S2n	0.29	0.555	0.29	0	10.045	0
12.8	12.8	1864.4	1.049	0.0*	1-S2n	0.391	0.792	0.391	0	11.377	0
19.2	19.2	1864.65	1.299	0.0*	1-S2n	0.493	0.976	0.493	0	12.46	0
25.6	25.6	1864.87	1.523	0.0*	1-S2n	0.575	1.133	0.575	0	13.631	0
32	32	1865.11	1.763	0.0*	1-S2n	0.637	1.275	0.637	0	14.441	0
38.4	38.4	1865.33	1.981	0.0*	1-S2n	0.699	1.405	0.699	0	15.202	0
44.8	44.8	1865.53	2.183	0.0*	1-S2n	0.761	1.522	0.761	0	15.796	0
51.2	51.2	1865.73	2.375	0.0*	1-S2n	0.822	1.629	0.822	0	16.302	0
57.6	57.6	1865.91	2.562	0.0*	1-S2n	0.868	1.733	0.868	0	16.926	0
64	64	1866.1	2.748	0.0*	1-S2n	0.915	1.832	0.915	0	17.47	0

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

Crest Elevation: 1868.00 Culvert Slope: 0.0464

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1863.35 ft

Outlet Station: 258.00 ft

Outlet Elevation: 1851.38 ft

Number of Barrels: 2

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1851.38 ft*
*1851.38 ft. represents the outlet invert elevation of Channel 1A-3, as it discharges on the hillside above receiving channel (S1A-5).

Culvert 1A-1A

Channel 1A-1A must be culverted beneath the haul road during placement of waste in Stage 1A. The culvert will be installed as the haul road is constructed. Channel 1A-1A will extend to the top of the Stage 1A pile. This culvert discharges into channel 1A-1B.

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)
0	0	2006.4	0	0	0-NF	0	0	1.15	1.15	0	0
7.3	7.3	2007.4	1.005	0.0*	1-S2n	0.357	0.782	0.357	1.15	12.845	0
14.6	14.6	2007.85	1.447	0.0*	1-S2n	0.472	1.116	0.472	1.15	16.883	0
21.9	21.9	2008.19	1.79	0.0*	1-S2n	0.583	1.376	0.583	1.15	18.77	0
29.2	29.2	2008.51	2.114	0.0*	1-S2n	0.694	1.599	0.694	1.15	19.88	0
36.5	36.5	2008.85	2.453	0.0*	1-S2n	0.774	1.799	0.774	1.15	21.617	0
43.8	43.8	2009.16	2.76	0.0*	1-S2n	0.842	1.979	0.842	1.15	22.547	0
51.1	51.1	2009.45	3.048	0.0*	1-S2n	0.909	2.141	0.909	1.15	23.572	0
58.4	58.4	2009.73	3.326	0.0*	1-S2n	0.976	2.296	0.976	1.15	24.404	0
65.7	65.7	2010	3.601	0.0*	1-S2n	1.044	2.443	1.05	1.15	24.906	0
73	73	2010.28	3.881	0.0*	1-S2n	1.106	2.579	1.106	1.15	25.822	0

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

Crest Elevation: 2012.00 Culvert Slope: 0.0780

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 2006.4 ft

Outlet Station: 409.00 ft

Outlet Elevation: 1974.50 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1975.65 ft*

*1975.65 ft. represents the elevation of the 100-yr flow depth in the receiving channel (1A-1B).

SUBJECT CURLEY HOLLOW SWMF

CULVERT CALCULATIONS SUMMARY

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gai consultants

Culvert 1B-1

Channel 1B-1 must be culverted beneath the haul road during Stage 1B waste placement. The culvert will be installed during placement of waste in Stage 1A, but will not receive significant flows until the 1B pile has been built up. This culvert discharges into channel 1A-1B.

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)
0	0	1979.55	0	0	0-NF	0	0	1.15	1.15	0	0
10.5	10.5	1980.8	1.255	0.0*	1-S2n	0.503	0.94	0.503	1.15	11.076	0
21	21	1981.36	1.814	0.0*	1-S2n	0.744	1.346	0.767	1.15	12.586	0
31.5	31.5	1981.87	2.319	0.0*	1-S2n	0.897	1.662	0.95	1.15	13.656	0
42	42	1982.33	2.78	0.0*	1-S2n	1.051	1.937	1.107	1.15	14.835	0
52.5	52.5	1982.75	3.196	0.0*	1-S2n	1.176	2.171	1.255	1.15	15.501	0
63	63	1983.14	3.593	0.0*	1-S2n	1.292	2.391	1.39	1.15	16.205	0
73.5	73.5	1983.54	3.995	0.0*	1-S2n	1.408	2.588	1.524	1.15	16.7	0
84	84	1983.97	4.419	0.0*	5-S2n	1.513	2.775	1.65	1.15	17.156	0
94.5	94.5	1984.43	4.882	0.246	5-S2n	1.611	2.943	1.771	1.15	17.586	0
105	105	1984.94	5.392	1.287	5-S2n	1.709	3.098	1.889	1.15	17.985	0

****

Straight Culvert

Crest Elevation: 1986.00 Culvert Slope: 0.0312

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1979.55 ft

Outlet Station: 146.00 ft

Outlet Elevation: 1975.00 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1976.15 ft*

*1976.15 ft. represents the elevation of the 100-yr flow depth in the receiving channel (1A-1B).

SUBJECT CURLEY HOLLOW SWMF

CULVERT CALCULATIONS SUMMARY

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Culvert East Perimeter 1B

Channel East Perimeter 1B must be culverted below the perimeter access road where it is adjacent to the haul road on the south end of Stage 1B, and discharges into Channel S1A-4B. Since the culvert will be covered by the Stage 2 Subgrade, the peak flow is taken from the Stage 1B Pond Pack model.

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)
0	0	2050	0	0	0-NF	0	0	0	0	0	0
7.3	7.3	2051.03	1.029	0.0*	1-S2n	0.31	0.845	0.31	0.16	23.266	7.24
14.6	14.6	2051.48	1.485	0.0*	1-S2n	0.432	1.213	0.432	0.241	22.589	9.35
21.9	21.9	2051.97	1.971	0.0*	1-S2n	0.551	1.505	0.569	0.306	23.675	10.82
29.2	29.2	2052.4	2.404	0.0*	1-S2n	0.625	1.745	0.665	0.362	24.793	11.98
36.5	36.5	2052.83	2.834	0.0*	1-S2n	0.7	1.96	0.753	0.413	26.118	12.95
43.8	43.8	2053.3	3.302	0.0*	5-S2n	0.774	2.153	0.833	0.459	27.377	13.78
51.1	51.1	2053.84	3.836	0.0*	5-S2n	0.841	2.323	0.91	0.502	28.116	14.52
58.4	58.4	2054.45	4.454	0.0*	5-S2n	0.897	2.47	0.982	0.543	28.921	15.18
65.7	65.7	2055.16	5.165	0.0*	5-S2n	0.953	2.595	1.053	0.581	29.621	15.79
73	73	2055.97	5.971	0.0*	5-S2n	1.009	2.696	1.125	0.617	30.194	16.35

****

Straight Culvert

Crest Elevation: 2056.00 Culvert Slope: 0.1673

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 2050.00 ft

Outlet Station: 110.00 ft

Outlet Elevation: 2031.60 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Trapezoidal Channel Bottom Width: 6.00 ft

Side Slope (H:V) 2:1 Channel Slope: 0.25 ft/ft Manning's n: 0.029*

Channel Invert Elevation: 2031.60 ft.

*Manning's n value of 0.029 represents 10" Filter Point Mat fabric Form.

Culvert East Perimeter B

Channel East Perimeter B must be culverted below the perimeter access road where it is adjacent to the haul road on the east side of the facility. This culvert will be installed during the construction of the Stage 2 Subgrade and will be in use for the life of the facility. This culvert discharges into channel East Perimeter C.

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)
0	0	2050.5	0	0	0-NF	0	0	1.9	1.9	0	0
14.3	14.3	2051.57	1.068	0.0*	1-JS1t	0.428	0.801	1.9	1.9	1.34	0
28.6	28.6	2052.04	1.543	0.0*	1-S2n	0.637	1.147	0.673	1.9	11.151	0
42.9	42.9	2052.46	1.961	0.0*	1-S2n	0.763	1.414	0.837	1.9	12.032	0
57.2	57.2	2052.85	2.354	0.0*	1-S2n	0.89	1.651	0.985	1.9	12.922	0
71.5	71.5	2053.21	2.706	0.0*	1-S2n	1.002	1.852	1.119	1.9	13.435	0
85.8	85.8	2053.54	3.039	0.116	1-S2n	1.098	2.035	1.245	1.9	13.971	0
100.1	100.1	2053.87	3.37	0.497	1-S2n	1.194	2.207	1.365	1.9	14.391	0
114.4	114.4	2054.21	3.714	0.898	5-S2n	1.287	2.366	1.48	1.9	14.764	0
128.7	128.7	2054.58	4.085	1.317	5-S2n	1.368	2.512	1.591	1.9	15.125	0
143	143	2054.99	4.49	2.185	5-S2n	1.449	2.646	1.696	1.9	15.475	0

****

Straight Culvert

Crest Elevation: 2056.00 Culvert Slope: 0.0329

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Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 2050.50 ft

Outlet Station: 76.00 ft

Outlet Elevation: 2048.00 ft

Number of Barrels: 2

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 2049.9 ft*

*2049.9 ft. represents the elevation of the 100-yr flow depth in the receiving channel (East Perimeter C).

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East Perimeter D2

Channel East Perimeter D is an existing culvert which will be in service for the life of the facility. The culvert begins in Drop Box 2.5 and discharges into Drop Box 2, which ultimately leads to the sedimentation Pond. The analysis is included to determine headwater conditions for Drop Box 2.5.

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)
0	0	1671.3	0	0	0-NF	0	0	3.5	13.58	0	0
31.7	31.7	1672.75	1.453	0.0*	1-JS1f	0.413	1.211	3.5	13.58	17.25	0
63.4	63.4	1673.54	2.241	0.0*	1-JS1f	0.607	1.742	3.5	13.58	34.51	0
95.1	95.1	1674.28	2.983	0.0*	1-JS1f	0.736	2.15	3.5	13.58	51.76	0
126.8	126.8	1675.06	3.764	0.0*	5-JS1f	0.854	2.493	3.5	13.58	69.02	0
158.5	158.5	1676	4.705	0.0*	5-JS1f	0.968	2.779	3.5	13.58	86.27	0
190.2	190.2	1677.17	5.869	0.0*	5-S2n	1.057	3.009	1.114	13.58	35.941	0
221.9	221.9	1678.57	7.273	0.0*	5-S2n	1.146	3.178	1.221	13.58	37.059	0
253.6	253.6	1680.21	8.909	0.0*	5-S2n	1.235	3.293	1.323	13.58	38.044	0
285.3	285.3	1682.06	10.761	0.0*	5-S2n	1.316	3.212	1.417	13.58	39.024	0
317	317	1684.17	12.875	0.0*	5-S2n	1.392	3.5	1.392	13.58	44.4	0

****

Straight Culvert

Crest Elevation: 1689 Culvert Slope: 0.1872

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1671.30 ft

Outlet Station: 188.00 ft

Outlet Elevation: 1636.10 ft

Number of Barrels: 2

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1646.00 ft*

*1646.00 ft. represents the top of Drop Box 2 elevation, which is a conservative analysis for the tailwater conditions.

The headwater elevation of 1684.17 calculated above is now used for tailwater conditions for Culvert East Perimeter D2 analysis. The headwater will be contained in Drop Box 2.5.

East Perimeter D1

Channel East Perimeter D is an existing culvert which will be in service for the life of the facility. The culvert begins in Drop Box 3 and discharges into Drop Box 2.5, which ultimately leads to the sedimentation Pond. The analysis is included to determine headwater conditions for Drop Box 3. East Perimeter D1 consists of two 42" pipes, and one 48" pipes. Therefore, two tables depicting the distribution of flow for each culvert set are shown.

2 – 42" Culvert

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)
0	0	1684.17	0	7.57	0-NF	0	0	3.5	12.87	0	0
31.7	19.19	1684.19	1.223	7.59	4-FFf	0.425	0.934	3.5	12.87	0.997	0
63.4	38.13	1684.28	1.767	7.678	4-FFf	0.628	1.332	3.5	12.87	1.981	0
95.1	57.12	1684.43	2.303	7.825	4-FFf	0.755	1.649	3.5	12.87	2.969	0
126.8	76.24	1684.63	2.769	8.032	4-FFf	0.88	1.912	3.5	12.87	3.962	0
158.5	95.21	1684.9	3.207	8.296	4-FFf	0.992	2.151	3.5	12.87	4.948	0
190.2	114.24	1685.22	3.661	8.619	4-FFf	1.085	2.365	3.5	12.87	5.937	0
221.9	133.25	1685.6	4.16	9.001	4-FFf	1.179	2.555	3.5	12.87	6.925	0
253.6	152.28	1686.04	4.725	9.442	4-FFf	1.273	2.727	3.5	12.87	7.914	0
285.3	171.32	1686.54	5.368	9.942	4-FFf	1.352	2.879	3.5	12.87	8.903	0
317	190.35	1687.1	6.096	10.5	4-FFf	1.431	3.01	3.5	12.87	9.892	0

****

Straight Culvert

Crest Elevation: 1687.50 Culvert Slope: 0.0609

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1676.60 ft

Outlet Station: 87.00 ft

Outlet Elevation: 1671.30 ft

Number of Barrels: 2

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1684.17 ft*

*1684.17 ft. represents the 100-yr water surface elevation in Drop Box 2.5, shown in East Perimeter D2 Analysis.

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1 – 48" Culvert

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)
0	0	1684.17	0	7.57	0-NF	0	0	4	12.87	0	0
31.7	12.71	1684.19	1.359	7.59	4-FFf	0.469	1.038	4	12.87	1.012	0
63.4	25.36	1684.28	1.965	7.678	4-FFf	0.686	1.483	4	12.87	2.018	0
95.1	38.04	1684.43	2.554	7.825	4-FFf	0.835	1.839	4	12.87	3.027	0
126.8	50.71	1684.63	3.067	8.032	4-FFf	0.967	2.133	4	12.87	4.035	0
158.5	63.35	1684.9	3.547	8.296	4-FFf	1.097	2.398	4	12.87	5.041	0
190.2	75.99	1685.22	4.033	8.619	4-FFf	1.197	2.636	4	12.87	6.047	0
221.9	88.66	1685.6	4.56	9.001	4-FFf	1.296	2.851	4	12.87	7.056	0
253.6	101.32	1686.04	5.148	9.442	4-FFf	1.396	3.045	4	12.87	8.063	0
285.3	113.99	1686.54	5.813	9.942	4-FFf	1.49	3.22	4	12.87	9.071	0
317	126.64	1687.1	6.563	10.5	4-FFf	1.574	3.373	4	12.87	10.078	0

****

Straight Culvert

Crest Elevation: 1687.50 Culvert Slope: 0.0609

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1676.60 ft

Outlet Station: 87.00 ft

Outlet Elevation: 1671.30 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1684.17 ft*

*1684.17 ft. represents the 100-yr water surface elevation in Drop Box 2.5, shown in East Perimeter D2 Analysis.

The output shows that Culvert East Perimeter D will convey the 100-yr design flow (317 cfs) by distributing 190.36 cfs in the two 42" pipes, and 126.64 cfs in the single 48" pipe. The resulting headwater elevation in Drop Box 3 is 1687.1 ft. which will be contained (top of Drop Box 3 elevation = 1687.5 ft.)

Culvert West Perimeter D

Channel West Perimeter D must be culverted beneath leachate channel S2-1 on the west side of the facility, by Channel West Perimeter D entering Drop Box 4 before discharging into sediment channel S1A-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)
0	0	1677	0	0	0-NF	0	0	0	0	0	0
37.4	37.4	1678.57	1.569	0.0*	1-S2n	0.462	1.266	0.462	0.299	22.329	10.44
74.8	74.8	1679.37	2.367	0.0*	1-S2n	0.674	1.822	0.701	0.457	25.099	13.64
112.2	112.2	1680.11	3.114	0.0*	1-S2n	0.823	2.249	0.823	0.588	29.817	15.91
149.6	149.6	1680.83	3.827	0.0*	1-S2n	0.952	2.615	0.996	0.703	30.403	17.73
187	187	1681.62	4.617	0.0*	5-S2n	1.081	2.928	1.121	0.809	32.484	19.26
224.4	224.4	1682.55	5.555	0.0*	5-S2n	1.18	3.196	1.24	0.908	33.703	20.6
261.8	261.8	1683.68	6.677	0.0*	5-S2n	1.277	3.419	1.354	1.001	34.85	21.79
299.2	299.2	1685	7.996	0.0*	5-S2n	1.374	3.592	1.463	1.09	35.949	22.88
336.6	336.6	1686.51	9.506	0.0*	5-S2n	1.469	3.718	1.567	1.176	36.83	23.86
374	374	1688.2	11.196	0.0*	5-S2n	1.551	3.8	1.672	1.258	37.517	24.78

****

Straight Culvert

Crest Elevation: 1690.00 Culvert Slope: 0.1404

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Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1677.00 ft

Outlet Station: 228.00 ft

Outlet Elevation: 1645.00 ft

Number of Barrels: 2

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Rectangular Channel

Bottom Width: 12.00 ft

Channel Slope: 0.038 ft/ft

Manning's n: 0.012*

Channel Invert Elevation: 1645.00 ft.

*Manning's n value of 0.012 represents Uniform Section Mat fabric Form.

The resulting headwater elevation in Drop Box 4 is 1688.2 ft. which will be contained (top of Drop Box 4 elevation = 1690.00 ft.)

Culvert Haul Road 2

Channel Haul Road 2 must be culverted beneath the site haul road. The culvert will be installed during Stage 2 of the facility, and will be in use throughout its life. The culvert starts in Drop Box 6 and discharges into Drop Box 7 before entering Channel S2-1, which ultimately discharges into the Final Leachate Pond.

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)
0	0	1674.36	0	2.86	0-NF	0	0	4	13.36	0	0
91.2	91.2	1674.49	1.887	2.989	1-S1f	0.741	1.405	4	13.36	1.9	0
182.4	182.4	1674.88	2.914	3.378	1-S1f	1.044	2.021	4	13.36	3.801	0
273.6	273.6	1675.54	3.785	4.036	1-S1f	1.285	2.495	4	13.36	5.701	0
364.8	364.8	1676.22	4.719	4.629	5-JS1f	1.505	2.892	4	13.36	7.601	0
456	456	1677.36	5.86	5.728	5-S1f	1.699	3.22	4	13.36	9.502	0
547.2	547.2	1678.78	7.277	6.847	5-JS1f	1.887	3.479	4	13.36	11.402	0
638.4	638.4	1680.49	8.986	8.288	5-JS1f	2.065	3.665	4	13.36	13.302	0
729.6	729.6	1682.47	10.971	9.95	5-JS1f	2.243	3.789	4	13.36	15.203	0
820.8	820.8	1684.77	13.275	11.835	5-JS1f	2.419	3.536	4	13.36	17.103	0
912	912	1687.42	15.919	13.941	4-FFf	2.599	4	4	13.36	19.003	0

****

Straight Culvert

Crest Elevation: 1690.00 Culvert Slope: 0.0375

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1671.50 ft

Outlet Station: 160.00 ft

Outlet Elevation: 1665.50 ft

Number of Barrels: 4

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1674.36 ft*

*1674.36 ft. represents the 100-yr headwater elevation in Drop Box 7, which is shown in the Culvert S2-1 Calculation at the end of this section.

The resulting headwater elevation in Drop Box 6 is 1687.42 ft. which will be contained (top of Drop Box 6 elevation = 1690.00 ft.)

Culvert LD-1

Channel Leachate Diversion 1 will be constructed only after areas above the Final Leachate Pond are stabilized, diverting uphill areas around the pond. It must culvert under the pond access road and discharges into the Combined Gabion Spillway Channel.

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)
0	0	164162	0	0	0-NF	0	0	0	0	0	0
1.8	1.8	1642.17	0.546	0.0*	1-S2n	0.164	0.432	0.164	0.059	8.784	7.35
3.6	3.6	1642.4	0.783	0.0*	1-S2n	0.259	0.62	0.28	0.09	11.52	9.58
5.4	5.4	1642.59	0.97	0.0*	1-S2n	0.309	0.764	0.359	0.115	12.098	11.15
7.2	7.2	1642.75	1.131	0.0*	1-S2n	0.36	0.886	0.407	0.136	13.62	12.4
9	9	1642.9	1.283	0.0*	1-S2n	0.411	0.995	0.455	0.155	14.729	13.46
10.8	10.8	1643.07	1.454	0.0*	1-S2n	0.459	1.099	0.502	0.173	15.627	14.39
12.6	12.6	1643.23	1.611	0.0*	1-S2n	0.49	1.192	0.551	0.189	15.545	15.21
14.4	14.4	1643.38	1.759	0.0*	1-S2n	0.521	1.278	0.598	0.205	15.845	15.95
16.2	16.2	1643.52	1.901	0.0*	1-S2n	0.552	1.356	0.641	0.219	16.218	16.63
18	18	1643.66	2.039	0.0*	1-S2n	0.583	1.434	0.68	0.233	16.672	17.26

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

Crest Elevation: 1646.00 Culvert Slope: 0.1074

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1641.62 ft

Outlet Station: 43.00 ft

Outlet Elevation: 1637.00 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Trapezoidal Channel Bottom Width: 4.00 ft

Side Slope (H:V) 2:1 Channel Slope: 0.69 ft/ft Manning's n: 0.025*

Channel Invert Elevation: 1637.00 ft.

***Manning's n value of 0.025 represents 2.2" Filter Point Mat fabric Form.

Culvert LD-2

Channel Leachate Diversion 2 will be constructed only after areas above the Final Leachate Pond are stabilized, diverting uphill areas around the pond. It must culvert under Singapura Road and discharges onto the floodplain of Meade Creek.

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)
0	0	1638	0	0	0-NF	0	0	0	0	0	0
9.4	9.4	1639.1	1.102	0.0*	1-S2n	0.334	0.924	0.365	0	22.076	0
18.8	18.8	1639.59	1.59	0.0*	1-S2n	0.448	1.322	0.494	0	22.006	0
28.2	28.2	1640.06	2.06	0.0*	1-S2n	0.562	1.638	0.608	0	25.022	0
37.6	37.6	1640.52	2.519	0.0*	1-S2n	0.661	1.899	0.708	0	26.795	0
47	47	1640.95	2.953	0.0*	1-S2n	0.73	2.137	0.806	0	27.814	0
56.4	56.4	1641.4	3.401	0.0*	1-S2n	0.8	2.349	0.894	0	28.949	0
65.8	65.8	1641.89	3.89	0.0*	5-S2n	0.869	2.54	0.98	0	29.903	0
75.2	75.2	1642.44	4.441	0.0*	5-S2n	0.939	2.711	1.06	0	30.46	0
84.6	84.6	1643.07	5.067	0.0*	5-S2n	0.995	2.863	1.142	0	30.932	0
94	94	1643.78	5.776	0.0*	5-S2n	1.048	2.995	1.218	0	31.502	0

****

Straight Culvert

Crest Elevation: 1644.60 Culvert Slope: 0.1895

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1638.00 ft

Outlet Station: 95.00 ft

Outlet Elevation: 1620.00 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1620.00 ft*

*1620.00 ft. represents the invert elevation of the culvert outlet, which is a conservative analysis.

SUBJECT CURLEY HOLLOW SWMF

CULVERT CALCULATIONS SUMMARY

BY KMB2 DATE 4/10/2013 PROJ. NO. C060702.52

CHKD. BY AA DATE 4/11/2013 SHEET NO. 15 OF 26

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Culvert 1B-2

Culvert 1B-2 will be installed under the 1B haul road during Stage 2 subgrade only after Channel S2-2 has been installed, as the runoff from this area will be conveyed down the remaining portion of Channel 1A-3 until reaching Channel S2-2. Flow from the channel will enter a drop inlet before entering Culvert 1B-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)
0	0	2029	0	0	0-NF	0	0	0	0	0	0
10.5	10.5	2030.23	1.234	0.0*	1-S2n	0.383	0.978	0.383	0.562	17.763	4.53
21	21	2030.79	1.791	0.0*	1-S2n	0.547	1.402	0.58	0.817	19.814	5.55
31.5	31.5	2031.36	2.358	0.0*	1-S2n	0.682	1.736	0.702	1.01	22.709	6.22
42	42	2031.85	2.854	0.0*	1-S2n	0.782	2.013	0.782	1.17	25.919	6.72
52.5	52.5	2032.34	3.342	0.0*	1-S2n	0.882	2.262	0.913	1.309	26.21	7.14
63	63	2032.87	3.869	0.0*	5-S2n	0.975	2.485	1.019	1.433	26.982	7.5
73.5	73.5	2033.47	4.467	0.0*	5-S2n	1.05	2.681	1.109	1.545	27.951	7.81
84	84	2034.16	5.156	0.0*	5-S2n	1.126	2.854	1.196	1.649	28.851	8.09
94.5	94.5	2034.95	5.947	0.0*	5-S2n	1.201	3.002	1.282	1.745	29.61	8.34
105	105	2035.85	6.845	0.0*	5-S2n	1.276	3.122	1.363	1.836	30.234	8.57

****

Straight Culvert

Crest Elevation: 2036.00 Culvert Slope: 0.1148

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 2029.00 ft

Outlet Station: 183.00 ft

Outlet Elevation: 2008.00 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.50 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Trapezoidal Channel Bottom Width: 3.00 ft

Side Slope (H:V) 2:1 Channel Slope: 0.02 ft/ft Manning's n: 0.026*

Channel Invert Elevation: 2008.00 ft.

*Manning's n value of 0.026 represents 4" Filter Point Mat Fabric Form.
Note: Channel 1B-1 peak flow (105 cfs) is used since this total area will drain into Culvert 1B-2 upon installation.

Culvert S2-4

Culvert S2-4 will be installed during Stage 2 subgrade, underneath the haul road, and will convey flow from Channel S2-4 to Channel S2-2.

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)
0	0	1705.57	0	0.32	0-NF	0	0	2.45	2.45	0	0
31.5	31.5	1706.44	1.191	0.36	1-JS1t	0.538	0.879	2.45	2.45	1.274	0
63	63	1707.03	1.779	0.478	1-JS1t	0.754	1.264	2.45	2.45	2.549	0
94.5	94.5	1707.54	2.292	0.676	1-S2n	0.931	1.564	0.998	2.45	11.455	0
126	126	1708	2.753	0.953	1-S2n	1.091	1.818	1.173	2.45	12.282	0
157.5	157.5	1708.48	3.227	1.309	5-S2n	1.228	2.037	1.339	2.45	12.898	0
189	189	1709.01	3.76	1.744	5-S2n	1.364	2.236	1.497	2.45	13.398	0
220.5	220.5	1709.63	4.381	2.258	5-S2n	1.489	2.407	1.647	2.45	13.865	0
252	252	1710.36	5.106	3.177	5-S2n	1.615	2.552	1.792	2.45	14.318	0
283.5	283.5	1711.19	5.942	3.907	5-S2n	1.739	2.669	1.931	2.45	14.733	0
315	315	1712.14	6.886	4.703	5-S2n	1.863	2.758	2.066	2.45	15.189	0

****

Straight Culvert

Crest Elevation: 1712.25 Culvert Slope: 0.0237

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1705.25 ft

Outlet Station: 90.00 ft

Outlet Elevation: 1703.12 ft

Number of Barrels: 4

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge w/ Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1705.57 ft*

*1705.57 ft. represents the 100-yr flow depth in the receiving channel (Channel S2-2).

SUBJECT CURLEY HOLLOW SWMF

CULVERT S2-1 ASSESSMENT

BY KMB2 DATE 4/4/2013 PROJ. NO. C060702.52

CHKD. BY KMB DATE 4/4/2013 SHEET NO. 1 OF 4

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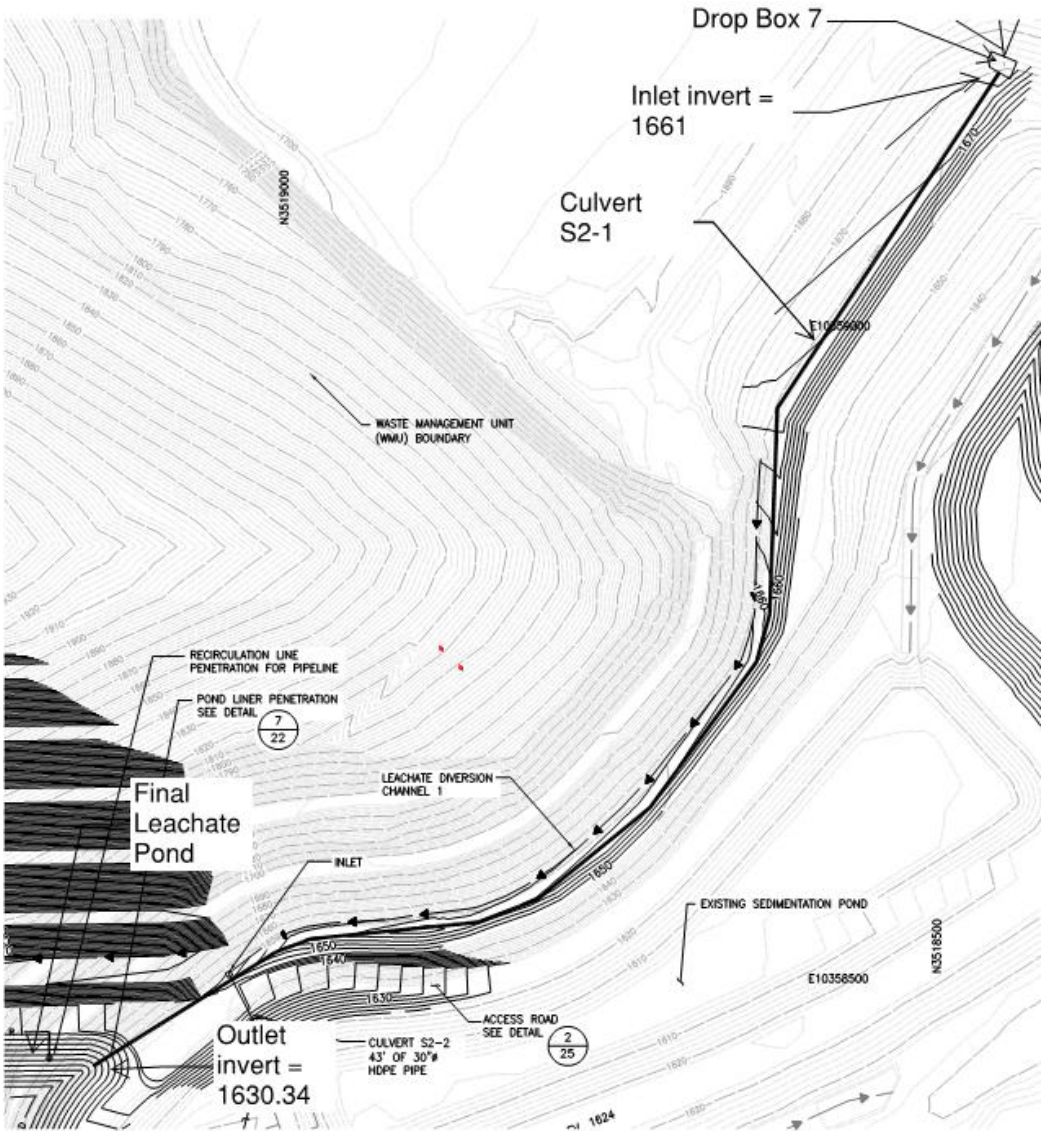
INTRODUCTION

This document contains the supporting hydraulics calculations for Culvert S2-1. The inlet of Culvert S2-1 begins at Drop Box 7, and conveys the 100-yr, 24-hr flow from Drop Box 7 to the Final Leachate Pond.

The 100-yr flow entering Drop Box 7 = 912 cfs. The supporting hydrology can be found in the Pond Pack models, which are provided in the Channel Calculation section.

The location of Channel S2-1is shown on the following image:



CULVERT DESIGN AND ANALYSIS

As a part of this calculation, the headwater elevation in Drop Box 7 will consequently be checked for headwater containment capacity for the 100-year design storm. This was performed using the computer program HY-8. The diameter of Culvert S2-1 as it exists Drop Box 7 is 10 feet, which immediately narrows down (reducer section) to 7.5 feet for the remaining length. The 10' diameter section is used to lower the headwater depth in Drop Box 7. The 10' section will be analyzed in HY-8. The 7.5' section will be analyzed using the computer program StormCAD V8i.

Headwater Assessment (HY-8)

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)
0	0	1669.75	0	8.75	0-NF	0	0	7.5	7.5	0	0
91.2	91.2	1669.79	3.796	8.795	9-A2t	-1	2.205	7.5	7.5	1.443	0
182.4	182.4	1669.93	5.478	8.928	9-A2t	-1	3.152	7.5	7.5	2.887	0
273.6	273.6	1670.15	6.738	9.151	9-A2t	-1	3.891	7.5	7.5	4.33	0
364.8	364.8	1670.46	7.817	9.46	9-A2t	-1	4.524	7.5	7.5	5.774	0
456	456	1670.86	8.776	9.855	9-A2t	-1	5.083	7.5	7.5	7.217	0
547.2	547.2	1671.33	9.669	10.334	9-A2t	-1	5.591	7.5	7.5	8.66	0
638.4	638.4	1671.89	10.539	10.894	9-A2t	-1	6.061	7.5	7.5	10.104	0
729.6	729.6	1672.53	11.424	11.532	9-A2t	-1	6.494	7.5	7.5	11.547	0
820.8	820.8	1673.36	12.356	12.25	9-JA2t	-1	6.901	7.5	7.5	13.01	0
912	912	1674.36	13.357	13.051	9-JA2t	-1	7.278	7.5	7.5	14.456	0

****

Crest Elevation: 1674.5 Culvert Slope: -0.2500

****

Site Data

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1661.00 ft

Outlet Station: 5.00 ft

Outlet Elevation: 1662.25 ft

Number of Barrels: 1

Culvert Data Summary

Barrel Shape: Circular

Barrel Diameter: 10.00 ft

Barrel Material: Smooth HDPE

Barrel Manning's n: 0.012

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Tailwater Channel Data

Tailwater Channel Option: Enter Constant Tailwater Elevation

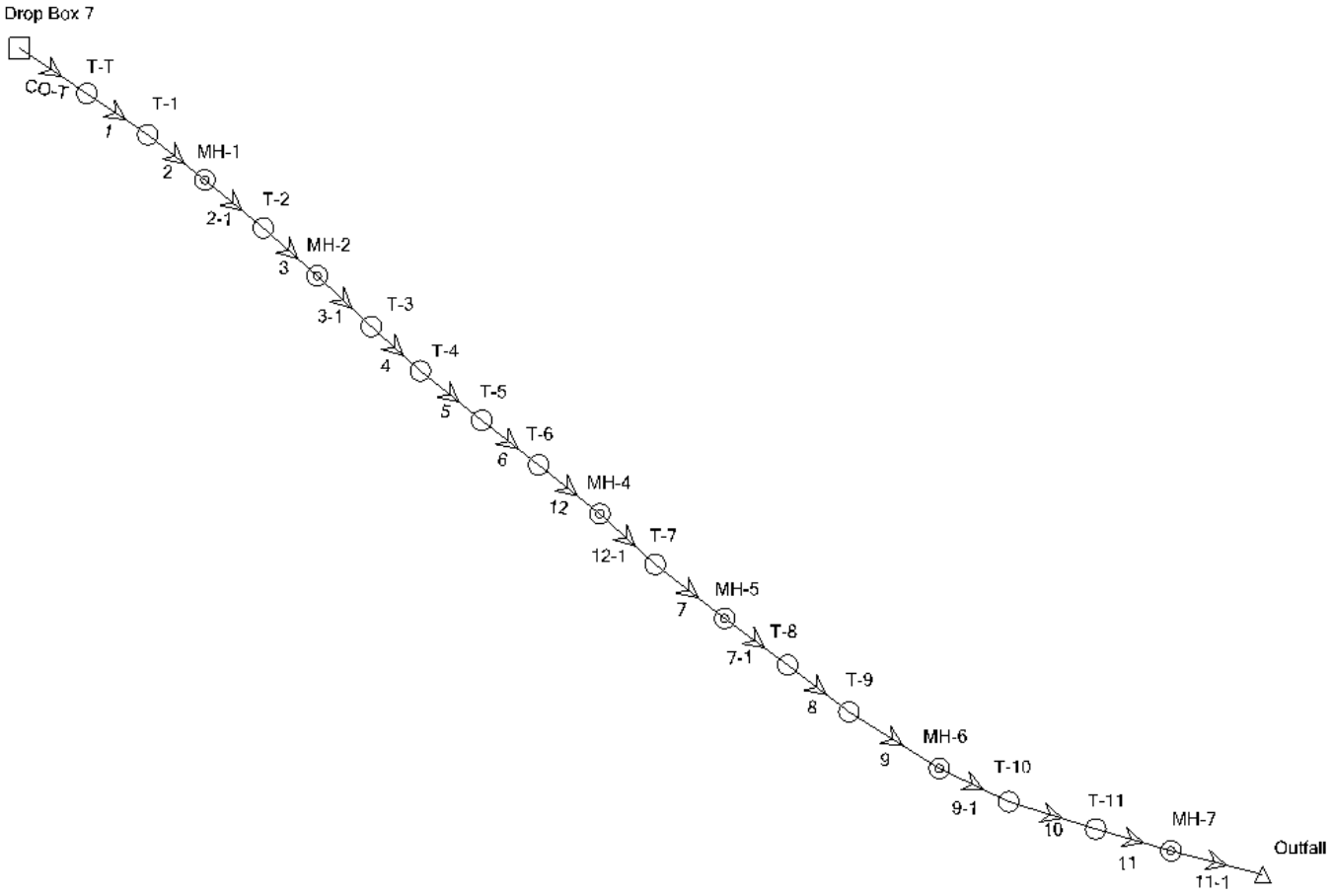
Constant Tailwater Elevation: 1669.75 ft*

*1669.75 ft. represents the elevation when the 7.5' section of pipe is flowing at full capacity.

The headwater elevation (water surface elev. in Drop Box 7) resulting from the proposed culvert S2-1 is 1674.36 ft, and will be contained. The top elevation of Drop Box 7 is 1674.5, which is shown on the details provided in the E&S drawings included in this package.

Pipe Capacity Assessment (StormCAD V8i)

The calculation performed in StormCAD is based on the schematic is shown below, which is a preliminary model of Culvert S2-1. The length of the culvert has decreased, along with the number of manhole locations. With the invert elevations remaining the same, the analysis provided below represents a conservative approach.



SUBJECT CURLEY HOLLOW SWMF

CULVERT S2-1 ASSESSMENT

BY KMB2 DATE 4/4/2013 PROJ. NO. C060702.52

CHKD. BY KMB DATE 4/4/2013 SHEET NO. 4 OF 4

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Pipe Segment Results

Pipe ID	Start Node	Stop Node	Length (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Slope (ft/ft)	Energy Grade Line (In Link) (ft)	Energy Grade Line (Out Link) (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
CO-T	Drop Box 7	T-T	20	1,661.00	1,660.66	0.017	1,670.83	1,670.52	1,667.60	1,667.60
1	T-T	T-1	272.7	1,660.66	1,657.04	0.013	1,671.76	1,668.17	1,667.34	1,663.98
2	T-1	MH-1	38.9	1,657.04	1,656.22	0.021	1,668.14	1,667.40	1,663.71	1,663.34
2-1	MH-1	T-2	166.2	1,656.22	1,652.73	0.021	1,667.32	1,663.86	1,662.89	1,659.67
3	T-2	MH-2	112.5	1,652.73	1,650.36	0.021	1,663.83	1,661.55	1,659.40	1,657.48
3-1	MH-2	T-3	64.5	1,650.36	1,649.01	0.021	1,661.46	1,660.14	1,657.04	1,655.95
4	T-3	T-4	111.4	1,649.01	1,647.92	0.01	1,660.11	1,659.05	1,655.68	1,654.86
5	T-4	T-5	65.2	1,647.92	1,647.28	0.01	1,659.02	1,658.41	1,654.59	1,654.22
6	T-5	T-6	43.8	1,647.28	1,646.85	0.01	1,658.38	1,657.98	1,653.95	1,653.79
12	T-6	MH-4	17.8	1,646.85	1,646.53	0.018	1,657.95	1,657.72	1,653.52	1,653.65
12-1	MH-4	T-7	111.4	1,646.53	1,644.57	0.018	1,657.63	1,655.70	1,653.21	1,651.51
7	T-7	MH-5	160.8	1,644.57	1,641.74	0.018	1,655.67	1,652.92	1,651.25	1,648.86
7-1	MH-5	T-8	85.3	1,641.74	1,640.23	0.018	1,652.84	1,651.37	1,648.41	1,647.18
8	T-8	T-9	156.1	1,640.23	1,637.48	0.018	1,651.34	1,648.62	1,646.91	1,644.43
9	T-9	MH-6	36.1	1,637.48	1,636.85	0.018	1,648.59	1,648.03	1,644.16	1,643.97
9-1	MH-6	T-10	67.2	1,636.85	1,635.66	0.018	1,647.95	1,646.80	1,643.52	1,642.61
10	T-10	T-11	54.6	1,635.66	1,634.70	0.018	1,646.77	1,645.83	1,642.34	1,641.64
11	T-11	MH-7	24.5	1,634.70	1,634.27	0.018	1,645.80	1,645.46	1,641.38	1,641.39
11-1	MH-7	Outfall	224.5	1,634.27	1,630.32	0.018	1,645.37	1,643.49	1,640.95	1,635.18

Manhole Data Results

Manhole ID	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
MH-1	1,656.22	1,656.22	1,663.34	1,662.89
MH-2	1,650.36	1,650.36	1,657.48	1,657.04
MH-4	1,646.53	1,646.53	1,653.65	1,653.21
MH-5	1,641.74	1,641.74	1,648.86	1,648.41
MH-6	1,636.85	1,636.85	1,643.97	1,643.52
MH-7	1,634.27	1,634.27	1,641.39	1,640.95

Drop Box 7 Results

Catch Basin ID	Elevation (Ground) (ft)	Elevation (Invert) (ft)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)
Drop Box 7	1,674.50	1,661.00	1,670.83	1,667.60

The results show that along the culvert, the flow depth in the shallowest region (Pipes 5 and 6) is around 6.7 feet. All flow will be contained in the drop box and in the manholes.

DROP BOXES

Calculation package includes:
1. Drop Box 2 Evaluation for Sediment Pond Expansion

Note: Drop Box 2.5 calculations are in the "Culverts" section.

DROP BOX 2 EVALUATION FOR SEDIMENT POND EXPANSION OCTOBER 25, 2013 PERMIT AMENDMENT 009 APPROVED DECEMBER 20, 2012

SUBJECT CURLEY HOLLOW SWMF

DROP BOX 2 (Stage 2 sediment pond modification) CALCULATION SUMMARY

BY KMB2 DATE 8/1/2013 PROJ. NO. C060702.52

CHKD. BY KMB DATE 8/1/2013 SHEET NO. 1 OF 2

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INTRODUCTION

As a result of the modifications to the existing Sediment Pond and corresponding drainage areas at the Curley Hollow Solid Waste Facility, the existing Drop Box 2 which is situated to the southeast, and upstream of the Sediment Pond. Revisions have been made to the drainage areas of the existing Sediment Pond and consequently the volume of the existing Sediment Pond itself. This calculation will evaluate the adequacy of Drop Box 2 with the revisions to the drainage areas.

MODIFICATION SUMMARY

Hydrologic analyses of the landfill stages were submitted in the 2013 Erosion and Sediment Control Plan, providing the corresponding peak flows to Drop Box 2. The Stage 2 Subgrade Model represented the landfill stage that results in the highest peak flow to Drop Box 2. An approximate area of 3.3 acres, which drains to the roadside ditch along Coal Loop Road to the South of the Sediment Pond, is to enter existing Drop Box 2 via an 18" HDPE culvert. The Stage 2 Subgrade Model has been modified to incorporate the additional flow into the box, and the results of both models are shown below.

Model	25-yr (cfs)	100-yr (cfs)
Stage 2 Subgrade	480	589
Stage 2 Subgrade (Modified)	495	609

Drop Box 2 has a primary outflow (Channel S1A-1), and an emergency overflow channel, which currently drains to the area directly south of the Sediment Pond. Under the 25-year storm, the box is not to discharge sediment-laden water through the emergency overflow weir. Therefore, the stage-discharge relationship of Drop Box 2 is evaluated and compared to the flow capacity of Channel S1A-1 in order to determine if Drop Box 2 can adequately pass the 25-year storm event.

CALCULATIONS

Drop Box 2

The outlet of Drop Box 2 to Channel S1A-1 is a set of three square (4' x 4') orifices. The table on the following page shows the discharge given the water level inside the drop box. The relevant inverts of the box are:

- Bottom of Box Elev. = 1632.42
- Top of Box Elev. = 1645.92
- Overflow Weir Invert = 1642.92

SUBJECT CURLEY HOLLOW SWMF

DROP BOX 2 (Stage 2 sediment pond modification) CALCULATION SUMMARY

BY KMB2 DATE 8/1/2013 PROJ. NO. C060702.52

CHKD. BY KMB DATE 8/1/2013 SHEET NO. 2 OF 2

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Stage-Discharge Table

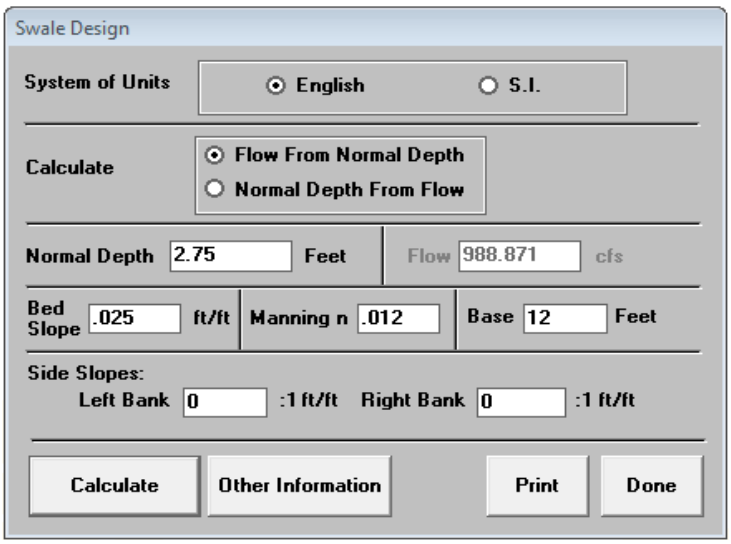
Elev. (ft)	Head on orifice	Flow in orifice
1632.42	0	0.0
1633	0.00	0.0
1634	0.00	0.0
1635	0.58	176.0
1636	1.58	290.5
1637	2.58	371.2
1638	3.58	437.3
1639	4.58	494.6
1640	5.58	545.9
1641	6.58	592.9
1642	7.58	636.3
1643	8.58	677.0
1642.92	8.50	673.8
1644	9.58	715.3
1645	10.58	751.8
1645.92	11.50	783.8

ORIFICE DATA	
Rectangular	
Height (ft)	4
Invert	1632.42
Area (sf)	48.000
CL el.	1634.42
C	0.6

The tables show that at a water level of 1642.92 in Drop Box 2 produces an outflow of 674 cfs, which is significantly less than the 25-year peak inflow (495 cfs), and the box will adequately pass the design flow without discharging through the overflow weir.

Channel S1A-1

Channel S1A-1 is a concrete channel with a 12 ft. bottom width, a 3.75 ft. depth, and vertical walls. The computer program VTPSUHM was used to analyze the capacity of the channel with a 1' freeboard at the mildest slope.



The results show that the flow capacity in Channel S1A-1 of 989 cfs is significantly higher than the discharge rate of Drop Box 2, and is adequate in handling the 25-year storm event.

SEDIMENTATION POND

Calculation package includes:
1. Dominion - Curley Hollow Solid Waste Facility
   Sedimentation Pond Analyses

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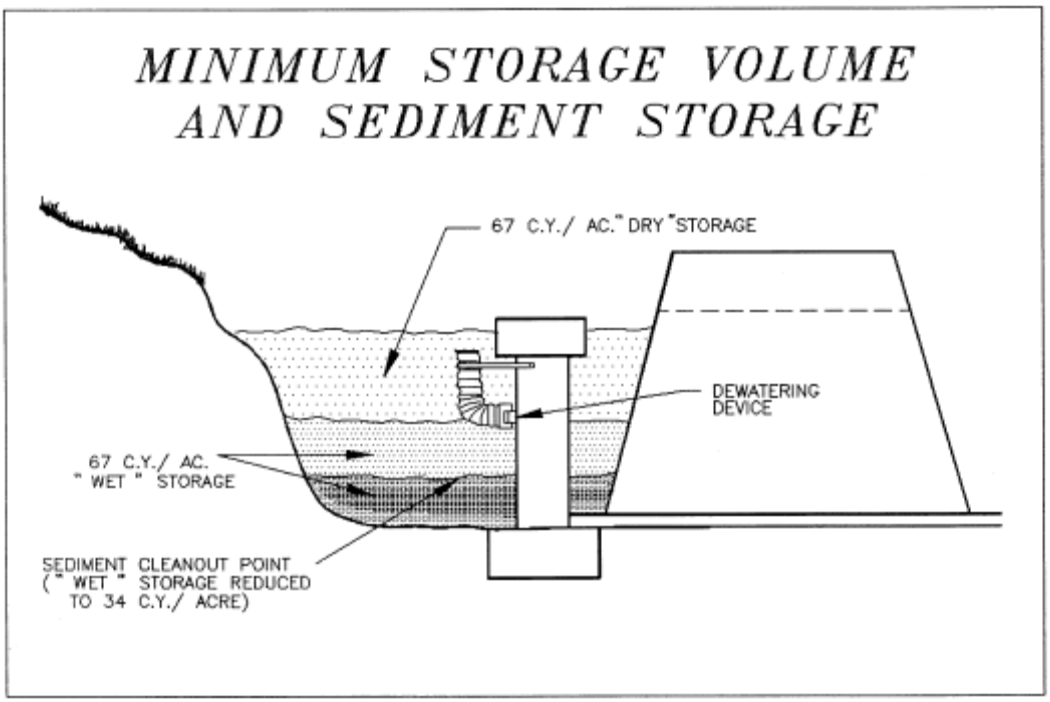
INTRODUCTION

The existing Sedimentation Pond at the Curley Hollow Solid Waste Management Facility has been sized for the duration of activities at the facility. This calculation will evaluate the adequacy of the pond's volume required and other necessary design features. Storage and discharge required will be based on Virginia Erosion and Sedimentation Control (E&S) and Stormwater Management (SWM) Regulations.

STORAGE REQUIRED

From the Virginia E&S Regulations, the following storage criteria will be utilized for the Sedimentation Pond:

- Capacity of at least 134 cubic yards per contributing acre
- 67 cubic yards per acre is to be permanent pool
- 67 cubic yards is to be drawdown area
- Sediment cleanout shall occur when wet storage is reduced to 34 cubic yards per acre (sediment occupies 33 cubic yards per acre)



Source: Va. DSWC Plate 3.14-1

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Storage Required continued

The Sedimentation Pond has been utilized from the initial earth disturbances to create the subgrade at the Curley Hollow Solid Waste Management Facility and will function throughout the facility's life.

202	acres of landfill area, maximum watershed possible over site life
8.6	acres of additional haul road draining to pond outside of landfill area
211	acres total
67	cy per watershed acre of wet volume yields
14,137	cy wet volume required
8.76	acre-feet wet volume required
67	cy per watershed acre of dry volume yields
14,137	cy dry volume required
8.76	acre-feet dry volume required
33	cy per watershed acre required sediment cleanout volume, maximum
6,963	cy volume at maximum sediment cleanout level
4.32	acre-feet volume at maximum sediment cleanout level

STORAGE PROVIDED

Assess the storage provided in the Sedimentation Pond and establish required wet and dry storage levels. Use average areas between elevations to calculate volume. Data in italics are interpolated for the given elevation.

Sedimentation Pond

Elevation (ft)	Surface Area (ac)	Total Volume (ac ft)	
1602	0.12	0.00	
1604	0.34	0.46	
1606	0.79	1.60	
1608	0.99	3.39	
1608.9	*1.05*	*4.30*	<--- Sediment Cleanout Elevation
1610	1.13	5.50	
1612	1.26	7.89	
1612.7	*1.31*	*8.79*	<--- Wet Volume Elevation
1614	1.40	10.55	
1616	1.54	13.50	8.8 ac-ft
1618	1.69	16.73	
1618.5	*1.72*	*17.59*	<--- Top of Required Dry Volume
1618.75	*1.74*	*18.02*	<--- Riser Crest Elevation
1620	1.83	20.26	
1622	1.98	24.07	
1624	2.13	28.19	

DISCHARGE REQUIREMENTS

From the Virginia E&S Regulations, the principal and emergency spillways must meet the following:

- The principal spillway must pass the peak flow from a 2-year 24-hour storm
- The two spillways combined must be capable of discharging the peak flow from a 25-year 24-hour storm with a minimum freeboard of one foot.
- The principal spillway riser crest must be a minimum of one foot below the emergency spillway crest.

In addition, since the pond will function as a long-term SWM pond, the SWM regulations state that the pond must adequately discharge the peak flow from a 100-year 24-hour storm.

The discharge system will consist of:

- 4.5-foot diameter High Density Polyethylene (HDPE) pipe used as a riser (crest elevation 1618.75)
- 3-foot diameter HDPE pipe used as a barrel
- Trapezoidal emergency spillway with 20-foot bottom width and 6:1 side slopes (to facilitate driving around the pond embankment). Crest elevation is 1620 (1.25 feet above the principal spillway crest).

Discharge Requirements continued

The 2-year, 25-year, and 100-year storms will be routed through the Sedimentation Pond as part of the landfill staging hydrologic analyses. The results are located in the hydrology sections of the calculations. Summarizing the results of the analyses:

Facility Development Phase	Storm Event	Maximum Discharge (cfs)	Maximum Water Surface Elevation
Stage 1A / Existing	2-year	0	1617.4
	10-year	33	1619.6
	25-year	76	1620.2
	100-year	221	1621.5
Stage 1B Subgrade	2-year	19	1619.5
	10-year	240	1622.0
	25-year	358	1622.5
	100-year	597	1623.3
Stage 2 Subgrade	2-year	96	1620.3
	10-year	485	1622.7
	25-year	606	1623.1
	100-year	820	1623.7
Stage 3 Subgrade	2-year	11	1619.2
	10-year	167	1621.1
	25-year	260	1621.7
	100-year	458	1622.6
Final Site Configuration	2-year	26	1619.4
	10-year	355	1622.2
	25-year	515	1622.8
	100-year	827	1623.7

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ADDITIONAL DESIGN FEATURES

Length to Width Ratio

The Virginia E&S Regulations dictate that "the effective flow length must be twice the effective flow width." The lateral dimensions of the Sedimentation Pond are:

Length = 650 feet at the pond crest along the centerline
Width = approximately 200 feet maximum at the pond crest

Length/Width ratio = 3.25, which is acceptable

Anti-Seep Considerations

The Virginia E&S Regulations require the use of an anti-seep collar or an alternative "filter diaphragm" around the principal spillway barrel. Since the Sedimentation Pond barrel will be constructed in cut, a filter diaphragm will be incorporated around the barrel. The calculation for this is attached at the end of this set.

Toe Drain

Since the pond will not be lined, a toe drain will be incorporated to the portion of the embankment in fill material. The calculation for this is attached at the end of this set.

Embankment Armoring for Flood Protection

A portion of the pond embankment will be within the 100-year flood plain for Meade Creek. Riprap armor protection will be provided. The design for this is included in the Meade Creek flood analysis calculations.

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EMERGENCY SPILLWAY

From the pond routing calculations, the emergency spillway will be a trapezoidal channel through the pond embankment with 20-foot bottom width, invert elevation 1620, and 6:1 side slopes (to accommodate driving through the spillway while it is not discharging).

The emergency spillway will pass the 100-year peak discharge below the pond crest elevation. A hydraulic assessment of the spillway follows:

Sedimentation Pond

Evaluate the stage-discharge characteristics of the emergency spillway for the North Sedimentation Pond

Spillway elevation	1620	
Bottom width	20	(L in rectangular weir equation)
Weir coefficient C	2.8	
Coefficient of discharge Cd	0.622	
Side Slopes	6 :1	(USE 6:1 SIDE SLOPES TO ALLOW DRIVING)
θ (degrees)	161	

The spillway will be divided as follows:

Flow through the rectangular section can be defined by the rectangular weir equation: $Q = C\ L\ H^{3/2}$

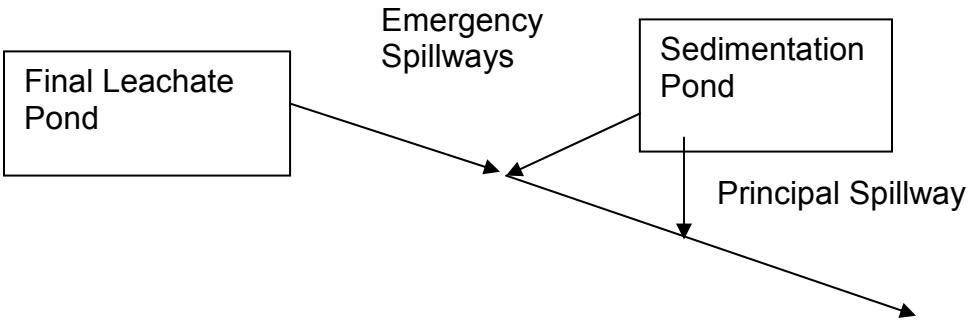
Flow through the triangular section can be defined by the triangular weir equation: $Q = C_d\ (8/15)\ (2g)^{1/2}\ \tan(\theta/2)\ h^{5/2}$

Elevation (ft)	Head over spillway (ft)	Rectangular section flow (cfs)	Triangular section flow (cfs)	Total flow (cfs)
1620	0	0	0	0
1621	1	56	16	72
1622	2	158	90	248
1623	3	291	248	539
1624	4	448	509	957

The emergency spillway will be lined with articulated concrete block to maintain integrity and allow driving over the surface.

Emergency Spillway continued

Once the spillway passes the brink of the pond embankment, the discharge will be carried by a system of drainage channels:



The spillway channel conveyance system is evaluated in a separate section of the calculations.

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DEWATERING

Virginia E&S Regulations state that the dewatering orifice must dewater the dry storage volume in at least 6 hours (use 24 hours). From the regulations:

A = flow area of orifice, in square feet

d = diameter of circular orifice, in feet

h = average driving head (maximum possible head measured from radius of orifice to crest of principal spillway divided by 2), in feet

Q = volumetric flowrate through orifice needed to achieve approximate 6-hour drawdown, cubic feet per second

S = total storage available in dry storage area, cubic feet

Q = S / 21,600 seconds

Use S for basin and find Q. Then substitute in calculated Q and find A:

$$A = \frac{Q}{\left(64.32 \times h\right)^{\frac{1}{2}} (0.6)}$$

Then, substitute in calculated A and find d:

$$d* = 2 \times \left(\frac{A}{3.14}\right)^{\frac{1}{2}}$$

The above example calculation, from the Virginia E&S manual, use a dewatering time of 6 hours (21,600 seconds). For the Curley Hollow Sedimentation Pond, use a dewatering time of 24 hours.

Dewatering continued

S = dry storage available =	9.23	acre-feet
Volume at riser crest =	18.02	acre-feet
Actual volume provided at wet storage level =	8.79	acre-feet
S = 402,059	cubic feet	
Use drawdown of 24 hours =	86,400	sec
Q = S / 86,400 seconds =	4.0	cfs
Invert elevation of orifice =	1612.7	
Riser crest elevation =	1618.75	
Average head =	3.02	feet
Required area =	0.48	sf
Required orifice diameter =	0.78	feet
	9.4	inches

Use a 21 inch orifice
Use a 24 inch perforated tube

SEDIMENTATION POND AS STORMWATER MANAGEMENT POND

Design calculations for a culvert system underneath the proposed Singapura Road relocation utilized existing conditions in the Curley Hollow watershed to produce design flows. The basis for using existing conditions in the watershed is that the Sedimentation Pond will serve as a stormwater management pond for the watershed, so that post-development peak discharges from the watershed are not greater than pre-development peak discharges. Virginia Department of Environmental Quality (DEQ) regulations state that the post-development peak 2-year and 10-year discharges from a watershed must not be greater than the predevelopment discharges. Conversations with the DEQ indicate that meeting 2-year and 10-year pre-development peak discharges during intermediate development is not a necessity, and, in fact, the required pond volume usually dampens peak flow sufficiently to meet pre-development conditions.

Stormwater Management continued

The existing peak discharges calculated from the Singapura Road culvert design are:

2-year	91 cfs
10-year	262 cfs
25-year	323 cfs
100-year	452 cfs

Comparing the above peak discharges to the summarized Sedimentation Pond discharges (sheet 5), it can be seen that "post-development" discharges are less than pre-development discharges except for two situations – Stage 1 subgrade development and final configuration of the Curley Hollow Solid Waste Management Facility. Of these two cases, the Stage 1 subgrade case is a very short-term interim phase, the 2-year requirement is met, and the 10-year flow is increased from 262 cfs to 309 cfs (18%). All hydrology calculations for the facility summarized on sheet 5 have been based on determining peak flows for individual drainage channels, and the hydrographs for these channels have been added together to route the flow through the ponds. Taken over the entire watershed, this procedure produces a conservative result, as the time of concentration for the entire watershed would be longer than that for the individual channels. In addition, E&S criteria dictate that the dewatering orifice in the riser not be considered when determining discharge characteristics of the pond, in the case that the dewatering sleeve would clog, also producing conservative results.

As a stormwater management pond, after site closure an orifice could be installed in the riser to allow flow from the pond at elevation 1610, the riser outlet pipe invert elevation. Using a 6-inch orifice at 1610, with an overall time of concentration for the entire watershed, produces the following (see attached hydrologic calculations after this page):

2-year	17 cfs
10-year	253 cfs
25-year	368 cfs
100-year	600 cfs

The pre-development/post-development discharge criteria are met for this pond. As a result, the receiving stream from the watershed (Meade Creek) will not see additional flow after site closure.

FINAL PILE
PEAK DISCHARGE
HYDROLOGY