APPENDIX F

Drainage Features

DRAINAGE ANALYSIS

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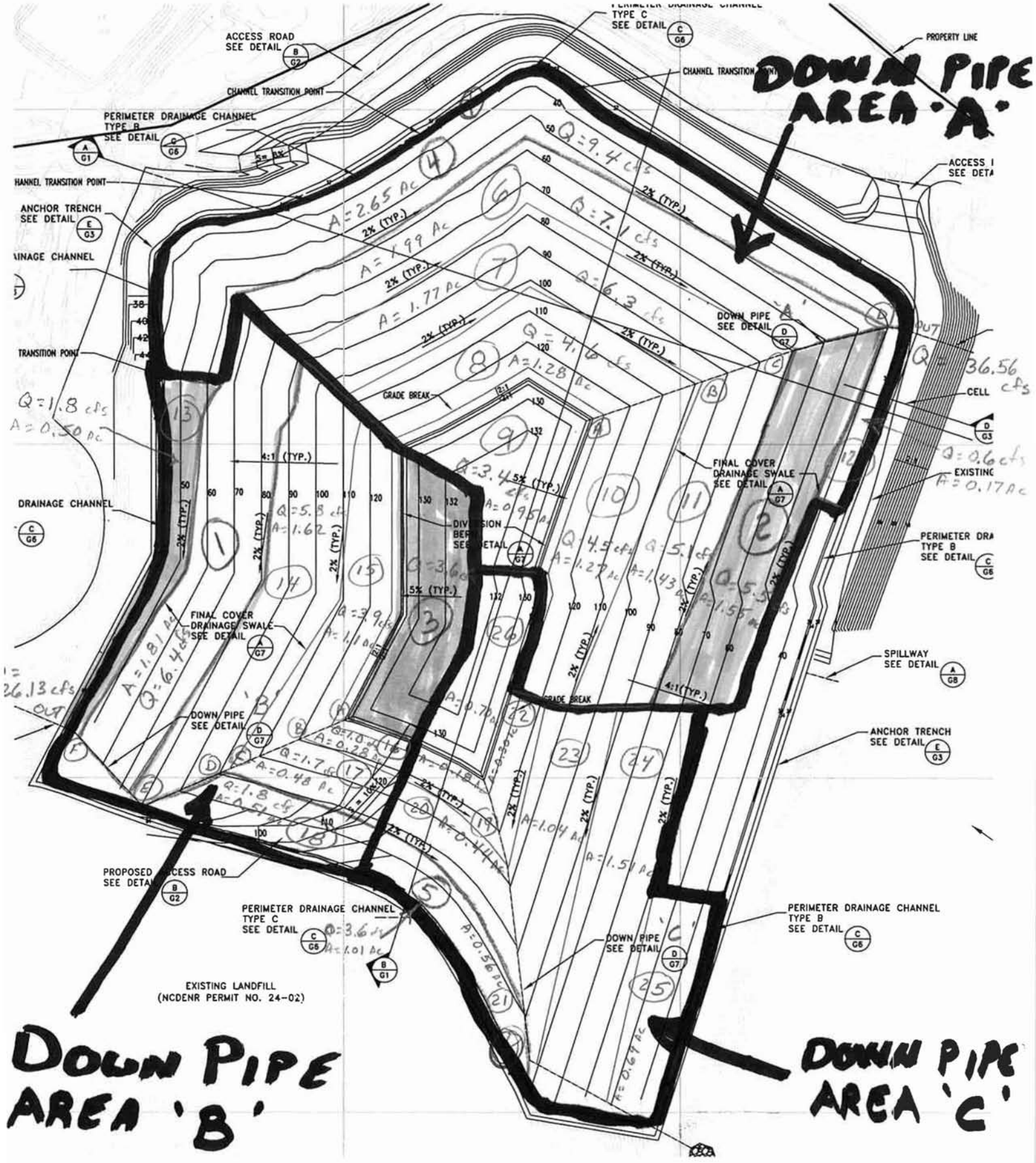
DOWN PIPE AREA 'A'
DOWN PIPE AREA 'B'
DOWN PIPE AREA 'C'
ACCESS ROAD SEE DETAIL
PERIMETER DRAINAGE CHANNEL TYPE C SEE DETAIL
PROPERTY LINE
CHANNEL TRANSITION POINT
PERIMETER DRAINAGE CHANNEL TYPE B SEE DETAIL
ANCHOR TRENCH SEE DETAIL
DRAINAGE CHANNEL
TRANSITION POINT
GRADE BREAK
DOWN PIPE SEE DETAIL
FINAL COVER DRAINAGE SWALE SEE DETAIL
DIVERSION BERM SEE DETAIL
SPILLWAY SEE DETAIL
PROPOSED ACCESS ROAD SEE DETAIL
EXISTING LANDFILL (NCDENR PERMIT NO. 24-02)
Q=9.4 cfs
Q=7.1 cfs
Q=6.3 cfs
Q=4.6 cfs
Q=36.56 cfs
Q=1.8 cfs
A=0.50 Ac
Q=0.6 cfs
A=0.17 Ac
Q=5.8 cfs
A=1.62
Q=3.4 cfs
Q=4.5 cfs
A=1.27 Ac
Q=5.1 cfs
A=1.43 Ac
Q=5.5 cfs
A=1.55 Ac
Q=3.6 cfs
Q=3.9 cfs
A=1.81 Ac
Q=6.4 cfs
Q=1.7 cfs
A=0.48 Ac
Q=1.8 cfs
A=0.51 Ac
Q=3.6 cfs
A=1.01 Ac
A=2.65 Ac
A=1.99 Ac
A=1.77 Ac
A=1.28 Ac
A=0.95 Ac
A=0.70 Ac
A=1.04 Ac
A=1.59 Ac
A=0.56 Ac
A=0.69 Ac
2% (TYP.)
5% (TYP.)
4:1 (TYP.)

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design#1		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.81 acres

Q_p = 6.4 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =**	**0.634**	
		C =	**0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.000**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**6.4**	**cfs**

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

North Carolina 34.351754 N 78.205299 W 9 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 3
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004

Extracted: Thu May 7 2009

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Docs

Precipitation Intensity Estimates (in/hr)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	
1	5.83	4.66	3.88	2.66	1.66	0.98	0.70	0.42	0.25	0.14	0.08	0.05	0.03	0.02	0.02	0.01	0.01	0
2	6.92	5.53	4.64	3.20	2.01	1.19	0.85	0.52	0.30	0.17	0.10	0.06	0.04	0.03	0.02	0.02	0.01	0
5	8.09	6.48	5.46	3.88	2.49	1.52	1.08	0.66	0.39	0.22	0.13	0.07	0.05	0.04	0.02	0.02	0.02	0
10	9.01	7.20	6.07	4.40	2.87	1.78	1.28	0.78	0.46	0.27	0.15	0.08	0.06	0.04	0.03	0.02	0.02	0
25	10.16	8.10	6.84	5.07	3.37	2.16	1.58	0.97	0.57	0.34	0.19	0.10	0.07	0.05	0.03	0.03	0.02	0
50	11.04	8.78	7.42	5.59	3.78	2.48	1.83	1.13	0.67	0.40	0.22	0.12	0.08	0.06	0.04	0.03	0.02	0
100	11.92	9.47	7.98	6.11	4.21	2.83	2.11	1.30	0.78	0.47	0.26	0.14	0.09	0.07	0.04	0.03	0.03	0
200	12.79	10.13	8.52	6.64	4.65	3.20	2.42	1.50	0.91	0.54	0.30	0.16	0.10	0.07	0.05	0.03	0.03	0
500	13.93	11.02	9.24	7.35	5.28	3.75	2.88	1.79	1.10	0.66	0.37	0.19	0.12	0.09	0.05	0.04	0.03	0
1000	14.86	11.69	9.79	7.92	5.78	4.21	3.28	2.05	1.26	0.77	0.42	0.21	0.13	0.10	0.06	0.04	0.03	0

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

*** Upper bound of the 90% confidence interval Precipitation Intensity Estimates (in/hr)**

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	
1	6.32	5.05	4.21	2.88	1.80	1.07	0.77	0.47	0.28	0.16	0.09	0.05	0.03	0.03	0.02	0.01	0.01	0
2	7.50	6.00	5.03	3.47	2.18	1.30	0.94	0.57	0.34	0.19	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0
5	8.77	7.02	5.92	4.21	2.70	1.66	1.19	0.73	0.43	0.25	0.14	0.08	0.05	0.04	0.03	0.02	0.02	0
10	9.74	7.79	6.57	4.76	3.10	1.95	1.41	0.86	0.52	0.30	0.17	0.09	0.06	0.05	0.03	0.02	0.02	0
25	10.97	8.74	7.38	5.47	3.64	2.36	1.73	1.06	0.64	0.37	0.21	0.11	0.07	0.06	0.04	0.03	0.02	0
50	11.90	9.49	8.00	6.03	4.08	2.71	2.01	1.24	0.75	0.44	0.25	0.13	0.08	0.06	0.04	0.03	0.02	0
100	12.86	10.22	8.61	6.59	4.54	3.08	2.31	1.43	0.87	0.52	0.29	0.15	0.10	0.07	0.04	0.03	0.03	0
200	13.80	10.94	9.20	7.16	5.02	3.49	2.65	1.64	1.00	0.60	0.34	0.17	0.11	0.08	0.05	0.04	0.03	0
500	15.06	11.92	10.00	7.95	5.71	4.09	3.15	1.96	1.21	0.74	0.41	0.21	0.13	0.09	0.06	0.04	0.03	0
1000	16.09	12.67	10.60	8.58	6.27	4.61	3.60	2.25	1.39	0.86	0.47	0.24	0.14	0.11	0.06	0.05	0.04	0

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

*** Lower bound of the 90% confidence interval Precipitation Intensity Estimates (in/hr)**

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design#1		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2): 4.1 in.

Total T_c = 0.05 hrs.

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	8					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.000**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

North Carolina 34.351754 N 78.205299 W 9 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 3
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NOAA, National Weather Service, Silver Spring, Maryland, 2004

Extracted: Thu May 7 2009

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Docs

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	
1	0.49	0.78	0.97	1.33	1.66	1.96	2.09	2.54	2.98	3.42	4.00	4.50	5.22	5.91	7.96	9.90	12.40	1
2	0.58	0.92	1.16	1.60	2.01	2.38	2.55	3.09	3.63	4.14	4.83	5.42	6.29	7.08	9.47	11.75	14.65	1
5	0.67	1.08	1.37	1.94	2.49	3.03	3.25	3.96	4.67	5.36	6.19	6.87	7.91	8.76	11.54	14.10	17.36	2
10	0.75	1.20	1.52	2.20	2.87	3.56	3.86	4.70	5.58	6.43	7.38	8.10	9.26	10.16	13.25	16.00	19.55	2
25	0.85	1.35	1.71	2.53	3.37	4.32	4.74	5.79	6.93	8.07	9.17	9.93	11.22	12.20	15.68	18.64	22.56	2
50	0.92	1.46	1.85	2.79	3.78	4.96	5.50	6.74	8.11	9.52	10.75	11.51	12.87	13.91	17.68	20.75	24.95	2
100	0.99	1.58	2.00	3.06	4.21	5.66	6.34	7.80	9.44	11.17	12.52	13.25	14.67	15.74	19.79	22.92	27.38	3
200	1.07	1.69	2.13	3.32	4.65	6.40	7.27	8.97	10.93	13.04	14.52	15.17	16.61	17.71	22.03	25.16	29.88	3
500	1.16	1.84	2.31	3.68	5.28	7.50	8.66	10.74	13.21	15.91	17.56	18.09	19.45	20.57	25.19	28.25	33.27	3
1000	1.24	1.95	2.45	3.96	5.78	8.43	9.86	12.28	15.21	18.45	20.20	20.60	21.82	22.93	27.77	30.68	35.93	3

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	
1	0.53	0.84	1.05	1.44	1.80	2.14	2.31	2.81	3.33	3.79	4.41	4.94	5.69	6.40	8.55	10.58	13.19	1
2	0.62	1.00	1.26	1.74	2.18	2.61	2.81	3.42	4.05	4.61	5.34	5.96	6.86	7.67	10.19	12.57	15.59	1
5	0.73	1.17	1.48	2.10	2.70	3.31	3.58	4.37	5.21	5.95	6.84	7.54	8.61	9.49	12.40	15.07	18.46	2
10	0.81	1.30	1.64	2.38	3.10	3.89	4.24	5.17	6.21	7.12	8.14	8.89	10.08	11.02	14.22	17.10	20.79	2
25	0.91	1.46	1.85	2.73	3.64	4.72	5.20	6.36	7.68	8.92	10.12	10.90	12.22	13.22	16.84	19.93	24.02	2
50	0.99	1.58	2.00	3.01	4.08	5.42	6.03	7.40	8.98	10.53	11.88	12.65	14.03	15.10	19.02	22.22	26.59	3
100	1.07	1.70	2.15	3.30	4.54	6.17	6.94	8.54	10.44	12.36	13.88	14.60	16.02	17.12	21.37	24.60	29.25	3
200	1.15	1.82	2.30	3.58	5.02	6.98	7.94	9.82	12.08	14.45	16.15	16.78	18.20	19.34	23.88	27.09	32.04	3
500	1.25	1.99	2.50	3.98	5.71	8.18	9.47	11.76	14.60	17.74	19.64	20.14	21.47	22.62	27.52	30.62	35.88	3
1000	1.34	2.11	2.65	4.29	6.27	9.22	10.80	13.47	16.79	20.68	22.73	23.10	24.25	25.40	30.54	33.44	38.97	4

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.

Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	

TABLE 5-2
VALUES OF RUNOFF COEFFICIENT (C) FOR RATIONAL FORMULA

Land Use	C	Land Use	C
Business:		Lawns:	
Downtown areas	0.70-0.95	Sandy soil, flat, 2%	0.05-0.10
Neighborhood areas	0.50-0.70	Sandy soil, average, 2-7%	0.10-0.15
		Sandy soil, steep, 7%	0.15-0.20
		Heavy soil, flat, 2%	0.13-0.17
		Heavy soil, average, 2-7%	0.18-0.22
		Heavy soil, steep, 7%	0.25-0.35
Residential:		Agricultural land:	
Single-family areas	0.30-0.50	Bare packed soil	
Multi units, detached	0.40-0.60	* Smooth	0.30-0.60
Multi units, attached	0.60-0.75	* Rough	0.20-0.50
Suburban	0.25-0.40	Cultivated rows	
		* Heavy soil, no crop	0.30-0.60
		* Heavy soil, with crop	0.20-0.50
		* Sandy soil, no crop	0.20-0.40
		* Sandy soil, with crop	0.10-0.25
		Pasture	
		* Heavy soil	0.15-0.45
		* Sandy soil	0.05-0.25
		Woodlands	0.05-0.25
Industrial:		Streets:	
Light areas	0.50-0.80	Asphaltic	0.70-0.95
Heavy areas	0.60-0.90	Concrete	0.80-0.95
		Brick	0.70-0.85
Parks, cemeteries	0.10-0.25	Unimproved areas	0.10-0.30
Playgrounds	0.20-0.35	Drives and walks	0.75-0.85
Railroad yard areas	0.20-0.40	Roofs	0.75-0.95

Note: The designer must use judgement to select the appropriate "C" value within the range. Generally, larger areas with permeable soils, flat slopes and dense vegetation should have the lowest C values. Smaller areas with dense soils, moderate to steep slopes, and sparse vegetation should be assigned the highest C values.

Source: American Society of Civil Engineers

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.810**	**0.35**	0.634
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.81		0.63

Manning's n for Sheet Flow	
Surface Description	n
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.050
Cultivated soils:	
- Residue cover <= 20%	0.060
- Residue cover > 20%	0.170
Grass types:	
- Short grass prairie	0.150
- Dense grass[1]	0.240
- Bermuda grass	0.410
Range (natural)	0.130
Woods:[2]	
- Light underbrush	0.400
- Dense underbrush	0.800

Note: [1] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[2] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design#1		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 6.4 cfs

V = 4.57 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.09**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.59**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sand**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.40**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**4.88**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.020**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**4.73**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**6.4**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**4.57**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Drainage Channel#2		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.55 acres

Q_p = 5.5 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") Total CA / Total DA	**CA =** **C =**	**0.543** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.000**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**5.5**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Drainage Channel#2		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	aa	**Date:**	8-Nov-44

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.05**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	13					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.000**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.550**	**0.35**	0.543
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.55		0.54

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Drainage Channel#2		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 5.5 cfs

V = 4.40 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.06**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.56**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.25**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**4.61**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.020**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**4.47**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**5.5**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**4.40**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #3		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.02 acres

Q_p = 3.6 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.357** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.10**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.100**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.001**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**7.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**3.6**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #3		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.10**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.050					ft/ft
Sheet Flow Time	0.100	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.100**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	18					ft
Water Course Slope, S	0.050					ft/ft
Average Velocity, V	3.61	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.001	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.001**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.020**	**0.35**	0.357
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.02		0.36

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #3		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 3.6 cfs

V = 1.60 ft/sec

Channel Characteristics				
Depth of Flow, d_F		d_F =	-0.16	ft
Min. Freeboard, FB		FB =	0.50	ft
Depth of Channel, d_C	$d_c = d_F + FB$	d_C =	0.34	ft
Side Slopes, m	2H:1V or Flatter minimum	m =	20	H:1V
Manning's n	Use Table to find Roughness Coefficient, n	n =	0.020	earth lined-sandy soils
Channel Design				
Channel Bottom Width , b		b =	0.00	ft
Wetted Area, A	$A = m*d_F^2 + d_F*b$	A =	2.25	ft^2
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	P =	13.44	ft
Slope. S	S = change in elevation/distance for change	S =	0.005	ft/ft
Channel Top Width, w	$w = 2*(m*d_c) + b$	w =	13.43	ft
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	Q =	3.6	cfs
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	V =	1.60	ft/sec

Project Name:	IP Reigelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #4a		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 2.65 acres

Q_p = 9.4 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.928** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.001**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**9.4**	**cfs**

Project Name:	IP Reigelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #4a		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.05**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	17					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.001	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.001**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**2.650**	**0.35**	0.928
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	2.65		0.93

Project Name:	IP Reigelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #4a		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 9.4 cfs

V = 2.95 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.18**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.68**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**2.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**3.19**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**7.58**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.005**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**7.42**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**9.4**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**2.95**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #5		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.01 acres

Q_p = 3.6 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =**	**0.354**	
		C =	**0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.046**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.000**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**3.6**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #5		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2): 4.1 in.

Total T_c = 0.05 hrs.

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	85					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.046	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.046**	**hrs.**
Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	0					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.000**	
Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.010**	**0.35**	0.354
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.01		0.35

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #5		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 3.6 cfs

V = 2.28 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**-0.07**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.43**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**2.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.58**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**5.51**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.005**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**5.41**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**3.6**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**2.28**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #6		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.99 acres

Q_p = 7.1 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.697** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.000**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**7.1**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #6		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2): 4.1 in.

Total T_c = 0.05 hrs.

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	9					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.000**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.990**	**0.35**	0.697
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.99		0.70

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #6		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 7.1 cfs

V = 4.69 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.12**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.62**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.51**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**5.07**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.020**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**4.92**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**7.1**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**4.69**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #7		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.77 acres

Q_p = 6.3 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.620** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.000**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**6.3**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #7		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.05**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	9					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.000**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.770**	**0.35**	0.620
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.77		0.62

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #7		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 6.3 cfs

V = 4.55 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.09**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.59**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.38**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**4.85**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.020**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**4.70**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**6.3**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**4.55**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #8		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.28 acres

Q_p = 4.6 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.448** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.001**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**4.6**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #8		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.05**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	29					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.001	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.001**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.280**	**0.35**	0.448
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.28		0.45

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #8		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	

Q_p = 4.6 cfs

V = 4.21 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.02**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.52**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.09**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**4.31**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.020**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**4.18**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**4.6**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**4.21**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #9		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 0.95 acres

Q_p = 3.4 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.333** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.10**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.100**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.001**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**7.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**3.4**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #9		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.10**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.050					ft/ft
Sheet Flow Time	0.100	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.100**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	18					ft
Water Course Slope, S	0.050					ft/ft
Average Velocity, V	3.61	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.001	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.001**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**0.950**	**0.35**	0.333
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	0.95		0.33

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #9		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 3.4 cfs

V = 1.57 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**-0.17**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.33**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**20**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**2.16**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**13.16**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.005**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**13.14**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**3.4**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**1.57**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #10		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.27 acres

Q_p = 4.5 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.445** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.001**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**4.5**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #10		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.05**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	31					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.001	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.001**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.270**	**0.35**	0.445
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.27		0.44

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #10		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 4.5 cfs

V = 4.19 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.02**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.52**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.07**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**4.27**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.020**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**4.15**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**4.5**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**4.19**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #11		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 1.43 acres

Q_p = 5.1 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.501** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.05**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.052**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.000**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**5.1**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #11		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.05**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	100					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.052	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.052**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	13					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.000**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**1.430**	**0.35**	0.501
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	1.43		0.50

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #11		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 5.1 cfs

V = 4.32 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**0.04**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.54**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**0.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**1.18**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**4.48**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.020**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**4.35**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**5.1**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**4.32**	**ft/sec**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #12		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Total DA (A_t): 0.17 acres

Q_p = 0.6 cfs

Runoff Coefficient				
Runoff Coefficient, C	CA = sum(Area x "C") C = Total CA / Total DA	**CA =** **C =**	**0.060** **0.350**	
Use Table 5-2 to determine Values of Runoff Coefficient (C) for Rational Formula based on Landuse				
Time of Concentration				
Time of Concentration, T_c	T_c = Calculated from TR-55 (use Worksheet Tc)	**T_c =**	**0.02**	**hrs.**
Overland Flow	See Worksheet Tc	**T_t =**	**SF = 0.022**	
Shallow Concentrated Flow	See Worksheet Tc	**T_t =**	**SCF = 0.000**	
Channel Flow	See Worksheet Tc	**T_t =**	**CF = 0.000**	
Duration				
Duration, D	D = T_c	**D =**	**5.00**	**min.**
Frequency				
Frequency, F	2 year: On-site Storm Drain 5 year: Local Street / Minor System 10 year: Collector Street / Major System 50 year: Culverts Under I-264	**F =**	**25**	**year design storm**
Intensity				
Intensity, I		**I =**	**10.16**	**in./hr.**
Discharge				
Discharge, Q_p	Q_p = C*I*A	**Q_p =**	**0.6**	**cfs**

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #12		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Input 2 Yr 24-hr Rainfall Depth (P_2):	**4.1**	**in.**

Total T_c =	**0.02**	**hrs.**

Sheet Flow						
Segment ID	1	2	3	4	5	Units
Input Surface Type (see SF n-table)	grass					
Input Manning's n (see SF n-table)	0.150					
Input Sheet Flow Length (≤ 100 ft), L	34					ft
Input Surface Slope, S	0.250					ft/ft
Sheet Flow Time	0.022	0.000	0.000	0.000	0.000	hrs.
Sheet Flow Time = $\frac{[0.007(n*L)^{0.8}]}{(P_2)^{0.5}S^{0.4}}$				**Total SF =**	**0.022**	**hrs.**

Shallow Concentrated Flow						
Segment ID	1	2	3	4	5	Units
Surface Description	Unpaved					
Flow Length, L	0					ft
Water Course Slope, S	0.250					ft/ft
Average Velocity, V	8.07	0.00	0.00	0.00	0.00	ft/s
Shallow Concentrated Flow Time	0	0.000	0.000	0.000	0.000	hrs.
Paved: $V = 20.3282*S^{1/2}$ Unpaved: $V = 16.1345*S^{1/2}$ Shallow Concentrated Flow Time = L/(3600*V)				**Total SCF =**	**0.000**	

Channel Flow						
Segment ID	1	2	3	4	5	Units
Flow Area, A						ft^2
Wetted Perimeter, P						ft
Channel Slope, S						ft/ft
Channel Manning's n						
Channel Flow Length, L						ft
Hydraulic Radius, R						ft
Velocity, V						ft/s
Channel Flow Time	0.000	0.000	0.000	0.000	0.000	hrs.
R = A/P $V = (1.49*R^{2/3}*S^{1/2}) / n$ Channel Flow Time = L/(3600*V)				**Total CF =**	**0.000**	**hrs.**

Landuse	Area (acres)	C value	CA
Disturbed	**0.000**	**0.5**	0.000
Undisturbed	**0.170**	**0.35**	0.060
Road	**0.000**	**0.8**	0.000
			0.000
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0

Totals	0.17		0.06

Project Name:	IP Riegelwood Liner System		
Project No.:	31826746		
File Name:	Final Cover Channel Design #12		
Design Engineer:	Lenore Gaier	**Date:**	7-May-09
Checked By:	Meme Diaz	**Date:**	4-Jun-09

Q_p = 0.6 cfs

V = 1.36 ft/sec

Channel Characteristics				
Depth of Flow, d_F		**d_F =**	**-0.33**	**ft**
Min. Freeboard, FB		**FB =**	**0.50**	**ft**
Depth of Channel, d_C	$d_c = d_F + FB$	**d_C =**	**0.17**	**ft**
Side Slopes, m	2H:1V or Flatter minimum	**m =**	**4**	**H:1V**
Manning's n	Use Table to find Roughness Coefficient, n	**n =**	**0.020**	**earth lined-sandy soils**
Channel Design				
Channel Bottom Width , b		**b =**	**2.00**	**ft**
Wetted Area, A	$A = m*d_F^2 + d_F*b$	**A =**	**0.44**	**ft^2**
Wetted Perimeter, P	$P = 2*d_F*(m^2 + 1)^{0.5} + b$	**P =**	**3.37**	**ft**
Slope. S	S = change in elevation/distance for change	**S =**	**0.005**	**ft/ft**
Channel Top Width, w	$w = 2*(m*d_c) + b$	**w =**	**3.33**	**ft**
Discharge				
Discharge, Q	$Q = (1.486/n)*A*R^{2/3}*S^{1/2}$	**Q =**	**0.6**	**cfs**
Set Q = Q_p by changing d_C. If need more capacity but can't increase depth of channel, increase b.				
Velocity				
Velocity, V	V = Q / A	**V =**	**1.36**	**ft/sec**

URS	PROJECT				JOB NO.	
	IP-Riegelwood Cell 2 Liner System				31826746	
	SUBJECT				SHEET NO.	
	Final Cover Drainage Swale Calculations				1	
CALCULATION SHEET	ORIGINATED BY	DATE	CHECKED BY	DATE	CALC. NO.	REV. NO.
	Lenore Gaier	5/12/2009	Meme Diaz	6/4/2009		

Velocity

Determine if grass vegetation is adequate lining for the channel

After calculating all the different drainage areas within the final cover
case 6 was the worse case. (See attached map)
Case 6: Q=7.1 cfs and V=4.69 f/s and S=2%

Using Table 5 to determine the maximum permissible velocity
Grass cover consist of Tall Fescue, Lespedeza and Red Top therefore Vmax=5 f/s

V=4<5=Vmax grass lining will be adaquate

Shear Force

Calculate the shear stress exerted by the flowing water on the channel lining

t=∂ x d x S
∂=62.4 lbs/ft3 = unit weight of water
d=0.4 ft = maximum depth
S=2% = slope
t=0.5 lb/ft2

Table 5-4 Permissible Shear Stresses
tp=0.60 lb/ft2 (for class D vegetation)

t=0.51<0.60=tp grass lining will be adaquate

Table 5-2. Classification of Vegetal Covers as to Degree of Retardance.**

Retardance Class	Cover	Condition
A	Weeping lovegrass Yellow bluestem Ischaemum	Excellent stand, tall, average 0.76 m (2.5 ft) Excellent stand, tall, average 0.91 m (3.0 ft)
B	Kudzu Bermuda grass Native grass mixture (Little bluestem, bluestem, blue gamma, and other long and short midwest grasses) Weeping lovegrass Lespedeza sericea Alfalfa Weeping lovegrass Kudzu Blue gamma	Very dense growth, uncut Good stand, tall, average 0.30 m (1.0 ft) Good stand, unmowed Good stand, tall, average 0.61 m (2.0 ft) Good stand, not woody, tall, average 0.48 m (1.6 ft) Good stand, uncut, average 0.28 m (0.91 ft) Good stand, unmowed, average 0.33 m (1.1 ft) Dense growth, uncut Good stand, uncut, average 0.33 m (1.1 ft)
C	Crabgrass Bermuda grass Common lespedeza Grass-legume mixture--summer (orchard grass, redtop Italian ryegrass, and common lespedeza) Centipedegrass Kentucky bluegrass	Fair stand, uncut, avg. 0.25 to 1.20 m (0.8 to 4.0 ft) Good stand, mowed, average 0.15 m (0.5 ft) Good stand, uncut, average 0.28 m (0.91 ft) Good stand, uncut, average 0.15 to 0.20 m (0.5 to 1.5 ft) Very dense cover, average 0.15 m (0.5 ft) Good stand, headed, avg. 0.15 to 0.30 m (0.5 to 1.0 ft)
D	Bermuda grass Common lespedeza Buffalo grass Grass-legume mixture--fall, spring (orchard grass, redtop, Italian ryegrass, and common lespedeza) Lespedeza sericea	Good stand, cut to 0.06 m (0.2 ft) Excellent stand, uncut, average 0.11 m (0.4 ft) Good stand, uncut, avg. .08 to 0.15 m (0.3 to 0.5 ft) Good stand, uncut, 0.10 to 0.13 m (0.3 to 0.4 ft) After cutting to 0.05 m (0.2 ft) height, very good stand before cutting
E	Bermuda grass Bermuda grass	Good stand, cut to average 0.04 m (0.1 ft) Burned stubble

Note: Covers classified have been tested in experimental channels. Covers were green and generally uniform.

**Reproduced from HEC-15[34]

Table 5-4. Permissible Shear Stresses for Lining Materials.**

Lining Category	Lining Type	Permissible Unit Shear Stress	
		Pa	lb/ft^2
Temporary*	Woven Paper Net	7.2	0.15
	Jute Net	21.6	0.45
	Fiberglass Roving:		
	Single	28.7	0.60
	Double	40.7	0.85
	Straw with Net	69.5	1.45
	Curled Wood Mat	74.3	1.55
	Synthetic Mat	95.7	2.00
Vegetative	Class A	177.2	3.70
	Class B	100.6	2.10
	Class C	47.9	1.00
	Class D	28.7	0.60
	Class E	16.8	0.35
Gravel Riprap	25 mm (1 in)	15.7	0.33
	50 mm (2 in)	31.4	0.67
Rock Riprap	150 mm (6 in)	95.7	2.00
	300 mm (12 in)	191.5	4.00
Bare Soil	Non-cohesive	see chart 23	
	Cohesive	see chart 24	

*Some "temporary linings become permanent when buried.
**Reproduced from HEC-15[34]

erosiveness of the soil in which the vegetation is growing and the slope of the channel. In this table the channel's soil is divided into two categories defined by the RUSLE's K-value found in Module 2, "erosion resistant" (K < 0.37) and "easily eroded" (K > 0.37). The values given in Table 5 are for good vegetative stands. If the stand of vegetation used provides less than full coverage, the values in Table 5 should be decreased accordingly.

Table 5. Maximum permissible velocities for vegetation lined channels. (Modified from Ree, 1949 and PA-DER, 1990).

	Maximum Permissible Velocities					
	Erosion Resistant Soils			Easily Eroded Soils		
	K < 0.37			K > 0.37		
	(percent slope)			(percent slope)		
	0-5	5-10	Over 10	0-5	5-10	Over 10
Cover	fps	fps	fps	fps	fps	fps
Bermuda Grass	8	7	6	6	5	4
Buffalo Grass Kentucky Bluegrass						
Smooth Bromegrass	7	6	5	5	4	3
Blue Grama Tall Fescue						
Grass Mixture	5	4	NR[a]	4	3	NR
Reed Canarygrass	5	4	NR	4	3	NR
Lespedeza Weeping Lovegrass Red Top						
Kudzu	3.5	NR	NR	2.5	NR	NR
Alfalfa Red Fescue Crabgrass						
Annuals for Temporary Protection	3.5	NR	NR	2.5	NR	NR
Sudangrass	3.5	NR	NR	2.5	NR	NR

[a]Not Recommeded.

Maximum Allowable Shear Stress or Tractive Force, τ_{all}

Maximum allowable tractive force is a measure of the shear stress exerted by the flowing water on the channel lining. If the actual shear stress, in lbs/ft^2, exceeds the maximum allowable shear stress or tractive force, the flowing water will erode the channel, usually at its deepest depth. Maximum allowable tractive forces for non-cohesive soils smaller than 6.35 mm (sands and gravels) are given in Figure 4. Allowable tractive forces for a wide variety of channel linings are shown in Table 6. The dimensions for the North Carolina rock classification are given in Table 7. Suggested products for use in controlling erosion on side slopes are given in Table 8.

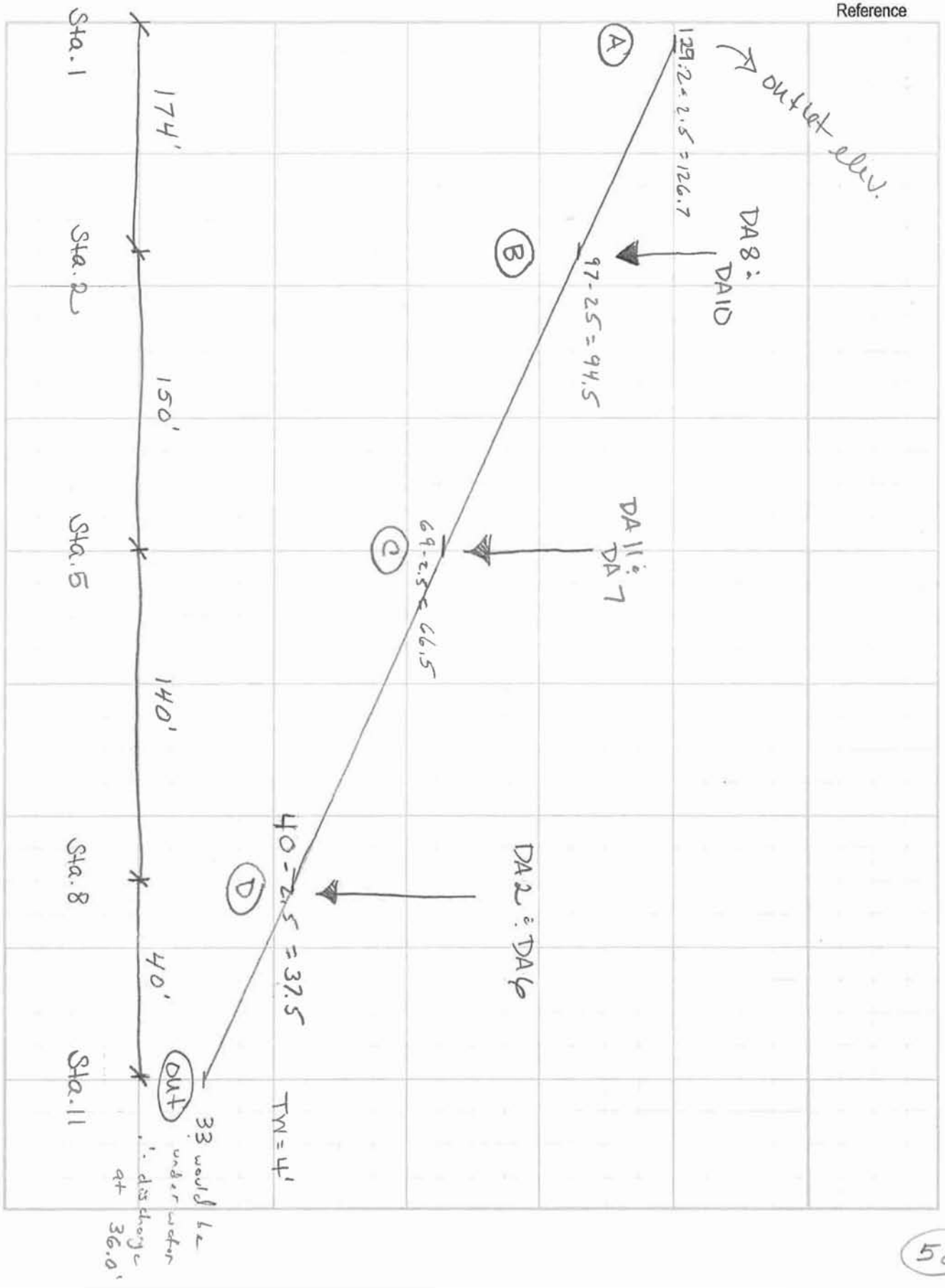
URS

Job Ringlwood | Project No. 31826746 | Page ____ of ____

Description Down Pipe Sizing | Computed by ____ | Sheet ____ of ____

'A'-NE corner cell 2 Final Cover | Checked by RKL | Date 6/8/09 | Date 6/15/09

Reference



URS Corporation - North Carolina

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6/15/09 1:39 PM

IP-Riegelwood.xls

INLET COMPUTATION SHEET

SHEET 1 OF

English Units

PROJECT NO. 31826746

COUNTY: Riegelwood Cell 2 Landfill DESIGNED BY: MAD

CHECKED BY: LG & MD

	LOCATION		ROADWAY			RUNOFF						TOTAL	INLET			
STR NO.	SHT NO.	STA	INLET ELEV	GRADE	CROSS SLOPE	DRAINAGE AREA	RUNOFF COEFF	TIME OF CONC	RAINFALL INTEN	DISCHRG FROM DA	DISCHRG CARYOVR	Q10 DISCHRG	SPREAD	INTRCEPT	BYPASS	REMARKS
1		9	130.20 / 128.70	-	-	0.95	0.35	5.0	10.2	3.38		3.38				OPEN END
2	0	A	129.20 / 126.70	-	-	0.95	0.35	5.0	10.2	3.39		3.39				TEE
	0	8	98.00 / 96.50	-	-	1.27	0.35	5.0	10.2	4.53		4.53				OPEN END
	0	10	98.00 / 96.50	-	-	1.28	0.35	5.0	10.2	4.57		4.57				OPEN END
		B	97.00 / 94.50			3.50	0.35	5.0	10.2	12.50		12.50				TEE
	0	11	70.00 / 68.50	-	-	1.43	0.35	5.0	10.2	5.11		5.11				OPEN END
	0	7	71.00 / 68.50	-	-	1.77	0.35	5.0	10.2	6.32		6.32				OPEN END
	0	C	69.00 / 66.50	-	-	6.70	0.35	5.0	10.2	23.92		23.92				TEE
	0	2	41.00 / 39.50	-	-	1.55	0.35	5.0	10.2	5.53		5.53				OPEN END
	0	6	41.00 / 39.50	-	-	1.99	0.35	5.0	10.2	7.10		7.10				OPEN END
	0	D	40.00 / 37.50	-	-	10.24	0.35	5.0	10.2	36.56		36.56				TEE

P:\Jobs4_Projects\International Paper\IP - Riegelwood\Cell 2 Landfill\Liner Construction Drawings\5.0 Cost Estimate & Bid Form & Calculations\Drainage Calculations\Down Pipe Sizing..XLS

URS Corporation - North Carolina
MORRISVILLE, NORTH CAROLINA

6/15/2009

IP-Riegelwood.xls
PROJECT NO. 31826746
0

STORM DRAIN DESIGN COMPUTATION
English Units
COUNTY: Riegelwood Cell 2 Landfill

SHEET OF
DESIGNED BY: MAD
CHECKED BY: LG & MD

				RUNOFF		PIPE DESIGN												
STR STR	SHT	STA		D.A. ACRE	SUM CA	PROPOSED LENGTH	INLET TIME	FLOW TIME	DESIGN TIME	INT (I)	DISCH Q10	ELEV INL	ELEV OUTL	SLOPE ft/ft	DIA in	CAP cfs	VEL fps	REMARKS
1	0	From	9	0.95	0.33	10.0	1.8	1.8	5.0	10.16	3.4	128.70	126.70	0.200	18	13.0	1.91	OPEN END
2		To	A												CSP			Depth= 1.50
2	0	From	A	0.95	0.33	174.0	1.8	1.8	5.0	10.16	3.4	126.70	94.50	0.185	30	43.0	0.69	TEE
0		To	B															Depth= 2.50
0	0	From	8	1.27	0.44	10.0	1.8	6.1	5.0	10.16	4.5	96.50	94.50	0.200	18	13.0	2.56	OPEN END
0		To	B												CSP			Depth= 1.50
0	0	From	10	1.28	0.45	10.0	1.8	6.1	5.0	10.16	4.6	96.50	94.50	0.200	18	13.0	2.58	OPEN END
0		To	B												CSP			Depth= 1.50
0	0	From	B	3.50	1.23	150.0	1.8	6.1	5.0	10.16	12.4	94.50	66.50	0.187	30	43.0	2.54	TEE
0		To	C															Depth= 2.50
0	0	From	11	1.43	0.50	10.0	1.8	7.1	5.0	10.16	5.1	68.50	66.50	0.200	18	13.0	2.88	OPEN END
0		To	C												CSP			Depth= 1.50
0	0	From	7	1.77	0.62	10.0	1.8	7.2	5.0	10.16	6.3	68.50	66.50	0.200	18	13.0	3.56	OPEN END
0		To	C												CSP			Depth= 2.50
0	0	From	C	6.70	2.35	140.0	1.8	7.2	5.0	10.16	23.8	66.50	37.50	0.207	30	43.0	4.85	TEE
0		To	D															Depth= 2.50
0	0	From	2	1.55	0.54	10.0	1.8	7.7	5.0	10.16	5.5	39.50	37.50	0.200	18	13.0	3.12	OPEN END
0		To	D												CSP			Depth= 1.50
0	0	From	6	1.99	0.70	10.0	1.8	7.7	5.0	10.16	7.1	39.50	37.50	0.200	18	13.0	4.00	OPEN END
0		To	D												CSP			Depth= 1.50
0	0	From	D	10.24	3.58	40.0	1.8	7.7	5.0	10.16	36.4	37.50	36.00	0.038	30	43.0	7.42	TEE
0		To	OUT															Depth= 2.50

URS Corporation - North Carolina

MORRISVILLE, NORTH CAROLINA

6/15/2009

IP-Riegelwood.xls

PROJECT NO. 31826746

0

HYDRAULIC GRADE LINE

English Units

COUNTY: Riegelwood Cell 2 Landfill

DESIGNED BY: MAD

SHEET OF

CHECKED BY: LG & MD

STR STR	SHT	STATION		OUTLET W.S. ELEV	Do (in)	Qo	Lo	HEAD LOSSES Hf	Hc	He	Hb	Ht	INLET W.S. ELEV	RIM ELEV	POTENTIAL WATER SURFACE DEPTH BELOW RIM
1	0	From	9	128.70	18	3.38	10.0	0.01	0.01	0.03	0.03	0.08	129.90	130.20	OK - Open End Pipe
2		To	A					n=0.024							d=1.20
2	0	From	A	96.50	30	3.38	174.0	0.02	0.00	0.02	0.00	0.12	128.70	129.20	0.50
0		To	B												
0	0	From	8	96.50	18	4.52	10.0	0.02	0.03	0.00	0.00	0.06	97.70	98.00	OK - Open End Pipe
0		To	B					n=0.024							d=1.20
0	0	From	10	95.70	18	4.55	10.0	0.02	0.03	0.05	0.05	0.15	97.70	98.00	OK - Open End Pipe
0		To	B					n=0.024							d=1.20
0	0	From	B	68.50	30	12.45	150.0	0.18	0.02	0.04	0.00	0.45	96.50	97.00	0.50
0		To	C												
0	0	From	11	68.50	18	5.09	10.0	0.03	0.03	0.05	0.05	0.16	69.70	70.00	OK - Open End Pipe
0		To	C					n=0.024							d=1.20
0	0	From	7	67.70	18	6.29	10.0	0.05	0.05	0.06	0.06	0.22	69.70	71.00	OK - Open End Pipe
0		To	C					n=0.024							d=1.20
0	0	From	C	39.50	30	23.83	140.0	0.63	0.09	0.07	0.00	1.17	68.50	69.00	0.50
0		To	D												
0	0	From	2	39.50	18	5.51	10.0	0.04	0.04	0.18	0.17	0.43	40.70	41.00	OK - Open End Pipe
0		To	D					n=0.024							d=1.20
0	0	From	6	38.70	18	7.08	10.0	0.06	0.06	0.08	0.07	0.27	40.70	41.00	OK - Open End Pipe
0		To	D					n=0.024							d=1.20
0	0	From	D	38.00	30	36.41	45.0	0.47	0.21	0.09	0.02	1.49	39.50	40.00	0.50
0		To	OUT												

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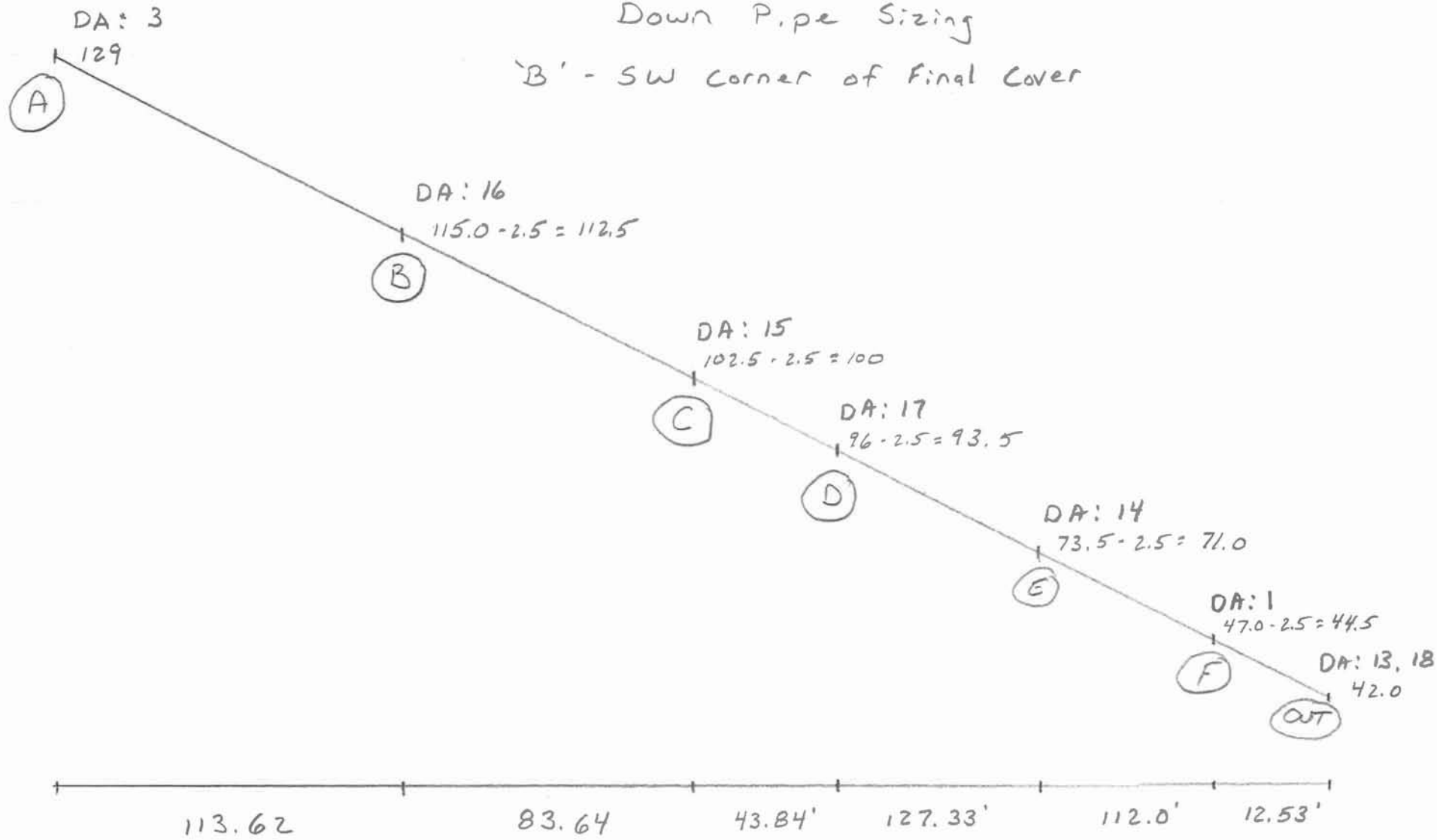
IP - Riegelwood Cell 2 Landfill

31826746

Down Pipe Sizing

'B' - SW Corner of Final Cover



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National® Brand
13-782 500 SHEETS, FILLER 5 SQUARE
42-381 50 SHEETS EYE-EASE® 5 SQUARE
42-382 100 SHEETS EYE-EASE® 5 SQUARE
42-389 200 SHEETS EYE-EASE® 5 SQUARE
42-392 100 RECYCLED WHITE 5 SQUARE
42-399 200 RECYCLED WHITE 5 SQUARE
Made in U.S.A.

URS Corporation - North Carolina

MORRISVILLE, NORTH CAROLINA

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IP-Riegelwood.xls

INLET COMPUTATION SHEET

English Units

SHEET 1 OF

PROJECT NO. 31826746

COUNTY: Riegelwood Cell 2 Landfill DESIGNED BY: MAD

CHECKED BY: LG & MD

LOCATION		ROADWAY			RUNOFF						TOTAL	INLET			
SHT NO.	STA	INLET ELEV	GRADE	CROSS SLOPE	DRAINAGE AREA	RUNOFF COEFF	TIME OF CONC	RAINFALL INTEN	DISCHRG FROM DA	DISCHRG CARYOVR	Q10 DISCHRG	SPREAD	INTRCEPT	BYPASS	REMARKS
	3	130.70 / 129.20	-	-	1.02	0.35	5.0	10.2	3.63		3.63				OPEN END
0	A	131.50 / 129.00	-	-	1.02	0.35	5.0	10.2	3.64		3.64				TEE
0	16	114.20 / 112.70	-	-	0.28	0.35	5.0	10.2	1.00		1.00				OPEN END
0	B	115.00 / 112.50	-	-	1.30	0.35	5.0	10.2	4.64		4.64				TEE
	15	101.70 / 100.20			1.10	0.35	5.0	10.2	3.93		3.93				OPEN END
0	C	102.50 / 100.00	-	-	2.40	0.35	5.0	10.2	8.57		8.57				TEE
0	17	96.20 / 93.70	-	-	0.48	0.35	5.0	10.2	1.71		1.71				OPEN END
0	D	96.00 / 93.50	-	-	2.88	0.35	5.0	10.2	10.28		10.28				TEE
0	14	72.70 / 71.20	-	-	1.62	0.35	5.0	10.2	5.78		5.78				OPEN END
0	E	73.50 / 71.00	-	-	4.50	0.35	5.0	10.2	16.07		16.07				TEE
0	1	46.20 / 44.70	-	-	1.81	0.35	5.0	10.2	6.46		6.46				OPEN END
0	F	47.00 / 44.50	-	-	6.31	0.35	5.0	10.2	22.53		22.53				TEE
0	13	43.70 / 42.20	-	-	0.50	0.35	5.0	10.2	1.79		1.79				OPEN END
0	18	43.70 / 42.20	-	-	0.51	0.35	5.0	10.2	1.82		1.82				OPEN END
0	Outlet	44.50 / 42.00	-	-	7.32	0.35	5.0	10.2	26.13		26.13				TEE

URS Corporation - North Carolina
MORRISVILLE, NORTH CAROLINA

6/16/2009

IP-Riegelwood.xls
PROJECT NO. 31826746
0

STORM DRAIN DESIGN COMPUTATION

English Units

COUNTY: Riegelwood Cell 2 Landfill

SHEET OF

DESIGNED BY: MAD

CHECKED BY: LG & MD

				RUNOFF		PIPE DESIGN												
STR STR	SHT	STA		D.A. ACRE	SUM CA	PROPOSED LENGTH	INLET TIME	FLOW TIME	DESIGN TIME	INT (I)	DISCH Q10	ELEV INL	ELEV OUTL	SLOPE ft/ft	DIA in	CAP cfs	VEL fps	REMARKS
1	0	From	3	1.02	0.36	10.0	1.8	1.8	5.0	10.16	3.6	129.20	129.00	0.020	18	12.8	2.05	OPEN END
2		To	A															Depth= 1.50
2	0	From	A	1.02	0.36	113.6	1.8	1.8	5.0	10.16	3.6	129.00	112.50	0.145	30	43.0	0.74	TEE
0		To	B															Depth= 2.50
0	0	From	16	0.28	0.10	10.0	1.8	4.4	5.0	10.16	1.0	112.70	112.50	0.020	18	12.8	0.56	OPEN END
0		To	B															Depth= 1.50
0	0	From	B	1.30	0.46	83.6	1.8	4.7	5.0	10.16	4.6	112.50	100.00	0.149	30	43.0	0.94	TEE
0		To	C															Depth= 2.50
0	0	From	15	1.10	0.39	10.0	1.8	4.7	5.0	10.16	3.9	100.20	100.00	0.020	18	12.8	2.21	OPEN END
0		To	C															Depth= 1.50
0	0	From	C	2.40	0.84	43.8	1.8	4.8	5.0	10.16	8.5	100.00	93.50	0.148	30	43.0	1.74	TEE
0		To	D															Depth= 2.50
0	0	From	17	0.48	0.17	10.0	1.8	5.2	5.0	10.16	1.7	93.70	93.50	0.020	18	12.8	0.97	OPEN END
0		To	D															Depth= 2.50
0	0	From	D	2.88	1.01	127.3	1.8	5.2	5.0	10.16	10.2	93.50	71.00	0.177	30	43.0	2.09	TEE
0		To	E															Depth= 2.50
0	0	From	14	1.62	0.57	10.0	1.8	6.2	5.0	10.16	5.8	71.20	71.00	0.020	18	12.8	3.26	OPEN END
0		To	E															Depth= 1.50
0	0	From	E	4.50	1.58	112.0	1.8	6.3	5.0	10.16	16.0	71.00	44.50	0.237	30	43.0	3.26	TEE
0		To	F															Depth= 2.50
0	0	From	1	1.81	0.63	10.0	1.8	6.3	5.0	10.16	6.4	44.70	44.50	0.020	18	12.8	3.64	OPEN END
0		To	F															Depth= 1.50
0	0	From	F	6.31	2.21	12.5	1.8	6.8	5.0	10.16	22.4	44.50	42.00	0.200	30	43.0	4.57	TEE
0		To	Outlet															Depth= 2.50
0	0	From	13	0.50	0.18	10.0	1.8	6.9	5.0	10.16	1.8	42.20	42.00	0.020	18	12.8	1.01	OPEN END
0		To	Outlet															Depth= 1.50
0	0	From	18	0.51	0.18	10.0	1.8	7.0	5.0	10.16	1.8	42.20	42.00	0.020	18	12.8	1.03	OPEN END
0		To	Outlet															Depth= 1.50
0	0	From	Outlet	7.32	2.56	10.0	1.8	7.0	5.0	10.16	26.0	42.00	41.00	0.100	30	43.0	5.30	TEE
0		To	OUT															Depth= 2.50

URS Corporation - North Carolina

MORRISVILLE, NORTH CAROLINA

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IP-Riegelwood.xls

PROJECT NO. 31826746

0

HYDRAULIC GRADE LINE

English Units

COUNTY: Riegelwood Cell 2 Landfill

DESIGNED BY: MAD

SHEET OF

CHECKED BY: LG & MD

STR STR	SHT	STATION		OUTLET W.S. ELEV	Do (in)	Qo	Lo	HEAD LOSSES Hf	Hc	He	Hb	Ht	INLET W.S. ELEV	RIM ELEV	POTENTIAL WATER SURFACE DEPTH BELOW RIM
1	0	From	3	131.00	18	3.63	10.0	0.02	0.02	0.03	0.03	0.10	131.10	130.70	OK - Open End Pipe
2		To	A												d=1.90
2	0	From	A	114.50	30	3.63	113.6	0.01	0.00	0.02	0.00	0.13	131.00	131.50	0.50
0		To	B												
0	0	From	16	114.50	18	1.00	10.0	0.00	0.00	0.00	0.00	0.01	114.51	114.20	OK - Open End Pipe
0		To	B												d=1.81
0	0	From	B	102.00	30	4.62	83.6	0.01	0.00	0.00	0.00	0.03	114.50	115.00	0.50
0		To	C												
0	0	From	15	102.00	18	3.91	10.0	0.02	0.02	0.01	0.01	0.05	102.05	101.70	OK - Open End Pipe
0		To	C												d=1.85
0	0	From	C	95.50	30	8.53	43.8	0.03	0.01	0.03	0.04	0.15	102.00	102.50	0.50
0		To	D												
0	0	From	17	95.50	18	1.71	10.0	0.00	0.00	0.02	0.02	0.05	95.55	96.20	OK - Open End Pipe
0		To	D												d=1.85
0	0	From	D	73.00	30	10.24	127.3	0.11	0.02	0.01	0.00	0.18	95.50	96.00	0.50
0		To	E												
0	0	From	14	73.00	18	5.76	10.0	0.04	0.04	0.03	0.03	0.15	73.15	72.70	OK - Open End Pipe
0		To	E												d=1.95
0	0	From	E	46.50	30	16.00	112.0	0.23	0.04	0.06	0.08	0.55	73.00	73.50	0.50
0		To	F												
0	0	From	1	46.50	18	6.44	45.0	0.22	0.05	0.08	0.08	0.44	46.94	46.20	OK - Open End Pipe
0		To	F												d=2.24
0	0	From	F	44.00	30	22.44	12.5	0.05	0.08	0.07	0.00	0.64	46.50	47.00	0.50
0		To	Outlet												
0	0	From	13	44.00	18	1.78	10.0	0.00	0.00	0.16	0.15	0.32	44.32	43.70	OK - Open End Pipe
0		To	Outlet												d=2.12
0	0	From	18	44.00	18	1.81	10.0	0.00	0.00	0.01	0.01	0.02	44.02	43.70	OK - Open End Pipe
0		To	Outlet												d=1.82
0	0	From	Outlet	43.00	30	26.03	45.0	0.24	0.11	0.01	0.00	0.70	44.00	44.50	0.50
0		To	OUT												

Riprap Energy Dissipator Design

Project Name:	IP-Riegelwood Cell 2 Liner System		
Project No.:	31826746		
File Name:	HEC-14 Riprap Energy Dissipator Design		
Design Engineer:	Lenore Gaier	**Date:**	11-Jun-09
Checked By:	Meme Diaz	**Date:**	11-Jun-09

HEC-14 Method[1]

Calculations reflect the suggested and minimum suggested basin dimensions. Calculated dimensions may not be utilized in order to adhere to other design considerations.

Pipe Diameter		**D**	=	**2.5**	**ft.**
10-Year Storm Pipe Flow		**Q**	=	**36.6**	**cfs**
Constant	K_u = 1.0 for English Units	K_u	=	**1.0**	
		$\frac{K_u * Q}{D^{2.5}}$	=	**3.70**	
Tail Water		**TW**	=	**0**	**ft.**
		$\frac{TW}{D}$	=	**0**	
	From HEC-14 Figure 3.4	$\frac{y_o}{D}$	=	**0.64**	
Outlet (Brink) Depth	$y_o = \frac{y_o}{D} * D$	y_o	=	**1.60**	**ft.**
	From HEC-14 Table B.2	$\frac{A}{D^2}$	=	**0.53**	
Area of Flow	$A = \frac{A}{D^2} * D^2$	**A**	=	**3.32**	**ft^2**
Culvert Outlet Velocity	$v_o = \frac{Q}{A}$	v_o	=	**11.02**	**ft/sec**
Equivalent Depth	$y_e = (A/2)^{0.5}$	y_e	=	**1.29**	**ft.**
Froude Number	$Fr = \frac{v_o}{[32.2 * y_e]^{0.5}}$	**Fr**	=	**1.71**	
Select a trial D_{50} and obtain h_s/y_e. Ensure $h_s/D_{50} \geq 2$ and $D_{50}/y_e \geq 0.1$					
		h_s/D_{50}	=	**1.4**	
		D_{50}/y_e	=	**0.5**	
Riprap Mean Diameter	Class B Stone	D_{50}	=	**0.67**	**ft.**
Acceleration Due to Gravity		**g**	=	**32.2**	**ft/sec**
		$\frac{TW}{y_e}$	=	**0**	
Tailwater Parameter	C_o = 1.4 when $TW/y_e < 0.75$ = $4.0 * (TW/y_e) - 1.0$ when $0.75<TW/y_e<1.0$ = 2.4 when $TW/y_e > 1.0$	C_o	=	**1.4**	

Project Name:	IP-Riegelwood Cell 2 Liner System		
Project No.:	31826746		
File Name:	HEC-14 Riprap Energy Dissipator Design		
Design Engineer:	Lenore Gaier	**Date:**	11-Jun-09
Checked By:	Meme Diaz	**Date:**	11-Jun-09

	$\frac{h_s}{y_e} = 0.86 * (D_{50}/y_e)^{-0.55} * [v_o/(g*y_e)^{0.5}] - C_c$	$\frac{h_s}{y_e} = 0.71$
Depth of Scour	$h_s = \frac{h_s}{y_e} * h_s$	$h_s = 0.92$ ft.

Basin Size		
Length of Dissipator Pool	$L_s = 10 * h_s$	$L_s = 9.2$ ft.
Minimum Length of Dissipator Pool	$L_{s\,min} = 3 * D$	$L_{s\,min} = 7.5$ ft.
Length of Apron	$L_A = 5 * h_s$	$L_A = 4.6$ ft.
Minimum Length of Apron	$L_{A\,min} = D$	$L_{A\,min} = 2.5$ ft.
Total Length of Basin	$L_B = 15 * h_s$	$L_B = 13.8$ ft.
Minimimum Total Length of Basin	$L_{B\,min} = 4* D$	$L_{B\,min} = 10.0$ ft.
Width of Basin	$W_B = D + 2*(L_B/3)$	$W_B = 11.7$ ft.

Basin Exit Depth		
	$\frac{Q^2}{g} = 41.5 = \frac{A_c^3}{T_c} = 34.0 = \frac{[y_c * (W_B + z*y_c)]^3}{(W_B + 2*z*y_c)} = 13.9$ ft.	
Critical Flow Basin Exit Depth		$y_c = 0.08$ ft.
Basin Side Slope		$z = 33$ ft/ft
Area of Exit Flow		$A_c = 8.8$ ft^2
Top Width of Exit Flow		$T_c = 20.3$ ft.
Exit Velocity	$V_c = \frac{Q}{A_c}$	$V_c = 4.14$ ft/sec

[1] Hydraulic Engineering Circular No. 14, Third Edition - Hydraulic Design of Energy Dissipators for Culverts and Channels

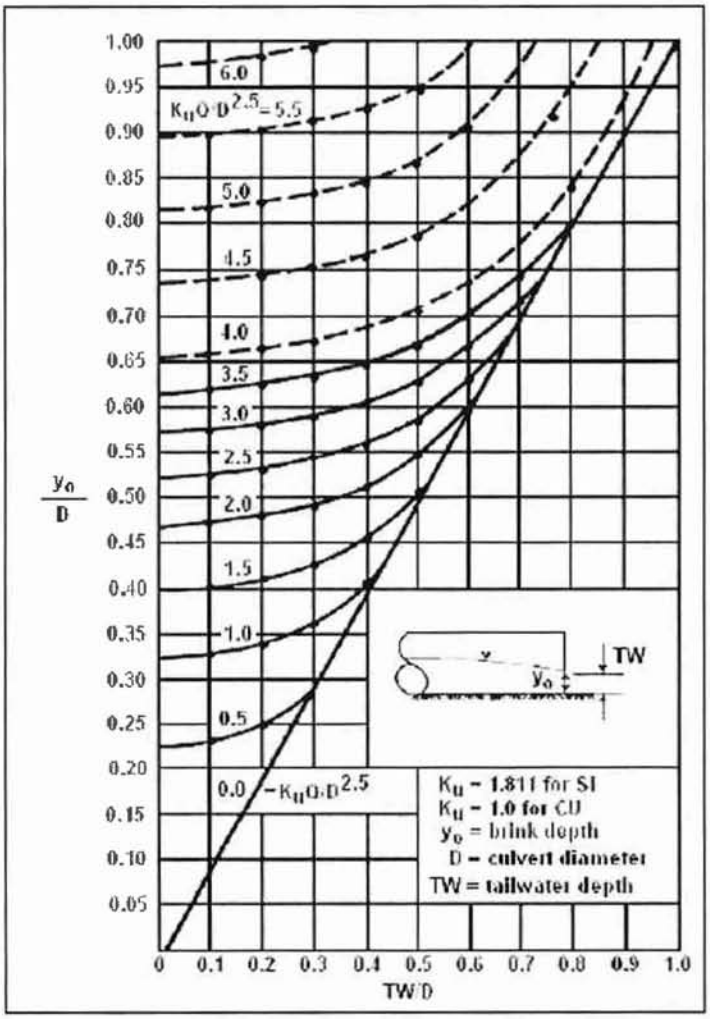

Figure 3.4. Dimensionless Rating Curves for the Outlets of Circular Culverts on Horizontal and Mild Slopes (Simons, 1970)

Table B.2. Uniform Flow in Circular Sections Flowing Partly Full

y/D	A/D²	R/D	$\frac{(aQn)}{(D^{8/3} S^{1/2})}$	$\frac{(aQn)}{(y^{5/3} S^{1/2})}$	y/D	A/D²	R/D	$\frac{(aQn)}{(D^{8/3} S^{1/2})}$	$\frac{(aQn)}{(y^{5/3} S^{1/2})}$
0.01	0.0013	0.0066	0.00007	15.04	0.51	0.4027	0.2531	0.239	1.442
0.02	0.0037	0.0132	0.00031	10.57	0.52	0.4127	0.2562	0.247	0.415
0.03	0.0069	0.0197	0.00074	8.56	0.53	0.4227	0.2592	0.255	1.388
0.04	0.0105	0.0262	0.00138	7.38	0.54	0.4327	0.2621	0.263	1.362
0.05	0.0147	0.0325	0.00222	6.55	0.55	0.4426	0.2649	0.271	1.336
0.06	0.0192	0.0389	0.00328	5.95	0.56	0.4526	0.2676	0.279	1.311
0.07	0.0294	0.0451	0.00455	5.47	0.57	0.1626	0.2703	0.287	1.286
0.08	0.0350	0.0513	0.00604	5.09	0.58	0.4724	0.2728	0.295	1.262
0.09	0.0378	0.0575	0.00775	4.76	0.59	0.4822	0.2753	0.303	1.238
0.10	0.0409	0.0635	0.0097	4.49	0.60	0.4920	0.2776	0.311	1.215
0.11	0.0470	0.0695	0.0118	4.25	0.61	0.5018	0.2799	0.319	1.192
0.12	0.0534	0.0755	0.0142	4.04	0.62	0.5115	0.2821	0.327	1.170
0.13	0.0600	0.0813	0.0167	3.86	0.63	0.5212	0.2842	0.335	1.148
0.14	0.0668	0.0871	0.0195	3.69	0.64	0.5308	0.2862	0.343	1.126
0.15	0.0739	0.0929	0.0225	3.54	0.65	0.5405	0.2888	0.350	1.105
0.16	0.0811	0.0985	0.0257	3.41	0.66	0.5499	0.2900	0.358	1.084
0.17	0.0885	0.1042	0.0291	3.28	0.67	0.5594	0.2917	0.366	1.064
0.18	0.0961	0.1097	0.0327	3.17	0.68	0.5687	0.2933	0.373	1.044
0.19	0.0139	0.1152	0.0365	3.06	0.69	0.5780	0.2948	0.380	1.024
0.20	0.1118	0.1206	0.0406	2.96	0.70	0.5872	0.2962	0.388	1.004
0.21	0.1199	0.1259	0.0448	2.87	0.71	0.5964	0.2975	0.395	0.985
0.22	0.1281	0.1312	0.0492	2.79	0.72	0.6054	0.2987	0.402	0.965
0.23	0.1365	0.1364	0.0537	2.71	0.73	0.6143	0.2998	0.409	0.947
0.24	0.1449	0.1416	0.0585	2.63	0.74	0.6231	0.3008	0.416	0.928
0.25	0.1535	0.1466	0.0634	2.56	0.75	0.6319	0.3042	0.422	0.910
0.26	0.1623	0.1516	0.0686	2.49	0.76	0.6405	0.3043	0.429	0.891
0.27	0.1711	0.1566	0.0739	2.42	0.77	0.6489	0.3043	0.435	0.873
0.28	0.1800	0.1614	0.0793	2.36	0.78	0.6573	0.3041	0.441	0.856
0.29	0.1890	0.1662	0.0849	2.30	0.79	0.6655	0.3039	0.447	0.838
0.30	0.1982	0.1709	0.0907	2.25	0.80	0.6736	0.3042	0.453	0.821
0.31	0.2074	0.1756	0.0966	2.20	0.81	0.6815	0.3043	0.458	0.804
0.32	0.2167	0.1802	0.1027	2.14	0.82	0.6893	0.3043	0.463	0.787
0.33	0.2260	0.1847	0.1089	2.09	0.83	0.6969	0.3041	0.468	0.770
0.34	0.2355	0.1891	0.1153	2.05	0.84	0.7043	0.3038	0.473	0.753
0.35	0.2450	0.1935	0.1218	2.00	0.85	0.7115	0.3033	0.453	0.736
0.36	0.2546	0.1978	0.1284	1.958	0.86	0.7186	0.3026	0.458	0.720

y/D	A/D²	R/D	$\frac{(aQn)}{(D^{8/3} S^{1/2})}$	$\frac{(aQn)}{(y^{5/3} S^{1/2})}$	y/D	A/D²	R/D	$\frac{(aQn)}{(D^{8/3} S^{1/2})}$	$\frac{(aQn)}{(y^{5/3} S^{1/2})}$
0.37	0.2642	0.2020	0.1351	1.915	0.87	0.7254	0.3018	0.485	0.703
0.38	0.2739	0.2062	0.1420	1.875	0.88	0.7320	0.3007	0.488	0.687
0.39	0.2836	0.2102	0.1490	1.835	0.89	0.7384	0.2995	0.491	0.670
0.40	0.2934	0.2142	0.1561	1.797	0.90	0.7445	0.2980	0.494	0.654
0.41	0.3032	0.2182	0.1633	1.760	0.91	0.7504	0.2963	0.496	0.637
0.42	0.3130	0.2220	0.1705	1.724	0.92	0.7560	0.2944	0.497	0.621
0.43	0.3229	0.2258	0.1779	1.689	0.93	0.7612	0.2921	0.498	0.604
0.44	0.3328	0.2295	0.1854	1.655	0.94	0.7662	0.2895	0.498	0.588
0.45	0.3428	0.2331	0.1929	1.622	0.95	0.7707	0.2865	0.498	0.571
0.46	0.3527	0.2366	0.201	1.590	0.96	0.7749	0.2829	0.496	0.553
0.47	0.3627	0.2401	0.208	1.559	0.97	0.7785	0.2787	0.494	0.535
0.48	0.3727	0.2435	0.216	1.530	0.98	0.7817	0.2735	0.489	0.517
0.49	0.3827	0.2468	0.224	1.500	0.99	0.7841	0.2666	0.483	0.498
0.50	0.3927	0.2500	0.232	1.471	1.00	0.7854	0.2500	0.463	0.463

y = depth of flow, m (ft)
D = diameter of pipe, m (ft)
A = area of flow, m² (ft²)
R = hydraulic radius, m (ft)
Source: USBR (1974)

Q = discharge by Manning's Equation, m³/s (ft³/s)
n = Manning's coefficient
S = channel bottom and water surface slope
a = units conversion = 1.49 for SI, 1 for CU

SECTION 1042
RIPRAP MATERIALS

1042-1 PLAIN RIPRAP

Stone for plain riprap consists of field stone or rough unhewn quarry stone. The stone shall be sound, tough, dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended. Where broken concrete from demolished structures or pavement is available, it may be used in place of stone provided that such use meets with the approval of the Engineer. However, the use of broken concrete that contains reinforcing steel will not be permitted.

All stone shall meet the approval of the Engineer. While no specific gradation is required, there should be equal distribution of the various sizes of the stone within the

required size range. The size of an individual stone particle will be determined by measuring its long dimension.

Stone or broken concrete for riprap shall meet the requirements of Table 1042-1 for the class and size distribution.

TABLE 1042-1
ACCEPTANCE CRITERIA FOR RIPRAP
AND STONE FOR EROSION CONTROL

	REQUIRED STONE SIZES - INCHES		
CLASS	MINIMUM	MIDRANGE	MAXIMUM
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23r

No more than 5.0% of the material furnished can be less than the minimum size specified nor no more than 10.0% of the material can exceed the maximum size specified.

1042-2 TESTING

Test riprap materials in accordance with the requirements of this section and Sections 1005-4(E) Resistance to Abrasion, and 1005-4(F) Soundness. Satisfactory resistance to abrasion will be considered to be a percentage of wear of not greater than 55 percent. Satisfactory soundness will be considered to be a loss in weight of not greater than 15 percent when subjected to 5 alterations of the soundness test.