United States Department of Agriculture

NRCS

Natural Resources Conservation Service
210 Walnut Street, Room 693
Des Moines, IA 50309-2180

March 3, 2008

NATIONAL ENGINEERING HANDBOOK
210-VI

SUBJECT: ENG – AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK, PART 651, AMENDMENT IA-1

Purpose. To transmit the updated Iowa amendments to the Animal Waste Management Field Handbook.

Effective Date. This amendment is effective upon receipt.

Explanation. The Animal Waste Management Field Handbook amendments have been updated and are now available in electronic format. This amendment (IA-1) replaces all previous Iowa amendments to the handbook.

Filing Instructions. Remove all green sheets and place the new ones as follows:

New Amendment Pages	File After AWMFH Page	New Amendment Pages	File After AWMFH Page
IA10-66 (1-22)	10-66	IA1-18 (1-3)	1-18
IA10A-8 (1-6)	10A-8	IA10-26 (1-14)	10-26
IA13C-17 (1-19)	13C-17	IA13-17 (1)	13-17
IA3-25 (1-2)	3-25	IA10C-31 (1-4)	10C-31
IA10B-7 (1-8)	10B-7		

This amendment is available in .pdf format and can be downloaded at
..\..\..\NRCS_statewide_shared\Iowa Bulletins and Manuals\AWMFH Amendments\IA-1\2-28-08_AWMFH Amendment IA-1_March 2008.pdf

If you have any questions pertaining to this distribution, please contact Mark Garrison, Environmental Engineer, at (515) 284-4357.

/s/Al Garner
Acting State Conservationist

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State Conservation Engineers in: MN, WI, ND, SD, NE, KS, MO, IL, MI, IN

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Grass Filter Design Procedures and Charts

Grass filters are designed to remove sediment, organic matter, and other pollutants from runoff or wastewater. In planning a grass filter, consideration should be given to the type and quantity of pollutant, slopes, soils, adapted vegetation species, time of year for proper establishment of vegetation, visual aspects, and other special needs.

A settling basin or low velocity channel is needed to remove solids from polluted runoff. A solids settling facility located between the waste source and the filter strip shall be provided when the animal feeding facility contains more than 100 – 1,000 (450 kg) animal units.

Grass filters may be designed either as a grass area located on the contour or as a grass channel. Minimum dimensions shall provide capacity for the peak runoff from a 2-year, 24-hour rainfall. The design charts on the following pages can be used to determine the minimum dimensions of the grass filter.

Example: Design a grass filter for an open feedlot in Story County with capacity for 200 head of cattle weighing 1,000 pounds each. The lot covers 2.0 acres and the solids are collected before the runoff reaches the grass filter. The predominant slope below the feedlot is 4.0%. The RCN for the feedlot is 90 with moderate slopes. Design (A) is a grass area filter strip and (B) is for a grass channel filter strip for this feedlot.

(A) Grass Area Filter Strip

ADA = 2.0 acres
RCN = 90 Moderate Slopes
2-yr, 24-hour Rainfall = 3.1 inches (NEH, Chapter 2)
2-yr, 24-hour Runoff = 2.08 inches
* Peak Flow = 3.6 cfs/inch runoff = (3.6)*(2.08) = 7.5 cfs

* Note: The curves in NEH, Chapter 2, for peak rates of discharge only read down to 5 acres of drainage area. Therefore, it is necessary to use the curves in Appendix D of Technical Release 55.

Provide 15 minutes flow through time at 0.5 inch depth of flow.
From Grass Filter Design Chart, for 4% slope,
Flow through velocity = 0.120 ft/sec

$$Length = 15\min * \frac{60\sec}{\min} * \frac{0.120\,ft}{\sec} = 108\,ft$$

Use 4:1 side slopes
From Grass Filter Design Chart, Sheet 14 of 20, for 4% slope,
Capacity of 4:1 side slopes

From Grass Filter Design Chart, for 4% slope,
Capacity of 4:1 triangular section = 0.001 cfs
Capacity per foot of bottom width = 0.005 cfs/ft

$$width = \frac{7.5 - 0.001}{0.005} = 1{,}499.8\,ft$$

Therefore, if a grass area filter strip is used, it must be at least 108 feet long (measured down slope), and 1,500 feet wide (measured across slope). A practical dimension would be 110 feet x 1,500 feet. It must be located generally on the contour. A level spreader is recommended along the upper edge of the filter strip to establish sheet flow.

(B) Grass Channel Filter Strip

ADA = 2.0 acres
RCN = 90 Moderate Slopes
2-yr, 24-hr Rainfall = 3.1 inches (NEH, Chapter 2)
2-yr, 24-hr Runoff = 2.08 inches
Peak Flow = 3.6 cfs/in. runoff = (3.6)*(2.08) = 7.5 cfs

Provide 30 minutes flow through time at 0.5 foot (6 inches) depth of flow.

From Grass Filter Design Chart, for 4% slope,
Flow through velocity = 2.558 ft/sec

$$Length = 30\min * \frac{60\sec}{\min} * 2.558\,ft/\sec = 4604.4\,ft$$

Use 4:1 side slopes

From Grass Filter Design Chart, for 4% slope,
Capacity of 4:1 triangular section = 0.385 cfs
Capacity per foot of bottom width = 1.2789 cfs/ft

$$Width = \frac{7.5 - 0.385}{1.2789} = 5.56\,ft$$

Therefore, if a grass channel filter strip is used, it must have a bottom width of 5.56 feet, 4:1 side slopes, and a length of 4,604.4 feet. This is not a practical solution. Try another design using a shallower depth of flow.

Depth of flow = 4 inches
Flow through velocity = 0.607 ft/sec
Capacity of triangular 4:1 section = 0.130 cfs
Capacity per feet of bottom width = 0.2023 cfs/ft

$$Length = 30\min * \frac{60\sec}{\min} * \frac{0.607\,ft}{\sec} = 1{,}092.6\,ft$$

$$Width = \frac{7.5 - 0.130}{0.2023} = 36.4\,ft$$

This is a more reasonable solution. If the site conditions will not allow this length of channel, it could be planned as a serpentine or switchback channel using a flatter grade.

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.10% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0008	0.019	0.0
0.050		0.000	0.000	0.000	0.000	0.000	0.000	0.0011	0.021	0.0
0.083	1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.0025	0.030	0.0
0.100		0.000	0.001	0.001	0.001	0.001	0.002	0.0034	0.034	0.0
0.125	1.5	0.001	0.001	0.002	0.002	0.002	0.003	0.0049	0.039	0.0
0.150		0.001	0.002	0.002	0.003	0.004	0.005	0.0066	0.044	0.0
0.167	2.0	0.002	0.002	0.003	0.004	0.005	0.007	0.0079	0.048	0.0
0.200		0.003	0.004	0.005	0.007	0.008	0.011	0.0107	0.054	0.0
0.208	2.5	0.003	0.004	0.006	0.007	0.009	0.012	0.0114	0.055	0.0
0.250	3.0	0.005	0.007	0.010	0.012	0.015	0.019	0.0155	0.062	0.0
0.292	3.5	0.007	0.011	0.015	0.018	0.022	0.029	0.0201	0.069	0.0
0.300		0.007	0.012	0.016	0.020	0.024	0.032	0.0211	0.070	0.0
0.333	4.0	0.010	0.015	0.021	0.026	0.031	0.042	0.0251	0.075	0.0
0.350		0.011	0.017	0.024	0.030	0.036	0.048	0.0272	0.078	0.1
0.375	4.5	0.013	0.021	0.028	0.036	0.043	0.057	0.0305	0.081	0.1
0.400		0.016	0.025	0.034	0.042	0.051	0.068	0.0340	0.085	0.1
0.417	5.0	0.018	0.028	0.038	0.047	0.057	0.076	0.0365	0.087	0.1
0.450		0.022	0.034	0.046	0.058	0.070	0.093	0.0414	0.092	0.1
0.458	5.5	0.023	0.036	0.048	0.061	0.073	0.098	0.0426	0.093	0.1
0.500	6.0	0.029	0.045	0.061	0.077	0.092	0.124	0.0493	0.099	0.1

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.20% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0011	0.027	0.0
0.050		0.000	0.000	0.000	0.000	0.000	0.000	0.0015	0.030	0.0
0.083	1.0	0.000	0.001	0.001	0.001	0.001	0.001	0.0035	0.042	0.0
0.100		0.001	0.001	0.001	0.001	0.002	0.002	0.0048	0.048	0.0
0.125	1.5	0.001	0.002	0.002	0.003	0.003	0.004	0.0069	0.055	0.0
0.150		0.002	0.003	0.003	0.004	0.005	0.007	0.0094	0.063	0.0
0.167	2.0	0.002	0.003	0.005	0.006	0.007	0.009	0.0112	0.067	0.0
0.200		0.004	0.006	0.007	0.009	0.011	0.015	0.0152	0.076	0.0
0.208	2.5	0.004	0.006	0.008	0.010	0.013	0.017	0.0162	0.078	0.0
0.250	3.0	0.006	0.010	0.014	0.017	0.021	0.028	0.0220	0.088	0.1
0.292	3.5	0.010	0.015	0.021	0.026	0.031	0.042	0.0285	0.097	0.1
0.300		0.010	0.016	0.022	0.028	0.033	0.045	0.0298	0.099	0.1
0.333	4.0	0.014	0.022	0.029	0.037	0.044	0.059	0.0354	0.106	0.1
0.350		0.016	0.025	0.033	0.042	0.050	0.068	0.0385	0.110	0.1
0.375	4.5	0.019	0.030	0.040	0.050	0.061	0.081	0.0432	0.115	0.1
0.400		0.023	0.035	0.048	0.060	0.072	0.096	0.0481	0.120	0.1
0.417	5.0	0.025	0.039	0.053	0.067	0.081	0.108	0.0516	0.124	0.1
0.450		0.031	0.048	0.065	0.082	0.099	0.132	0.0585	0.130	0.1
0.458	5.5	0.032	0.050	0.068	0.086	0.103	0.138	0.0603	0.132	0.1
0.500	6.0	0.041	0.064	0.086	0.108	0.131	0.175	0.0698	0.140	0.1

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.30% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0014	0.033	0.0
0.050		0.000	0.000	0.000	0.000	0.000	0.000	0.0018	0.037	0.0
0.083	1.0	0.000	0.001	0.001	0.001	0.001	0.002	0.0043	0.052	0.0
0.100		0.001	0.001	0.001	0.002	0.002	0.003	0.0058	0.058	0.0
0.125	1.5	0.001	0.002	0.003	0.003	0.004	0.005	0.0085	0.068	0.0
0.150		0.002	0.003	0.004	0.005	0.006	0.009	0.0115	0.077	0.0
0.167	2.0	0.003	0.004	0.006	0.007	0.009	0.012	0.0137	0.082	0.0
0.200		0.004	0.007	0.009	0.012	0.014	0.019	0.0186	0.093	0.1
0.208	2.5	0.005	0.008	0.010	0.013	0.015	0.021	0.0198	0.095	0.1
0.250	3.0	0.008	0.012	0.017	0.021	0.025	0.034	0.0269	0.108	0.1
0.292	3.5	0.012	0.019	0.025	0.032	0.038	0.051	0.0349	0.119	0.1
0.300		0.013	0.020	0.027	0.034	0.041	0.055	0.0365	0.122	0.1
0.333	4.0	0.017	0.026	0.036	0.045	0.054	0.072	0.0434	0.130	0.1
0.350		0.019	0.030	0.041	0.051	0.062	0.083	0.0472	0.135	0.1
0.375	4.5	0.023	0.036	0.049	0.062	0.074	0.099	0.0529	0.141	0.1
0.400		0.028	0.043	0.058	0.073	0.088	0.118	0.0589	0.147	0.1
0.417	5.0	0.031	0.048	0.065	0.082	0.099	0.132	0.0631	0.151	0.2
0.450		0.038	0.059	0.080	0.100	0.121	0.162	0.0717	0.159	0.2
0.458	5.5	0.040	0.062	0.084	0.105	0.127	0.170	0.0738	0.161	0.2
0.500	6.0	0.040	0.062	0.084	0.105	0.127	0.170	0.0738	0.161	0.2

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.40% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0016	0.038	0.0
0.050		0.000	0.000	0.000	0.000	0.000	0.001	0.0021	0.043	0.0
0.083	1.0	0.000	0.001	0.001	0.001	0.002	0.002	0.0049	0.060	0.0
0.100		0.001	0.001	0.002	0.002	0.003	0.003	0.0067	0.067	0.0
0.125	1.5	0.001	0.002	0.003	0.004	0.005	0.006	0.0098	0.078	0.0
0.150		0.002	0.004	0.005	0.006	0.007	0.010	0.0133	0.088	0.0
0.167	2.0	0.003	0.005	0.007	0.008	0.010	0.013	0.0159	0.095	0.0
0.200		0.005	0.008	0.011	0.013	0.016	0.021	0.0214	0.107	0.1
0.208	2.5	0.006	0.009	0.012	0.015	0.018	0.024	0.0229	0.110	0.1
0.250	3.0	0.009	0.014	0.019	0.024	0.029	0.039	0.0311	0.124	0.1
0.292	3.5	0.014	0.021	0.029	0.037	0.044	0.059	0.0403	0.138	0.1
0.300		0.015	0.023	0.031	0.039	0.047	0.063	0.0421	0.140	0.1
0.333	4.0	0.020	0.030	0.041	0.052	0.063	0.084	0.0501	0.151	0.1
0.350		0.022	0.035	0.047	0.059	0.071	0.096	0.0545	0.156	0.1
0.375	4.5	0.027	0.042	0.057	0.071	0.086	0.115	0.0611	0.163	0.2
0.400		0.032	0.050	0.067	0.085	0.102	0.136	0.0680	0.170	0.2
0.417	5.0	0.036	0.055	0.075	0.095	0.144	0.152	0.0729	0.175	0.2
0.450		0.044	0.068	0.092	0.116	0.140	0.187	0.0828	0.184	0.2
0.458	5.5	0.046	0.071	0.096	0.121	0.146	0.196	0.0853	0.186	0.2
0.500	6.0	0.058	0.090	0.122	0.153	0.185	0.247	0.0987	0.197	0.2

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.50% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0018	0.042	0.0
0.050		0.000	0.000	0.000	0.000	0.000	0.001	0.0024	0.048	0.0
0.083	1.0	0.001	0.001	0.001	0.001	0.002	0.002	0.0055	0.067	0.0
0.100		0.001	0.001	0.002	0.002	0.003	0.004	0.0075	0.075	0.0
0.125	1.5	0.002	0.002	0.003	0.004	0.005	0.007	0.0109	0.088	0.0
0.150		0.003	0.004	0.005	0.007	0.008	0.011	0.0148	0.099	0.0
0.167	2.0	0.003	0.005	0.007	0.009	0.011	0.015	0.0177	0.106	0.1
0.200		0.006	0.009	0.012	0.015	0.018	0.024	0.0240	0.120	0.1
0.208	2.5	0.006	0.010	0.013	0.017	0.020	0.027	0.0256	0.123	0.1
0.250	3.0	0.010	0.016	0.021	0.027	0.033	0.044	0.0347	0.139	0.1
0.292	3.5	0.015	0.024	0.032	0.041	0.049	0.066	0.0450	0.154	0.1
0.300		0.017	0.026	0.035	0.044	0.053	0.071	0.0471	0.157	0.1
0.333	4.0	0.022	0.034	0.046	0.058	0.070	0.094	0.0560	0.168	0.2
0.350		0.025	0.039	0.053	0.066	0.080	0.107	0.0609	0.174	0.2
0.375	4.5	0.030	0.047	0.063	0.080	0.096	0.128	0.0683	0.182	0.2
0.400		0.036	0.056	0.075	0.095	0.114	0.153	0.0761	0.190	0.2
0.417	5.0	0.040	0.062	0.084	0.106	0.127	0.170	0.0815	0.195	0.2
0.450		0.049	0.076	0.103	0.129	0.156	0.209	0.0926	0.206	0.2
0.458	5.5	0.051	0.080	0.108	0.136	0.164	0.219	0.0953	0.208	0.3
0.500	6.0	0.065	0.101	0.136	0.171	0.207	0.277	0.1103	0.221	0.3

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.60% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0019	0.046	0.0
0.050		0.000	0.000	0.000	0.000	0.000	0.001	0.0026	0.052	0.0
0.083	1.0	0.001	0.001	0.001	0.002	0.002	0.003	0.0061	0.073	0.0
0.100		0.001	0.002	0.002	0.003	0.003	0.004	0.0083	0.083	0.0
0.125	1.5	0.002	0.003	0.004	0.005	0.006	0.008	0.0120	0.096	0.0
0.150		0.003	0.004	0.006	0.008	0.009	0.012	0.0162	0.108	0.1
0.167	2.0	0.004	0.006	0.008	0.010	0.012	0.016	0.0194	0.116	0.1
0.200		0.006	0.010	0.013	0.016	0.020	0.026	0.0262	0.131	0.1
0.208	2.5	0.007	0.011	0.014	0.018	0.022	0.029	0.0280	0.135	0.1
0.250	3.0	0.011	0.017	0.024	0.030	0.036	0.048	0.0381	0.152	0.1
0.292	3.5	0.017	0.026	0.036	0.045	0.054	0.072	0.0493	0.169	0.2
0.300		0.018	0.028	0.038	0.048	0.058	0.078	0.0516	0.172	0.2
0.333	4.0	0.024	0.037	0.050	0.064	0.077	0.102	0.0614	0.184	0.2
0.350		0.027	0.043	0.058	0.073	0.087	0.117	0.0667	0.191	0.2
0.375	4.5	0.303	0.051	0.069	0.087	0.105	0.141	0.0748	0.200	0.2
0.400		0.039	0.061	0.082	0.104	0.125	0.167	0.0833	0.208	0.2
0.417	5.0	0.044	0.068	0.092	0.116	0.139	0.187	0.0893	0.214	0.3
0.450		0.053	0.083	0.113	0.142	0.171	0.229	0.1014	0.225	0.3
0.458	5.5	0.056	0.087	0.118	0.149	0.179	0.240	0.1044	0.228	0.3
0.500	6.0	0.071	0.110	0.149	0.188	0.226	0.303	0.1209	0.242	0.3

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.70% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0021	0.050	0.0
0.050		0.000	0.000	0.000	0.000	0.001	0.001	0.0028	0.056	0.0
0.083	1.0	0.001	0.001	0.001	0.002	0.002	0.003	0.0065	0.079	0.0
0.100		0.001	0.002	0.002	0.003	0.003	0.004	0.0089	0.089	0.0
0.125	1.5	0.002	0.003	0.004	0.005	0.006	0.008	0.0130	0.104	0.0
0.150		0.003	0.005	0.007	0.008	0.010	0.013	0.0175	0.117	0.1
0.167	2.0	0.004	0.006	0.009	0.011	0.013	0.018	0.0210	0.126	0.1
0.200		0.007	0.010	0.014	0.018	0.021	0.028	0.0283	0.142	0.1
0.208	2.5	0.007	0.011	0.016	0.020	0.024	0.032	0.0303	0.145	0.1
0.250	3.0	0.012	0.019	0.025	0.032	0.038	0.052	0.0411	0.164	0.1
0.292	3.5	0.018	0.028	0.038	0.048	0.058	0.078	0.0533	0.182	0.2
0.300		0.020	0.030	0.041	0.052	0.063	0.084	0.0557	0.186	0.2
0.333	4.0	0.026	0.040	0.055	0.069	0.083	0.111	0.0663	0.199	0.2
0.350		0.029	0.046	0.062	0.078	0.094	0.126	0.0720	0.206	0.2
0.375	4.5	0.035	0.055	0.075	0.094	0.114	0.152	0.0808	0.216	0.2
0.400		0.042	0.066	0.089	0.112	0.135	0.180	0.090	0.225	0.3
0.417	5.0	0.047	0.073	0.099	0.125	0.151	0.202	0.0965	0.231	0.3
0.450		0.058	0.090	0.122	0.153	0.185	0.247	0.1095	0.243	0.3
0.458	5.5	0.060	0.094	0.128	0.161	0.193	0.259	0.1128	0.246	0.3
0.500	6.0	0.076	0.119	0.161	0.203	0.244	0.327	0.1305	0.261	0.4

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.80% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.0022	0.054	0.0
0.050		0.000	0.000	0.000	0.000	0.001	0.001	0.0030	0.060	0.0
0.083	1.0	0.001	0.001	0.001	0.002	0.002	0.003	0.0070	0.084	0.0
0.100		0.001	0.002	0.002	0.003	0.004	0.005	0.0095	0.095	0.0
0.125	1.5	0.002	0.003	0.004	0.005	0.006	0.009	0.0138	0.111	0.1
0.150		0.003	0.005	0.007	0.009	0.011	0.014	0.0188	0.125	0.1
0.167	2.0	0.004	0.007	0.009	0.012	0.014	0.019	0.0224	0.134	0.1
0.200		0.007	0.011	0.015	0.019	0.023	0.030	0.0303	0.152	0.1
0.208	2.5	0.008	0.012	0.017	0.021	0.025	0.034	0.0324	0.156	0.1
0.250	3.0	0.013	0.020	0.027	0.034	0.041	0.055	0.0440	0.176	0.2
0.292	3.5	0.019	0.030	0.041	0.052	0.062	0.083	0.0569	0.195	0.2
0.300		0.021	0.033	0.044	0.056	0.067	0.090	0.0596	0.199	0.2
0.333	4.0	0.028	0.043	0.058	0.073	0.088	0.118	0.0709	0.213	0.2
0.350		0.032	0.049	0.067	0.084	0.101	0.135	0.0770	0.220	0.2
0.375	4.5	0.038	0.059	0.80	0.101	0.121	0.162	0.0864	0.230	0.3
0.400		0.045	0.070	0.095	0.120	0.144	0.193	0.0962	0.241	0.3
0.417	5.0	0.050	0.078	0.106	0.134	0.161	0.216	0.1031	0.247	0.3
0.450		0.062	0.096	0.130	0.164	0.197	0.264	0.1171	0.260	0.3
0.458	5.5	0.065	0.101	0.136	0.172	0.207	0.277	0.1277	0.263	0.4
0.500	6.0	0.082	0.127	0.172	0.217	0.261	0.350	0.1395	0.279	0.4

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 0.90% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.001	0.0024	0.057	0.0
0.050		0.000	0.000	0.000	0.000	0.001	0.001	0.0032	0.064	0.0
0.083	1.0	0.001	0.001	0.002	0.002	0.002	0.003	0.0074	0.089	0.0
0.100		0.001	0.002	0.003	0.003	0.004	0.005	0.0101	0.101	0.0
0.125	1.5	0.002	0.003	0.005	0.006	0.007	0.009	0.0147	0.117	0.1
0.150		0.003	0.005	0.007	0.009	0.011	0.015	0.0199	0.133	0.1
0.167	2.0	0.005	0.007	0.010	0.012	0.015	0.020	0.0238	0.143	0.1
0.200		0.008	0.012	0.016	0.020	0.024	0.032	0.0321	0.161	0.1
0.208	2.5	0.008	0.013	0.018	0.022	0.027	0.036	0.0343	0.165	0.1
0.250	3.0	0.014	0.021	0.029	0.036	0.044	0.058	0.0466	0.186	0.2
0.292	3.5	0.021	0.032	0.044	0.055	0.066	0.088	0.0604	0.207	0.2
0.300		0.022	0.035	0.047	0.059	0.071	0.095	0.0632	0.211	0.2
0.333	4.0	0.029	0.046	0.062	0.078	0.094	0.126	0.0752	0.226	0.2
0.350		0.033	0.052	0.071	0.089	0.107	0.143	0.0817	0.233	0.3
0.375	4.5	0.040	0.063	0.085	0.107	0.129	0.172	0.0916	0.244	0.3
0.400		0.048	0.074	0.101	0.127	0.153	0.205	0.1020	0.255	0.3
0.417	5.0	0.053	0.083	0.113	0.142	0.171	0.229	0.1094	0.262	0.3
0.450		0.065	0.102	0.138	0.174	0.209	0.280	0.1242	0.276	0.4
0.458	5.5	0.069	0.107	0.145	0.182	0.219	0.294	0.1279	0.279	0.4
0.500	6.0	0.087	0.135	0.183	0.230	0.277	0.371	0.1480	0.296	0.4

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 1.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.001	0.0025	0.060	0.0
0.050		0.000	0.000	0.000	0.001	0.001	0.001	0.0034	0.067	0.0
0.083	1.0	0.001	0.001	0.002	0.002	0.002	0.003	0.0078	0.094	0.0
0.100		0.001	0.002	0.003	0.003	0.004	0.005	0.0107	0.107	0.0
0.125	1.5	0.002	0.004	0.005	0.006	0.007	0.010	0.0155	0.124	0.1
0.150		0.004	0.006	0.008	0.010	0.012	0.016	0.0210	0.140	0.1
0.167	2.0	0.005	0.008	0.010	0.013	0.016	0.021	0.0251	0.150	0.1
0.200		0.008	0.012	0.017	0.021	0.025	0.034	0.0339	0.169	0.1
0.208	2.5	0.009	0.014	0.019	0.023	0.028	0.038	0.0362	0.174	0.1
0.250	3.0	0.014	0.022	0.030	0.038	0.046	0.062	0.0491	0.197	0.2
0.292	3.5	0.022	0.034	0.046	0.058	0.070	0.093	0.0637	0.218	0.2
0.300		0.023	0.036	0.049	0.062	0.075	0.100	0.0666	0.222	0.2
0.333	4.0	0.031	0.048	0.065	0.082	0.099	0.132	0.0792	0.238	0.3
0.350		0.035	0.055	0.074	0.094	0.113	0.151	0.0861	0.246	0.3
0.375	4.5	0.042	0.066	0.089	0.113	0.136	0.182	0.0966	0.258	0.3
0.400		0.050	0.079	0.106	0.134	0.161	0.216	0.1076	0.269	0.3
0.417	5.0	0.056	0.088	0.119	0.149	0.180	0.241	0.1153	0.276	0.4
0.450		0.069	0.107	0.145	0.183	0.221	0.295	0.1309	0.291	0.4
0.458	5.5	0.072	0.113	0.152	0.192	0.231	0.310	0.1348	0.294	0.4
0.500	6.0	0.091	0.142	0.193	0.243	0.292	0.391	0.1889	0.378	0.5

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 1.50% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.000	0.001	0.0031	0.073	0.0
0.050		0.000	0.000	0.001	0.001	0.001	0.001	0.0041	0.082	0.0
0.083	1.0	0.001	0.001	0.002	0.002	0.003	0.004	0.0096	0.115	0.0
0.100		0.002	0.002	0.003	0.004	0.005	0.007	0.0131	0.131	0.1
0.125	1.5	0.003	0.004	0.006	0.007	0.009	0.012	0.0190	0.152	0.1
0.150		0.005	0.007	0.010	0.012	0.014	0.019	0.0257	0.171	0.1
0.167	2.0	0.006	0.009	0.013	0.016	0.019	0.026	0.0307	0.184	0.1
0.200		0.010	0.015	0.020	0.026	0.031	0.042	0.0415	0.207	0.2
0.208	2.5	0.011	0.017	0.023	0.029	0.035	0.046	0.0443	0.213	0.2
0.250	3.0	0.018	0.027	0.037	0.047	0.056	0.075	0.0602	0.241	0.2
0.292	3.5	0.027	0.042	0.056	0.071	0.085	0.114	0.0780	0.267	0.3
0.300		0.029	0.045	0.060	0.076	0.092	0.123	0.0816	0.272	0.3
0.333	4.0	0.038	0.059	0.080	0.100	0.121	0.162	0.0971	0.291	0.4
0.350		0.043	0.067	0.091	0.115	0.138	0.185	0.1055	0.301	0.4
0.375	4.5	0.052	0.081	0.110	0.138	0.166	0.222	0.1183	0.315	0.4
0.400		0.062	0.096	0.130	0.164	0.197	0.264	0.1317	0.329	0.5
0.417	5.0	0.069	0.107	0.145	0.183	0.221	0.295	0.1412	0.339	0.5
0.450		0.084	0.132	0.178	0.224	0.270	0.362	0.2122	0.472	0.7
0.458	5.5	0.088	0.138	0.187	0.235	0.283	0.379	0.2390	0.522	0.7
0.500	6.0	0.112	0.174	0.236	0.297	0.358	0.479	0.3941	0.788	1.0

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 2.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.000	0.001	0.001	0.0036	0.085	0.0
0.050		0.000	0.000	0.001	0.001	0.001	0.001	0.0048	0.095	0.0
0.083	1.0	0.001	0.002	0.002	0.003	0.003	0.005	0.0111	0.133	0.1
0.100		0.002	0.003	0.004	0.005	0.006	0.008	0.0151	0.151	0.1
0.125	1.5	0.003	0.005	0.007	0.009	0.010	0.014	0.0219	0.175	0.1
0.150		0.005	0.008	0.011	0.014	0.017	0.022	0.0297	0.198	0.1
0.167	2.0	0.007	0.011	0.015	0.018	0.022	0.030	0.0355	0.212	0.2
0.200		0.011	0.017	0.024	0.030	0.036	0.048	0.0479	0.240	0.2
0.208	2.5	0.012	0.019	0.026	0.033	0.040	0.053	0.0512	0.246	0.2
0.250	3.0	0.020	0.032	0.043	0.054	0.065	0.087	0.0695	0.278	0.3
0.292	3.5	0.031	0.048	0.065	0.082	0.098	0.132	0.0900	0.308	0.4
0.300		0.033	0.052	0.070	0.088	0.106	0.142	0.0942	0.314	0.4
0.333	4.0	0.044	0.068	0.092	0.116	0.140	0.187	0.1121	0.337	0.4
0.350		0.050	0.078	0.105	0.132	0.160	0.214	0.1218	0.348	0.5
0.375	4.5	0.060	0.093	0.127	0.159	0.192	0.257	0.1366	0.364	0.5
0.400		0.071	0.111	0.150	0.189	0.228	0.305	0.1674	0.419	0.6
0.417	5.0	0.080	0.124	0.168	0.211	0.255	0.341	0.2274	0.545	0.8
0.450		0.097	0.152	0.206	0.259	0.312	0.418	0.3564	0.792	1.1
0.458	5.5	0.102	0.159	0.216	0.271	0.327	0.438	0.3912	0.854	1.1
0.500	6.0	0.129	0.201	0.272	0.343	0.413	0.553	0.5888	1.178	1.5

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 3.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.000	0.001	0.001	0.001	0.0044	0.104	0.0
0.050		0.000	0.001	0.001	0.001	0.001	0.001	0.0058	0.116	0.0
0.083	1.0	0.001	0.002	0.003	0.003	0.004	0.006	0.0135	0.163	0.1
0.100		0.002	0.003	0.005	0.006	0.007	0.009	0.0185	0.185	0.1
0.125	1.5	0.004	0.006	0.008	0.010	0.013	0.017	0.0268	0.214	0.1
0.150		0.006	0.010	0.013	0.017	0.020	0.027	0.0363	0.242	0.2
0.167	2.0	0.008	0.013	0.018	0.023	0.027	0.036	0.0434	0.260	0.2
0.200		0.014	0.021	0.029	0.036	0.044	0.059	0.0587	0.293	0.3
0.208	2.5	0.015	0.024	0.032	0.041	0.049	0.065	0.0626	0.301	0.3
0.250	3.0	0.025	0.039	0.053	0.066	0.080	0.107	0.0851	0.340	0.4
0.292	3.5	0.038	0.059	0.080	0.100	0.121	0.161	0.1103	0.378	0.5
0.300		0.040	0.063	0.085	0.108	0.130	0.173	0.1153	0.384	0.5
0.333	4.0	0.053	0.083	0.113	0.142	0.171	0.229	0.1373	0.412	0.6
0.350		0.061	0.095	0.129	0.162	0.195	0.262	0.1511	0.432	0.6
0.375	4.5	0.073	0.114	0.155	0.195	0.235	0.315	0.2516	0.671	0.9
0.400		0.087	0.136	0.184	0.232	0.279	0.374	0.3639	0.910	1.2
0.417	5.0	0.097	0.152	0.206	0.259	0.312	0.417	0.4499	1.079	1.4
0.450		0.119	0.186	0.252	0.317	0.382	0.512	0.6318	1.404	1.8
0.458	5.5	0.125	0.195	0.264	0.332	0.400	0.536	0.6741	1.472	1.9
0.500	6.0	0.158	0.247	0.334	0.420	0.506	0.677	0.9517	1.903	2.4

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 4.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.001	0.001	0.001	0.001	0.0050	0.120	0.0
0.050		0.000	0.001	0.001	0.001	0.001	0.002	0.0067	0.134	0.0
0.083	1.0	0.002	0.002	0.003	0.004	0.005	0.007	0.0156	0.189	0.1
0.100		0.002	0.004	0.005	0.007	0.008	0.011	0.0213	0.213	0.1
0.125	1.5	0.005	0.007	0.010	0.012	0.014	0.019	0.0310	0.240	0.2
0.150		0.007	0.011	0.016	0.020	0.024	0.032	0.0420	0.280	0.2
0.167	2.0	0.010	0.015	0.021	0.026	0.031	0.042	0.0502	0.300	0.3
0.200		0.016	0.025	0.033	0.042	0.051	0.068	0.0678	0.339	0.4
0.208	2.5	0.018	0.027	0.037	0.047	0.056	0.075	0.0723	0.348	0.4
0.250	3.0	0.029	0.045	0.061	0.076	0.092	0.123	0.0983	0.393	0.5
0.292	3.5	0.043	0.068	0.092	0.116	0.139	0.186	0.1273	0.436	0.6
0.300		0.047	0.073	0.099	0.124	0.150	0.200	0.1332	0.444	0.6
0.333	4.0	0.062	0.096	0.130	0.164	0.198	0.265	0.2023	0.607	0.9
0.350		0.70	0.110	0.149	0.187	0.226	0.302	0.2802	0.800	1.1
0.375	4.5	0.085	0.132	0.179	0.225	0.271	0.363	0.4076	1.087	1.4
0.400		0.101	0.157	0.212	0.268	0.322	0.431	0.5504	1.376	1.8
0.417	5.0	0.112	0.175	0.237	0.299	0.360	0.482	0.6595	1.582	2.0
0.450		0.138	0.215	0.291	0.366	0.441	0.591	0.8861	1.969	2.5
0.458	5.5	0.144	0.225	0.305	0.384	0.462	0.619	0.9467	2.067	2.6
0.500	6.0	0.182	0.285	0.385	0.485	0.584	0.782	1.2789	2.558	3.1

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 5.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.001	0.001	0.001	0.001	0.0056	0.134	0.0
0.050		0.000	0.001	0.001	0.001	0.001	0.002	0.0075	0.150	0.0
0.083	1.0	0.002	0.003	0.004	0.005	0.005	0.007	0.0175	0.211	0.1
0.100		0.003	0.004	0.006	0.007	0.009	0.012	0.0239	0.239	0.2
0.125	1.5	0.005	0.008	0.011	0.013	0.016	0.022	0.0346	0.277	0.2
0.150		0.008	0.013	0.017	0.022	0.026	0.035	0.0469	0.313	0.3
0.167	2.0	0.011	0.017	0.023	0.029	0.035	0.047	0.0561	0.336	0.3
0.200		0.018	0.028	0.037	0.047	0.057	0.076	0.0758	0.379	0.4
0.208	2.5	0.020	0.031	0.042	0.052	0.063	0.084	0.0809	0.389	0.4
0.250	3.0	0.032	0.050	0.068	0.085	0.103	0.138	0.1099	0.440	0.6
0.292	3.5	0.049	0.076	0.103	0.129	0.156	0.208	0.1423	0.478	0.7
0.300		0.052	0.082	0.110	0.139	0.167	0.224	0.1495	0.498	0.7
0.333	4.0	0.069	0.108	0.146	0.183	0.221	0.296	0.3100	0.931	1.3
0.350		0.079	0.123	0.166	0.209	0.252	0.338	0.4034	1.152	1.5
0.375	4.5	0.095	0.148	0.200	0.252	0.303	0.406	0.5564	1.484	1.9
0.400		0.113	0.176	0.238	0.299	0.360	0.482	0.7256	1.814	2.3
0.417	5.0	0.126	0.196	0.265	0.334	0.403	0.539	0.8554	2.051	2.6
0.450		0.153	0.240	0.325	0.409	0.493	0.660	1.1197	2.488	3.1
0.458	5.5	0.161	0.252	0.341	0.429	0.517	0.692	1.1909	2.600	3.2
0.500	6.0	0.204	0.318	0.431	0.542	0.653	0.875	1.5717	3.143	3.8

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 6.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.000	0.001	0.001	0.001	0.001	0.0062	0.147	0.0
0.050		0.000	0.001	0.001	0.001	0.002	0.002	0.0082	0.165	0.1
0.083	1.0	0.002	0.003	0.004	0.005	0.006	0.008	0.0192	0.231	0.1
0.100		0.003	0.005	0.006	0.008	0.010	0.013	0.0261	0.261	0.2
0.125	1.5	0.006	0.009	0.012	0.015	0.018	0.024	0.0379	0.303	0.2
0.150		0.009	0.014	0.019	0.024	0.029	0.039	0.0514	0.343	0.3
0.167	2.0	0.012	0.019	0.025	0.032	0.038	0.051	0.0614	0.368	0.4
0.200		0.019	0.030	0.041	0.052	0.062	0.083	0.0830	0.415	0.5
0.208	2.5	0.022	0.034	0.046	0.057	0.069	0.092	0.0886	0.426	0.5
0.250	3.0	0.035	0.055	0.074	0.094	0.113	0.151	0.1204	0.482	0.6
0.292	3.5	0.053	0.083	0.112	0.142	0.171	0.228	0.1885	0.645	0.9
0.300		0.057	0.089	0.121	0.152	0.183	0.245	0.2279	0.760	1.1
0.333	4.0	0.076	0.118	0.160	0.201	0.242	0.324	0.4135	1.242	1.6
0.350		0.086	0.135	0.182	0.229	0.276	0.370	0.5214	1.490	1.9
0.375	4.5	0.104	0.162	0.219	0.276	0.332	0.445	0.6969	1.858	2.4
0.400		0.123	0.192	0.260	0.328	0.395	0.528	0.8891	2.248	2.8
0.417	5.0	0.138	0.215	0.291	0.366	0.441	0.590	1.0368	2.486	3.1
0.450		0.169	0.263	0.356	0.449	0.540	0.723	1.3509	3.002	3.7
0.458	5.5	0.177	0.276	0.373	0.470	0.566	0.758	1.4318	3.126	3.8
0.500	6.0	0.223	0.349	0.472	0.594	0.716	0.958	1.8660	3.732	4.5

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 7.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.001	0.001	0.001	0.001	0.001	0.0067	0.158	0.0
0.050		0.001	0.001	0.001	0.001	0.002	0.002	0.0089	0.178	0.1
0.083	1.0	0.002	0.003	0.004	0.005	0.006	0.009	0.0207	0.249	0.1
0.100		0.003	0.005	0.007	0.009	0.011	0.014	0.0282	0.282	0.2
0.125	1.5	0.006	0.009	0.013	0.016	0.019	0.026	0.0410	0.328	0.3
0.150		0.010	0.015	0.021	0.026	0.031	0.042	0.0555	0.370	0.4
0.167	2.0	0.013	0.020	0.027	0.034	0.042	0.056	0.0664	0.397	0.4
0.200		0.021	0.033	0.044	0.056	0.067	0.090	0.0896	0.448	0.5
0.208	2.5	0.023	0.036	0.049	0.062	0.075	0.100	0.0957	0.460	0.6
0.250	3.0	0.038	0.059	0.080	0.101	0.122	0.163	0.1300	0.520	0.7
0.292	3.5	0.058	0.090	0.121	0.153	0.184	0.247	0.2581	0.884	1.2
0.300		0.062	0.096	0.131	0.164	0.198	0.265	0.3039	1.013	1.4
0.333	4.0	0.082	0.127	0.172	0.217	0.261	0.350	0.5130	1.540	2.0
0.350		0.093	0.145	0.197	0.248	0.299	0.400	0.6396	1.827	2.3
0.375	4.5	0.112	0.175	0.237	0.298	0.359	0.480	0.8384	2.236	2.8
0.400		0.133	0.208	0.281	0.354	0.426	0.571	1.0543	2.636	3.3
0.417	5.0	0.149	0.232	0.314	0.395	0.476	0.638	1.2207	2.927	3.6
0.450		0.182	0.284	0.385	0.484	0.584	0.781	1.5495	3.443	4.2
0.458	5.5	0.191	0.298	0.403	0.508	0.612	0.819	1.6395	3.580	4.3
0.500	6.0	0.241	0.377	0.510	0.642	0.773	1.035	2.1437	4.287	5.1

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 8.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.001	0.001	0.001	0.001	0.001	0.0071	0.169	0.1
0.050		0.001	0.001	0.001	0.001	0.002	0.002	0.0095	0.190	0.1
0.083	1.0	0.002	0.003	0.005	0.006	0.007	0.009	0.0221	0.267	0.2
0.100		0.004	0.006	0.007	0.009	0.011	0.015	0.0302	0.302	0.2
0.125	1.5	0.006	0.010	0.014	0.017	0.020	0.027	0.0438	0.350	0.3
0.150		0.010	0.016	0.022	0.028	0.033	0.045	0.0593	0.396	0.4
0.167	2.0	0.014	0.022	0.029	0.037	0.044	0.059	0.0710	0.425	0.5
0.200		0.022	0.035	0.047	0.060	0.072	0.096	0.0958	0.479	0.6
0.208	2.5	0.025	0.039	0.053	0.066	0.080	0.107	0.1023	0.492	0.6
0.250	3.0	0.041	0.063	0.086	0.108	0.130	0.174	0.1390	0.556	0.8
0.292	3.5	0.061	0.096	0.130	0.163	0.197	0.264	0.3274	1.121	1.5
0.300		0.066	0.103	0.140	0.176	0.212	0.283	0.3768	1.256	1.7
0.333	4.0	0.087	0.136	0.184	0.232	0.280	0.374	0.6135	1.842	1.4
0.350		0.100	0.156	0.210	0.265	0.319	0.427	0.7479	2.137	2.7
0.375	4.5	0.120	0.187	0.253	0.319	0.384	0.514	0.9639	2.570	3.2
0.400		0.142	0.222	0.301	0.378	0.456	0.610	1.2142	3.035	3.7
0.417	5.0	0.159	0.248	0.336	0.423	0.509	0.682	1.3971	3.350	4.1
0.450		0.195	0.304	0.411	0.518	0.624	0.835	1.7594	3.910	4.7
0.458	5.5	0.204	0.319	0.431	0.543	0.654	0.875	1.8578	4.056	4.9
0.500	6.0	0.258	0.403	0.545	0.686	0.826	1.106	2.4074	4.815	5.7

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 9.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.001	0.001	0.001	0.001	0.002	0.0075	0.180	0.1
0.050		0.001	0.001	0.001	0.002	0.002	0.003	0.0101	0.202	0.1
0.083	1.0	0.002	0.004	0.005	0.006	0.007	0.010	0.0235	0.283	0.2
0.100		0.004	0.006	0.008	0.010	0.012	0.016	0.0320	0.320	0.2
0.125	1.5	0.007	0.011	0.014	0.018	0.022	0.029	0.0464	0.371	0.3
0.150		0.011	0.017	0.023	0.029	0.035	0.047	0.0629	0.420	0.4
0.167	2.0	0.015	0.023	0.031	0.039	0.047	0.063	0.0753	0.451	0.5
0.200		0.024	0.037	0.050	0.063	0.076	0.102	0.1016	0.508	0.6
0.208	2.5	0.026	0.041	0.056	0.070	0.085	0.113	0.1085	0.522	0.7
0.250	3.0	0.043	0.067	0.091	0.115	0.138	0.185	0.1474	0.590	0.9
0.292	3.5	0.065	0.102	0.138	0.173	0.209	0.280	0.3935	1.347	1.8
0.300		0.070	0.109	0.148	0.186	0.224	0.300	0.4505	1.502	2.0
0.333	4.0	0.093	0.144	0.195	0.246	0.297	0.397	0.7052	2.118	2.7
0.350		0.100	0.165	0.223	0.281	0.339	0.453	0.8593	2.455	3.1
0.375	4.5	0.127	0.198	0.268	0.338	0.407	0.545	1.0961	2.923	3.6
0.400		0.151	0.236	0.319	0.401	0.483	0.657	1.3683	3.421	4.2
0.417	5.0	0.169	0.263	0.356	0.448	0.540	0.723	1.5457	3.707	4.5
0.450		0.207	0.322	0.436	0.549	0.662	0.886	1.9606	4.357	5.2
0.458	5.5	0.217	0.338	0.457	0.576	0.694	0.929	2.0669	4.513	5.4
0.500	6.0	0.274	0.427	0.578	0.728	0.877	1.173	2.6154	5.231	6.2

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

GRASS FILTER – DESIGN CHART TRAPEZOIDAL VEGETATED CHANNEL									S = 10.00% C Retardance	
Depth Of Flow		Capacity of Triangular Section						Capacity Per Foot Bottom Width cfs	Velocity	
		Side Slope Ratio							Flow Through C Retardance fps	Stability Check D Retardance fps
(ft)	(in)	2:1 cfs	3:1 cfs	4:1 cfs	5:1 cfs	6:1 cfs	8:1 cfs			
0.042	0.5	0.000	0.001	0.001	0.001	0.001	0.002	0.0079	0.189	0.1
0.050		0.001	0.001	0.001	0.002	0.002	0.003	0.0106	0.213	0.1
0.083	1.0	0.002	0.004	0.005	0.006	0.008	0.010	0.0247	0.298	0.2
0.100		0.004	0.006	0.008	0.010	0.013	0.017	0.0337	0.337	0.3
0.125	1.5	0.007	0.011	0.015	0.019	0.023	0.031	0.0489	0.392	0.4
0.150		0.012	0.018	0.025	0.031	0.037	0.050	0.0663	0.442	0.5
0.167	2.0	0.015	0.024	0.033	0.041	0.050	0.066	0.0793	0.475	0.5
0.200		0.025	0.039	0.053	0.067	0.080	0.107	0.1071	0.536	0.7
0.208	2.5	0.028	0.043	0.059	0.074	0.089	0.119	0.1144	0.550	0.7
0.250	3.0	0.045	0.071	0.096	0.121	0.146	0.195	0.1849	0.740	1.1
0.292	3.5	0.069	0.107	0.145	0.183	0.220	0.295	0.4606	1.578	2.1
0.300		0.074	0.115	0.156	0.196	0.237	0.317	0.5193	1.731	2.3
0.333	4.0	0.098	0.152	0.206	0.259	0.313	0.418	0.8008	2.405	3.0
0.350		0.111	0.174	0.235	0.296	0.357	0.478	0.9566	2.733	3.4
0.375	4.5	0.134	0.209	0.283	0.356	0.429	0.574	1.2243	3.265	4.0
0.400		0.159	0.248	0.336	0.423	0.510	0.682	1.4962	3.740	4.6
0.417	5.0	0.178	0.277	0.375	0.473	0.569	0.762	1.7094	4.099	4.9
0.450		0.218	0.340	0.460	0.579	0.698	0.934	2.1541	4.787	5.7
0.458	5.5	0.228	0.356	0.482	0.607	0.731	0.979	2.2677	4.951	5.9
0.500	6.0	0.289	0.450	0.609	0.806	1.012	1.407	2.8572	5.714	6.7

Bottom Width = (Filter Design Capacity – Capacity of Triangular Section) / Capacity per Foot Bottom Width
Top Width = (2 x Side Slope Ratio x Depth) + Bottom Width
Contact Time = Filter Length / Flow Through Velocity

AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK
210-I-AWMFH – AMENDMENT IA-1

Agricultural Waste Management System Design Sheets

This amendment includes worksheets for the design of animal waste system components. Worksheets cover sediment basin, stacking facility, vegetative filter strip, and mortality compost bin designs.

Sediment Basin Design Worksheet < 100 AU

United States Department of Agriculture - Natural Resources Conservation Service

Client:		**Date:**	
Designed by:		**County:**	
Checked by:		**Twp -Range -Sec:**	
Approved by:			

Section I: (non-excluded roof areas may be included with concrete)

Concrete Area in ft^2 of feedlot: _____ ft^2

Earthen Area in ft^2 of feedlot: _____ ft^2

Other Area in ft^2: _____ ft^2

Section II:

1. Solid Manure Runoff into Settling Basin

Total combined feedlot area (ft^2): _____ Solids Volume (0.5" depth): _____

2. Storm Volume

A. Q_{10}, 24 hour rainfall (inches of rainfall) = _____

B. Q_{10}, 24 hour runoff (from concrete areas using RCN 98) = _____

C. Q_{10}, 24 hour runoff (from earthen areas using RCN 90) = _____

D. Q_{10}, 24 hour runoff (from other areas) = RCN = _____ _____

E. Runoff depth/12" x total concrete area = Runoff Volume (ft^3) = _____

F. Runoff depth/12" x total earthen area = Runoff Volume (ft^3) = _____

G. Runoff depth/12" x total other area = Runoff Volume (ft^3) = _____

3. Total Volume (1 + 2E + 2F + 2G) (ft^3) = _____

Section III:

Emergency spillway or freeboard are not required for settling basins with less than 100 animal units. It is recommended that settling basins are not deeper than 4.0 ft, usually 1.5 ft to 2.5 ft is ideal. Outlet structures may be wooden slatted walls, pipe intakes with holes, or a combination. Concrete ramp slabs shall not be steeper than 8:1, but 10:1 is recommended to facilitate cleanout. Walls can be made out of compacted clay, reinforced concrete, or timber. Sediment basins are designed to be emptied after receiving a significant accumulation of sediment. Owner/Operator shall not store solids in the basin. If storage is needed then stacking facilities options shall be considered.

Sediment Basin Design Worksheet > 100 AU

United States Department of Agriculture - Natural Resources Conservation Service

Client: _____ **Date:** _____

Designed by: _____ **County:** _____

Checked by: _____ **Twp -Range -Sec:** _____

Approved by: _____

Section I: (non-excluded roof areas may be included with concrete)

Concrete Area in ft^2 of feedlot: [ ] ft^2

Earthen Area in ft^2 of feedlot: [ ] ft^2

Other Area in ft^2: [ ] ft^2

Section II:

1. Solid Manure Runoff into Settling Basin

Total combined feedlot area (ft^2): [ ] Solids Volume (0.5" depth): [ ]

2. Storm Volume

A. Q_{10}, 1 hour rainfall (inches of rainfall) = [ ]

B. Q_{10}, 1 hour runoff (from concrete areas using RCN 98) = [ ]

C. Q_{10}, 1 hour runoff (from earthen areas using RCN 90) = [ ]

D. Q_{10}, 1 hour runoff (from other areas) = RCN = [ ] [ ]

E. Runoff depth/12" x total concrete area = Runoff Volume (ft^3) = [ ]

F. Runoff depth/12" x total earthen area = Runoff Volume (ft^3) = [ ]

G. Runoff depth/12" x total other area = Runoff Volume (ft^3) = [ ]

3. Emergency Storm Volume - (Compute if storing this volume, if not go to 5 and Section III)

A. Q_{25}, 24 hour rainfall (inches of rainfall) = [ ]

B. Q_{25}, 24 hour runoff (from concrete areas using RCN 98) = [ ]

C. Q_{25}, 24 hour runoff (from earthen areas using RCN 90) = [ ]

D. Q_{25}, 24 hour runoff (from other areas) = RCN = [ ] [ ]

E. Runoff depth/12" x total concrete area = Runoff Volume (ft^3) = [ ]

F. Runoff depth/12" x total earthen area = Runoff Volume (ft^3) = [ ]

G. Runoff depth/12" x total other area = Runoff Volume (ft^3) = [ ]

4. Total Volume: (1 + 2E + 2F + 2G +3E + 3F + 3G) (ft^3) = [ ]

5. Total Volume: If passing the Q_{25} via spillway (1 + 2E + 2F + 2G) (ft^3) = [ ]

Section III:

If the size of your feedlot is smaller than 15,000 ft^2, use a minimum flow depth of 0.5 ft and minimum channel width of 5 ft for the minimum emergency spillway dimensions.

Section IV:

Once the size of the basin has been established, make sure there is at least 450 ft^2 of surface area of basin per ft^3 of runoff from a Q_{10}, 1 hour storm.

Solid Stacking Facility Design Worksheet

United States Department of Agriculture - Natural Resources Conservation Service

Client:		**Date:**	
Designed by:		**County:**	
Checked by:		**Twp -Range -Sec:**	
Approved by:			

Section I: Animal Waste

	Animal Type	# of Animals	Manure (ft^3/day)	Total (ft^3)
1.				
2.				
3.				
4.				
5.				
6.	Total Animal Waste		x Days of Storage	Total (ft^3)=

Section II: Bedding

1. Bedding (ft^3/day) _____ x Days of Storage _____ Total (ft^3)= _____

Section III: Total Volume Required

Total of Section I _____ + Total of Section II _____ Total (ft^3) _____

Section IV:

Solid stacking facilities are used to provide storage for solid manure from dairy parlors, loafing sheds, open feedlots, or any confinement facility that produces solid manure and bedding where liquids can be separated. Solid stacking facilities should not be confused with solid settling basins, they are not the same. The structure shall provide for a minimum storage period of no less than 30 days. Runoff from open feedlots shall be excluded from solid stacking facilities. The structure may be built using formed reinforced concrete walls, precast concrete walls, timber walls, compacted clay embankment, or other materials specified by the engineer. For permit sized operations runoff from manure stacking facilities must be contained. For other operations, runoff can be routed to a vegetative filter strip before release.

Vegetative Filter Strip Design Worksheet

United States Department of Agriculture - Natural Resources Conservation Service

Client: _____ **Date:** _____

Designed by: _____ **County:** _____

Checked by: _____ **Twp -Range -Sec:** _____

Approved by: _____

Section I:

Drainage Area (acres): [ ]

Length of Drainage Area (ft): [ ]

Slope of Drainage Area (%): [ ]

Section II:

RCN: [ ] (use 90 for unpaved lots)

(use 98 for paved lots)

(Compute RCN for other areas)

Q_2 24 hr: Calculate the peak flow using Ohio programs.

Rainfall (in) = [ ]

Runoff (in) = [ ] Peak Flow (Q - cfs) = [ ]

Trial I:

Side Slope = [ ] Channel Slope = [ ] Channel Depth = [ ]

Bottom Width = (Peak Flow - Capacity of Δ Section) / Capacity per ft of Bottom Width

BW = ([ ] (cfs) - [ ] (cfs) **)** / [ ] (cfs/ft) = [ ] (ft)

Length of channel = 30 minutes x 60 seconds/minute x flow through velocity

Length = 30 (min) x 60 (sec/min) x [ ] (fps) = [ ] (ft)

Trial II:

Side Slope = [ ] Channel Slope = [ ] Channel Depth = [ ]

Bottom Width = (Peak Flow - Capacity of Δ Section) / Capacity per ft of Bottom Width

BW = ([ ] (cfs) - [ ] (cfs) **)** / [ ] (cfs/ft) = [ ] (ft)

Length of channel = 30 minutes x 60 seconds/minute x flow through velocity

Length = 30 (min) x 60 (sec/min) x [ ] (fps) = [ ] (ft)

Animal Mortality Composting Facility Design Worksheet

United States Department of Agriculture - Natural Resources Conservation Service

Client: _____ **Date:** _____

Designed by: _____ **County:** _____

Checked by: _____ **Twp -Range -Sec:** _____

Approved by: _____

Section I: Animal Waste

	Animal Type	Average Wt (lbs)	No. of Animals	Mortality Loss (%)	Daily Loss (lbs)
1.					
2.					
3.					
4.					
5.					

Total Daily Mortality Loss (lbs) = _____

Daily Loss = (Ave Wt x No. of Animals x Loss %)/365

Section II: Primary and Secondary Compost Volumes

Primary Volume (ft^2) = (Total Daily Loss x 20) = _____

Secondary Volume (ft^2)= Primary Volume = _____

Section III: Bin Volume and Numbers

Bin Depth (ft) = _____

Bin Width (ft) = _____

Bin Length (ft) = _____

Individual Bin Vol. (ft) = Length x Width x Depth = _____

# of Primary Bins = Primary Vol/Individual Bin Vol = _____

(Round primary bins up to nearest whole # and add one bin)

# of Secondary Bins = Primary Vol/Individual Bin Vol = _____

(Round secondary bins up to nearest whole #)

# of Materials Bins (usually at least one) = _____

Total # of Bins = Primary + secondary + materials = _____

Actual Bin Dimensions

Depth = Bin Depth +1 = _____

Width (same as above)= _____

Length (same as above)= _____

Cost Estimate

Inside Bin Area (# of bins x width x length) = _____

Cost per ft^2 of inside bin area (use $40/$ft^2$) = _____

Total Cost $ (inside bin area x Cost/ft^2) = _____

Section IV:

Primary and secondary volumes based on 20 ft^3 per pound of average daily loss. Sequencing will require a minimum of 2 primary bins in most cases. An extra secondary and a materials bin are suggested as well.

AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK
210-I-AWMFH – AMENDMENT IA-1

Operation and Maintenance Guidance for Animal Waste Systems

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Operation and Maintenance of Agricultural Waste Management Systems

Waste Management Systems must be properly planned, designed, and installed to prevent or minimize degradation of air, soil, and water resources and to protect public health and safety.

The goal should be to develop waste management systems which prevent pollution of surface or ground water. Such systems include those for treatment of agricultural wastes, effluent from municipal waste treatment plants, and food processing wastes.

Planning, designing, and installing waste management systems that function properly requires multi-disciplinary decisions by soil scientists, geologists, plant scientists, biologists, engineers, contractors, and landowners. The combined effort will be to no avail if the waste management system and its components are not properly operated and maintained.

The operation and maintenance is the responsibility of the owner/operator, who must have sufficient training and guidance to know what and when specific operations and inspections must be done.

It is the responsibility of NRCS, working jointly with landowners, to develop an operation and maintenance (O&M) plan for the systems installed with NRCS technical assistance. Planning for O&M begins when the planner starts developing alternatives for managing the wastes produced at a site. After each component is installed, the written O&M plan for the specific component must be reviewed with the owner/operator to insure that he understands the steps required to properly operate and maintain the installation.

This guide has been developed to assist the planner and designer in developing an adequate O&M plan.

Waste Management System – General

A properly designed waste management system should provide storage, treatment, and utilization of the waste produced. The waste can be applied to and incorporated into cropland to furnish nitrogen, phosphorous, and potassium for crop needs. The recommended fertilizer rates for these nutrients should be adjusted downward to compensate for the amount of nutrients in the waste applied. When the owner/operator sells the waste to others, proper management will help retain nutrients in the waste and thus produce a waste material more valuable to the buyer.

The owner/operator is responsible for operating and maintaining the system. When NRCS is furnishing technical assistance, the person developing the plan must work with the owner/operator and prepare the O&M plan for the system. This plan must meet the standard for Waste Utilization (633) or Nutrient Management (590) and should provide for using agricultural waste or other wastes in an environmentally acceptable manner while maintaining or improving soil, water, and plant resources. The O&M plan must provide specific details concerning the operation and maintenance of each component and should include:

1. Timing; rates of application of waste; and, if appropriate, approximate number of trips for hauling equipment and an estimate of the time required.
2. Acreage and location of sites for utilization.
3. Minimum and maximum operation levels for storage and treatment ponds and lagoons and other operations specific to the practice such as estimated frequency of solids removed, checking pH, methods of loading, salinity checks, etc.
4. Safety warnings, particularly where there is danger of drowning or exposure to poisonous or explosive gases.
5. Maintenance requirements for each of the practices which are components of the waste management system.

General Safety Notes

Waste storage structures must be considered "High Hazard Areas." The biodegradation of waste forms noxious gases such as methane (CH_4), hydrogen sulfide (H_2S), ammonia (NH_3), and carbon dioxide (CO_2), which can be fatal to both animals and human beings.

With the proper gas to air ratio, some of the gases can be explosive. Be cautious with open flames, welding torches and arcs, and electrical motors with brushes that spark, (i.e.: skill saws, electrical drills, shop vacuums, etc.), when near waste storage structures. Be sure the work area is well ventilated.

Agitation of liquid manure can release large volumes of these noxious gases. Special care must be taken to provide adequate ventilation during agitation and emptying of the storage structures. If there is a question regarding the adequacy of ventilation, animals should be evacuated from the building and the operator should wear an oxygen mask.

Operators should avoid working along during agitation and emptying of totally or semi-enclosed structures.

A pit, tank, or other storage facility that has contained liquid/slurry manure waste should not be entered because gases may remain in the structure. When it is necessary for someone to enter one of the structures for repairs, the following precautions must be taken:

1. There should be at least two people present – one to remain on the outside and one to enter the structure.
2. The one entering the structure must have a safety harness with a safety line attached to a winch or hoist so the "outside" man can pull him out without entering the structure.
3. The one entering must have an air mask which furnishes outside air through an air line and compressor, SCUBA equipment with air tanks, or other means of positively furnished outside air to the "inside" person.
4. Gas masks must not be used because they operate on the principle of chemically removing unwanted gases from "air" so the wearer can breathe safely. In waste storage/treatment structures, the "air" has been displaced by the noxious gases and when the gases are removed by the gas mask, the wearer will suffocate because there is no air for him to breathe.

All lids, gates, hatch covers, and safety grills/guards must be secured in place when tanks and pit openings are left unattended. It has been reported that heavy slide-in-place covers have been moved by livestock. Never leave an unattended ladder standing against an above-ground waste storage structure.

All waste storage and treatment structures must be posted with signs with the following or similar warning: "DANGER – KEEP OUT" – This is a waste storage/treatment facility and prolonged exposure may be hazardous to your health.

Waste Storage Facility – Tank

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 20-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs.
2. Follow your comprehensive nutrient management plan (CNMP).
3. Do not dispose of dead animals, greases, syringes, human waste, or other wastes in the tank.
4. Inspect concrete sumps, pits, walls, ramps, slats, and floors often for separations and/or cracks which would indicate potential failure. Repairs should be made immediately. A thorough inspection should be made each time the waste tank is emptied.
5. Check backfill areas around concrete structures often for unusual settlement. Determine if settlement is caused by backfill consolidation or failure of concrete walls. Repair walls or fill as appropriate.
6. A good vegetative cover of recommended grassed should be maintained on backfill around structures. If the vegetative cover is damaged it should be re-established as soon as possible. The vegetative cover should be mowed 2 times a year to stimulate a vigorous plant growth.
7. Outlets of foundation and sub-drains should be checked frequently and kept open. The outflow from these drains should be checked when storage is being used to determine if there is leakage from the tank. If leakage is detected, repairs should be planned and made when the facility is empty.
8. Inspect haul roads and approaches to and from the storage facility frequently to determine the need for replacement stone or other stabilizing materials.
9. All fences, railings, and/or warning signs shall be maintained to prevent unauthorized human or livestock entry.
10. All appurtenances - pipes, pumps, manure pumps, valves, gates, etc., should be inspected periodically (minimum of 2 times a year) to make sure they are functional, structurally sound, and are not cracked, broken, and/or a safety hazard to the operator or livestock. Maintain grounding rods and wiring for all electrical equipment in good condition. Repair as needed.
11. Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials and re-seed.
12. Waste storage structure signs should be clearly posted and maintained. These signs should state the type of structure and the dangers of entering potentially hazardous air space. Do not allow human entry to any enclosed structure without safety equipment that includes ladders and breathing apparatus. The biodegradation of the waste releases a number of gases which could be explosive or suffocative.
13. Do not operate loaded feed wagon, trucks, manure spreaders, or other heavy equipment within five feet of the tank walls.
14. Maintain the depth gauge that visually shows the following elevations:
    - Maximum operating level
    - Top of emergency volume
    - Top of freeboard volume
15. Begin emptying or drawdown according to the schedule in the CNMP or sooner if the contents of the storage facility reach the maximum operating level.
16. Inspect the outlet of any artificial drainage system installed to lower a perched seasonal high water table adjacent to the waste storage facility. The inspections should occur at least 2 times a year: (a) once during the high water table season to ensure that water is flowing indicating the system is operating [not blocked], and (b) once during the dry season to ensure there is no direct leakage from the storage facility into the drainage system that may be indicated by high

flow rate, turbidity, discoloration, odors, or other unusual characteristics of the flow. Immediately investigate any indication of blockage or leakage and consult a qualified individual for any corrective action needed.

Waste Storage Facility – Stacking Facility

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 20-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs.
2. Follow your comprehensive nutrient management plan (CNMP).
3. Do not dispose of animal mortality, greases, syringes, human waste, or other wastes in the stacking facility.
4. Inspect concrete and wood walls, concrete floors, and roofs often for separations and/or cracks which would indicate potential failure. Repairs should be made immediately. A thorough inspection should be made each time the stacking facility is emptied.
5. Inspect haul roads and approaches to and from the storage facility frequently to determine the need for stone or other stabilizing materials.
6. All gates should be inspected periodically (minimum of 2 times per year) to make sure they are functional, structurally sound, and are not cracked, broken, and/or a safety hazard to the operator or the animals.
7. Earth embankments should be mowed 2 times per year. A good vegetative cover should be maintained on earth embankments. If the vegetative cover is damaged, embankments should be revegetated as soon as possible.
8. When accessible to children or livestock the facility should be gated or fenced. All fences and gates shall be inspected for damage at least 2 times a year. Damaged fences and gates should be repaired or replaced as soon as possible.
9. Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials and re-seed.

Waste Storage Facility – Pond

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 20-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs.
2. Follow your comprehensive nutrient management plan (CNMP).
3. Do not dispose of animal mortality, greases, syringes, human waste, or other wastes in the pond.
4. A thorough inspection of clay or geosynthetic liners and concrete sumps, pits, walls, ramps and floors often for separations and/or cracks which would indicate potential failure should be made each time the pond is emptied. Repairs should be made immediately.
5. Inspect haul roads and approaches to and from the storage facility frequently to determine the need for stone or other stabilizing materials. Repair roads as needed.
6. All pipes, pumps, valves, gates, etc., should be inspected a minimum of 2 times a year. Inspect for functional and structural soundness. Repair as needed.
7. Mow the embankments 2 times a year. Good vegetative cover should be maintained on earth embankments. If the vegetative cover is damaged, embankments should be re-vegetated as soon as possible.
8. Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials and re-seed.
9. The livestock facility, including the embankments, should be fenced. All fences and gates should be inspected at least 2 times a year. Damaged fences and gates should be repaired or replaced as soon as possible.
10. Maintain appropriate warning signs.
11. Safety stations should be inspected at least 2 times a year. Safety items such as ropes and swim rings should be replaced as necessary.
12. Maintain the depth gauge that visually shows the following elevations:
    - Maximum operating level
    - Top of emergency volume
    - Top of freeboard volume
13. Begin emptying or drawdown according to the schedule in the CNMP or sooner if the contents of the storage facility reach the maximum operating level.
14. Inspect the outlet of any artificial drainage system installed to lower a perched seasonal high water table adjacent to the waste storage facility. The inspections should occur at least 2 times a year: (a) once during the high water table season to ensure that water is flowing indicating the system is operating [not blocked], and (b) once during the dry season to ensure there is no direct leakage from the storage facility into the drainage system that may be indicated by high flow rate, turbidity, discoloration, odors, or other unusual characteristics of the flow. Immediately investigate any indication of blockage or leakage and consult a qualified individual for any corrective action needed.

Pond Sealing or Lining – Compacted Clay Liner

A properly operated and maintained pond lining or sealing is an asset to the farm. This system was designed and installed to reduce seepage in a pond. The estimated life span of this installation is at least 15 years. The life of this installation can be assured and usually increased by developing and carrying out a good operation and maintenance program.

This practice will require you to perform periodic operation to maintain satisfactory performance. Here are some recommendations to help you develop a good operation and maintenance program:

1. Maintain the soil covering on liners at the construction depth.
2. Limit the use or travel of any equipment in the area that was sealed. Avoid excessive speeds and sharp turns.
3. Prevent all livestock from using any area of the pond which was sealed by artificial liners.
4. Fences shall be maintained to provide warning and/or prevent unauthorized human or livestock entry.
5. Settlement or cracks in the soil weaken earthen sections and may accelerate the development of flow paths that may result in structure failure. This should be investigated to determine the cause and immediately repaired.
6. Inspect for damage from rodents or burrowing animals. Repair any damage. Take appropriate corrective actions to alleviate further damage.
7. Immediately remove any debris that may harm or reduce the effectiveness of sealants.
8. Immediately repair any vandalism, vehicular, or livestock damage to any earthfills, spillways, outlets, or other apparatuses.

Pond Sealing or Lining – Bentonite Treatment

A properly operated and maintained pond lining or sealing is an asset to the farm. This system was designed and installed to reduce seepage in a pond. The estimated life span of this installation is at least 15 years. The life of this installation can be assured and usually increased by developing and carrying out a good operation and maintenance program.

This practice will require you to perform periodic operation to maintain satisfactory performance. Here are some recommendations to help you develop a good operation and maintenance program:

1. Where erosion has damaged the bentonite liner and/or soil cover, identify the source of the water causing the erosion, repair liner damage and soil cover, and implement corrective measures to divert the water or control the erosion.
2. Where the soil cover has slipped along the sides of the pond and the bentonite liner is exposed, consult a qualified professional to determine the cause of the slippage, identify any needed corrective measures, and implement the corrective measures.
3. Repair any settlement or erosion that occurs with soil and re-seed or resurface, as needed.
4. Check frequently for burrowing animals. When found, remove the burrowing animals and, where needed, repair bentonite liner, replace soil cover, and re-seed or resurface.
5. Install and maintain a fence to prevent damage to the bentonite liner from animals, humans, vehicles, and/or equipment.

Pond Sealing or Lining – Flexible Membrane

A properly operated and maintained pond lining or sealing is an asset to the farm. This system was designed and installed to reduce seepage in a pond. The estimated life span of this installation is at least 15 years. The life of this installation can be assured and usually increased by developing and carrying out a good operation and maintenance program.

This practice will require you to perform periodic operation to maintain satisfactory performance. Here are some recommendations to help you develop a good operation and maintenance program:

1. Where erosion has damaged the flexible membrane liner and/or soil cover, identify the source of the water causing the erosion, repair liner damage and soil cover, and implement corrective measures to divert the water or control the erosion.
2. Where the soil cover has slipped along the sides of the pond and the flexible membrane liner is exposed, consult a qualified professional to determine the cause of the slippage, identify any needed corrective measures, and implement the corrective measures.
3. Repair any settlement or erosion that occurs with soil and re-seed or resurface, as needed.
4. Check frequently for burrowing animals. When found, remove the burrowing animals and, where needed, repair flexible membrane liner, replace soil cover, and re-seed or resurface.
5. Install and maintain a fence to prevent damage to the flexible membrane liner from animals, humans, vehicles, and/or equipment.

Pond Sealing or Lining – Soil Dispersant

A properly operated and maintained pond lining or sealing is an asset to the farm. This system was designed and installed to reduce seepage in a pond. The estimated life span of this installation is at least 15 years. The life of this installation can be assured and usually increased by developing and carrying out a good operation and maintenance program.

This practice will require you to perform periodic operation to maintain satisfactory performance. Here are some recommendations to help you develop a good operation and maintenance program:

1. Where erosion has damaged the soil dispersant liner and/or soil cover, identify the source of the water causing the erosion, repair liner damage and soil cover, and implement corrective measures to divert the water or control the erosion.
2. Where the soil cover has slipped along the sides of the pond and the soil dispersant liner is exposed, consult a qualified professional to determine the cause of the slippage, identify any needed corrective measures, and implement the corrective measures.
3. Repair any settlement or erosion that occurs with soil and re-seed or resurface, as needed.
4. Check frequently for burrowing animals. When found, remove the burrowing animals and, where needed, repair soil dispersant liner, replace soil cover, and re-seed or resurface.
5. Install and maintain a fence to prevent damage to the soil dispersant liner from animals, humans, vehicles, and/or equipment.

Waste Facility Cover

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 20-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs.
2. Conduct maintenance and repairs in accordance with the manufacturer's recommendations.
3. Promptly repair or replace all damaged, inoperable, or missing components and safety features, including fences and warning signs.
4. If cover ballooning exceeds manufacture's limits due to gas accumulation, promptly implement manufacture's recommended emergency procedures.
5. Follow your comprehensive nutrient management plan.
6. Keep direct precipitation collection components and drainage structures clean and functional.
7. All complementary appurtenances, (e.g.: pipes, pumps, fences, gates, etc.), should be inspected to ensure they are functional, structurally sound, and are not a safety hazard to the operator or livestock. Repair as needed.

Manure Transfer

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 5-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs.
2. Follow your comprehensive nutrient management plan (CNMP).
3. Perform routine maintenance of all mechanical components in accordance with manufacturer's recommendations.
4. Inspect or test all pipe, sumps, pumps, electrical systems, controls, and other components and appurtenances.
5. Promptly repair or replace damaged or inoperable components.
6. Protect the components from damage by farm equipment and livestock.
7. Repair any settlement or erosion that occurs around the pipe with soil and re-seed as needed. If this problem persists, evaluate the pipe for leakage and erosion of the fill material into or along the pipe.

Anaerobic Digester

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 25-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs.
2. Follow the operational plan developed by the designer. The operational plan should include, but not be limited to, the following:
    - Proper loading rate of the digester and total solids content of the influent.
    - Proper operating procedures for the digester.
    - Estimates of biogas production, methane content, and potential energy recovery.
    - Description of the planned startup procedures, normal operation, safety issues, and normal maintenance items.
    - Alternative operation procedures in the event of equipment failure.
    - Instructions for safe use or flaring of biogas.
    - Digester and other component maintenance.
    - Troubleshooting guide.
    - Monitoring plan with frequency of measuring and recording digester inflow, operating temperatures, biogas yield, and/or other information as appropriate.
3. Follow your comprehensive nutrient management plan.
4. Inspect safety signs, equipment, and systems to ensure they are functioning in accordance with the operational plan. Repairs should be made immediately.
5. Load into the digester only those waste products identified in the operational plan. Do not dispose of animal mortality, syringes, or other large or non-biodegradable wastes in the digester.
6. Inspect concrete sumps, pits, walls, ramps, slats, and floors often for separations and/or cracks, which would indicate potential failure. Repairs should be made immediately.
7. Check backfill areas around concrete structures often for unusual settlement. Determine if settlement is caused by backfill consolidation or failure of concrete walls. Repair walls or fill as appropriate.
8. A good vegetative cover of recommended grasses should be maintained on backfill around structures. If the vegetative cover is damaged, it should be re-established as soon as possible. The vegetative cover should be mowed 2 times a year to stimulate a vigorous plant growth.
9. Outlets of foundation and sub-drains should be checked frequently and kept open. The outflow from these drains should be checked when digester is being used to determine if there is leakage from the digester. If leakage is detected, repairs should be planned and made when the facility is empty.
10. Inspect haul roads and approaches to and from the digester frequently to determine the need for replacement stone or other stabilizing materials.
11. All exposed appurtenances - pipes, pumps, manure pumps, valves, gates, etc., should be inspected periodically (minimum of 2 times a year) to make sure they are functional, structurally sound, and are not cracked, broken, and/or a safety hazard to the operator or livestock. Repair as needed.
12. Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials, and re-seed.
13. Do not operate loaded feed wagon, trucks, manure spreaders, or other heavy equipment within 5 feet of the digester walls.

Closure of Waste Impoundments

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the first 20 years after the waste impoundment is decommissioned include, but are not limited to, the following.

For sites where the land is reclaimed:

1. Inspect at least annually to identify repair and maintenance needs.
2. Repair any settlement or erosion that occurs; add fill and re-vegetate or re-surface as needed.
3. Maintain mounding and/or water diversions to prevent accumulation of water over the site.
4. Maintain vegetated areas in adequate cover; re-seed and mow as needed.

For sites converted to fresh water storage or other use:

The converted impoundment shall meet the requirements as set forth in the NRCS practice standard for the intended purpose (i.e.: Pond). Follow the Operation & Maintenance guidance for that NRCS practice.

Roof Runoff Management

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 15-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs.
2. Follow your comprehensive nutrient management plan.
3. Keep roof runoff structures clean and free of obstructions that reduce flow.
4. Conduct maintenance and repairs in accordance with the manufacturer's recommendations.
5. Promptly repair or replace all damaged, inoperable, or missing components and safety features to ensure they are functional, structurally sound, and are not a safety hazard. Repair as needed.
6. Protect the components from damage by farm equipment and livestock.
7. Where the roof runoff structure discharges into an underground outlet, follow the Operation and Maintenance Plan for Underground Outlet.

Wastewater Filter Strip

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 10-year design life of the practice include, but are not limited to, the following:

1. Inspect after significant storm events and at least annually to identify repair and maintenance needs. Complete needed repairs as soon as possible.
2. Protect the wastewater treatment strip from damage by farm equipment, traffic, and livestock.
    - Do not use as a roadway.
    - Avoid operations that displace soil, compact soil, damage vegetation, or alter design flow depth or uniformity of flow.
    - Avoid damaging wastewater treatment areas with herbicides. When spraying for grass control on adjoining cropland, spray only when drift is away from wastewater treatment strip.
    - Limit access and control grazing.
3. Manage the collection system in the following manner:
    - The liquid in the solids and dry weather leachate storage areas may not be directed to the wastewater treatment strip during a runoff event.
    - To facilitate dewatering of accumulated solids, the liquid in the solids and dry weather leachate storage area may be directed to the wastewater treatment strip after the runoff event has ended.
    - Stored dry weather leachate may not be directed to the wastewater treatment strip.
    - The solids and dry weather leachate storage area shall be emptied within 72 hours of a runoff event or weekly when dry weather leachate has accumulated.
    - The collected solids and dry weather leachate shall be transferred to a storage facility or utilized in accordance with Nutrient Management (590).
4. For maximum nutrient removal from the water to be treated, vegetation must be maintained in a vigorous condition. Grass stems must remain upright during design flow. Re-seed areas where vegetation fails. Periodic mowing and harvesting of the forage is required.
    - Fertilize according to a soil test as necessary.
    - Maintain adequate vegetative plant density. It may require over-seeding or other management methods such as clipping and harvesting to promote an adequate density of plant stems.
    - Mowing and/or vegetation harvest must be performed on a regular basis to stimulate growth, maintain an upright growth habit, plus provide for removal of nutrients that are contained in the plant tissue. Vegetation height after mowing should not be less than 6 inches.
    - Where livestock grazing is planned to harvest the vegetation, only allow the livestock access to the wastewater treatment strip when soil moisture conditions are low enough that damage will not occur from tracking and compaction. Also limit the livestock access to the time needed to harvest the vegetation.
5. Development of rills and small channels from erosion, equipment, or other means within the wastewater treatment area must be minimized. Needed repairs must be made immediately to reshape the area and re-establish sheet (overland) flow. Rake rock checks in wastewater treatment strip channels at least annually to keep them level and remove any build-up of deposited materials. Maintain other types of level spreaders as necessary. For overland flow wastewater treatment strips, a shallow furrow on the contour across the wastewater treatment strip can be used to re-establish sheet flow.
6. Brush and weeds are undesirable and must be controlled with herbicides or mowing. Use only those pesticides that are labeled for the specific use. Refer to Iowa State University publications and specific label instructions for guidance on pesticide selection and use.

Feed/Silage Leachate Waste Management

Manage the feed storage areas and feed residuals to minimize leachate and to minimize the contact between feed residuals and runoff water. Practices to consider include:

1. Harvest/storage moisture: The moisture of the feed material at the time it enters storage is the single greatest risk factor for leachate production. At harvest, forage whole plant moisture should not exceed 70 percent (at least 30 percent dry matter). Other wet feeds may leach at different moisture levels and management should be adjusted accordingly.
2. Filling and Packing: Fill and pack methods are critical to obtain maximum oxygen exclusion, thereby reducing respiration of plant material, dry matter loss, and leachate generation. Fill bunkers, silos, and piles using the progressive wedge technique with packing layers of 6 inches or less. Continuous packing during fill with approximately 1,000 pounds of packing tractor weight per ton harvested per hour is recommended.
3. Cover: Effort should be made to prevent rainwater from coming into contact with stored feed. Plastic covers or equivalent alternatives that are used to exclude oxygen should also shed water. It is not enough to simply shed rainwater and snow melt from the top of the storage, the water needs to be diverted away from all of the feed. For instance, covers that only divert water to the walls of a bunker silo where it then enters the feed along the edge are undesirable.
4. Feed Out: Maintain a smooth and vertical feed out face. Avoid knocking down more feed than will be used on that day. Keep loader traffic areas smooth to minimize feed spill. Frequently scrape and/or sweep the storage floor and apron to collect feed that is spilled.

Fencing for Animal Waste Facilities

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 10-year design life of the practice include, but are not limited to, the following:

1. The fencing has been provided to prevent livestock and others from using the waste facilities for other than the planned purposes.
2. Weeds, grass, and spouts along and under the fence should be clipped at least annually.
3. The gate should be kept closed and latched to prevent swinging and sagging.
4. The signs posted on the fence should be inspected to determine if they are still visible and legible. Damaged and illegible signs should be replaced with new signs.
5. Tension in the fencing should be checked, the wire crimped, and the fence repaired when the wire's sag is excessive.
6. Do not burn weeds and grasses under and around fences as this destroys the galvanized coating and accelerates rusting.
7. The fence should be inspected at least once a year to ensure that is not cut, broken, or pushed down and the posts and braces are in place and intact. Loose and lost staples, fasteners, and broken tie wires should be replaced during the annual fence inspection.

Composting Facility

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program. Items to inspect and maintain during the 15-year design life of the practice include, but are not limited to, the following:

Temperature. Operating temperature of the composting material should be 131° F to 170° F once the process has begun. Operating temperature should be reached in about 7 days and remain elevated for up to 14 days. The pile should remain at or above 110° F for the remainder of the designated composting period.

If temperature falls significantly during the composting period, odors develop, or if material does not reach operating temperature, investigate piles for moisture content, porosity, and thoroughness of mixing. Compost managed at the required temperatures will favor destruction of pathogens, plant diseases, and weed seeds.

Aeration. Heat generated by the process causes piles to dehydrate. As the process proceeds, material consolidates and the volume of voids decreases, restricting air flow. Select materials for the composting mix that will insure adequate air movement throughout the composting process. Periodically turning the pile and maintaining proper moisture levels for windrows and static piles will normally provide adequate aeration.

Pathogens. Composting of dead animal carcasses and animal parts should include strict temperature monitoring to insure pathogens are destroyed. For active piles, the temperature must be maintained at 131° F or higher for 3 consecutive days to achieve pathogen reduction. For aerated windrows, the temperature must be maintained at 131° F or higher for at least 15 consecutive days and the windrow must be turned at least 5 times during the high temperature period.

Vectors. Flies, rats, and birds may be attracted to raw compost feedstocks. Mosquitoes may reproduce where standing water is present. To minimize vector problems, reduce exposed feedstock storage, turn piles frequently, eliminate standing water, and keep the area clean.

Nutrients. Keep compost well aerated to minimize nitrogen loss by denitrification. Keep pH at neutral or slightly lower to avoid nitrogen loss by ammonification. High amounts of available carbon will aid nitrogen immobilization.

Include compost nutrients in nutrient management plans. Prevent loss of nutrients and pollutants to surface and ground water.

Testing Needs. Test compost material for carbon, nitrogen, moisture, and pH if compost fails to reach desired temperature or if odor problems develop. The finished compost material should be periodically tested for constituents that could cause plant phytotoxicity as the result of application to crops. Compost made from dead animals or animal parts should be tested for indicator pathogens such as E.coli and salmonella. Composted materials that are prepared for the retail market require testing for labeling purposes.

1. Do not allow any equipment that exceeds design load limits on or within 20 feet of the structure.
2. Poisonous gasses are often heavier than air and may be trapped in closed waste storage structures. Do not allow human entry into any closed structure without safety equipment, including ladders and breathing apparatus. Maintain all lids, grates, and shields on openings to underground or enclosed structures.
3. Maintain all electrical and mechanical equipment in good operating condition by following electrical codes and manufacturer's recommendations. Inspect and repair grounding rods, switches, and wiring.
4. Fences, railings, and/or warning signs must be maintained to provide warning and prevent unauthorized entry.
5. Repair any vandalism, vehicular, or animal damage. Inspect and maintain runoff control structures.

Mortality Composting Facility

Inspections and maintenance are required to achieve the intended function, benefits, and life of the practice. The landowner/operator is responsible to establish and implement an inspection and maintenance program during the 15-year design life of the practice.

The proper carbon to nitrogen (C:N) ratio shall be maintained by using a mix of 100 ft^3 per 1,000 lbs of carcass or other mix as specified to maintain a C:N ratio of 20-30 to 1.

The proper moisture content shall be maintained at 50-60 percent by the following:

- Using damp (but not wet) bulking materials (i.e.: sawdust).
- Adding extra water as needed to reach the optimal moisture content.
- Allowing wet (green) bulking materials to dry before using in compost mix.

The temperature of the compost shall be monitored and shall reach a minimum of 135° F. The temperature probe must penetrate one-third of the distance from the outside of the pile to the center of the mass. Compost that does not reach this temperature shall be dismantled, corrected, and rebuilt in order to reach optimal temperature. When the temperature of the compost falls below 105° F, compost shall be turned to a secondary storage bin.

The following items shall be followed during the loading of the facility:

1. One foot of bulking material shall be placed on the bottom of the bin.
2. Carcasses shall be placed in layers with at least one foot of bulking material in between each layer.
3. Carcasses shall be completely covered with at least one foot of bulking material.
4. Large carcasses shall have one foot of bulking material in between carcasses within a layer.
5. A minimum of 6 inches of bulking material shall be maintained between the carcasses and the sides of the bins.

Compost shall be loaded in bins in the following manner (for minimum 3-bin composting system without a bulking material storage bin):

1. The first bin shall be filled over a 2-month period.
2. The second bin shall be filled over the second 2-month period.
3. After the second 2-month period, compost from the first bin shall be turned into the third bin for secondary composting.
4. The first bin shall now be filled again for 2 months.
5. After the 2-month period, compost from third bin shall be removed for final disposal and the second bin shall be turned to the third bin.
6. The second bin shall now be filled again.
7. This method shall be adjusted for the number of bins as specified in this plan and design.

The completed compost shall be land-applied in accordance with the comprehensive nutrient management plan. When conditions are not suitable for application, the completed compost shall be stored until conditions are adequate.

Waste Treatment Lagoon

A properly operated and maintained waste treatment lagoon is an asset to your farm. These waste storage structures are designed and installed to biologically treat animal waste. The estimated life span of this installation is at least 20 years. The life of this installation can be assured and usually increased by developing and carrying out a good operation and maintenance program.

This practice will require you to perform periodic operation and maintenance to maintain satisfactory performance. Here are some recommendations to help you develop a good operation and maintenance program:

1. Do not allow human entry to any enclosed structure without safety equipment that includes ladders and breathing apparatus. Maintain appropriate warning signs.
2. Safety stations should be inspected 2 times a year. Safety items such as ropes, ladders, and swim rings should be replaced as necessary.
3. Do not allow the operation of any equipment that exceeds the design load limit on or within twenty feet of the structure.
4. Maintain all pumps, agitators, piping, valves, and all other electrical and mechanical equipment in good operating condition by following the manufacturer's recommendations. Repair as necessary.
5. Maintain grounding rods and wiring for all electrical equipment in good condition.
6. Inspect haul roads and approaches to and from the waste storage facility frequently to determine the need for stabilizing materials.
7. A thorough inspection of pond liners and concrete sumps, pits, walls, ramps, and floors for damage, separation and/or cracks should be made each time the pond is emptied. Repair any damage prior to refilling the pond.
8. Do not dispose of dead animals, greases, syringes, or other non-animal waste products in the facility.
9. All fences, railings, and/or warning signs shall be maintained to prevent unauthorized human or livestock entry.
10. Annually inspect pond for damage from normal use. At no more than 3- to 6-month intervals open and close gates and valves to assure proper function. Immediately remove any blockage or obstructions and repair any damage.
11. Inspect inlet, embankments, and outlets after heavy rains for possible damage. Promptly repair any damage.
12. Annually inspect the downstream toe of the embankment. If there are wet areas or seeps, contact the local NRCS office or designer for additional assistance.
13. Maintain vigorous growth of vegetative coverings. This includes re-seeding, fertilization, and application of herbicides when necessary. Periodic mowing may also be needed to control height.
14. Fill rills and gullies that occur on the embankments and/or spillway and re-vegetate.
15. Maintain a grass filter strip around the perimeter of the pond to trap sediment.
16. If fences are installed they shall be maintained to prevent unauthorized or livestock entry.
17. Immediately repair any vandalism, vehicular, or livestock damage.
18. Repair spalls, cracks, and weathered areas in concrete surfaces.
19. Repair or replace rusted or damaged metal and paint.
20. Inspect embankments for damage from rodents or burrowing animals. Repair any damage. Take appropriate corrective actions to alleviate further damage.
21. Remove woody vegetation from embankments.
22. Avoid excessive travel on any portion of the system that will harm or destroy the vegetative cover.
23. Apply insecticides for insect control as per manufacturer's recommendations and precautions, as needed.

24. Operate system in a manner to minimize odors and air drift.

Waste Treatment

A properly operated and maintained waste treatment system is an asset to your farm. This facility was designed and installed to use mechanical, chemical, or biological treatment facilities and/processes as part of an agricultural waste management system:

- To improve ground and surface water quality by reducing the nutrient content, organic strength, and/or pathogen levels of agricultural waste.
- To improve air quality by reducing odors and gaseous emissions.
- To produce value added byproducts.
- To facilitate desirable waste handling, storage, or land application alternatives.

The estimated life span of this installation is at least 10 years. The life of this installation can be assured and usually increased by developing and carrying out a good operation and maintenance program.

This practice will require you to perform periodic operation and maintenance to maintain satisfactory performance. Here are some recommendations to help you develop a good operation and maintenance program:

1. Do not allow human entry to any enclosed structure without appropriate safety equipment. Maintain appropriate warning signs.
2. Inspect safety items 2 times a year and repair or replace as necessary.
3. Ensure that all warning signs and safety instructions are posted in a visible location and in readable condition. Repair or replace as necessary.
4. Maintain all electrical and mechanical equipment in good operating condition by following the manufacturer's recommendations. Repair as necessary.
5. Repair spalls, cracks, and weathered areas in concrete surfaces.
6. Repair or replace rusted or damaged metal and apply paint as a protective coating.
7. Maintain grounding rods and wiring for all electrical equipment in good condition.
8. Immediately repair any vandalism, vehicular, or livestock damage.

System Specific Recommendations:

1. Recommended loading rates of the waste treatment facility or process for hydraulic and critical pollutant parameters.
2. Proper operating procedures for the waste treatment facility or process, including the amount and timing of any chemicals added.
3. Operation and maintenance manuals for pumps, blowers, instrumentation and control devices, and other equipment used as components of the waste treatment facility or process.
4. Description of the planned startup procedures, normal operation, safety issues, and normal maintenance items. This includes procedures for the planned replacement of components with less than a 10-year service life.
5. Alternative operation procedures in the event of equipment failure.
6. Troubleshooting guide.
7. Monitoring and reporting plan designed to demonstrate system performance on an ongoing basis.

Solid-Liquid Separation

A properly operated and maintained solid/liquid waste separation facility is an asset to your farm. This facility was designed and installed to separate solid and liquid waste as part of a conservation management system. The estimated life span of this installation is at least 10 years. The life of this installation can be assured and usually increased by developing and carrying out a good operation and maintenance program.

This practice will require you to perform periodic operation and maintenance to maintain satisfactory performance. Here are some recommendations to help you develop a good operation and maintenance program.

1. Do not allow human entry to any enclosed structure without appropriate safety equipment. Maintain appropriate warning signs.
2. Inspect safety items 2 times a year and repair or replace as necessary.
3. Ensure that all warning signs and safety instructions are posted in a visible location and in readable condition. Repair or replace as necessary.
4. Maintain all electrical and mechanical equipment in good operating condition by following the manufacturer's recommendations. Repair as necessary.
5. Repair spalls, cracks, and weathered areas in concrete surfaces.
6. Repair or replace rusted or damaged metal and apply paint as a protective coating.
7. Maintain grounding rods and wiring for all electrical equipment in good condition.
8. Inspect haul roads and approaches to and from the facility frequently to determine the need for stabilizing materials.
9. All fences, railings, and/or warning signs shall be maintained to prevent unauthorized human or livestock entry.
10. Immediately repair any vandalism, vehicular, or livestock damage.
11. Inspect for damage from rodents or burrowing animals. Repair any damage. Take appropriate corrective actions to alleviate further damage.

System Specific Recommendations

The O&M plan shall be consistent with the purposes of the solid/liquid separation device chosen, its intended life, safety requirements, and the criteria for its design. The plan shall contain operation and maintenance requirements including but not limited to:

1. Documentation of design assumptions.
2. Design capacity for the facility.
3. A description of normal operation of the facility, safety issues, and normal maintenance items.
4. Alternative operation procedures in the event of equipment failure.
5. Daily inspection of the following:
6. Separation device and support structure.
7. Screens and outlets.
8. Remaining capacity in storage facilities.

Resources for Planning and Designing Animal Waste Facilities

This amendment includes sources that are agreed upon by Iowa State University Extension Service, Iowa Department of Natural Resources, and the Natural Resources Conservation Service. These values are to be used for designing and planning animal waste collection; handling, storage, or utilization facilities; and for developing and planning manure management plans unless the producer provides manure sample test results. The resource list is not designed to be all inclusive. Other resources are available on the IMMAG website at **http://www.agronext.iastate.edu/immag/**

Sources of Information

Manure Management Publications

DOC #	TITLE
PM 287	Take a Good Sample to Help Make Good Decisions
PM 569	Warm-Season Grasses for Hay and Pasture
PM 869	Fertilizing Pastures
PM 1268	Establishing Realistic Yields
PM 1310	Interpretation of Soil Test Results
PM 1558	Management Practices: How to Sample Manure for Nutrient Analysis
PM 1584	Cornstalk Testing to Evaluate Nitrogen Management
PM 1609	You Can't Afford Not to Haul Manure
PM 1688	General Guide for Crop Nutrient Recommendations in Iowa
PM-1714	Nitrogen Fertilizer Recommendations for Corn in Iowa
PM 1811	Managing Manure Nutrient for Crop Production
PM 1901G	Resources Conservation Practices: Manure and Tillage Management
PM 1931	Developing Whole-Farm Nutrient Plans for Feedlots
PM 1941	Calibration and Uniformity of Solid Manure Spreaders
PM 1948	Calibrating Liquid Tank Manure Applicators
PM 1993	10 Questions about the Phosphorus (P) Index in Iowa
PM 2015	Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn Agricultural Nitrogen Management for Water Quality Protection in the Midwest
PM 2021	Data Collection Worksheet for RUSLE2 and Iowa Phosphorus Index

Other Useful Publications

DOC #	TITLE
PM 1518K	Manure Storage Poses Invisible Risks
MWPS-18	Livestock Waste Facilities Handbook
MWPS-18 S2	Manure Storages
MWPS-36	Rectangular Concrete Manure Storages
TR-9	Circular Concrete Manure Tanks
FS925-D	Covers for Manure Storage Units
Chapter 65	Chapter 65, Iowa Administrative Code

Precipitation and Runoff Tables

The precipitation table notes the monthly and annual precipitation, in inches, for the counties of Iowa. The runoff tables for CN-90 and CN-98 note runoff expressed, in inches, for each month and on an annual basis for both earthen and concrete lots. They are to be used for determining runoff from normal precipitation in lieu of the present procedure shown in Part VI of Chapter 12 of the AWMFH. For designing Roof Runoff Control Structures (558) a table of 10- and 25-year, 5-minute storm event depth, in inches, by county is included.

Normal Annual and Monthly Precipitation (inches)

County	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adair	34.86	0.89	1.01	2.23	3.50	4.40	4.48	4.51	3.92	3.83	2.56	2.12	1.19
Adams	35.31	0.83	1.01	2.27	3.39	4.52	4.48	4.58	3.96	4.09	2.63	2.18	1.15
Allamakee	33.72	0.92	0.92	1.90	3.61	3.80	4.44	4.35	4.59	3.29	2.28	2.22	1.17
Appanoose	37.17	1.01	1.13	2.31	3.47	4.74	4.49	5.03	3.98	4.02	2.87	2.46	1.45
Audubon	33.60	0.85	0.91	2.25	3.38	4.24	4.53	4.36	3.79	3.57	2.59	1.86	1.06
Benton	35.19	1.01	1.04	2.17	3.40	4.18	4.79	4.16	4.44	3.52	2.57	2.35	1.34
Black Hawk	34.53	0.93	1.02	2.11	3.34	4.16	4.99	4.26	4.35	3.22	2.52	2.22	1.21
Boone	34.13	0.88	0.91	2.16	3.30	4.27	5.04	4.34	4.22	3.11	2.50	2.03	1.16
Bremer	35.21	0.97	0.96	2.08	3.49	4.20	4.97	4.36	4.81	3.22	2.52	2.25	1.17
Buchanan	35.13	1.02	1.04	2.05	3.37	4.08	4.86	4.15	4.80	3.43	2.49	2.31	1.30
Buena Vista	31.83	0.67	0.63	2.05	3.32	3.84	4.85	4.13	4.31	3.12	2.19	1.67	0.84
Butler	34.40	0.88	0.90	2.05	3.34	4.20	5.12	4.42	4.42	3.23	2.51	2.12	1.12
Calhoun	32.06	0.79	0.71	2.08	3.21	4.17	4.66	4.06	3.90	3.23	2.33	1.71	0.98
Carroll	32.7	0.84	0.82	2.24	3.32	4.20	4.65	4.23	3.67	3.32	2.43	1.76	1.01
Cass	34.57	0.82	0.95	2.26	3.39	4.44	4.57	4.56	3.89	3.85	2.60	1.95	1.08
Cedar	36.24	1.29	1.28	2.48	3.42	4.23	4.42	3.96	4.54	3.47	2.61	2.52	1.80
Cerro Gordo	34.00	0.90	0.79	2.05	3.29	4.15	5.02	4.38	4.46	3.24	2.44	1.97	1.08
Cherokee	29.64	0.65	0.63	1.98	3.00	3.73	4.54	3.85	3.76	2.89	2.02	1.60	0.79
Chickasaw	35.34	0.98	0.93	2.08	3.59	4.16	4.84	4.42	4.87	3.26	2.50	2.25	1.24
Clarke	35.95	0.89	1.10	2.21	3.55	4.62	4.49	4.62	4.05	3.96	2.67	2.30	1.26
Clay	30.18	0.62	0.57	1.95	3.10	3.65	4.61	4.00	4.18	2.86	2.03	1.63	0.75
Clayton	34.23	1.03	1.10	2.05	3.54	3.88	4.52	4.10	4.66	3.21	2.35	2.32	1.26
Clinton	35.82	1.35	1.36	2.51	3.38	4.04	4.47	3.61	4.56	3.26	2.62	2.57	1.88
Crawford	31.32	0.75	0.72	2.17	3.16	4.12	4.45	3.99	3.57	3.29	2.33	1.61	0.95
Dallas	33.80	0.87	0.94	2.14	3.32	4.31	4.73	4.27	4.05	3.29	2.5	2.01	1.15
Davis	37.41	1.17	1.22	2.42	3.48	4.77	4.31	4.76	4.03	4.02	2.81	2.58	1.63
Decatur	36.53	0.89	1.14	2.32	3.51	4.67	4.40	4.77	3.95	4.07	2.92	2.35	1.32
Delaware	35.13	1.07	1.11	2.10	3.40	4.06	4.58	4.00	4.95	3.41	2.50	2.39	1.35
Des Moines	36.75	1.30	1.41	2.67	3.49	4.35	4.22	4.25	3.89	3.60	2.71	2.67	1.97
Dickinson	29.27	0.64	0.58	1.91	3.00	3.63	4.61	3.75	3.86	2.73	2.01	1.64	0.71
Dubuque	34.80	1.16	1.25	2.29	3.36	3.83	4.45	3.83	4.58	3.46	2.42	2.44	1.52
Emmet	30.04	0.73	0.59	1.86	3.08	3.65	4.64	3.92	4.01	2.74	2.14	1.68	0.77
Fayette	35.17	1.02	1.05	2.04	3.57	4.05	4.68	4.20	4.97	3.35	2.47	2.25	1.30
Floyd	34.57	0.94	0.84	2.01	3.39	4.18	5.06	4.40	4.57	3.31	2.46	2.07	1.12
Franklin	33.84	0.85	0.82	2.04	3.21	4.19	5.15	4.36	4.32	3.16	2.44	1.98	1.10
Fremont	34.03	0.77	0.91	2.35	3.27	4.51	4.37	4.79	3.81	3.49	2.52	1.98	1.04
Greene	33.02	0.87	0.87	2.14	3.23	4.19	4.80	4.23	3.94	3.13	2.42	1.88	1.11
Grundy	34.61	0.89	0.97	2.18	3.26	4.26	5.25	4.34	4.16	3.10	2.56	2.23	1.20
Guthrie	34.19	0.87	0.96	2.24	3.36	4.34	4.68	4.36	4.11	3.43	2.51	1.95	1.16
Hamilton	33.78	0.87	0.83	2.02	3.13	4.05	5.37	4.31	4.44	3.09	2.43	1.92	1.11
Hancock	32.15	0.80	0.72	1.93	3.21	3.89	4.81	4.23	4.22	3.02	2.26	1.83	1.01
Hardin	34.22	0.91	0.90	2.13	3.19	4.20	5.29	4.23	4.24	3.14	2.51	2.15	1.13
Harrison	31.69	0.73	0.75	2.25	3.15	4.33	4.42	4.03	3.42	3.37	2.39	1.68	0.94
Henry	36.96	1.28	1.32	2.59	3.40	4.47	4.17	4.45	3.99	3.89	2.69	2.66	1.84
Howard	34.80	0.98	0.87	2.04	3.48	3.97	4.66	4.47	4.89	3.44	2.4	2.19	1.19
Humboldt	32.37	0.83	0.72	2.05	3.20	3.94	4.77	4.22	4.20	3.12	2.28	1.80	1.02
Ida	30.71	0.77	0.67	2.11	3.14	3.97	4.59	3.85	3.78	3.01	2.17	1.57	0.89
Iowa	35.84	1.05	1.06	2.20	3.41	4.39	4.61	4.25	4.51	3.65	2.61	2.46	1.42
Jackson	35.24	1.21	1.32	2.36	3.34	3.91	4.48	3.55	4.54	3.52	2.51	2.56	1.71
Jasper	35.08	0.97	1.05	2.18	3.35	4.45	4.65	4.27	4.32	3.46	2.67	2.28	1.22

Normal Annual and Monthly Precipitation (inches)

County	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jefferson	36.48	1.22	1.23	2.46	3.39	4.55	4.08	4.45	4.00	3.87	2.77	2.55	1.70
Johnson	35.85	1.09	1.12	2.31	3.47	4.26	4.57	4.22	4.53	3.51	2.59	2.42	1.55
Jones	35.32	1.20	1.22	2.34	3.36	4.02	4.49	3.85	4.62	3.43	2.50	2.50	1.59
Keokuk	35.74	1.07	1.10	2.35	3.37	4.40	4.28	4.31	4.20	3.79	2.70	2.52	1.44
Kossuth	31.25	0.74	0.65	1.89	3.11	3.86	4.71	4.20	4.13	2.85	2.24	1.78	0.88
Lee	37.89	1.39	1.46	2.79	3.52	4.72	4.18	4.34	3.72	3.81	2.79	2.88	2.08
Linn	35.37	1.08	1.09	2.18	3.40	4.16	4.65	4.12	4.58	3.52	2.50	2.41	1.46
Louisa	36.19	1.24	1.32	2.58	3.44	4.29	4.11	4.17	4.17	3.57	2.67	2.57	1.85
Lucas	36.36	0.92	1.15	2.23	3.52	4.60	4.57	4.67	3.99	4.05	2.84	2.35	1.25
Lyon	27.16	0.53	0.55	1.87	2.71	3.35	4.24	3.43	3.58	2.52	1.94	1.54	0.67
Madison	34.86	0.94	1.05	2.20	3.53	4.39	4.56	4.37	3.98	3.70	2.56	2.18	1.20
Mahaska	35.87	1.02	1.14	2.18	3.40	4.49	4.38	4.37	4.18	3.83	2.73	2.56	1.36
Marion	35.49	0.92	1.10	2.11	3.64	4.49	4.47	4.38	4.17	3.68	2.75	2.33	1.23
Marshall	35.05	0.94	0.97	2.19	3.20	4.36	5.01	4.44	4.45	3.22	2.56	2.26	1.23
Mills	33.42	0.73	0.85	2.26	3.27	4.61	4.54	4.51	3.76	3.42	2.42	1.85	0.99
Mitchell	34.17	0.98	0.80	1.99	3.38	4.09	4.78	4.37	4.65	3.37	2.40	2.03	1.14
Monona	30.32	0.66	0.65	2.15	3.14	4.11	4.33	3.87	3.47	3.06	2.28	1.54	0.84
Monroe	36.72	1.05	1.17	2.26	3.51	4.63	4.45	4.84	3.94	4.03	2.72	2.52	1.40
Montgomery	35.36	0.85	1.03	2.29	3.45	4.63	4.62	4.63	3.93	3.9	2.58	2.08	1.13
Muscatine	36.08	1.27	1.30	2.53	3.38	4.18	4.32	4.09	4.32	3.46	2.63	2.54	1.83
O'Brien	29.38	0.65	0.65	1.89	2.98	3.58	4.59	3.90	4.00	2.68	1.95	1.57	0.71
Osceola	28.61	0.58	0.57	1.92	2.92	3.52	4.49	3.58	3.85	2.8	1.95	1.52	0.68
Page	35.37	0.86	1.00	2.34	3.30	4.59	4.54	4.78	3.98	3.82	2.63	2.21	1.10
Palo Alto	31.09	0.74	0.64	1.95	3.13	3.71	4.70	4.17	4.17	2.88	2.19	1.76	0.85
Plymouth	27.23	0.59	0.57	1.91	2.8	3.61	4.12	3.48	3.21	2.56	2.02	1.45	0.71
Pocahontas	32.00	0.81	0.70	2.07	3.20	3.90	4.66	4.20	4.23	3.11	2.20	1.77	0.93
Polk	34.40	0.89	1.02	2.15	3.35	4.32	4.81	4.30	4.29	3.24	2.55	2.09	1.19
Pottawattamie	33.30	0.76	0.84	2.28	3.30	4.50	4.55	4.48	3.57	3.60	2.41	1.8	0.99
Poweshiek	35.74	1.05	1.11	2.19	3.44	4.36	4.53	4.25	4.43	3.72	2.70	2.43	1.31
Ringgold	35.80	0.83	1.06	2.31	3.26	4.53	4.44	4.73	4.00	4.03	2.91	2.25	1.24
Sac	32.02	0.77	0.71	2.19	3.28	4.07	4.70	4.06	3.90	3.19	2.30	1.69	0.97
Scott	35.82	1.34	1.35	2.56	3.41	4.04	4.50	3.78	4.37	3.19	2.60	2.56	1.91
Shelby	33.11	0.78	0.81	2.21	3.28	4.26	4.48	4.22	3.69	3.86	2.53	1.77	1.00
Sioux	27.67	0.60	0.59	1.92	2.77	3.46	4.27	3.56	3.52	2.54	1.99	1.53	0.72
Story	34.61	0.87	0.91	2.14	3.19	4.21	5.19	4.62	4.40	3.10	2.48	2.14	1.14
Tama	35.48	0.99	1.05	2.20	3.33	4.27	5.07	4.37	4.37	3.43	2.62	2.32	1.26
Taylor	36.01	0.88	1.04	2.32	3.27	4.62	4.50	4.87	4.00	4.02	2.84	2.27	1.17
Union	35.15	0.87	1.05	2.21	3.45	4.48	4.45	4.55	3.8	3.96	2.64	2.27	1.21
Van Buren	37.14	1.30	1.28	2.49	3.51	4.69	4.16	4.55	3.72	3.93	2.79	2.65	1.84
Wapello	36.30	1.09	1.17	2.36	3.38	4.56	4.31	4.59	3.99	3.9	2.72	2.51	1.49
Warren	35.13	0.95	1.10	2.16	3.58	4.48	4.59	4.35	3.97	3.62	2.70	2.19	1.23
Washington	35.62	1.18	1.16	2.38	3.27	4.37	4.19	4.27	4.15	3.68	2.63	2.47	1.66
Wayne	36.91	0.95	1.14	2.31	3.52	4.63	4.42	4.95	3.97	4.10	2.93	2.41	1.35
Webster	33.39	0.86	0.79	2.10	3.27	4.16	4.98	4.31	4.22	3.17	2.37	1.86	1.08
Winnebago	32.44	0.84	0.67	1.90	3.19	3.92	4.83	4.27	4.51	2.95	2.30	1.86	0.99
Winneshiek	34.31	0.94	0.90	1.96	3.60	3.82	4.56	4.33	4.85	3.42	2.35	2.17	1.19
Woodbury	28.76	0.63	0.63	2.05	3.01	3.89	4.17	3.63	3.34	2.76	2.13	1.51	0.78
Worth	33.39	0.93	0.72	2.01	3.27	4.01	4.76	4.33	4.55	3.20	2.37	1.95	1.07
Wright	33.03	0.80	0.75	1.99	3.21	4.05	5.13	4.26	4.23	3.13	2.35	1.88	1.04

Normal Annual and Monthly Unpaved Lot Runoff – CN 90 (inches)

County	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adair	33.6	0.3	0.3	1.3	2.4	3.3	3.4	3.4	2.8	2.8	1.6	1.2	0.5
Adams	34.0	0.2	0.3	1.3	2.3	3.4	3.4	3.5	2.9	3.0	1.6	1.2	0.4
Allamakee	32.4	0.3	0.3	1.0	2.6	2.7	3.3	3.3	3.5	2.3	1.3	1.3	0.4
Appanoose	35.9	0.3	0.4	1.4	2.4	3.6	3.4	3.9	2.9	2.9	1.9	1.5	0.6
Audubon	32.3	0.2	0.3	1.3	2.3	3.1	3.4	3.3	2.7	2.5	1.6	1.0	0.4
Benton	33.9	0.3	0.3	1.2	2.4	3.1	3.7	3.1	3.3	2.5	1.6	1.4	0.6
Black Hawk	33.2	0.3	0.3	1.2	2.3	3.1	3.9	3.2	3.3	2.2	1.5	1.3	0.5
Boone	32.8	0.2	0.3	1.2	2.3	3.2	3.9	3.2	3.1	2.1	1.5	1.1	0.4
Bremer	33.9	0.3	0.3	1.2	2.4	3.1	3.8	3.3	3.7	2.2	1.5	1.3	0.4
Buchanan	33.8	0.3	0.3	1.1	2.3	3.0	3.7	3.1	3.7	2.4	1.5	1.4	0.5
Buena Vista	30.5	0.1	0.1	1.1	2.3	2.8	3.7	3.0	3.2	2.1	1.3	0.8	0.2
Butler	33.1	0.2	0.3	1.1	2.3	3.1	4.0	3.3	3.2	2.2	1.5	1.2	0.4
Calhoun	30.8	0.2	0.1	1.2	2.2	3.1	3.5	3.0	2.8	2.2	1.4	0.9	0.3
Carroll	31.4	0.2	0.2	1.3	2.3	3.1	3.5	3.1	2.6	2.3	1.5	0.9	0.3
Cass	33.3	0.2	0.3	1.3	2.3	3.3	3.5	3.5	2.8	2.8	1.6	1.1	0.4
Cedar	34.9	0.5	0.5	1.5	2.4	3.1	3.3	2.9	3.4	2.4	1.6	1.5	0.9
Cerro Gordo	32.7	0.3	0.2	1.1	2.3	3.1	3.9	3.3	3.4	2.2	1.5	1.1	0.4
Cherokee	28.3	0.1	0.1	1.1	2.0	2.7	3.4	2.8	2.7	1.9	1.1	0.8	0.2
Chickasaw	34.0	0.3	0.3	1.2	2.5	3.1	3.7	3.3	3.8	2.2	1.5	1.3	0.5
Clarke	34.7	0.3	0.4	1.3	2.5	3.5	3.4	3.5	3.0	2.9	1.7	1.4	0.5
Clay	28.9	0.1	0.1	1.1	2.1	2.6	3.5	2.9	3.1	1.9	1.1	0.8	0.2
Clayton	32.9	0.3	0.4	1.1	2.5	2.8	3.4	3.0	3.5	2.2	1.4	1.4	0.5
Clinton	34.5	0.6	0.6	1.5	2.3	3.0	3.4	2.6	3.5	2.2	1.6	1.6	1.0
Crawford	30.0	0.2	0.2	1.2	2.1	3.0	3.3	2.9	2.5	2.3	1.4	0.8	0.3
Dallas	32.5	0.2	0.3	1.2	2.3	3.2	3.6	3.2	3.0	2.3	1.5	1.1	0.4
Davis	36.1	0.4	0.5	1.5	2.4	3.7	3.2	3.6	2.9	2.9	1.8	1.6	0.8
Decatur	35.2	0.3	0.4	1.4	2.5	3.6	3.3	3.7	2.9	3.0	1.9	1.4	0.5
Delaware	33.8	0.4	0.4	1.2	2.4	3.0	3.5	2.9	3.8	2.4	1.5	1.4	0.6
Des Moines	35.4	0.5	0.6	1.7	2.4	3.3	3.1	3.2	2.8	2.5	1.7	1.7	1.1
Dickinson	28.0	0.1	0.1	1.0	2.0	2.6	3.5	2.7	2.8	1.7	1.1	0.8	0.1
Dubuque	33.5	0.4	0.5	1.3	2.3	2.8	3.3	2.8	3.5	2.4	1.5	1.5	0.7
Emmet	28.7	0.2	0.1	1.0	2.1	2.6	3.5	2.8	2.9	1.7	1.2	0.8	0.2
Fayette	33.9	0.3	0.4	1.1	2.5	3.0	3.6	3.1	3.8	2.3	1.5	1.3	0.5
Floyd	33.3	0.3	0.2	1.1	2.3	3.1	3.9	3.3	3.5	2.3	1.5	1.2	0.4
Franklin	32.5	0.2	0.2	1.1	2.2	3.1	4.0	3.3	3.2	2.1	1.5	1.1	0.4
Fremont	32.7	0.2	0.3	1.4	2.2	3.4	3.3	3.7	2.7	2.4	1.5	1.1	0.3
Greene	31.7	0.2	0.2	1.2	2.2	3.1	3.7	3.1	2.9	2.1	1.5	1.0	0.4
Grundy	33.3	0.3	0.3	1.2	2.2	3.2	4.1	3.2	3.1	2.1	1.6	1.3	0.5
Guthrie	32.9	0.2	0.3	1.3	2.3	3.2	3.6	3.3	3.0	2.4	1.5	1.1	0.4
Hamilton	32.5	0.2	0.2	1.1	2.1	3.0	4.2	3.2	3.3	2.1	1.5	1.0	0.4
Hancock	30.9	0.2	0.2	1.0	2.2	2.8	3.7	3.1	3.1	2.0	1.3	1.0	0.3
Hardin	32.9	0.3	0.3	1.2	2.2	3.1	4.2	3.1	3.1	2.1	1.5	1.2	0.4
Harrison	30.4	0.2	0.2	1.3	2.1	3.2	3.3	2.9	2.4	2.3	1.4	0.8	0.3
Henry	35.7	0.5	0.5	1.6	2.4	3.4	3.1	3.3	2.9	2.8	1.7	1.7	1.0
Howard	33.5	0.3	0.2	1.1	2.4	2.9	3.5	3.4	3.8	2.4	1.4	1.3	0.5
Humboldt	31.3	0.2	0.2	1.1	2.2	2.9	3.7	3.1	3.1	2.1	1.3	0.9	0.3
Ida	29.4	0.2	0.1	1.2	2.1	2.9	3.5	2.8	2.7	2.0	1.2	0.7	0.3
Iowa	34.5	0.4	0.4	1.3	2.4	3.3	3.5	3.2	3.4	2.6	1.6	1.5	0.6
Jackson	33.9	0.5	0.5	1.4	2.3	2.8	3.4	2.5	3.4	2.5	1.5	1.6	0.9
Jasper	33.8	0.3	0.4	1.2	2.3	3.3	3.5	3.2	3.2	2.4	1.7	1.3	0.5

Normal Annual and Monthly Unpaved Lot Runoff – CN 90 (inches)

County	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jefferson	35.2	0.5	0.5	1.5	2.3	3.4	3.0	3.3	2.9	2.8	1.8	1.6	0.6
Johnson	34.6	0.4	0.4	1.4	2.4	3.2	3.5	3.1	3.4	2.5	1.7	1.5	0.6
Jones	34.0	0.5	0.5	1.4	2.3	2.9	3.4	2.8	3.5	2.4	1.5	1.5	0.8
Keokuk	34.4	0.4	0.4	1.4	2.3	3.3	3.2	3.2	3.1	2.7	1.7	1.5	0.6
Kossuth	30.0	0.2	0.1	1.0	2.1	2.8	3.6	3.1	3.0	1.8	1.3	0.9	0.2
Lee	36.6	0.6	0.7	1.8	2.5	3.6	3.1	3.2	2.7	2.7	1.8	1.9	1.2
Linn	34.1	0.4	0.4	1.2	2.4	3.1	3.5	3.0	3.5	2.5	1.5	1.5	0.7
Louisa	34.9	0.5	0.5	1.6	2.4	3.2	3.0	3.1	3.1	2.5	1.7	1.6	1.0
Lucas	35.1	0.3	0.4	1.3	2.5	3.5	3.5	3.6	2.9	3.0	1.8	1.4	0.5
Lyon	25.9	0.1	0.1	1.0	1.7	2.3	3.1	2.4	2.5	1.5	1.0	0.7	0.1
Madison	33.6	0.3	0.4	1.3	2.5	3.3	3.5	3.3	2.9	2.6	1.6	1.2	0.5
Mahaska	34.6	0.3	0.4	1.2	2.4	3.4	3.3	3.3	3.1	2.8	1.7	1.6	0.6
Marion	34.2	0.3	0.4	1.2	2.6	3.4	3.4	3.3	3.1	2.6	1.8	1.4	0.5
Marshall	33.8	0.3	0.3	1.3	2.2	3.3	3.9	3.3	3.3	2.2	1.6	1.3	0.5
Mills	32.1	0.2	0.2	1.3	2.2	3.5	3.4	3.4	2.7	2.4	1.5	1.0	0.3
Mitchell	32.9	0.3	0.2	1.1	2.3	3.0	3.7	3.3	3.5	2.3	1.4	1.1	0.4
Monona	29.0	0.1	0.1	1.2	2.1	3.0	3.2	2.8	2.4	2.0	1.3	0.7	0.2
Monroe	35.4	0.4	0.4	1.3	2.5	3.5	3.3	3.7	2.9	2.9	1.7	1.5	0.6
Montgomery	34.1	0.2	0.3	1.3	2.4	3.5	3.5	3.5	2.9	2.8	1.6	1.2	0.4
Muscatine	34.8	0.5	0.5	1.6	2.3	3.1	3.2	3.0	3.2	2.4	1.6	1.6	1.0
O'Brien	28.1	0.1	0.1	1.0	2.0	2.5	3.5	2.8	2.9	1.7	1.1	0.7	0.1
Osceola	27.3	0.1	0.1	1.0	1.9	2.5	3.4	2.5	2.8	1.8	1.1	0.7	0.1
Page	34.1	0.2	0.3	1.4	2.3	3.5	3.4	3.7	2.9	2.7	1.6	1.3	0.4
Palo Alto	29.8	0.2	0.1	1.1	2.1	2.6	3.6	3.1	3.1	1.9	1.3	0.9	0.2
Plymouth	25.9	0.1	0.1	1.0	1.8	2.6	3.0	2.4	2.2	1.6	1.1	0.6	0.1
Pocahontas	30.7	0.2	0.1	1.2	2.2	2.8	3.5	3.1	3.1	2.1	1.3	0.9	0.3
Polk	33.1	0.3	0.3	1.2	2.3	3.2	3.7	3.2	3.2	2.2	1.6	1.2	0.5
Pottawattamie	32.0	0.2	0.2	1.3	2.3	3.4	3.4	3.4	2.5	2.5	1.5	0.9	0.3
Poweshiek	34.4	0.4	0.4	1.3	2.4	3.3	3.4	3.2	3.3	2.7	1.7	1.5	0.5
Ringgold	34.5	0.2	0.4	1.4	2.2	3.4	3.3	3.6	2.9	2.9	1.9	1.3	0.5
Sac	30.7	0.2	0.1	1.3	2.2	3.0	3.6	3.0	2.8	2.2	1.4	0.8	0.3
Scott	34.5	0.6	0.6	1.6	2.4	3.0	3.4	2.7	3.3	2.2	1.6	1.6	1.0
Shelby	31.8	0.2	0.2	1.3	2.2	3.2	3.4	3.1	2.6	2.8	1.6	0.9	0.3
Sioux	26.4	0.1	0.1	1.0	1.8	2.4	3.2	2.5	2.5	1.6	1.1	0.7	0.2
Story	33.3	0.2	0.3	1.2	2.2	3.1	4.1	3.5	3.3	2.1	1.5	1.2	0.4
Tama	34.2	0.3	0.4	1.3	2.3	3.2	3.9	3.3	3.3	2.4	1.6	1.4	0.5
Taylor	34.7	0.2	0.3	1.4	2.2	3.5	3.4	3.8	2.9	2.9	1.8	1.3	0.4
Union	33.9	0.2	0.4	1.3	2.4	3.4	3.3	3.4	2.7	2.9	1.7	1.3	0.5
Van Buren	35.8	0.5	0.5	1.5	2.5	3.6	3.1	3.4	2.7	2.9	1.8	1.7	1.0
Wapello	35.0	0.4	0.4	1.4	2.3	3.5	3.2	3.5	2.9	2.8	1.7	1.5	0.7
Warren	33.8	0.3	0.4	1.2	2.5	3.4	3.5	3.3	2.9	2.6	1.7	1.3	0.5
Washington	34.3	0.4	0.4	1.4	2.2	3.3	3.1	3.2	3.1	2.6	1.6	1.5	0.8
Wayne	35.6	0.3	0.4	1.4	2.5	3.5	3.3	3.8	2.9	3.0	1.9	1.5	0.6
Webster	32.1	0.2	0.2	1.2	2.2	3.1	3.9	3.2	3.1	2.1	1.4	1.0	0.4
Winnebago	31.1	0.2	0.1	1.0	2.2	2.8	3.7	3.2	3.4	1.9	1.4	1.0	0.3
Winneshiek	33.0	0.3	0.3	1.1	2.5	2.7	3.5	3.2	3.7	2.4	1.4	1.2	0.5
Woodbury	27.5	0.1	0.1	1.1	2.0	2.8	3.1	2.6	2.3	1.8	1.2	0.7	0.2
Worth	32.1	0.3	0.2	1.1	2.2	2.9	3.6	3.2	3.4	2.2	1.4	1.1	0.4
Wright	31.7	0.2	0.2	1.1	2.2	3.0	4.0	3.2	3.1	2.1	1.4	1.0	0.3

Normal Annual and Monthly Paved Lot Runoff – CN 98 (inches)

County	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adair	34.6	0.7	0.8	2.0	3.3	4.2	4.2	4.3	3.7	3.6	2.3	1.9	1.0
Adams	35.1	0.6	0.8	2.0	3.2	4.3	4.2	4.3	3.7	3.9	2.4	2.0	0.9
Allamakee	33.5	0.7	0.7	1.7	3.4	3.6	4.2	4.1	4.4	3.1	2.1	2.0	1.0
Appanoose	36.9	0.8	0.9	2.1	3.2	4.5	4.3	4.8	3.7	3.8	2.6	2.2	1.2
Audubon	33.4	0.6	0.7	2.0	3.1	4.0	4.3	4.1	3.6	3.3	2.4	1.6	0.8
Benton	34.9	0.8	0.8	1.9	3.2	3.9	4.6	3.9	4.2	3.3	2.3	2.1	1.1
Black Hawk	34.3	0.7	0.8	1.9	3.1	3.9	4.8	4.0	4.1	3.0	2.3	2.0	1.0
Boone	33.9	0.7	0.7	1.9	3.1	4.0	4.8	4.1	4.0	2.9	2.3	1.8	0.9
Bremer	35.0	0.8	0.8	1.9	3.3	4.0	4.7	4.1	4.6	3.0	2.3	2.0	1.0
Buchanan	34.9	0.8	0.8	1.8	3.1	3.8	4.6	3.9	4.6	3.2	2.3	2.1	1.1
Buena Vista	31.6	0.5	0.4	1.8	3.1	3.6	4.6	3.9	4.1	2.9	2.0	1.4	0.6
Butler	34.2	0.7	0.7	1.8	3.1	4.0	4.9	4.2	4.1	3.0	2.3	1.9	0.9
Calhoun	31.8	0.6	0.5	1.9	3.0	3.9	4.4	3.8	3.7	3.0	2.1	1.5	0.8
Carroll	32.5	0.6	0.6	2.0	3.1	4.0	4.4	4.0	3.4	3.1	2.2	1.5	0.8
Cass	34.3	0.6	0.7	2.0	3.2	4.2	4.3	4.3	3.7	3.6	2.4	1.7	0.9
Cedar	36.0	1.1	1.1	2.3	3.2	4.0	4.2	3.7	4.3	3.2	2.4	2.3	1.6
Cerro Gordo	33.8	0.7	0.6	1.8	3.1	3.9	4.8	4.1	4.2	3.0	2.2	1.7	0.9
Cherokee	29.4	0.5	0.4	1.8	2.8	3.5	4.3	3.6	3.5	2.7	1.8	1.4	0.6
Chickasaw	35.1	0.8	0.7	1.9	3.4	3.9	4.6	4.2	4.6	3.0	2.3	2.0	1.0
Clarke	35.7	0.7	0.9	2.0	3.3	4.4	4.3	4.4	3.8	3.7	2.4	2.1	1.0
Clay	29.9	0.4	0.4	1.7	2.9	3.4	4.4	3.8	3.9	2.6	1.8	1.4	0.6
Clayton	34.0	0.8	0.9	1.8	3.3	3.6	4.3	3.9	4.4	3.0	2.1	2.1	1.0
Clinton	35.6	1.1	1.1	2.3	3.1	3.8	4.2	3.4	4.3	3.0	2.4	2.3	1.7
Crawford	31.1	0.6	0.5	1.9	2.9	3.9	4.2	3.8	3.3	3.1	2.1	1.4	0.7
Dallas	33.6	0.7	0.7	1.9	3.1	4.1	4.5	4.0	3.8	3.1	2.3	1.8	0.9
Davis	37.2	1.0	1.0	2.2	3.2	4.5	4.1	4.5	3.8	3.8	2.6	2.4	1.4
Decatur	36.3	0.7	0.9	2.1	3.3	4.4	4.2	4.5	3.7	3.8	2.7	2.1	1.1
Delaware	34.9	0.9	0.9	1.9	3.2	3.8	4.3	3.8	4.7	3.2	2.3	2.2	1.1
Des Moines	36.5	1.1	1.2	2.4	3.3	4.1	4.0	4.0	3.7	3.4	2.5	2.4	1.7
Dickinson	29.0	0.4	0.4	1.7	2.8	3.4	4.4	3.5	3.6	2.5	1.8	1.4	0.5
Dubuque	34.6	0.9	1.0	2.1	3.1	3.6	4.2	3.6	4.3	3.2	2.2	2.2	1.3
Emmet	29.8	0.5	0.4	1.6	2.8	3.4	4.4	3.7	3.8	2.5	1.9	1.5	0.6
Fayette	34.9	0.8	0.8	1.8	3.3	3.8	4.4	4.0	4.7	3.1	2.2	2.0	1.1
Floyd	34.3	0.7	0.6	1.8	3.2	3.9	4.8	4.2	4.3	3.1	2.2	1.8	0.9
Franklin	33.6	0.6	0.6	1.8	3.0	4.0	4.9	4.1	4.1	2.9	2.2	1.8	0.9
Fremont	33.8	0.6	0.7	2.1	3.0	4.3	4.1	4.6	3.6	3.3	2.3	1.8	0.8
Greene	32.8	0.7	0.7	1.9	3.0	4.0	4.6	4.0	3.7	2.9	2.2	1.7	0.9
Grundy	34.4	0.7	0.8	2.0	3.0	4.0	5.0	4.1	3.9	2.9	2.3	2.0	1.0
Guthrie	33.9	0.7	0.8	2.0	3.1	4.1	4.4	4.1	3.9	3.2	2.3	1.7	0.9
Hamilton	33.5	0.7	0.6	1.8	2.9	3.8	5.1	4.1	4.2	2.9	2.2	1.7	0.9
Hancock	31.9	0.6	0.5	1.7	3.0	3.7	4.6	4.0	4.0	2.8	2.0	1.6	0.8
Hardin	34.0	0.7	0.7	1.9	3.0	4.0	5.1	4.0	4.0	2.9	2.3	1.9	0.9
Harrison	31.4	0.5	0.6	2.0	2.9	4.1	4.2	3.8	3.2	3.1	2.2	1.5	0.7
Henry	36.7	1.1	1.1	2.4	3.2	4.2	3.9	4.2	3.8	3.7	2.5	2.4	1.6
Howard	34.6	0.8	0.7	1.8	3.2	3.7	4.4	4.2	4.7	3.2	2.2	2.0	1.0
Humboldt	32.1	0.6	0.5	1.8	3.0	3.7	4.5	4.0	4.0	2.9	2.1	1.6	0.8
Ida	30.5	0.6	0.5	1.9	2.9	3.7	4.4	3.6	3.5	2.8	1.9	1.3	0.7
Iowa	35.6	0.8	0.8	2.0	3.2	4.2	4.4	4.0	4.3	3.4	2.4	2.2	1.2
Jackson	35.0	1.0	1.1	2.1	3.1	3.7	4.2	3.3	4.3	3.3	2.3	2.3	1.5
Jasper	34.8	0.8	0.8	2.0	3.1	4.2	4.4	4.0	4.1	3.2	2.4	2.1	1.0

Normal Annual and Monthly Paved Lot Runoff – CN 98 (inches)

County	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jefferson	36.2	1.0	1.0	2.2	3.2	4.3	3.8	4.2	3.8	3.6	2.5	2.3	1.5
Johnson	35.6	0.9	0.9	2.1	3.2	4.0	4.3	4.0	4.3	3.3	2.4	2.2	1.3
Jones	35.1	1.0	1.0	2.1	3.1	3.8	4.3	3.6	4.4	3.2	2.3	2.3	1.4
Keokuk	35.5	0.9	0.9	2.1	3.1	4.2	4.0	4.1	4.0	3.6	2.5	2.3	1.2
Kossuth	31.0	0.5	0.5	1.7	2.9	3.6	4.5	4.0	3.9	2.6	2.0	1.6	0.7
Lee	37.6	1.2	1.2	2.6	3.3	4.5	3.9	4.1	3.5	3.6	2.6	2.6	1.9
Linn	35.1	0.9	0.9	2.0	3.2	3.9	4.4	3.9	4.3	3.3	2.3	2.2	1.2
Louisa	35.9	1.0	1.1	2.4	3.2	4.1	3.9	3.9	3.9	3.3	2.4	2.3	1.6
Lucas	36.1	0.7	0.9	2.0	3.3	4.4	4.3	4.4	3.8	3.8	2.6	2.1	1.0
Lyon	26.9	0.3	0.4	1.6	2.5	3.1	4.0	3.2	3.3	2.3	1.7	1.3	0.5
Madison	34.6	0.7	0.8	2.0	3.3	4.2	4.3	4.1	3.7	3.5	2.3	2.0	1.0
Mahaska	35.6	0.8	0.9	2.0	3.2	4.3	4.1	4.1	3.9	3.6	2.5	2.3	1.1
Marion	35.2	0.7	0.9	1.9	3.4	4.3	4.2	4.1	3.9	3.4	2.5	2.1	1.0
Marshall	34.8	0.7	0.8	2.0	3.0	4.1	4.8	4.2	4.2	3.0	2.3	2.0	1.0
Mills	33.2	0.5	0.6	2.0	3.0	4.4	4.3	4.3	3.5	3.2	2.2	1.6	0.8
Mitchell	33.9	0.8	0.6	1.8	3.1	3.9	4.5	4.1	4.4	3.1	2.2	1.8	0.9
Monona	30.1	0.5	0.5	1.9	2.9	3.9	4.1	3.6	3.2	2.8	2.1	1.3	0.6
Monroe	36.5	0.8	1.0	2.0	3.3	4.4	4.2	4.6	3.7	3.8	2.5	2.3	1.2
Montgomery	35.1	0.6	0.8	2.1	3.2	4.4	4.4	4.4	3.7	3.7	2.4	1.9	0.9
Muscatine	35.8	1.1	1.1	2.3	3.1	3.9	4.1	3.9	4.1	3.2	2.4	2.3	1.6
O'Brien	29.1	0.5	0.5	1.7	2.7	3.3	4.4	3.7	3.8	2.4	1.7	1.3	0.5
Osceola	28.4	0.4	0.4	1.7	2.7	3.3	4.3	3.3	3.6	2.6	1.7	1.3	0.5
Page	35.1	0.7	0.8	2.1	3.1	4.4	4.3	4.5	3.7	3.6	2.4	2.0	0.9
Palo Alto	30.8	0.5	0.4	1.7	2.9	3.5	4.5	3.9	3.9	2.6	2.0	1.5	0.6
Plymouth	27.0	0.4	0.4	1.7	2.6	3.4	3.9	3.2	3.0	2.3	1.8	1.2	0.5
Pocahontas	31.8	0.6	0.5	1.8	3.0	3.7	4.4	4.0	4.0	2.9	2.0	1.5	0.7
Polk	34.2	0.7	0.8	1.9	3.1	4.1	4.6	4.1	4.1	3.0	2.3	1.9	1.0
Pottawattamie	33.1	0.6	0.6	2.1	3.1	4.3	4.3	4.2	3.3	3.4	2.2	1.6	0.8
Poweshiek	35.5	0.8	0.9	2.0	3.2	4.1	4.3	4.0	4.2	3.5	2.5	2.2	1.1
Ringgold	35.6	0.6	0.8	2.1	3.0	4.3	4.2	4.5	3.8	3.8	2.7	2.0	1.0
Sac	31.8	0.6	0.5	2.0	3.0	3.8	4.5	3.8	3.7	3.0	2.1	1.5	0.8
Scott	35.6	1.1	1.1	2.3	3.2	3.8	4.3	3.5	4.1	3.0	2.4	2.3	1.7
Shelby	32.9	0.6	0.6	2.0	3.0	4.0	4.2	4.0	3.5	3.6	2.3	1.5	0.8
Sioux	27.4	0.4	0.4	1.7	2.5	3.2	4.0	3.3	3.3	2.3	1.8	1.3	0.5
Story	34.4	0.7	0.7	1.9	3.0	4.0	5.0	4.4	4.2	2.9	2.3	1.9	0.9
Tama	35.2	0.8	0.8	2.0	3.1	4.0	4.8	4.1	4.1	3.2	2.4	2.1	1.0
Taylor	35.8	0.7	0.8	2.1	3.0	4.4	4.3	4.6	3.8	3.8	2.6	2.0	1.0
Union	34.9	0.7	0.8	2.0	3.2	4.2	4.2	4.3	3.6	3.7	2.4	2.0	1.0
Van Buren	36.9	1.1	1.1	2.3	3.3	4.5	3.9	4.3	3.5	3.7	2.6	2.4	1.6
Wapello	36.1	0.9	1.0	2.1	3.1	4.3	4.1	4.4	3.8	3.7	2.5	2.3	1.3
Warren	34.9	0.7	0.9	1.9	3.3	4.2	4.4	4.1	3.7	3.4	2.5	2.0	1.0
Washington	35.4	1.0	0.9	2.2	3.0	4.1	4.0	4.0	3.9	3.4	2.4	2.2	1.4
Wayne	36.7	0.7	0.9	2.1	3.3	4.4	4.2	4.7	3.7	3.9	2.7	2.2	1.1
Webster	33.1	0.7	0.6	1.9	3.0	3.9	4.7	4.1	4.0	2.9	2.1	1.6	0.9
Winnebago	32.2	0.6	0.5	1.7	3.0	3.7	4.6	4.0	4.3	2.7	2.1	1.6	0.8
Winneshiek	34.1	0.7	0.7	1.7	3.4	3.6	4.3	4.1	4.6	3.2	2.1	1.9	1.0
Woodbury	28.5	0.4	0.4	1.8	2.8	3.7	3.9	3.4	3.1	2.5	1.9	1.3	0.6
Worth	33.1	0.7	0.5	1.8	3.0	3.8	4.5	4.1	4.3	3.0	2.1	1.7	0.9
Wright	32.8	0.6	0.6	1.8	3.0	3.8	4.9	4.0	4.0	2.9	2.1	1.7	0.8

10- and 25-Year – 5-Minute Precipitation Event by County (inches)

County	Precipitation Event		County	Precipitation Event	
	10 Year	25 Year		10 Year	25 Year
Adair	0.55	0.67	**Jefferson**	0.56	0.68
Adams	0.55	0.67	**Johnson**	0.53	0.65
Allamakee	0.52	0.61	**Jones**	0.53	0.65
Appanoose	0.56	0.69	**Keokuk**	0.56	0.68
Audubon	0.52	0.63	**Kossuth**	0.53	0.64
Benton	0.53	0.65	**Lee**	0.56	0.68
Black Hawk	0.52	0.61	**Linn**	0.53	0.65
Boone	0.51	0.62	**Louisa**	0.56	0.68
Bremer	0.52	0.61	**Lucas**	0.56	0.69
Buchanan	0.52	0.61	**Lyon**	0.50	0.61
Buena Vista	0.50	0.61	**Madison**	0.56	0.69
Butler	0.53	0.64	**Mahaska**	0.56	0.68
Calhoun	0.52	0.63	**Marion**	0.56	0.69
Carroll	0.52	0.63	**Marshall**	0.51	0.62
Cass	0.55	0.67	**Mills**	0.55	0.67
Cedar	0.53	0.65	**Mitchell**	0.53	0.64
Cerro Gordo	0.53	0.64	**Monona**	0.52	0.63
Cherokee	0.50	0.61	**Monroe**	0.56	0.69
Chickasaw	0.52	0.61	**Montgomery**	0.55	0.67
Clarke	0.56	0.69	**Muscatine**	0.53	0.65
Clay	0.50	0.61	**O'Brien**	0.50	0.61
Clayton	0.52	0.61	**Osceola**	0.50	0.61
Clinton	0.53	0.65	**Page**	0.55	0.67
Crawford	0.52	0.63	**Palo Alto**	0.50	0.61
Dallas	0.51	0.62	**Plymouth**	0.50	0.61
Davis	0.56	0.68	**Pocahontas**	0.50	0.61
Decatur	0.56	0.69	**Polk**	0.51	0.62
Delaware	0.52	0.61	**Pottawattamie**	0.55	0.67
Des Moines	0.56	0.68	**Poweshiek**	0.51	0.62
Dickinson	0.50	0.61	**Ringgold**	0.56	0.69
Dubuque	0.52	0.61	**Sac**	0.52	0.63
Emmet	0.50	0.61	**Scott**	0.53	0.65
Fayette	0.52	0.61	**Shelby**	0.52	0.63
Floyd	0.53	0.64	**Sioux**	0.50	0.61
Franklin	0.53	0.64	**Story**	0.51	0.62
Fremont	0.55	0.67	**Tama**	0.51	0.62
Greene	0.52	0.63	**Taylor**	0.55	0.67
Grundy	0.51	0.62	**Union**	0.56	0.69
Guthrie	0.52	0.63	**Van Buren**	0.56	0.68
Hamilton	0.51	0.62	**Wapello**	0.56	0.68
Hancock	0.53	0.64	**Warren**	0.56	0.69
Hardin	0.51	0.62	**Washington**	0.56	0.68
Harrison	0.52	0.63	**Wayne**	0.56	0.69
Henry	0.56	0.68	**Webster**	0.51	0.62
Howard	0.52	0.61	**Winnebago**	0.53	0.64
Humboldt	0.53	0.64	**Winneshiek**	0.52	0.61
Ida	0.52	0.63	**Woodbury**	0.52	0.63
Iowa	0.53	0.65	**Worth**	0.53	0.64
Jackson	0.53	0.65	**Wright**	0.53	0.64
Jasper	0.51	0.62			

Animal Waste Regulations Guide

All producers should be encouraged to be familiar with federal, state, and local laws, rules, and regulations, and as promulgated by the Iowa Department of Natural Resources (IDNR), Environmental Protection Agency (EPA), or others. This document provides links to the different sections within the IDNR Chapter 65 regulations for animal waste management. Links are also provided for other sources of regulatory related information.

IDNR Regulations – Quick Reference

Topic	IAC 567, Chapter 65 Section(s)
Confinement Operations – Division I	65.1
Land Application	65.3
Operation Permits	65.6
Construction Permits	65.7 – 65.10
Storage Structure Design Requirements	65.15
Manure Management Plan Requirements	65.16 – 65.17
Manure Applicators Certification	65.19
Open Feedlot Operations – Division II	65.100
Minimum Open Feedlot Effluent Control Requirements and Release Reporting	65.101
NPDES Permits	65.104
Construction Permits	65.105
Settled Open Feedlot Effluent Basins – Investigation, Design, and Construction	65.109
Alternative Technology Systems – Design Requirements	65.110
Nutrient Management Plan Requirements	65.112
Other – Separation Distances	65.11

For Site-Specific Permit Determinations and Current Rulings Contact:

Your Area IDNR Field Office – (***http://www.iowadnr.com/fo/index.html***)
Map of field offices – (***http://www.iowadnr.gov/fo/fomap.html***)

or

Iowa Department of Natural Resources (***http://www.iowadnr.com/***)
Environmental Protection Division – Animal Feeding Operations
(515) 281-5918

Manure Management & Regulation Resource Websites

Environmental Protection Agency – Animal Feeding Operations
http://cfpub.epa.gov/npdes/home.cfm?program_id=7

Iowa Department of Agriculture and Land Stewardship
http://www.agriculture.state.ia.us/

Iowa Legislature (Administrative Code)
http://www.legis.state.ia.us/

IDNR – Animal Feeding Operations
http://www.iowadnr.com/afo/

Iowa Manure Management Action Group
http://www.agronext.iastate.edu/immag/

MidWest Plan Service
http://www.mwpshq.org/

Natural Resources Conservation Service - Iowa
http://www.ia.nrcs.usda.gov/

VOLUME DETERMINATION OF LAGOONS

NRCS approved computer programs exist to calculate the volume of various types of storage facilities. For situations where a computer program is not available, the following approved methods are included in this Handbook for your use. Examples for the computer programs are not included here, as each program should have its own documentation to describe the assumptions and instructions for using the programs.

The following four methods are described within this document.

1. Graph/tabular solution
2. General formula solution
3. Simplified formula solution
4. Prismoidal formula solution

The graphs and tables may be used with various combinations of depth, bottom length, bottom width, and side slopes. The general formula, described at the end of this document, may be used to calculate volumes if the side slopes are not all equal. The simplified formula is a special situation of the general formula where all the side slopes are the same. The prismoidal formula may be used with any shaped bottom with varying side slopes as long as each slope is uniform from bottom to top.

Graph/Tabular Solution

The graphs and tables can be used to:

1. Calculate the volume of existing basins
2. Determine alternative dimensions necessary to contain a required volume

The attached graphs and tables present a simplified, rapid method for determining approximate volumes of storage or excavations which are rectangular or square in plan view. They were developed to aid in sizing waste lagoons, but can be used for pond excavations, and other excavations with four sides, right angle corners, and uniform side slopes (pyramid frustrums). Data in graphs and tables were only compiled to maximum dimensions of 130 feet, but may be extended. (Note: Linear interpolations may be made between bottom widths for any given depth. However, interpolations between different depths or side slopes are not linear and would only be approximations.)

The graphs on the follow pages give the volume of an excavation with a square bottom. Table 1 gives the volume of a 1-foot thick slice. Thus, the volume of a basin with a rectangular bottom can be determined by finding the volume for the square bottom width from the appropriate graph and adding sufficient 1-foot increments from Table 1 to give the desired length.

General Formula Solution

This equation allows for all side slopes to have different values if necessary. See Figure A.

$$Volume = WLD + \frac{W(Z_1 + Z_3)D^2}{2} + \frac{L(Z_2 + Z_4)D^2}{2} + \frac{(Z_1 + Z_3)(Z_2 + Z_4)D^3}{3}$$

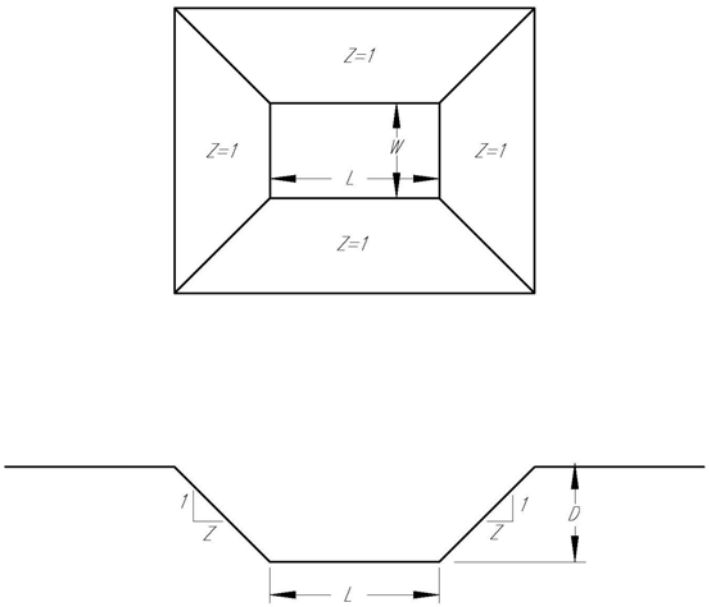


Figure A. Details for the General Formula

Simplified Formula Solution

The simplified formula for volume can be expressed as:

$$Volume = WLD + WZD^2 + LZD^2 + \frac{4Z^2D^3}{3}$$

Where: W = bottom width
L = bottom length
D = depth
Z = side slope as in Z:1

This procedure may be used only if all side slopes have the same value, Z

If W = L, then the equation further reduces to:

$$Volume = WD + 2\left(WZD^2\right) + \frac{4Z^2D^3}{3}$$

This is the formula used to develop the graphs on the following pages and the appropriate version of the formula is given on the graph for each side slope ratio.

Additional storage created by increasing one dimension of the bottom to make a rectangular basin can be calculated by the formula:

$$Volume = (L - W)(W + ZD)(D)$$

This formula was used to develop Table 1.

Prismoidal Formula Solution

The prismoidal formula is as follows:

$$Volume = \frac{(BottomArea) + (4)(MidpointArea) + (TopArea)}{6}(Depth)$$

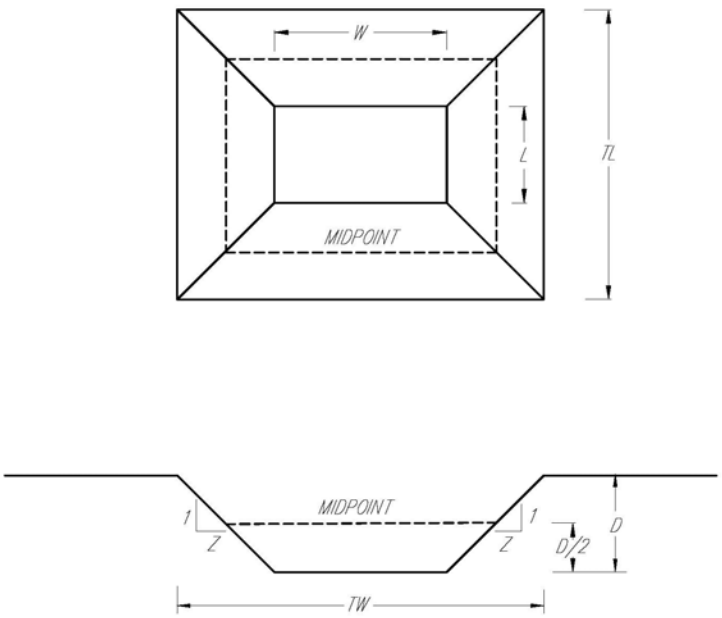


Figure B. Details for Prismoidal Formula

The prismoidal formula may be used with any shape bottom and various side slopes as long as the side slopes are uniform from bottom to top on each side.

Example 1:

Find the volume of a lagoon having 3:1 side slopes (Z = 3), depth (D = 8 ft), bottom length (L = 65 ft), bottom width (W = 40 ft).

Graph/table solution:

1. On the graph for square storages with 3:1 side slopes, find the volume for W = 40 ft and D = 8.0 ft. Enter where W = 40, move vertically to intersect the curve for D = 8.0, move horizontally to read V = 34,500. V_1 = 34,500 ft^3
2. In Table 1, find volume for a 1.0 ft segment of storage when D = 8 ft, W = 40 ft, and side slopes = 3:1. This equals 512 ft^3. The bottom length is 25 ft longer than the bottom width (65 – 40 = 25). Therefore, twenty five 1.0 ft segments must be added. V_2 = 25*512 = 12,800 ft^3
3. Total Volume: V = V_1 + V_2 = 34,500 + 12,800 = 47,300 ft^3

OR

Simplified formula solution:

$$Volume = WLD + WZD^2 + LZD^2 + \frac{4Z^2D^3}{3}$$ W = 40, L = 65, D = 8, Z = 3

$$= 40*65*8 + 40*3*8^2 + 65*3*8^2 + \frac{4*3^2*8^3}{3}$$

= 20,800 + 7,680 + 12,480 + 6,144

= 47,104 ft^3

OR

Prismoidal formula:

$$Volume = \frac{(BottomArea) + (4)(MidpointArea) + (TopArea)}{6}(Depth)$$

Calculate Areas:

Bottom Area = L * W = 65 * 40 = 2,600 ft^2

Midpoint Area = (L at midpoint) * (W at midpoint)

L at midpoint = 65 + 2*Z*(D/2)
= 65 + 2*3*(8/2)
= 89 ft

W at midpoint = 40 + 2*Z*(D/2)
= 40 + 2*3*(8/2)
= 64 ft

Midpoint Area = L*W = 89*64 = 5,696 ft^2

Area Top = (L at top)*(W at top)

L at top = 65 + 2*Z*D
= 65 + 2*3*8
= 113 ft

W at top = 40 + 2*Z*D
= 40 + 2*3*8
= 88 ft

Top Area = L * W = 113 * 88 = 9,944 ft^2

$$Volume = \frac{(BottomArea) + (4)(MidpointArea) + (TopArea)}{6}(Depth)$$

$$Volume = \frac{2{,}600 + 4*5{,}696 + 9{,}944}{6}*8$$

Volume = 47,104 ft^2

Example 2:

Determine the approximate size of a lagoon necessary to contain 120,000 ft^3 of volume. Assume Z = 3 (3:1 side slopes) and that the desired depth is 12 feet. Find the bottom length and width of a lagoon to store the required volume.

Recommended solution

1. Find the graph for 3:1 side slopes
2. Enter at V = 120,000 ft^3
3. Proceed horizontally to intersection with line for D = 12
4. Move vertically down to read W = 62 ft
5. This storage is square in plan view so L = W and a lagoon with a 62 ft x 62 ft bottom, 3:1 side slopes, and 12 ft deep will contain approximately 120,000 ft^3.
6. Check using the simplified formula:

$$V = W^2 D + 2\left(ZD^2 W\right) + \frac{4\left(Z^2 D^3\right)}{3}$$

$$V = 62^2 * 12 + 2 * 3 * 12^2 * 62 + \frac{4 * 3^2 * 12^3}{3}$$

V = 46,128 + 53,568 + 20,736

V = 120,432 ft^3

7. If the site doesn't lend itself to a square lagoon, use the following steps:
   - Select a bottom width which will fit the site. Assume for this example that W = 40 ft
   - Enter Figure 3 at W = 40 and proceed vertically to the intersection with the curve D = 12
   - Proceed horizontally to read the volume as V = 74,500 ft^3
   - Additional storage needed = 120,000 – 74,500 = 45,500 ft^3
   - From Table 1 (3:1 side slopes) when W = 40 ft and D = 12 ft for each 1-ft segment of length gives an additional 912 ft^3 of storage
   - Additional segments required = 45,500/912 = 49.9 (use 50 segments)

     Use 50, 1.0 ft segments = 50 ft

     Total length = 40 +50 = 90 ft

     A rectangular bottom lagoon with 40 ft x 90 ft bottom will also contain approximately 120,000 ft^3

     Check using the simplified formula

$$Volume = WLD + WZD^2 + LZD^2 + \frac{4Z^2 D^3}{3}$$

Volume = $40*90*12 + 3*12^2*90 + 3*12^2*40 + 4*3^2*12^3/3$

Volume = 43,200 + 38,880 + 17,280 + 20,736

Volume = 120,096 ft^3

8. Various depth, side slope ratio, length, and width combinations can be rapidly investigated by reading values from the various graphs and tables using the procedure described above.

   The following combinations give an approximate volume of 120,000 ft^3

Z	D	W	L (nearest ft)
3:1	12	62	62
3:1	12	60	65
3:1	12	50	79
3:1	12	40	90
3:1	12	30	152

Example 3:

Find the volume of a lagoon having 2, 3:1 side slopes (Z = 3), on end slope (Z = 4), one end slope (Z = 8), depth = 8 ft, bottom length (L) = 65 ft, bottom width (W) = 40 ft

Because of the different side slopes, use the general formula solution for this example.

Assign the following values:

$Z_1 = 4$
$Z_2 = 3$
$Z_3 = 8$
$Z_4 = 3$

$$Volume = WLD + \frac{W(Z_1 + Z_3)D^2}{2} + \frac{L(Z_2 + Z_4)D^2}{2} + \frac{(Z_1 + Z_3)(Z_2 + Z_4)D^3}{3}$$

$$Volume = 40 * 65 * 8 + \frac{40 * (4+8) * 8^2}{2} + \frac{65 * (3+3) * 8^2}{2} + \frac{(4+8) * (3+3) * 8^3}{3}$$

Volume = 20,800 + 15,360 + 12,480 + 12,288

Volume = 60,928 ft^3

TRAPEZOIDAL DESIGN STORAGE - TABLE 1															
VOLUME IN CUBIC FEET PER FOOT LENGTH															
Side Slopes	Depth, feet	Bottom Width in Feet													
		0	10	20	30	40	50	60	70	80	90	100	110	120	130
2	4	32	72	112	152	192	232	272	312	352	392	432	472	512	552
	5	50	100	150	200	250	300	350	400	450	500	550	600	650	700
	6	72	132	192	252	312	372	432	492	552	612	672	732	792	852
	7	98	168	238	308	378	448	518	588	658	728	798	868	938	1008
	8	128	208	288	368	448	528	608	688	768	848	928	1008	1088	1168
	9	162	252	342	432	522	612	702	792	882	972	1062	1152	1242	1332
	10	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
	11	242	352	462	572	682	792	902	1012	1122	1232	1342	1452	1562	1672
	12	288	408	528	648	768	888	1008	1128	1248	1368	1488	1608	1728	1848
	13	338	468	598	728	858	988	1118	1248	1378	1508	1638	1768	1898	2028
	14	392	532	672	812	952	1092	1232	1372	1512	1652	1792	1932	2072	2212
	15	450	600	750	900	1050	1200	1350	1500	1650	1800	1950	2100	2250	2400
	16	512	672	832	992	1152	1312	1472	1632	1792	1952	2112	2272	2432	2592
	17	578	748	918	1088	1258	1428	1598	1768	1938	2108	2278	2448	2618	2788
	18	648	828	1008	1188	1368	1548	1728	1908	2088	2268	2448	2628	2808	2988
	19	722	912	1102	1292	1482	1672	1862	2052	2242	2432	2622	2812	3002	3192
	20	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400
2.5	4	40	80	120	160	200	240	280	320	360	400	440	480	520	560
	5	63	113	163	213	263	313	363	413	463	513	563	613	663	713
	6	90	150	210	270	330	390	450	510	570	630	690	750	810	870
	7	123	193	263	333	403	473	543	613	683	753	823	893	963	1033
	8	160	240	320	400	480	560	640	720	800	880	960	1040	1120	1200
	9	203	293	383	473	563	653	743	833	923	1013	1103	1193	1283	1373
	10	250	350	450	550	650	750	850	950	1050	1150	1250	1350	1450	1550
	11	303	413	523	633	743	853	963	1073	1183	1293	1403	1513	1623	1733
	12	360	480	600	720	840	960	1080	1200	1320	1440	1560	1680	1800	1920
	13	423	553	683	813	943	1073	1203	1333	1463	1593	1723	1853	1983	2113
	14	490	630	770	910	1050	1190	1330	1470	1610	1750	1890	2030	2170	2310
	15	563	713	863	1013	1163	1313	1463	1613	1763	1913	2063	2213	2363	2513
	16	640	800	960	1120	1280	1440	1600	1760	1920	2080	2240	2400	2560	2720
	17	723	893	1063	1233	1403	1573	1743	1913	2083	2253	2423	2593	2763	2933
	18	810	990	1170	1350	1530	1710	1890	2070	2250	2430	2610	2790	2970	3150
	19	903	1093	1283	1473	1663	1853	2043	2233	2423	2613	2803	2993	3183	3373
	20	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600

Side slopes are ___ horizontal to 1 vertical

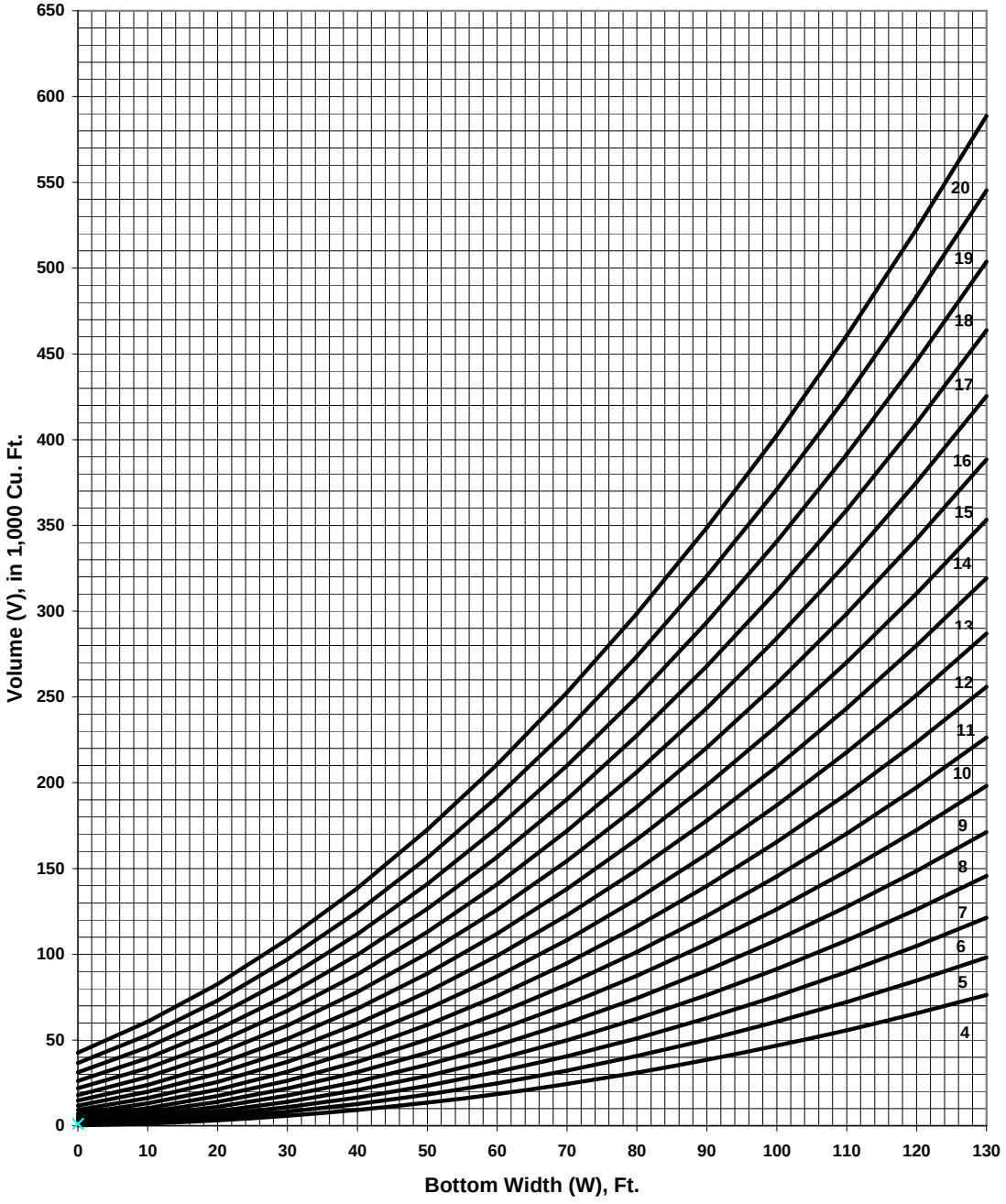
TRAPEZOIDAL DESIGN STORAGE - TABLE 1 VOLUME IN CUBIC FEET PER FOOT LENGTH															
Side Slopes	Depth, feet	Bottom Width in Feet													
		0	10	20	30	40	50	60	70	80	90	100	110	120	130
3	4	48	88	128	168	208	248	288	328	368	408	448	488	528	568
	5	75	125	175	225	275	325	375	425	475	525	575	625	675	725
	6	108	168	228	288	348	408	468	528	588	648	708	768	828	888
	7	147	217	287	357	427	497	567	637	707	777	847	917	987	1057
	8	192	272	352	432	512	592	672	752	832	912	992	1072	1152	1232
	9	243	333	423	513	603	693	783	873	963	1053	1143	1233	1323	1413
	10	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
	11	363	473	583	693	803	913	1023	1133	1243	1353	1463	1573	1683	1793
	12	432	552	672	792	912	1032	1152	1272	1392	1512	1632	1752	1872	1992
	13	507	637	767	897	1027	1157	1287	1417	1547	1677	1807	1937	2067	2197
	14	588	728	868	1008	1148	1288	1428	1568	1708	1848	1988	2128	2268	2408
	15	675	825	975	1125	1275	1425	1575	1725	1875	2025	2175	2325	2475	2625
	16	768	928	1088	1248	1408	1568	1728	1888	2048	2208	2368	2528	2688	2848
	17	867	1037	1207	1377	1547	1717	1887	2057	2227	2397	2567	2737	2907	3077
	18	972	1152	1332	1512	1692	1872	2052	2232	2412	2592	2772	2952	3132	3312
	19	1083	1273	1463	1653	1843	2033	2223	2413	2603	2793	2983	3173	3363	3553
	20	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800
3.5	4	56	96	136	176	216	256	296	336	376	416	456	496	536	576
	5	88	138	188	238	288	338	388	438	488	538	588	638	688	738
	6	126	186	246	306	366	426	486	546	606	666	726	786	846	906
	7	172	242	312	382	452	522	592	662	732	802	872	942	1012	1082
	8	224	304	384	464	544	624	704	784	864	944	1024	1104	1184	1264
	9	284	374	464	554	644	734	824	914	1004	1094	1184	1274	1364	1454
	10	350	450	550	650	750	850	950	1050	1150	1250	1350	1450	1550	1650
	11	424	534	644	754	864	974	1084	1194	1304	1414	1524	1634	1744	1854
	12	504	624	744	864	984	1104	1224	1344	1464	1584	1704	1824	1944	2064
	13	592	722	852	982	1112	1242	1372	1502	1632	1762	1892	2022	2152	2282
	14	686	826	966	1106	1246	1386	1526	1666	1806	1946	2086	2226	2366	2506
	15	788	938	1088	1238	1388	1538	1688	1838	1988	2138	2288	2438	2588	2738
	16	896	1056	1216	1376	1536	1696	1856	2016	2176	2336	2496	2656	2816	2976
	17	1012	1182	1352	1522	1692	1862	2032	2202	2372	2542	2712	2882	3052	3222
	18	1134	1314	1494	1674	1854	2034	2214	2394	2574	2754	2934	3114	3294	3474
	19	1264	1454	1644	1834	2024	2214	2404	2594	2784	2974	3164	3354	3544	3734
	20	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000

Side slopes are ___ horizontal to 1 vertical

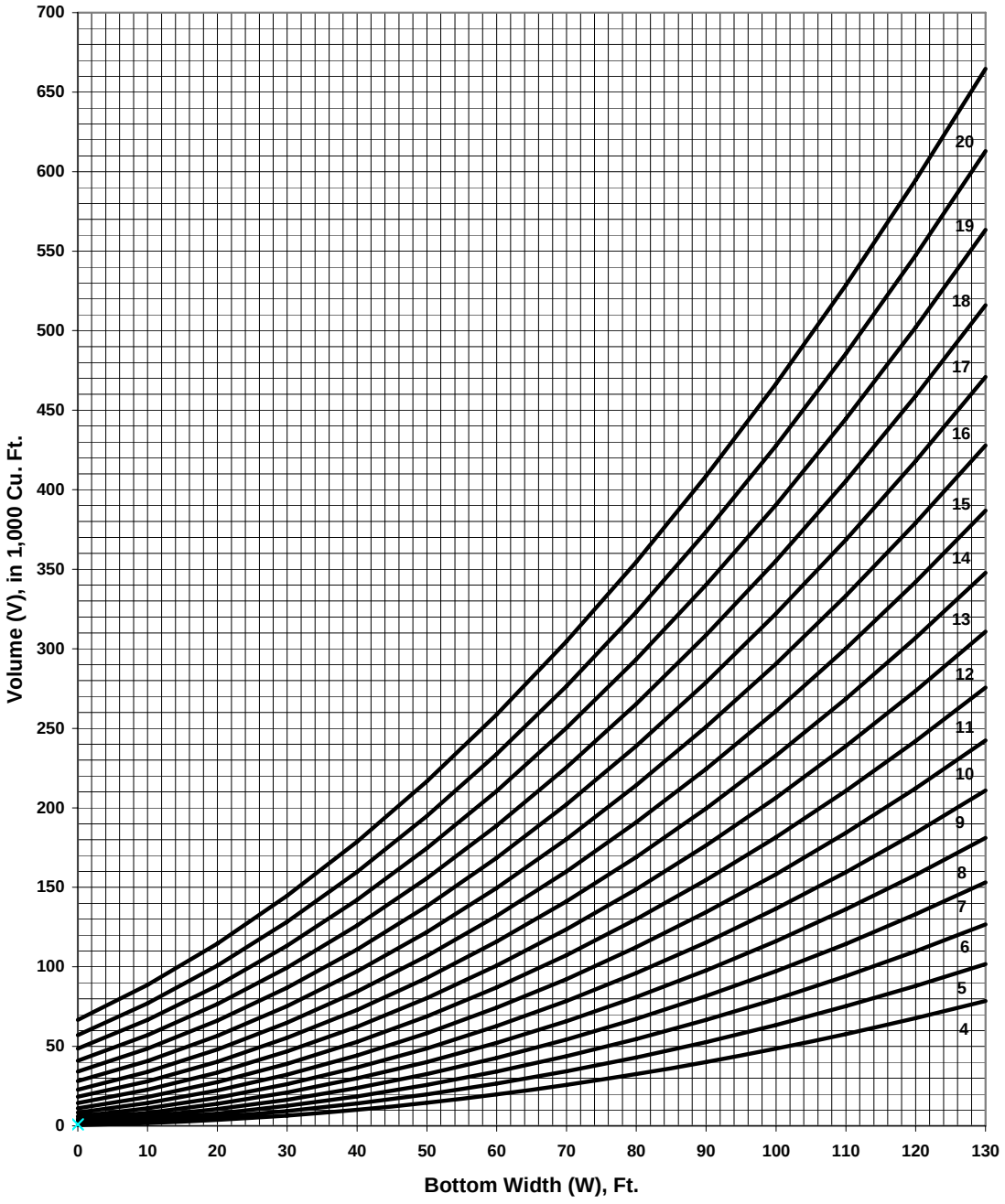
TRAPEZOIDAL DESIGN STORAGE - TABLE 1 VOLUME IN CUBIC FEET PER FOOT LENGTH															
Side Slopes	Depth, feet	Bottom Width in Feet													
		0	10	20	30	40	50	60	70	80	90	100	110	120	130
4	4	64	104	144	184	224	264	304	344	384	424	464	504	544	584
	5	100	150	200	250	300	350	400	450	500	550	600	650	700	750
	6	144	204	264	324	384	444	504	564	624	684	744	804	864	924
	7	196	266	336	406	476	546	616	686	756	826	896	966	1036	1106
	8	256	336	416	496	576	656	736	816	896	976	1056	1136	1216	1296
	9	324	414	504	594	684	774	864	954	1044	1134	1224	1314	1404	1494
	10	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700
	11	484	594	704	814	924	1034	1144	1254	1364	1474	1584	1694	1804	1914
	12	576	696	816	936	1056	1176	1296	1416	1536	1656	1776	1896	2016	2136
	13	676	806	936	1066	1196	1326	1456	1586	1716	1846	1976	2106	2236	2366
	14	784	924	1064	1204	1344	1484	1624	1764	1904	2044	2184	2324	2464	2604
	15	900	1050	1200	1350	1500	1650	1800	1950	2100	2250	2400	2550	2700	2850
	16	1024	1184	1344	1504	1664	1824	1984	2144	2304	2464	2624	2784	2944	3104
	17	1156	1326	1496	1666	1836	2006	2176	2346	2516	2686	2856	3026	3196	3366
	18	1296	1476	1656	1836	2016	2196	2376	2556	2736	2916	3096	3276	3456	3636
	19	1444	1634	1824	2014	2204	2394	2584	2774	2964	3154	3344	3534	3724	3914
	20	1600	1800	2000	2200	2400	2600	2800	3000	3200	3400	3600	3800	4000	4200

Side slopes are ___ horizontal to 1 vertical

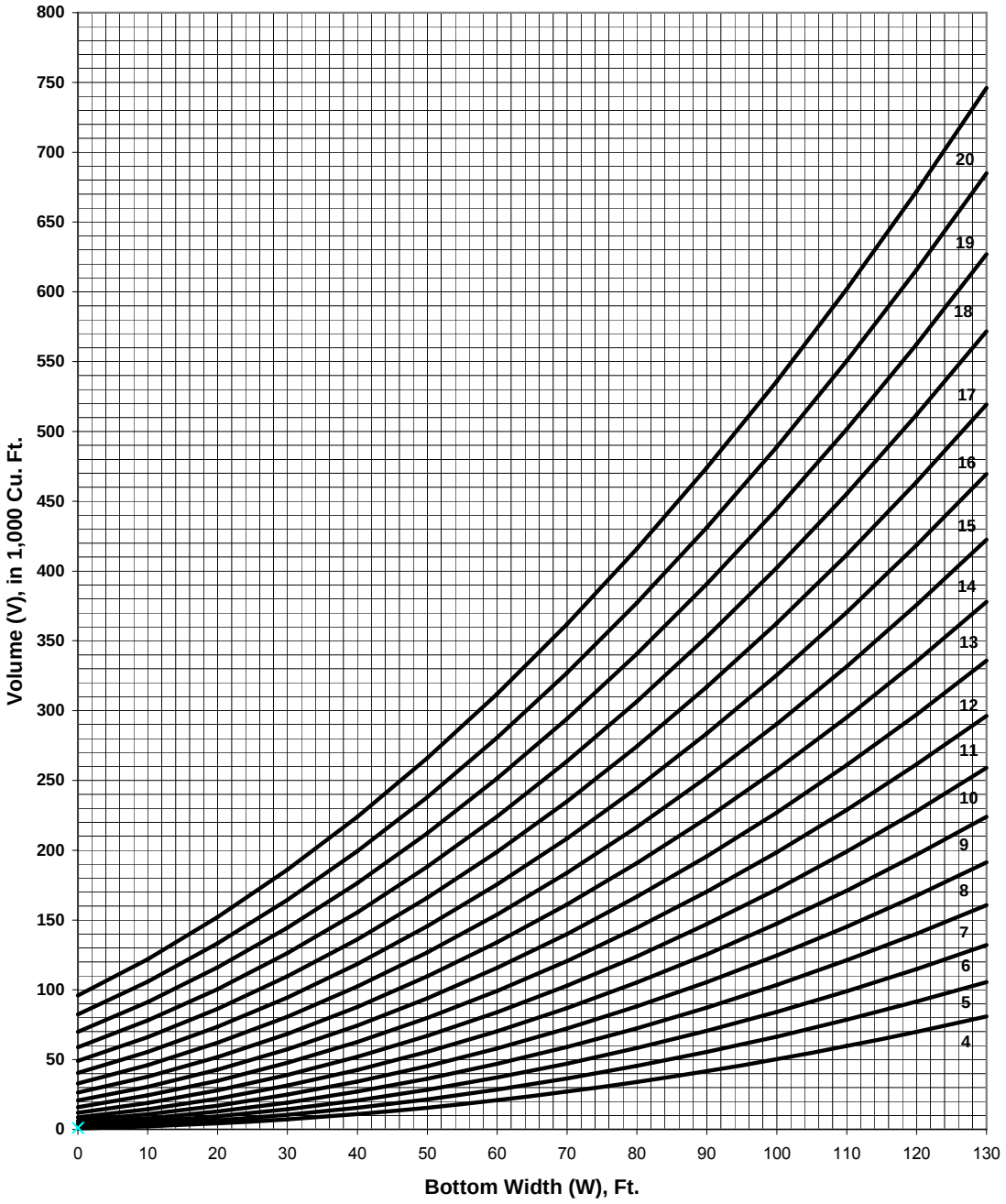
Volume of Square Storage (2:1 Sideslopes)



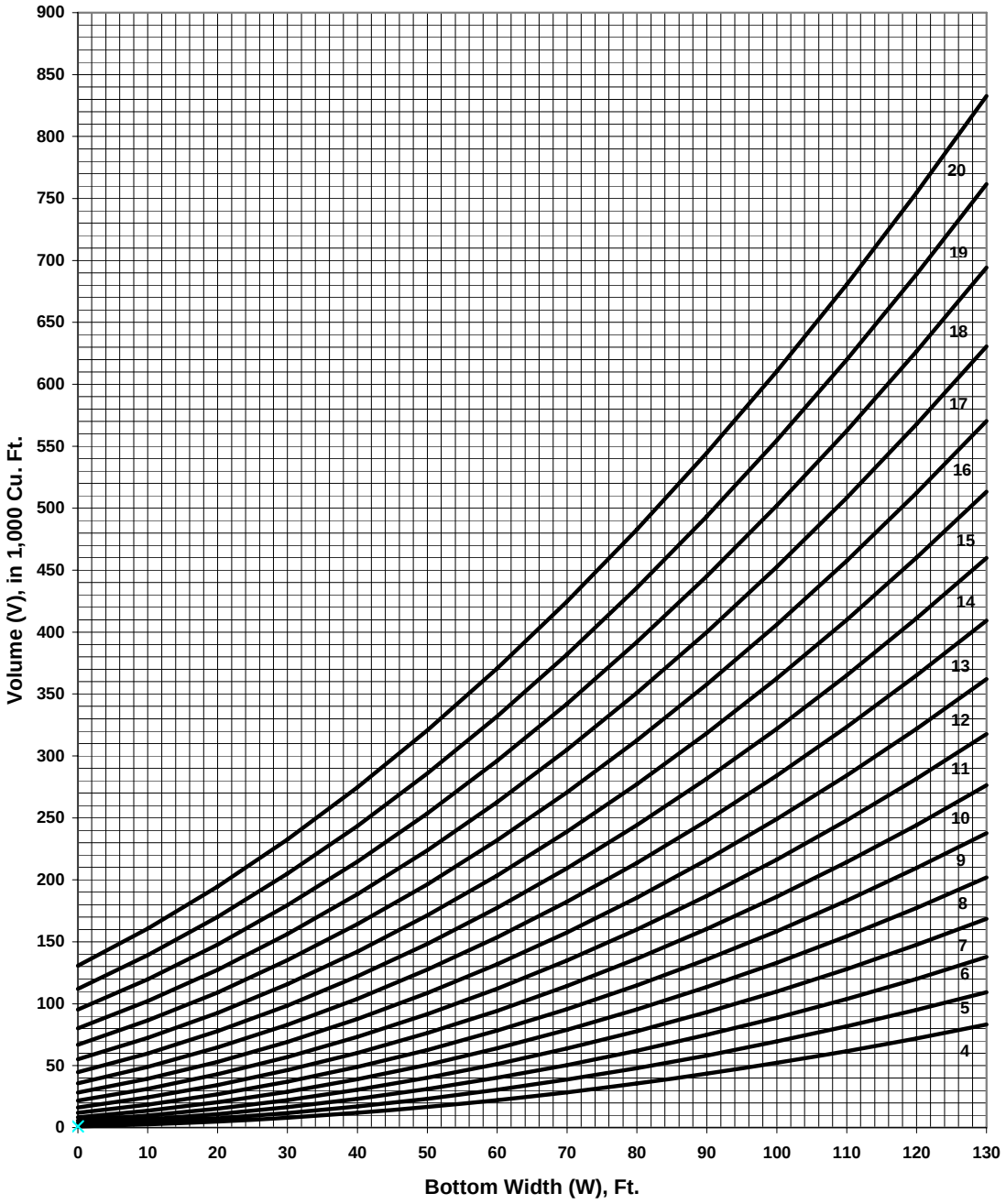
Volume of Square Storage (2.5:1 Sideslopes)



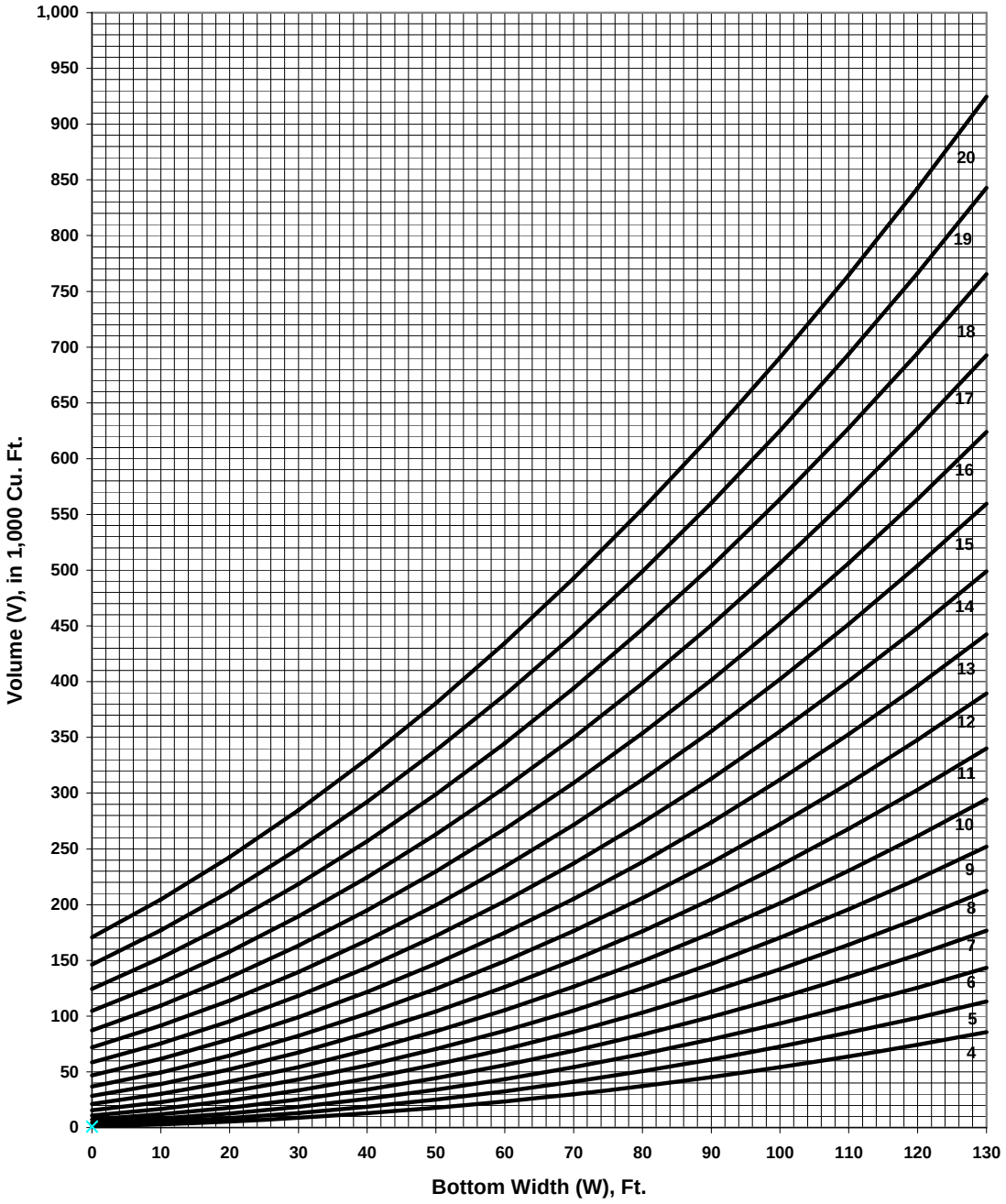
Volume of Square Storage (3:1 Sideslopes)



Volume of Square Storage (3.5:1 Sideslopes)



Volume of Square Storage (4:1 Sideslopes)



Emergency Action Plans

All producers should be encouraged to develop an Emergency Action Plan (EAP) to help prepare themselves, their employees, and/or individuals that may work at the facility for the possibility of an accident or emergency situation.

An emergency action plan should contain, at minimum, four items: action plan, detailed maps of the site, list names and contacts for personnel involved with the operation, and emergency personnel (fire, rescue, and etc. contact information). The phone numbers, directions to site, and E-911 address should be visibly posted near phones and entrances/exits.

A copy of a template EAP is available for download from the Internet at the following Iowa State University Extension website: **http://www.extension.iastate.edu/Publications/PM1859.pdf**

It is recommended to keep a copy of the EAP with the comprehensive manure or nutrient management plan or records, production records, or somewhere that is easily accessible to the producer, family members, or employees.

The plan shall indicate the actions that need to be taken quickly to reduce the impact of various emergencies. A well-designed and implemented EAP can reduce the severity of an emergency, reduce risk to humans and animals, reduce economic losses, and reduce the potential of environmental contamination. Having a response plan and spill kit, for example, can help when an unintentional manure spill occurs. Having a loader tractor or hay bales available will assist in the creation of retaining dams in a drainage way to reduce runoff to provide temporary containment of a manure spill. The plan shall consider all possible emergencies including: catastrophic animal mortality, weather-related emergencies (flooding, tornados, etc.), utility related failures (electrical, plumbing, etc.), or other mechanical failure at the site.

When a livestock production system includes manure storage, the plan shall include reminders about the dangers associated with entry into the storage and manure transfer area enclosed spaces for any purpose is strictly prohibited unless proper self-contained breathing apparatus is used. Agitation of under-building storage without proper building ventilation (maximum ventilation) may result in dangerous conditions for both humans and animals in the upper portions of the building.

Producers should be encouraged to contact the local emergency response personnel to evaluate the facility and determine areas where self-contained breathing apparatus may be required for future emergencies.

In an event of a manure spill or leak, every effort possible should be made to prevent the movement of manure off-site. If necessary, contact neighbors or nearby contractors that have earth-moving equipment available to assist with containment. If tile intakes are present, have devices on hand to cover or surround intakes to prevent manure from entering the tile lines. Contact neighbors with manure handling equipment to land-apply the spilled manure. Prevent manure from entering bodies of water or other environmentally sensitive areas such as sinkholes or agricultural drainage wells.

For assistance contact the local law enforcement agency or other emergency response personnel in the county. **State law requires that a manure spill or leak be reported to the Iowa Department of Natural Resources within 6 hours of noticing the problem (have contact number in plan).**

AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK
210-I-AWMFH – AMENDMENT IA-1

Open Feedlot Effluent Control Alternatives for Open Feedlot Operations

This amendment deals with the Open Feedlot Effluent Control Alternatives for Open Feedlot Operations taken from Title 567 – Chapter 65 (Division II – Open Feedlot Operations) of the Iowa Administrative Code, setting forth minimum criteria for five waste control alternatives for open feedlots requiring Iowa Department of Natural Resources permits. Specifically, this amendment has tables that note the feedlot runoff and normal runoff (in inches) for each county needed to design each of the five alternative systems. The 25-year, 24-hour precipitation values for each county needed for design is contained in the engineering field handbook amendment dealing with precipitation. A brief description of the five systems is contained in the table on the next page. Detailed descriptions of the individual systems of the feedlot and normal runoff values are contained in the Iowa Administrative Code, Title 567-Chapter 65 Rules.

IDNR Open Feedlot Effluent Control Alternative System Descriptions

System	Brief System Description
1	Adequate capacity must be provided to collect and store the average annual runoff from all feedlot and non-feedlot areas which drain into the open feedlot effluent control system (additional storage is required if open feedlot effluent from other sources also drains into the control system). Collected open feedlot effluent must be removed from the control system and land-applied at least once annually (interval between successive applications cannot exceed 12 months).
2	Adequate capacity must be provided to collect and store the average runoff expected to occur over the 9-month period from November 1 through July 31 from all feedlot and non-feedlot areas which drain into the open feedlot effluent control system (additional storage is required if open feedlot effluent from other sources also drains into the control system). Collected open feedlot effluent may be removed from the control system and land-applied during any period of the year that conditions are suitable. While application during other periods will minimize the need for July and October application, sufficient open feedlot effluent must still be disposed of during July and October to reduce the volume of open feedlot effluent remaining in the control system during these months to less than 10 percent of the system's design open feedlot effluent storage volume.
3	Adequate capacity must be provided to collect and store the average runoff expected to occur during the 6-month period from November 1 through April 30 from all feedlot and non-feedlot areas which drain into the open feedlot effluent control system (additional storage is required if open feedlot effluent from other sources also drains into the control system). Collected open feedlot effluent may be removed from the control system and land-applied during any period of the year that conditions are suitable. While application during other periods will minimize the need for application during the specified application months, sufficient open feedlot effluent must still be disposed of during April, July and October to reduce the volume of open feedlot effluent remaining in the control system during these months to less than 10 percent of the system's design open feedlot effluent storage volume.
4	Adequate capacity must be provided to collect and store the runoff expected to occur as a result of the 25-year, 24-hour precipitation event from all feedlot and non-feedlot areas which drain into the open feedlot effluent control system (additional storage is required if open feedlot effluent from other sources also drains into the control system). Collected open feedlot effluent must be removed from the control system and land-applied whenever the available (unoccupied) storage capacity remaining in the control system is less than 90 percent of that needed to store runoff from the 25-year, 24-hour precipitation event; land application must begin on the first day that conditions are suitable and must continue until application is completed. 4/12/06
5	Adequate capacity must be provided to collect and store the average runoff expected to occur over the 8-month period from October 1 through May 31 from all feedlot and non-feedlot areas which drain into the open feedlot effluent control system (additional storage is required if open feedlot effluent from other sources also drains into the control system). Collected open feedlot effluent may be removed from the control system and land-applied during any period of the year that conditions are suitable. While application during other periods will minimize the need for application during the April/May and the October/November periods, sufficient open feedlot effluent must still be disposed of during each of these two-month periods to reduce the volume of open feedlot effluent remaining in the control system during these periods to less than 10 percent of the system's design open feedlot effluent storage volume.

IDNR RAINFALL AND RUNOFF VALUES FOR WASTE STORAGE DESIGN

IDNR Disposal System →	Feedlot Runoff - Inches										Outside Lot Runoff (i.e. Cropland) – inches				
	Unpaved					Paved									
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Adair	12.0	9.0	7.0	4.5	10.0	18.0	13.5	10.5	5.0	15.0	5.0	4.0	2.0	0.0	3.0
Adams	12.0	9.0	7.0	4.5	10.0	18.0	13.5	10.5	5.0	15.0	5.0	4.0	2.0	0.0	3.0
Allamakee	13.0	12.0	8.0	3.9	11.0	19.5	18.0	12.0	4.4	16.5	6.5	5.2	2.6	0.0	3.9
Appanoose	13.0	10.0	7.0	4.5	10.0	19.5	15.0	10.5	5.0	15.0	6.8	5.4	2.7	0.0	4.1
Audubon	12.0	9.0	6.0	4.3	9.0	18.0	13.5	9.0	4.8	13.5	4.5	3.6	1.8	0.0	2.7
Benton	13.0	11.0	7.0	4.2	10.0	19.5	16.5	10.5	4.7	15.0	7.0	5.6	2.8	0.0	4.2
Black Hawk	13.0	11.0	7.0	4.1	10.0	19.5	16.5	10.5	4.6	15.0	6.5	5.2	2.6	0.0	3.9
Boone	12.0	9.0	7.0	4.3	10.0	18.0	13.5	10.5	4.8	15.0	5.0	4.0	2.0	0.0	3.0
Bremer	12.0	11.0	7.0	4.1	10.0	18.0	16.5	10.5	4.6	15.0	6.0	4.8	2.4	0.0	4.8
Buchanan	13.0	12.0	7.0	4.1	10.0	19.5	18.0	10.5	4.6	15.0	7.0	5.6	2.8	0.0	4.2
Buena Vista	11.0	8.0	6.0	4.1	9.0	16.5	12.0	9.0	4.6	13.5	3.5	2.8	1.4	0.0	2.1
Butler	12.0	10.0	7.0	4.1	10.0	18.0	15.0	10.5	4.6	15.0	5.7	4.6	2.3	0.0	3.4
Calhoun	11.0	9.0	7.0	4.2	9.0	16.5	13.5	9.0	4.7	13.5	4.5	3.6	1.8	0.0	2.7
Carroll	11.0	9.0	7.0	4.3	9.0	16.5	13.5	9.0	4.8	13.5	4.5	3.6	1.8	0.0	2.7
Cass	12.0	9.0	7.0	4.4	9.0	18.0	13.5	9.0	4.9	13.5	5.0	4.0	2.0	0.0	3.0
Cedar	14.0	12.0	8.0	4.1	11.0	21.0	18.0	12.0	4.6	16.5	8.0	6.4	3.2	0.0	4.8
Cerro Gordo	12.0	10.0	7.0	4.1	10.0	18.0	15.0	10.5	4.6	15.0	5.0	4.0	2.0	0.0	3.0
Cherokee	11.0	8.0	6.0	4.0	9.0	16.5	12.0	9.0	4.5	13.5	3.0	2.4	1.2	0.0	1.8
Chickasaw	12.0	11.0	7.0	4.0	10.0	18.0	16.5	10.5	4.5	15.0	6.0	4.8	2.4	0.0	3.6
Clarke	12.0	9.0	7.0	4.5	10.0	18.0	13.5	10.5	5.0	15.0	6.0	4.8	2.4	0.0	3.6
Clay	11.0	8.0	6.0	3.9	9.0	16.5	12.0	9.0	4.4	13.5	3.0	2.4	1.2	0.0	1.8
Clayton	13.0	12.0	8.0	4.0	11.0	19.5	18.0	12.0	4.5	16.5	7.0	5.6	2.8	0.0	4.2
Clinton	14.0	12.0	8.0	4.0	11.0	21.0	18.0	12.0	4.5	16.5	8.0	6.4	3.2	0.0	4.8
Crawford	11.0	8.0	6.0	4.2	9.0	16.5	12.0	9.0	4.7	13.5	4.0	3.2	1.6	0.0	2.4
Dallas	12.0	9.0	7.0	4.4	10.0	18.0	13.5	10.5	4.9	15.0	5.0	4.0	2.0	0.0	3.0
Davis	14.0	10.0	7.0	4.5	10.0	21.0	15.0	10.5	5.0	15.0	7.0	5.6	2.8	0.0	4.2
Decatur	13.0	9.0	7.0	4.6	10.0	19.5	13.5	10.5	5.1	15.0	6.0	4.8	2.4	0.0	3.6
Delaware	13.0	12.0	8.0	4.0	11.0	19.5	18.0	12.0	4.5	16.5	7.5	6.0	3.0	0.0	4.5
Des Moines	14.0	11.0	8.0	4.3	11.0	21.0	16.5	12.0	4.8	16.5	8.0	6.4	3.2	0.0	4.8
Dickinson	10.0	8.0	6.0	3.9	9.0	15.0	12.0	9.0	4.4	13.5	3.0	2.4	1.2	0.0	1.8
Dubuque	14.0	12.0	8.0	3.9	11.0	21.0	18.0	12.0	4.4	16.5	8.0	6.4	3.2	0.0	4.8
Emmet	11.0	8.0	6.0	3.9	9.0	16.5	12.0	9.0	4.4	13.5	3.5	2.8	1.4	0.0	2.1
Fayette	13.0	12.0	8.0	4.0	11.0	19.5	18.0	12.0	4.5	16.5	6.5	5.2	2.6	0.0	3.9
Floyd	12.0	11.0	7.0	4.1	10.0	18.0	16.5	10.5	4.6	15.0	5.5	4.4	2.2	0.0	3.3
Franklin	12.0	10.0	7.0	4.1	10.0	18.0	15.0	10.5	4.6	15.0	5.5	4.4	2.2	0.0	3.3
Fremont	12.0	8.0	6.0	4.5	9.0	18.0	12.0	9.0	5.0	13.5	5.0	4.0	2.0	0.0	3.0
Greene	12.0	9.0	7.0	4.3	10.0	18.0	13.5	10.5	4.8	15.0	5.0	4.0	2.0	0.0	3.0
Grundy	12.0	10.0	7.0	4.2	10.0	18.0	15.0	10.5	4.7	15.0	6.0	4.8	2.4	0.0	3.6
Guthrie	12.0	9.0	7.0	4.4	10.0	18.0	13.5	10.5	4.9	15.0	5.0	4.0	2.0	0.0	3.0
Hamilton	12.0	9.0	7.0	4.2	10.0	18.0	13.5	10.5	4.7	15.0	5.0	4.0	2.0	0.0	3.0
Hancock	12.0	9.0	7.0	4.1	10.0	18.0	13.5	10.5	4.6	15.0	5.0	4.0	2.0	0.0	3.0
Hardin	12.0	10.0	7.0	4.2	10.0	18.0	15.0	10.5	4.7	15.0	5.5	4.4	2.2	0.0	3.3
Harrison	11.0	8.0	6.0	4.2	9.0	16.5	12.0	9.0	4.7	13.5	4.0	3.2	1.6	0.0	2.4
Henry	14.0	11.0	7.0	4.3	10.0	21.0	16.5	10.5	4.8	15.0	7.5	6.0	3.0	0.0	4.5
Howard	12.0	11.0	7.0	4.0	10.0	18.0	16.5	10.5	4.5	15.0	6.0	4.8	2.4	0.0	3.6
Humboldt	11.0	9.0	6.0	4.1	9.0	16.5	13.5	9.0	4.6	13.5	4.5	3.6	1.8	0.0	2.7
Ida	11.0	8.0	6.0	4.1	9.0	16.5	12.0	9.0	4.6	13.5	3.5	2.8	1.4	0.0	2.1
Iowa	13.0	11.0	7.0	4.3	10.0	19.5	16.5	10.5	4.8	15.0	7.0	5.6	2.8	0.0	4.2
Jackson	14.0	12.0	8.0	4.0	11.0	21.0	18.0	12.0	4.5	16.5	8.0	6.4	3.2	0.0	4.8
Jasper	13.0	10.0	7.0	4.2	10.0	19.5	15.0	10.5	4.7	15.0	6.0	4.8	2.4	0.0	3.6

IDNR RAINFALL AND RUNOFF VALUES FOR WASTE STORAGE DESIGN

IDNR Disposal System →	Feedlot Runoff - Inches										Outside Lot Runoff (i.e. Cropland) – inches				
	Unpaved					Paved									
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Jefferson	14.0	11.0	7.0	4.3	10.0	21.0	16.5	10.5	4.8	15.0	7.5	6.0	3.0	0.0	4.5
Johnson	14.0	11.0	7.0	4.2	10.0	21.0	16.5	10.5	4.7	15.0	7.5	6.0	3.0	0.0	4.5
Jones	14.0	12.0	8.0	4.0	11.0	21.0	18.0	12.0	4.5	16.5	8.0	6.4	3.2	0.0	4.8
Keokuk	13.0	11.0	7.0	4.3	10.0	19.5	16.5	10.5	4.8	15.0	7.0	5.6	2.8	0.0	4.2
Kossuth	11.0	9.0	6.0	4.0	9.0	16.5	13.5	9.0	4.5	13.5	4.0	3.2	1.6	0.0	2.4
Lee	14.0	11.0	7.0	4.3	10.0	21.0	16.5	10.5	4.8	15.0	7.5	6.0	3.0	0.0	4.5
Linn	13.0	12.0	8.0	4.1	11.0	19.5	18.0	12.0	4.6	16.5	7.5	6.0	3.0	0.0	4.5
Louisa	14.0	11.0	8.0	4.2	11.0	21.0	16.5	12.0	4.7	16.5	8.0	6.4	3.2	0.0	4.8
Lucas	13.0	9.0	7.0	4.5	10.0	19.5	13.5	10.5	5.0	15.0	6.5	5.2	2.6	0.0	3.9
Lyon	10.0	7.0	5.0	3.8	8.0	15.0	10.5	7.5	4.3	12.0	2.0	1.6	0.8	0.0	1.2
Madison	12.0	9.0	7.0	4.5	10.0	18.0	13.5	10.5	5.0	15.0	5.5	4.4	2.2	0.0	3.3
Mahaska	13.0	10.0	7.0	4.4	10.0	19.5	15.0	10.5	4.9	15.0	6.5	5.2	2.6	0.0	3.9
Marion	13.0	10.0	7.0	4.4	10.0	19.5	15.0	10.5	4.9	15.0	6.5	5.2	2.6	0.0	3.9
Marshall	12.0	10.0	7.0	4.3	10.0	18.0	15.0	10.5	4.8	15.0	6.0	4.8	2.4	0.0	3.6
Mills	11.0	8.0	6.0	4.4	9.0	16.5	12.0	9.0	4.9	13.5	4.5	3.6	1.8	0.0	2.7
Mitchell	12.0	11.0	7.0	4.0	10.0	18.0	16.5	10.5	4.5	15.0	5.5	4.4	2.2	0.0	3.3
Monona	11.0	8.0	6.0	4.1	9.0	16.5	12.0	9.0	4.6	13.5	3.5	2.8	1.4	0.0	2.1
Monroe	13.0	10.0	7.0	4.5	10.0	19.5	15.0	10.5	5.0	15.0	6.5	5.2	2.6	0.0	3.9
Montgomery	12.0	9.0	6.0	4.5	9.0	18.0	13.5	9.0	5.0	13.5	5.0	4.0	2.0	0.0	3.0
Muscatine	14.0	12.0	8.0	4.1	11.0	21.0	18.0	12.0	4.6	16.5	8.0	6.4	3.2	0.0	4.8
O'Brien	10.0	8.0	5.0	3.9	8.0	15.0	12.0	7.5	4.4	12.0	3.0	2.4	1.2	0.0	1.8
Osceola	10.0	7.0	5.0	3.8	8.0	15.0	10.5	7.5	4.3	12.0	2.0	1.6	0.8	0.0	1.2
Page	12.0	9.0	7.0	4.6	10.0	18.0	13.5	10.5	5.1	15.0	5.0	4.0	2.0	0.0	3.0
Palo Alto	11.0	8.0	6.0	4.0	9.0	16.5	12.0	9.0	4.5	13.5	4.0	3.2	1.6	0.0	2.4
Plymouth	10.0	7.0	5.0	3.9	8.0	15.0	10.5	7.5	4.4	12.0	2.5	2.0	1.0	0.0	1.5
Pocahontas	11.0	8.0	6.0	4.1	9.0	16.5	12.0	9.0	4.6	13.5	4.0	3.2	1.6	0.0	2.4
Polk	12.0	9.0	7.0	4.4	10.0	18.0	13.5	10.5	4.9	15.0	5.5	4.4	2.2	0.0	3.3
Pottawattamie	11.0	8.0	6.0	4.4	9.0	16.5	12.0	9.0	4.9	13.5	4.5	3.6	1.8	0.0	2.7
Poweshiek	13.0	10.0	7.0	4.3	10.0	19.5	15.0	10.5	4.8	15.0	6.5	5.2	2.6	0.0	3.9
Ringgold	12.0	9.0	7.0	4.6	10.0	18.0	13.5	10.5	5.1	15.0	5.5	4.4	2.2	0.0	3.3
Sac	11.0	8.0	6.0	4.1	9.0	16.5	12.0	9.0	4.6	13.5	4.0	3.2	1.6	0.0	2.4
Scott	14.0	12.0	8.0	4.0	11.0	21.0	18.0	12.0	4.5	16.5	8.0	6.4	3.2	0.0	4.8
Shelby	11.0	8.0	6.0	4.3	9.0	16.5	12.0	9.0	4.8	13.5	4.5	3.6	1.8	0.0	2.7
Sioux	10.0	7.0	5.0	3.8	8.0	15.0	10.5	7.5	4.3	12.0	2.0	1.6	0.8	0.0	1.2
Story	12.0	9.0	7.0	4.3	10.0	18.0	13.5	10.5	4.8	15.0	5.5	4.4	2.2	0.0	3.3
Tama	13.0	11.0	7.0	4.2	10.0	19.5	16.5	10.5	4.7	15.0	6.5	5.2	2.6	0.0	3.9
Taylor	12.0	9.0	7.0	4.6	10.0	18.0	13.5	10.5	5.1	15.0	5.5	4.4	2.2	0.0	3.3
Union	12.0	9.0	7.0	4.6	10.0	18.0	13.5	10.5	5.1	15.0	5.5	4.4	2.2	0.0	3.3
Van Buren	14.0	11.0	7.0	4.4	10.0	21.0	16.5	10.5	4.9	15.0	7.5	6.0	3.0	0.0	4.5
Wapello	13.0	10.0	7.0	4.4	10.0	19.5	15.0	10.5	4.9	15.0	7.0	5.6	2.8	0.0	4.2
Warren	12.0	9.0	7.0	4.5	10.0	18.0	13.5	10.5	5.0	15.0	6.0	4.8	2.4	0.0	3.6
Washington	14.0	11.0	7.0	4.3	10.0	21.0	16.5	10.5	4.8	15.0	7.5	6.0	3.0	0.0	4.5
Wayne	13.0	9.0	7.0	4.6	10.0	19.5	13.5	10.5	5.1	15.0	6.5	5.2	2.6	0.0	3.9
Webster	12.0	9.0	7.0	4.2	10.0	18.0	13.5	10.5	4.7	15.0	5.0	4.0	2.0	0.0	3.0
Winnebago	11.0	9.0	7.0	4.0	10.0	16.5	13.5	10.5	4.5	15.0	4.5	3.6	1.8	0.0	2.7
Winneshiek	13.0	12.0	8.0	4.0	11.0	19.5	18.0	12.0	4.5	16.5	6.5	5.2	2.6	0.0	3.9
Woodbury	11.0	8.0	6.0	4.0	9.0	16.5	12.0	9.0	4.5	13.5	3.0	2.4	1.2	0.0	1.8
Worth	12.0	10.0	7.0	4.0	10.0	18.0	15.0	10.5	4.5	15.0	5.0	4.0	2.0	0.0	3.0
Wright	12.0	9.0	7.0	4.1	10.0	18.0	13.5	10.5	4.6	15.0	5.0	4.0	2.0	0.0	3.0