

**Hydrology and
Hydraulic Analysis
for
Wilderness & Woodspring
Detention Reservoirs
in
Tall Grass Golf Course
Wichita, Kansas**

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SECTION I

INTRODUCTION

- A. **Purpose:** The purpose of this report is to outline the design parameters used in the development of Wilderness and Woodspring Detention Reservoirs in the Tall Grass Golf Course. These reservoirs are two of seven reservoirs that will be used to control runoff such that there will be no net increase of stormwater runoff from development of the basin. The basin was considered to be that portion of the drainage area above 21st Street.

The purpose of this report is also to insure that any reservoir construction meets dam safety requirements. The calculations for the National Dam Safety Requirements will be required only when the storage volume between the top of the structure and the existing channel flowline exceeds 30 acre feet. The Division of Water Resources (DWR) does not review reservoir plans when the volume is less than 30 acre feet and does not require consideration of the Probable Maximum Precipitation (PMP) events. After initial studies, the volume of both lakes were set at less than 30 acre feet.

- B. **Scope:** The scope of the study involves the following major tasks:
1. Develop existing and future runoff hydrographs for the 100 year 6 hour storm event.
 2. Through the use of reservoir routing, determine the maximum water surface elevations in the detention reservoirs for the 100 year 6 hour storm.
 3. Develop a proposed grading plan and spillway design for each detention reservoir.

SECTION II

DESIGN METHODOLOGY

- A. **Design Criteria:** The following criteria were utilized in the development of the detention reservoir:
1. The net increase in peak runoff due to development for the 100 year 6 hour storm event would be zero for the total basin above 21st Street.
 2. The detention structure would be able to pass the 100 year 6 hour storm.
- B. **Hydrology Computation Methods:** Runoff volumes and peak flows were calculated through the use of SCS (Soil Conservation Service) procedures.

Runoff volumes were determined through the use of SCS Hydrologic Soil Groupings and appropriate runoff curve numbers (CN) for the drainage basin under consideration. Runoff volume was also distributed over the storm duration in accordance with SCS recommendations.

Time of concentration (Tc) was determined by basin characteristics and through the use of the Kirpich Nomograph

$$T_c = \left(\frac{11.9L^3}{H} \right)^{.385}$$

L = Length of Basin (miles)
H = Elevation Difference in Basin (feet)

Unit hydrographs were developed and summed for the 100 year storm. Computer calculations utilizing SCS Soil Group Numbers, CN, Tc, drainage basin areas, etc. were performed to develop hydrographs and to provide the inflow hydrographs for routing purposes. The following formula was utilized in the computations:

$$Q_p = \frac{484 AR}{T_p}$$

where A = Area in square miles
R = Total runoff in inches (1 inch for unit hydrograph)
T_p = Time in hours from start of rise to peak rate

SECTION III

COMPUTATIONS

A. **Drainage Areas:** The total drainage area into the Woodspring Detention Reservoir is 209.9 acres. The drainage area into Wilderness is 190.3 acres.

B. **Soil Complex Number (CN):** Discussion with the local SCS office in Wichita indicated the basin to contain 25% soil type B and 75% soil type D. From Ref. 1, p. 19 the existing condition of "Meadow: good condition" would produce a CN value of:

$$CN = 0.25(58) + 0.75(78) = 73$$

Future CN values were obtained by dividing the basin into 8 sub-basins according to future planned development. These are shown on Figure 1. These areas were then used to develop a composite CN value. The calculations for this are shown in the following table.

DEVELOPMENT OF SOIL COMPLEX NUMBER

<u>Area No.</u>	<u>Future Development</u>	<u>Area (Acres)</u>	<u>% Total Area</u>	<u>CN*</u>	<u>Combined CN (% Area x CN)</u>
1	Light Industrial	35.2	16.8	92	15.5
2	Residential - 1/4 Acre Lots	43.9	20.9	84	17.6
3	Light Industrial	14.7	7.0	92	6.4
4	Residential - 1/4 Acre Lots	41.3	19.7	84	16.5
5	Residential - 1/4 Acre Lots	21.3	10.2	84	8.6
6	Residential - 1/2 Acre Lots	20.0	9.5	81	7.7
7	Light Industrial	13.9	6.6	92	6.1
8	Residential - 1/2 Acre Lots	19.6	9.3	81	<u>7.5</u>
Total CN					85.9

* From Ref. 1 (Ave. 25% soil type B and 75% soil type D)

C. **Hydrographs and Detention Reservoir:** To produce the required detention, each of the reservoirs was designed to serve a dual purpose of flood control and to serve as a recreational lake. The lakes, as designed, would maintain a normal pool and would attenuate the 100 year 6 hour design storm to compensate for the additional development.

In order to meet landscaping and storage requirements, the general shape of each of the lakes varies considerably from that of existing contours. A 4 foot wide notch in the concrete dam will be provided to maintain the normal water pool elevation in each reservoir while the top of the dams will serve as the emergency spillways.

The following computations and parameters were utilized in the development of the design hydrographs, routing, and dam design.

General Procedure from Ref. 2, p. 76-83

Drainage Area - Wilderness = 190.3 Acres = 0.297 sq.mi.

Woodspring = 209.9 Acres = 0.328 sq.mi.

From Ref. 3, Fig. 2-3

100 Yr, 6 hr. rainfall for 10 square miles

P = 5.9"

6 Hr. Rainfall Distributed by the House

(See Graph C, Fig. 2-6, Ref. 3)

Hour	%	100 yr. - 6 hr.	
		Accum. Rainfall	Inc. Rainfall
1	.08	0.5	0.5
2	.22	1.3	0.8
3	.70	4.1	2.8
4	.84	5.0	0.9
5	.93	5.5	0.5
6	1.00	5.9	0.4

Wilderness Lake
Storage and Outflow Vs. Elevation

Elev Ft.	Accumulated Storage Ac.Ft.	Outflow CFS	
202.00	0.00	0.00	Normal Pool
202.50	2.31	4.59	
203.00	4.62	12.65	
203.50	7.20	22.64	
204.00	9.77	33.91	
204.50	12.71	46.07	
205.00	15.64	58.83	
205.50	19.08	71.95	
206.00	22.51	85.25	Top of Structure
206.50	26.65	193.60	
207.00	30.79	404.90	
207.50	35.72	697.00	
208.00	40.64	1064.80	

Woodspring Lake
Storage and Outflow Vs. Elevation

Elev. Ft.	Accumulated Storage Ac.Ft.	Outflow CFS	
198.00	0.00	0.00	Normal Pool
198.50	1.30	4.59	
199.00	5.59	12.65	
199.50	4.06	22.64	
200.00	5.52	33.91	
200.50	7.18	46.07	
201.00	8.83	58.83	
201.50	10.70	71.95	
202.00	12.57	85.25	Top of Structure
202.50	14.68	175.90	
203.00	16.78	354.90	
203.50	19.16	605.30	
204.00	21.53	923.50	

Hydrograph and Elevation Information

	<u>Wilderness</u>	<u>Woodspring</u>
Existing 100 yr. (cfs)	326	352
Future Routed 100 yr. (cfs)	316	265
Future 100 yr. Elevation	206.8	202.7
Normal Pool Elevation	202.0	198.0
Top of Structure	206.0	202.0

Miscellaneous Information

Spillway	Opening	4' x 4'	4' x 4'
Spillway (Upper Segment)	Width	106'	95'
	Side Slopes	4:1	4:1
Flood Storage (100 yr.-6 hr.)	Ac.Ft.	29.05	16.40
Storage of Top of Structure	Ac.Ft.	22.51	13.19

Individual hydrographs were developed by computer and the printout data are shown in Appendix A. The existing inflow hydrographs are based on the present undeveloped state of the drainage basin. The design inflow hydrographs are based on the future development of the entire basin. The routed outflow hydrograph from Woodspring indicates the effect of the proposed detention reservoir on the design inflow hydrographs. The 100 year 6 hour design peak inflow of cfs for the total basin was reduced via storage to a cfs peak on the reservoir outflow hydrograph. This is less than the calculated existing undeveloped peak inflow of cfs, therefore, the detention reservoirs will function to prevent any increase in peak runoff rates from the basin due to development.

REFERENCES

1. Determination of Peak Discharge From Rainfall Data for Urbanized Basins, Wichita, Kansas, U.S.G.S. Open File Report 78-974.
2. Design of Small Dams - 1974, Bureau of Reclamation.
3. Earth Dams and Reservoirs, TR 60 U.S. Dept. of Agriculture, S.C.S.
4. SCS National Engineering Handbook, Section 4.

APPENDIX

HYDROGRAPH FROM RAINFALL AND WATERSHED DATA

WILDERNESS LAKE 100 YEAR STORM EXISTING CONDITIONS FINAL

WATERSHED DATA

 AREA (SQ.MI.) = 0.297
 LENGTH (MI.) = 0.72
 HEIGHT (FT.) = 31.00
 CURVE NUMBER = 73.00
 TIME OF CONCENTRATION (COMPUTED IF NOT GIVEN) = 0.473 HR.

RAINFALL DATA

 TIME (HRS.) TOTAL ACCUM.
 RAINFALL (IN.)
 1.00 0.50
 2.00 1.30
 3.00 4.10
 4.00 5.00
 5.00 5.50
 6.00 5.90

OUTPUT HYDROGRAPH--PLOTING INTERVAL 0.25 HRS.

 TIME (HRS.) DISCHARGE Q
 CFS

0.25	0.0
0.50	0.0
0.75	0.0
1.00	0.0
1.25	0.0
1.50	1.0
1.75	8.0
2.00	21.9
2.25	74.8
2.50	177.4
2.75	270.3
3.00	325.7
3.25	286.4
3.50	187.6
3.75	134.7
4.00	131.1
4.25	115.3
4.50	89.9
4.75	77.4
5.00	76.6
5.25	72.5
5.50	65.8
5.75	62.8
6.00	58.5
6.25	31.2
6.50	8.0
6.75	0.0

HYDROGRAPH FROM RAINFALL AND WATERSHED DATA

WILDERNESS LAKE 100 YR STORM DEVELOPED NP202 TOP206 4 NOTCH L 90 FINAL

WATERSHED DATA

 AREA (SQ.MI.) = 0.297
 LENGTH (MI.) = 0.72
 HEIGHT (FT.) = 31.00
 CURVE NUMBER = 85.90
 TIME OF CONCENTRATION (COMPUTED IF NOT GIVEN) = 0.473 HR.

RAINFALL DATA

 TIME (HRS.) TOTAL ACCUM.
 RAINFALL (IN.)
 1.00 0.50
 2.00 1.30
 3.00 4.10
 4.00 5.00
 5.00 5.50
 6.00 5.90

OUTPUT HYDROGRAPH--PLOTING INTERVAL 0.25 HRS.

 TIME (HRS.) DISCHARGE Q
 CFS
 0.25 16.6
 0.50 16.3
 0.75 6.5
 1.00 3.8
 1.25 17.1
 1.50 39.4
 1.75 60.1
 2.00 80.6
 2.25 170.2
 2.50 320.0
 2.75 418.7
 3.00 451.7
 3.25 374.1
 3.50 236.2
 3.75 165.1
 4.00 158.5
 4.25 138.1
 4.50 106.8
 4.75 91.2
 5.00 89.9
 5.25 84.7
 5.50 76.6
 5.75 72.7
 6.00 67.5
 6.25 35.9
 6.50 9.2
 6.75 0.0

OUTFLOW HYDROGRAPH FROM STORAGE AND OUTLET DATA

WILDERNESS LAKE 100 YR STORM DEVELOPED NP202 TOP206 4 NOTCH L 90 FINAL

STORAGE AND OUTFLOW VS. ELEVATION

ELEV. FT.	STORAGE AC.FT.	OUTFLOW CFS
202.00	0.00	0.00
202.50	2.31	4.59
203.00	4.62	12.65
203.50	7.20	22.64
204.00	9.77	33.91
204.50	12.71	46.07
205.00	15.64	58.83
205.50	19.08	71.95
206.00	22.51	85.25
206.50	26.65	193.60
207.00	30.79	404.90
207.50	35.72	697.00
208.00	40.64	1064.80

DISCHARGE, STORAGE, AND ELEVATION VS TIME

TIME HRS.	Q-IN CFS	Q-OUT CFS	STORAGE AC.FT.	ELEV. FT.
0.00	0.00	0.00	0.00	202.00
0.25	16.65	0.66	0.33	202.07
0.50	16.33	1.29	0.65	202.14
0.75	6.57	1.50	0.75	202.16
1.00	3.83	1.59	0.80	202.17
1.25	17.16	2.21	1.11	202.24
1.50	39.47	3.71	1.87	202.40
1.75	60.19	7.02	3.00	202.65
2.00	80.67	12.14	4.47	202.96
2.25	170.22	24.51	7.62	203.58
2.50	320.02	49.44	13.48	204.63
2.75	418.74	78.63	20.80	205.75
3.00	451.76	230.80	27.37	206.58
3.25	374.18	316.20	29.05	206.79
3.50	236.29	255.80	27.86	206.64
3.75	165.15	193.03	26.62	206.49
4.00	158.50	177.68	26.04	206.42
4.25	138.15	159.96	25.36	206.34
4.50	106.85	136.89	24.48	206.23
4.75	91.29	117.37	23.73	206.14
5.00	89.93	105.70	23.29	206.09
5.25	84.72	96.72	22.94	206.05
5.50	76.61	88.27	22.62	206.01
5.75	72.77	84.67	22.36	205.97
6.00	67.55	83.35	22.02	205.92
6.25	35.96	79.69	21.07	205.79
6.50	9.27	74.26	19.67	205.58
6.75	0.00	74.26	19.67	205.58

HYDROGRAPH FROM RAINFALL AND WATERSHED DATA

WOODSPRING LAKE ENTIRE BASIN EXISTING CONDITIONS FINAL

WATERSHED DATA

AREA (SQ.MI.) = 0.328
 LENGTH (MI.) = 0.80
 HEIGHT (FT.) = 35.00
 CURVE NUMBER = 73.00
 TIME OF CONCENTRATION (COMPUTED IF NOT GIVEN) = 0.510 HR.

RAINFALL DATA

TIME (HRS.)	TOTAL ACCUM. RAINFALL (IN.)
1.00	0.50
2.00	1.30
3.00	4.10
4.00	5.00
5.00	5.50
6.00	5.90

OUTPUT HYDROGRAPH--PLOTING INTERVAL 0.25 HRS.

TIME (HRS.)	DISCHARGE Q CFS
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0.25	0.0
0.50	0.0
0.75	0.0
1.00	0.0
1.25	0.0
1.50	1.1
1.75	8.0
2.00	22.7
2.25	76.8
2.50	182.7
2.75	285.9
3.00	352.3
3.25	321.4
3.50	220.7
3.75	157.6
4.00	144.1
4.25	129.4
4.50	102.6
4.75	87.3
5.00	84.4
5.25	80.6
5.50	73.5
5.75	69.7
6.00	69.3
6.25	51.3
6.50	19.9
6.75	3.0

HYDROGRAPH FROM RAINFALL AND WATERSHED DATA

Input Hydrograph

WOODSPRING LAKE NO 4 100 YR STORM DEVELOPED

~~PARTIAL AREA~~ FINAL

WATERSHED DATA

 AREA (SQ.MI.) = 0.031
 LENGTH (MI.) = 0.25
 HEIGHT (FT.) = 20.00
 CURVE NUMBER = 85.90
 TIME OF CONCENTRATION (COMPUTED IF NOT GIVEN) = 0.165 HR.

RAINFALL DATA

 TIME (HRS.) TOTAL ACCUM.
 RAINFALL (IN.)
 1.00 0.50
 2.00 1.30
 3.00 4.10
 4.00 5.00
 5.00 5.50
 6.00 5.90

OUTPUT HYDROGRAPH--PLOTTING INTERVAL 0.25 HRS.

 TIME (HRS.) DISCHARGE Q
 CFS Q_{out} Q_{in}
 Wilderness Woodspring

0.25	0.0	0.66	0.7
0.50	0.0	1.29	1.3
0.75	0.0	1.50	1.5
1.00	1.2	1.59	2.8
1.25	4.1	2.21	6.3
1.50	6.3	3.71	10.0
1.75	7.9	7.02	14.9
2.00	9.6	12.14	21.7
2.25	37.6	24.51	62.1
2.50	44.6	49.44	94.0
2.75	48.0	78.63	126.6
3.00	49.4	230.80	280.2
3.25	17.6	316.20	333.8
3.50	16.5	255.80	272.3
3.75	16.6	193.03	209.6
4.00	16.7	177.68	194.4
4.25	9.6	159.96	109.6
4.50	9.3	136.89	146.2
4.75	9.3	117.37	126.7
5.00	9.3	105.70	115.0
5.25	7.6	96.72	104.3
5.50	7.5	88.27	95.8
5.75	7.5	84.67	92.2
6.00	8.6	83.35	92.0
6.25	19.5	79.69	99.1
		74.26	74.2
		74.26	0.0

HYDROGRAPH FROM RAINFALL AND WATERSHED DATA

WOODSPRING LAKE 100 YEAR STORM DEVEL INPUT HYDROGRAPH NP198 T202 N4 L75

WATERSHED DATA

 AREA (SQ.MI.)= 0.328
 LENGTH (MI.) = 0.97
 HEIGHT (FT.) = 35.00
 CURVE NUMBER = 85.90
 TIME OF CONCENTRATION (COMPUTED IF NOT GIVEN) = 0.637 HR.

RAINFALL DATA

 TIME (HRS.) TOTAL ACCUM.
 RAINFALL (IN.)
 1.00 0.50
 2.00 1.30
 3.00 4.10
 4.00 5.00
 5.00 5.50
 6.00 5.90

OUTPUT HYDROGRAPH--PLOTING INTERVAL 0.25 HRS.

 TIME (HRS.) DISCHARGE Q
 CFS
 0.25 0.7
 0.50 1.3
 0.75 1.5
 1.00 2.8
 1.25 6.3
 1.50 10.0
 1.75 14.9
 2.00 21.7
 2.25 62.1
 2.50 94.0
 2.75 126.6
 3.00 280.2
 3.25 333.8
 3.50 272.3
 3.75 209.6
 4.00 194.4
 4.25 109.6
 4.50 146.2
 4.75 126.7
 5.00 115.0
 5.25 104.3
 5.50 95.8
 5.75 92.2
 6.00 92.0
 6.25 99.1
 6.50 74.2
 6.75 0.0

OUTFLOW HYDROGRAPH FROM STORAGE AND OUTLET DATA

WOODSPRING LAKE 100 YEAR STORM DEVEL INPUT HYDROGRAPH NP198 T202 N4 L75

STORAGE AND OUTFLOW VS. ELEVATION

ELEV. FT.	STORAGE AC.FT.	OUTFLOW CFS
198.00	0.00	0.00
198.50	1.38	4.59
199.00	2.76	12.65
199.50	4.32	22.64
200.00	5.87	33.91
200.50	7.61	46.07
201.00	9.34	58.83
201.50	11.27	71.95
202.00	13.19	85.25
202.50	15.34	175.90
203.00	17.48	354.90
203.50	19.98	605.30
204.00	22.48	923.50

DISCHARGE, STORAGE, AND ELEVATION VS TIME

TIME HRS.	Q-IN CFS	Q-OUT CFS	STORAGE AC.FT.	ELEV. FT.
0.00	0.00	0.00	0.00	198.00
0.25	0.70	0.04	0.01	198.00
0.50	1.30	0.12	0.03	198.01
0.75	1.50	0.22	0.06	198.02
1.00	2.80	0.39	0.11	198.04
1.25	6.30	0.78	0.23	198.08
1.50	10.00	1.39	0.41	198.15
1.75	14.90	2.29	0.68	198.24
2.00	21.70	3.58	1.07	198.39
2.25	62.10	9.56	2.23	198.80
2.50	94.00	19.78	3.87	199.35
2.75	126.60	34.35	5.93	200.01
3.00	280.20	67.83	10.66	201.34
3.25	333.80	211.43	15.76	202.59
3.50	272.30	265.16	16.40	202.74
3.75	209.60	211.31	15.76	202.59
4.00	194.40	194.55	15.56	202.55
4.25	109.60	139.29	14.47	202.29
4.50	146.20	143.77	14.57	202.32
4.75	126.70	133.97	14.34	202.26
5.00	115.00	123.30	14.09	202.20
5.25	104.30	117.89	13.84	202.15
5.50	95.80	103.89	13.63	202.10
5.75	92.20	98.37	13.50	202.07
6.00	92.00	96.24	13.45	202.06
6.25	99.19	99.59	13.53	202.07
6.50	74.26	163.53	15.04	202.43
6.75	0.00	162.69	15.02	202.42

