0032

CONSULTANTS / ENGINEERS
DAUGHN HANSEN ASSOCIATES
WATERBURY PLAZA - SUITE A
5620 SOUTH 1475 EAST
SALT LAKE CITY, UTAH 84121
(801) 272-5263

June 14, 1983

Mr. Rob Wiley
Price River Coal Company
P. O. Box 629
Helper, Utah 84526

RECEIVED
JUL 08 1983
DIVISION OF
OIL, GAS & MINING

Dear Rob:

As you requested, I have estimated the peak discharge of Willow Creek near its confluence with the Price River, resulting from the following precipitation events: 2-year 24-hour, 5-year 24-hour, 10-year 24-hour, 25-year 24-hour, 50-year 24-hour and 100-year 24-hour. In addition, for comparison with the above indicated events, I have prepared a quick frequency analysis on peak instantaneous flows of lower Willow Creek from 20 years of available USGS gaging records.

From the analysis of the USGS records, it is interesting to note that peak instantaneous flows on Willow Creek for only 5 years out of 20 years were snowmelt related. Peak instantaneous flows for 15 years out of 20 years (including all flows in excess of 262 cfs) resulted from summer thunderstorm activity (not necessarily and probably not the 24-hour event).

Peak discharges from the above indicated precipitation events were estimated from the SCS unit hydrograph technique. The results for both analyses are presented below and computation sheets are attached.

SCS UNIT HYDROGRAPH
PEAK FLOWS FROM 24-HOUR EVENTS

Precipitation Event	Peak Flow cfs
2-year 24-hour (1.4 inches)	68
5-year 24 hour (1.7 inches)	192
10-year 24-hour (2.0 inches)	393
25-year 24-hour (2.3 inches)	668
50-year 24-hour (2.6 inches)	1149
100-year 24-hour (2.9 inches)	1556

FREQUENCY ANALYSIS
USGS FLOW RECORDS
WILLOW CREEK

Event	Peak Flow cfs
2-year	220
5-year	455
10-year	700
25-year	1100
50-year	1460
100-year	1900

Should you need additional clarification, please call.

Sincerely,

Marvin E. Allen, P.E.
Executive Vice President

Enclosures

MEA/jd

Registered Professional Engineer
MARVIN
E. ALLEN
#6292
State of Utah

III - Predicted flow rates from the 2-year, 5-year, 10-year, 50-year, and 100-year 24-hour precipitation event on Willow Creek (using the USGS unit hydrograph technique).

A - Drainage Area = 49540 acres

B - Basin Slope = $\frac{\text{Length of Contour} * \text{Contour interval}}{\text{Drainage Area}} * 100$

$= \frac{654,720' (1000')}{49540 \text{ acres } (43560 \text{ ft}^2/\text{ac})} * 100 = 31\%$

C - Hydraulic Length = 82,900 ft.

D - Curve Number - See Table A-4 pg 538 - Design of Small Dams USBR

1 - 6400 acres - Juniper Grass Complex - Soil Group C - Condition Fair - CN = 70
2 - 18900 acres - Sage Grass Complex - Soil Group C - Condition Fair to Good CN = 57
3 - 12100 acres - Pine - Aspen Complex - Soil Group C - Condition Fair to Good CN = 50
4 - 12140 acres Juniper Grass - Soil Group C - Condition Fair to Good - CN = 66

Wt. Curve Numbers are obtained by weighting runoff volumes from each complex and storm - (see attached table)

E - Design Storm from NOAA Atlas:

2-year	24-hour	=	1.4"
5-year	"	=	1.7"
10-year	"	=	2.0"
25-year	"	=	2.3"
50-year	"	=	2.6"
100-year	"	=	2.9"

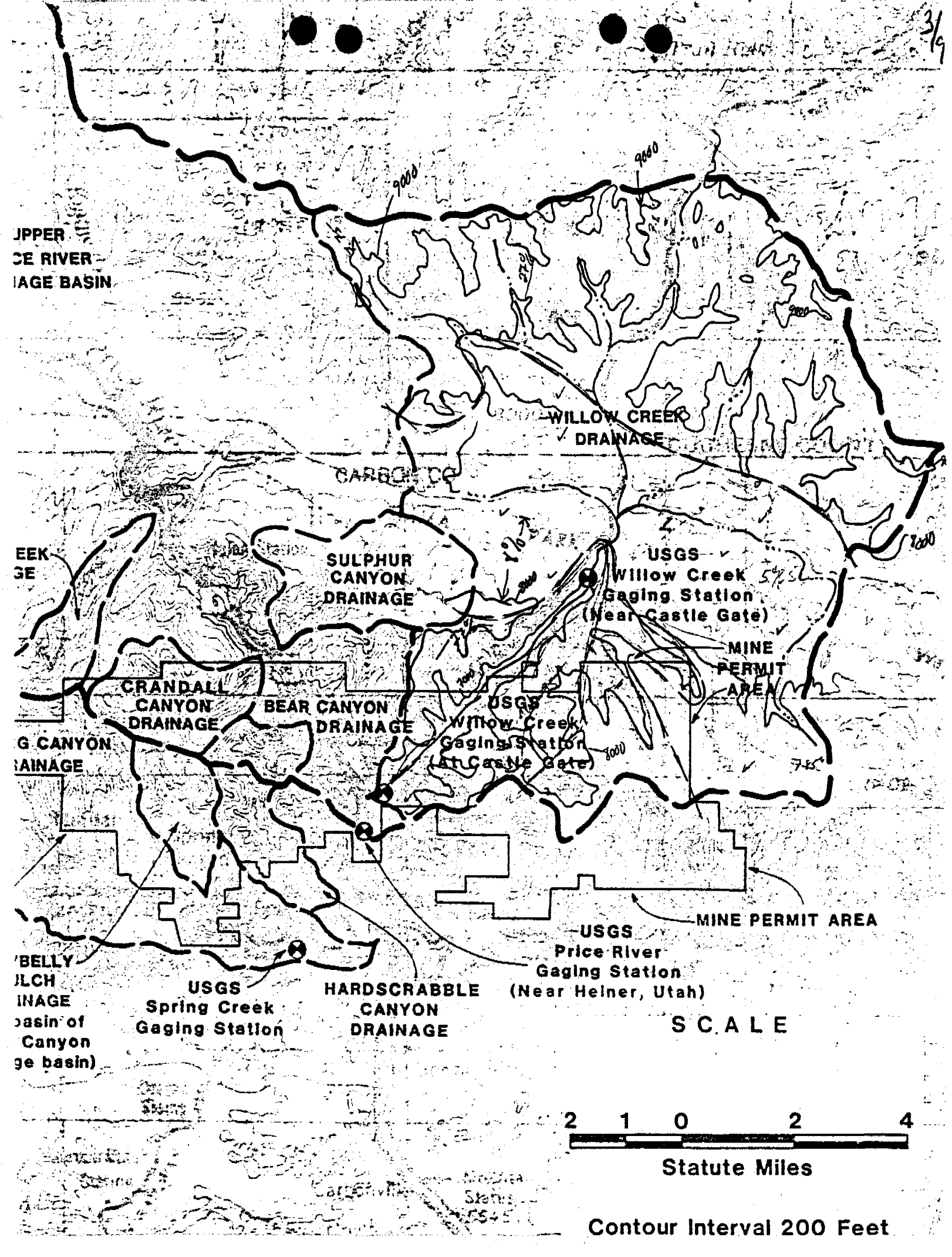
VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED CMA. CLIENT Price River Coal
CHECKED _____ PROJECT _____
DATE 6/10/83 FEATURE Willow Creek Peak

Flow Prediction - SCS Technique.

Cover Complex	Fraction of Total Area	2yr 24hr (1.4in) Q in	2yr 24hr (1.4in) Wt Q in	5yr 24hr (1.7in) Q in	5yr 24hr (1.7in) Wt Q in	10yr 24hr (2.0in) Q in	10yr 24hr (2.0in) Wt. Q in	25yr 24hr (2.3in) Q in	25yr 24hr (2.3in) Wt. Q in	50yr 24hr (2.6in) Q in	50yr 24hr (2.6in) Wt. Q in	100yr 24hr (2.9in) Q in	100yr 24hr (2.9in) Wt. Q in
Juniper Grass - Fair CN=70 S=4.29 0.2S=0.86	0.129	0.061	0.008	0.139	0.018	0.241	0.031	0.363	0.047	0.504	0.065	0.659	0.085
Sage Gras - Fair to Good CN=57 S=7.54/0.2S=1.51	0.382	0	0	0.005	0.002	0.030	0.011	0.075	0.029	0.138	0.053	0.217	0.083
Pine-Aspen - Fair to Good CN=50 S=10 0.2S=2.0	0.244	0	0	0	0	0	0	0.009	0.002	0.038	0.008	0.074	0.018
Juniper Grass - Fair to Good CN=66 S=5.15 0.2S=1.03	0.245	0.025	0.006	0.077	0.019	0.154	0.038	0.251	0.062	0.367	0.090	0.498	0.122
			Σ=0.014		Σ=0.039		Σ=0.080		Σ=0.14		Σ=0.216		Σ=0.308
Wt. CN to give Σ Wt Q for the given precipitation			64		63		62		61		61		60

2/9


UPPER
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WILLOW CREEK
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CANYON
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USGS
Willow Creek
Gaging Station
(Near Castle Gate)
MINE
PERMIT
AREA
CRANDALL
CANYON
DRAINAGE
BEAR CANYON
DRAINAGE
USGS
Willow Creek
Gaging Station
(At Castle Gate)
G CANYON
AINAGE
MINE PERMIT AREA
USGS
Price River
Gaging Station
(Near Helper, Utah)
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Spring Creek
Gaging Station
HARDSCRABBLE
CANYON
DRAINAGE
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Statute Miles
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PEAK DISCHARGE
2-YEAR 24-HOUR EVENT

AREA= 49540.0 ACRES
AVERAGE BASIN SLOPE= 31.0 PERCENT
INCREMENT OF RAINFALL EXCESS= .43 HOURS
CURVE NUMBER=64.0
DESIGN STORM= 1.40 INCHES
STORM DURATION= 24.0 HOURS
HYDRAULIC LENGTH= 82900. FEET

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
12.90	1.0704	0.0000	0.0000	0.0	0.00
13.33	1.1057	0.0000	0.0000	0.0	0.00
13.76	1.1339	.0000	.0000	133.9	.00
14.19	1.1586	.0002	.0002	1087.6	.04
14.62	1.1807	.0005	.0003	3049.0	.29
15.05	1.1976	.0009	.0004	5530.3	1.07
15.48	1.2144	.0014	.0005	7901.9	2.67
15.91	1.2290	.0019	.0005	9709.0	5.25
16.34	1.2425	.0024	.0005	10749.4	8.83
16.77	1.2550	.0029	.0005	11028.0	13.25
17.20	1.2676	.0035	.0006	10674.0	18.27
17.63	1.2801	.0042	.0006	9867.5	23.67
18.06	1.2909	.0048	.0006	8789.3	29.25
18.49	1.3017	.0054	.0006	7592.4	34.81
18.92	1.3114	.0060	.0006	6391.7	40.18
19.35	1.3210	.0066	.0006	5264.1	45.20
19.78	1.3291	.0071	.0005	4254.2	49.73
20.21	1.3375	.0077	.0006	3381.9	53.68
20.64	1.3471	.0084	.0007	2649.9	57.00
21.07	1.3564	.0091	.0007	2049.8	59.80
21.50	1.3636	.0097	.0006	1567.7	62.26
21.93	1.3696	.0102	.0005	1186.7	64.38
22.36	1.3766	.0108	.0006	890.0	66.06
22.79	1.3831	.0113	.0005	661.9	67.23
23.22	1.3891	.0118	.0005	488.6	67.90
23.65	1.3951	.0124	.0005	358.1	68.13
24.08	1.3951	.0124	0.0000	260.8	67.92
24.51	1.3951	.0124	0.0000	188.8	66.93
24.94	1.3951	.0124	0.0000	135.9	64.73
25.37	1.3951	.0124	0.0000	97.4	61.13
25.80	1.3951	.0124	0.0000	69.4	56.25
26.23	1.3951	.0124	0.0000	49.3	50.43

HYDROGRAPH PEAK = 68.13 CFS
TIME TO PEAK= 23.66 HOURS

PEAK DISCHARGE
5-YEAR 24-HOUR EVENT

AREA= 49540.0 ACRES
AVERAGE BASIN SLOPE= 31.0 PERCENT
INCREMENT OF RAINFALL EXCESS= .44 HOURS
CURVE NUMBER=63.0
DESIGN STORM= 1.70 INCHES
STORM DURATION= 24.0 HOURS
HYDRAULIC LENGTH= 82900. FEET

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
11.00	.4012	0.0000	0.0000	0.0	0.00
11.44	.4715	0.0000	0.0000	0.0	0.00
11.88	.9721	0.0000	0.0000	0.0	0.00
12.32	1.2054	.0002	.0002	129.4	.02
12.76	1.2822	.0019	.0018	1052.0	.40
13.20	1.3308	.0040	.0021	2952.9	2.62
13.64	1.3683	.0062	.0021	5363.0	8.60
14.08	1.3994	.0083	.0021	7672.6	19.50
14.52	1.4290	.0106	.0023	9439.3	35.27
14.96	1.4499	.0123	.0018	10464.2	54.93
15.40	1.4708	.0142	.0019	10749.2	76.72
15.84	1.4895	.0160	.0018	10417.3	98.79
16.28	1.5065	.0178	.0017	9642.7	119.58
16.72	1.5222	.0194	.0017	8599.9	138.00
17.16	1.5377	.0211	.0017	7438.4	153.43
17.60	1.5535	.0230	.0018	6270.1	165.75
18.04	1.5669	.0246	.0016	5170.5	175.23
18.48	1.5804	.0262	.0017	4183.9	182.23
18.92	1.5924	.0278	.0015	3330.3	187.08
19.36	1.6044	.0293	.0016	2612.8	190.09
19.80	1.6143	.0306	.0013	2023.7	191.52
20.24	1.6249	.0321	.0014	1549.7	191.51
20.68	1.6369	.0337	.0017	1174.6	190.31
21.12	1.6480	.0353	.0016	882.0	188.39
21.56	1.6568	.0366	.0013	656.9	186.21
22.00	1.6643	.0377	.0011	485.4	183.86
22.44	1.6733	.0390	.0013	356.2	181.11

HYDROGRAPH PEAK = 191.69 CFS
TIME TO PEAK= 20.02 HOURS

PEAK DISCHARGE
10-YEAR 24-HOUR EVENT

AREA= 49540.0 ACRES
AVERAGE BASIN SLOPE= 31.0 PERCENT
INCREMENT OF RAINFALL EXCESS= .45 HOURS
CURVE NUMBER=62.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 24.0 HOURS
HYDRAULIC LENGTH= 82900. FEET

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
6.75	.1900	0.0000	0.0000	0.0	0.00
7.20	.2088	0.0000	0.0000	0.0	0.00
7.65	.2274	0.0000	0.0000	0.0	0.00
8.10	.2448	0.0000	0.0000	0.0	0.00
9.90	.3548	0.0000	0.0000	0.0	0.00
10.35	.3942	0.0000	0.0000	0.0	0.00
10.80	.4464	0.0000	0.0000	0.0	0.00
11.25	.5190	0.0000	0.0000	0.0	0.00
11.70	.8700	0.0000	0.0000	0.0	0.00
12.15	1.3692	.0033	.0033	124.9	.41
12.60	1.4848	.0105	.0072	1016.6	4.23
13.05	1.5494	.0162	.0057	2857.8	17.43
13.50	1.5980	.0213	.0051	5197.6	44.13
13.95	1.6358	.0257	.0044	7446.8	84.03
14.40	1.6720	.0303	.0046	9174.8	133.19
14.85	1.6996	.0340	.0037	10186.0	186.39
15.30	1.7248	.0376	.0036	10478.5	238.45
15.75	1.7480	.0410	.0034	10169.9	285.17
16.20	1.7688	.0442	.0032	9427.3	323.93
16.65	1.7880	.0472	.0030	8420.2	353.60
17.10	1.8064	.0502	.0030	7293.5	374.17
17.55	1.8258	.0535	.0033	6156.9	386.55
18.00	1.8420	.0563	.0028	5084.6	392.30
18.45	1.8582	.0591	.0029	4120.5	392.94
18.90	1.8728	.0618	.0026	3284.6	389.79
19.35	1.8872	.0644	.0026	2580.7	383.88
19.80	1.8992	.0667	.0022	2001.8	375.98
20.25	1.9120	.0691	.0024	1535.1	366.58
20.70	1.9264	.0719	.0028	1165.2	356.16
21.15	1.9396	.0745	.0026	876.3	345.51

HYDROGRAPH PEAK = 393.15 CFS
TIME TO PEAK= 18.30 HOURS

PEAK DISCHARGE
25-YEAR 24-HOUR EVENT

AREA= 49540.0 ACRES
AVERAGE BASIN SLOPE= 31.0 PERCENT
INCREMENT OF RAINFALL EXCESS= .46 HOURS
CURVE NUMBER=61.0
DESIGN STORM= 2.30 INCHES
STORM DURATION= 24.0 HOURS
HYDRAULIC LENGTH= 82900. FEET

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
9.20	.3528	0.0000	0.0000	0.0	0.00
9.66	.3881	0.0000	0.0000	0.0	0.00
10.12	.4290	0.0000	0.0000	0.0	0.00
10.58	.4810	0.0000	0.0000	0.0	0.00
11.04	.5514	0.0000	0.0000	0.0	0.00
11.50	.6509	0.0000	0.0000	0.0	0.00
11.96	1.4550	.0047	.0047	120.3	.57
12.42	1.6640	.0219	.0172	981.4	6.71
12.88	1.7552	.0330	.0111	2763.3	31.27
13.34	1.8178	.0419	.0089	5034.1	83.27
13.80	1.8667	.0495	.0076	7224.4	161.05
14.26	1.9099	.0567	.0072	8915.4	255.20
14.72	1.9462	.0631	.0064	9914.1	354.03
15.18	1.9758	.0685	.0054	10215.4	447.12
15.64	2.0041	.0739	.0054	9930.7	526.77
16.10	2.0291	.0788	.0049	9220.7	588.76
16.56	2.0521	.0835	.0046	8249.1	631.92
17.02	2.0733	.0878	.0044	7157.0	657.28
17.48	2.0966	.0928	.0049	6051.5	667.28
17.94	2.1158	.0969	.0042	5005.7	665.37
18.40	2.1349	.1011	.0042	4063.1	654.90
18.86	2.1522	.1050	.0039	3244.2	638.63
19.32	2.1692	.1089	.0039	2553.1	618.69
19.78	2.1835	.1122	.0033	1983.6	596.65
20.24	2.1984	.1157	.0035	1523.7	573.46

HYDROGRAPH PEAK = 667.97 CFS
TIME TO PEAK= 17.64 HOURS

PEAK DISCHARGE
50-YEAR 24-HOUR EVENT

AREA= 49540.0 ACRES
AVERAGE BASIN SLOPE= 31.0 PERCENT
INCREMENT OF RAINFALL EXCESS= .46 HOURS
CURVE NUMBER=61.0
DESIGN STORM= 2.60 INCHES
STORM DURATION= 24.0 HOURS
HYDRAULIC LENGTH= 82900. FEET

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
9.66	.4388	0.0000	0.0000	0.0	0.00
10.12	.4850	0.0000	0.0000	0.0	0.00
10.58	.5437	0.0000	0.0000	0.0	0.00
11.04	.6234	0.0000	0.0000	0.0	0.00
11.50	.7358	0.0000	0.0000	0.0	0.00
11.96	1.6448	.0198	.0198	120.3	2.39
12.42	1.8810	.0519	.0320	981.4	23.31
12.88	1.9841	.0701	.0182	2763.3	88.42
13.34	2.0549	.0840	.0139	5034.1	207.91
13.80	2.1102	.0957	.0116	7224.4	369.99
14.26	2.1590	.1065	.0109	8915.4	551.28
14.72	2.2000	.1160	.0095	9914.1	728.10
15.18	2.2335	.1241	.0080	10215.4	882.39
15.64	2.2655	.1320	.0079	9930.7	1003.14
16.10	2.2937	.1391	.0071	9220.7	1086.34
16.56	2.3197	.1458	.0067	8249.1	1133.34
17.02	2.3437	.1521	.0063	7157.0	1148.75
17.48	2.3701	.1591	.0070	6051.5	1138.89
17.94	2.3918	.1651	.0059	5005.7	1110.96
18.40	2.4133	.1710	.0060	4063.1	1071.37
18.86	2.4330	.1765	.0055	3244.2	1025.15
19.32	2.4521	.1820	.0054	2553.1	975.95
19.78	2.4683	.1866	.0047	1983.6	926.28

HYDROGRAPH PEAK =1148.90 CFS
TIME TO PEAK= 17.07 HOURS

PEAK DISCHARGE
100-YEAR 24-HOUR EVENT

AREA= 49540.0 ACRES
AVERAGE BASIN SLOPE= 31.0 PERCENT
INCREMENT OF RAINFALL EXCESS= .47 HOURS
CURVE NUMBER=60.0
DESIGN STORM= 2.90 INCHES
STORM DURATION= 24.0 HOURS
HYDRAULIC LENGTH= 82900. FEET

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
8.93	.4202	0.0000	0.0000	0.0	0.00
9.40	.4634	0.0000	0.0000	0.0	0.00
9.87	.5113	0.0000	0.0000	0.0	0.00
10.34	.5703	0.0000	0.0000	0.0	0.00
10.81	.6491	0.0000	0.0000	0.0	0.00
11.28	.7607	0.0000	0.0000	0.0	0.00
11.75	1.3717	.0002	.0002	115.9	.03
12.22	2.0146	.0632	.0629	946.5	7.50
12.69	2.1723	.0938	.0306	2669.9	63.71
13.16	2.2639	.1140	.0202	4872.7	200.43
13.63	2.3329	.1303	.0164	7005.3	410.97
14.10	2.3896	.1445	.0141	8660.7	663.04
14.57	2.4417	.1580	.0135	9648.2	918.74
15.04	2.4798	.1682	.0102	9959.4	1147.54
15.51	2.5179	.1787	.0105	9699.2	1329.81
15.98	2.5506	.1879	.0092	9022.1	1457.21
16.45	2.5807	.1966	.0087	8085.9	1530.41
16.92	2.6083	.2047	.0081	7028.1	1555.67
17.39	2.6378	.2135	.0088	5953.3	1542.30
17.86	2.6636	.2213	.0078	4933.3	1500.91
18.33	2.6881	.2288	.0075	4011.6	1441.40
18.80	2.7109	.2359	.0071	3208.8	1371.75
19.27	2.7327	.2428	.0069	2529.8	1297.81
19.74	2.7518	.2488	.0061	1969.1	1223.59

HYDROGRAPH PEAK =1556.13 CFS
TIME TO PEAK= 16.99 HOURS

VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED [illegible] CLIENT Price River Coal
CHECKED _____ PROJECT Peak Flow Prediction
DATE 6/9/83 FEATURE Willow Creek - Frequency Anal.

Peak Instantaneous Flow - Willow Creek @ USGS station near Castle Gate and at Castle Gate.

Water Year	Willow Creek Near Castle Gate Flow cfs	Willow Creek Near Castle Gate Date	Willow Creek @ Castle Gate Flow cfs	Willow Creek @ Castle Gate Date
1962	800	Sept. 21	* 849	
1963	292	Oct. 5 Base Flow = 1.1	* 311	
1964	106	June 28 B = 3.5	* 114	
1965	262	May 21,	* 279	
1966	388	July 1, B = 6.0	* 413	
1967	550	July 15, B = 7.0	* 584	
1968	206	Aug 9, B = 7 cfs.	* 220	
1969	214	Apr. 21,	* 228	
1970	152	Sept 5, B = 0.5 cfs	* 162	
1971	119	Aug 16, B = 0.5 cfs	* 127	
1972	91	Sept 19, B = 0.7 cfs	* 98	
1973	836	Aug 6., B = 8 cfs	* 887	
1974	28	July 18, B = 1.0 cfs.	* 31	
1975	115	April 22	* 123.	
1976	808	July 25, B = 1.5	* 858	
1977	313	July 19,	* 333	
1978	124	April 11	* 133	
1979	242 163	May 5	* 258	
1980.	400 **	May 3	—	
1981	207	Apr. 9.	189	
1982	182	Aug 21	*194	
1983		—		

From 1971 Book.

* Predicted from relationship on following page.
** Peak daily flow.

VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED [illegible] CLIENT Price River Coal
CHECKED / PROJECT Peak flow Prediction
DATE 6/9/83 FEATURE Willow Creek Frequency Analysis

2/4

Correlated Peak Bailey flows of Willow Creek between the gaging station near Willow Creek and the Gaging Station at Willow Creek.

Date	Willow Creek Near Castle Gate cfs	Willow Creek @ Castle Gate cfs.	
5/6/80	130	140	10
5/15/80	82	86	4
5/23/80	200	210	10
6/1/80	57	74	17
8/25/80	8	8.2	.2
10/15/80	8.7	8.4	.3
4/9/81	40	40	0
4/15/81	30	32	2
5/3/81	14	16	2
6/3/81	7.4	8.1	.7
7/2/81	4.0	5.3	.7

Linear regression

$R^2 = 0.996$

Willow Creek @ Castle Gate = 1.3 + 1.06 (Willow Creek near Castle Gate)

VAUGHN HANSEN ASSOCIATES
CONSULTANTS / ENGINEERS

COMPUTED [illegible] CLIENT Price River Coal
CHECKED [illegible] PROJECT Peak Flow Prediction Willow Creek
DATE FEATURE Frequency Analysis

3/4

Peak Instantaneous Flows on Willow Creek Ranked

Rank m	Year	Flow	Plotting Position m/n+1
1	1974	31	0.048
2	1972	98	0.095
3	1964	114	0.14
4	1975	123	0.19
5	1971	127	0.24
6	1978	133	0.28
7	1970	162	0.33
8	1981	189	0.38
9	1982	194	0.43
10	1968	220	0.48
11	1969	228	0.52
12	1979	258	0.57
13	1965	279	0.62
14	1963	311	0.67
15	1977	333	0.71
16	1966	413	0.76
17	1967	584	0.81
18	1962	849	0.86
19	1976	858	0.91
20	1973	887	0.95

K+E PROBABILITY X 2 LOG CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

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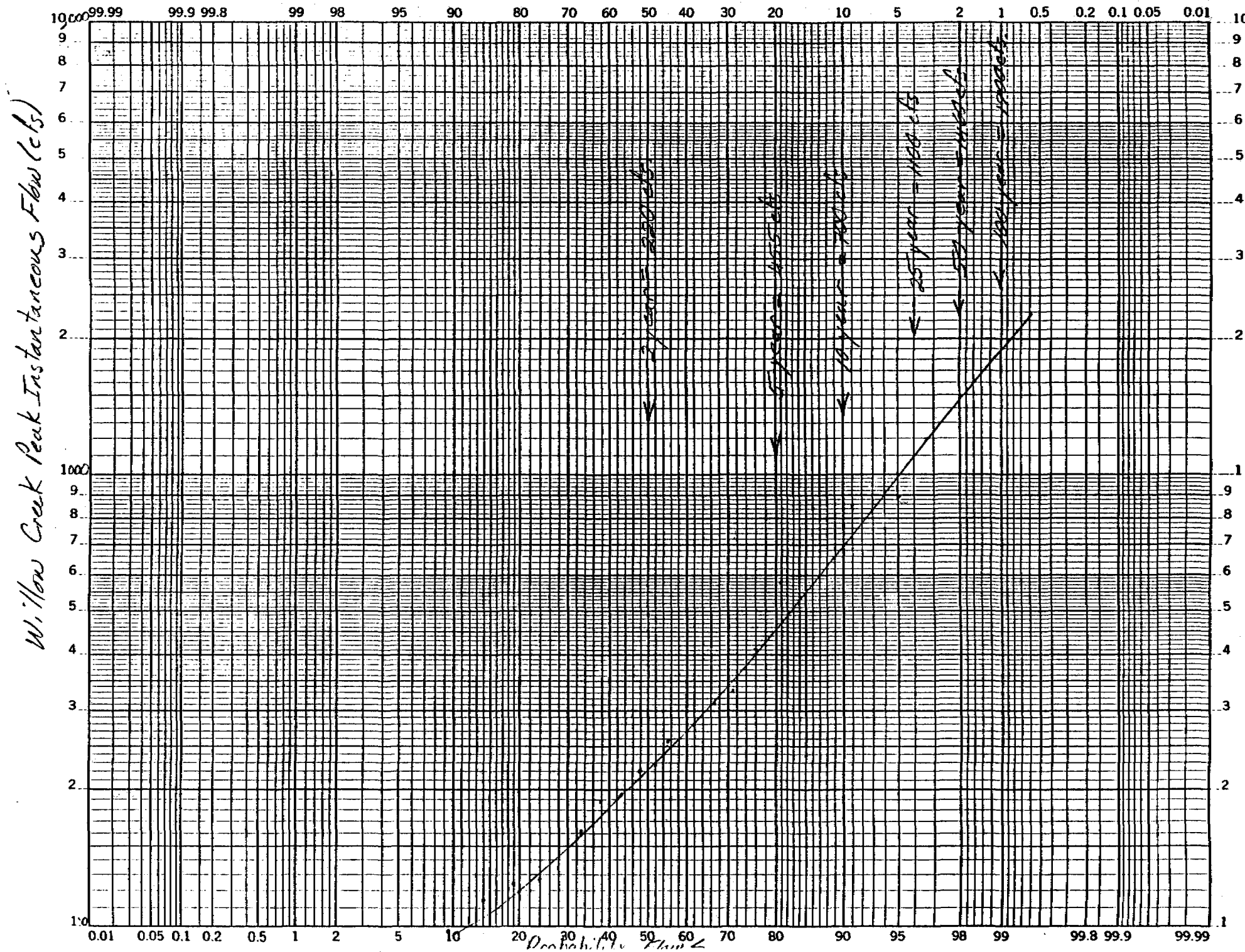
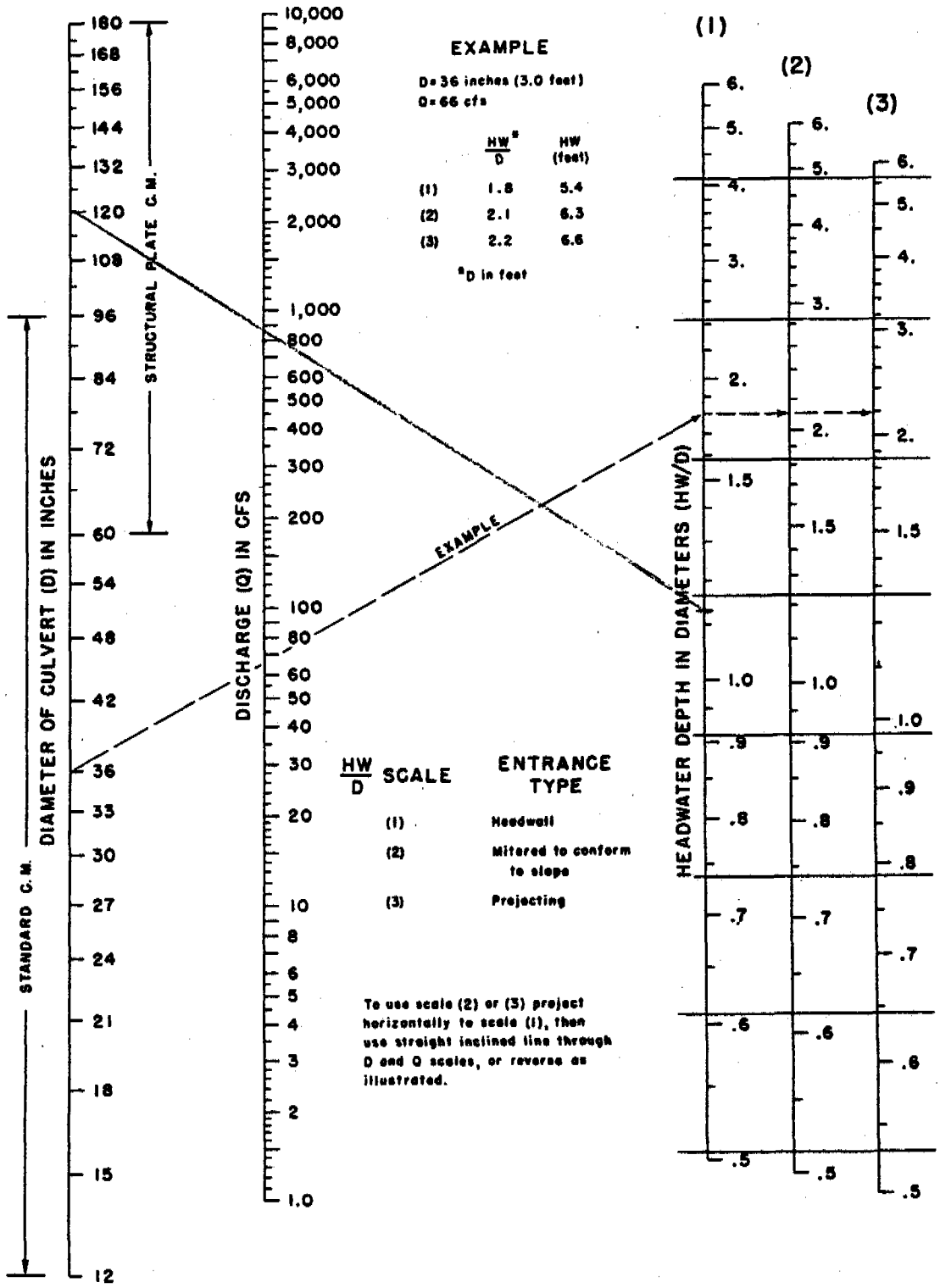
Chart 2-53: HEADWATER DEPTH FOR C.M.P. CULVERTS WITH INLET CONTROL