

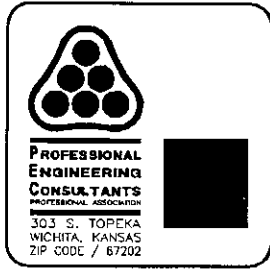
**DRAINAGE PLAN
AND
SUPPORTING CALCULATIONS
FOR**

Newmarket Square

ADDITION TO
WICHITA, SEDGWICK COUNTY, KANSAS

8/28/97

PREPARED FOR:
Newmarket Square, L.L.C.
Wichita, KS



NEWMARKET SQUARE ADDITION

Wichita, Sedgwick County, Kansas

08/28/97

Newmarket Square Addition is a 67 acre commercial development in Northwest Wichita, Kansas. The drainage plan, supporting computations and data required for platting are presented herein. The analysis made is based on the available site data which includes the following: 1" = 100' topographic map with 2' contours of the site and adjacent areas; Sedgwick County Soil Survey Map; Wichita West, Kansas Quadrangle Topographic Map and references noted herein.

Hydrology

The proposed plat lies in the S.E. 1/4, Section 6, T27S, R1W. The existing landscape is a grass farm and is quite flat with poor drainage. A pond along the west edge of the plat will store drainage from nearly two-thirds of the total area being platted. Due to economics, the pond system will serve to detain nearly 100% of storm water runoff from a 105 acre area for a 100 year storm. Approximately half of the drainage area from lots abutting 21st Street and Maize Road (lots 2-8) will drain to connections made to future storm sewers or proposed street inlets.

A hydrologic model for the pond has been designed to establish minimum openings for specific lots affected by head developed in the pond. Minimum opening on other lots not near the pond is a function of storm sewer overflow locations for each locality and will be governed by the individual grading plans for each parcel.

Future development has been considered in analyzing the detention pond basin. West of the pond will be single family developments and north of the pond will be a mixture of land uses ranging from multi-family to office parks. In residential areas, the minor storm has a recurrence interval of two years and in commercial areas it has a recurrence interval of five years. The major storm evaluated has a recurrence interval of one hundred years. The Rational Method has been used to determine runoff quantities for all storm sewer systems that serve the development in accordance with the reference materials. Runoff coefficients were estimated based on tables presented in the Design Aids section. A minimum time of concentration of 15 minutes has been assumed.

Inlet Design

Curb-deep flow is tolerable for the minor storm and each inlet has been checked to ensure street flooding and inlet capacity is appropriately sized for the minor storm. A "cascade effect" has been designed to provide a drainage release point in the event of system failure for the storm sewer system. Future storm sewer systems directed toward the pond should be designed for the minor storm but owners and designers should consider the amount of parking lot flooding tolerable and the time it will take for it to drain out. (See Table herein) In any case, all inlets should be cascaded in the event of pipe or inlet blockage with an overland outlet.

Inlet capacities were determined by the methods described in the reference materials using Chart #12 in the Design Aids section. It has been assumed that 1/4 in./ft. street cross-slopes, City of Wichita 6-5/8" standard curb and gutter and Type 1A street inlets will be used throughout. City of Wichita standard grate inlets have been assumed for all area inlet drains. Minimum walk grade has been assumed to be 0.5 feet above top of curb unless otherwise noted.

Pipe Design

Storm sewers are designed for the minor storm, with major storm overflows to be routed through easements and rights-of-way to an appropriate outlet.

Hydraulic computation for the storm sewer pipe systems was performed using PEC's STORM computer program. This program uses Manning's Equation to calculate friction losses for pipes flowing full. Minor losses are computed by momentum principles at each structure. All pipes were assumed to be reinforced concrete with a Manning's "n" factor of 0.013. The hydraulic grade line has been checked to ensure that it is at least one foot below the top of curb elevations for the minor storm in all cases.

To simplify the analysis it has been assumed that time of concentration is identical for both pipe flow and street flow for both major and minor storms; a conservative estimate since pipe velocities generally exceed gutter velocities.

All channels have been sized using major storm discharges (Q100) and FEMA's QUICK-2 computer program. This program uses Manning's equation for open channel flow to calculate a normal depth by iteration, given a channel cross-section and discharge. All major storm overflows have also been sized using QUICK-2.

Hydraulic Models for Detention

This plan incorporates a pond for the purposes of aesthetic, borrow and storm water detention. The pond was analyzed using a 100 year-18 hour storm. Runoff and storage requirements were computed using the NRCS (formerly SCS) unit hydrograph procedure utilizing the Curve Number method. For control structures, the energy/momentum, weir and orifice equations were used to develop a stage-discharge curve in accordance with the reference materials. Reservoir routing is computed using the Puls Inventory Method to get 5, 10, 25, 50 & 100 year peak water surface elevations.

The pond was analyzed using the unit hydrograph procedure utilizing the curve number method and the inventory method for routing. For control structures, energy/momentum, weir and orifice equations were used to develop a stage-discharge curve.

The pond model used for this development is found in the Pond Design section of this document. The pond is of critical importance to this development as a considerable amount of fill material will be required for site development. Also, the pond will have an impact on parking lot grading and inlet elevations. Refer to the tables below for options available for site development and parking drainage factors.

Storm Event	5	10	25	50	100
Pond High-water or Inlet Elevation	163.10	163.50	163.80	164.30	164.60
Time to Drain Parking Lot to Inlet Tops	30 Hours	24 Hours	16 Hours	8 Hours	0 Hours

The pond itself will take 60 hours or 2.5 days to drain back down to the normal water surface elevation of 161.50 after a 100 year-18 hour storm of 7.3 inches through a 24" pipe.

Pond depth is also an important issue as it will be governed by the needed fill to develop the site. Based on a 2:1 slope below the static pool and an average elevation of 163.0 on the natural ground excavation quantities can be expected to be as follows:

Pond Depth (ft)	15	12	10	8
Yield (Cu. Yds)	400,100	320,100	266,750	213,400

It should be expected that fills up to 8' could be experience near the east line of basin 3A.

Design Aids

This section includes material used to assist in designing the drainage system. A 1"=100' scale drainage plan map is enclosed in the pocket.

References

Interim Drainage and Storm Sewer Policy for Design Criteria and Documentation, City of Wichita, July 1987, Guideline for the hydrologic and hydraulic computations.

Design of Urban Highway Drainage - The State of the Art, Reitz & Jens, Inc., April 1980.

Drainage of Highway Pavements, Hydraulic Engineering Circular #12 by Tye Engineering, Inc., March 1984.

Fundamentals of Hydraulic Engineering, A.L. Prasuhn, 1987

Urban Hydrology for Small Watersheds, Technical Release No. 55, Engineering Division, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C., Jan. 1975, Rev. 1986

Rational Formula Revisited, Ronald L. Rossmiller, Iowa State Univ.

Proceedings of the Conference of Storm Water Detention Facilities, Planning, Design, Operation, and Maintenance, American Society of Civil Engineers, 1982

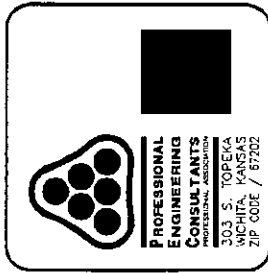
Open Channel Flow, F.M. Henderson, 1966

Storm Water Management, Martin P. Wanielista, & Yousef A. Yousef, 1993

Hydraulic Design of Highway Culverts (HDS #5), Federal Highway Administration, September 1985 (Formerly HEC-5)

Managing Floodplain Development in Approximate Zone A Areas - A guide for Obtaining and Developing Base (100-Year) Flood Elevations, Federal Emergency Management Agency, July 1995

Drainage Plan for Aberdeen 2nd Addition, Poe & Associates, Inc., 1997.
(Layout Only; No calculations available.)



Newmarket Square

HYDROLOGY

8/28/97

BASIN #	AREA (ac)	'C' Minor	'C' 100	Tc	'i' Minor	'i' 100	Q Minor (cfs)	Q100 (cfs)	Comment
1A	2.90	0.69	0.80	15	3.83	7.37	7.66	17.10	
1B	2.30	0.69	0.80	15	3.83	7.37	6.08	13.56	
1C	1.90	0.69	0.80	15	3.83	7.37	5.02	11.20	
2A	21.00	0.40	0.58	25	3.57	5.90	29.99	71.86	* NW Christian Church - Off Site
2B	2.70	0.69	0.80	15	3.83	7.37	7.14	15.92	
2C	0.50	0.69	0.80	15	3.83	7.37	1.32	2.95	
2D	2.60	0.69	0.80	15	3.83	7.37	6.87	15.33	
2E	0.80	0.69	0.80	15	3.83	7.37	2.11	4.72	
3A	105.00	0.66	0.79	22	3.83	6.33	265.42	525.07	* See Pond Hydrology
3B	1.20	0.88	0.93	15	3.83	7.37	4.04	8.22	
3C	1.40	0.88	0.93	15	3.83	7.37	4.72	9.60	
3D	2.80	0.88	0.93	15	3.83	7.37	9.44	19.19	
3E	2.30	0.88	0.93	15	3.83	7.37	7.75	15.76	
4A	50.90	0.64	0.76	25	3.57	5.90	116.30	228.24	* Future Development - Off Site
5A	11.60	0.50	0.76	15	3.83	7.67	22.21	67.62	Future Single Family - Off Site
5B	7.50	0.50	0.76	15	3.83	7.37	14.36	42.01	Future Single Family - Off Site
5C	8.70	0.44	0.61	15	3.83	7.37	14.66	39.11	Future Single Family - Off Site
5D	4.60	0.44	0.61	15	3.83	7.37	7.75	20.68	Future Single Family - Off Site

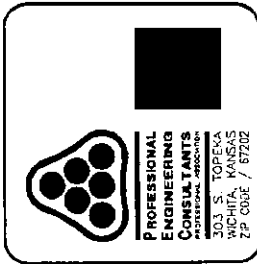
Total Area = 230.70 Acres

Total Q2 = 532.85 cfs

* - Weighted 'C' for different soil types or multi-use basin.

Total Q100 = 1128.14 cfs

Hydrology



Newmarket Square STREET FLOW AND INLET DESIGN

8/28/97

Comp by: PDM

Design Storm = Q 5 z=(1/Sx)/n= 3125 for 1A Inlets

Hydrology		Approaching Flow				Inlet		Sump Inlet			Intercept		Bypass		* Area Inlet	
Basin /Node	Initial Flow Qo (cfs)	Total Flow Qo+Qb (cfs)	C&G Slope So (%)	X-Slope Sx (ft/ft)	Depth d (ft)	Spread T (ft)	Type	Size (feet)	Sump Depth di (ft)	Curb Depth d (ft)	Spread T (ft)	Qi (cfs)	Qb (cfs)	Overflow Depth (ft)		
3D 330/340	9.44	9.44	0.50	0.0200	0.38	18.84	1A	5	0.72	0.56	27.84	9.44	0.00	N/A	2 - Inlets	
3E 350	7.75	7.75	1.00	0.0200	0.31	19.69	Area	2x2	0.31		17.26	3.72	0.00	*	1.00	
3B 310	4.04	4.04	1.00	0.0200	0.31	15.43	Area	2x2	0.31		17.12	3.72	0.00	*	1.00	
3C 320	4.72	4.72	1.00	0.0200	0.33	16.35	Area	2x2	0.33		18.14	4.10	0.00	*	1.00	

Input File: nms.stm

NEWMARKET SQUARE
STORM WATER SEWER - SYSTEM 300
PROFESSIONAL ENGINEERING CONSULTANTS, P.A.
WICHITA, KS.
PDM 8/28/97
FILE : 0:\1997\97763\NMS.STM

Storm Frequency = 5-Year

* * * H Y D R O L O G Y * * *

Tributary Area										Hydrology Summation				Conduit Data				
Node to Node	C	Area (Ac)	Slope (%)	Length (Ft)	TC(0) (Min)	I(0) (In/Hr)	Q(0) (CFS)	TC (Min)	I (In/Hr)	Q (CFS)	Sum Q (CFS)	Size	Velocity (Ft/Sec)	Length (Ft)	TT (Min)	TT+TC (Min)		
300 301	.00	.00	.00	.0	550.00	.46	16.00	550.00	.46	16.00	16.00	24"	5.09	120.00	.39	550.39		
301 302	.00	.00	.00	.0	.00	.00	.00	550.39	.46	.00	16.00	24"	5.09	720.00	2.36	552.75		
302 310	.00	.00	.00	.0	.00	.00	.00	552.75	.46	.00	16.00	24"	5.09	200.00	.65	553.40		
310 320	.00	.00	.00	.0	15.00	4.56	4.04	553.40	.46	.40	16.40	24"	5.22	180.00	.57	553.98		
320 330	.00	.00	.00	.0	15.00	4.56	4.72	553.98	.46	.47	16.88	30"	3.44	215.00	1.04	555.02		
330 340	.00	.00	.00	.0	15.00	4.56	3.44	555.02	.45	.34	17.22	30"	3.51	50.00	.24	555.26		
340 350	.00	.00	.00	.0	15.00	4.56	6.00	555.26	.45	.60	17.82	36"	2.52	330.00	2.18	557.44		
350 399	.00	.00	.00	.0	15.00	4.56	7.75	557.44	.45	.77	18.59	36"	2.63	250.00	1.58	559.02		

Input File: nms.stm

NEWMARKET SQUARE
STORM WATER SEWER - SYSTEM 300
PROFESSIONAL ENGINEERING CONSULTANTS, P.A.
WICHITA, KS.
PDM 8/28/97
FILE : 0:\1997\97763\NMS.STM

Storm Frequency = 5-Year

* * * H Y D R A U L I C S * * *

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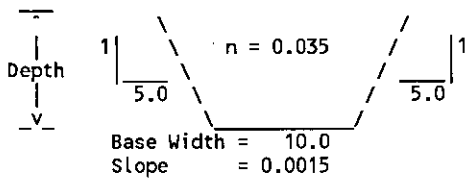
*****
Node      Hyd-Slope  Friction  Bend      Transition  Manhole  Deflection  Junction  Total  Hyd-Gl  Desired  Diff.
(Ft/Ft)   (Ft)      (Ft)      (Ft)      (Ft)        (Ft)     (Ft)       (Ft)     (Ft)   Elevation  Elevation (Ft)
*****
300      .00426    .5115    .0000    .0000      .0000    .0000     .0000    .5115  165.3135  163.8000  -1.51
301      .00426    3.0688   .0000    .0000      .0201    .1363     .0213    3.2466  164.8020  165.0000   .20
302      .00426    .8524    .0000    .0000      .0201    .2014     .0213    1.0953  161.5555  163.5000   1.94
310      .00448    .8064    .0000    .0021      .0000    .0000     .0632    .8716  160.4601  163.8000   3.34
320      .00144    .3101    .0000    .0480      .0000    .0000     -.1988   .1593  159.5885  163.8000   4.21
330      .00150    .0751    .0000    .0008      .0000    .0000     .0225    .0983  159.4292  163.8000   4.37
340      .00061    .2006    .0000    .0185      .0000    .0000     -.0752   .1439  159.3309  163.8000   4.47
350      .00066    .1654    .0000    .0009      .0000    .0000     .0207    .1870  159.1870  163.8000   4.61
399      .00000    .0000    .0000    .0000      .0000    .0000     .0000    .0000  159.0000  165.0000   6.00
*****

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QUICK - 2
CHANNEL CAPACITY
Trapezoidal Channel

INPUT VARIABLES

OUTPUT VARIABLES



Depth (ft)	1.50
Discharge (cfs)	44.2
Velocity (ft/s)	1.69
Top Width (ft)	25.0
Froude No.	0.29
Flow Type:	SUBCRITICAL

EMERGENCY (>100 yr Storm)
OVERFLOW CHANNEL
FAIL SAFE OUTLET FOR POND

Pond Hydrology

Site Characteristics

Project : Newmarket Square Location : Wichita, KS
 Project # : 36-97763-3104 Legal Description SE 1/4, Sec.6, T27S, R1W

Basin Area = **105.0 Acres** Abbr. SCS Soil Class ↓
 Design Storm = ↓ Years Hydrologic Soil Group #N/A

Custom Storm (SCS Type II Storm)

Time of Concentration

Assumed Tc
 Calculated Tc

Pre-Dev. Tc = **128.0 min** Post-Dev. Tc = **21.5 min**
 Pre-Dev. Intensity = **2.37 in/hr** Post-Dev. Intensity = **6.33 in/hr**
 24 Hour Precipitation = **7.8 Inches**

Pre-Developed Land Use

↓

Cultivated
 Pasture
 Urban

Rational 'C' = **0.44**
 SCS 'CN' = **76**

Post-Developed Land Use

↓

Cultivated
 Pasture
 Urban

Rational 'C' = **0.79**
 SCS 'CN' = **90**

Peak Flowrates

Rational			SCS TR-55		
Post-Developed Q =	522	CFS	Post-Developed Q =	6.60	In.
Pre-Developed Q =	110	CFS	Pre-Developed Q =	5.03	In.
Increased Q =	412	CFS	Increased Q =	1.57	In.

Maximum Outflow Criteria

Peak Pre-Developed Q
 User Defined
 Max. Outflow = **75 CFS**
 Limit Q to **1** cfs per Acre

Hydrograph Routing Method

SCS Hydrograph Routing*
 Simplified Storage Routing
 FAA - Mass Inflow Method
 Rational Hydrograph Routing

*Pond Routing calculated using Puls Inventory Method

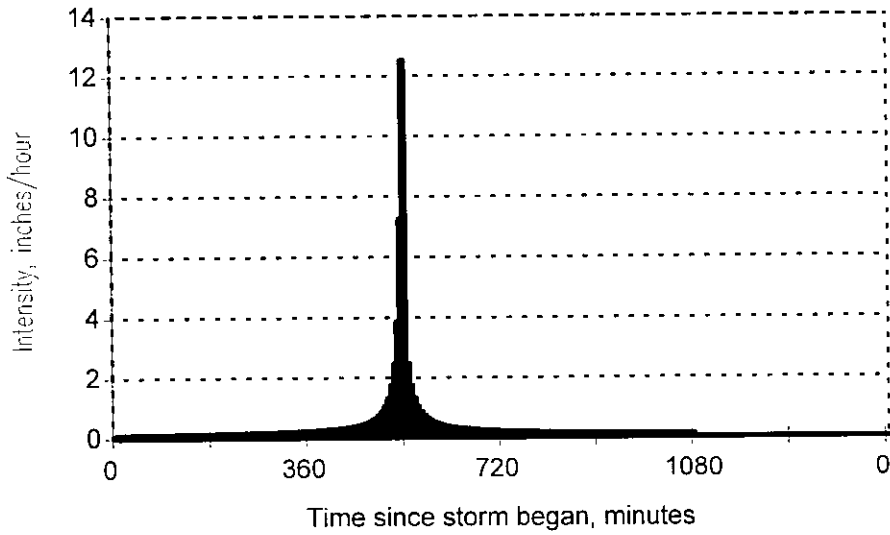
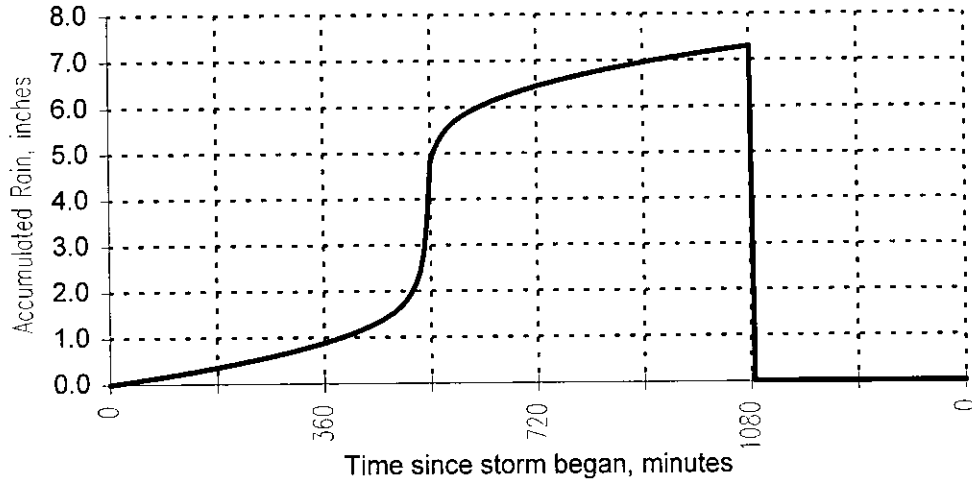
SCS Type II Storm

Project : Newmarket Square

Location :

Wichita, KS

100 year, 18.0 Hour Storm of 7.30 inches



Composite Runoff Coefficients

Project : **Newmarket Square**

Pre-Developed Land Use

	Ground Cover	SCS Soil Class	CN	'C'	% of Area
1	Grass Farm- SG (C) poor	B	74	0.35	37%
2	Grass Farm- SG (C) poor	C	82	0.54	5%
3	Grass Farm- SG (C) poor	D	85	0.62	30%
4	Open Space- M&W poor	B	62	0.25	17%
5	Open Space- M&W poor	D	81	0.52	11%
Composite Coefficients			76	0.44	100%

Post-Developed Land Use

	Ground Cover	SCS Soil Class	CN	'C'	% of Area
1	Light Commercial	B/C	92	0.80	36%
2	Light Commercial	D	94	0.82	23%
3	1/4 Ac. Single Family	B	75	0.61	16%
4	1/4 Ac. Single Family	D	87	0.76	12%
5	Lake- Impervious	B/D	98	0.93	13%
Composite Coefficients			90	0.79	100%

Tc Method

Project : Newmarket Square

Pre-Developed

Development Factor = **1.00**
 Hydraulic Length to Catch Point = **4450 Ft.**
 Average Slope to Catch Point = **0.30 %**
 Average Manning 'n' = **0.050**
 Estimated Impervious Area = **1.0 %**

Method	Tc (min)	I (in/hr)	Use
FAA	118.0	2.49	<input type="radio"/>
Kerby	41.3	4.58	<input type="radio"/>
Kirpich	47.1	4.26	<input type="radio"/>
Modified SCS Lag	128.0	2.37	<input checked="" type="radio"/>

Design Storm Intensity = **2.37 in/hr**

Post-Developed

Development Factor = **0.90**
 Hydraulic Length to Catch Point = **2050 Ft.**
 Average Slope to Catch Point = **1.00 %**
 Average Manning 'n' = **0.030**
 Estimated Impervious Area = **67.0 %**

Method	Tc (min)	I (in/hr)	Use
FAA	25.6	5.83	<input type="radio"/>
Kerby	87.0	3.00	<input type="radio"/>
Kirpich	16.3	7.12	<input type="radio"/>
Modified SCS Lag	21.5	6.33	<input checked="" type="radio"/>

Design Storm Intensity = **6.33 in/hr**

* Development Factor accounts for urban considerations
 not analyzed in calculation for SCS Lag Time
 such as basin shape. D.F. * L
 1.0 = Before Development.
 .90 = Urban Neighborhood
 .80 = Urban Concentrated

SCS Hydrographs

Ref: Urban Hydrology for Small Watersheds, TR-55 (1975)

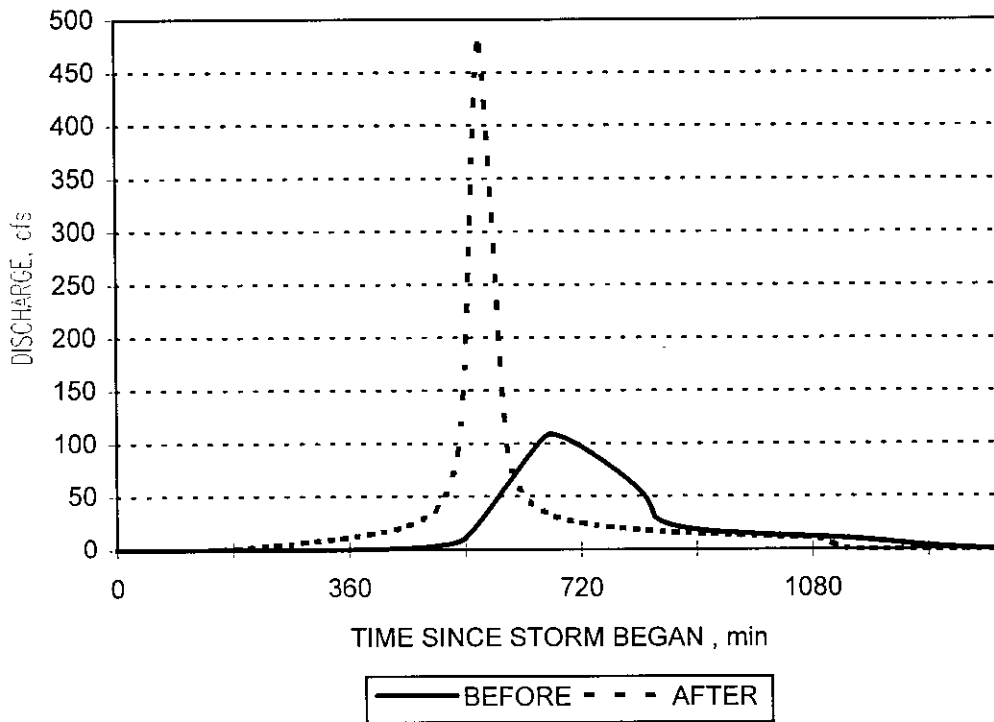
Project : Newmarket Square

Location : Wichita, KS

100 year, 1080 minute Storm of 7.30 inches

COMPOSITE HYDROGRAPH RESULTS:	Before	After
Total Runoff, in.	4.57	6.11
Peak Discharge, cfs	109	486
Volume of Runoff, Acre-ft	40.0	53.4
Volume req'd storage -----	34.6 ac-ft	1,507,872 cu. ft.

Before and After Hydrographs
by SCS Hydrograph Method



Stage-Storage Relationship

Project: Newmarket Square

Pond ID: Lake

Reservoir Characteristics

Top of Bank Elevation =	165
Bank Slope (X:1) =	4
Design Surface Area (ac) =	15
Starting Water Surface Elevation =	161.5
Pond Depth (ft) =	15

Discharge Control

Weir, Orifice or Pipe

Channel

Select one option to continue.

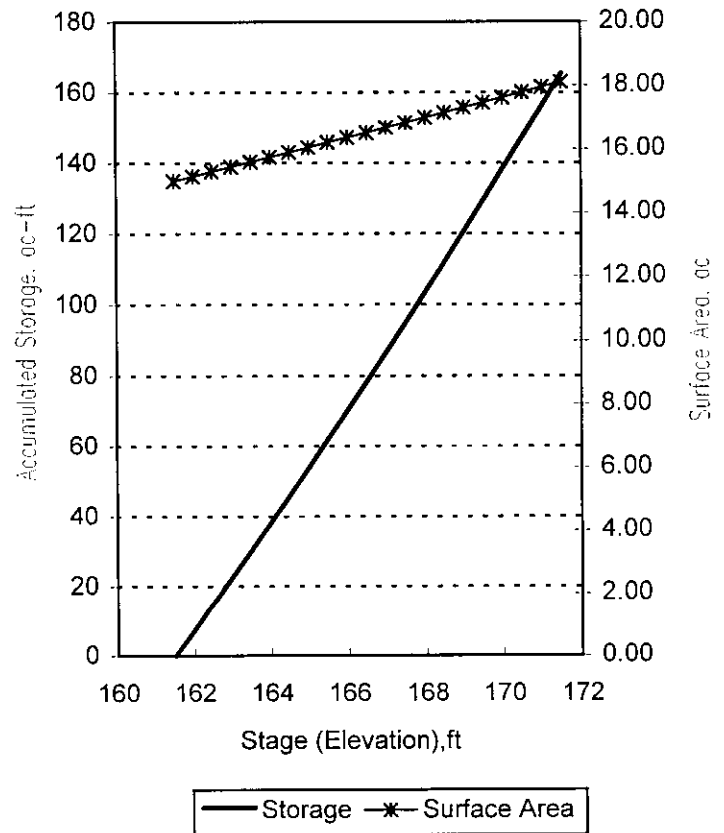
Pond Type

Detention Pond (Dry)

Retention Pond (Wet)

Elevation	Surf. area	Incr. Vol.	Acc. Vol
feet	acres	ac-ft	ac-ft
161.5	15.00	0.00	0.00
162.0	15.15	7.54	7.54
162.5	15.30	7.61	15.15
163.0	15.45	7.69	22.84
163.5	15.60	7.76	30.60
164.0	15.75	7.84	38.44
164.5	15.90	7.91	46.35
165.0	16.06	7.99	54.34
165.5	16.21	8.07	62.41
166.0	16.37	8.14	70.55
166.5	16.52	8.22	78.77
167.0	16.68	8.30	87.07
167.5	16.83	8.38	95.45
168.0	16.99	8.46	103.91
168.5	17.15	8.54	112.44
169.0	17.31	8.61	121.06
169.5	17.47	8.69	129.75
170.0	17.63	8.77	138.53
170.5	17.79	8.86	147.38
171.0	17.95	8.94	156.32
171.5	18.12	9.02	165.34
172.0	18.28	9.10	174.43
172.5	18.44	9.18	183.62
173.0	18.61	9.26	192.88
173.5	18.77	9.35	202.22
174.0	18.94	9.43	211.65

Stage-Storage and Stage-Area Curves



Stage-Discharge Relationship

Project : Newmarket Square
Pond ID: Lake

Target Discharge (cfs)= 75

Standpipe Characteristics

Weir Control $Q=CLH^{1.5}$	
Weir Coefficient =	0
Inlet Perimeter (ft) =	20
Inlet Top Elev. (D.W.S) =	161.5
Orifice Control $Q=CA(2gH)^{0.5}$	
Orifice Coefficient =	0.00
Orifice Area (ft ²) =	25
(Assumes 40% Blockage)	
To use for culvert analysis only enter 0 for coefficients.	

Pipe Characteristics *

* Inlet Control Simulated Weir/Orifice	
Orifice Coefficient =	0.67
Pipe Diameter (in) =	24
Upstream Flow Line Elev. =	161.5
* Outlet Control Energy Equation	
# Starting T.W. Elevation. =	159
Outlet Flow Line Elev. =	158.8
Pipe Length (ft) =	2060
Slope of Pipe (%) =	0.13
Manning 'n' for pipe =	0.012
Entrance Loss Coef. =	0.5

Overflow Characteristics

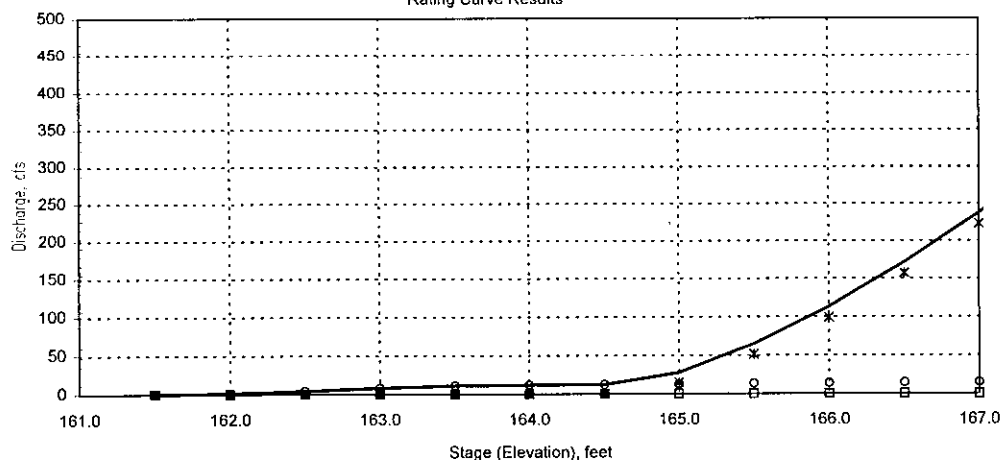
Weir Control $Q=CLH^{1.5}$	
Weir Coefficient =	3
Overflow Length (ft) =	20
Overflow Elevation =	164.6

* For circular pipes only.

* Use 25 Year H.W. of receiving body.

W.S. Elevation	Standpipe		Pipe		Pipe Velocity	Overflow	Pond Outflow	Outflow Velocity
	Weir	Orifice	Inlet	Outlet				
161.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
162.0	0.0	0.0	0.0	1.3	9.1	0.4	0.0	1.3
162.5	0.0	0.0	0.0	4.1	9.8	4.1	0.0	4.1
163.0	0.0	0.0	0.0	8.0	10.5	8.0	0.0	8.0
163.5	0.0	0.0	0.0	13.0	11.1	11.1	0.0	11.1
164.0	0.0	0.0	0.0	20.7	11.7	11.7	0.0	11.7
164.5	0.0	0.0	0.0	23.9	12.3	12.3	0.0	12.3
165.0	0.0	0.0	0.0	26.7	12.8	12.8	4.1	28.0
165.5	0.0	0.0	0.0	29.3	13.3	13.3	4.2	51.2
166.0	0.0	0.0	0.0	31.6	13.9	13.9	4.4	99.4
166.5	0.0	0.0	0.0	33.8	14.3	14.3	4.6	157.1
167.0	0.0	0.0	0.0	35.8	14.8	14.8	4.7	223.1
167.5	0.0	0.0	0.0	37.8	15.3	15.3	4.9	296.3
168.0	0.0	0.0	0.0	39.6	15.7	15.7	5.0	376.2
168.5	0.0	0.0	0.0	41.4	16.1	16.1	5.1	462.1
169.0	0.0	0.0	0.0	43.1	16.6	16.6	5.3	553.8
169.5	0.0	0.0	0.0	44.7	17.0	17.0	5.4	650.8
170.0	0.0	0.0	0.0	46.3	17.4	17.4	5.5	752.9
170.5	0.0	0.0	0.0	47.8	17.8	17.8	5.7	859.9
171.0	0.0	0.0	0.0	49.2	18.1	18.1	5.8	971.5
171.5	0.0	0.0	0.0	50.7	18.5	18.5	5.9	1087.5
172.0	0.0	0.0	0.0	52.1	18.9	18.9	6.0	1207.8
172.5	0.0	0.0	0.0	53.4	19.2	19.2	6.1	1332.3
173.0	0.0	0.0	0.0	54.7	19.6	19.6	6.2	1460.7
173.5	0.0	0.0	0.0	56.0	19.9	19.9	6.3	1593.1
174.0	0.0	0.0	0.0	57.3	20.3	20.3	6.5	1729.2

Stage-Discharge Relationship
Rating Curve Results



Primary
 Pipe
 Overflow
 Outflow

Summary of Calculations

Project : Newmarket Square
 Project # : 36-97763-3104

Location : Wichita, KS
 Legal Description : SE 1/4, Sec.6, T27S, R1W

Design Storm Characteristics:

Storm duration, hours	18
Return period, years	100
Storm depth, inches	7.30
Time Increment	6

Hydrology

Area, acres	105	Before	After
Average land slope %		0.30	1.00
Hydraulic length, ft.		4450	2050
Time of Concentration, min		128	21
Discharge, cfs		109	486

Design Criteria

Storage Volume Required, cu. ft. (ac-ft)	1,507,872	34.62
Maximum allowable outflow, cfs	75	

Pond Design *

	Pond ID: Lake
Storage Volume Designed, cu. ft. (ac-ft)	2,110,015 48.44
Design Volume at H.W., cu. ft. (ac-ft)	2,168,389 49.78
Static Water Elevation	161.5
Top of Bank Elevation	165
Overflow Elevation	164.6
Culvert Structure Flow line at Pond	161.5
Outlet Elevation Pipe	158.8
Manning's 'n' for Pipe	0.012

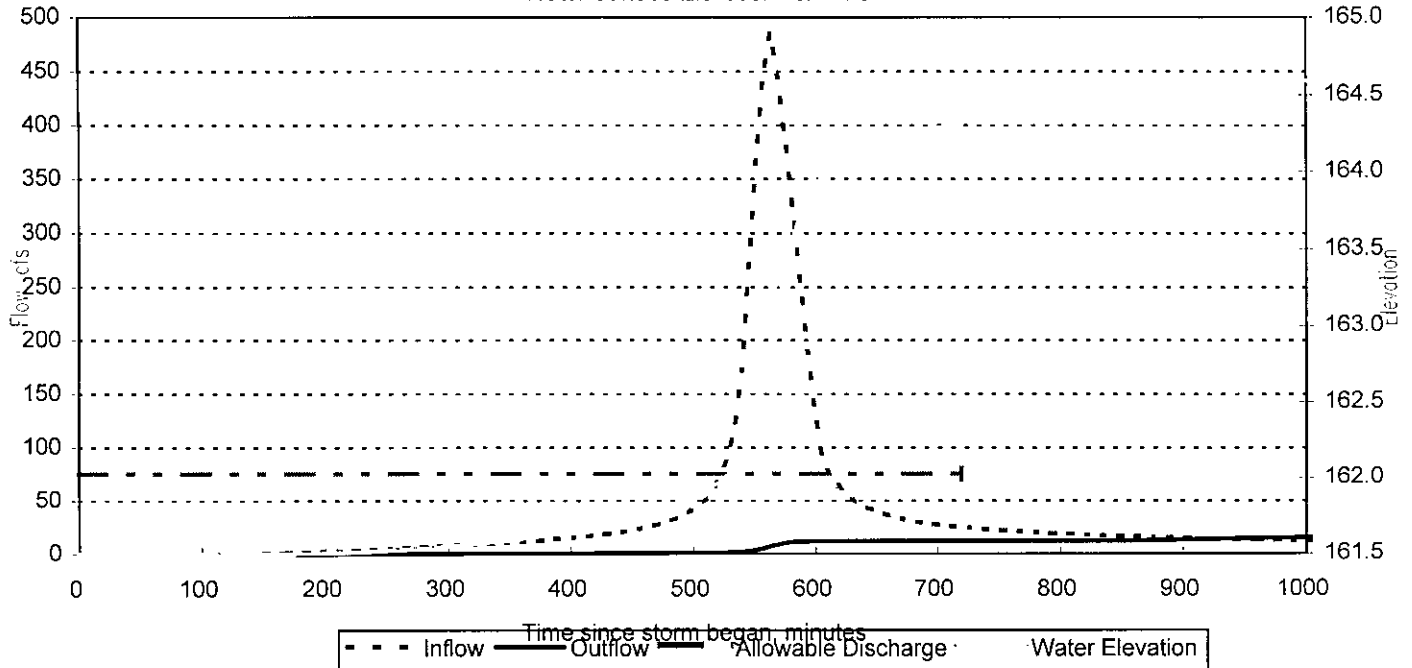
Retention Pond

Peak Design Discharge, cfs	16
Peak Time, min	1098
High Water Elevation	164.6
Peak Time, min	1092

Reduction in Discharge 78%

* SCS Hydrograph Routing only.

Pond Inflow and Outflow Hydrographs *
 Water Surface Elevation vs. Time *



CURRENT DATE: 07-31-1997
CURRENT TIME: 19:25:44

FILE DATE: 8/27/97
FILE NAME: NMS

FHWA CULVERT ANALYSIS
HY-8, VERSION 3.2

C U L V	SITE DATA			CULVERT SHAPE, MATERIAL, INLET					
	INLET ELEV. (FT)	OUTLET ELEV. (FT)	CULVERT LENGTH (FT)	BARRELS SHAPE MATERIAL	HW (FT)	SPAN (FT)	RISE (FT)	MANNING n	INLET TYPE
1	161.50	158.80	2060.00	1 RCP	164.70	1.50	1.50	.012	CONVENTIONAL
2	161.50	158.80	2060.00	1 RCP	164.60	2.00	2.00	.012	CONVENTIONAL
3	161.50	158.80	2060.00	1 RCP	164.50	2.50	2.50	.012	CONVENTIONAL
4	161.50	159.80	1150.00	1 RCP	164.70	1.50	1.50	.012	CONVENTIONAL
5	161.50	159.80	1150.00	1 RCP	164.60	2.00	2.00	.012	CONVENTIONAL
6	161.50	159.80	1150.00	1 RCP	164.90	2.50	2.50	.012	CONVENTIONAL
7	161.50	158.80	2060.00	1 RCP	164.30	3.00	3.00	.012	" "

SUMMARY OF CULVERT FLOWS (CFS) FILE: NMS DATE: 8/27/97

ELEV (FT)	TOTAL	1	2	3	4	5	6	ROADWAY	ITR
161.50	0	0	0	0	0	0	0	0	0
162.19	13	2	2	2	2	2	2	0	5
162.51	25	3	4	5	3	4	5	0	2
162.81	38	4	6	8	4	6	8	0	3
163.15	50	4	9	12	5	9	12	0	4
163.65	63	5	10	16	5	10	17	0	6
164.66	75	5	11	18	6	12	20	1	3
164.85	88	5	11	19	6	13	21	11	4
165.00	100	5	11	19	6	13	22	23	4
165.12	113	6	11	20	7	13	22	34	3
165.23	125	6	11	20	7	13	22	45	3
164.60	73	5	11	18	6	12	20	OVERTOPPING	

SUMMARY OF ITERATIVE SOLUTION ERRORS FILE: NMS DATE: 8/27/97

HEAD ELEV(FT)	HEAD ERROR(FT)	TOTAL FLOW(CFS)	FLOW ERROR(CFS)	% FLOW ERROR
161.50	0.00	0	0	0.00
162.19	-0.00	13	0	0.17
162.51	-0.00	25	0	0.03
162.81	0.00	38	-0	-0.46
163.15	0.00	50	-0	-0.31
163.65	0.01	63	-0	-0.26
164.66	1.00	75	0	0.43
164.85	-0.01	88	1	0.93
165.00	-0.00	100	0	0.37
165.12	-0.01	113	1	0.78
165.23	-0.01	125	1	0.63

<1> TOLERANCE (FT) = 0.010

<2> TOLERANCE (%) = 1.000

CURRENT DATE: 07-31-1997
 CURRENT TIME: 19:25:44

FILE DATE: 8/27/97
 FILE NAME: NMS

CULVERT # 2

PERFORMANCE CURVE FOR 1 BARREL(S)

Q (cfs)	HWE (ft)	TWE (ft)	ICH (ft)	OCH (ft)	FLOW TYPE	CCE (ft)	FCE (ft)	TCE (ft)	VO (fps)
0	161.50	159.00	0.00	-2.50	0-NF	0.00	161.50	0.00	0.00
2	162.18	159.00	0.68	-1.30	4-FF	0.00	0.00	0.00	3.44
4	162.50	159.00	1.00	-0.68	4-FF	0.00	0.00	0.00	4.18
6	162.81	159.00	1.31	0.28	4-FF	0.00	0.00	0.00	4.76
9	163.14	159.00	1.57	1.64	4-FF	0.00	0.00	0.00	6.46
10	163.65	159.00	1.65	2.15	4-FF	0.00	0.00	0.00	7.00
11	164.65	159.00	1.79	3.15	4-FF	0.00	0.00	0.00	7.96
11	164.84	159.00	1.82	3.34	4-FF	0.00	0.00	0.00	8.12
11	165.00	159.00	1.84	3.50	4-FF	0.00	0.00	0.00	8.26
11	165.12	159.00	1.85	3.62	4-FF	0.00	0.00	0.00	8.36
11	165.23	159.00	1.86	3.73	4-FF	0.00	0.00	0.00	8.46

El. inlet face invert 161.50 ft El. outlet invert 158.80 ft
 El. inlet throat invert 0.00 ft El. inlet crest 0.00 ft

***** SITE DATA ***** CULVERT INVERT *****
 INLET STATION (FT) 0.00
 INLET ELEVATION (FT) 161.50
 OUTLET STATION (FT) 2060.00
 OUTLET ELEVATION (FT) 158.80
 NUMBER OF BARRELS 1.00
 SLOPE (V-FT/H-FT) 0.0013
 CULVERT LENGTH ALONG SLOPE (FT) 2060.00

***** CULVERT DATA SUMMARY *****
 BARREL SHAPE CIRCULAR
 BARREL DIAMETER 2.00 FT
 BARREL MATERIAL CONCRETE
 BARREL MANNING'S N 0.012
 INLET TYPE CONVENTIONAL
 INLET EDGE AND WALL SQUARE EDGE WITH HEADWALL
 INLET DEPRESSION NONE

CURRENT DATE: 07-31-1997
 CURRENT TIME: 19:25:44

FILE DATE: 8/27/97
 FILE NAME: NMS

CULVERT # 3

PERFORMANCE CURVE FOR 1 BARREL(S)

Q (cfs)	HWE (ft)	TWE (ft)	ICH (ft)	OCH (ft)	FLOW TYPE	CCE (ft)	FCE (ft)	TCE (ft)	VO (fps)
0	161.50	159.00	0.00	-2.50	0-NF	0.00	161.50	0.00	0.00
2	162.19	159.00	0.69	-1.13	4-FF	0.00	0.00	0.00	3.40
5	162.52	159.00	1.02	-0.79	4-FF	0.00	0.00	0.00	4.15
8	162.82	159.00	1.32	-0.24	4-FF	0.00	0.00	0.00	4.78
12	163.15	159.00	1.65	0.62	4-FF	0.00	0.00	0.00	5.36
16	163.65	159.00	2.02	2.15	4-FF	0.00	0.00	0.00	7.47
18	164.65	159.00	2.21	3.15	4-FF	0.00	0.00	0.00	8.60
19	164.85	159.00	2.24	3.35	4-FF	0.00	0.00	0.00	8.80
19	165.00	159.00	2.27	3.50	4-FF	0.00	0.00	0.00	8.96
20	165.12	159.00	2.29	3.62	4-FF	0.00	0.00	0.00	9.08
20	165.23	159.00	2.31	3.73	4-FF	0.00	0.00	0.00	9.19

El. inlet face invert 161.50 ft El. outlet invert 158.80 ft
 El. inlet throat invert 0.00 ft El. inlet crest 0.00 ft

***** SITE DATA ***** CULVERT INVERT *****
 INLET STATION (FT) 0.00
 INLET ELEVATION (FT) 161.50
 OUTLET STATION (FT) 2060.00
 OUTLET ELEVATION (FT) 158.80
 NUMBER OF BARRELS 1.00
 SLOPE (V-FT/H-FT) 0.0013
 CULVERT LENGTH ALONG SLOPE (FT) 2060.00

***** CULVERT DATA SUMMARY *****
 BARREL SHAPE CIRCULAR
 BARREL DIAMETER 2.50 FT
 BARREL MATERIAL CONCRETE
 BARREL MANNING'S N 0.012
 INLET TYPE CONVENTIONAL
 INLET EDGE AND WALL SQUARE EDGE WITH HEADWALL
 INLET DEPRESSION NONE

CURRENT DATE: 07-31-1997
CURRENT TIME: 19:25:44

FILE DATE: 8/27/97
FILE NAME: NMS

TAILWATER

CONSTANT WATER SURFACE ELEVATION
159.00

ROADWAY OVERTOPPING DATA

WEIR COEFFICIENT	3.00
EMBANKMENT TOP WIDTH (FT)	100.00
CREST LENGTH (FT)	30.00
OVERTOPPING CREST ELEVATION (FT)	164.60

April 15, 1986

ATTACHMENT A
DRAINAGE CRITERIA MANUAL

CITY OF WICHITA, KANSAS

RAINFALL INTENSITY TABLE FOR SEDGWICK COUNTY, KANSAS

The following tabulation contains rainfall intensity in inches per hour as derived from ESSA Weather Bureau Technical Paper 40 Modified to NWS Hydro-35, 1977 During First Hour

JDF

DURATION IN MINUTES	RETURN PERIODS OF						
	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
5	4.18	5.57	6.53	7.41	8.52	9.48	10.32
6	3.99	5.32	6.25	7.09	8.16	9.09	9.89
7	3.81	5.09	5.99	6.81	7.84	8.74	9.50
8	3.66	4.89	5.75	6.55	7.55	8.42	9.15
9	3.52	4.70	5.54	6.31	7.28	8.13	8.83
10	3.39	4.52	5.34	6.09	7.04	7.86	8.54
11	3.27	4.36	5.16	5.89	6.81	7.61	8.27
12	3.18	4.21	4.99	5.71	6.60	7.38	8.02
13	3.05	4.08	4.84	5.53	6.41	7.17	7.79
14	2.96	3.95	4.69	5.37	6.23	6.97	7.57
15	2.87	3.83	4.56	5.22	6.06	6.78	7.37
16	2.78	3.72	4.43	5.08	5.90	6.60	7.18
17	2.71	3.61	4.31	4.95	5.75	6.44	7.00
18	2.63	3.51	4.20	4.83	5.61	6.29	6.84
19	2.56	3.42	4.10	4.71	5.47	6.14	6.68
20	2.50	3.33	4.00	4.60	5.35	6.00	6.53
21	2.44	3.25	3.90	4.50	5.23	5.87	6.39
22	2.38	3.17	3.81	4.40	5.12	5.75	6.26
23	2.32	3.10	3.73	4.31	5.01	5.63	6.13
24	2.27	3.03	3.65	4.22	4.91	5.52	6.01
25	2.22	2.96	3.57	4.13	4.81	5.41	5.90
26	2.20	2.90	3.50	4.05	4.72	5.31	5.79
27	2.16	2.84	3.43	3.98	4.63	5.21	5.69
28	2.14	2.78	3.37	3.90	4.55	5.12	5.59
29	2.11	2.72	3.30	3.83	4.47	5.03	5.49
30	2.08	2.67	3.24	3.76	4.39	4.94	5.40
31	2.05	2.62	3.19	3.70	4.32	4.86	5.32
32	2.02	2.57	3.10	3.63	4.25	4.79	5.22
33	1.99	2.52	3.05	3.57	4.18	4.71	5.14
34	1.96	2.48	3.01	3.51	4.11	4.63	5.07
35	1.93	2.44	2.98	3.46	4.05	4.56	5.00
36	1.91	2.39	2.93	3.41	3.99	4.50	4.93
37	1.89	2.35	2.88	3.36	3.93	4.43	4.86
38	1.87	2.32	2.84	3.31	3.87	4.37	4.79
39	1.85	2.28	2.80	3.26	3.82	4.31	4.73
40	1.83	2.24	2.76	3.22	3.76	4.25	4.66
41	1.81	2.21	2.72	3.17	3.71	4.19	4.60
42	1.79	2.18	2.68	3.13	3.66	4.13	4.54
43	1.77	2.14	2.64	3.09	3.61	4.08	4.49
44	1.75	2.11	2.61	3.05	3.57	4.03	4.43
45	1.73	2.08	2.57	3.01	3.52	3.98	4.38

ATTACHMENT A CONTINUED

Page 2

DURATION IN MINUTES	RETURN PERIODS OF						
	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
46	1.70	2.05	2.54	2.97	3.48	3.93	4.33
47	1.67	2.02	2.50	2.93	3.44	3.88	4.28
48	1.66	2.00	2.47	2.90	3.39	3.84	4.23
49	1.64	1.97	2.44	2.86	3.35	3.79	4.18
50	1.61	1.95	2.41	2.83	3.32	3.75	4.13
51	1.59	1.92	2.38	2.79	3.28	3.71	4.09
52	1.56	1.89	2.35	2.76	3.24	3.67	4.05
53	1.54	1.86	2.33	2.73	3.20	3.63	4.00
54	1.52	1.84	2.30	2.70	3.17	3.59	3.96
55	1.50	1.81	2.27	2.67	3.14	3.55	3.92
56	1.47	1.79	2.25	2.64	3.10	3.51	3.88
57	1.45	1.76	2.22	2.61	3.07	3.48	3.84
58	1.43	1.74	2.20	2.59	3.04	3.44	3.81
59	1.42	1.72	2.18	2.56	3.01	3.41	3.77
60	1.40	1.69	2.15	2.53	2.98	3.37	3.73
61	1.38	1.67	2.13	2.51	2.95	3.34	3.70
62	1.36	1.65	2.11	2.48	2.92	3.31	3.67
63	1.34	1.63	2.09	2.46	2.89	3.28	3.63
64	1.33	1.61	2.07	2.44	2.86	3.25	3.60
65	1.31	1.59	2.05	2.41	2.84	3.22	3.57
66	1.30	1.57	2.03	2.39	2.81	3.19	3.54
67	1.28	1.56	2.01	2.37	2.79	3.16	3.51
68	1.26	1.54	1.99	2.35	2.76	3.13	3.48
69	1.25	1.52	1.97	2.33	2.74	3.10	3.45
70	1.24	1.50	1.95	2.31	2.71	3.08	3.42
71	1.22	1.49	1.93	2.28	2.69	3.05	3.39
72	1.21	1.47	1.92	2.26	2.67	3.02	3.36
73	1.20	1.46	1.90	2.25	2.64	3.00	3.34
74	1.18	1.44	1.88	2.23	2.63	2.98	3.31
75	1.17	1.43	1.86	2.21	2.61	2.95	3.29
76	1.16	1.41	1.85	2.19	2.58	2.93	3.26
77	1.15	1.40	1.83	2.17	2.55	2.90	3.24
78	1.13	1.38	1.82	2.15	2.53	2.88	3.22
79	1.12	1.37	1.80	2.14	2.50	2.86	3.19
80	1.11	1.36	1.79	2.12	2.48	2.84	3.16
81	1.10	1.34	1.77	2.10	2.46	2.82	3.13
82	1.09	1.33	1.76	2.08	2.43	2.79	3.10
83	1.08	1.32	1.74	2.06	2.41	2.76	3.07
84	1.07	1.31	1.73	2.04	2.39	2.74	3.04
85	1.06	1.30	1.72	2.02	2.37	2.71	3.01
86	1.05	1.28	1.70	2.00	2.34	2.69	2.99
87	1.04	1.27	1.69	1.99	2.32	2.66	2.96
88	1.03	1.26	1.68	1.97	2.30	2.64	2.93
89	1.02	1.25	1.68	1.95	2.28	2.62	2.91
90	1.01	1.24	1.66	1.93	2.26	2.59	2.88

<u>DURATION IN MINUTES</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
91	1.00	1.23	1.65	1.92	2.24	2.57	2.86
92	1.00	1.22	1.63	1.90	2.22	2.55	2.83
93	0.99	1.21	1.62	1.89	2.20	2.53	2.81
94	0.98	1.20	1.61	1.87	2.19	2.51	2.79
95	0.97	1.19	1.59	1.85	2.17	2.49	2.76
96	0.96	1.18	1.58	1.84	2.15	2.46	2.74
97	0.96	1.17	1.57	1.82	2.13	2.44	2.72
98	0.95	1.16	1.56	1.81	2.12	2.42	2.70
99	0.94	1.15	1.54	1.80	2.10	2.41	2.67
100	0.93	1.14	1.53	1.78	2.08	2.39	2.65
101	0.93	1.13	1.52	1.77	2.07	2.39	2.65
102	0.92	1.13	1.51	1.75	2.05	2.35	2.61
103	0.91	1.12	1.50	1.74	2.04	2.33	2.59
104	0.90	1.11	1.49	1.73	2.02	2.31	2.57
105	0.90	1.10	1.47	1.72	2.01	2.30	2.55
106	0.89	1.09	1.46	1.70	1.99	2.28	2.54
107	0.88	1.09	1.45	1.69	1.98	2.26	2.52
108	0.88	1.08	1.44	1.68	1.96	2.25	2.50
109	0.87	1.07	1.43	1.67	1.95	2.23	2.48
110	0.87	1.06	1.42	1.65	1.93	2.21	2.46
111	0.86	1.06	1.41	1.64	1.92	2.20	2.45
112	0.85	1.05	1.40	1.63	1.91	2.18	2.43
113	0.85	1.04	1.39	1.62	1.89	2.17	2.41
114	0.84	1.03	1.38	1.61	1.88	2.15	2.40
115	0.84	1.03	1.37	1.60	1.87	2.14	2.38
116	0.83	1.02	1.36	1.59	1.86	2.12	2.36
117	0.82	1.01	1.36	1.58	1.84	2.11	2.35
118	0.82	1.01	1.35	1.57	1.83	2.09	2.33
119	0.81	1.00	1.34	1.56	1.82	2.08	2.32
120	0.81	0.99	1.33	1.55	1.81	2.07	2.30

<u>DURATION IN HOURS</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
2	0.81	0.99	1.33	1.55	1.81	2.07	2.30
3	0.59	0.72	0.97	1.13	1.32	1.51	1.68
4	0.47	0.58	0.78	0.91	1.06	1.21	1.35
5	0.40	0.49	0.66	0.77	0.89	1.02	1.14
6	0.35	0.42	0.57	0.67	0.78	0.89	0.99
8	0.28	0.34	0.46	0.53	0.62	0.71	0.79
10	0.23	0.29	0.39	0.45	0.52	0.60	0.67
12	0.20	0.25	0.33	0.39	0.45	0.52	0.58
18	0.15	0.18	0.24	0.28	0.33	0.38	0.42
24	0.12	0.15	0.20	0.23	0.27	0.31	0.34

SOIL LEGEND

SYMBOL	HYDROLOGIC GROUP	NAME
Aa	B	Albion-Shellabarger sandy loams, 1 to 4 percent slopes
Ab	B	Albion and Shellabarger sandy loams, 7 to 15 percent slopes
Ba	C	Blanket silt loam, 0 to 1 percent slopes
Bb	C	Blanket silt loam, 1 to 3 percent slopes
Ca	B	Canadian fine sandy loam
Cb	B	Canadian-Waldeck fine sandy loams
Cc	D	Carwile fine sandy loam
Cd	B	Clark-Ost clay loams, 1 to 4 percent slopes
Ce	C	Clime silty clay, 3 to 6 percent slopes
Ea	B	Elandco silt loam
Eb	B	Elandco silt loam, occasionally flooded
Ec	B	Elandco silt loam, frequently flooded
Fa	B	Farnum loam, 0 to 1 percent slopes
Fb	B	Farnum loam, 1 to 3 percent slopes
Fc	B	Farnum loam, sandy substratum, 0 to 1 percent slopes
Ga	D	Goessel silty clay, 0 to 1 percent slopes
Gb	D	Goessel silty clay, 1 to 2 percent slopes
Ia	D	Irwin silty clay loam, 1 to 3 percent slopes
Ib	D	Irwin silty clay loam, 3 to 6 percent slopes
Ic	D	Irwin silty clay loam, 2 to 6 percent slopes, eroded
La	C	Lesho loam
Lb	A	Lincoln soils
Ma	B	Milan loam, 1 to 3 percent slopes
Mb	B	Milan loam, 3 to 6 percent slopes
Mc	B	Milan clay loam, 2 to 6 percent slopes, eroded
Na	B	Naron fine sandy loam
Oc	D	Owens clay loam, 1 to 3 percent slopes
Od	D	Owens-Rock outcrop complex, 3 to 10 percent slopes
Pa		Pits
Pb	D	Pievna fine sandy loam
Pc	A	Pratt loamy fine sand, undulating
Pd	A	Pratt-Tivoli complex, rolling
Ra	D	Renfrow silty clay loam, 1 to 3 percent slopes
Rb	D	Renfrow silty clay loam, 3 to 6 percent slopes
Rc	D	Renfrow-Owens clay loams, 1 to 4 percent slopes
Rd	D	Rosehill silty clay, 1 to 3 percent slopes
Sa	B	Shellabarger sandy loam, 1 to 3 percent slopes
Sb	B	Shellabarger sandy loam, 3 to 6 percent slopes
Sc	B	Shellabarger sandy loam, 3 to 6 percent slopes, eroded
Ta	D	Tabler silty clay loam
Tb	D	Tabler-Drummond complex
Ua	B	Urban land-Canadian complex
Ub	B	Urban land-Elandco complex
Uc	B	Urban land-Farnum complex, 0 to 3 percent slopes
Ud	D	Urban land-Irwin complex, 1 to 3 percent slopes
Ue	D	Urban land-Tabler complex
Va	B	Vanoss silt loam, 0 to 1 percent slopes
Vb	B	Vanoss silt loam, 1 to 3 percent slopes
Vc	B	Vanoss silt loam, 3 to 6 percent slopes
Vd	B	Vanoss silt loam, 3 to 6 percent slopes, eroded
Ve	D	Vernon sandy loam, 1 to 3 percent slopes
Vf	D	Vernon sandy loam, 3 to 6 percent slopes
Wa	C	Waldeck sandy loam
Wb	D	Waurika silt loam

Table I. Runoff Curve Numbers for Selected Areas For Antecedent Moisture Condition II
 (for $I_a = 0.2 \cdot S$) *Selected Conditions Only - Reproduced from USDA, SCS (1986)*

Fully developed urban areas (vegetation established)

Cover Description	Average % Impervious Area	Curve numbers for hydrologic soil group --			
		A	B	C	D
Cover Type					
Hydrologic Condition					
Open space (lawns, parks, golf courses, cemeteries, etc)		68	79	86	89
Poor condition (grass cover < 50%)		49	69	79	84
Fair condition (grass cover 50 to 75%)		39	61	74	80
Good condition (grass cover > 75%)					
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved: open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Urban districts:					
Commercial and business	85	96	96	96	96
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8-acre or less (townhouses)	65	77	85	90	92
1/4-acre	38	61	75	83	87
1/3-acre	30	57	72	81	86
1/2-acre	25	54	70	80	85
1-acre	20	51	68	79	84
2-acre	12	46	65	77	82

Rural areas		Hydrologic Condition	Hydrologic Soil Group			
Land Use	Cover Treatment or Practice		A	B	C	D
Fallow	Straight row	---	77	86	91	94
Row crops	Straight row	poor	72	81	88	91
	Straight row	good	67	78	85	89
Small grain	Contoured	poor	70	79	84	88
	Contoured	good	65	75	82	86
	Contoured and terraced	poor	66	74	80	82
	Contoured and terraced	good	62	71	78	81
	Straight row	poor	65	76	84	88
	Straight row	good	63	75	83	87
	Contoured	poor	63	74	82	85
	Contoured	good	61	73	81	84
	Contoured and terraced	poor	61	72	79	82
	Contoured and terraced	good	59	70	78	81
Pasture or range	poor	68	79	86	89	
	fair	49	69	79	84	
	good	39	61	74	80	
	good	30	58	71	78	
Meadow	poor	45	66	77	83	
	fair	46	60	73	79	
Woods	good	25	55	70	77	
	good	59	74	82	86	
Farmsteads	---	72	82	87	89	
Roads (dirt, including right-of-way)	---	74	84	90	92	
Roads (hard surface, including right of way)	---					

Handwritten notes: "wbo" next to Meadow; "62" next to 77; "74" next to 83; "81" next to 83.

ATTACHMENT D

DRAINAGE CRITERIA

CITY OF WICHITA, KANSAS

RECOMMENDED RUNOFF COEFFICIENTS FOR RATIONAL METHOD
AND PERCENT IMPERVIOUS FOR UNIT HYDROGRAPH METHOD

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		2	5	10	100
1. Business:					
Downtown Areas	95	0.84	0.85	0.87	0.91
Neighborhood Areas	70	0.68	0.69	0.73	0.80
2. Residential:					
<u>Single Family (Soil Group D)</u>					
1/8 Acre	50	0.57	0.61	0.66	0.79
1/4 Acre	38	0.50	0.54	0.62	0.76
1/3 Acre	30	0.46	0.50	0.59	0.73
1/2 Acre	25	0.42	0.48	0.56	0.72
3/4 Acre	22	0.42	0.46	0.55	0.71
1 Acre	20	0.41	0.45	0.54	0.71
<u>Multi-Family (Soil Group D)</u>					
Multi-Unit (detached)	60	0.62	0.66	0.72	0.82
Multi-Unit (attached)	65	0.64	0.68	0.73	0.83
Apartments	75	0.70	0.73	0.79	0.86
<u>Single Family (Soil Group C)</u>					
1/8 Acre	50	0.55	0.58	0.64	0.73
1/4 Acre	38	0.48	0.51	0.57	0.68
1/3 Acre	30	0.43	0.46	0.53	0.65
1/2 Acre	25	0.40	0.43	0.50	0.63
3/4 Acre	22	0.39	0.42	0.49	0.62
1 Acre	20	0.37	0.40	0.48	0.61
<u>Multi-Family (Soil Group C)</u>					
Multi-Unit (detached)	60	0.60	0.63	0.69	0.77
Multi-Unit (attached)	65	0.63	0.66	0.71	0.79
Apartments	75	0.68	0.72	0.77	0.83
<u>Single-Family (Soil Group B)</u>					
1/8 Acre	50	0.52	0.54	0.59	0.67
1/4 Acre	38	0.44	0.46	0.52	0.61
1/3 Acre	30	0.39	0.41	0.47	0.57
1/2 Acre	25	0.36	0.38	0.44	0.54
3/4 Acre	22	0.34	0.36	0.42	0.52
1 Acre	20	0.33	0.35	0.40	0.51
<u>Multi-Family (Soil Group B)</u>					
Multi-Unit (detached)	60	0.58	0.60	0.65	0.72
Multi-Unit (attached)	65	0.61	0.64	0.68	0.75
Apartments	75	0.67	0.70	0.74	0.80

Land Use or Area Characteristics	Percent Impervious	Frequency			
		2	5	10	100
<u>Single Family (Soil Group A)</u>					
1/8 Acre	50	0.47	0.50	0.54	0.60
1/4 Acre	38	0.39	0.41	0.45	0.52
1/3 Acre	30	0.33	0.35	0.39	0.47
1/2 Acre	25	0.30	0.31	0.35	0.44
3/4 Acre	22	0.28	0.29	0.33	0.42
1 Acre	20	0.26	0.28	0.32	0.40
<u>Multi-Family (Soil Group A)</u>					
Multi-Unit (detached)	60	0.55	0.57	0.61	0.67
Multi-Unit (attached)	65	0.58	0.60	0.64	0.70
Apartments	75	0.65	0.68	0.72	0.77
<u>Industrial:</u>					
Light Areas	70	0.68	0.69	0.73	0.80
Heavy Areas	80	0.74	0.76	0.79	0.84
<u>Playgrounds:</u>					
	15	0.33	0.35	0.42	0.55
<u>5. Schools:</u>					
	40	0.49	0.51	0.56	0.66
<u>Railroad Yard Areas:</u>					
	30	0.43	0.45	0.50	0.62
<u>Undeveloped Urban Areas:</u>					
Offsite Flow Analysis (when land use not defined)	45	0.52	0.54	0.59	0.68
<u>Streets:</u>					
Paved	99	0.87	0.88	0.90	0.93
Gravel	00	0.24	0.26	0.33	0.48
<u>Drive, Parking Lots and Walks:</u>					
	96	0.87	0.87	0.88	0.89
<u>10. Roofs:</u>					
	90	0.80	0.85	0.90	0.93
<u>11. Urban Lawn Areas (See Note No. 1 below):</u>					
<u>Soil Group A</u>					
Slope less than 1%	00	0.08	0.09	0.13	0.23
Slope 1% to 4%	00	0.12	0.13	0.17	0.27
Slope more than 4%	00	0.16	0.17	0.21	0.31
<u>Soil Group B</u>					
Slope less than 1%	00	0.16	0.18	0.24	0.37
Slope 1% to 4%	00	0.20	0.22	0.28	0.41
Slope more than 4%	00	0.24	0.26	0.32	0.45
<u>Soil Group C</u>					
Slope less than 1%	00	0.24	0.27	0.35	0.51
Slope 1% to 4%	00	0.26	0.29	0.37	0.53
Slope more than 4%	00	0.28	0.31	0.39	0.55

Land Use or
Surface Characteristics

Percent
Impervious

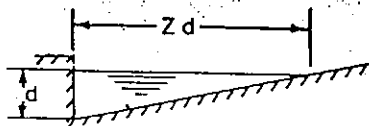
Frequency

Soil Group D

		<u>2</u>	<u>5</u>	<u>10</u>	<u>100</u>
Slope less than 1%	00	0.28	0.33	0.43	0.63
Slope 1% to 4%	00	0.30	0.35	0.45	0.65
Slope more than 4%	00	0.32	0.37	0.47	0.67

Note No. 1: Coefficients shown in the above table are for pervious open space areas with thick turf which includes pervious areas in parks and cemeteries. Coefficients shown above must be increased 0.02 for use with agricultural pasture areas. Coefficients shown above must be reduced by 0.04 for use with agricultural cultivated areas. Group A soils are well-drained, coarse textured sands with high infiltration rates. Group B soils are moderately well-drained, moderately coarse textured soils with moderate infiltration rates. Group C soils are moderately poor-drained, moderately fine textured soils with slow infiltration rates. Group D soils are poor-drained, fine textured soils with very slow infiltration rates.

GENERAL NOTE: These Rational Formula Coefficients may not be valid for basins 320 acres or larger.



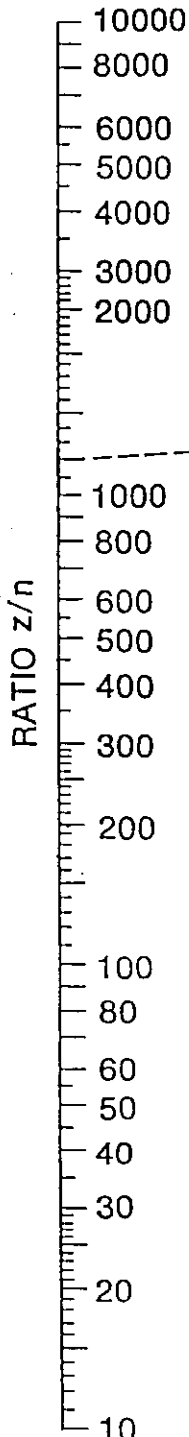
Equation: $Q = 0.56 \left(\frac{Z}{n}\right) s^{1/2} d^{3/2}$
 n is roughness coefficient in Manning formula appropriate to material in bottom of channel
 Z is reciprocal of cross slope

Reference: H. R. B. proceedings 1946, page 150, equation (14)

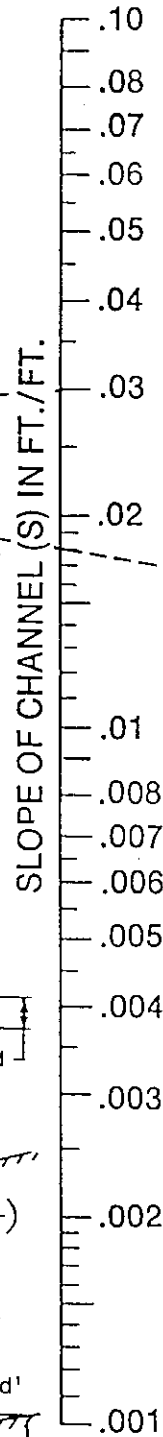
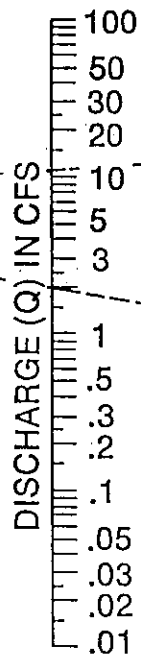
Example (see dashed lines)

Given: $s = 0.03$
 $z = 24$ } $z/n = 1200$
 $n = .02$
 $d = 0.22$

Find: $Q = 2.0$ CFS.

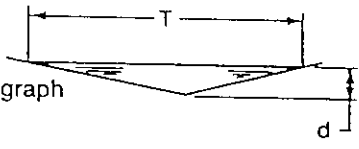


TURNING LINE



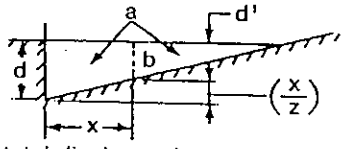
INSTRUCTIONS

1. Connect z/n ratio with slope (s) and connect discharge (Q) with depth (d). These two lines must intersect at turning line for complete solution.



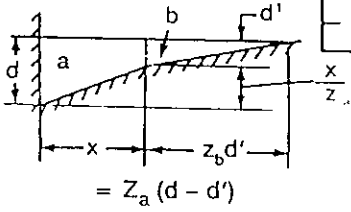
2. For shallow v-shaped channel as shown use nomograph with $z = \frac{T}{d}$

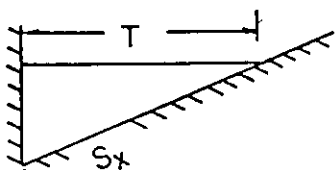
3. To determine discharge Q_x in portion of channel having width x: determine depth d for total discharge in entire section a. Then use nomograph to determine Q_b in section b for depth.



$d' = d - \left(\frac{x}{z}\right)$

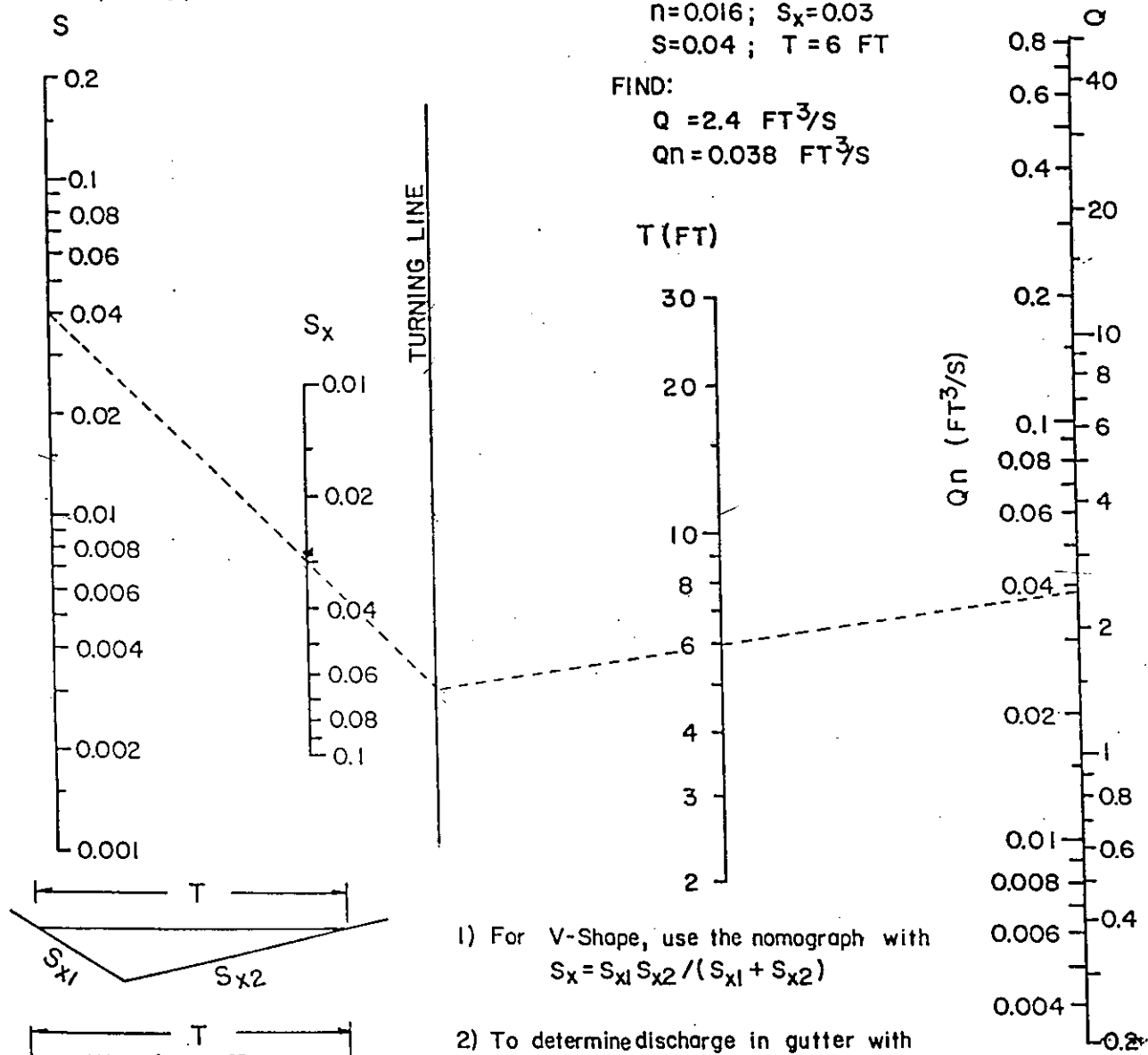
4. To determine discharge in composite section: - follow instruction 3. To obtain discharge in section a at assumed depth d: obtain Q_b for slope ration Z_b and depth d' , then $Q_T = Q_a \cdot Q_b$





$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

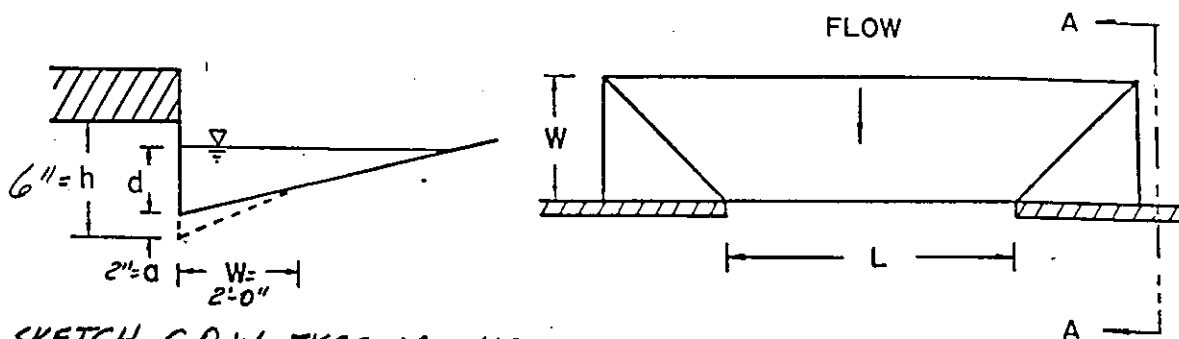
EXAMPLE: GIVEN:
 $n=0.016$; $S_x=0.03$
 $S=0.04$; $T=6$ FT
 FIND:
 $Q = 2.4$ FT³/S
 $Qn = 0.038$ FT³/S



- 1) For V-Shape, use the nomograph with $S_x = S_{x1} S_{x2} / (S_{x1} + S_{x2})$
- 2) To determine discharge in gutter with composite cross slopes, find Q_s using T_s and S_x . Then, use CHART 4 to find E_o . The total discharge is $Q = Q_s / (1 - E_o)$, and $Q_w = Q - Q_s$.

CHART 3. Flow in triangular gutter sections.

From: HEC-12: DRAINAGE OF HIGHWAY PAVEMENTS, F.H.W.A., Mar. 1984



DEF. SKETCH, C.D.W. TYPE 1A INLET

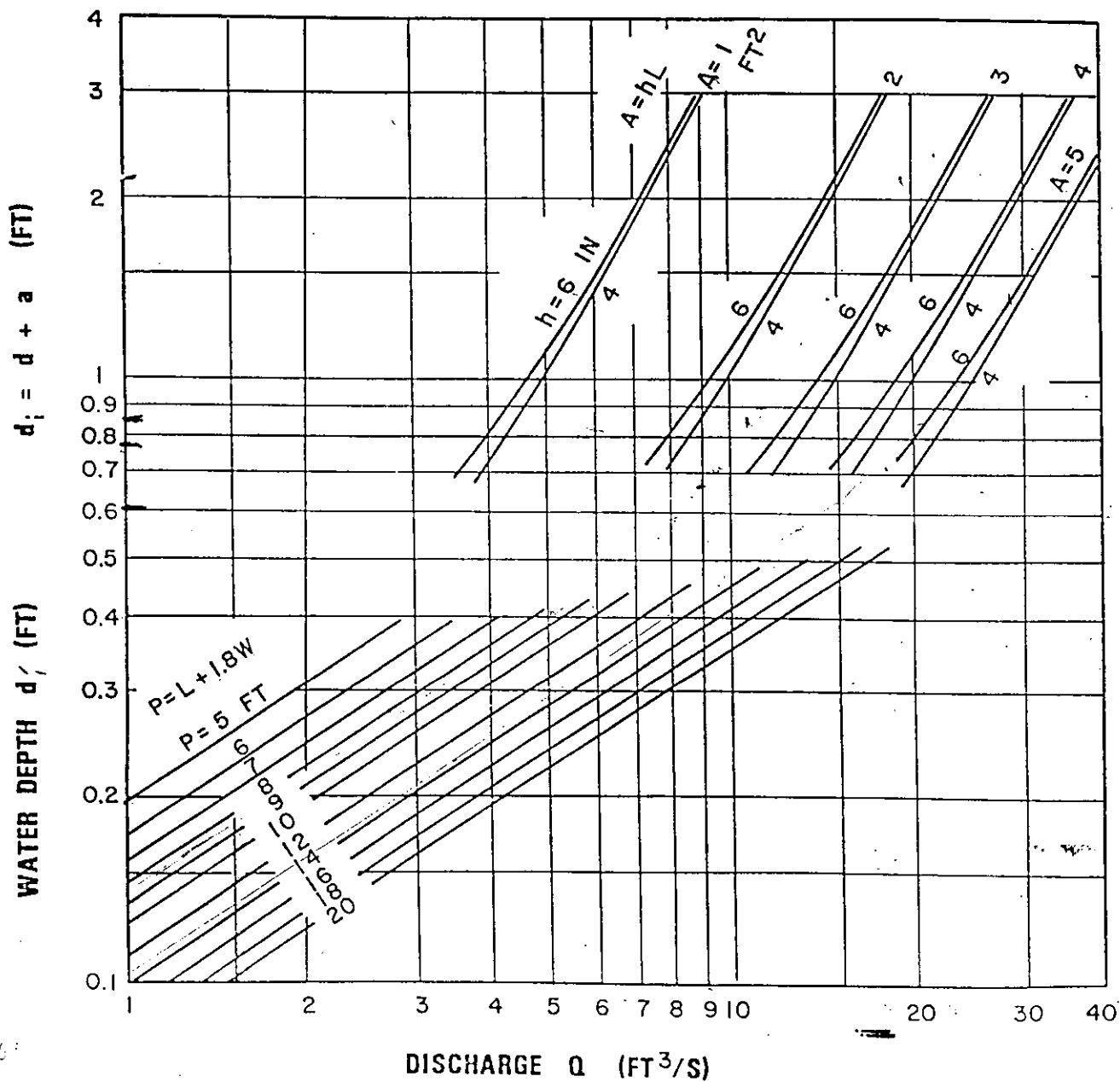


CHART 12. Depressed curb-opening inlet capacity in sump locations.

FROM: HEC-12, DRAINAGE OF HIGHWAY PAVEMENTS, F.H.W.A., MAR., 1984

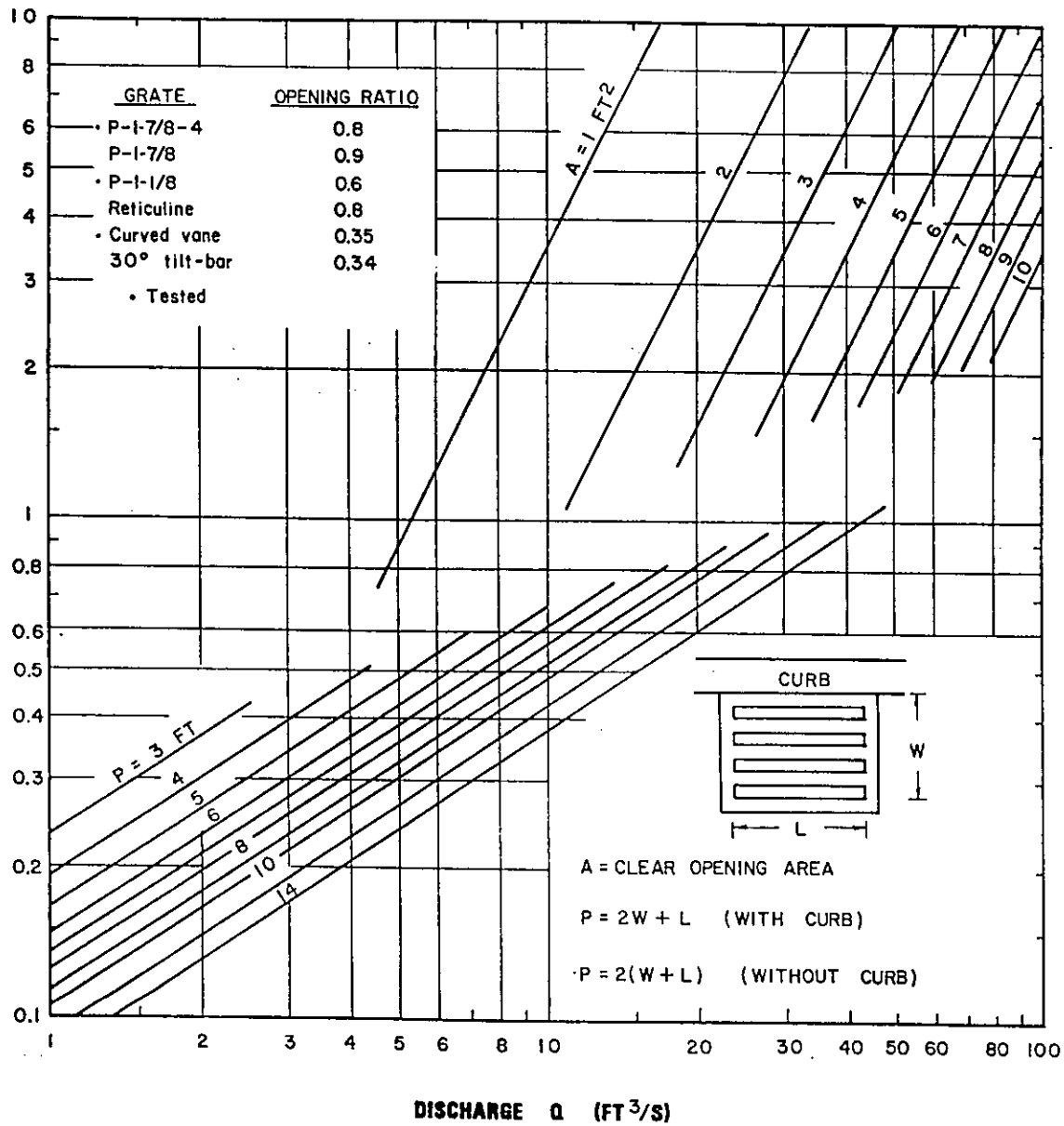


CHART 11. Grate inlet capacity in sump conditions.

TABLE 3

FULL FLOW COEFFICIENT VALUES
CIRCULAR CONCRETE PIPE

$S = 4\frac{1}{4}\%$
 $S = 0.03$
 $Q = 1.5$
 $K = 0.15$

D Pipe Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{4/3} = K$			
			n=0.010	n=0.011	n=0.012	n=0.013
8	0.349	0.167	15.8	14.3	13.1	12.1
10	0.545	0.208	28.4	25.8	23.6	21.8
12	0.785	0.250	46.4	42.1	38.6	35.7
15	1.227	0.312	84.1	76.5	70.1	64.7
18	1.767	0.375	137	124	114	105
21	2.405	0.437	206	187	172	158
24	3.142	0.500	294	267	245	226
27	3.976	0.562	402	366	335	310
30	4.909	0.625	533	485	444	410
33	5.940	0.688	686	624	574	530
36	7.069	0.750	867	788	722	666
42	9.621	0.875	1308	1189	1090	1006
48	12.566	1.000	1867	1698	1556	1436
54	15.904	1.125	2557	2325	2131	1967
50	19.635	1.250	3385	3077	2821	2604
66	23.758	1.375	4364	3967	3636	3357
72	28.274	1.500	5504	5004	4587	4234
78	33.183	1.625	6815	6195	5679	5242
84	38.485	1.750	8304	7549	6920	6388
90	44.170	1.875	9985	9078	8321	7681
96	50.266	2.000	11850	10780	9878	9119
102	56.745	2.125	13940	12670	11620	10720
108	63.617	2.250	16230	14760	13530	12490
114	70.882	2.375	18750	17040	15620	14420
120	78.540	2.500	21500	19540	17920	16540
126	86.590	2.625	24480	22260	20400	18830
132	95.033	2.750	27720	25200	23100	21330
138	103.870	2.875	31210	28370	26010	24010
144	113.100	3.000	34960	31780	29130	26890

TABLE 4

FULL FLOW COEFFICIENT VALUES
ELLIPTICAL CONCRETE PIPE

Pipe Size R x S (HE) S x R (VE) (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{4/3} = K$			
				n=0.010	n=0.011	n=0.012	n=0.013
14 x 23	18	1.8	0.367	138	125	116	108
19 x 30	24	3.3	0.490	274	252	232	213
22 x 34	27	4.1	0.546	405	368	339	313
24 x 38	30	5.1	0.613	547	497	456	421
27 x 42	33	6.3	0.686	728	662	607	560
29 x 45	36	7.4	0.736	891	810	746	686
32 x 49	39	8.8	0.812	1140	1036	948	875
34 x 53	42	10.2	0.875	1386	1260	1156	1067
38 x 60	48	12.9	0.969	1878	1707	1565	1445
43 x 68	54	16.6	1.106	2635	2395	2196	2027
48 x 76	60	20.5	1.229	3491	3174	2910	2686
53 x 83	66	24.8	1.352	4503	4094	3753	3464
58 x 91	72	29.5	1.475	5680	5164	4734	4370
63 x 98	78	34.6	1.598	7027	6388	5856	5406
68 x 106	84	40.1	1.721	8560	7790	7140	6590
72 x 113	90	46.1	1.845	10300	9365	8584	7925
77 x 121	96	52.4	1.967	12220	11110	10190	9403
82 x 128	102	59.2	2.091	14380	13070	11980	11060
87 x 136	108	66.4	2.215	16770	15240	13970	12900
92 x 143	114	74.0	2.340	19380	17620	16150	14910
97 x 151	120	82.0	2.461	22190	20180	18490	17070
106 x 166	132	99.2	2.707	28630	26020	23860	22020
116 x 180	144	118.6	2.968	36400	33100	30340	28000

TABLE 5

FULL FLOW COEFFICIENT VALUES
CONCRETE ARCH PIPE

Pipe Size R x S (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{4/3} = K$			
				n=0.010	n=0.011	n=0.012	n=0.013
11 x 18	15	1.1	0.25	65	59	54	50
13 1/2 x 22	18	1.6	0.30	110	100	91	84
15 1/2 x 26	21	2.2	0.36	165	150	137	127
18 x 28 1/2	24	2.8	0.45	243	221	203	187
22 1/2 x 36 1/4	30	4.4	0.56	441	401	368	339
25 1/2 x 43 3/4	36	6.4	0.68	736	669	613	566
31 1/2 x 51 1/2	42	8.8	0.80	1125	1023	938	866
36 x 58 1/2	48	11.4	0.90	1579	1435	1315	1214
40 x 65	54	14.3	1.01	2140	1945	1783	1646
45 x 73	60	17.7	1.13	2851	2592	2376	2193
54 x 88	72	25.6	1.35	4641	4219	3867	3569
62 x 102	84	34.6	1.57	6941	6310	5784	5339
72 x 115	90	44.5	1.77	9668	8789	8056	7436
77 1/2 x 122	96	51.7	1.92	11850	10770	9872	9112
87 1/2 x 138	108	66.0	2.17	16430	14940	13690	12640
96 1/2 x 154	120	81.8	2.42	21975	19977	18312	16904
106 1/2 x 168 1/4	132	99.1	2.65	28292	25720	23577	21763

TABLE 7

**SLOPES REQUIRED FOR V = 2fps
AT FULL AND HALF FULL FLOW**

Pipe Diameter (Inches)	Slope in %			
	n = 0.010	n = 0.011	n = 0.012	n = 0.013
8	0.197	0.238	0.284	0.332
10	0.147	0.178	0.213	0.248
12	0.115	0.139	0.166	0.194
15	0.086	0.104	0.123	0.145
18	0.067	0.081	0.097	0.114
21	0.055	0.066	0.079	0.092
24	0.046	0.055	0.066	0.077
27	0.039	0.047	0.056	0.065
30	0.034	0.041	0.049	0.057
33	0.030	0.036	0.043	0.051
36	0.027	0.032	0.038	0.045
42	0.022	0.026	0.031	0.036
48	0.018	0.022	0.026	0.031
54	0.015	0.019	0.022	0.027
60	0.013	0.016	0.019	0.023
66	0.012	0.014	0.017	0.020
72	0.011	0.013	0.015	0.018
78	0.010	0.011	0.014	0.016
84	0.009	0.010	0.012	0.015
90	0.008	0.010	0.011	0.013
96	0.007	0.009	0.010	0.012
102	0.007	0.008	0.010	0.011
108	0.006	0.007	0.009	0.010
114	0.006	0.007	0.008	0.010
120	0.005	0.006	0.008	0.009
126	0.005	0.006	0.007	0.008
132	0.004	0.006	0.007	0.008
138	0.004	0.005	0.006	0.007
144	0.004	0.005	0.006	0.007

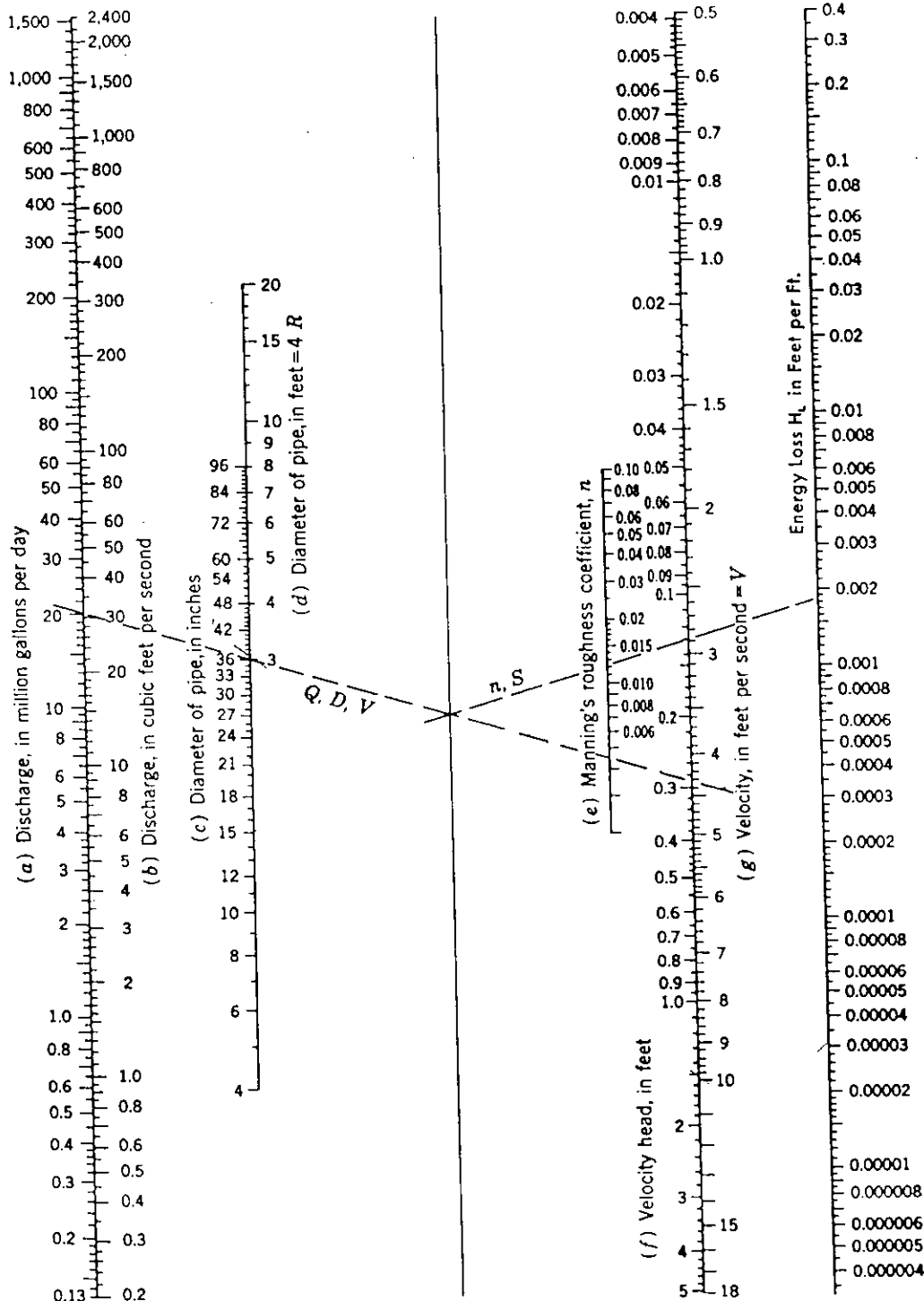
Note: For a velocity V other than 2fps, multiple the above by $\frac{V^2}{4}$.

TABLE 6

**FULL FLOW COEFFICIENT VALUES
PRECAST CONCRETE BOX SECTIONS**

Box Size Span x Rise (Feet)	C = 1.486/(A x R ^{2/3})	
	R	A
3 X 2	5.78	43.88
3 X 3	8.78	52.88
4 X 2	7.65	61.88
4 X 3	11.65	70.88
4 X 4	15.65	79.88
5 X 3	14.50	88.61
5 X 4	19.50	98.61
5 X 5	24.50	108.32
6 X 3	17.32	119.32
6 X 4	23.32	127.30
6 X 5	29.32	137.00
6 X 6	35.32	148.00
7 X 4	27.11	157.00
7 X 5	34.11	161.00
7 X 6	41.11	167.00
7 X 7	48.11	170.00
8 X 4	31.11	177.00
8 X 5	39.11	185.00
8 X 6	47.11	198.00
8 X 7	55.11	214.00
8 X 8	63.11	230.00
9 X 2	5.78	43.88
9 X 3	8.78	52.88
9 X 4	11.65	61.88
9 X 5	14.50	70.88
9 X 6	17.32	79.88
9 X 7	20.30	88.61
9 X 8	23.32	98.61
9 X 9	26.60	108.32
9 X 10	29.32	119.32
10 X 2	5.78	43.88
10 X 3	8.78	52.88
10 X 4	11.65	61.88
10 X 5	14.50	70.88
10 X 6	17.32	79.88
10 X 7	20.30	88.61
10 X 8	23.32	98.61
10 X 9	26.60	108.32
10 X 10	29.32	119.32
11 X 2	5.78	43.88
11 X 3	8.78	52.88
11 X 4	11.65	61.88
11 X 5	14.50	70.88
11 X 6	17.32	79.88
11 X 7	20.30	88.61
11 X 8	23.32	98.61
11 X 9	26.60	108.32
11 X 10	29.32	119.32
12 X 2	5.78	43.88
12 X 3	8.78	52.88
12 X 4	11.65	61.88
12 X 5	14.50	70.88
12 X 6	17.32	79.88
12 X 7	20.30	88.61
12 X 8	23.32	98.61
12 X 9	26.60	108.32
12 X 10	29.32	119.32
12 X 11	31.11	127.30
12 X 12	33.11	137.00
13 X 2	5.78	43.88
13 X 3	8.78	52.88
13 X 4	11.65	61.88
13 X 5	14.50	70.88
13 X 6	17.32	79.88
13 X 7	20.30	88.61
13 X 8	23.32	98.61
13 X 9	26.60	108.32
13 X 10	29.32	119.32
13 X 11	31.11	127.30
13 X 12	33.11	137.00
14 X 2	5.78	43.88
14 X 3	8.78	52.88
14 X 4	11.65	61.88
14 X 5	14.50	70.88
14 X 6	17.32	79.88
14 X 7	20.30	88.61
14 X 8	23.32	98.61
14 X 9	26.60	108.32
14 X 10	29.32	119.32
14 X 11	31.11	127.30
14 X 12	33.11	137.00
15 X 2	5.78	43.88
15 X 3	8.78	52.88
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15 X 7	20.30	88.61
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15 X 9	26.60	108.32
15 X 10	29.32	119.32
15 X 11	31.11	127.30
15 X 12	33.11	137.00
16 X 2	5.78	43.88
16 X 3	8.78	52.88
16 X 4	11.65	61.88
16 X 5	14.50	70.88
16 X 6	17.32	79.88
16 X 7	20.30	88.61
16 X 8	23.32	98.61
16 X 9	26.60	108.32
16 X 10	29.32	119.32
16 X 11	31.11	127.30
16 X 12	33.11	137.00
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19 X 5	14.50	70.88
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21 X 12	33.11	137.00
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22 X 3	8.78	52.88
22 X 4	11.65	61.88
22 X 5	14.50	70.88
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22 X 12	33.11	137.00
23 X 2	5.78	43.88
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30 X 11	31.11	127.30
30 X 12	33.11	137.00
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33 X 7	20.30	88.61
33 X 8	23.32	98.61
33 X 9	26.60	108.32
33 X 10	29.32	119.32
33 X 11	31.11	127.30
33 X		

Although the friction slope S_f appears as a second order term in the expression for 'C' the resulting discharge is not sensitive to this term. Table 4.11 shows the difference (%) in discharge computed using the Kutter equation compared with that obtained by Manning. The table gives the relationship between the diameter (D) and the hydraulic radius (R) assuming full flow in a circular pipe. The values in Table 4.11 are also valid for noncircular pipes flowing partially full.



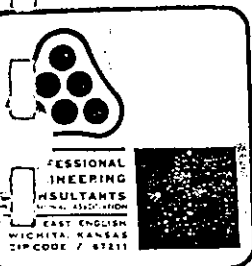
Alignment chart for energy loss in pipes, for Manning's formula.
 Note: Use chart for flow computations, $H_L = S$

Figure 4.8 Nomograph for solution of Manning's formula.

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Project _____

Item Minimum Storm Drain Slopes



For Reinf. Conc. Pipe w/n = 0.013 find S_{min} for 2 f.p.s @ 0.2d

d _o (in.)	S _{min} (%)	d _o (in.)	S _{min} (%)
12	0.51	39	0.11
15	0.38	42	0.10
18	0.30	48	0.08
21	0.24	54	0.07
24	0.20	60	0.06
27	0.17	66	0.05
30	0.15	72	0.05
33	0.13	84	0.04
36	0.12	96	0.03

Pipe thickness
 $= \frac{d}{12} + 1" = t \text{ (in.)}$

For CMP w/n as shown find S_{min} for 3 @ 2 f.p.s @ 0.2d

d _o (in.)	Corrugations*	Mannings n (3)	S _{min} (%) 3 f.p.s.	S _{min} (%) 2 f.p.s.
12	H & C	0.014 ^{0.024}	7.34 3.94	5.65 1.75
15	H & C	0.014 ^{0.024}	7.05 2.93	5.44 1.30
18	H & C	0.015 ^{0.024}	6.90 2.29	5.75 1.02
21	H & C	0.024	1.87	0.83
24	H & C	0.024	1.56	0.70
30	H & C	0.024	1.16	0.52
36	H & C	0.024	0.91	0.40
42	H & C	0.024	0.74	0.33
48	H & C	0.024	0.62	0.28
54	H & C	0.024	0.53	0.24
60	C	0.027 ^{0.024}	0.58 0.46	0.26 0.20
66	C	0.027 ^{0.024}	0.57 0.41	0.23 0.18
72	C	0.027	0.46	0.20
78	C	0.027	0.41	0.18
84	C	0.027	0.37	0.17
90	C	0.027	0.34	0.15
96	C	0.027	0.31	0.14

* C = Circumferential
 H = Helical

① 2 3/8 x 1/2 corrugations } from specifications

② 3 x 1 corrugations

③ "N" from Section III.2.2 p. 11 "Interim Drainage & Storm Sew. Policy for Kansas Criteria and Documentation - C.O.W., KS." Adopted 4-15-86, Revised 11-01-86.

Appendix A.—TABLES

Table 1.—Manning roughness coefficients, n ¹

	Manning's n range ²	
I. Closed conduits:		
A. Concrete pipe.....	0.011-0.013	
B. Corrugated-metal pipe or pipe-arch:		
1. 23½ by 14-in. corrugation (riveted pipe): ³		
a. Plain or fully coated.....	0.024	
b. Paved invert (range values are for 25 and 50 percent of circumference paved):		
(1) Flow full depth.....	0.021-0.018	
(2) Flow 0.8 depth.....	0.021-0.016	
(3) Flow 0.6 depth.....	0.019-0.013	
2. 6 by 2-in. corrugation (field bolted).....	0.03	
C. Vitrified clay pipe.....	0.012-0.014	
D. Cast-iron pipe, uncoated.....	0.013	
E. Steel pipe.....	0.009-0.011	
F. Brick.....	0.014-0.017	
G. Monolithic concrete:		
1. Wood forms, rough.....	0.015-0.017	
2. Wood forms, smooth.....	0.012-0.014	
3. Steel forms.....	0.012-0.013	
H. Cemented rubble masonry walls:		
1. Concrete floor and top.....	0.017-0.022	
2. Natural floor.....	0.019-0.025	
I. Laminated treated wood.....	0.015-0.017	
J. Vitrified clay liner plates.....	0.016	
II. Open channels, lined⁴ (straight alignment):⁴		
A. Concrete, with surfaces as indicated:		
1. Formed, no finish.....	0.012-0.017	
2. Trowel finish.....	0.012-0.014	
3. Float finish.....	0.013-0.015	
4. Float finish, some gravel on bottom.....	0.015-0.017	
5. Gunite, good section.....	0.015-0.019	
6. Gunite, wavy section.....	0.018-0.022	
B. Concrete, bottom float finished, sides as indicated:		
1. Dressed stone in mortar.....	0.015-0.017	
2. Random stone in mortar.....	0.017-0.020	
3. Cement rubble masonry.....	0.020-0.025	
4. Cement rubble masonry, plastered.....	0.016-0.020	
5. Dry rubble (riprap).....	0.020-0.030	
C. Gravel bottom, sides as indicated:		
1. Formed concrete.....	0.017-0.020	
2. Random stone in mortar.....	0.020-0.023	
3. Dry rubble (riprap).....	0.023-0.033	
D. Brick.....	0.014-0.017	
E. Asphalt:		
1. Smooth.....	0.013	
2. Rough.....	0.016	
F. Wood, planed, clean.....	0.011-0.013	
G. Concrete-lined excavated rock:		
1. Good section.....	0.017-0.020	
2. Irregular section.....	0.022-0.027	
III. Open channels, excavated⁴ (straight alignment,⁴ natural lining):		
A. Earth, uniform section:		
1. Clean, recently completed.....	0.014-0.018	
2. Clean, after weathering.....	0.018-0.020	
3. With short grass, few weeds.....	0.022-0.027	
4. In gravelly soil, uniform section, clean.....	0.022-0.025	
B. Earth, fairly uniform section:		
1. No vegetation.....	0.022-0.025	
2. Grass, some weeds.....	0.025-0.030	
3. Dense weeds or aquatic plants in deep channels.....	0.030-0.035	
4. Sides clean, gravel bottom.....	0.025-0.030	
5. Sides clean, cobble bottom.....	0.030-0.040	
C. Dragline excavated or dredged:		
1. No vegetation.....	0.028-0.033	
2. Light brush on banks.....	0.035-0.050	
D. Rock:		
1. Based on design section.....	0.035	
2. Based on actual mean section:		
a. Smooth and uniform.....	0.035-0.040	
b. Jagged and irregular.....	0.040-0.045	
E. Channels not maintained, weeds and brush uncut:		
1. Dense weeds, high as flow depth.....	0.08-0.12	
2. Clean bottom, brush on sides.....	0.05-0.08	
3. Clean bottom, brush on sides, highest stage of flow.....	0.07-0.11	
4. Dense brush, high stage.....	0.10-0.14	
IV. Highway channels and swales with maintained vegetation⁴: (values shown are for velocities of 2 and 6 f.p.s.):		
A. Depth of flow up to 0.7 foot:		
1. Bermudagrass, Kentucky bluegrass, buffalograss:		
a. Mowed to 2 inches.....	0.07-0.045	Manning's n range ²
b. Length 4-6 inches.....	0.09-0.05	
2. Good stand, any grass:		
a. Length about 12 inches.....	0.18-0.09	
b. Length about 24 inches.....	0.20-0.15	
3. Fair stand, any grass:		
a. Length about 12 inches.....	0.14-0.08	
b. Length about 24 inches.....	0.25-0.13	
B. Depth of flow 0.7-1.5 feet:		
1. Bermudagrass, Kentucky bluegrass, buffalograss:		
a. Mowed to 2 inches.....	0.05-0.035	
b. Length 4 to 6 inches.....	0.06-0.04	
2. Good stand, any grass:		
a. Length about 12 inches.....	0.12-0.07	
b. Length about 24 inches.....	0.20-0.10	
3. Fair stand, any grass:		
a. Length about 12 inches.....	0.10-0.06	
b. Length about 24 inches.....	0.17-0.09	
V. Street and expressway gutters:		
A. Concrete gutter, troweled finish.....		
	0.012	
B. Asphalt pavement:		
1. Smooth texture.....	0.013	
2. Rough texture.....	0.016	
C. Concrete gutter with asphalt pavement:		
1. Smooth.....	0.013	
2. Rough.....	0.015	
D. Concrete pavement:		
1. Float finish.....	0.014	
2. Broom finish.....	0.016	
E. For gutters with small slope, where sediment may accumulate, increase above values of n by.....		
	0.002	
VI. Natural stream channels:⁵		
A. Minor streams ⁶ (surface width at flood stage less than 100 ft.):		
1. Fairly regular section:		
a. Some grass and weeds, little or no brush.....	0.030-0.035	
b. Dense growth of weeds, depth of flow materially greater than weed height.....	0.035-0.05	
c. Some weeds, light brush on banks.....	0.035-0.05	
d. Some weeds, heavy brush on banks.....	0.05-0.07	
e. Some weeds, dense willows on banks.....	0.06-0.08	
f. For trees within channel, with branches submerged at high stage, increase all above values by.....	0.01-0.02	
2. Irregular sections, with pools, slight channel meander; increase values given in 1-a-e about.....		
	0.01-0.02	
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:		
a. Bottom of gravel, cobbles, and few boulders.....	0.04-0.05	
b. Bottom of cobbles, with large boulders.....	0.05-0.07	
B. Flood plains (adjacent to natural streams):		
1. Pasture, no brush:		
a. Short grass.....	0.030-0.035	
b. High grass.....	0.035-0.05	
2. Cultivated areas:		
a. No crop.....	0.03-0.04	
b. Mature row crops.....	0.035-0.045	
c. Mature field crops.....	0.04-0.05	
d. Heavy weeds, scattered brush.....	0.05-0.07	
3. Light brush and trees: ¹⁰		
a. Winter.....	0.05-0.06	
b. Summer.....	0.06-0.08	
4. Medium to dense brush: ¹⁰		
a. Winter.....	0.07-0.11	
b. Summer.....	0.10-0.16	
5. Dense willows, summer, not bent over by current.....		
	0.15-0.20	
6. Cleared land with tree stumps, 100-150 per acre:		
a. No sprouts.....	0.04-0.05	
b. With heavy growth of sprouts.....	0.06-0.08	
7. Heavy stand of timber, a few down trees, little undergrowth:		
a. Flood depth below branches.....	0.10-0.12	
b. Flood depth reaches branches.....	0.12-0.16	
C. Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follow recommendation in publication cited ⁸ if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of.....		
	0.028-0.033	

Footnotes to table 1 appear at the top of page 101.

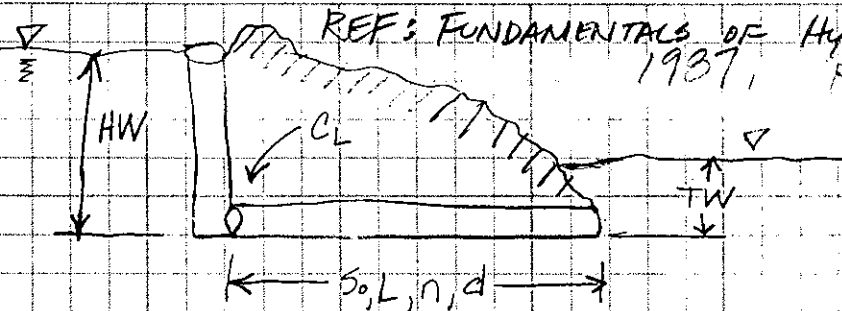


PROFESSIONAL ENGINEERING CONSULTANTS
 PROFESSIONAL ASSOCIATION
 303 S. TOPEKA
 WICHITA, KANSAS
 ZIP CODE 67202

Date 5/24/97 PDM Page of

Project Outlet Control for Culvert Analysis

Item for PNDRTING . XLS



REF: FUNDAMENTALS OF HYDRAULIC ENGINEERING, A.L. PRASUN
 1937, P. 432-451

Outlet Control is based on ENERGY Balance between inflow & outflow configurations.

$$HW + S_o L + \frac{V_o^2}{2g} = TW + H_L$$

$$HW + S_o L + \frac{(Q_1)^2}{2g A_1^2} = TW + \left(C_L + 1 + \frac{gn^2 L}{1.49 R^{4/3}} \right) \frac{8 Q_2^2}{\pi^2 D^4}$$

Solve for Q_2

$$HW - TW + S_o L + \frac{(Q_1)^2}{2g A_1^2}$$

$$= Q_2^2$$

$R = \frac{D}{4}$ for ϕ pipe

$$\left(C_L + 1 + \frac{gn^2 L}{1.49 R^{4/3}} \right) \frac{8}{\pi^2 D^4}$$

$$Q_2 = \sqrt{\frac{HW - TW + S_o L + \frac{(Q_1)^2}{2g A_1^2}}{\left(C_L + 1 + \frac{gn^2 L}{1.49 \left(\frac{D}{4}\right)^{4/3}} \right) \frac{8}{\pi^2 D^4}}}$$

$$\left(0.21 - 0.02 \right) - (0.12 - 0.13) + \frac{(0.15 \times 0.14)}{100} + \frac{\left[\frac{0.21}{(1.0 \times (0.8/12)^2)} \right]^2}{64.4}$$

$$\left[1 + 0.17 + \frac{32.2 (0.16)^2 (0.14)}{1.11 \left(\frac{0.8/12}{4}\right)^{4/3}} \right] \frac{8}{(4.11)^2 (32.2) (0.8/12)^4}$$



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WICHITA, KANSAS
ZIP CODE 67202

Date 8/25/97 PDM Page _____ of _____

Project INLET CONTROL FOR CULVERT ANALYSIS

Item FOR PDM-V5.1, XLS

REF: HDS #5 - HYDRAULIC DESIGN OF HIGHWAY CULVERTS
P. 145-146 ©1985

EQN # 27 SERVES FOR UNSUBMERGED CONDITIONS

THIS CALCULATION FOR ϕ PIPES ONLY!

ϕ ASSUMES THE OUTFALL CULVERT WILL
HAVE A END SECTION IF NO STAND PIPE
IS USED. (M=0.60, K=0.525)

$$\frac{HW}{d} = 0.525 \left[\frac{Q}{A d^{0.5}} \right]^{0.6}$$

① SOLVE FOR Q.

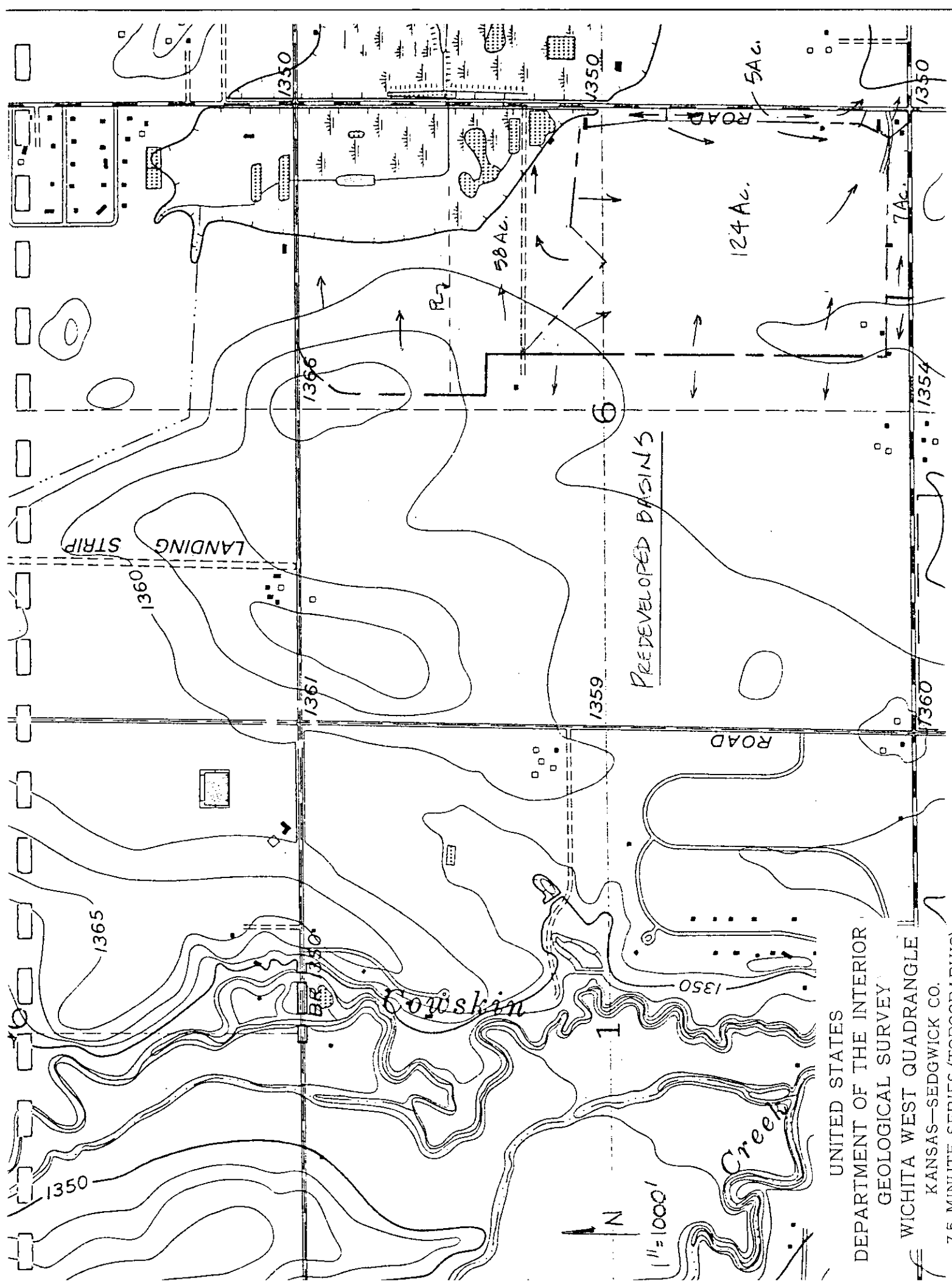
$$Q = A \sqrt{d} \left(\frac{1.9 HW}{d} \right)^{1.67}$$

$$Q = \left[\pi \left(\frac{HB}{12} \right)^2 \right] \left(\frac{HB}{12} \right)^{0.5} \left(\frac{1.9 (B-21 - H_9)}{\left(\frac{HB}{12} \right)} \right)^{1.67}$$

② FOR STAND PIPES & SUBMERGED CULVERTS THE ORIFICE

EQUATION SHALL GOVERN $Q = CA (2gH)^{0.5}$

TO DETERMINE INLET CONTROL REQUIREMENTS.

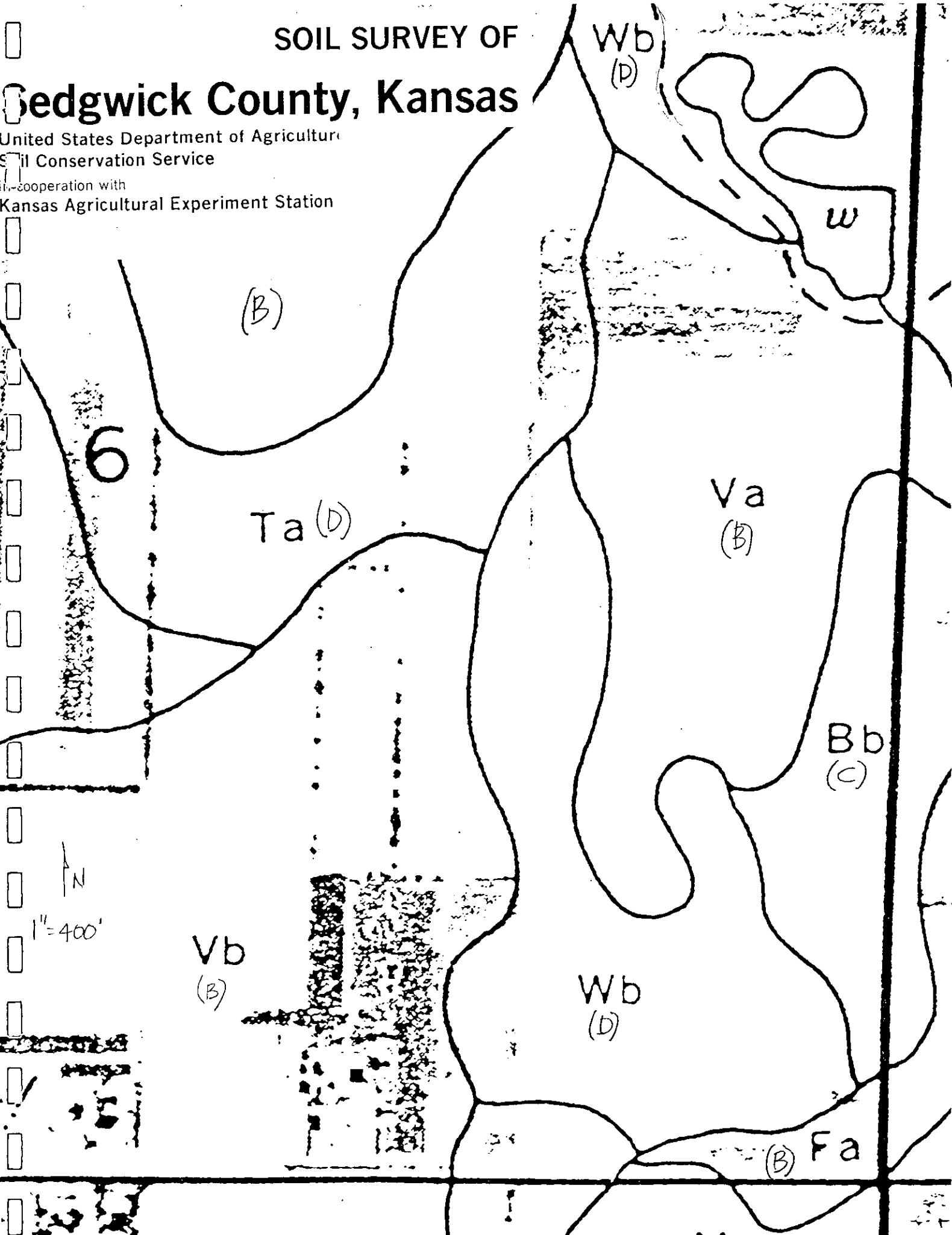


UNITED STATES
 DEPARTMENT OF THE INTERIOR
 GEOLOGICAL SURVEY
 WICHITA WEST QUADRANGLE
 KANSAS—SEDGWICK CO.
 7.5 MINUTE SERIES (TOPOGRAPHIC)

SOIL SURVEY OF

Sedgwick County, Kansas

United States Department of Agriculture
Soil Conservation Service
in cooperation with
Kansas Agricultural Experiment Station



FIRM

FLOOD INSURANCE RATE MAP

SEDGWICK,
COUNTY,
KANSAS
(UNINCORPORATED AREAS)

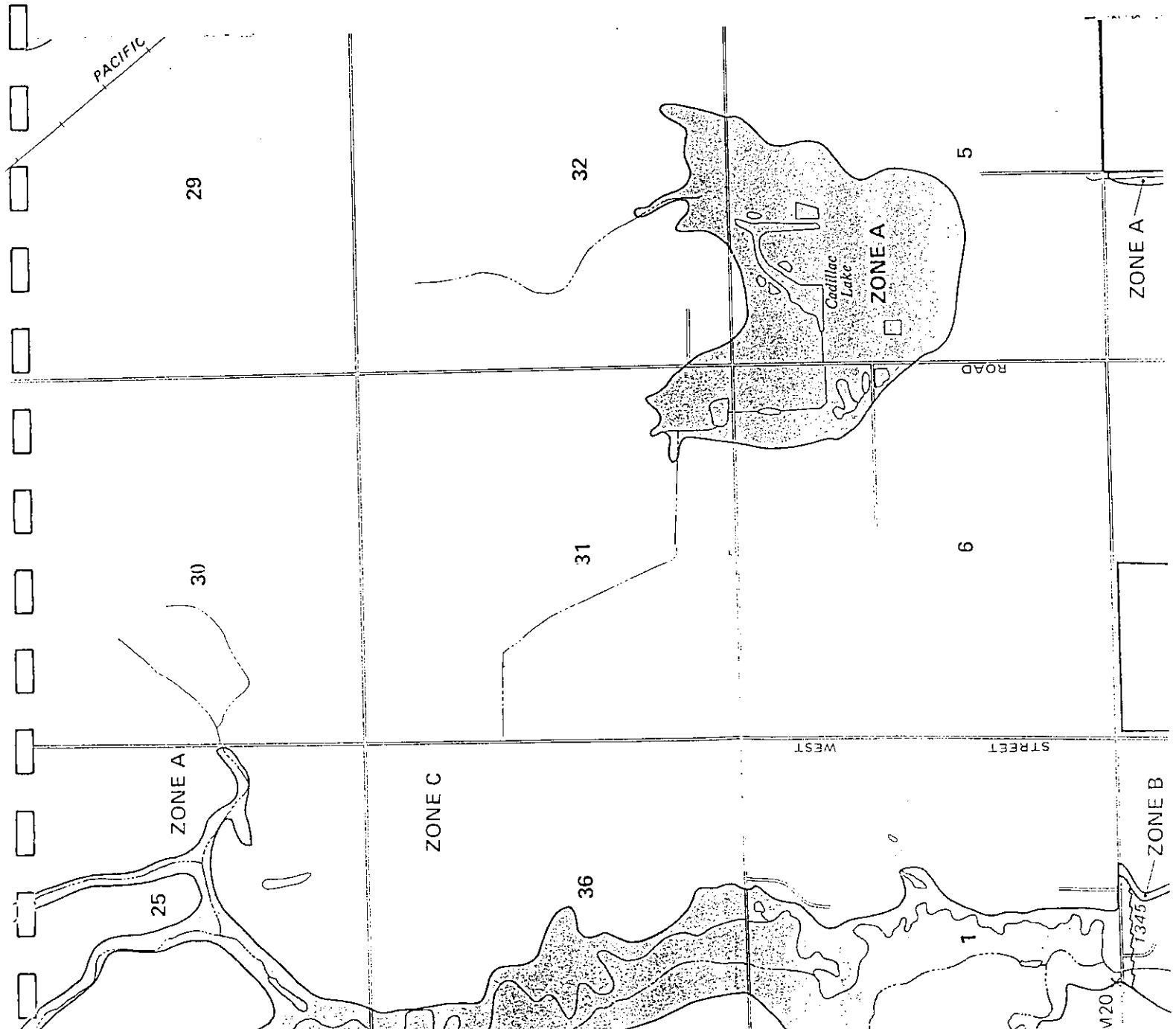
PANEL 125 OF 300

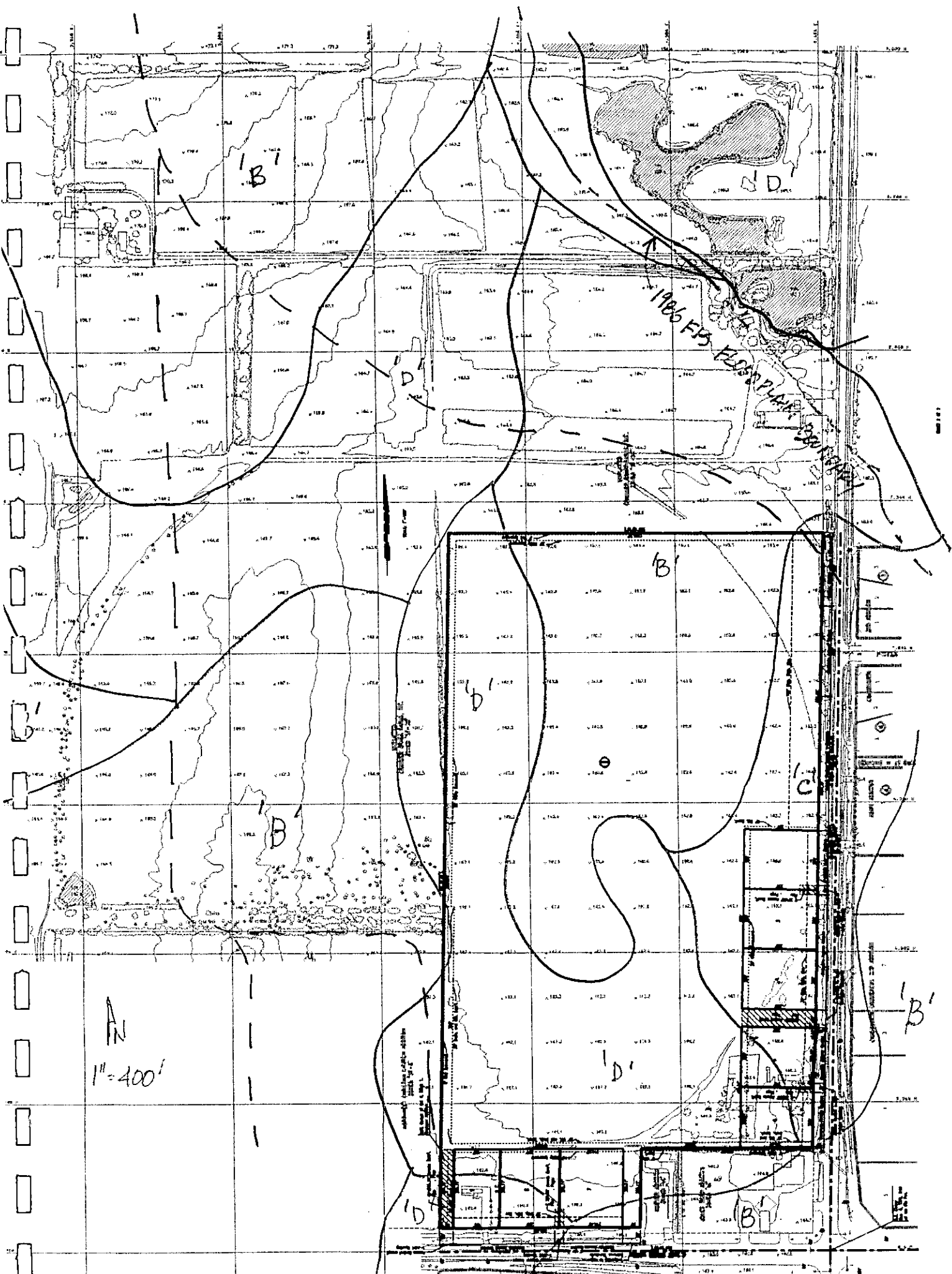
COMMUNITY-PANEL NUMBER
200321 0125 A

EFFECTIVE DATE:
JUNE 3, 1986



Federal Emergency Management Agency





A
1" = 400'

1986 FFS FLOOD PLAN

B

D

D

B

B

C

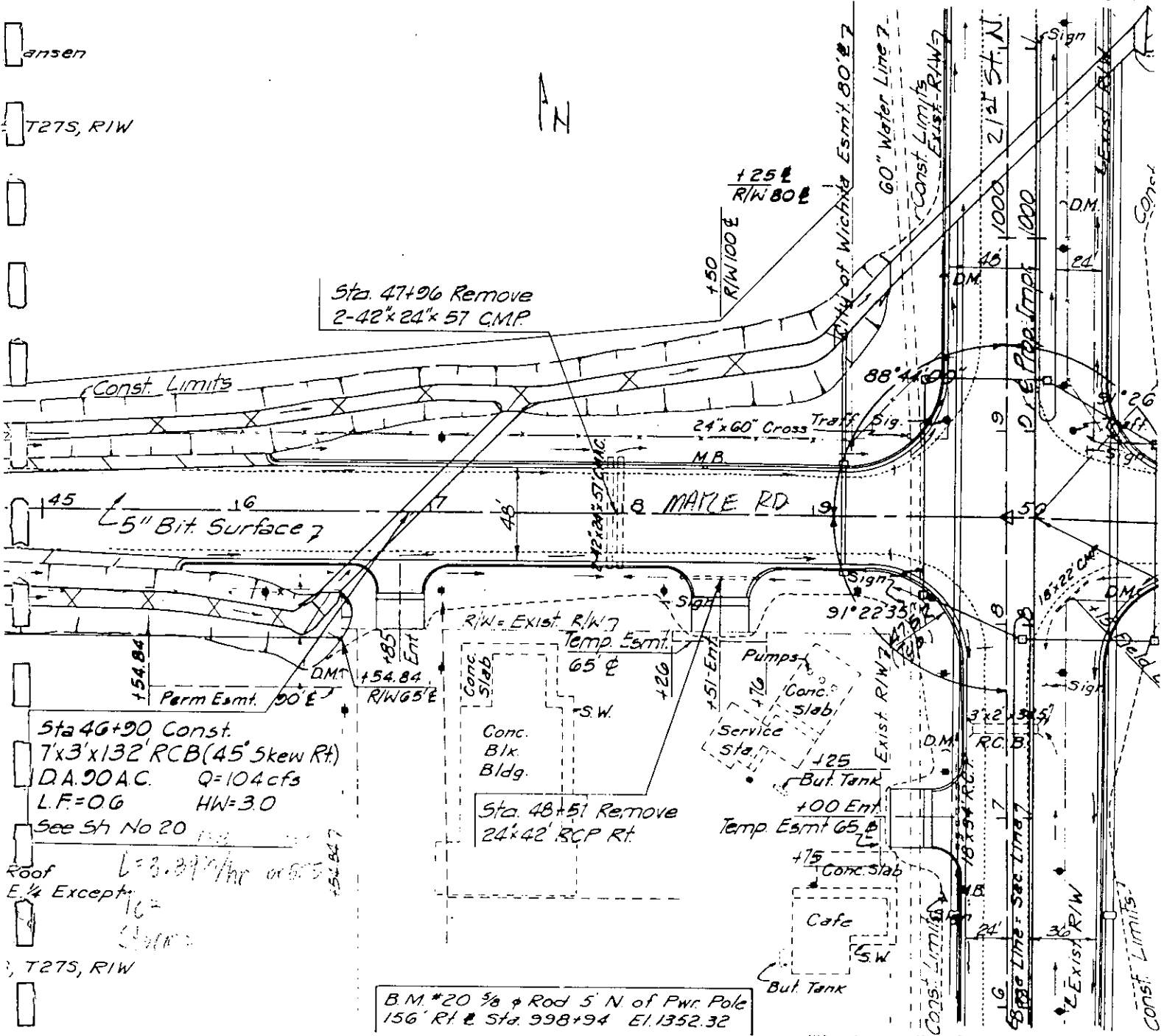
B

B

B

D

ansen
T27S, RIW



Sta. 47+96 Remove
2-42'x24'x57 CMP

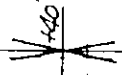
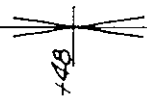
Sta 46+90 Const.
7x3'x132' RCB (45° skew Rt)
D.A. 90 AC Q=104 cfs
L.F.=OG HW=3.0
See Sh No 20

Sta. 48+51 Remove
24'x42' RCP Rt.

B.M. #20 3/8 & Rod 5' N of Pwr. Pole
156' Rt @ Sta. 998+94 El. 1352.32

Roof
E 1/4 Except
T27S, RIW

No Dt. Lt
No Dt. Rt



No D

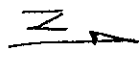
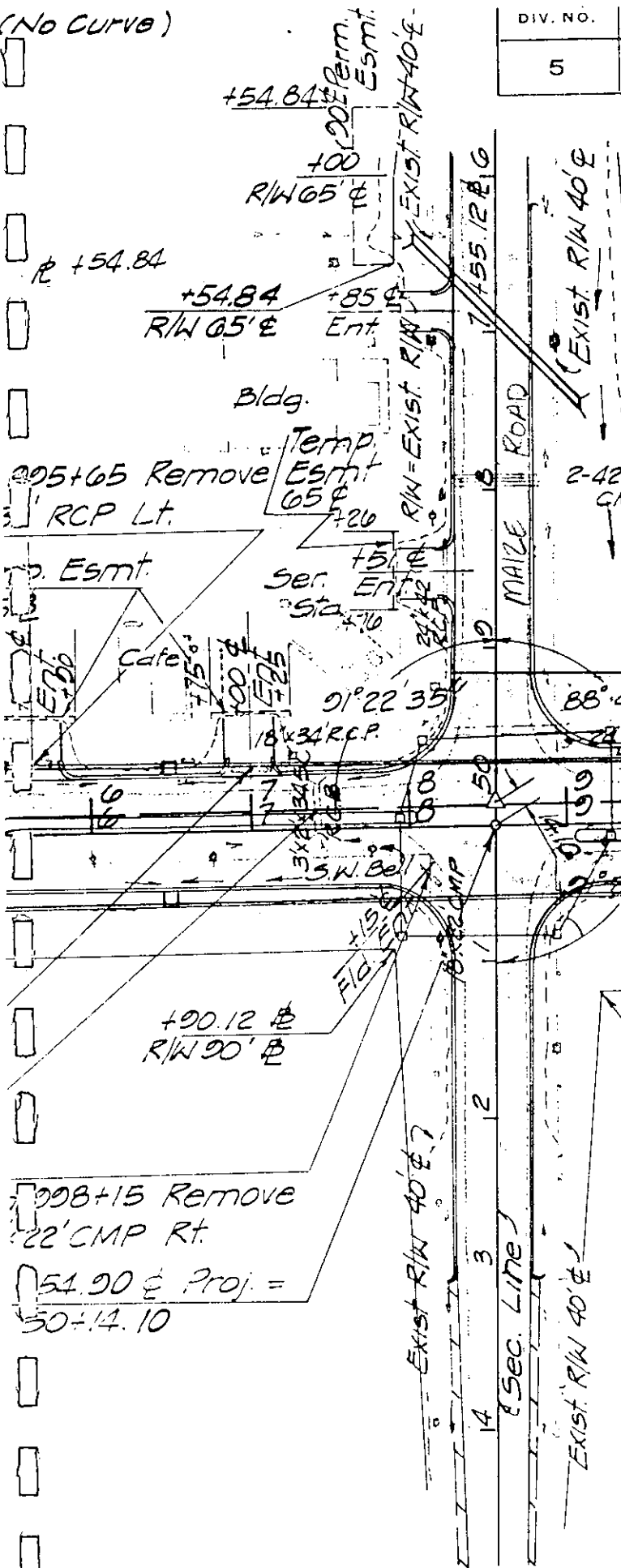
(NO CURVES)

DIV. NO.	NO.	YEAR	NO.	SHEETS
5	KANSAS 87RS-428(18)	1973	4	61

Sec. 5, T27S, R1W

Wm. Jansen

Sta. 1000+55 Const.
 8x3x177' RCB Special
 (45° skew Lt.) With Apron Rt
 D.A=102 Ac. Q=112 cfs.
 L.F=0.6 H.W=2.8'
 See Sh No 26



City of Wichita Water Es

Cons. Exist. R/W 30' E

12th St. 2' 3' 3'
 Exist R/W 30' E

(Const. Limits

R/W 120' E

+20.12 E
 R/W 120' E

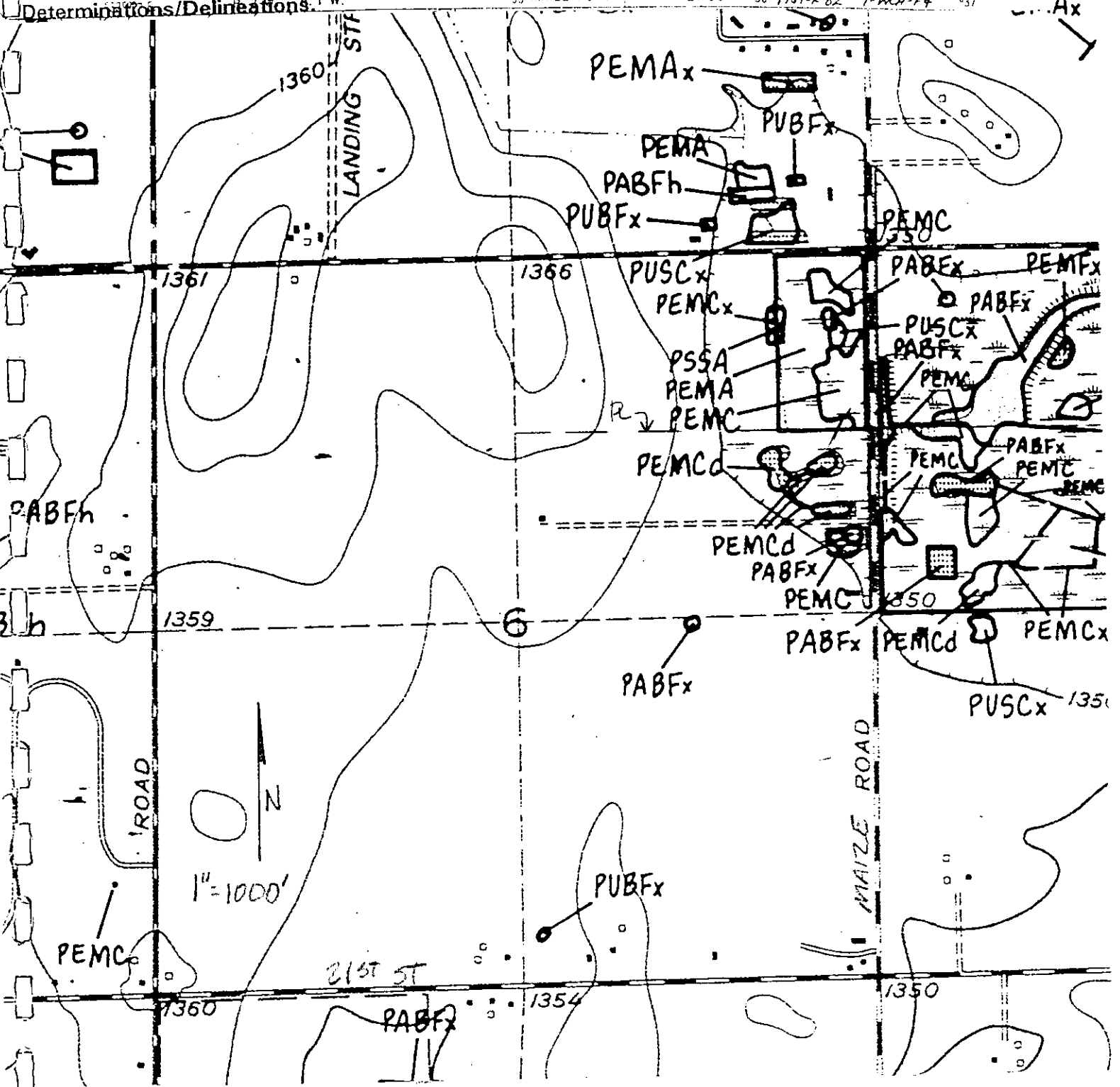
Sta. 1001+00 to Sta. 1001+47
 Const. 147.9 Sq. Yds Conc. Cult.
 Ditch Lining Rt.
 See Sh. No 20, 31 & 41

Josephine Weber Sec. 8, T27S, R1W

- S.W. Cor. Sec. 5, T27S, R1W
- 1. 5/8" Iron Bar in Thimble at Cor.
- 2. X" on RCB 114.0' W.N.W.
- 3. X" on RCB 114.0' W.S.W.
- 4. 3 Nails in φ 95.8' S.W.
- 5. 3 Nails in φ 86.44' S.W.

20 5/8" φ Rod 5' N. of Power Pole
 Sta. 998+94 EI 1352.32

National Wetland Inventory maps are not valid for Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA); Section 404 of Clean Water Act, and Subtitle B of the Food Security Act for Wetland Determinations/Delineations. 1 W. 27'30" 136 1961-R'82 1-WCH-FF 437



SH 1 OF 2
SEE LEGEND ON SH. 2 OF 2

HYDROLOGIC STUDY FOR
PRACHT WETLAND

SEDGWICK COUNTY, KANSAS

FEBRUARY 1994

PREFACE

This report documents the hydrological analysis of the Pracht Wetland; locally known as Cadillac Lake. The study was conducted for various parties who are interested in the wetland's management. The parties include landowners and county, city, state, and federal agencies. Pracht Wetland is located in Sedgwick County, Kansas adjacent to the City of Wichita. The wetland is essentially bordered on the west by Maize Road and on the north by 29th Street. Residential subdivisions border the wetland to the south with future residential development anticipated for the croplands to the east.

Soil Conservation Service (SCS) maps, aerial photographs, topographic surveys, and the United States Geological Survey (USGS) topographic maps were used to establish the parameters in determining the "Cadillac Lake" hydrologic model. The parameters were then used in the HEC-1 model to determine the peak flows and the maximum water surface elevations for 2, 5, 10, and 100-year, 6-hour storm frequencies. Table 1 shows the peak inflows and outflows, and water surface elevation for each frequency event.

<u>Event Frequency</u>	<u>Peak Inflow (cfs)</u>	<u>Peak Outflow (cfs)</u>	<u>Max. Water Elev.</u>
2	149	96	1347.52
5	348	119	1348.26
10	492	134	1348.73
100	934	221	1350.15

Table 1. Summary of Hydrologic Analysis

Outflows occur through 2 - 36 inch RCP culverts into the Chadsworth development to the south. Overland outflows also begin to occur prior to elevation 1350.15; however, this analysis assumes that overland flows are contained and outflow is limited through the culverts.

TABLE OF CONTENTS

Preface.....	i
Introduction.....	1
Investigation and Analysis.....	1
Summary.....	

Appendices

- ~~Appendix A: Aerial Photograph~~ - *Shows Basin Delineations* - NOT AVAILABLE FROM NRCS, SCCS
- Appendix B: Topographic Map - Acquired SCEPS, 2011
- Appendix C: Soil Conservation Service Map - Acquired OR Baughman Co.
- Appendix D: HEC-1 Input and Output Data - Acquired
- Appendix E: HEC-1 Hydrographs - Acquired

INTRODUCTION

The hydrologic study of the Pracht Wetland was performed in order to establish a basis for the design, development, preservation, and management of the wetland for recreation, environmental education, and other potential uses. The project is headed by the Precht Wetland Task Force which was formed in June of 1992. The Precht Wetland Task Force includes landowners and county, city, state, and federal agencies.

INVESTIGATION and ANALYSIS

The HEC-1 computer model was used to analyze the hydrologic response of Cadillac Lake to the 2, 5, 10, and 100-year, 6-hour storm frequencies. Analysis included determination of the watershed area (2050 acres), SCS soil types (54% B, 16% C and 30%D), and water surface elevation versus both area and storage volume. Table 2 shows the peak inflow, peak outflow, and water surface elevation for each frequency.

<u>Event Frequency</u>	<u>Peak Inflow (cfs)</u>	<u>Peak Outflow (cfs)</u>	<u>Max. Water Elev.</u>
2	149	96	1347.52
5	348	119	1348.26
10	492	134	1348.73
100	934	221	1350.15

Table 2. Summary of Hydrologic Analysis

6 hour storm !

The analysis began with a topographic map prepared from an aerial photograph taken April 26, 1993. The storage volume and surface area of the lake was determined for the NW quarter, Section 5, R27 W1. The map was drawn to a scale of 1 inch equal 100 feet, with a contour interval of 2 feet. Unfortunately, this contour interval did not permit the standard method of finding areas within each closed contour. Instead, ground control "shots" were assumed representative of the surrounding 22,500 sq. ft. after noting that ground control for the aerial survey had been established on a 150 foot grid. The same assumption is used when estimating average precipitation depth by the Thiessen network method. Where ground control was missing, surrounding shots were used to

estimate the missing data. The topographic map used in this analysis can be found in Appendix A.

Both surface area and storage volume were determined at 0.1 foot intervals. The resulting values are shown in Table 3. Although Table 3 indicates surface elevations exceeding 1350, water will begin to flow off of the quarter section at lesser elevations.

<u>Elevation</u> <u>(NGVD)</u>	<u>Surface Area</u> <u>(acres)</u>	<u>Volume</u> <u>(acre-ft)</u>	<u>Elevation</u> <u>(NGVD)</u>	<u>Surface Area</u> <u>(acres)</u>	<u>Volume</u> <u>(acre-ft)</u>
1346.1	*0	*0	1348.8	126.0	161.1
1346.2	1.5	0.2	1348.9	129.1	174.0
1346.3	3.6	0.5	1349.0	129.6	187.0
1346.4	4.6	1.0	1349.1	130.7	200.0
1346.5	7.7	1.8	1349.2	132.7	213.3
1346.6	9.3	2.7	1349.3	135.3	226.9
1346.7	11.4	3.8	1349.4	136.4	240.5
1346.8	15.0	5.3	1349.5	137.4	254.2
1346.9	18.1	7.1	1349.6	140.0	268.2
1347.0	21.7	9.3	1349.7	141.0	282.3
1347.1	25.3	11.8	1349.8	141.0	296.4
1347.2	26.9	14.5	1349.9	141.0	310.5
1347.3	29.4	17.5	1350.0	142.0	324.7
1347.4	38.7	21.3	1350.1	142.6	339.0
1347.5	54.8	26.8	1350.2	143.6	353.4
1347.6	68.2	33.6	1350.3	144.6	367.8
1347.7	74.9	41.1	1350.4	145.1	382.3
1347.8	83.7	49.5	1350.5	145.7	396.9
1347.9	87.8	58.3	1350.6	146.2	411.5
1348.0	93.0	67.6	1350.7	146.2	426.1
1348.1	100.2	77.6	1350.8	146.2	440.8
1348.2	111.1	88.7	1350.9	147.7	455.5
1348.3	115.2	100.2	1351.0	148.2	470.4
1348.4	117.8	112.0	1351.1	148.2	485.2
1348.5	118.8	123.9	1351.2	148.8	500.1
1348.6	121.9	136.1	1351.3	148.8	514.9
1348.7	124.5	148.5			

*Does not include areas inundated by water at time aerial photos were taken.

Table 3. Data from Topographic Map

For the purpose of this analysis, flow off-site was assumed to be restricted to 2 - 36 inch RCP culverts located at the southern border of the wetland. Volumes below the water surface elevations shown on the topographic map are not included in the calculated volume values in Table 3. Areas do include the existing pond water surface areas. Numerous ponds were present when the aerial photographs were taken. Pool water levels were as low as 1346.1 and as high as 1347.4.

The watershed was delineated on a USGS 7 1/2 minute topographic map with a contour interval of 5 feet. The watershed is located in parts of Sections 29, 30, 31 and 32 of R26 W1; Section 36 of R26 W2; and Sections 4, 5 and 6, R27 W1. Total area of the watershed was estimated to be 2,050 acres.

The SCS soils maps for Sedgwick County were consulted to determine the soil types existing in the watershed. The watershed is primarily agricultural land, but includes the City of Maize. The soil types and the corresponding hydrologic classifications are shown in Table 4. A copy of the soils map is located in Appendix C. The watershed was transferred approximately from the USGS 7 1/2 minute topographic map and the fraction of each soil type within the watershed was found. A composite SCS Curve Number of 80 was determined based on agricultural land use.

<u>Soil Description</u>	<u>Hydrologic Type</u>
Blanket Silt Loam, 0-1% slope	C
Blanket Silt Loam, 1-3% slope	C
Carwile Fine Sandy Loam	D
Farnum Loam, 0-1% slope	B
Farnum Loam, 1-3% slope	B
Milan Loam, 1-3% slope	B
Shellabarger Sandy Loam, 1-3% slope	B
Tabler Silty Clay	D
Vanuss Silt Loam, 0-1% slope	B
Vanuss Silt Loam, 1-3% slope	B
Waurika Silt Loam	D

Table 4. Hydrologic Classification of Soils in Watershed

The primary inflow into the Pracht Wetland occurs through a 36-inch RCP from the west side of Maize Road. A storage volume upstream from the pipe was

determined from a topographic map and the flow was routed through the storage using the 36-inch RCP culvert. Other sources of inflow, mostly overland flow, were also considered in the analysis.

Analysis of outflow from the Pracht Wetland was limited to the two 36-inch RCP into the Chadsworth development. The HY8 program model was used to derive a rating curve for the two pipes, including flow over the roadway. Results of the rating curve analysis are indicated on the following page in Table 5.

<u>Water Surface Elevation</u>	<u>Total Flow (cfs)</u>	<u>Flow Over Roadway (cfs)</u>
1344.45	0	0
1346.08	45	0
1347.01	90	0
1347.83	135	0
1349.68	180	0
1350.67	225	24
1350.79	250	46
1351.05	315	104

Table 5. Rating Curve for 2 - 36-inch RCP Culverts

SUMMARY

The study was limited to the quarter section intended to become wetlands and to approximately 40 acres on the west side of Maize Road. The HEC-1 model considered the area west of Maize Road as one sub-watershed and the area to the east of Maize Road as another sub-watershed. The model assumes that water is available for outflow as soon as it enters the wetlands area. This may not be true, however, as there are numerous pot holds which must fill before the water wends to the outlet. Input, output, and hydrographs generated by HEC-1 can be found in Appendices D and E.

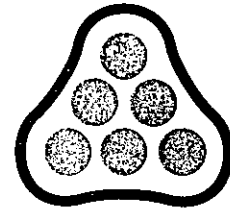
Finally, the results of the study are only as good as the topographic data. As described earlier, there were not enough contour lines on the map to use the standard approach for determining storage volumes. The method used to determine the storage volumes produced the most accurate results attainable with the available data.

August 14, 1997

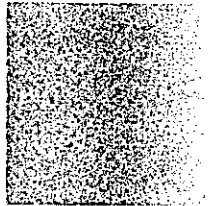
Baughman Company, P.A.
315 Ellis
Wichita, KS 67211

Attention: Mr. Jeff Bradley

Reference: 21st & Maize Drainage
COW # 472-76-245-81815
COW # 472-76-245-82191
COW # 472-76-245-82273
COW # 472-76-245-82366
COW # 472-76-245-82615
PEC # 36-97763-3104



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ENGINEERING
CONSULTANTS
PROFESSIONAL ASSOCIATION



Dear Mr. Bradley:

Thank you for being so cooperative in providing information about the hydrology near 21st and Maize Road. As discussed in our conversation on August 13, 1997, PEC will make the following assumptions for the 7'x3' RCB and subsequent extension of the 8'x3' RCB along 21st Street in lieu of more definitive information.

1. The pre-developed flow rate and associated pre-developed drainage basin at the upstream end of the 7'x3' RCB will control the size of our proposed detention pond on the Cramner Property.
2. The pre-developed 25 year flow rate from the drainage area northwest of the reference intersection has been considered in the culvert extension and will cause the 7'x3' culvert to flow with a hydraulic grade line of 161.72 city datum or top of the culvert.
3. The area used for the proposed 30" PVC storm sewer in Maize Road is consistent with strip development.

If you have any additional information to aid in our analysis, questions or comments please contact our office at your convenience at (316) 262-2691.

Very truly yours,

PROFESSIONAL ENGINEERING CONSULTANTS, P.A.

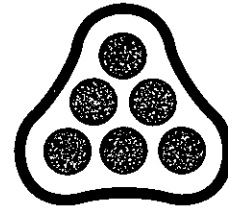
Paul D. Miller, I.E.
Design Engineer
Land Development Division

August 29, 1997

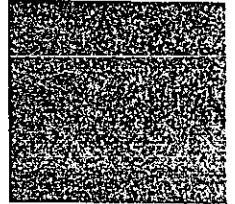
City of Wichita
455 N. Main
Wichita, KS 67211

Attention: Mr. Larry Schaler

Reference: 21st & Maize Drainage
COW # 472-76-245-81815
COW # 472-76-245-82191
COW # 472-76-245-82273
COW # 472-76-245-82366
COW # 472-76-245-82615
PEC # 36-97763-3104



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ENGINEERING
CONSULTANTS
PROFESSIONAL ASSOCIATION



Dear Mr. Schaler:

As discussed in our telephone conversation on August 29, 1997 about 21st and Maize Road, please lower the flow line on the 18" PVC SWS at Sta 7+00.2 of Line #7 to an elevation of 160.45. This change will put the pipe on 0.5% grade for 59' and aid in draining the existing church nearby as future development occurs between there and Maize Road along 21st Street.

If you have any questions or comments please contact our office at your convenience at (316) 262-2691.

Very truly yours,

PROFESSIONAL ENGINEERING CONSULTANTS, P.A.

Paul D. Miller, I.E.
Design Engineer
Land Development Division

DIRECTORS: / D.E. MALTBIE, P.E. / W.H. KELTNER, P.E. / R.D. PLETCHER, P.E. / M.D. SCHOMAKER, P.E. / G.D. SCHOCK, P.E.
J.H. BAILEY, P.E., PH.D. / D.I. NORTON, P.E. / B.E. REMSBERG, P.E. / G.K. GREENWOOD, P.E. / D.E. HAGER, P.E.
ASSOCIATE DIRECTORS: / G.L. ADAMS, P.E. / M.W. BERRY, P.E.

303 S. TOPEKA
WICHITA, KANSAS 67202
(316) 262-2691
FAX (316) 262-3003

NEW MARKET SQUARE - DRAINAGE

8/11/97 PDM

(A) PRIMARY OUTLET - 7'x3' RCB.

FROM Phase IV PLANS 87C-0943-01
PEC 30-77221-24

DA = 90 AC, Q = 104 cfs
HW = 3.0'

(B) TIED 8'x3' RCB ACROSS 21ST
FROM 87RS-428(18)
PEC 30-70098-24

DA = 102 AC Q = 112 cfs
HW = 2.8'

NOW EXTENDED 8'x3' 1530' E TO Timber Ridge Add.
ALSO CLOSED IN BETWEEN 7'x3' & 8'x3' @ INTERSECTION
OF MARIE & 21ST (NE CORNER) FOR ABOUT 200'

#1) DESIGN STORM FOR THESE CULVERTS WERE ORIGINALLY
25 YEARS. BY THE LAND FACTOR METHOD.

#2) SEVERAL SWS HAVE BEEN ADDED INTO
7'x3' BOX, LIMITING ITS CAPACITY
TO THE CRAMER SITE.

THE AFFECTS OF DOING SUCH
TO THE HYDRAULIC GRADE LINE
ARE UNKNOWN, BECAUSE NO HYDRAULIC
ANALYSIS IS AVAILABLE ON THE PROPOSED
1530' 8'x3' CULVERT EXTENSION.

#3) MAPPED D.A. FOR 7'x3' RCB IS
MORE ACCURATELY 124 ACRES FROM MOICE
DETAILED SURVEY, COUNTY DRAINAGE MAPS & USGS.

8/11/97
PDM

A) FIND CAPACITY OF 7'x3' RCB BY BACKWARD ANALYSIS OF CUMULATIVE DRAINAGE

AREAS, FLOWRATES & MAXIMUM CAPACITIES.

- START @ North PART OF MAIZE ROAD WORKING SOUTH.

	AREA(Ac)	Q ₅ (cfs)	Q ₁₀₀ (cfs)	DESCRIPTION
W	1.65	6.8	10.9	NW SW5 @ 2-15" DIP (MAIZE)
	0.94	3.9	6.2	NE " "
	1.90	7.8	12.6	12" PVC FROM AGAPE ADD
	0.67	2.7	4.4	" "
W	1.30	5.3	8.6	15" DIP W MAIZE
	1.00	4.1	6.6	" " E MAIZE
	3.70	15.2	24.5	18" RCP E MAIZE CHADSWORTH COM.
	<u>Σ = 11.16 Ac</u>	<u>45.8 cfs</u>	<u>73.8 cfs</u>	@ N.L. of CRANNER Addition

24" PVC MUST CONVEY
MAX CAPACITY = Q = K_s V³
S = .10% n = .01

$$Q = 294 \sqrt{.001}$$

$$Q = 9.3 \text{ cfs}$$

SAY 12 cfs
WITH HEAD
IN PIPE & AT INLETS

8/11/97 PDM

A) CONT' SOUTH OF N.L. @ CRAMNER Addition.

AREA (Ac)	Q ₅ (cfs)	Q ₁₀₀ (cfs)	DESCRIPTION
11.16	12	STREET FLOW	FROM 24" PVC (N)
1.68	6.9	11.1	MAX CAPACITY
1.40	5.7	9.3	} MAIZE ROAD 15" OIP
3.43	14.1	22.8	
4.02	16.5	26.7	Lot 2 Chadsworth 18" RCP
			Lot 4 " " 18" RCP
<u>Σ 21.69</u>	<u>55.2</u>	STREET	<u>TOTAL FROM MAIZE 30" PVC</u>

West Side
= 4.63

Added DRAINAGE AREA
= 21.69 - 4.63 = 17.06 Ac

MAX PIPE CAPACITY
30" PVC
n = .01 S = 0.01%
Q = 533 √(0.0007) = 14.1

SAY 18 cfs
for added head
due to street
& INLET FLOODING.

∴ THE CAPACITY OF THE ORIGINAL 7x3' RCB
has been REDUCED by : 1) ENLARGING
THE DRAINAGE AREA BY 17 ACRES
2) MAGNIFYING THE BACKWATER EFFECTS BY
ENCLOSING THE FLOW FOR AN
ADDITIONAL 1530' FT. (INCREASE FRICTION
LOSS.)

3) DECREASING THE ALLOWABLE FLOW AT THE UPSTREAM
END BY AN ESTIMATED 7.0 CFS

CONCLUSION

8/11/07 PDW

1) NEW ESTIMATED CAPACITY OF 7'x3' RCB

$$104 - 20 - 10 = \underline{74 \text{ cfs}} \text{ for 25 year Storm}$$

↑ ORIGINAL Q when full
↑ PROP 30" PVC
↑ UNKNOWN BACKWATER FROM 8'x3' RCB EXTENTION
↑ MAX FLOW FROM CRAMMER BASIN TO MAKE 7'x3' RCB FULL

2) ALL AREA ADDED TO THE PROP 30" PVC SHOULD BE DETAINED OR NOT UTILIZED AT ALL & DIRECTED TOWARD POND. SINCE PIPE CAPACITY IS MAXED FOR < Q5, ALONG MAIZE ROAD.

3) PROPOSE LARGER CULVERT ENTIRE LENGTH OF MAIZE ROAD & REPLACEMENT OF MAIN TRUNK LINE (8'x3' / 7'x3' COMBO) ALONG 21ST ST. WITH 2 - 7'x3' OR BIGGER. (ESTIMATED)

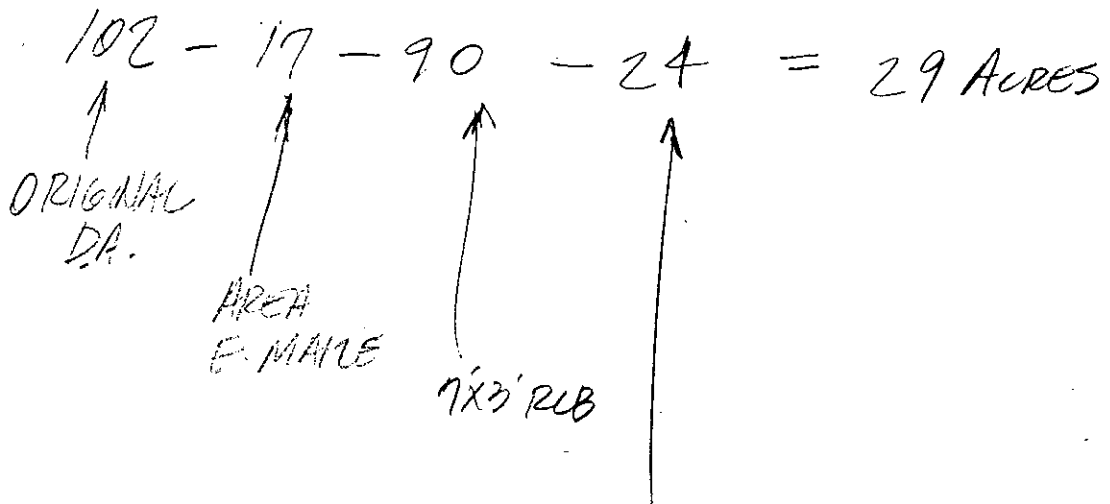
4) ANALYZE POND FOR MAX Q of 75 cfs for 25 year Storm with 3' of HEAD ON 7'x3' RCB.

5) USE EXIST RIDGE ON 21ST (E) OR MAIZE Rd (S) AS BASIS FOR MIN. PAD ELEVATIONS. & MAX HEAD ON OUTLET 7'x3' RCB OR POND OUTFLOW PIPE.

B) 8'x3' RCB ACROSS 21ST E/W/M PDM

This Box has a similar dilemma in that the DRAINAGE BASIN WAS ORIGINALLY 102 AC WITH A MAX Q OF 112 cfs FLOWING 90% FULL.

#1) THE BASIN HAS BEEN INCREASED BY AT LEAST 25 AC FROM SWS BEING ADDED DUE TO SURROUNDING DEVELOPMENT.



#2) THE SAME BOX HAS BEEN EXTENDED 1330 FT EAST ON 0.11% GRADE. 21ST SWS SYSTEMS

A QUICK CALC FOR ITS DEVELOPED CAPACITY (25 yr)

$$Q = \frac{1.49 (24)^{5/3}}{0.13 (25)^{2/3}} (.0011)^{1/2} = 89 \text{ cfs}$$

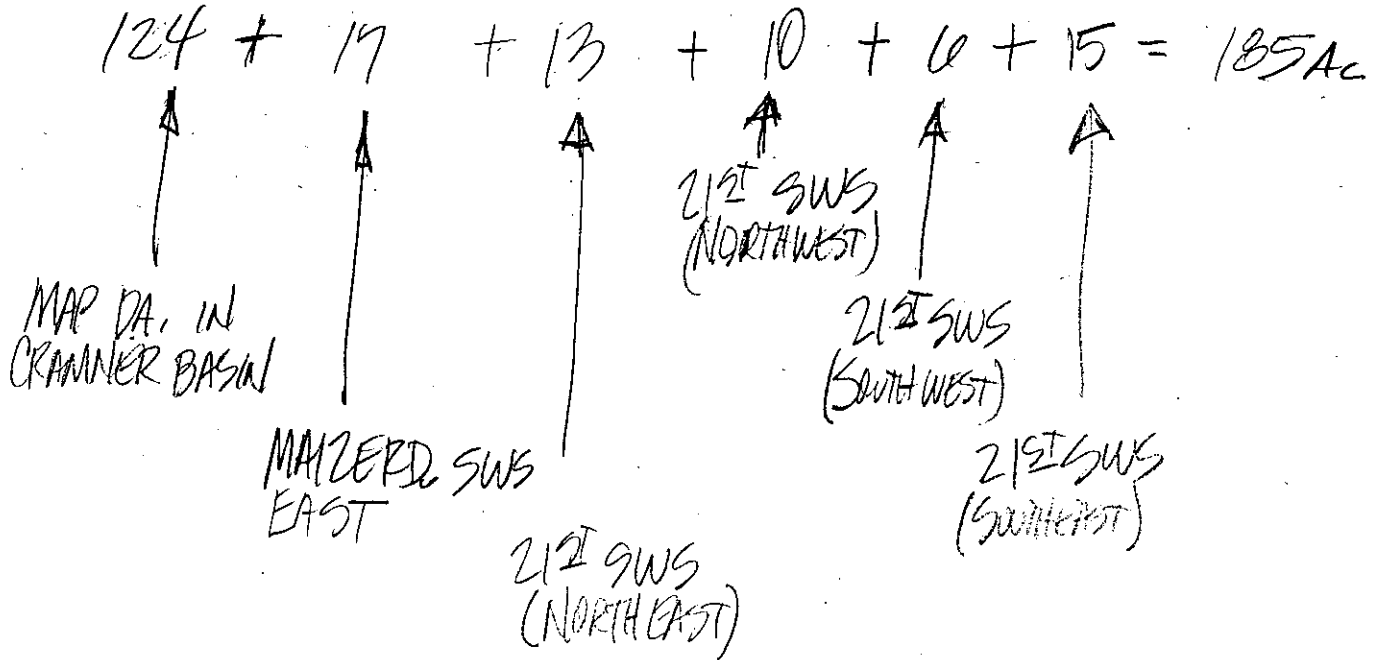
Estimated $T_c = 40 \text{ min}$
 $C = 3.76 \text{ in/hr}$

$$A = \frac{Q}{C} = \frac{89}{(0.85)(3.76)} = 28 \text{ Acres}$$

B) CONCLUSION: 8'x3' RCB EXTENSION 8/11/97 PDM

DEVELOPED D.A. ALLOWED FOR 8'x3'
RCB 15 30 ACRES.

CURRENT DA IS:



* RECOMMEND LARGER SECTION PARTICULARLY LONG EXTENSION.

ANALYZED CRAMNER SITE AS IF 75 cfs CAN SAFELY PASS THROUGH RCB'S. THAT 75 cfs WILL CAUSE 3' OF HEAD TO DEVELOP. AT INLET OF 7'x3' - TRY ALTERNATES WITH OVERFLOWS DIRECTED TOWARD CATALAWA LAKE BASIN & 21ST ST. OVERFLOWS.

ANALYZE WITH PREDEVELOPED Q FOR ORIGINAL GOAL: BASIN. WITH SAME ASSUMPTION AS IN ① EXCEPT Q₂₅.

RETAIN 100% OF THE 100 YEAR STORM & DISCHARGE THROUGH SMALL PIPE. PUMP DOWN W/ STORMWATER PUMP TO INCREASE STORAGE CAPACITY & DECREASE SITE

3-20 P
12800004
SETTLER

SURFACE WATER DRAINAGE EASEMENT

WHEREAS, Cranmer Grass Farms, Inc. is the owner of Tract 1, described as follows:

That part of the S.E. 1/4 of the S.E. 1/4 of Section 6, T.27 S., R.1 W. of the 6th P.M., Sedgwick County, Kansas lying North and West of CRANMER ADDITION, Sedgwick County, Kansas.

AND WHEREAS, Northwest Christian Church, a Corporation, is the owner of land being platted as NORTHWEST CHRISTIAN CHURCH ADDITION, Sedgwick County, Kansas, said platted land hereinafter referred to as Tract 2, being described as follows:

Beginning at the S.E. corner of the W. 1/2 of the S.E. 1/4 of Sec. 6, T.27 S., R.1 W. of the 6th P.M., Sedgwick County, Kansas; thence West along the South line of said S.E. 1/4 with an assumed bearing of S. 88° 37' 10" W., a distance of 427.00'; thence N 00° 01' 44" W., parallel with the East line of the W. 1/2 of said S.E. 1/4, a distance of 552.86'; thence S. 88° 49' 02" W., parallel with the North line of said S.E. 1/4, a distance of 23.00'; thence N. 00° 01' 44" W., a distance of 520.00'; thence N. 88° 49' 02" E., parallel with the North line of said S.E. 1/4, a distance of 450.00' to a point in the East line of the W. 1/2 of said S.E. 1/4; thence S. 00° 01' 44" E., a distance of 1071.45' to the point of beginning, except the South 80.00' thereof.

AND WHEREAS, the natural drainage of surface water presently is from Tract 2 across part of Tract 1, and said owner of Tract 1 does not wish to disturb the direction of said natural drainage.

NOW THEREFORE, in consideration of One Dollar (\$1.00) and other good and valuable consideration, the receipt of which is hereby acknowledged, the owner of Tract 1 does hereby grant an easement for surface water drainage from Tract 2 across Tract 1 along the present established natural drainage way, which easement shall run with the land and shall be binding upon the successors, assigns, heirs, administrators and executors of said owner, but may be terminated at any time by mutual recordable instrument, executed by the parties who are at the time of termination, the owners of the afore described real property.

[Handwritten signatures and notes]

