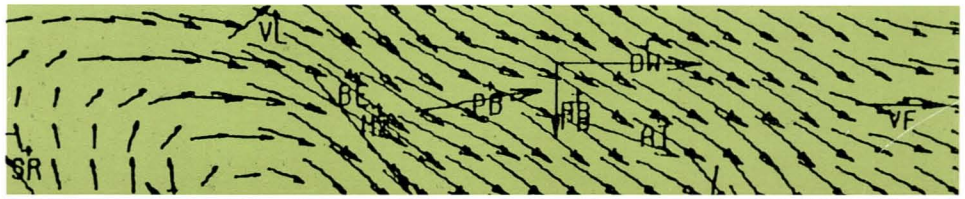
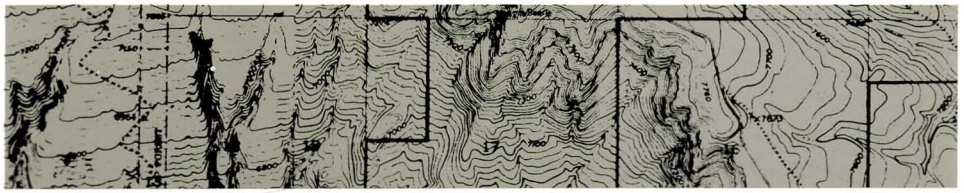
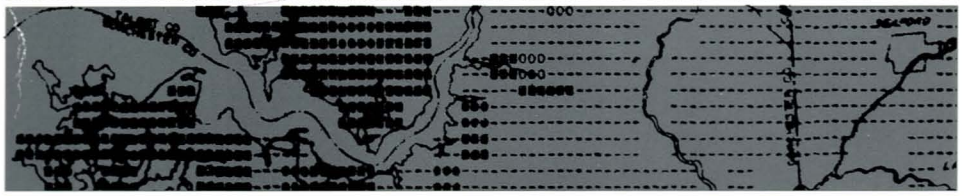
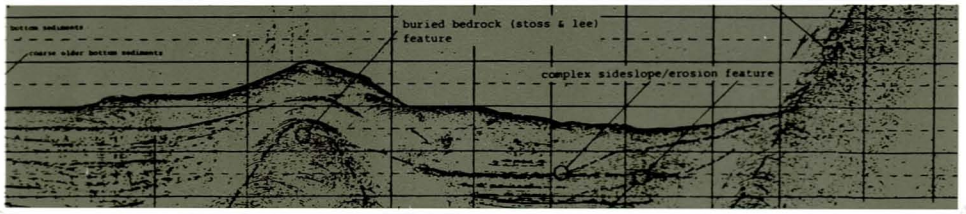








PHASE I REPORT
PROJECT CALCULATIONS
HYDROLOGIC ANALYSIS
BUCKEYE FLOODWATER RETARDING
STRUCTURES #1, #2, AND #3
FOR
FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY
FCD PROJECT 88-63

DAMES & MOORE

Property of
Flood Control District of MC Library
Please Return to
2801 W. Durango
Phoenix, AZ 85009

PHASE I REPORT
PROJECT CALCULATIONS
HYDROLOGIC ANALYSIS
BUCKEYE FLOODWATER RETARDING STRUCTURES #1, #2, AND #3
FOR
FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY
FCD PROJECT 88-63

DAMES & MOORE

D&M Job No. 15448-003-022
January 23, 1990

DAMES & MOORE A PROFESSIONAL LIMITED PARTNERSHIP
POINTE CORPORATE CENTRE, 7500 NORTH DREAMY DRAW DRIVE, SUITE 145
PHOENIX, ARIZONA 85020 (602) 371-1110

January 23, 1990

D&M Job No. 15448-003-022

Flood Control District of
Maricopa County
3355 West Durango Street
Phoenix, Arizona 85009

Attention: Mr. Joe Rumann, Hydrologist III

Phase I Report
Hydrologic Analysis
Buckeye Floodwater Retarding
Structures #1, #2, and #3
for the Flood Control District
of Maricopa County
FCD Project 88-63

With this letter, we are pleased to submit the following items:

- Five copies of the above-referenced report.
- Three bound sets of the project calculations.
- One full size bound set of HEC-1 printouts.
- One floppy disk of the HEC-1 input files.

This submission completes the work required for Phase I of this project. We have enjoyed completing Phase I of this project for you. Should you have any questions regarding any of the materials submitted, please contact us.

Very truly yours,

DAMES & MOORE

George J. Geiser, P.E.
Project Manager

Robert J. Neukirchner, P.E.
Manager, Design Services Group

GJG/RJN/baw

PHASE I REPORT

PROJECT CALCULATIONS
HYDROLOGIC ANALYSIS
BUCKEYE FLOODWATER RETARDING
STRUCTURES #1, #2, AND #3

FOR

FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY
FCD PROJECT 88-63

Dames & Moore
Pointe Corporate Centre
7500 North Dreamy Draw Drive, Suite 145
Phoenix, Arizona 85020

TABLE OF CONTENTS

	Page
PRECIPITATION CALCULATIONS	1
DEVELOPING THE 6-HOUR & 72-HOUR PMP STORM DISTRIBUTIONS	1A
DEVELOPING HEC-1 INPUT PARAMETERS	33
CONFIRMING CAPACITY DATA	131
MUSKINGUM CHANNEL ROUTING PARAMETERS	151
RESERVOIR ROUTING - - OUTFLOW	157

CALCULATIONS COVER SHEET
DAMES & MOORE
DESIGN SERVICES GROUP

PROJECT NUMBER 13445 004 - 0 - 0
SUBJECT Buckeye FRS
SHEET 1 OF ~~32~~ 161

Precipitation Calculations
TITLE OF CALCULATIONS

Buckeye FRS
TITLE OF PROJECT

CALCULATIONS BY: John Fannin
PRINT NAME

John Fannin — 11/08/89
SIGNATURE — DATE

ASSUMPTIONS CHECKED BY CONSULTANT: GEORGE J GELSER
PRINT NAME

G J Gelser — 12/19/89
SIGNATURE — DATE

CALCULATIONS CHECKED BY: Richard Allen
PRINT NAME

Richard Allen — 11/8/89
SIGNATURE — DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT OR PM) GEORGE J GELSER
PRINT NAME

G J Gelser — 12/19/89
SIGNATURE — DATE

APPROVAL NOTES:
IF CALCULATIONS ARE ONLY SPOT CHECKED, DO NOT REQUIRE CHECKING OR ARE ASSUMED TO BE CORRECT BY EXPERIENCE OR ENGINEERING JUDGEMENT, IT SHOULD BE NOTED HERE. Calcs Spot Chkd As Noted

REVISION NUMBER	DATE	BY	CHECKED BY (INITIALS)	APPROVAL
1				
2				
3				
4				

BY JDF DATE 11/08/89
CHECKED BHA 11/8/89
ORIGINAL TO PROJECT FILE

Summary Table of Precipitation Depths

Storm Duration	100 yr inches	(1) General PMP inches	Local PMP inches
5 min	0.7	0.9	3.1
10 min	1.1	2.8	4.9
15 min	1.3	3.3	6.2
30 min	1.8	3.9	8.3
45 min	--	4.2	9.2
1 hr	2.3	4.6	10.0
2 hr	2.7	6.1	11.8
3 hr	2.8	7.4	12.8
4 hr	--	8.5	13.4
5 hr	--	9.4	13.9
6 hr	3.2	10.2	14.3
12 hr	3.7	12.5	--
18 hr	--	13.8	--
24 hr	4.2	14.6	--
48 hr	--	16.9	--
72 hr	--	17.8	--

(1) Note: 5-min to 5-hr rainfall depth were derived from smooth fit curve.

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/08/89
CHECKED BY RHA 11/08/89
COPY TO EO ____

Precipitation Estimates: 100yr, 6 hr + 24 hr PMP.

Purpose: To develop the 100 Yr storm, the 6 hr PMP, and the 24 hr PMP.

References:

1. Precipitation-Frequency Atlas of the Western United States. Volume VIII-Arizona US. Dept. of Commerce, NOAA, 1973.

2. Hydrometeorological Report No. 49; Probable Maximum Precipitation Estimates Colorado River and Great Basin Drainages; U.S. Dept. of Commerce, NOAA, US Dept. of Army Corps of Engineers; Silver Springs, MD September, 1977.

3. U.S.G.S. Maps:

   Buckeye Quadrangle + White Tanks Mts Quadrangle, AZ- Maricopa Co. 15 min Series (Topographic), USGS, 1958.

Given: Site Location

Latitude N 33° 30′

Longitude 112° 37′ 30″

Approximatly 8 miles North of Buckeye AZ

Proceedure as outlined in Texts Ref 1 + 2.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 11/08/89
CHECKED BY RHA 11/8/89
COPY TO EO ____

Dames & Moore

Calculations: for 100 yr Storm only.

From Isopluvials [Ref ①], the following precipitation depths were obtained for the given storms.

100 yr ~~Storm~~ 6 hr = 3.2

100 yr storm 24 hr = 4.2

On the following Pages the 5, 10, 15, 30, 60, 120, 180, 360, 720, and 1440-hr duration Storm precipitation depths are developed for the 100 yr storm.

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/08/89
CHECKED BY RHA 11/8/89
COPY TO EO ____

945 1 (12/88) PRINTED IN U.S.A.

Estimating the 1 hr, 2 hr, 3 hr, and 12 hr duration precipitation depths for the ~~2, 5, 10, 25, 50~~, + 100 year storm:

Estimating the 1 hr depths for the ~~2 +~~ 100yr Storms:

Table 11. *Equations for estimating 1-hr values in Arizona with statistical parameters for each equation*

Equation	Corr. coeff.	No. of stations	Mean of computed stn. values (inches)	Standard error of estimate (inches)
$Y_2 = -0.011 + 0.942[(X_1)(X_1/X_2)]$	0.95	86	0.72	0.085
$Y_{100} = 0.494 + 0.755[(X_3)(X_3/X_4)]$	.90	85	1.96	.290

List of variables
Y_2 = 2-yr 1-hr estimated value
Y_{100} = 100-yr 1-hr estimated value
X_1 = 2-yr 6-hr value from precipitation-frequency maps
X_2 = 2-yr 24-hr value from precipitation-frequency maps
X_3 = 100-yr 6-hr value from precipitation-frequency maps
X_4 = 100-yr 24-hr value from precipitation-frequency maps

Ref. 1

For X_1 = and X_2 = [From Table 1.]

$Y_2 = -0.011 + 0.942[(\quad)(\quad/\quad)] =$ _____

For $X_3 = 3.2$ and $X_4 = 4.2$ [From Table 1.]

$Y_{100} = 0.494 + 0.755[(3.2)(3.2/4.2)] =$ 2.33

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/08/88
CHECKED BY RHA 11/8/89
COPY TO EO ____

Dames & Moore

945.1 (12/88) PRINTED IN U.S.A.

N/A

Estimating the 1-hr depths for the 5, 10, 25, and 50-yr Storms:

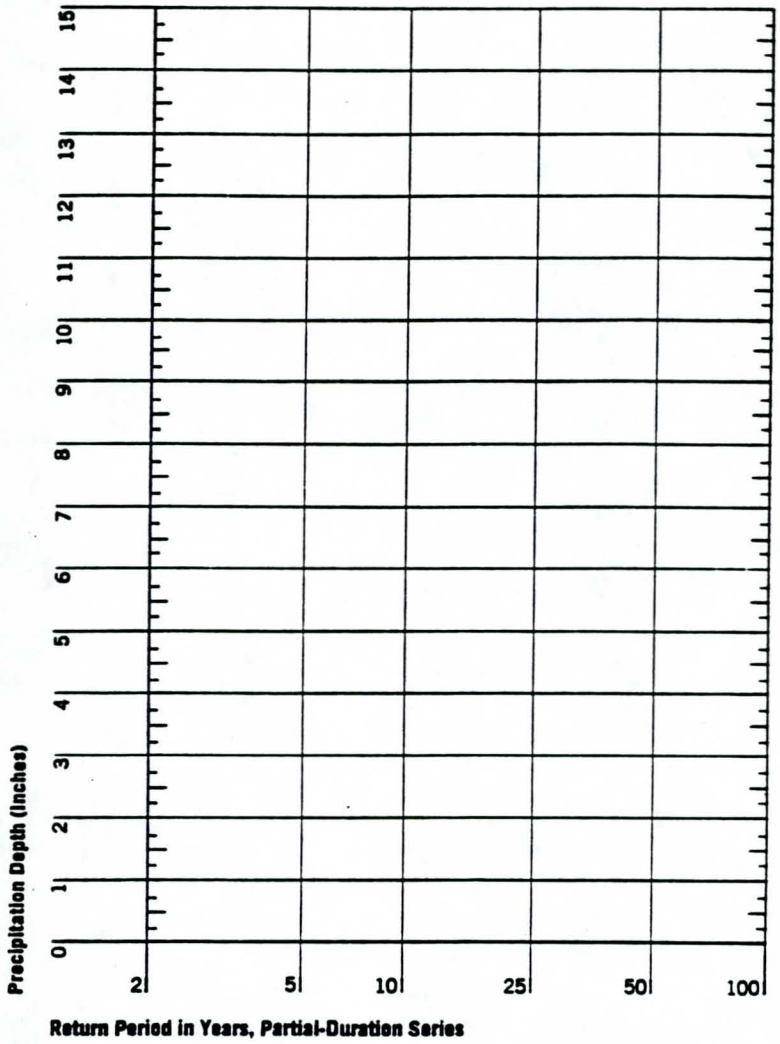


Figure 6. *Precipitation depth versus return period for partial-duration series.* Ref 1

Return Period (yr)	1-hr Duration Depths (in)
2	
5	
10	
25	
50	
100	

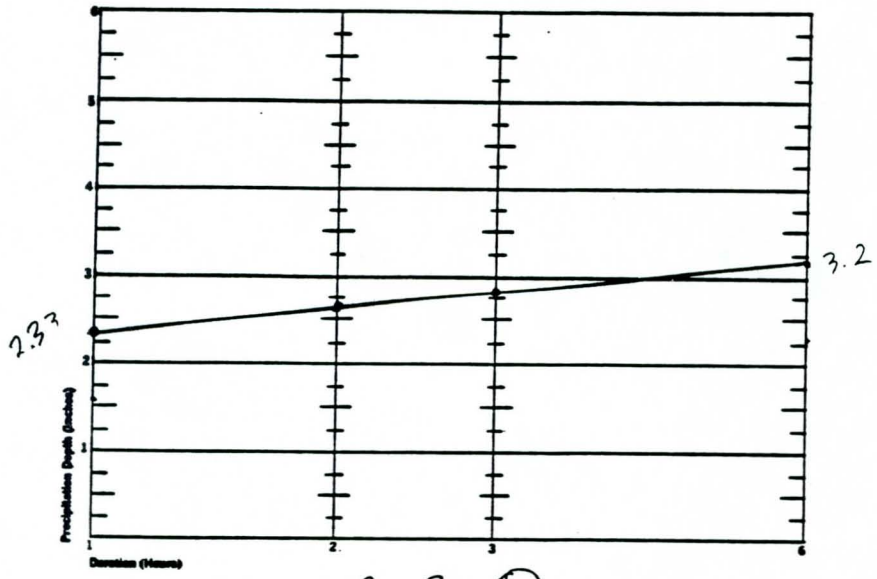
REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

BY JDF DATE 11/08/89
CHECKED BY RHH 11/8/89
COPY TO EO _____

Dames & Moore

Estimating the 2 and 3 hour depth:

Figure 15. *Precipitation depth-duration diagram (1- to 6-hr).*



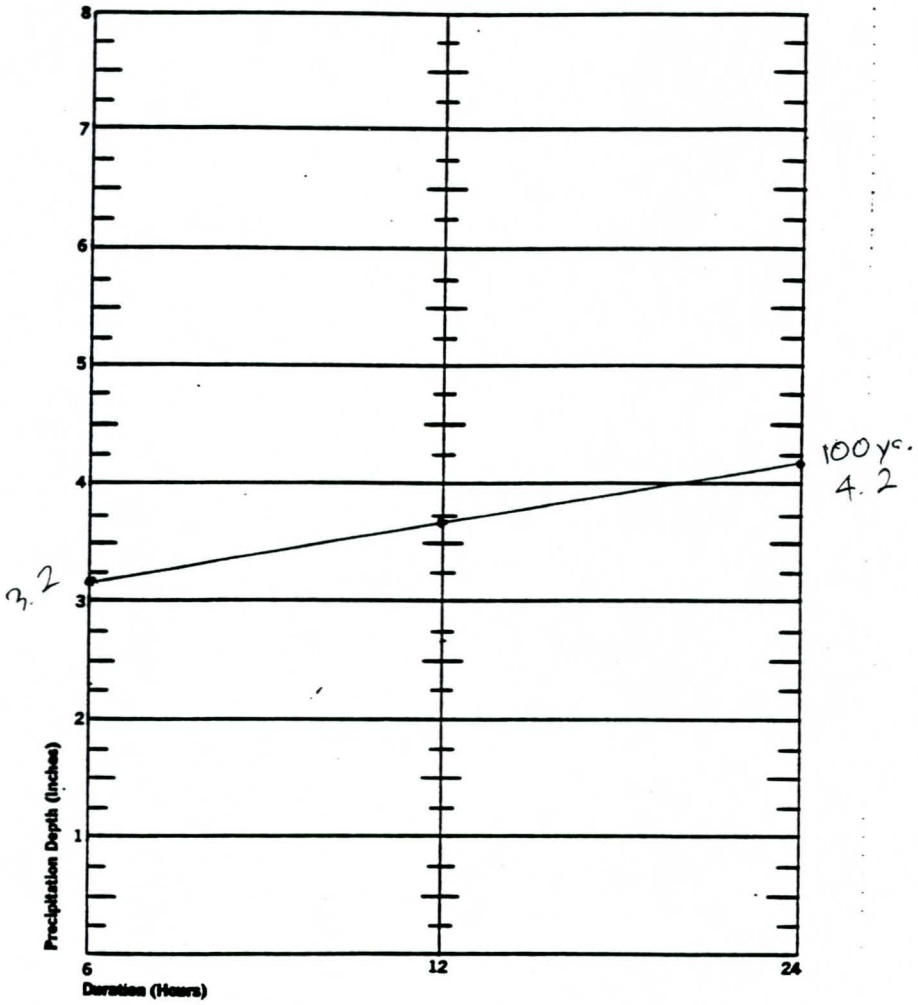
Ref ①

Return Period	2-Hr. Depth inches	3-Hr Depth inches
2		
5		
10		
25		
50		
100	~~2.7~~ 2.65	2.8

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/08/89
CHECKED BY RHA 11/8/89
COPY TO EO ____

Estimating the 12-Hour depth:



Ref ①

Figure 16. *Precipitation depth-duration diagram (6- to 24-hr).*

Return Period Yr	12-hr Depth inches
2	
5	
10	
25	
50	
100	3.7 ✓

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/08/88
CHECKED BY RHA 11/8/89
COPY TO EO ____

Dames & Moore

Estimating the 5, 10, 15, and 30 min depths:

Table 12. *Adjustment factors to obtain n-min estimates from 1-hr values*

Ref (1)

Duration (min)	5	10	15	30
Ratio to 1-hr	0.29	0.45	0.57	0.79

(Adopted from *U.S. Weather Bureau Technical Paper* No. 40, 1961.)

Return Period Yr	5-min depth in	10-min depth in	15-min depth in	30-min depth in	1-hr depth in	
100	0.7	~~1.0~~	1.3	1.8	2.33	Report 2.3
		1.1				
		JDF				

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/08/89
CHECKED BY BHA 11/8/89
COPY TO EO ____

RITA 11/08/89

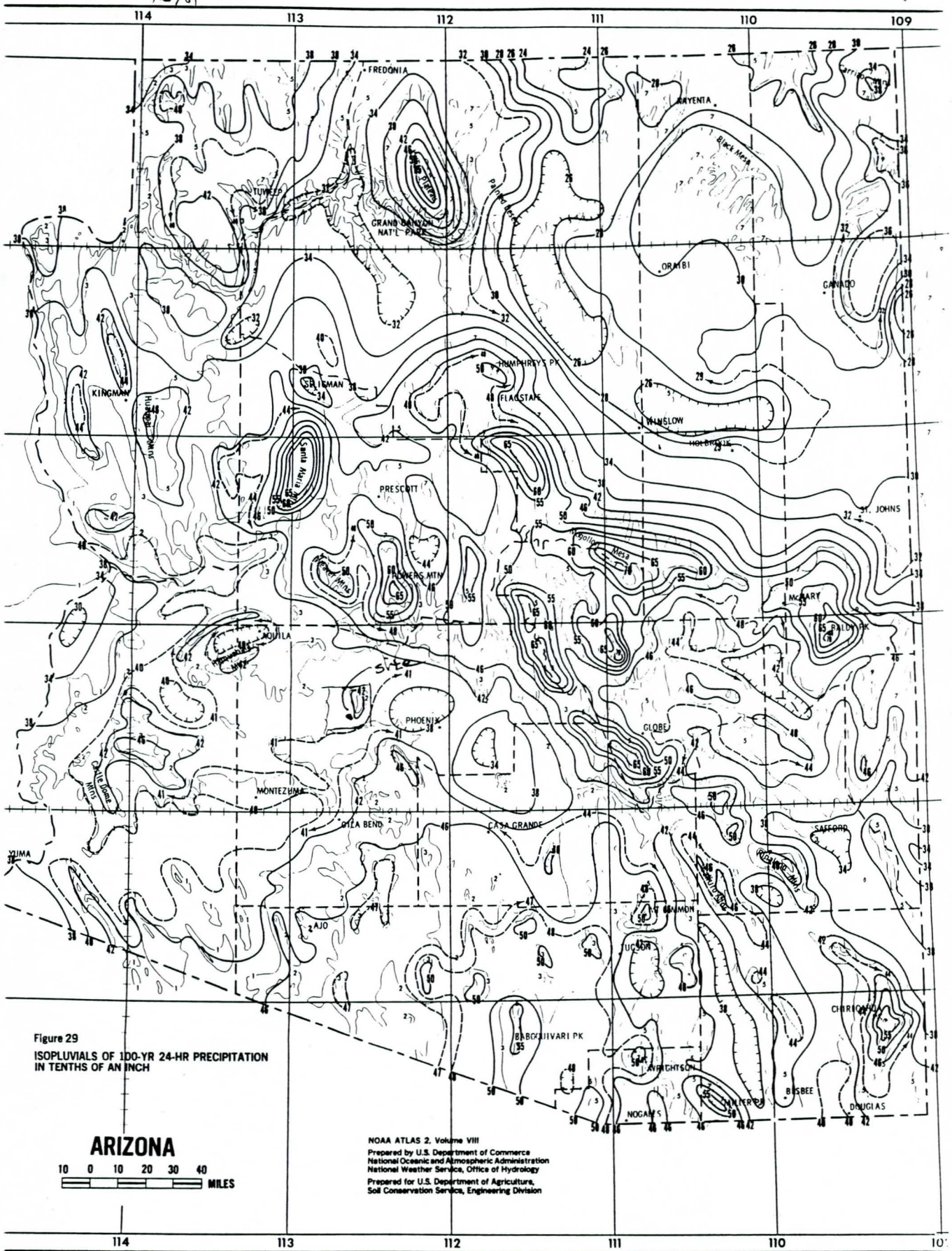


Figure 29

ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

ARIZONA

10 0 10 20 30 40 MILES

NOAA ATLAS 2, Volume VIII

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

15448-003-012
Backup FRS
10 of 32
161

JDF
11/08/89
RHA
11/8/89

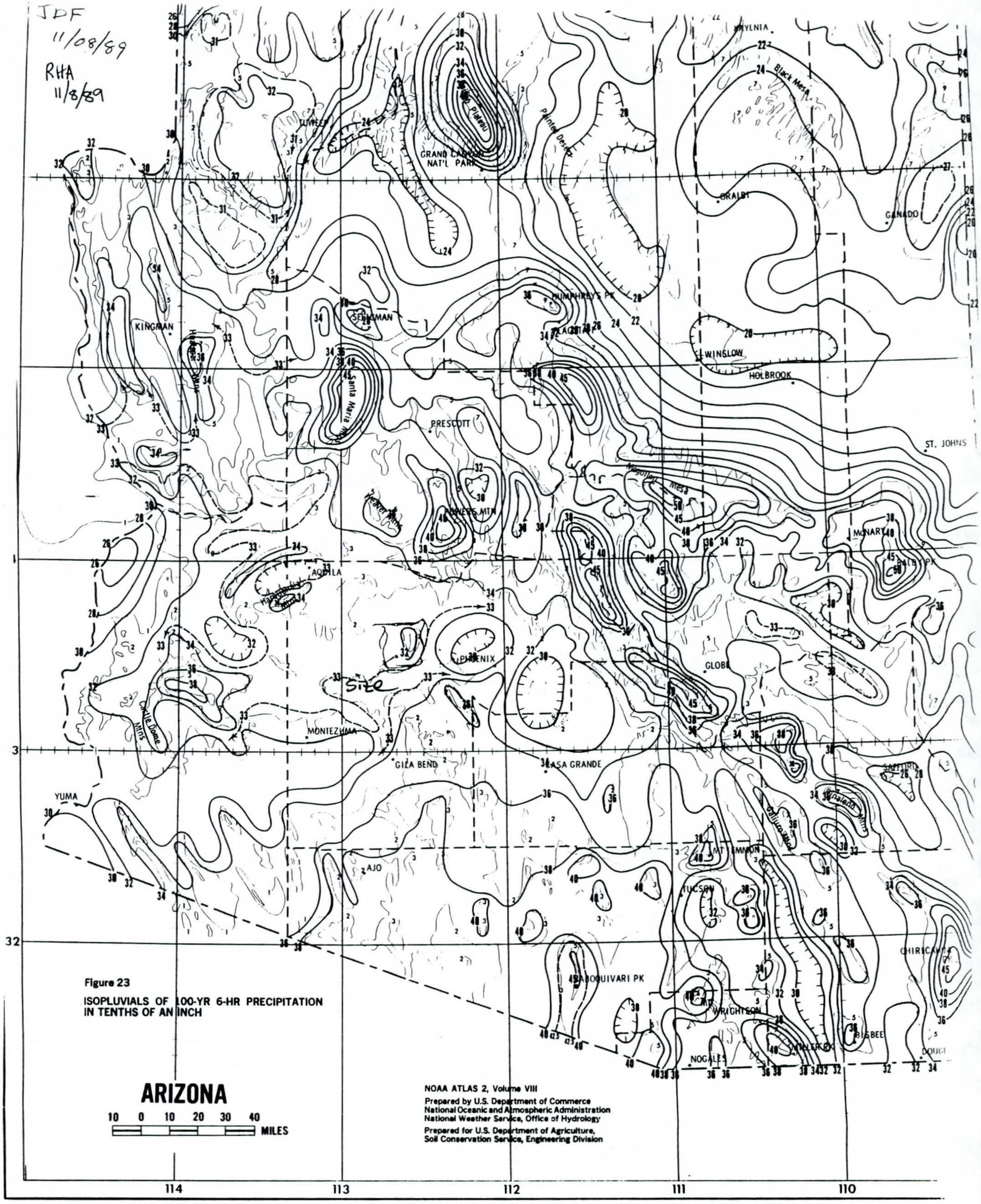


Figure 23

ISOPLUVIALS OF 100-YR 6-HR PRECIPITATION IN TENTHS OF AN INCH

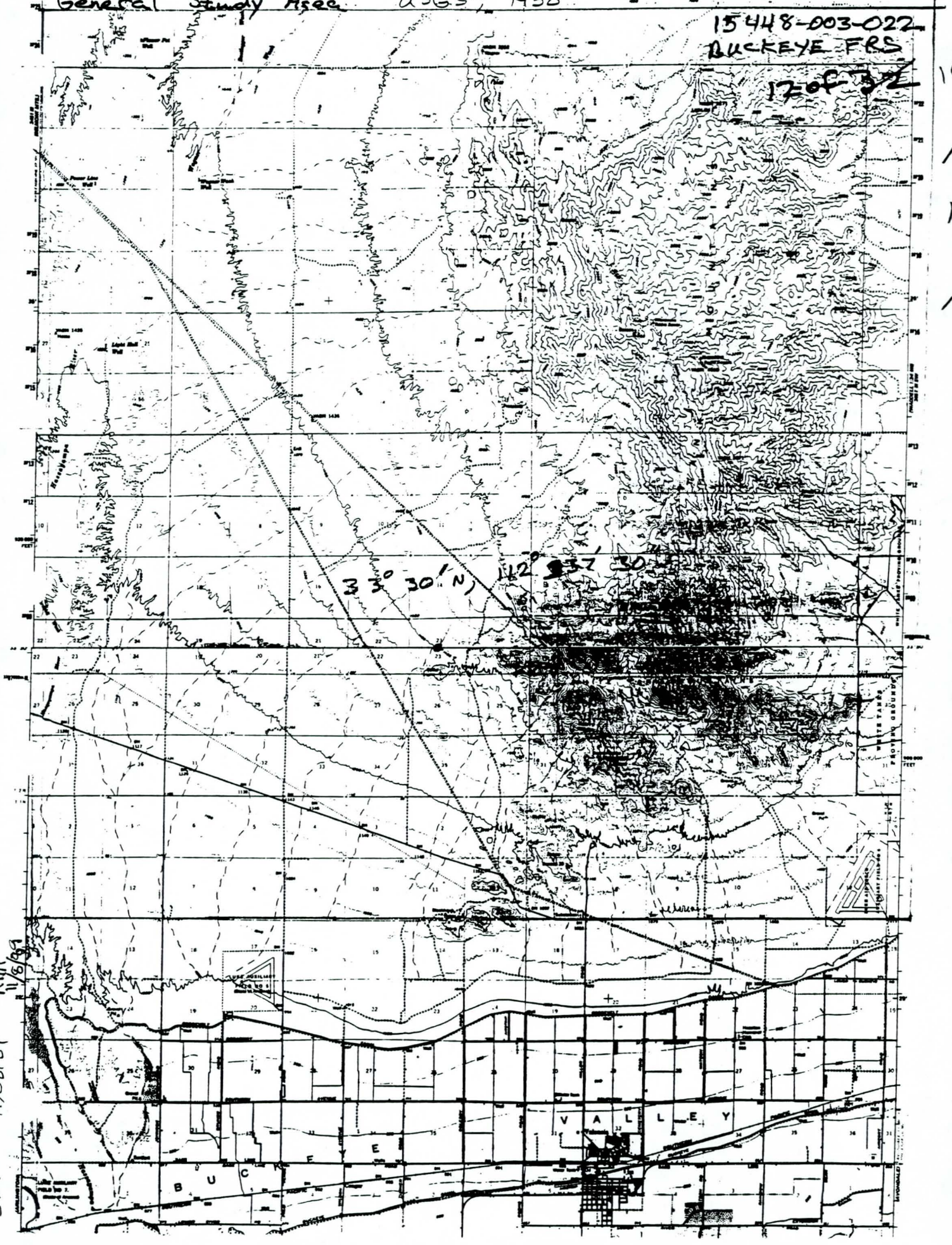
15448-003-022
Buckeye FRS
11 of 82
161

Buckeye Quadrangle, Arizona - Maricopa Co. 15 min Series (Topogs
White Tank Mts.,

General Study Area USGS, 1958

15448-003-022
BUCKEYE FRS
12 of 32

16



RHA 11/8/89

11/08/89

JDF

FILE 15448-003-022
SUBJECT Buckeye FRS
SHEET 13 OF ~~3~~ 16

Determining 6 hr + 48 hr PMP's.

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

BY JDF DATE 11/08/89
CHECKED BY RHA 11/8/89
COPY TO EO _____

Dames & Moore

15440-003-002
Buckeye FRS

14 of ~~32~~ 161

Table 6.1.—General-storm PMP computations for the Colorado River and Great basin

Drainage Buckeye FRS Area 8 mi^2 (km^2)

Latitude 33° 30′ N, Longitude 112° 37′ 33″ of basin center

Month ~~Sep~~ August

Assumed Typical For Sub Basin BOS

Step	Duration (hrs) 6	12	18	24	48	72	
A. Convergence PMP							
1. Drainage average value from one of figures 2.5 to 2.16	14.0						in. (mm)
2. Reduction for barrier-elevation [fig. 2.18]	90						%
3. Barrier-elevation reduced PMP [step 1 X step 2]	12.6						in. (mm)
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].	75	89	96	100	112	116	%
5. Convergence PMP for indicated durations [steps 3 X 4]	9.5	11.2	12.1	12.6	14.1	14.6	in. (mm)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]	9.5	1.7	0.9	0.5	1.5	0.5	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]	100						%
8. Areally reduced PMP [step 6 X step 7]							in. (mm)
9. Drainage average PMP [accumulated values of step 8]	9.5	11.2	12.1	12.6	14.1	14.6	in. (mm)
B. Orographic PMP							
1. Drainage average orographic index from figure 3.11a to d. (Revised)	2.6						in. (mm)
2. Areal reduction [figure 3.20]	100						%
3. Adjustment for month [one of figs. 3.12 to 3.17]	100						% ? Fig 3.15
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	2.0						in. (mm)
5. Durational variation [table 3.9]	36	63	84	100	141	160	%
6. Orographic PMP for given durations [steps 4 X 5]	0.7	1.3	1.7	2.0	2.8	3.2	in. (mm)
C. Total PMP							
1. Add steps A9 and B6	10.2	12.5	13.8	14.6	~~17.6~~ 16.9	17.8	in. (mm)

2. PMP for other durations from smooth curve fitted to plot of computed data.

3. Comparison with local-storm PMP (see sec. 6.3).

JJ 11/08/89 RHA 11/8/89

Same Same

Buckeye FRS
15 of ~~32~~ 161

Table 6.3A.—Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

Drainage Buckeye FRS Area 8 mi^2 (km^2)
Latitude 33° 30′ Longitude 112 38′ Minimum Elevation 1050 ft (m)

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 11.7 in. (mm)

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. 100 %

   b. Multiply step 1 by step 2a. 11.7 in. (mm)

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.35

	Duration (hr)									
	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	69	86	94	100	116	124	129	133	135	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	8.1	10.1	11.0	11.7	13.6	14.5	15.1	15.6	15.8	in. (mm)
6. Areal reduction [fig. 4.9].	77	82	84	85	87	88	88.5	89	90.5	%
7. Areal reduced PMP [steps 5 X 6].	6.2	8.3	9.2	10.0	11.8	12.8	13.4	13.9	14.3	in. (mm)
8. Incremental PMP [successive subtraction in step 7].				10.0	1.8	1.0	0.6	0.5	0.4	in. (mm)
	6.2	2.1	0.9	0.8	} 15-min. increments					

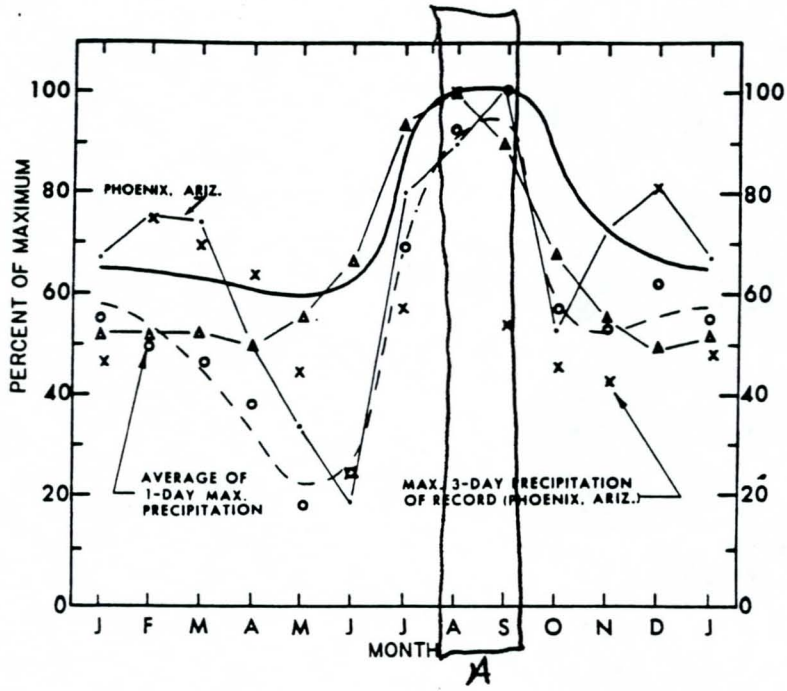
9. Time sequence of incremental PMP according to:

   Hourly increments [table 4.7]. 0.4 0.6 1.8 10.0 1.0 0.5 in. (mm) ?

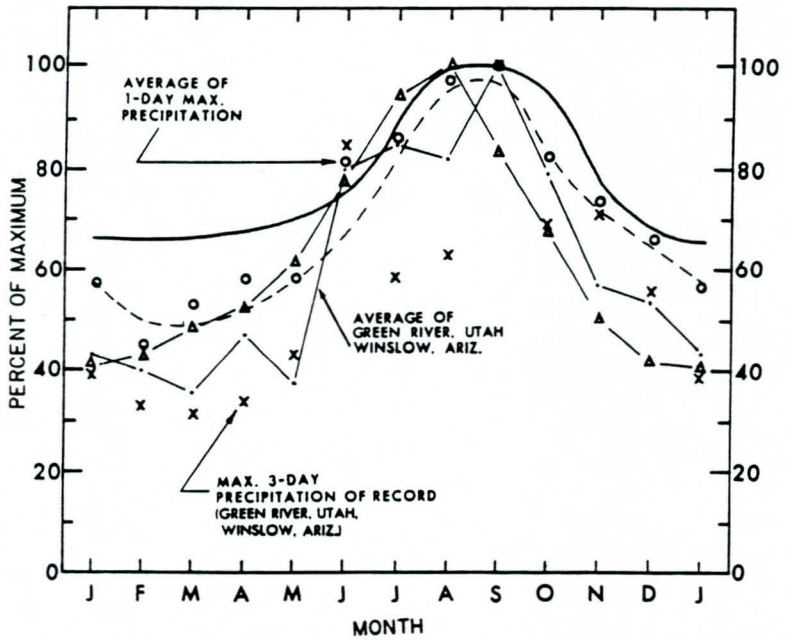
   Four largest 15-min. increments [table 4.8]. 6.2 2.1 0.9 0.8 in. (mm)

11/08/89
4/8/89
KHA

15448-003-022
Buckeye F.R.S.
16 of ~~32~~ 15
161



a. Southwest Arizona



b. Northeast Arizona

▲——▲ Maximum precipitable water at subregion midpoint
— — — — "Eye" smoothed 1-day station average (stations listed in table 2.2)
·——·—— 0.02 probability level of 3-day maximum rains
——— 1000-mb (100-kPa) convergence PMP at subregion midpoint taken from analyses in figures 2.5 to 2.16

Figure 2.4.--Seasonal variation of convergence PMP and supporting data for least-orographic subregions. All values given in percent of the maximum monthly value for that parameter.

RHA 1/06/89 1/8/89

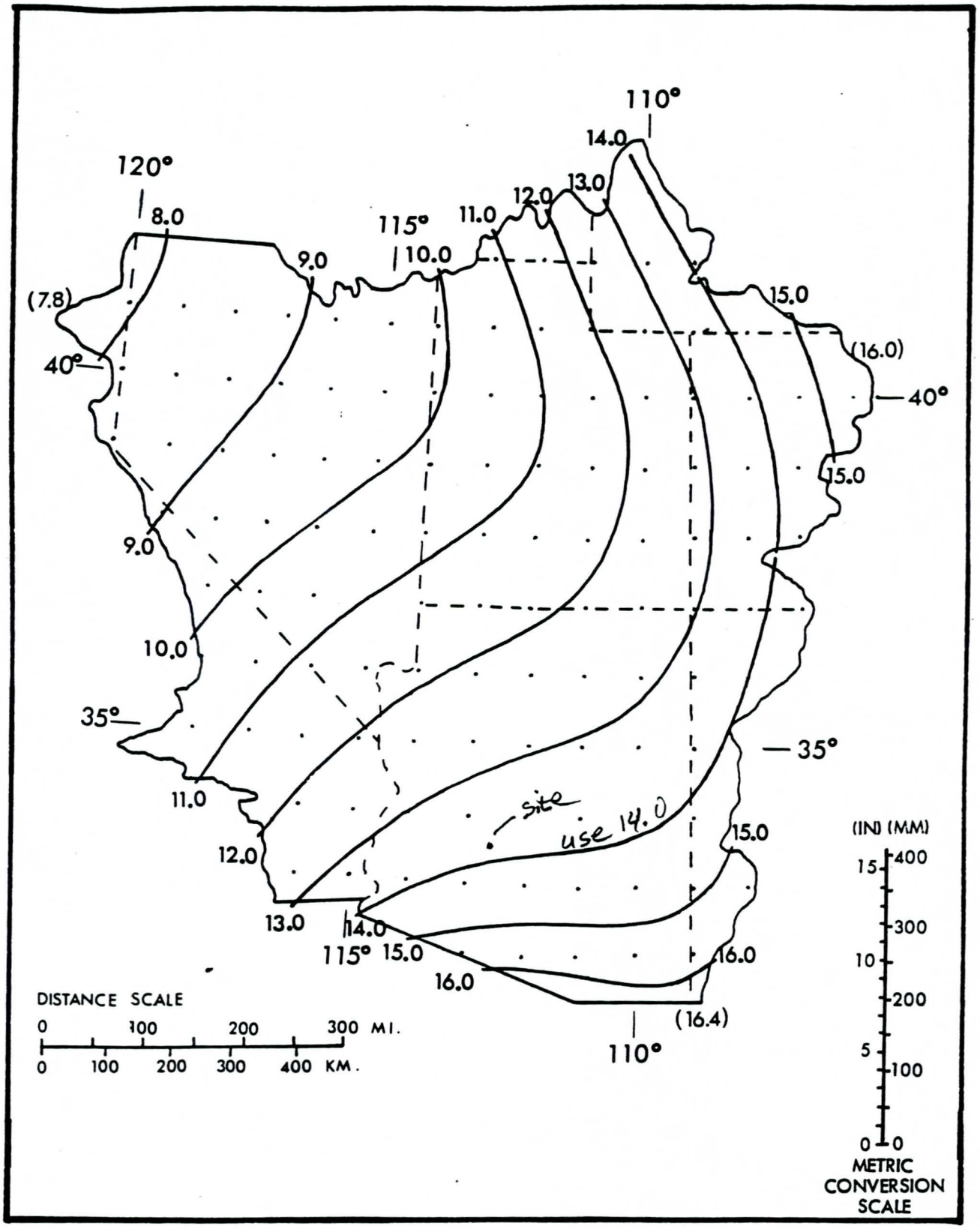
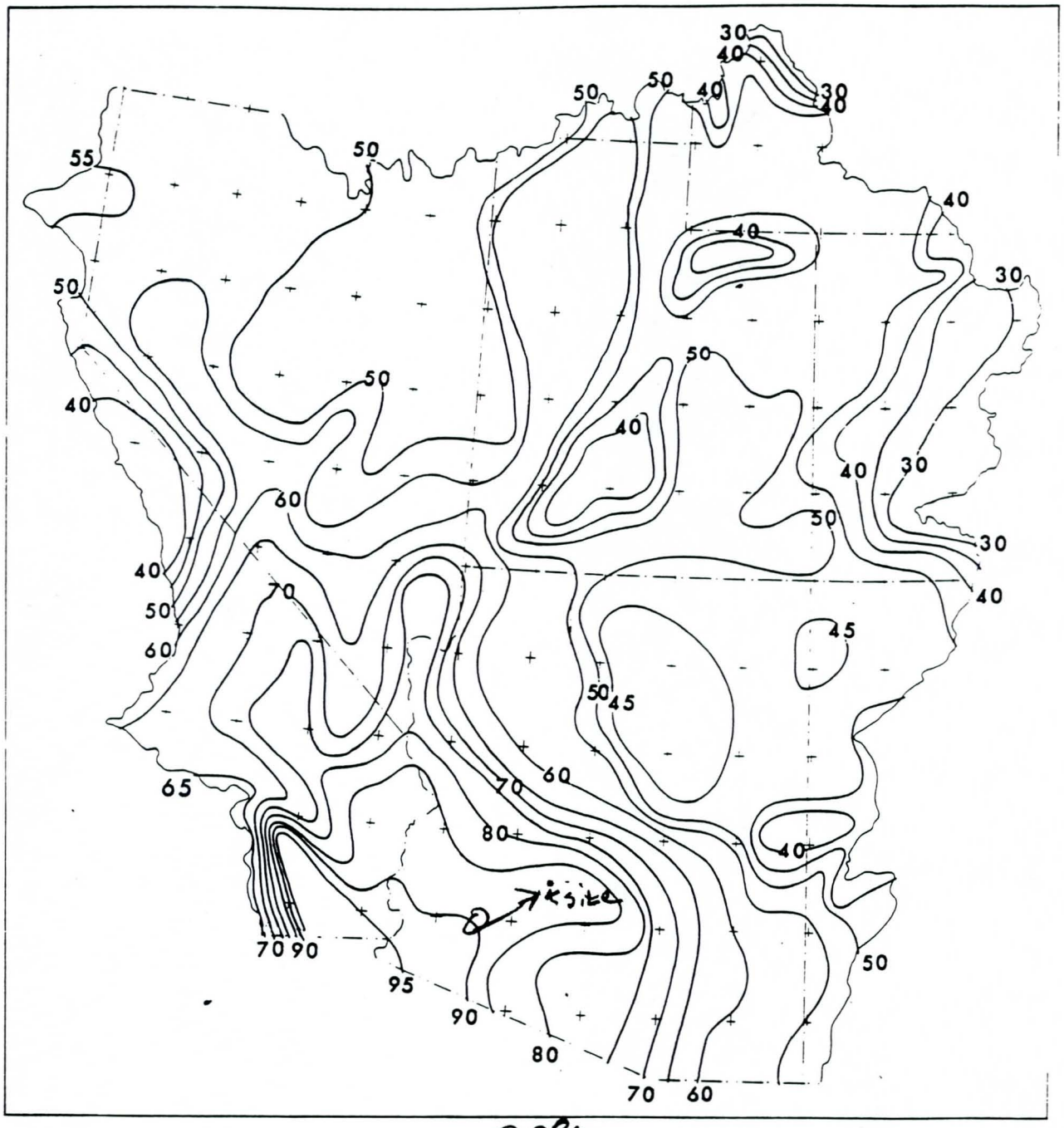


Figure 2.12.--1000-mb (100-kPa) 24-hr convergence PMP (inches) for 10 mi^2 (26 km^2) for August. Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

11/08/89
4/8/89
F
RHA

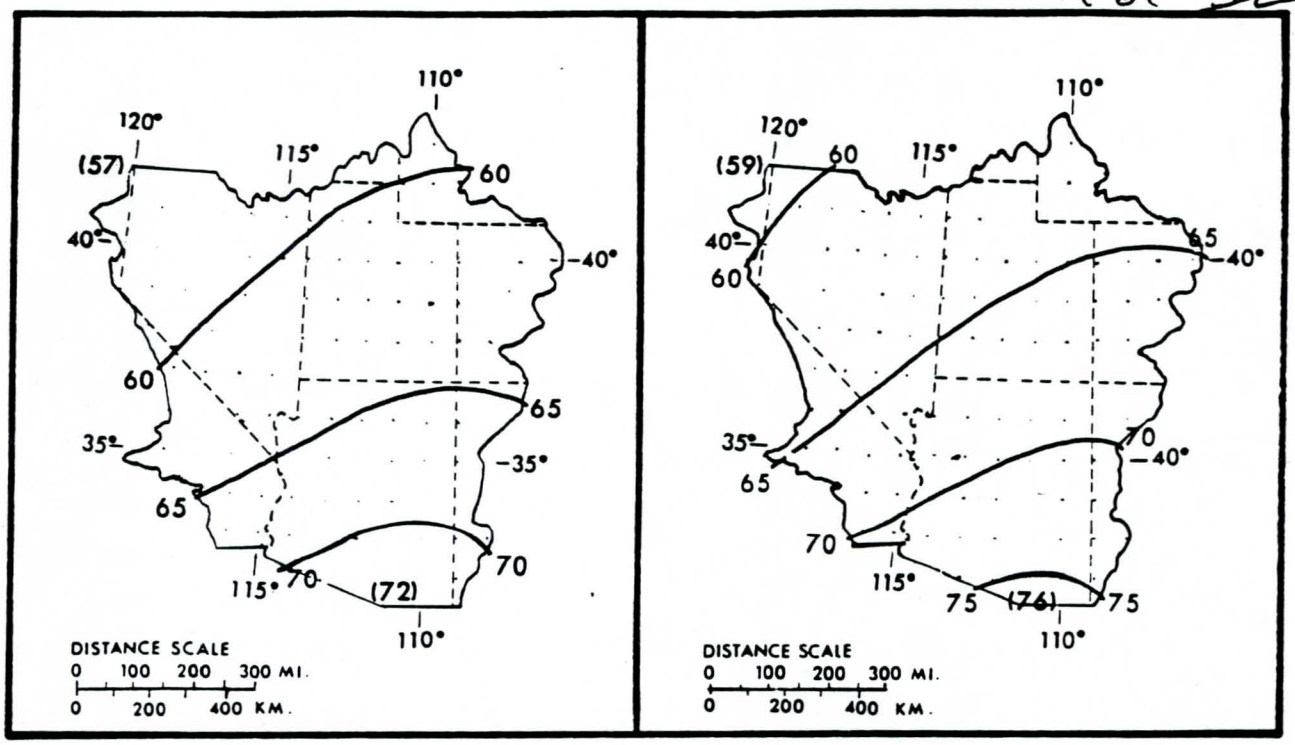
15448-003-022
Buckey FRS 37
161
18 of 32



use 90%

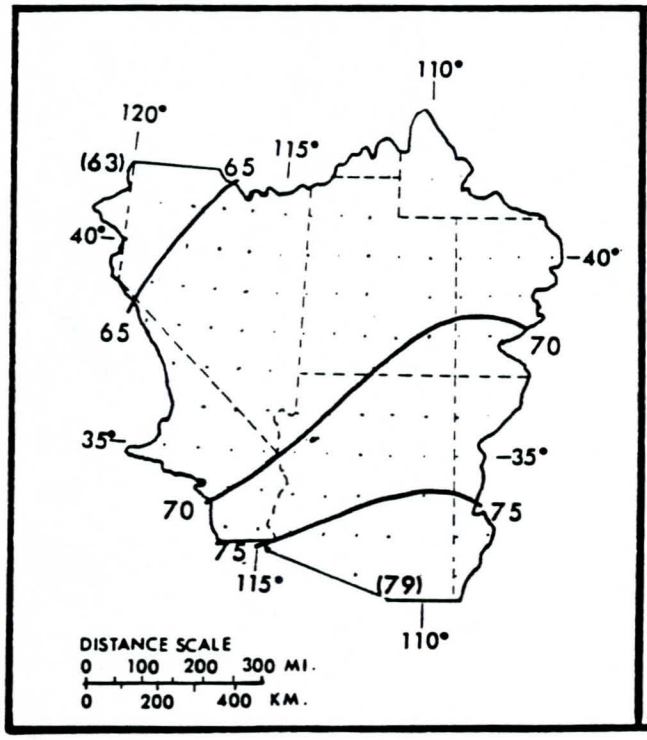
Figure 2.18.--Percent of 1000-mb (100-kPa) convergence PMP resulting from effective elevation and barrier considerations. Isolines drawn for every five percent.

15448-003-022
Buckeye FRS
19 of 32 161

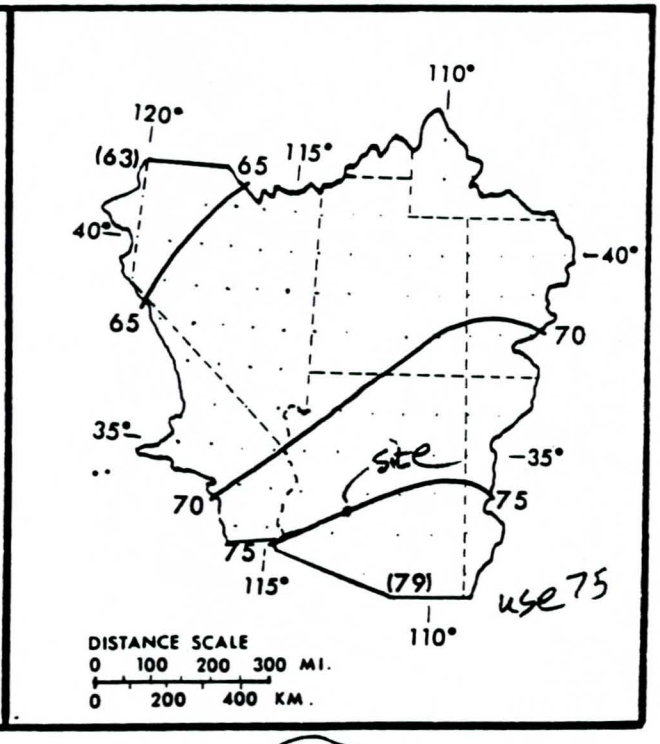


May

June



July



August

Figure 2.26.--Regional variation of 6/24-hr ratios by month (percent). Values in parentheses are limiting values and are to facilitate extrapolation beyond the indicated gradient.

JDE 11/08/89
RHA 11/8/89

15448-003-022
Buckeye FRS
20 of 32
161

For the range of 6/24-hr ratios included in figures 2.25 to 2.27, depth-duration values in percent of 24-hr amounts are found in table 2.7. The regional ratio maps, and the depth-duration curves presented in figure 2.20 were used in adjusting the major storm data to 24-hr amounts listed in table 2.1.

Table 2.7.--Durational variation of convergence PMP (in percent of 24-hr amount).

Duration (Hrs)						Duration (Hrs)					
6	12	18	24	48	72	6	12	18	24	48	72
50	76	90	100	129	150	66	84	93	100	116	124
51	77	90	100	128	148	67	85	94	100	116	123
52	77	90	100	127	146	68	85	94	100	115	122
53	77	91	100	127	144	69	86	94	100	115	121
54	78	91	100	126	142						
55	78	91	100	125	140	70	87	94	100	114	120
56	79	91	100	124	138	71	87	95	100	114	119
57	79	92	100	123	137	72	88	95	100	113	118
58	80	92	100	122	135	73	88	95	100	113	118
59	80	92	100	121	134	74	89	95	100	112	117
						75	89	96	100	112	116
60	81	92	100	120	132	76	90	96	100	111	115
61	81	92	100	120	131	77	90	96	100	110	114
62	82	93	100	119	129	78	91	96	100	110	114
63	82	93	100	118	128	79	92	97	100	109	113
64	83	93	100	117	126						
65	84	93	100	117	125	80	92	97	100	109	113

Note: For use, enter first column (6 hr) with 6/24-hr ratio from figures 2.25 to 2.27.

2.5 Areal Reduction for Basin Size

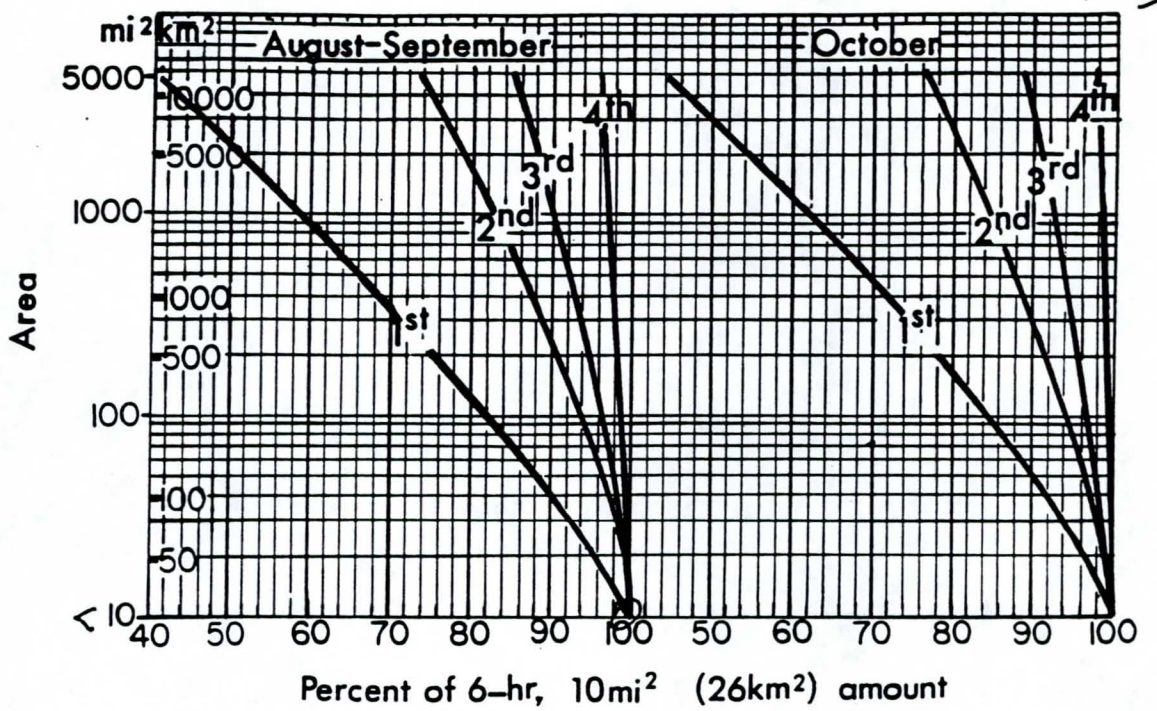
For operational use, basin average values of convergence PMP are needed rather than 10-mi^2 (26-km^2) values. Preferably, the method for reducing 10-mi^2 (26-km^2) values to basin average rainfalls should be derived from depth-area relations of storms in the region. However, all general storms in the region include large proportions or orographic precipitation.

Our solution was to use generalized depth-area relations developed for PMP estimates within bordering zones in the Central and Eastern United States (Riedel et al. 1956). The smoothed areal variations adopted for the Southwestern States are shown in figures 2.28 and 2.29 for each month or a combination of months where differences are insignificant.

Figures 2.28 and 2.29 give depth-area relations that reduce 10-mi^2 (26-km^2) convergence PMP for basin sizes up to 5,000 mi^2 (12,950 km^2) for each month. Areal variations are given for the 4 greatest (1st to 4th) 6-hr PMP increments. After the 4th increment no reduction for basin size is required. Application of these figures will become clear through consideration of an example of PMP computation in chapter 6.

DF 11/08/89
RHA 11/8/89

15448-003-022
Buckeye FRS
21 of 32
161



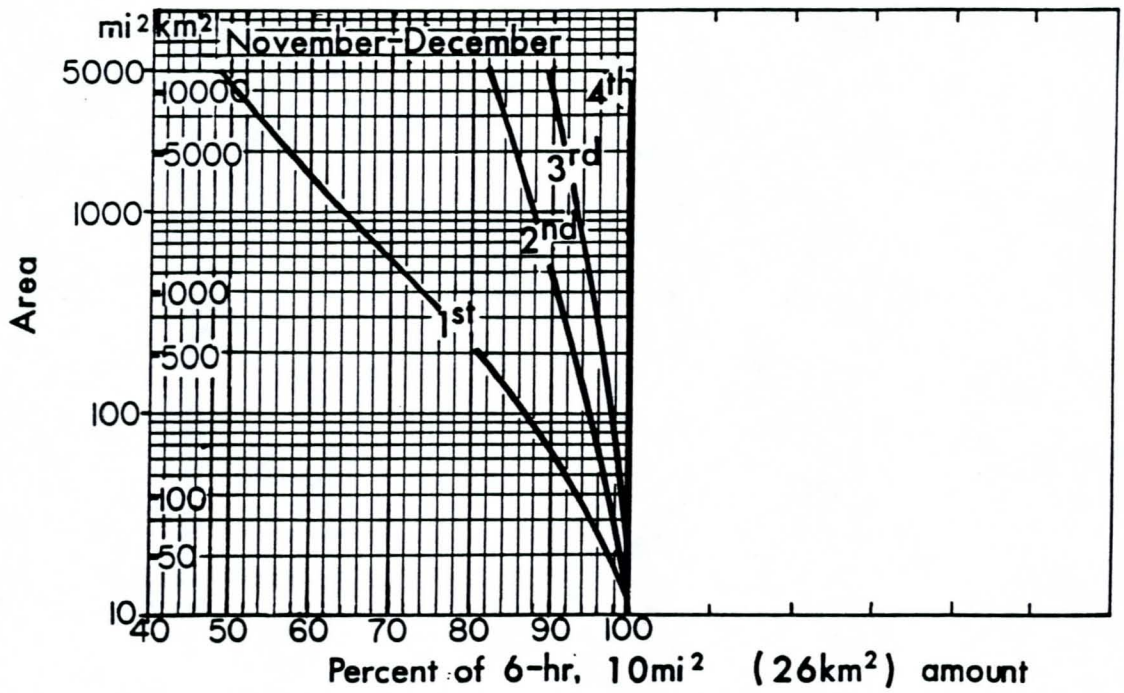


Figure 2.29.--Depth-area variation for convergence PMP for first to fourth 6-hr increments.

DF 11/06/88
KHA 11/8/89

DF 11/08/89
RHA 11/8/89

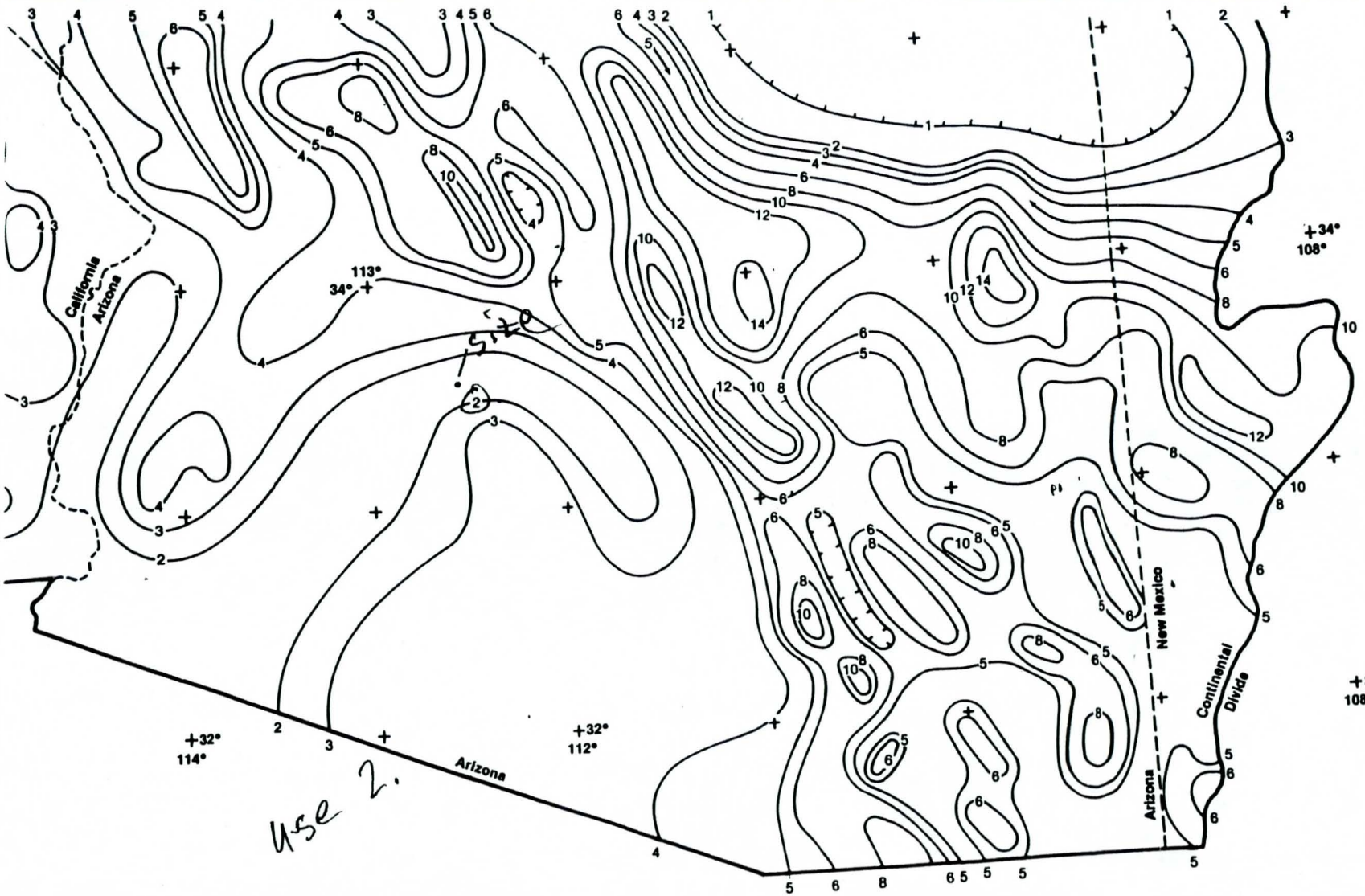


FIGURE 3.11d (Revised) — 10-mi² (26-km²) 24-hr orographic PMP index map (inches), southern section.

13448-003-022
Buckeye FRS
22 of 32
121

TJF
RHA
11/08/89
11/8/89

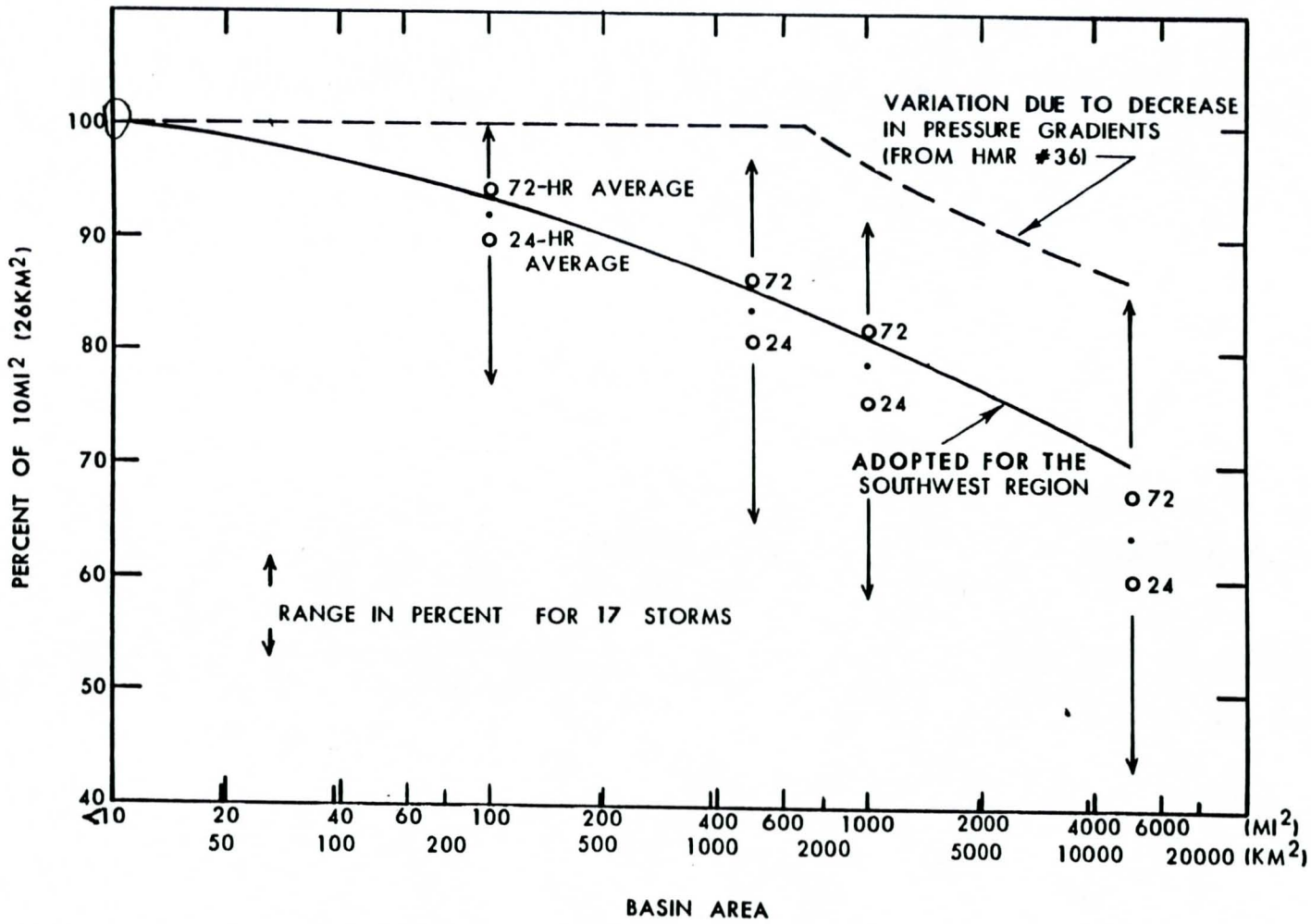


Figure 3.20.--Variation of orographic PMP with basin size.

15448-0032022
Buckeye ERS
23 of 32
161

[redacted]

J.JF 11/08/89

RHA 11/8/89

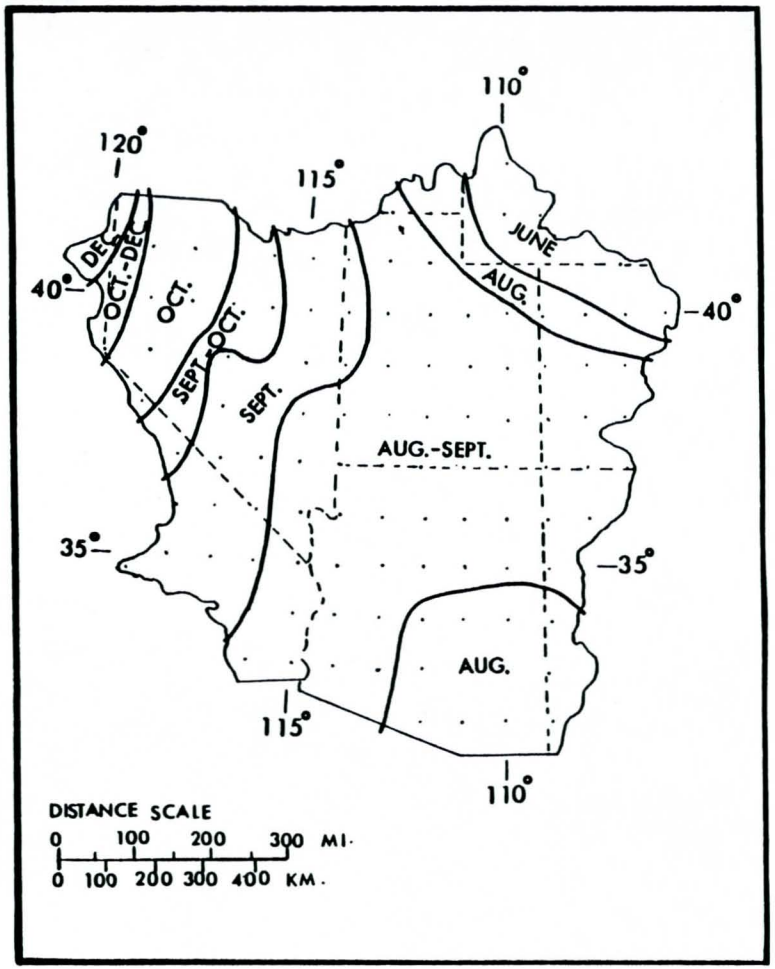


Figure 3.18.--Months of maximum total general-storm PMP for Southwest States, 10 mi^2 (26 km^2) 24 hr.

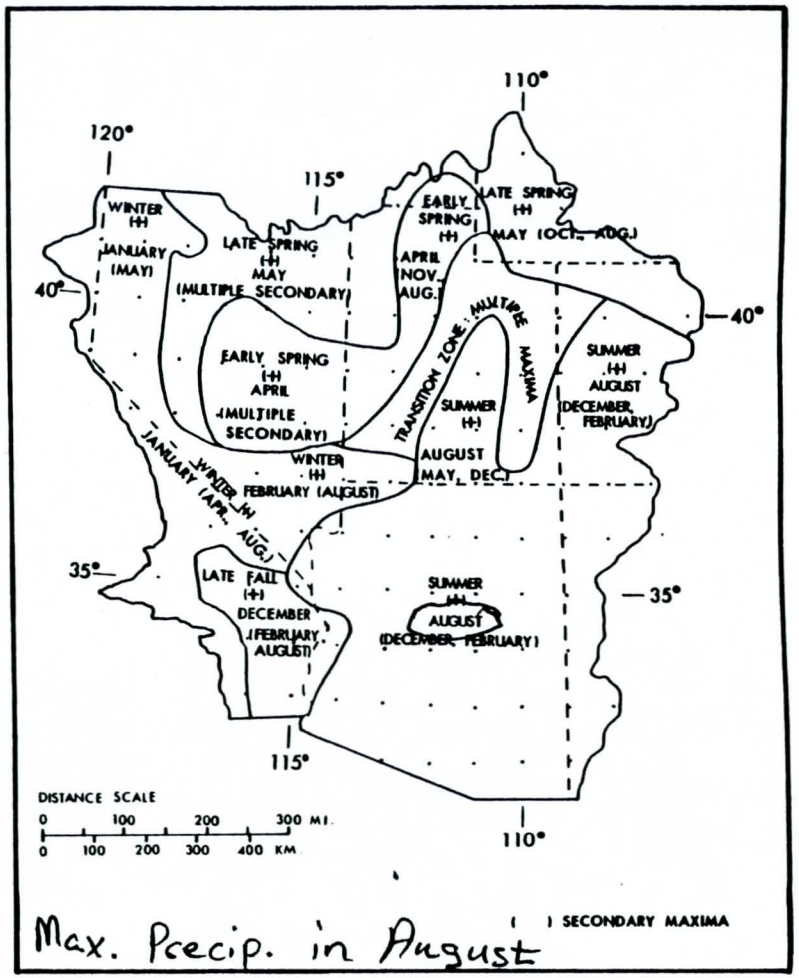
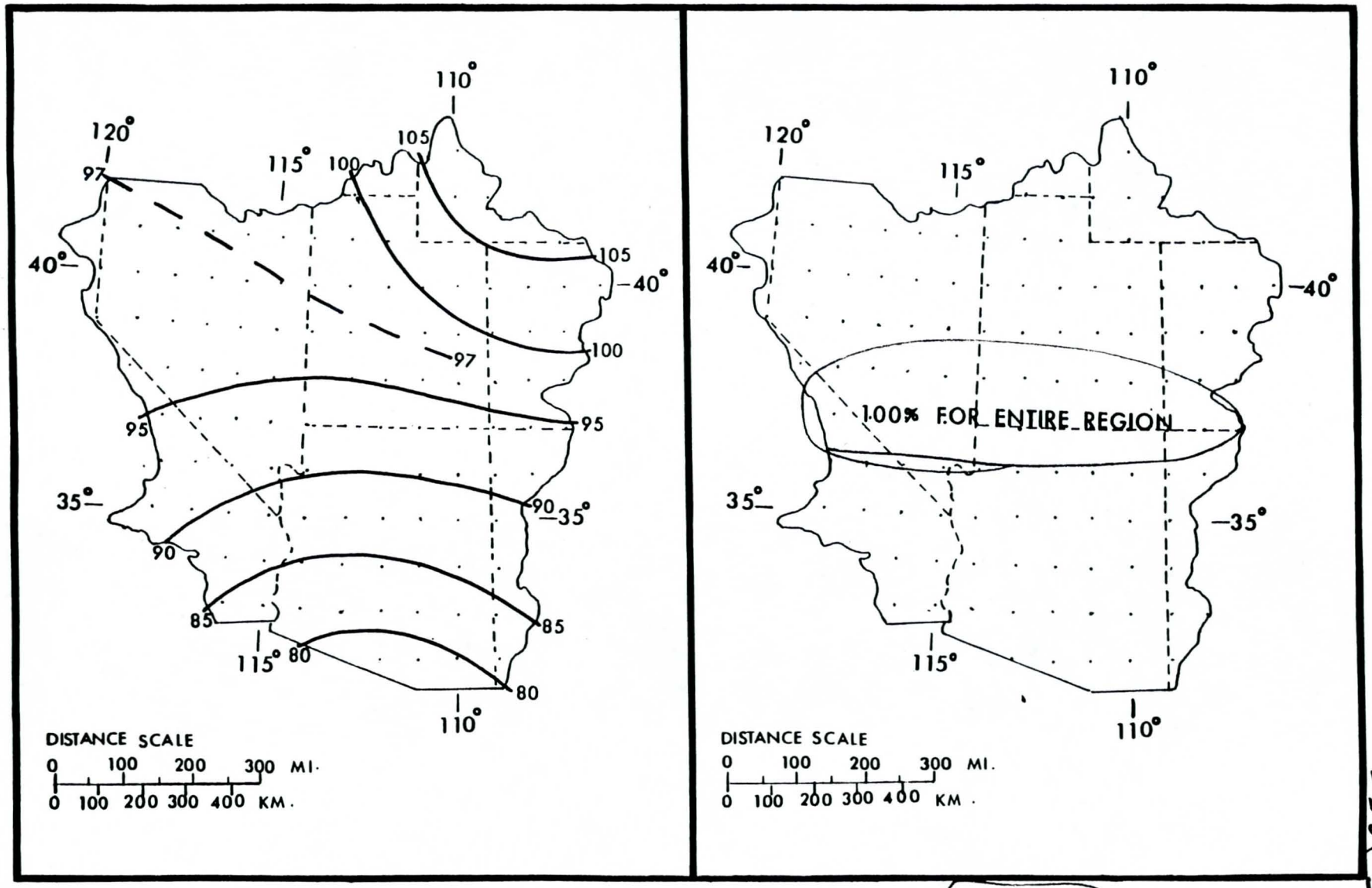


Figure 3.19.--Season and month of maximum and secondary maximum 24-hr station precipitation after Pyke (1972).

13448-003-022
Buckeye FRS 87
24 of 32 (6)

JDF 11/08/89
RHA 11/8/89



July *August*

Figure 3.15.--Seasonal variation in 10-mi^2 (26-km^2) 24-hr orographic PMP for the study region (in percent of values in figure 3.11).

15448-00 3-02
Buckeye FRS
25 of 32 161

15448-003-022
Buckeye FRS
26 of 32
161

Table 3.9.--Durational variation of orographic PMP

Latitude °N	Percent of 24-hr value					
	6 hr	12	18	24	48	72
42	28	55	79	100	161	190
41	29	56	79	100	160	189
40	30	57	80	100	159	187
39	30	57	80	100	157	185
38	31	58	81	100	155	182
37	32	59	81	100	152	177
36	33	60	82	100	149	172
35	34	61	82	100	146	167 use
34	35	62	83	100	143	162
33	36	63	84	100	139	157 63 84 100 141 16
32	37	64	84	100	135	152
31	39	66	85	100	132	146

4. LOCAL-STORM PMP FOR THE SOUTHWESTERN REGION AND CALIFORNIA

4.1 Introduction

This chapter provides generalized estimates of local or thunderstorm probable maximum precipitation. By "generalized" is meant that mapped values are given from which estimates of PMP may be determined for any selected drainage.

4.1.1 Region of Interest

Local-storm PMP was not included in the "Interim Report, Probable Maximum Precipitation in California" (HMR No. 36). During the formulation of the present study, we decided that the local-storm part of the study should include California west of the Sierra Nevada. It was also noted that PMP for summer thunderstorms was not considered west of the Cascade Divide in the Northwestern Region (HMR No. 43). As stated in the latter report, "No summer thunderstorms have been reported there (west of the Divide) of an intensity of those to the east, for which the moisture source is often the Gulf of Mexico or Gulf of California. The Cascade Divide offers an additional barrier to such moisture inflows to coastal areas where, in addition, the Pacific Ocean to the west has a stabilizing influence on the air to hinder the occurrence of intense summer local storms." Therefore, it was necessary to establish some continuation of the Cascade Divide into California so that the local-storm PMP definition would have continuity between the two regions.

The stabilizing influence of the Pacific air is at times interrupted by the warm moist tropical air from the south pushing into California, although it is difficult to determine where the limit of southerly flow occurs. General storms having the tropical characteristic of excessive thunderstorm rains are observed as far north as the northern end of the Sacramento Valley. Thus, a northern boundary has been selected for this study, excluding that portion of

JL 11/08/89
RHA 11/8/89

15448-003-022
Buckeye FRS
115
27 of 33

LATITUDE MARKINGS ON 110, 115, 120
ARE NOT CORRECT

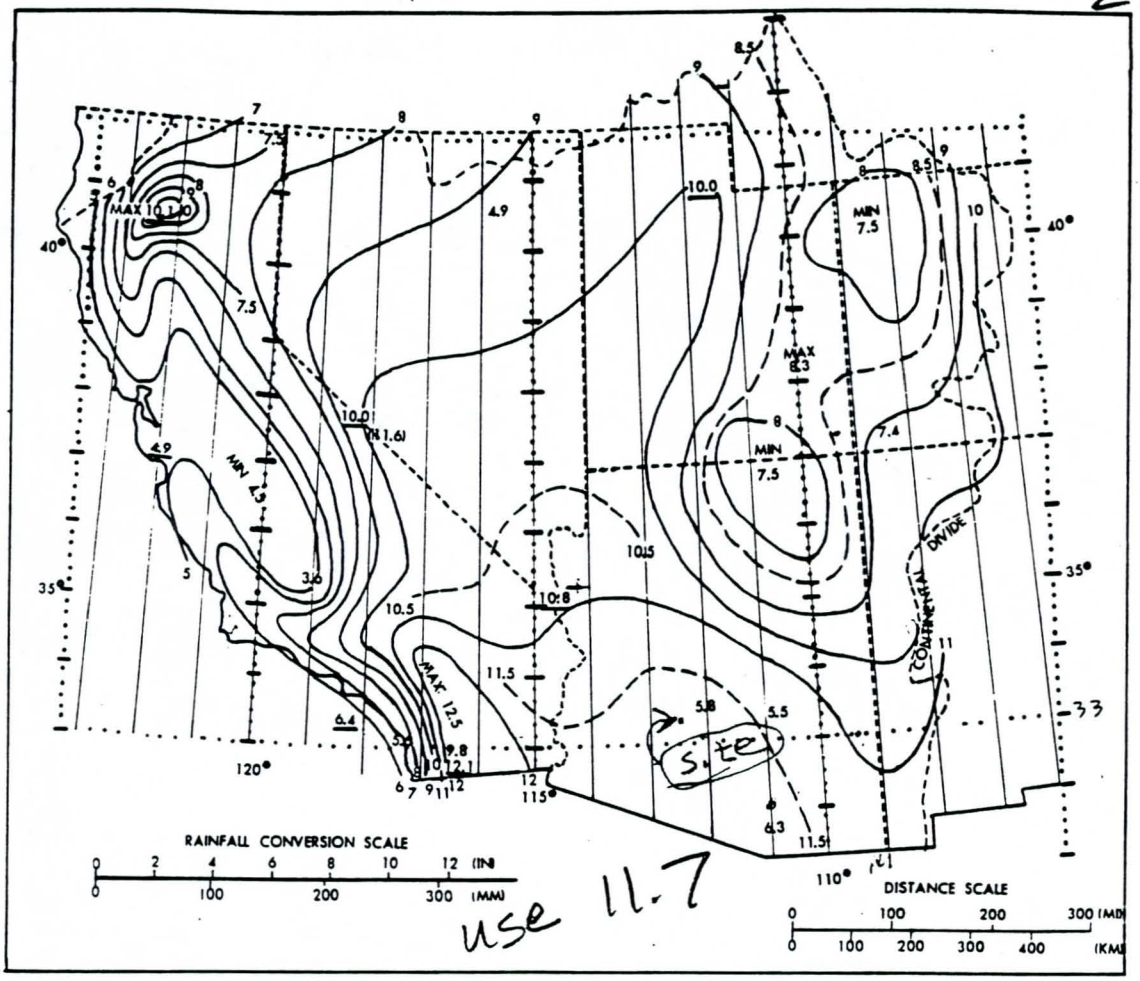


Figure 4.5--Local-storm PMP for 1 mi^2 (2.6 km^2) 1 hr. Directly applicable for locations between sea level and 5000 ft (1524 m). Elevation adjustment must be applied for locations above 5000 ft.

events. In contrast to figure 4.4, figure 4.5 maintains a maximum between these two locations. There is no known meteorological basis for a different solution. The ãnalysis suggests that in the northern portion of the region maximum PMP occurs between the Sierra Nevada on the west and the Wasatch range on the east.

A discrete maximum (> 10 inches, 254 mm) occurs at the north end of the Sacramento Valley in northern California because the northward-flowing moist air is increasingly channeled and forced upslope. Support for this PMP center comes from the Newton, Kennett, and Red Bluff storms (fig. 4.1). Although the analysis in this region appears to be an extension of the broad maximum through the center of the Southwestern Region, it does not indicate the direction of moist inflow. The pattern has evolved primarily as a result of attempts to tie plotted maxima into a reasonable picture while considering inflow directions, terrain effects, and moisture potential.

11/08/89
11/8/89
JDF
RHA

15448-003-02
Buckeye FRS
28 of 32
161

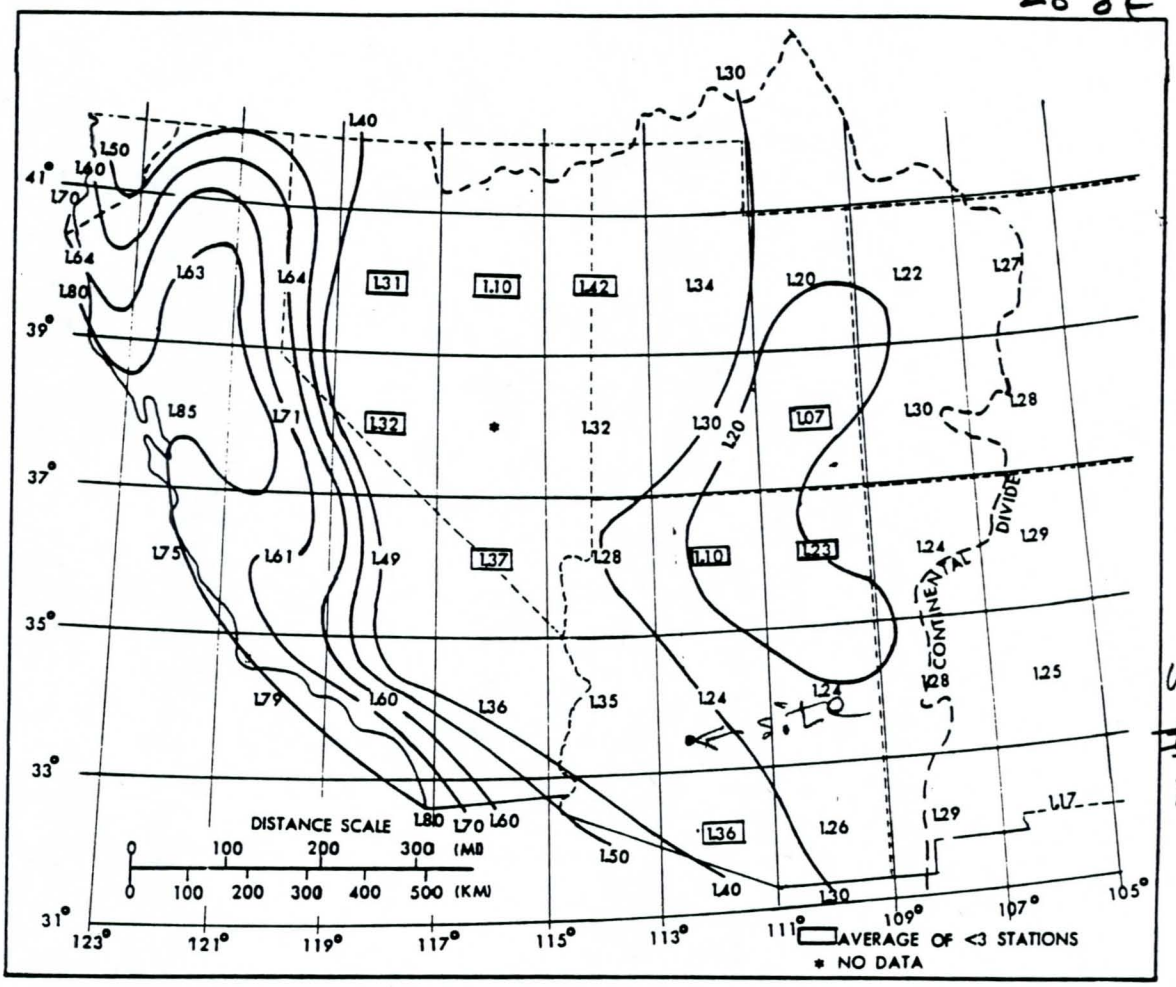


Figure 4.7.--Analysis of 6/1-hr ratios of averaged maximum station data (plotted at midpoints of a 2° latitude-longitude grid).

use ~~1.30~~ 1.35

establish the basic depth-duration curve, then structure a variable set of depth-duration curves to cover the range of 6/1-hr ratios that are needed.

Three sets of data were considered for obtaining a base relation (see table 4.3 for depth-duration data):

a. An average of depth-duration relations from each of 17 greatest 3-hr rains from summer storms (1940-49) in Utah (U. S. Weather Bureau 1951b) and in unpublished tabulations for Nevada and Arizona (1940-63). The 3-hr amounts ranged from 1 to 3 inches (25 to 76 mm) in these events.

b. An average depth-duration relation from 14 of the most extreme short-duration storms listed in Storm Rainfall (U. S. Army, Corps of Engineers 1945-). These storms come from Eastern and Central States and have 3-hr amounts of 5 to 22 inches (127 to 559 mm).

11/08/89
11/8/89
RHA

15448-003-022
Buckeye FRS
29 of 32
161

ratios than storms with high 3/1-hr ratios. The geographical distribution of 15-min to 1-hr ratios also were inversely correlated with magnitudes of the 6/1-hr ratios of figure 4.7. For example, Los Angeles and San Diego (high 6/1-hr ratios) have low 15-min to 1-hr ratios (approximately 0.60) whereas the 15-min to 1-hr ratios in Arizona and Utah (low 6/1-hr ratios) were generally higher (approximately 0.75).

Depth-duration relations for durations less than 1 hour were then smoothed to provide a family of curves consistent with the relations determined for 1 to 6 hours, as shown in figure 4.3. Adjustment was necessary to some of the curves to provide smoother relations through the common point at 1 hour.

We believe we were justified in reducing the number of the curves shown in figure 4.3 for durations less than 1 hour, letting one curve apply to a range of 6/1-hr ratios. The corresponding curves have been indicated by letter designators, A-D, on figure 4.3. As an example, for any 6-hr amount between 115% and 135% of 1-hr, 1-mi^2 (2.6-km^2) PMP, the associated values for durations less than 1 hour are obtained from the curve designated as "B".

Table 4.4 lists durational variations in percent of 1-hr PMP for selected 6/1-hr rain ratios. These values were interpolated from figure 4.3.

To determine 6-hr PMP for a basin, use figure 4.3 (or table 4.4) and the geographical distribution of 6/1-hr ratios given in figure 4.7.

Table 4.4.--Durational variation of 1-mi^2 (2.6-km^2) local-storm PMP in percent of 1-hr PMP (see figure 4.3)

6/1-hr ratio	Duration (hr) 1/4	1/2	3/4	1	2	3	4	5	6
1.1	86	93	97	100	107	109	110	110	110
1.2	74	89	95	100	110	115	118	119	120
1.3	74	89	95	100	114	121	125	128	130
1.4	63	83	93	100	118	126	132	137	140
1.5	63	83	93	100	121	132	140	145	150
1.6	43	70	87	100	124	138	147	154	160
1.8	43	70	87	100	130	149	161	171	180
2.0	43	70	87	100	137	161	175	188	200

use Average

4.5 Depth-Area Relation

We have thus far developed local-storm PMP for an area of 1 mi^2 (2.6 km^2). To apply PMP to a basin, we need to determine how 1-mi^2 (2.6-km^2) PMP should decrease with increasing area. We have adopted depth-area relations based on rainfalls in the Southwest and from consideration of a model thunderstorm.

JDP 11/8/89
RHA 11/8/89

JDF 11/08/89
RHA 11/8/89

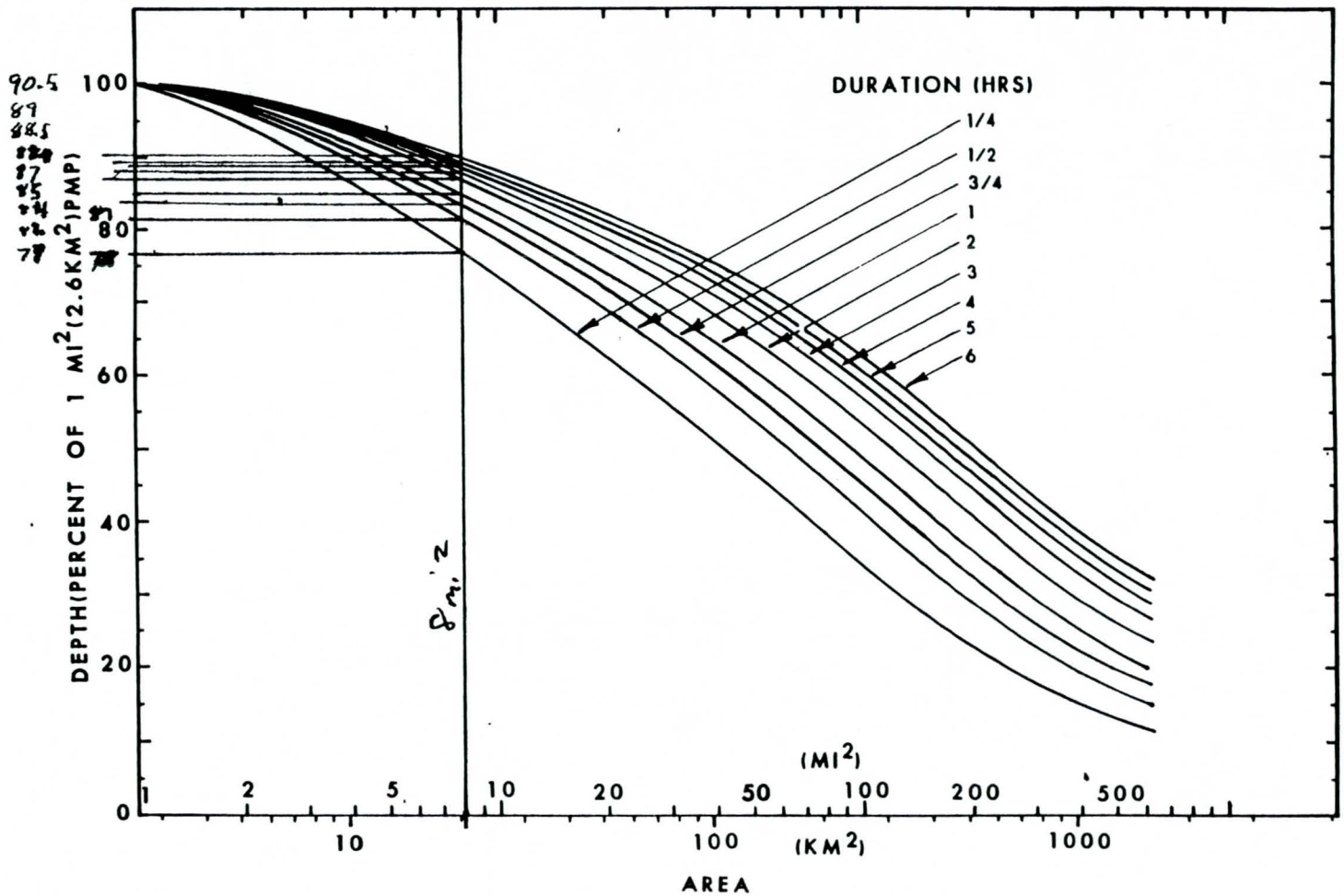
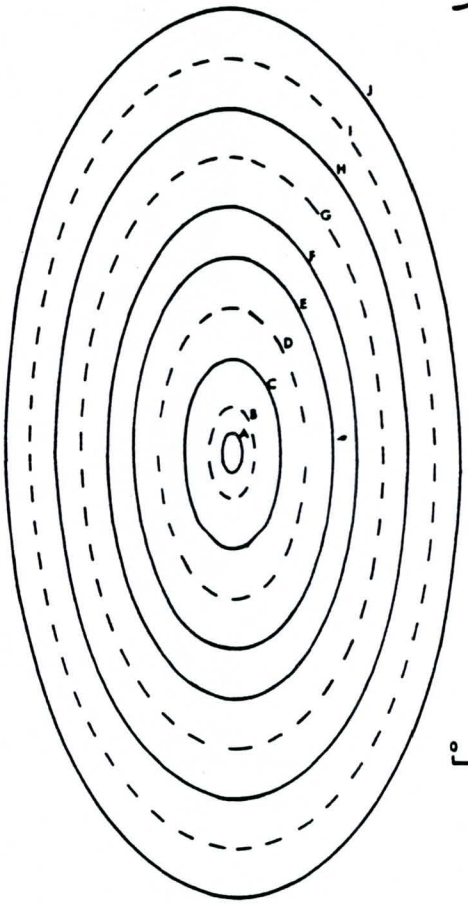


Figure 4.9.--Adopted depth-area relations for local-storm PMP.

15448-003-022
Buckeye ERS123
30 of 32
161

15448-003-022
Buckeye FRS
31 of 32
161



ISOHYET	INCLOSED AREA (SQ.MI.)	(KM^2)
A	1	2.6
B	5	13
C	25	65
D	55	142
E	95	246
F	150	388
G	220	570
H	300	777
I	385	997
J	500	1295

DISTANCE SCALE
0 2 4 6 8 (MI.)
2 4 6 8 10 12 (KM.)
SCALE 1:500,000

Figure 4.10.--Idealized local-storm isohyetal pattern.

storm period. The sequence of hourly incremental PMP for the Southwest 6-hr thunderstorm in accord with this study is presented in column 2 of table 4.7. A small variation from this sequence is given in Engineering Manual 1110-2-1411 (U. S. Army, Corps of Engineers 1965). The latter, listed in column 3 of table 4.7, places greater incremental amounts somewhat more toward the end of the 6-hr storm period. In application, the choice of either of these distributions is left to the user since one may prove to be more critical in a specific case than the other.

Table 4.7.--Time sequence for hourly incremental PMP in 6-hr storm

Increment	HMR No. 5[1] Sequence Position	EM1110-2-1411[2] Sequence Position	DSD
Largest hourly amount	Third	Fourth	4
2nd largest	Fourth	Third	5
3rd largest	Second	Fifth	3
4th largest	Fifth	Second	2
5th largest	First	Last	6
least	Last	First	1

[1]U. S. Weather Bureau 1947.
[2]U. S. Corps of Engineers 1952.

5 JE 11/08/89
RHA 11/8/89

13448-003-022
Buckeye FRS

32 of 32
161

Also of importance is the sequence of the four 15-min incremental PMP values. We recommend a time distribution, table 4.8, giving the greatest intensity in the first 15-min interval (U.S. Weather Bureau 1947). This is based on data from a broad geographical region. Additional support for this time distribution is found in the reports of specific storms by Keppell (1963) and Osborn and Renard (1969).

Table 4.8.--Time sequence for 15-min incremental PMP within 1 hr.

Increment	Sequence Position
Largest 15-min amount	First
2nd largest	Second
3rd largest	Third
least	Last

4.8 Seasonal Distribution

The time of the year when local-storm PMP is most likely is of interest. Guidance was obtained from analysis of the distribution of maximum 1-hr thunderstorm events through the warm season at the recording stations in Utah, Arizona, and in southern California (south of 37°N and east of the Sierra Nevada ridgeline). The period of record used was for 1940-72 with an average record length for the stations considered of 27 years. The month with the one greatest thunderstorm rainfall for the period of record at each station was noted. The totals of these events for each month, by States, are shown in table 4.9.

Table 4.9.--Seasonal distribution of thunderstorm rainfalls.

(The maximum event at each of 108 stations, period of record 1940-72.)

	Month						
	M	J	J	A	S	O	No. of Cases
Utah	1	5	9	14	5		34
Arizona		4	16	19	4		43
S. Calif.*		14	10	7			31
No. of cases/mo.	1	23	35	40	9	0	

*South of 37°N and east of Sierra Nevada ridgeline.

11/08/89
11/8/89
JK
RHA

CALCULATIONS COVER SHEET
DAMES & MOORE
DESIGN SERVICES GROUP

PROJECT NUMBER 15446-003-022
SUBJECT Buckeye FRS
SHEET 1A OF 161

Developing 6-Hr. + 72-Hr Storm Distributions
TITLE OF CALCULATIONS

Buckeye FRS
TITLE OF PROJECT

CALCULATIONS BY: John Fannin
PRINT NAME
John Fannin — 1/5/89
SIGNATURE — DATE

ASSUMPTIONS CHECKED BY CONSULTANT: George J Geisen
PRINT NAME
G J Geisen — 1/22/90
SIGNATURE — DATE

CALCULATIONS CHECKED BY: Richard Allen
PRINT NAME
Richard Allen — 1/22/90
SIGNATURE — DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT OR PM) George J Geisen
PRINT NAME
G J Geisen — 1/22/90
SIGNATURE — DATE

APPROVAL NOTES:
IF CALCULATIONS ARE ONLY SPOT CHECKED, DO NOT REQUIRE CHECKING OR ARE ASSUMED TO BE CORRECT BY EXPERIENCE OR ENGINEERING JUDGEMENT, IT SHOULD BE NOTED HERE.

REVISION NUMBER	DATE	BY	CHECKED BY (INITIALS)	APPROVAL
1				
2				
3				
4				

BY JJL DATE 1/5/90
CHECKED BY RHA 1/22/90
ORIGINAL TO PROJECT FILE

Developing PMP Distribution

Purpose: Develope 6-hr +72-hr PMP Distribution for Hec-1 input.

Reference: HMR-49.

Method:

Storm Distribution is as follows: [Ref Page 125]

Table 4.7.--Time sequence for hourly incremental PMP in 6-hr storm

Increment	HMR No. 5[1] Sequence Position	EM1110-2-1411[2] Sequence Position
Largest hourly amount	Third	Fourth
2nd largest	Fourth	Third
3rd largest	Second	Fifth
4th largest	Fifth	Second
5th largest	First	Last
least	Last	First
	Least Cons	Most Cons

[1] U. S. Weather Bureau 1947.
[2] U. S. Corps of Engineers 1952.

Table 4.8.--Time sequence for 15-min incremental PMP within 1 hr.

Increment	Sequence Position
Largest 15-min amount	First
2nd largest	Second
3rd largest	Third
least	Last

Distribution will be based on EM1110-2-1411 for the hourly increments.

Table 4.8 will apply to only the Peak 1-hr within a storm.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JOF DATE 1/23/90 CHECKED BY RHA DATE 1/22/90 COPY TO EO ____

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

BY JDF DATE 1/5/90
CHECKED BY RHA DATE 1/22/90
COPY TO EO _____

6-hr PMP: Distribution Process

The HEC-1 Computer models require the distribution to be in 5-min intervals. HMR-49 lists only the distribution for 1-hr intervals. To transform the 1-hr into a 5 min interval distribution the following steps will be taken:

1. Plot Precip. depth vs. Time

2. Determine the 5-min depths for each hour by scaling off the plot. Calculate the difference in depth for the 5min interval.

3. Since each hour increment listed in table 4.7 is the summation of a set of 5min intervals, the Distribution shall be:

Before Peak: The 5-min intervals that make up the increment in question will be placed in accending order within that hourly period.

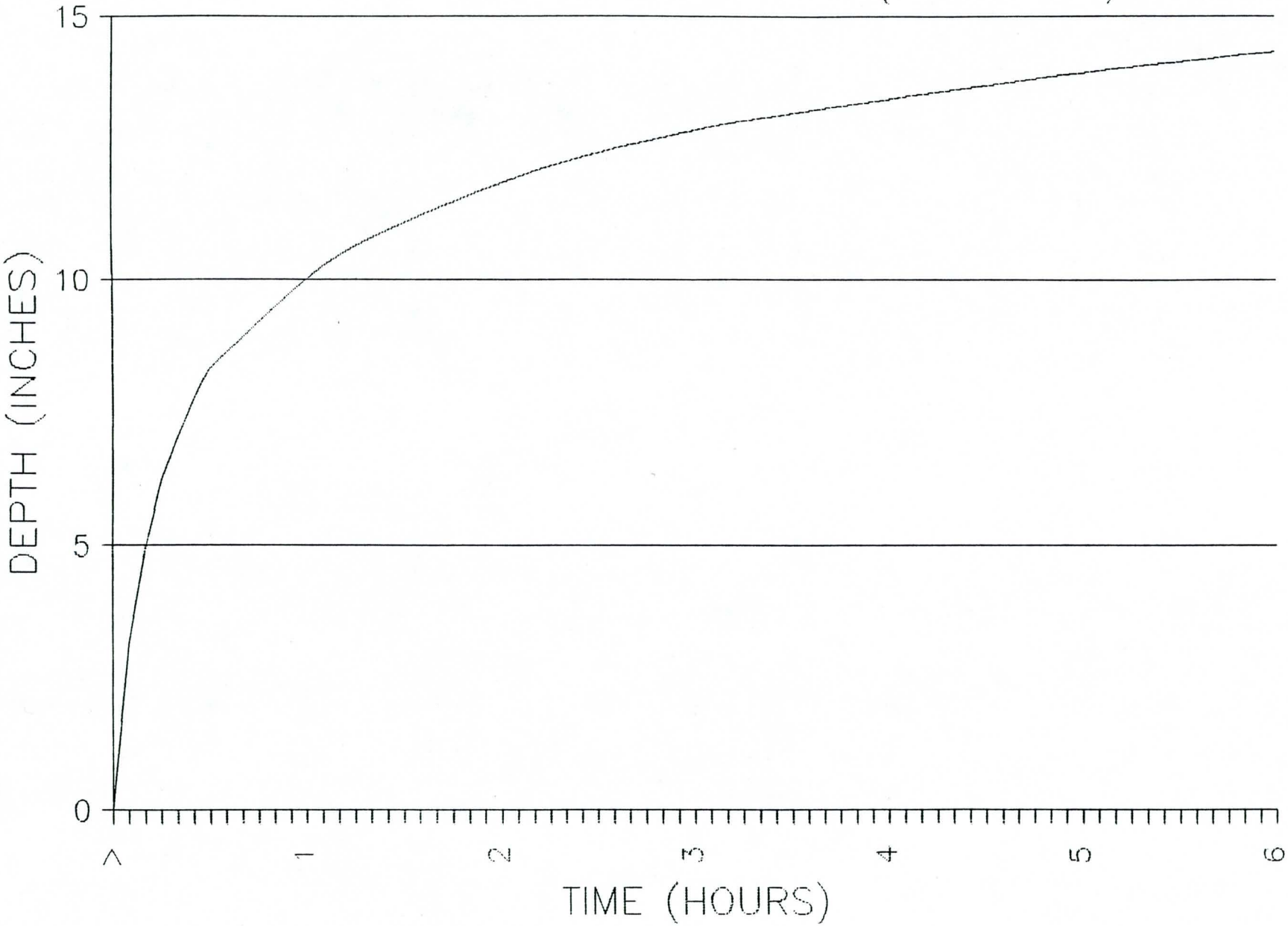
Peak: Highest 5-min Depth will be placed at the begining of the hour, the rest will be sequenced in decending order.

Post-Peak: Decending order.

945.1 (12/88) PRINTED IN U.S.A.

DAMES & MOORE JOB # 15448-003-022

RAINFALL DEPTH VS. DURATION (6-HR PMP)



Buckeye FKS

JOF 1/5/99
Checked RHA 1/20/99

4F of 161

6-hr PMP Distribution Data

6th Largest Hourly Amount Sequence Position: 1st					
Time from Start of Storm hrs.	Measured Depth (D) in	Incremental Depth Change $D_n - D_{n-1}$ in		HEC-1 Sequence Time of Occurance for Distribution hrs	Depth in
0505	13.9372	0.0372		0005	0.030
0510	13.9736	0.0364		0010	0.030
0515	14.0094	0.0358		0015	0.031
0520	14.0444	0.0350		0020	0.032
0525	14.0788	0.0344		0025	0.032
0530	14.1125	0.0337		0030	0.033
0535	14.1455	0.0330		0035	0.034
0540	14.1778	0.0323		0040	0.034
0545	14.2094	0.0316		0045	0.035
0550	14.2403	0.0309		0050	0.036
0555	14.2705	0.0302		0055	0.036
0600	14.300	0.0295		0100	0.037
					$\Sigma = 0.400$

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY ____ DATE 1/22/96
CHECKED BY RHA
COPY TO EO ____

945 1 (12 88) PRINTED IN U.S.A.

6-hr PMP Distribution Data

4th Largest Hourly Amount Sequence Position: 2nd					
Time from Start of Storm hrs.	Measured Depth (D) in	Incremental Depth Change $D_n - D_{n-1}$ in		HEC-1 Sequence Time of Occurance for Distribution hrs	① Depth (adjusted) in
0305	12.8641	0.0641		0105	0.044
0310	12.9239	0.0598		0110	0.044
0315	12.9800	0.0561		0115	0.045
0320	13.0327	0.0527		0120	0.045
0325	13.0821	0.0494		0125	0.045
0330	13.1300	0.0479		0130	0.047
0335	13.1770	0.0467		0135	0.048
0340	13.2220	0.0450 ~~0.0444~~		0140	0.049
0345	13.2670	0.0448		0145	0.052
0350	13.3120	0.0445		0150	0.056
0355	13.3560	0.0443		0155	0.060
0400	13.400	0.0453		0200	0.064
				Σ =	0.600

① Depths were adjusted to provide a smooth Distribution.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JLP DATE 1/22/90
CHECKED BY RHA 1/22/90
COPY TO EO

945 1 (12 88) PRINTED IN U S A

6-hr PMP Distribution Data

2nd Largest Hourly Amount
Sequence Position: 3rd

Time from Start of Storm hrs.	Measured Depth (D) in	Incremental Depth Change $D_n - D_{n-1}$ in		HEC-1 Sequence Time of Occurance for Distribution hrs	HEC-1 Sequence Depth in
0105	10.2264	0.2264		0205	0.118
0110	10.4239	0.1975		0210	0.120
0115	10.6009	0.1770		0215	0.121
0120	10.7627	0.1618		0220	0.125
0125	10.9177	0.1550		0225	0.129
0130	11.0535	0.1358		0230	0.134
0135	11.1876	0.1347		0235	0.136
0140	11.3167	0.1291		0240	0.155
0145	11.4415	0.1248		0245	0.162
0150	11.5626	0.1211		0250	0.177
0155	11.6824	0.1198		0255	0.197
0200	11.80	0.1176		0300	0.226
				$\Sigma =$	1.800

BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____
BY JJ DATE 1/22/91
CHECKED BY RHA 1/22/91
COPY TO EO ____

945 1 (12 88) PRINTED IN U S A

6-hr PMP Distribution Data

1st Largest Hourly Amount Sequence Position: 4th					
Time from Start of Storm hrs.	Measured Depth (D) in	Incremental Depth Change $D_n - D_{n-1}$ in		HEC-1 Sequence Time of Occurance for Distribution hrs	Depth in
0005	3.10	3.10		0305	3.10
0010	4.90	1.80		0310	1.80
0015	6.20	1.30		0315	1.30
0020	7.00	0.800		0320	0.800
0025	7.700	0.700		0325	0.700
0030	8.300	0.600		0330	0.600
0035	8.610	0.310		0335	0.310
0040	8.910	0.300		0340	0.300
0045	9.200	0.290		0345	0.290
0050	9.480	0.280		0350	0.280
0055	9.745	0.265		0355	0.265
0060	10.000	0.255		0360	0.255
				Σ =	10.000

BY JD DATE 1/90
CHECKED BY RHA 1/22/90
COPY TO EO

REVISIONS BY DATE TO EO
BY DATE TO EO

945 1 (12 88) PRINTED IN U.S.A

6-hr PMP Distribution Data

3rd Largest Hourly Amount					
Sequence Position: 5th					
Time from Start of Storm hrs.	Measured Depth (D) in	Incremental Depth Change $D_n - D_{n-1}$ in		HEC-1 Sequence	
				Time of Occurance for Distribution hrs	Depth in
0205	11.9120	0.1120		0405	0.112
0210	12.0164	0.1044		0410	0.104
0215	12.1138	0.0974		0415	0.097
0220	12.2049	0.0911		0420	0.091
0225	12.2908	0.0859		0425	0.086
0230	12.3725	0.0817		0430	0.082
0235	12.4499	0.0774		0435	0.077
0240	12.5244	0.0745		0440	0.075
0245	12.5954	0.0710		0445	0.071
0250	12.6653	0.0699		0450	0.070
0255	12.7344	0.0691		0455	0.069
0300	12.8000	0.0656		0500	0.066
				Σ =	1.000

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY ____ DATE ____
CHECKED BY RHA 1/22/90
COPY TO EO ____

945 1 (12 88) PRINTED IN U.S.A.

6-hr PMP Distribution Data

5th Largest Hourly Amount Sequence Position: Last					
Time from Start of Storm hrs.	Measured Depth (D) in	Incremental Depth Change $D_n - D_{n-1}$ in		HEC-1 Sequence Time of Occurance for Distribution hrs	Depth in
0405	13.4455	0.0455		0505	0.045
0410	13.4903	0.0448		0510	0.045
0415	13.5344	0.0441		0515	0.044
0420	13.5778	0.0434		0520	0.043
0425	13.6205	0.0427		0525	0.043
0430	13.6625	0.0420		0530	0.042
0435	13.7038	0.0413		0535	0.041
0440	13.7444	0.0406		0540	0.041
0445	13.7844	0.0400		0545	0.040
0450	13.8236	0.0392		0550	0.039
0455	13.8622	0.0386		0555	0.039
0500	13.900	0.0378		0600	0.038
				$\Sigma =$	0.500

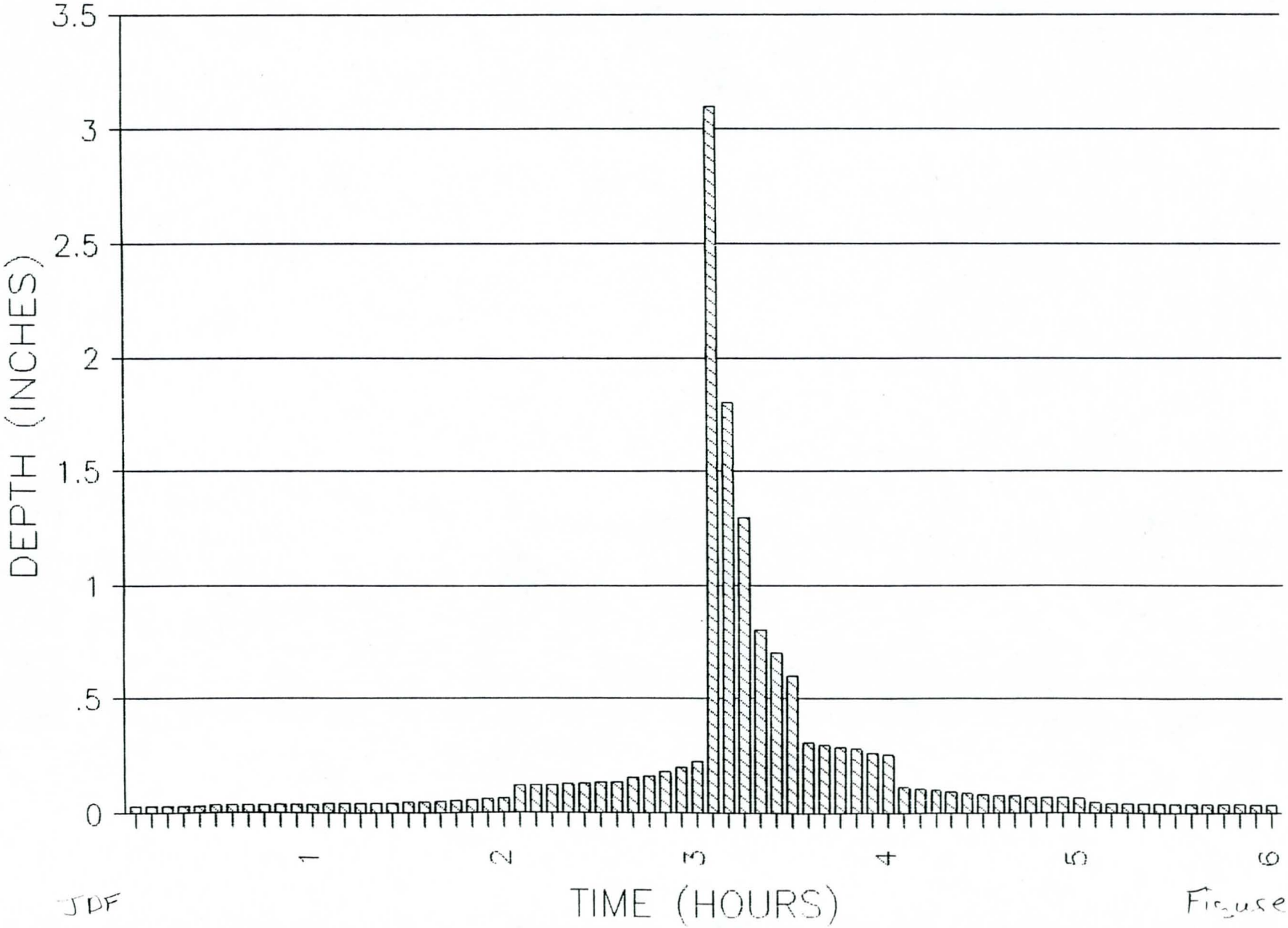
REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JW DATE 1/90
CHECKED BY RHA 1/22/90
COPY TO EO ____

945 1 (12 88) PRINTED IN U S A

DAMES & MOORE JOB # 15448-003-022

6-HOUR PMP STORM DISTRIBUTION



JDF

Figure 2.

11A & 16I
Buckeye FRS
JDF 1/5/90
CKD RHA 1/22/90

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

72-HR PMP Distribution

Procedure is the same as that for 6-Hr except that HMR-49 does not list a distribution method for the 72-hr PMP. The following Assumptions will be made.

1. 72-hr storm can be divided into 6 12-hr blocks:

$$\frac{72}{12} = 6$$

Occurring at	End Time
Block 1	1200 hrs
Block 2	2400 hrs
Block 3	3600 hrs
Block 4	4800 hrs
Block 5	6000 hrs
Block 6	7200 hrs

The storm's 12-hr Block Distribution will be the same as the 6-hr PMP's hourly distribution.

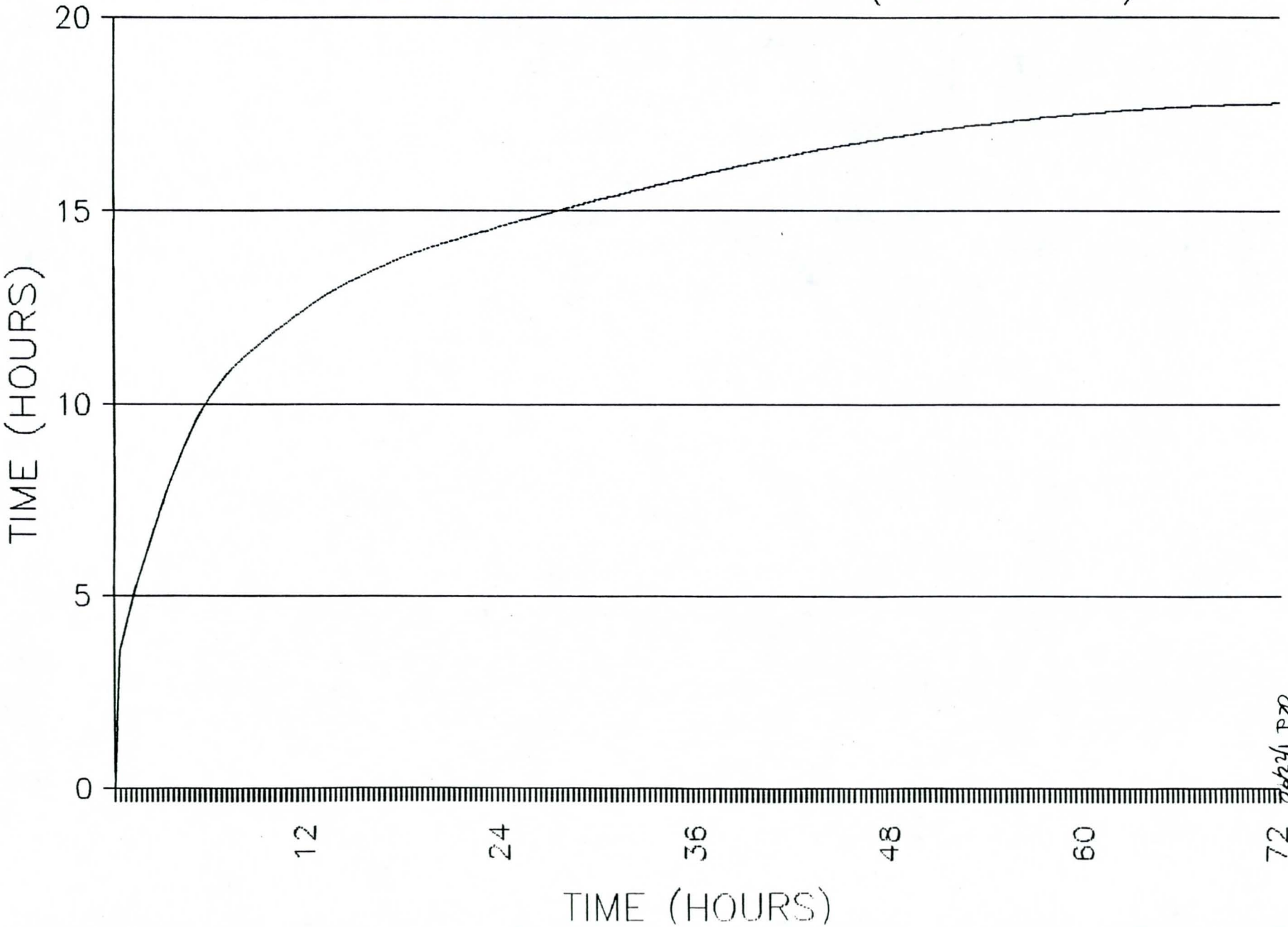
BY JDF DATE 1/5/90
CHECKED BY RHA DATE 1/22/90
COPY TO EO ____

945.1 (12/88) PRINTED IN U.S.A.

FIGURE 3.

DAMES & MOORE JOB # 15448-003-022

RAINFALL DEPTH VS. DURATION (72-HR PMP)



13A 161
Buckeye FRS
JDF 1/5/90
CKD 1/22/90

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDP DATE 1-3-90 CHECKED BY RHA 1/22/90 COPY TO EO ____

Calculations for the 72-hr Storm Distribution:

Key to Tables

Column	Discription
A	Minutes since Start of Storm
B	Depth of Rainfall occuring at that time. Scaled off From Figure 3.
C	$C = A_2 - A_1$ Time increment.
D	$D = B_2 - B_1$ Change in depth occuring during the time interval
E	$E = \sum D$ during a 12-hr interval. (12-hr Block).
F	Sequencerce # from Table 4.7 HMR-49 for the 12-hr Block.
G	Total Elapsed time in hours.
H	$H = \sum D$ (Calculation Check Compared with Column B.)
I + J	Sequenced 12-hr + 20min rainfall distribution.

Dames & Moore

DAMES & MOORE JOB # 15448-003-022
BUCKEYE FRS

DEVELOPMENT OF THE 12-HR PMP DISTRIBUTION
20-MIN, AND 12-HR INTERVALS

TIME	TOTAL DEPTH	INCREMENTAL DEPTH CHANGE (ΔD)				DATA CHECK		DISTRIBUTION	
MIN A	IN B	TIME MIN C	20-MIN IN D	12-HR IN E	12-HR SEQ. # F	TIME HR G	DEPTH IN H	12-HR I	20-MIN J
20	3.540	20	3.540			.33	3.54		.003
40	4.095	20	.555			.67	4.10		.003
60	4.628	20	.533			1.00	4.63		.003
80	5.139	20	.511			1.33	5.14		.004
100	5.625	20	.486			1.67	5.63		.004
120	6.092	20	.467			2.00	6.09		.004
140	6.537	20	.445			2.33	6.54		.005
160	6.960	20	.423			2.67	6.96		.005
180	7.383	20	.423			3.00	7.38		.005
200	7.784	20	.401			3.33	7.78		.005
220	8.163	20	.379			3.67	8.16		.006
240	8.520	20	.357			4.00	8.52		.006
260	8.855	20	.335			4.33	8.86		.006
280	9.168	20	.313			4.67	9.17		.006
300	9.457	20	.289			5.00	9.46		.007
320	9.728	20	.271			5.33	9.73		.007
340	9.975	20	.247			5.67	9.98		.007
360	10.200	20	.225			6.00	10.20		.008
380	10.403	20	.203			6.33	10.40		.008
400	10.585	20	.182			6.67	10.58		.008
420	10.751	20	.166			7.00	10.75		.008
440	10.904	20	.153			7.33	10.90		.009
460	11.047	20	.143			7.67	11.05		.009
480	11.181	20	.135			8.00	11.18		.009
500	11.309	20	.128			8.33	11.31		.009
520	11.431	20	.122			8.67	11.43		.010
540	11.549	20	.118			9.00	11.55		.010
560	11.663	20	.114			9.33	11.66		.010
580	11.774	20	.111			9.67	11.77		.010
600	11.882	20	.108			10.00	11.88		.011
620	11.989	20	.106			10.33	11.99		.011
640	12.093	20	.105			10.67	12.09		.011
660	12.197	20	.103			11.00	12.20		.012
680	12.299	20	.102			11.33	12.30		.012
700	12.400	20	.101			11.67	12.40		.012
720	12.500	20	.100	12.5	4	12.00	12.50	.2749997	.012
740	12.597	20	.097			12.33	12.60		.022
760	12.689	20	.092			12.67	12.69		.023
780	12.777	20	.088			13.00	12.78		.023
800	12.861	20	.084			13.33	12.86		.024
820	12.941	20	.080			13.67	12.94		.024
840	13.019	20	.077			14.00	13.02		.024
860	13.093	20	.075			14.33	13.09		.025

Buckeye FRS
JDF 1/5/90
CKD RHA 1/22/90

DAMES & MOORE JOB # 15448-003-022
BUCKEYE FRS

DEVELOPMENT OF THE 12-HR PMP DISTRIBUTION
20-MIN, AND 12-HR INTERVALS

TIME	TOTAL	INCREMENTAL DEPTH CHANGE				DATA CHECK		DISTRIBUTION	
MIN	DEPTH IN	TIME MIN	20-MIN IN	12-HR IN	12-HR SEQ. #	TIME HR	DEPTH IN	12-HR	20-MIN
880	13.165	20	.072			14.67	13.17		.025
900	13.235	20	.070			15.00	13.24		.025
920	13.303	20	.068			15.33	13.30		.026
940	13.370	20	.066			15.67	13.37		.026
960	13.435	20	.065			16.00	13.43		.026
980	13.498	20	.063			16.33	13.50		.027
1000	13.560	20	.062			16.67	13.56		.027
1020	13.622	20	.061			17.00	13.62		.027
1040	13.682	20	.060			17.33	13.68		.027
1060	13.741	20	.059			17.67	13.74		.028
1080	13.800	20	.059			18.00	13.80		.028
1100	13.856	20	.056			18.33	13.86		.028
1120	13.909	20	.053			18.67	13.91		.029
1140	13.960	20	.050			19.00	13.96		.029
1160	14.007	20	.048			19.33	14.01		.029
1180	14.054	20	.046			19.67	14.05		.029
1200	14.098	20	.045			20.00	14.10		.029
1220	14.142	20	.044			20.33	14.14		.030
1240	14.185	20	.043			20.67	14.18		.030
1260	14.227	20	.042			21.00	14.23		.030
1280	14.268	20	.042			21.33	14.27		.030
1300	14.310	20	.041			21.67	14.31		.031
1320	14.351	20	.041			22.00	14.35		.031
1340	14.392	20	.041			22.33	14.39		.031
1360	14.434	20	.041			22.67	14.43		.031
1380	14.475	20	.041			23.00	14.48		.031
1400	14.517	20	.041			23.33	14.52		.032
1420	14.558	20	.042			23.67	14.56		.032
1440	14.600	20	.042	2.1	3	24.00	14.60	1.000999	.032
1460	14.642	20	.042			24.33	14.64		.041
1480	14.683	20	.041			24.67	14.68		.041
1500	14.724	20	.041			25.00	14.72		.041
1520	14.764	20	.040			25.33	14.76		.041
1540	14.804	20	.040			25.67	14.80		.041
1560	14.843	20	.039			26.00	14.84		.041
1580	14.882	20	.039			26.33	14.88		.042
1600	14.921	20	.039			26.67	14.92		.042
1620	14.959	20	.038			27.00	14.96		.042
1640	14.997	20	.038			27.33	15.00		.042
1660	15.035	20	.038			27.67	15.03		.043
1680	15.072	20	.037			28.00	15.07		.044
1700	15.109	20	.037			28.33	15.11		.045
1720	15.146	20	.037			28.67	15.15		.046

ICA .E 161
JDF
1/5/90
ckd RHA 1/24/9

DAMES & MOORE JOB # 15448-003-022
BUCKEYE FRS

DEVELOPMENT OF THE 12-HR PMP DISTRIBUTION
20-MIN, AND 12-HR INTERVALS

TIME	TOTAL DEPTH	INCREMENTAL DEPTH CHANGE				DATA CHECK		DISTRIBUTION	
MIN	IN	TIME MIN	20-MIN IN	12-HR IN	12-HR SEQ. #	TIME HR	DEPTH IN	12-HR	20-MIN
1740	15.183	20	.037			29.00	15.18		.048
1760	15.219	20	.036			29.33	15.22		.050
1780	15.255	20	.036			29.67	15.25		.053
1800	15.291	20	.036			30.00	15.29		.056
1820	15.326	20	.036			30.33	15.33		.059
1840	15.362	20	.035			30.67	15.36		.059
1860	15.397	20	.035			31.00	15.40		.060
1880	15.432	20	.035			31.33	15.43		.061
1900	15.466	20	.035			31.67	15.47		.062
1920	15.501	20	.034			32.00	15.50		.063
1940	15.535	20	.034			32.33	15.54		.065
1960	15.569	20	.034			32.67	15.57		.066
1980	15.603	20	.034			33.00	15.60		.068
2000	15.637	20	.034			33.33	15.64		.070
2020	15.670	20	.033			33.67	15.67		.072
2040	15.703	20	.033			34.00	15.70		.075
2060	15.736	20	.033			34.33	15.74		.077
2080	15.769	20	.033			34.67	15.77		.080
2100	15.802	20	.033			35.00	15.80		.084
2120	15.835	20	.033			35.33	15.83		.088
2140	15.867	20	.032			35.67	15.87		.092
2160	15.899	20	.032	1.299001	5	36.00	15.90	2.1	.097
2180	15.931	20	.032			36.33	15.93		3.540
2200	15.963	20	.032			36.67	15.96		.555
2220	15.994	20	.032			37.00	15.99		.533
2240	16.026	20	.031			37.33	16.03		.511
2260	16.057	20	.031			37.67	16.06		.486
2280	16.088	20	.031			38.00	16.09		.467
2300	16.118	20	.031			38.33	16.12		.445
2320	16.149	20	.031			38.67	16.15		.423
2340	16.179	20	.030			39.00	16.18		.423
2360	16.209	20	.030			39.33	16.21		.401
2380	16.239	20	.030			39.67	16.24		.379
2400	16.269	20	.030			40.00	16.27		.357
2420	16.299	20	.029			40.33	16.30		.335
2440	16.328	20	.029			40.67	16.33		.313
2460	16.357	20	.029			41.00	16.36		.289
2480	16.386	20	.029			41.33	16.39		.271
2500	16.414	20	.029			41.67	16.41		.247
2520	16.442	20	.028			42.00	16.44		.225
2540	16.470	20	.028			42.33	16.47		.203
2560	16.498	20	.028			42.67	16.50		.182
2580	16.526	20	.027			43.00	16.53		.166

17A of 161
JDF
1/5/90
CKd RHA 1/22/90

DAMES & MOORE JOB # 15448-003-022
BUCKEYE FRS

DEVELOPMENT OF THE 12-HR PMP DISTRIBUTION
20-MIN, AND 12-HR INTERVALS

TIME	TOTAL DEPTH	INCREMENTAL DEPTH CHANGE				DATA CHECK		DISTRIBUTION	
MIN	IN	TIME MIN	20-MIN IN	12-HR IN	12-HR SEQ. #	TIME HR	DEPTH IN	12-HR	20-MIN
2600	16.553	20	.027			43.33	16.55		.153
2620	16.580	20	.027			43.67	16.58		.143
2640	16.606	20	.027			44.00	16.61		.135
2660	16.633	20	.026			44.33	16.63		.128
2680	16.659	20	.026			44.67	16.66		.122
2700	16.684	20	.026			45.00	16.68		.118
2720	16.710	20	.025			45.33	16.71		.114
2740	16.735	20	.025			45.67	16.73		.111
2760	16.760	20	.025			46.00	16.76		.108
2780	16.784	20	.024			46.33	16.78		.106
2800	16.808	20	.024			46.67	16.81		.105
2820	16.831	20	.024			47.00	16.83		.103
2840	16.855	20	.023			47.33	16.85		.102
2860	16.878	20	.023			47.67	16.88		.101
2880	16.900	20	.022	1.000999	2	48.00	16.90	12.5	.100
2900	16.922	20	.022			48.33	16.92		.042
2920	16.944	20	.022			48.67	16.94		.041
2940	16.965	20	.022			49.00	16.97		.041
2960	16.987	20	.021			49.33	16.99		.040
2980	17.008	20	.021			49.67	17.01		.040
3000	17.028	20	.021			50.00	17.03		.039
3020	17.049	20	.020			50.33	17.05		.039
3040	17.069	20	.020			50.67	17.07		.039
3060	17.089	20	.020			51.00	17.09		.038
3080	17.109	20	.020			51.33	17.11		.038
3100	17.128	20	.019			51.67	17.13		.038
3120	17.147	20	.019			52.00	17.15		.037
3140	17.166	20	.019			52.33	17.17		.037
3160	17.185	20	.019			52.67	17.18		.037
3180	17.203	20	.018			53.00	17.20		.037
3200	17.221	20	.018			53.33	17.22		.036
3220	17.239	20	.018			53.67	17.24		.036
3240	17.256	20	.017			54.00	17.26		.036
3260	17.273	20	.017			54.33	17.27		.036
3280	17.290	20	.017			54.67	17.29		.035
3300	17.307	20	.017			55.00	17.31		.035
3320	17.324	20	.016			55.33	17.32		.035
3340	17.340	20	.016			55.67	17.34		.035
3360	17.356	20	.016			56.00	17.36		.034
3380	17.371	20	.016			56.33	17.37		.034
3400	17.386	20	.015			56.67	17.39		.034
3420	17.402	20	.015			57.00	17.40		.034
3440	17.416	20	.015			57.33	17.42		.034

JDF
1/5/90
Ckd RHA 1/22/90

17A of 161

DAMES & MOORE JOB # 15448-003-022
BUCKEYE FRS

DEVELOPMENT OF THE 12-HR PMP DISTRIBUTION
20-MIN, AND 12-HR INTERVALS

TIME	TOTAL DEPTH	INCREMENTAL DEPTH CHANGE				DATA CHECK		DISTRIBUTION	
MIN	IN	TIME MIN	20-MIN IN	12-HR IN	12-HR SEQ. #	TIME HR	DEPTH IN	12-HR	20-MIN
3460	17.431	20	.015			57.67	17.43		.033
3480	17.445	20	.014			58.00	17.45		.033
3500	17.459	20	.014			58.33	17.46		.033
3520	17.473	20	.014			58.67	17.47		.033
3540	17.486	20	.013			59.00	17.49		.033
3560	17.499	20	.013			59.33	17.50		.033
3580	17.512	20	.013			59.67	17.51		.032
3600	17.525	20	.013	.6250003	6	60.00	17.53	1.299001	.032
3620	17.537	20	.012			60.33	17.54		.022
3640	17.549	20	.012			60.67	17.55		.022
3660	17.561	20	.012			61.00	17.56		.022
3680	17.573	20	.012			61.33	17.57		.021
3700	17.584	20	.011			61.67	17.58		.021
3720	17.595	20	.011			62.00	17.60		.021
3740	17.606	20	.011			62.33	17.61		.020
3760	17.616	20	.010			62.67	17.62		.020
3780	17.627	20	.010			63.00	17.63		.020
3800	17.636	20	.010			63.33	17.64		.020
3820	17.646	20	.010			63.67	17.65		.019
3840	17.656	20	.009			64.00	17.66		.019
3860	17.665	20	.009			64.33	17.66		.019
3880	17.674	20	.009			64.67	17.67		.019
3900	17.682	20	.009			65.00	17.68		.018
3920	17.690	20	.008			65.33	17.69		.018
3940	17.698	20	.008			65.67	17.70		.018
3960	17.706	20	.008			66.00	17.71		.017
3980	17.714	20	.008			66.33	17.71		.017
4000	17.721	20	.007			66.67	17.72		.017
4020	17.728	20	.007			67.00	17.73		.017
4040	17.735	20	.007			67.33	17.73		.016
4060	17.741	20	.006			67.67	17.74		.016
4080	17.747	20	.006			68.00	17.75		.016
4100	17.753	20	.006			68.33	17.75		.016
4120	17.759	20	.006			68.67	17.76		.015
4140	17.764	20	.005			69.00	17.76		.015
4160	17.769	20	.005			69.33	17.77		.015
4180	17.774	20	.005			69.67	17.77		.015
4200	17.778	20	.005			70.00	17.78		.014
4220	17.783	20	.004			70.33	17.78		.014
4240	17.787	20	.004			70.67	17.79		.014
4260	17.790	20	.004			71.00	17.79		.013
4280	17.794	20	.003			71.33	17.79		.013
4300	17.797	20	.003			71.67	17.80		.013

JDF
1/5/90
CKd RHA 1/22/90

18 A 0 5 1 0 1

DAMES & MOORE JOB # 15448-003-022
BUCKEYE FRS

DEVELOPMENT OF THE 12-HR PMP DISTRIBUTION
20-MIN, AND 12-HR INTERVALS

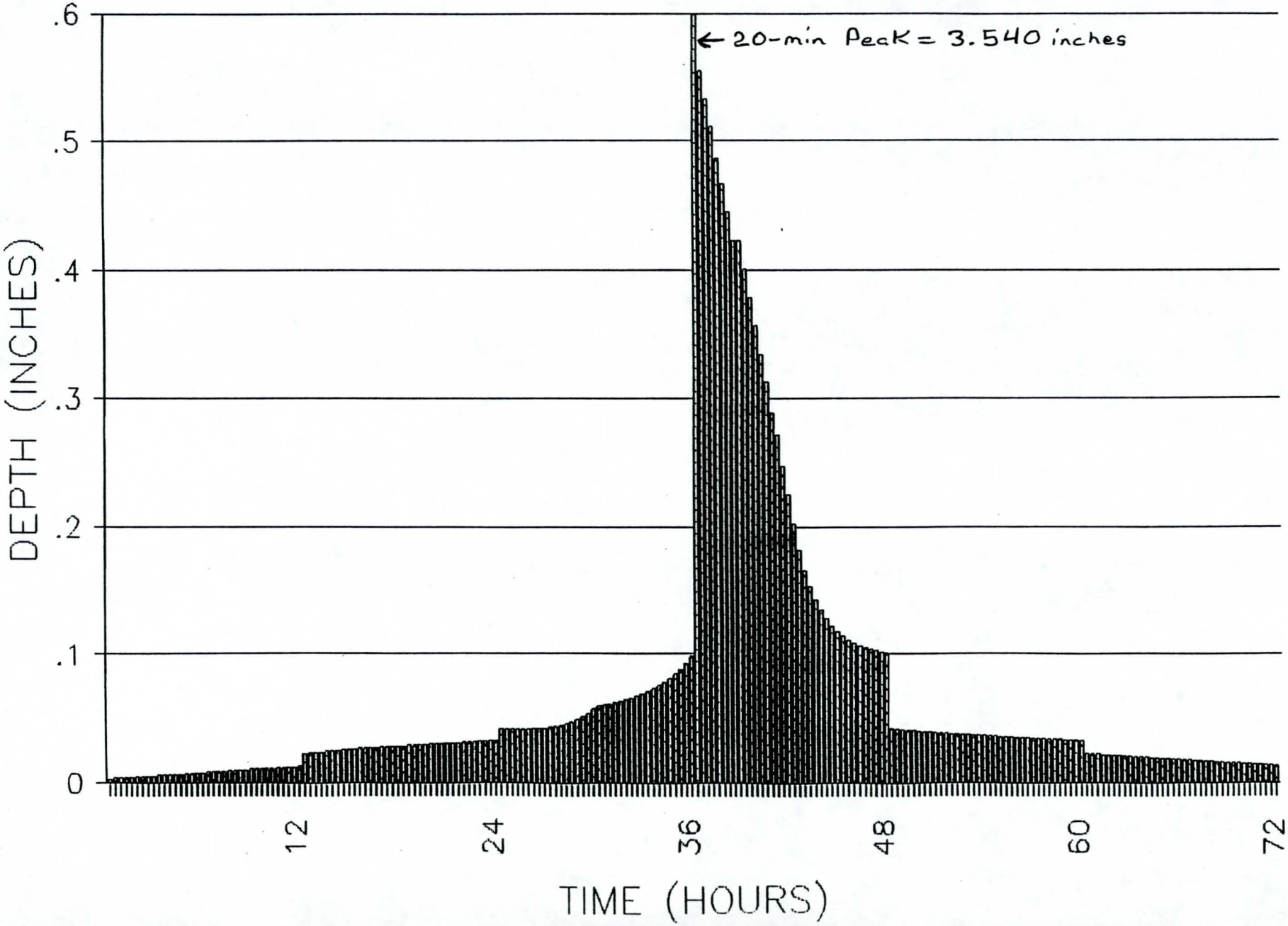
TIME	TOTAL DEPTH	INCREMENTAL DEPTH CHANGE				DATA CHECK		DISTRIBUTION	
MIN	IN	TIME MIN	20-MIN IN	12-HR IN	12-HR SEQ. #	TIME HR	DEPTH IN	12-HR	20-MIN
4320	17.800	20	.003	.2749997	1	72.00	17.80	.6250003	.013

JDF
1/5/90
ckd RHA 1/22/90

FIGURE 4.

DAMES & MOORE JOB # 15448-003-022

72-HR PMP STORM DISTRIBUTION



Sheet 2 of 16
JDF 1/5/90
Ckd RHA 1/22/90

CALCULATIONS COVER SHEET
DAMES & MOORE
DESIGN SERVICES GROUP

PROJECT NUMBER 15448-003-002
SUBJECT Buckeye FRS
SHEET 33 OF 161

Developing HEC-1 Input Parameters
TITLE OF CALCULATIONS

Buckeye FRS
TITLE OF PROJECT

CALCULATIONS BY: John Fannin
PRINT NAME
John Fannin 12/1/89
SIGNATURE DATE

ASSUMPTIONS CHECKED BY CONSULTANT: George J Geiser
PRINT NAME
G J Geiser 12/19/89
SIGNATURE DATE

CALCULATIONS CHECKED BY: George J Geiser
PRINT NAME
G J Geiser 12/19/89
SIGNATURE DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT OR PM) George J Geiser
PRINT NAME
G J Geiser
SIGNATURE DATE

APPROVAL NOTES:
IF CALCULATIONS ARE ONLY SPOT CHECKED, DO NOT REQUIRE CHECKING OR ARE ASSUMED TO BE CORRECT BY EXPERIENCE OR ENGINEERING JUDGEMENT, IT SHOULD BE NOTED HERE.

Checked Input sheets, CN Estimates, T_c for method 4 and Area Analysis for FRS #1, FRS #2 and FRS #3

Richard Allen 12/17/89

REVISION NUMBER	DATE	BY	CHECKED BY INITIALS	APPROVAL
1				
2				
3				
4				

DATE
CHECKED BY
ORIGINAL TO PROJECT FILE

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 1

Designated Area Index ① CP1-1

Sub Basin Area 1781 acres (2.78 sq miles)

CN Estimate AMC II 84
AMC III 93

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	1.04
2.	2.26
3.	2.00
4	1.25

Selected t_c 1.25 hrs.

Lag Time = $0.6\ t_c$ = 0.75 hrs.

① CP1-1 is located upstream of Floodway #2. It will be assumed that all runoff from this sub-basin is retained by FRS #1.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/82 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 1

Designated Area Index CP1-2

Sub Basin Area 4546 acres (7.10 sq. miles)

CN Estimate AMC II 81
AMC III 92

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	1.36
2.	3.41
3.	4.00
4	1.85

Selected t_c 1.85 hrs.

Lag Time = $0.6\ t_c$ = 1.11 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/84 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 1

Designated Area Index CP1-3

Sub Basin Area 12,367 acres (19.32 □ miles)

CN Estimate AMC II 82
AMC III 92

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	2.55
2.	6.41
3.	Not Applicable
4	3.44

Selected t_c 3.44 hrs.

Lag Time = $0.6\ t_c$ = 2.06 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 1

Designated Area Index CP1-4

Sub Basin Area 5366 acres (8.38 sq mi)

CN Estimate AMC II 83
AMC III 93

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	1.93
2.	4.54
3.	Not Applicable
4	2.47

Selected t_c 2.47 hrs.

Lag Time = $0.6\ t_c$ = 1.48 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89
CHECKED BY ____
COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 1

Designated Area Index CP1- 5

Sub Basin Area 3485 acres (5.45 [illegible])

CN Estimate AMC II 79
AMC III 91

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	2.16
2.	3.92
3.	Not Applicable
4	2.23

Selected t_c 2.23 hrs.

Lag Time = $0.6\ t_c$ = 1.34 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89
CHECKED BY [illegible]
COPY TO EO ____

Summary of Sub-Basin HEC-1 Input Parameters.

FRS # 1

Designated Area Index CP1-6

Sub Basin Area 3286 acres (5.13 □ miles)

CN Estimate AMC II 82
AMC III 92

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	1.38
2.	4.05
3.	Not Applicable
4	1.91

Selected t_c 1.91 hrs.

Lag Time = $0.6\ t_c$ = 1.15 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1 Input Parameters.

FRS # 1

Designated Area Index CPI-7

Sub Basin Area 5548 acres (8.67 sq. mi.)

CN Estimate AMC II 82
AMC III 92

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	1.14
2.	2.76
3.	3.67
4	1.48

Selected t_c 1.48 hrs.

Lag Time = $0.6\ t_c$ = 0.89 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 1

Designated Area Index CP1-8

Sub Basin Area 1696 acres (2.65 □ miles)

CN Estimate AMC II 87
AMC III 95

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	1.14
2.	1.82
3.	2.50
4	0.98

Selected t_c 0.98 hrs.

Lag Time = $0.6\ t_c$ = 0.59 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 1

Designated Area Index CP1-9

Sub Basin Area 10,488 acres (16.39 mi²)

CN Estimate AMC II 78
AMC III 90

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	4.11
2.	9.98
3.	Not Applicable
4	5.36

Selected t_c 5.36 hrs.

Lag Time = $0.6\ t_c$ = 3.22 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 2

Designated Area Index CP2-1

Sub Basin Area 1251 acres (1.95 □ miles)

CN Estimate AMC II 83
AMC III 93

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	0.51
2.	0.98
3.	1.03
4	0.53

Selected t_c 0.53 hrs.

Lag Time = $0.6\ t_c$ = 0.32 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89
CHECKED BY
COPY TO EO

Summary of Sub-Basin HEC-1 Input Parameters.

FRS # 2

Designated Area Index CP2-2

Sub Basin Area 1577 acres (2.46 □ miles)

CN Estimate AMC II 82
AMC III 92

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	0.86
2.	1.76
3.	1.17
4	0.94

Selected t_c 0.94 hrs.

Lag Time = $0.6\ t_c$ = 0.56 hrs.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/82 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 2

Designated Area Index CP2-3

Sub Basin Area 891 acres (1.39 ☐ miles)

CN Estimate AMC II 82
AMC III 92

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	0.66
2.	1.04
3.	1.42
4	0.55

Selected t_c 0.55 hrs.

Lag Time = $0.6\ t_c$ = 0.33 hrs.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 3

Designated Area Index CP3-1

Sub Basin Area 911 acres (1.42 sq mi)

CN Estimate AMC II 86
AMC III 94

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	0.32
2.	0.59
3.	0.52
4	0.28

Selected t_c 0.28 hrs.

Lag Time = $0.6\ t_c$ = 0.17 hrs.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89
CHECKED BY ____
COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 3

Designated Area Index CP3-2

Sub Basin Area 1521 acres (2.38 ☐ miles)

CN Estimate AMC II 87
AMC III 95

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	0.45
2.	0.69
3.	0.43
4	0.38

Selected t_c 0.38 hrs.

Lag Time = $0.6\ t_c$ = 0.23 hrs.

EVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 3

Designated Area Index CP3-3

Sub Basin Area 1673 acres (2.61 □ mi)

CN Estimate AMC II 84
AMC III 93

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	0.95
2.	1.75
3.	0.62
4	0.80

Selected t_c 0.80 hrs.

Lag Time = $0.6\ t_c$ = 0.48 hrs.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Summary of Sub-Basin HEC-1
Input Parameters.

FRS # 3

Designated Area Index CP3-4

Sub Basin Area 1467 acres (2.29 sq mi)

CN Estimate AMC II 83
AMC III 93

Time of Concentration Calculations:

Method NO.	Estimated t_c hrs.
1.	1.48
2.	2.56
3.	0.93
4	1.39

Selected t_c 1.39 hrs.

Lag Time = $0.6\ t_c$ = 0.83 hrs.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

Soils - Cover Evaluation + Complex Number Selection

Purpose: To evaluate the soils in the study Basin area, estimate sub-basin areas, and estimate sub-basin CNs.

References:

1. Soil Survey of Aguila-Casefree Area, Maricopa and Pinal Counties, Arizona, US Dept. of Agriculture, April 1986.
2. Soil Survey of Maricopa County, Arizona Central Part, US Dept. of Agriculture, Sept. 1977
3. SCS, National Engineering Handbook, Sec 4., U.S. Dept. of Agriculture 1972.

Proceeduce:

1. Assess types of soil in study area based on soil maps, and obtain the hydrologic group classification for each soil type. [Ref 1+2]
2. Transfer soils information onto working site map. (show hydrologic group boundries)
3. Estimate an SCS Cover Complex Number (CN) for each hydrologic group of soils in the study area. [Ref 3.]
4. Estimate the area of each sub-Basin and the area of each soil group in the sub-Basin

BY JDF DATE 12/1/89
CHECKED BY _____
COPY TO EO _____

5. Develop a weighted CN for each sub-basin based on area.

Analysis:

The soils in the study area were classified by hydrologic group characteristics. CN estimates for each hydrologic group are:

Hydrologic Group	CN Ref. 3, P 9.2 Table 9.1
A	68
B	79
C	86
D	89

Sub-Basin areas + calculations for estimating a sub-Basin CN are included in the following pages. Calculated CN's are for the AMC II condition. CN's for AMC I + AMC III were selected using Table 10.1, [Ref 3, P 10.7]. The CN for the AMC II condition will be used for HEC-1 modeling of the study basin for 100 Yr Event. Use AMC III for PMP

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____
BY JDF DATE 12/1/89
CHECKED BY ____
COPY TO EO ____

245-1 (12/88) PRINTED IN U.S.A.

Basin Area Measurements -- Planimeter Calibration.

Method of area measurement: Planimeter

Instrument Data:

Make: LASICO
Type: Auto-Scaler
Model #: L-1250 S-1
Serial #: 48139

Calibration:

Arm Length Set At: 15.70 cm.

Area Measured = 640 ac ($1 mi^2$)

Instrument Readings: Switch on A

Trial #	Reading units^2
1	3574
2	3574
3	3574

Average = 3574 units^2

Conversion Factor: $\frac{640 \text{ ac}}{3574 \text{ units}^2} = 0.179$ ✓

Auto-Scaler set at 0.179
Instrument readout is direct in acres
No conversion is required.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY TDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

Table 9.1.--Runoff curve numbers for hydrologic soil-cover complexes

CN Selection

(Antecedent moisture condition II, and $I_a = 0.2\ S$)

Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

Selected

1/ Close-drilled or broadcast.
2/ Including right-of-way.

Table 10.1. Curve numbers (CN) and constants for the case $I_a = 0.2\ S$

1	2	3	4	5	1	2	3	4	5
CN for condition II	CN for conditions I	CN for conditions III	S values*	Curve* starts where P =	CN for condition II	CN for conditions I	CN for conditions III	S values*	Curve* starts where P =
			(inches)	(inches)				(inches)	(inches)
100	100	100	0	0	60	40	78	6.67	1.33
99	97	100	.101	.02	59	39	77	6.95	1.39
98	94	99	.204	.04	58	38	76	7.24	1.45
97	91	99	.309	.06	57	37	75	7.54	1.51
96	89	99	.417	.08	56	36	75	7.86	1.57
95	87	98	.526	.11	55	35	74	8.18	1.64
94	85	98	.638	.13	54	34	73	8.52	1.70
93	83	98	.753	.15	53	33	72	8.87	1.77
92	81	97	.870	.17	52	32	71	9.23	1.85
91	80	97	.989	.20	51	31	70	9.61	1.92
90	78	96	1.11	.22	50	31	70	10.0	2.00
89	76	96	1.24	.25	49	30	69	10.4	2.08
88	75	95	1.36	.27	48	29	68	10.8	2.16
87	73	95	1.49	.30	47	28	67	11.3	2.26
86	72	94	1.63	.33	46	27	66	11.7	2.34
85	70	94	1.76	.35	45	26	65	12.2	2.44
84	68	93	1.90	.38	44	25	64	12.7	2.54
83	67	93	2.05	.41	43	25	63	13.2	2.64
82	66	92	2.20	.44	42	24	62	13.8	2.76
81	64	92	2.34	.47	41	23	61	14.4	2.88
80	63	91	2.50	.50	40	22	60	15.0	3.00
79	62	91	2.66	.53	39	21	59	15.6	3.12
78	60	90	2.82	.56	38	21	58	16.3	3.26
77	59	89	2.99	.60	37	20	57	17.0	3.40
76	58	89	3.16	.63	36	19	56	17.8	3.56
75	57	88	3.33	.67	35	18	55	18.6	3.72
74	55	88	3.51	.70	34	18	54	19.4	3.88
73	54	87	3.70	.74	33	17	53	20.3	4.06
72	53	86	3.89	.78	32	16	52	21.2	4.24
71	52	86	4.08	.82	31	16	51	22.2	4.44
70	51	85	4.28	.86	30	15	50	23.3	4.66
69	50	84	4.49	.90					
68	48	84	4.70	.94	25	12	43	30.0	6.00
67	47	83	4.92	.98	20	9	37	40.0	8.00
66	46	82	5.15	1.03	15	6	30	56.7	11.34
65	45	82	5.38	1.08	10	4	22	90.0	18.00
64	44	81	5.62	1.12	5	2	13	190.0	38.00
63	43	80	5.87	1.17	0	0	0	infinity	infinity
62	42	79	6.13	1.23					
61	41	78	6.39	1.28					

*For CN in column 1.

JDF 12/1/89

Time of Concentration Calculations:

Purpose: To estimate the time of concentrations for the designated areas in the Buckeye FRS study area.

References:

1. Design of Small Dams; U.S. Dept. of the Interior, Bureau of Reclamation; 2nd ed, 1973 (Revised 1977)

2. SCS National Engineering Handbook, Section 4, Hydrology; US Dept. of Agriculture; 1972

3. Hydrology For Engineers, 3rd ed., McGraw Hill Book Company; 1982.

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDE DATE 12/1/89
CHECKED BY ____
COPY TO EO ____

945 1 (12/88) PRINTED IN U.S.A.

Procedure:

The time of concentration will be evaluated using 4 methods for each DA. A T_c to be use as the HEC-1 input parameter will be selected from the 4 estimated T_c's based on basin characteristics and judgement.

Method #1: [Ref 1., p. 67]

$$T_c = \left[\frac{11.9 \quad L^3}{H}\right]^{0.385}$$

where: L = Length of longest water course in miles. ✓

H = Elevation difference in ft associated with L. ✓

Method #2: [Ref. 2, p. 15-6] SCS Upland Method

DA < 2000 acres (DA > 2000 ac, Accuracy Decreases

1. Assume overland flow predominates.
2. Subdivide the DA into hydrologic componentes:
   - significant slope changes
   - gullies
   - waterways
3. Select longest water route + estimate
   - length of flow route
   - slopes.

BY JDF DATE 12/1/89
CHECKED BY
COPY TO EO

VISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Method 2 contd:

4. Estimate the velocity of flow for each section using Figure 15.2. on page 15-8 of Ref 2.

5. Estimate the travel time (T_t) of the flow over each section using the following equation:

$$T_t = \frac{L}{3600\,V}$$

Where T_t = Travel time in hrs
L = hydraulic length in ft.
V = Velocity in feet per second.

6. Estimate the time of concentration (T_c) using the following equation:

$$T_c = \Sigma T_t$$

Note: It will be assumed that small gullies are the predominant drainage components for all drainage areas. (Conservative).

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/1/87 CHECKED BY ____ COPY TO EO ____

Method 3. [Ref. 2, p 15-7] SCS C.N. Method

DA < 2000 acres.

1. Estimate average slope and the longest hydraulic length for the DA.
2. Estimate the lag time for the DA based on the basin's estimated CN and the hydraulic length L using Figure 15.3 on page 15-10 of Ref. 2.
3. Use the following equation to convert Lag to T_c:

$$T_c\,(\text{hrs}) = \text{Lag}/0.6$$

Method 4:

1. Assume overland flow predominates
2. Subdivide DA basin into hydraulic components based on significant slope changes.
3. Use Mannings equation to calculate an estimated velocity of flow over each section.

$$V = \frac{1.49}{n} \cancel{R^{2/3}}^{\,R=1\ \text{(sheet flow)}}\, S^{1/2}$$

where: V = velocity in fps

n = Manning's n assumed to be 0.040

R = Hydraulic Radius (Assume R=1)

S = slope ft/ft.

VISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____
BY JPF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____
Dames & Moore

Method 4 contd;

4. Calculate an estimated travel time (T_t) for each segment:

$$T_t = \left(\frac{L}{V \times 3600\ \text{sec/hr}}\right)$$

where T_t = Segment travel time

L = segment hydraulic length in ft.

V = calculated segment velocity ft/sec

5. Calculate an estimated T_c;

$$T_c = \Sigma T_t$$

Selection:

Tc estimates to be used as input parameters will be selected based on sub-basin characteristics, information gained from the site visit, and judgement.

Post Analysis -- Selection:

T_c estimates developed using Method 4 were considered representative of the study area and will be used as input parameters for the HEC 1 modeling of the study basin.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____
BY JDF DATE 12/1/89 CHECKED BY ____ COPY TO EO ____

045-1 (12/88) PRINTED IN U.S.A.

Addendum to Tc Analysis:

SCS CN estimates were revised after the completion of the Tc evaluation. Method 3, SCS Curve Number Method, for estimating Tc was not re-calculated based on the revised CN's for the sub-basins in the study area.

Tc's calculated using Method 3 were not considered representative of the study area, and no further analysis based on the revised CN's was considered necessary.

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

BY IDF DATE 12/1/89
CHECKED BY _____
COPY TO EO _____

15448-003-022
Buckeye FRS
Sheet 61 of 16

Tc Method 2

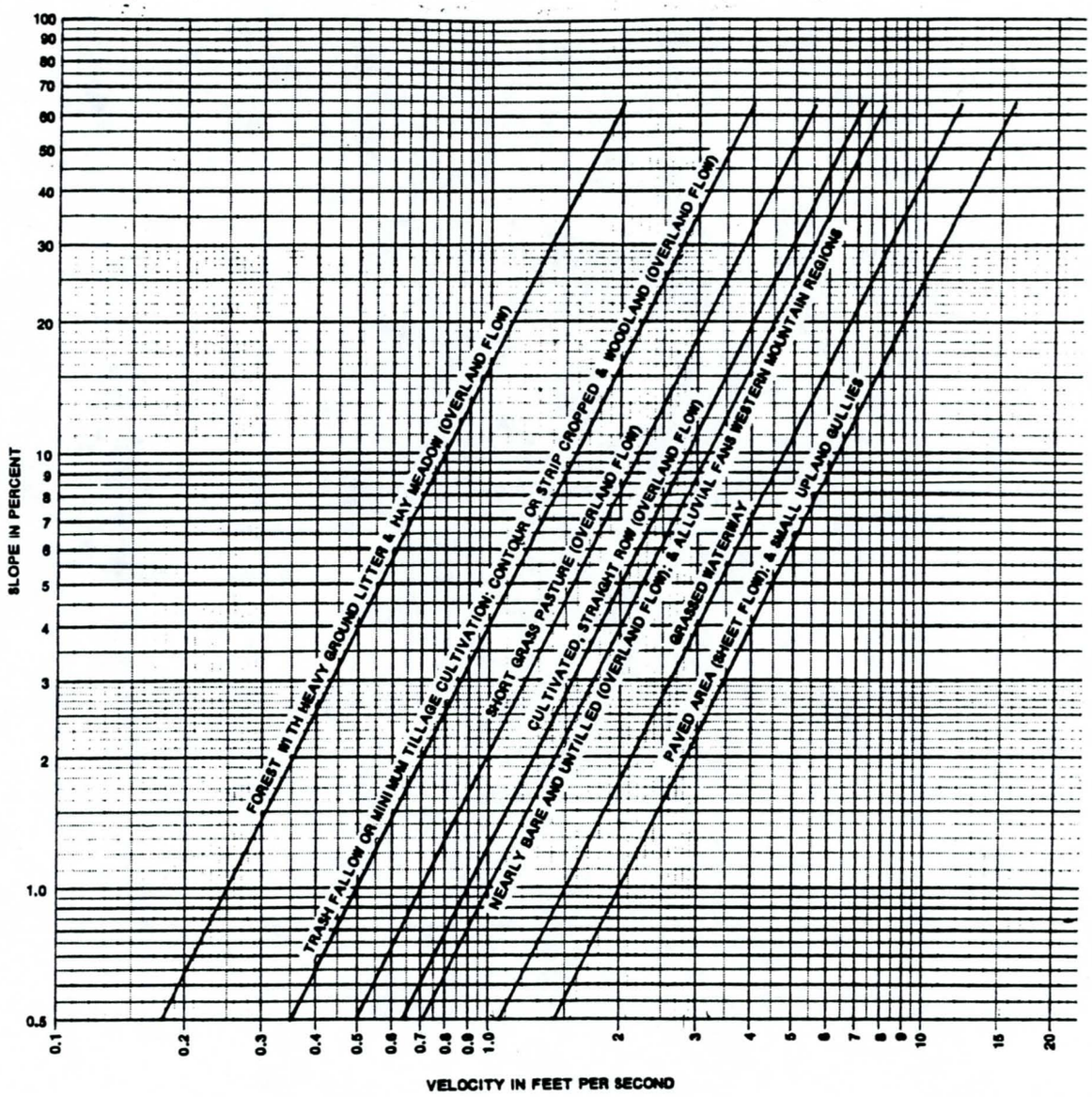


Figure 15.2.—Velocities for upland method of estimating T_c

JDF 12/1/89

Tc, Method 3

Buckeye FRS
Sheet 62 of 16

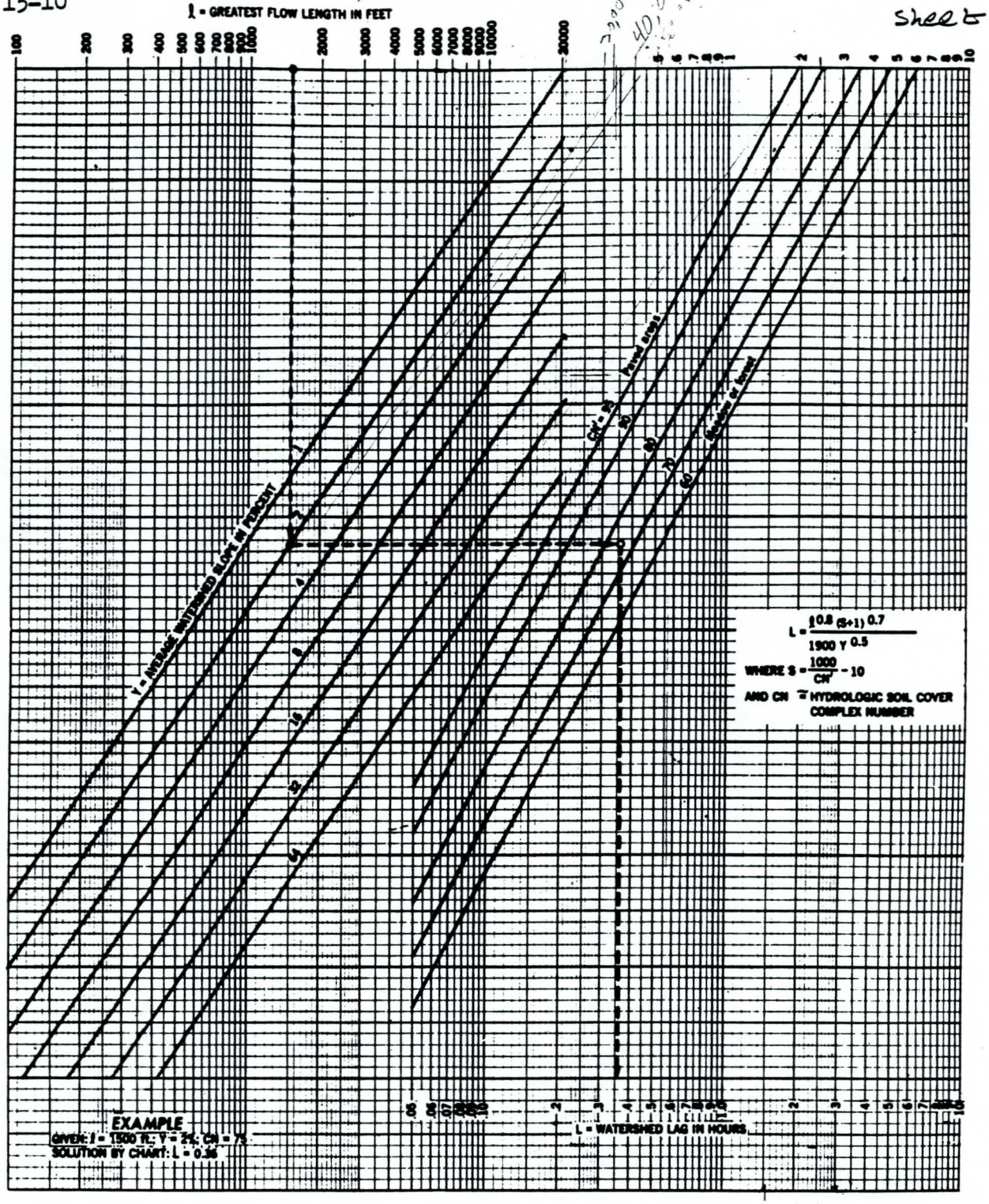


Figure 15.3.—Curve number method for estimating lag (L)

$$t_c \cong \frac{L}{0.6}$$

HEC-1 Input Parameters

FRS #1

DAI CP1-1

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	—
B	978	54.9
C	—	—
D	803	45.1
Total	1781	100

Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—	—		
B	54.9	79	4337.1	
C	—	—		
D	45.1	89	4013.9	
Total	100		8351.0	83.5

CN Selected [REF 1. for AMC I + III]

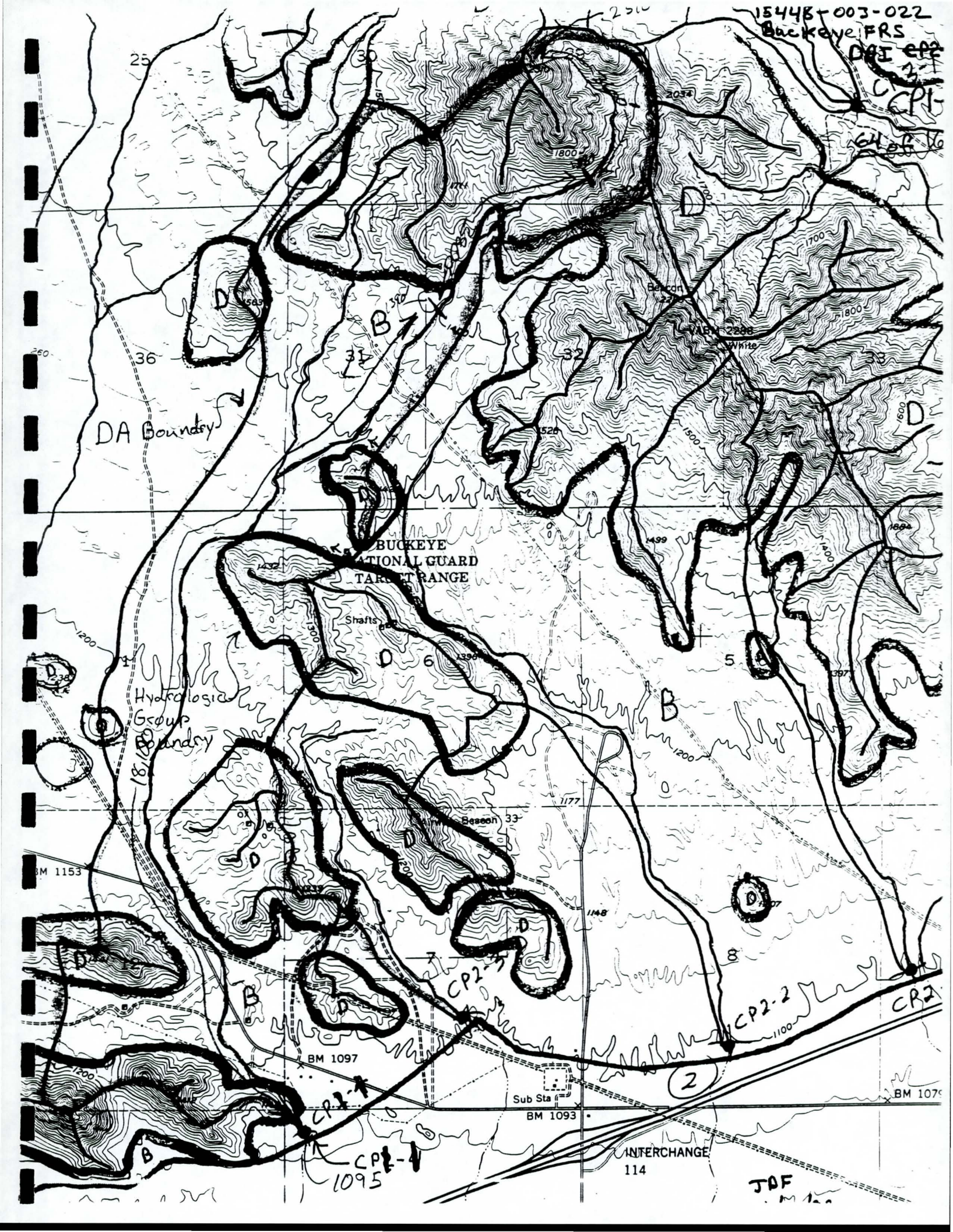
AMC I 68

AMC II 84

AMC III 92

REVIEWS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDE DATE 12/1/83 CHECKED BY ____ COPY TO EO ____


15448-003-022
Buckeye FRS
DA Boundry
Hydrologic Group Boundry
BUCKEYE
NATIONAL GUARD
TARGET RANGE
Shafts
Beacon 33
BM 1153
BM 1097
Sub Sta
BM 1093
BM 1079
INTERCHANGE
114
CP2-1
CP2-2
CP1-1
JDF

FRS 1
CP1-1
DA = 1781 acres < 2000 acres
Tc Evaluation

Method 1.

$$L = 3600 + 3800 + 18100 = 25,500' = 4.830 \text{ mi}$$

$$H = 2310 - 1095 = 1,215$$

$$T_c = \left[\frac{11.9\,(4.830)^3}{1215}\right]^{0.385} = 1.039$$

$$\underline{\underline{T_c = 1.04 \text{ hrs}}}$$

Method 2.

Sec No	Discription	L ft	ELV1 ft	ELV2 ft	S (Elv1 − Elv2)/L ft/ft	V Fig 15.2 fps	Tt = L/(3600 V)
1	Sm Gulley	3600	2310	1590	0.200	10.0	0.100
2	Sm Gulley	3800	1590	1390	0.053	4.6	0.229
3	Sm Gulley	18100	1390	1095	0.016	2.6	1.934

$$\underline{\Sigma T_t = 2.263 \text{ hr}}$$

$$\underline{\underline{T_c = 2.26 \text{ hrs}}}$$ ✓

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/21/89
CHECKED BY ____
COPY TO EO ____

Method 3

$L = 25,500$

$CN = 87$

$\bar{S} = 10\%$

$Lag = 1.2$

$T_c = \frac{1.2}{0.6} = 2.000$ hrs

$T_c = 2.00$ hrs ✓

Method 4

$R = 1$

Sec No	S ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600 V}$
1	0.200	3600	0.040	16.659	0.060
2.	0.053	3800	0.040	8.576	0.123
3	0.016	18100	0.040	4.712	1.067

$\Sigma T_t = 1.250$ ✓

$T_c = 1.25$ hrs ✓

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/21/89
CHECKED BY ____
COPY TO EO ____

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

HEC-1 Input Parameters

FRS #1

DAI CP1-2

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	3611	79.4
C	19	0.4
D	916	20.2
Total	4546	100

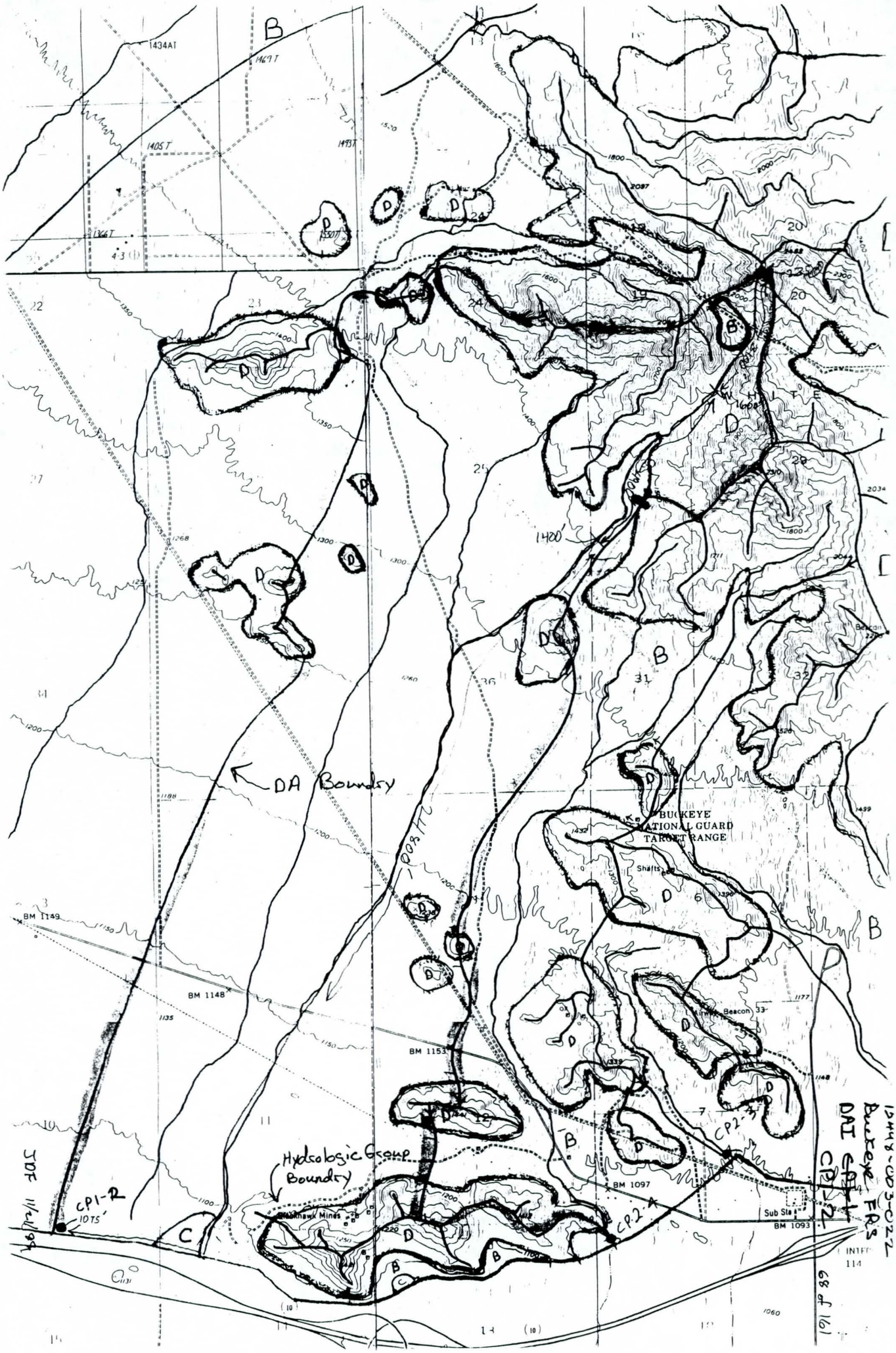
Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted CN = $\frac{\Sigma CN \times \%}{100}$
A				
B	79.4	79	6272.6	
C	0.4	86	34.4	
D	20.2	89	1797.8	
Total	100		8104.8	81.0

BY JDF DATE 11/21/89
CHECKED BY ____
COPY TO EO ____

CN Selected [REF 1. for AMC I + III]

AMC I 64
AMC II 81
AMC III 92


DA Boundry
BUCKEYE
NATIONAL GUARD
TARGET RANGE
Shafts
BM 1149
BM 1148
BM 1153
BM 1097
BM 1093
Sub Sta
Hydrologic Group
Boundry
CP1-R
CP2
JDF 11/21/99
Buckeye FRS
DAI
CP1-R
68 of 161

FRS #1

DAI CP1-2

Time of Concentration Evaluation

DA = 4546 acres > 2000 ac

Accuracy decreases for areas > 2000 ac.

Method 1.

$L = 3100 + 4900 + 24{,}800 = 32{,}800' = 6.21$ mi

$H = 2350 - 1075 = 1275'$

$$T_c = \left[\frac{11.9\,(6.21)^3}{1275}\right]^{0.385} = 1.36 \text{ hrs}$$

$T_c = 1.36$ hrs

Method 2.

Sec No	Discsiption of Flow	L ft	Elv_1 ft	Elv_2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600\,V}$ hrs
1	Small gulley	3100	2350	1600	0.242	10.0	0.086
2	" "	4900	1600	1400	0.041	4.1	0.332
3	" "	24800	1400	1075	0.013	2.3	2.995

$\Sigma T_t = 3.413$ hr

$T_c = 3.41$ hrs

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-89
CHECKED BY ____
COPY TO EO ____

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Method 3.

$L = 32{,}800'$

$CN' = 84$

$\bar{S}_{avg} = 3.9\%$

$Lag = 2.4$ hrs From Fig 15.3

$T_c = \frac{2.4}{0.6} = 4$ hrs

$T_c = 4.00$ hrs

Method 4

A=1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.242	3100	0.040	18.33	0.047
2	0.041	4900	0.040	7.54	0.181
3	0.013	24800	0.040	4.25	1.621

$\Sigma T_t = 1.849$

$T_c = 1.85$ hrs ✓

BY JDF DATE 1-29-90
CHECKED BY ____
COPY TO EO ____

Dames & Moore

HEC-1 Input Parameters

FRS #1

DAI CP1-3

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	8171	66.1
C	351	2.8
D	3845	31.1
Total	12,367	100

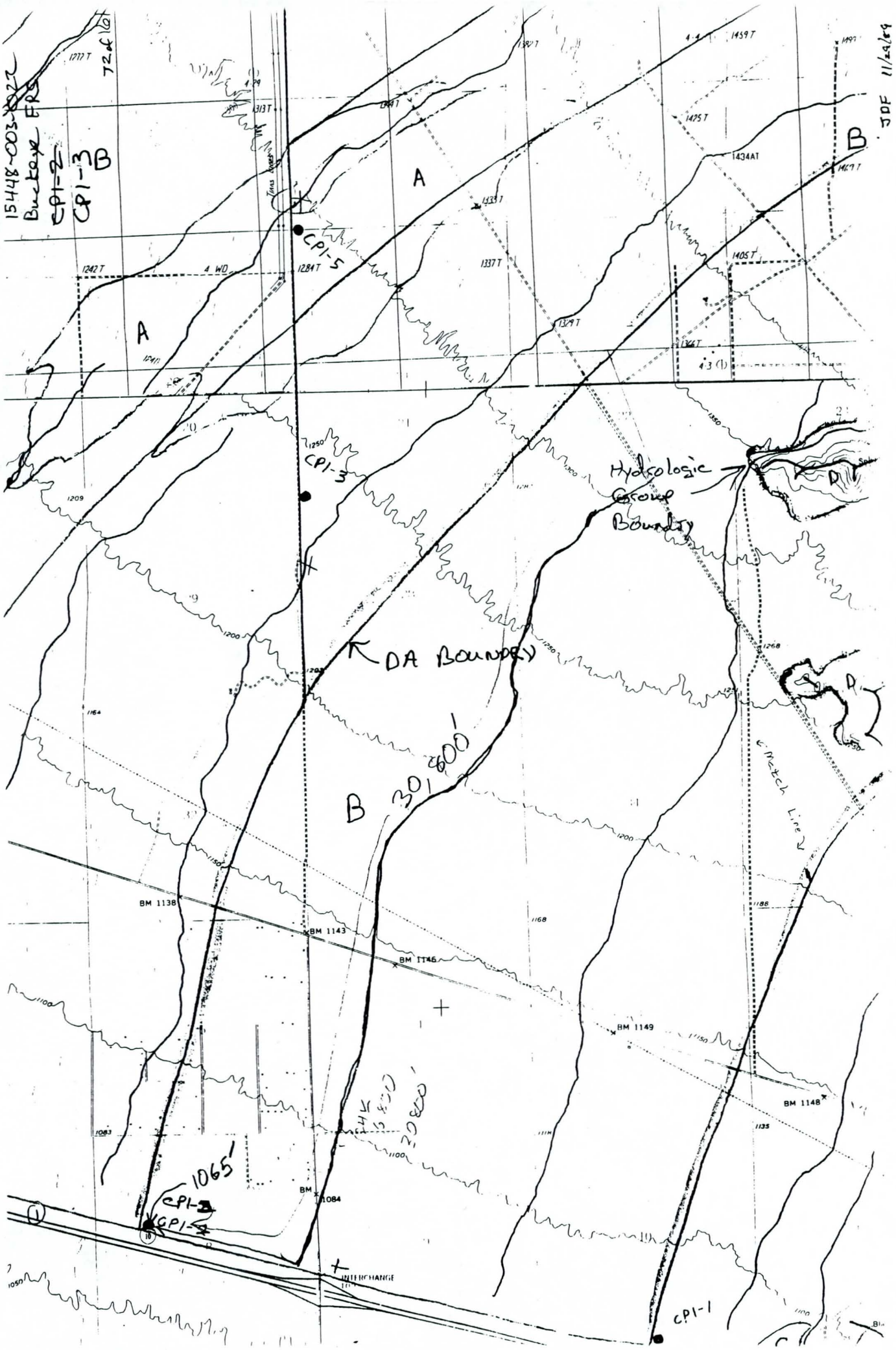
Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A				
B	66.1	79	5221.9	
C	2.8	86	240.8	
D	31.1	89	2767.9	
Total	100		8230.6	82.3

BY JDF DATE 11/29/89
CHECKED BY ____
COPY TO EO ____

CN Selected [REF 1. for AMC I + III]

AMC I 66
AMC II 82
AMC III 92


15448-003-022
Buckeye ERG
CP1-2
CP1-3B
JDF 11/29/89
CP1-5
CP1-3
CP1-4
CP1-1
A
B
D
Hydrologic Group Boundary
DA BOUNDRY
B 30,600'
1065'
Match Line
BM 1138
BM 1143
BM 1146
BM 1149
BM 1148
BM 1084
INTERCHANGE

B
D
C
21,400
3800'
5900
2180
1950
1400
13
18
16
20
21
22
25
36
Petroglyphs
15448-003-022
Buckeye FRS
~~CP1-2~~
CP1-3
73 of 161
JDF 11/29/84

FRS #1

DAI CP1-3

Time of Concentration Evaluation

DA = 12,367 acres > 2000 ac

Accuracy decreases for areas > 2000 ac.

Method 1.

$L = 5900 + 3800 + 21{,}400 + 30{,}800 = 61{,}900' = 11.72$

$H = 2750 - 1065 = 1685$

$$T_c = \left[\frac{11.9\,(11.72)^3}{1685}\right]^{0.385} = 2.55 \text{ hrs}$$

$T_c = 2.55$ hrs

Method 2.

Sec No	Description	L ft	Elv1 ft	Elv2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600\,V}$ hrs
1	Sm Gulley	5900	2750	2180	0.097	6.3	0.260
2	Sm Gulley	3800	2180	1950	0.061	4.9	0.215
3	overland	21400	1950	1400	0.026	3.2	1.858
4	overland	30800	1400	1065	0.011	2.1	4.074

$\Sigma T_t = 6.407$

$T_c = 6.41$ hrs

BY JDF DATE 11-29-89
CHECKED BY
COPY TO EO

REVISIONS BY DATE TO EO
BY DATE TO EO

045-1 (12/88) PRINTED IN U.S.A.

Method 3. Could not use for evaluation

L =

CN' = 86

$\bar{S}_{avg}$ = 2.7 %

Lag = From Fig 15.3

$T_c = \frac{\quad}{0.6} =$

$T_c =$

Method 4.

A = 1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.097	5900	0.040	11.601	0.141
2	0.061	3800	0.040	9.200	0.115
3	0.026	21400	0.040	6.006	0.990
4	0.011	30800	0.040	3.907	2.190

ΣT_t = 3.436

T_c = 3.44 hrs

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-90 CHECKED BY ____ COPY TO EO ____

045 1 (12/88) PRINTED IN U.S.A.

HEC-1 Input Parameters

FRS #1

DAI CP1-4

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	145	2.7
B	3062	57.0
C	481	9.0
D	1678	31.3
Total	5366	100

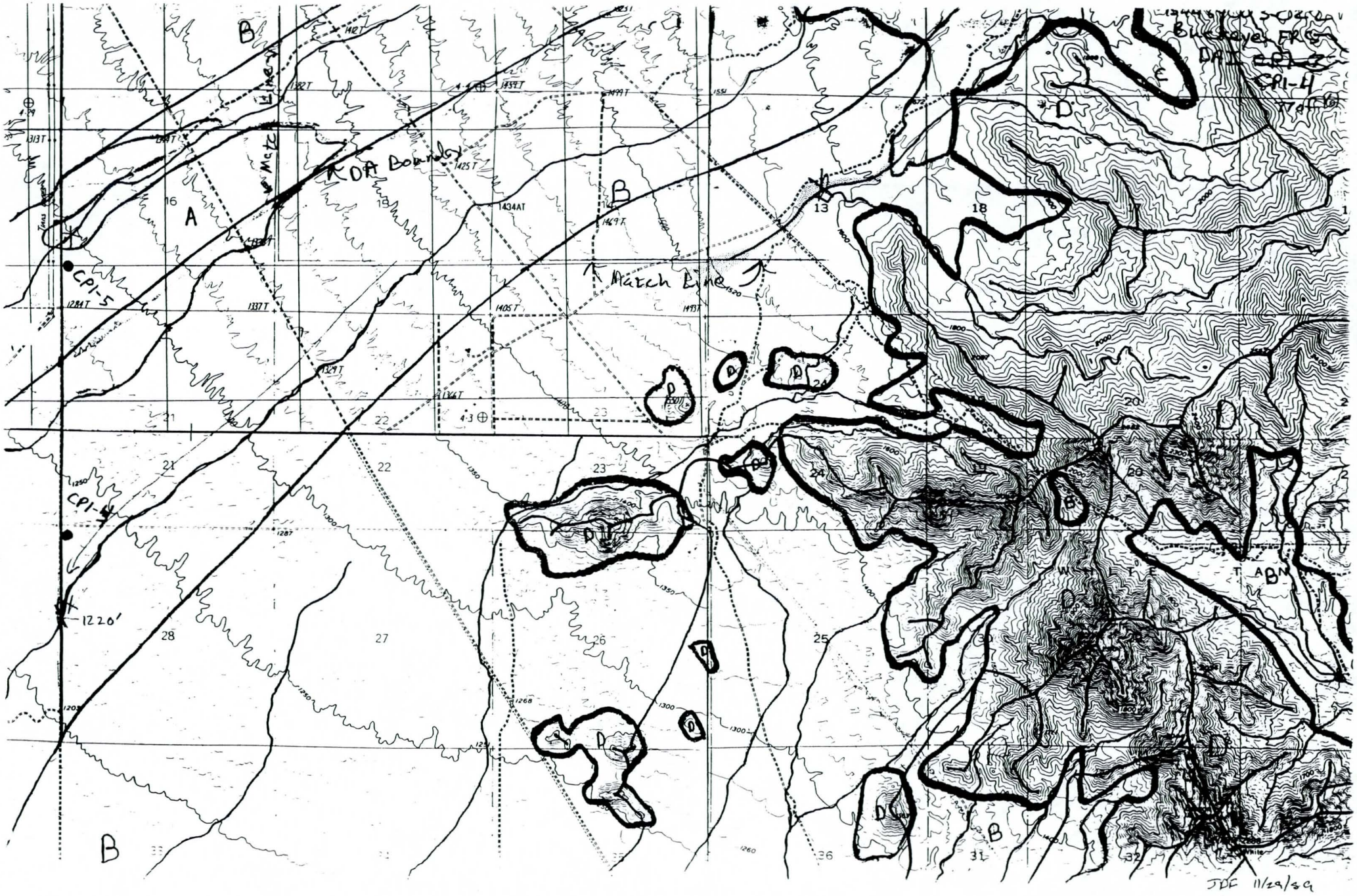
Curve Number Estimate

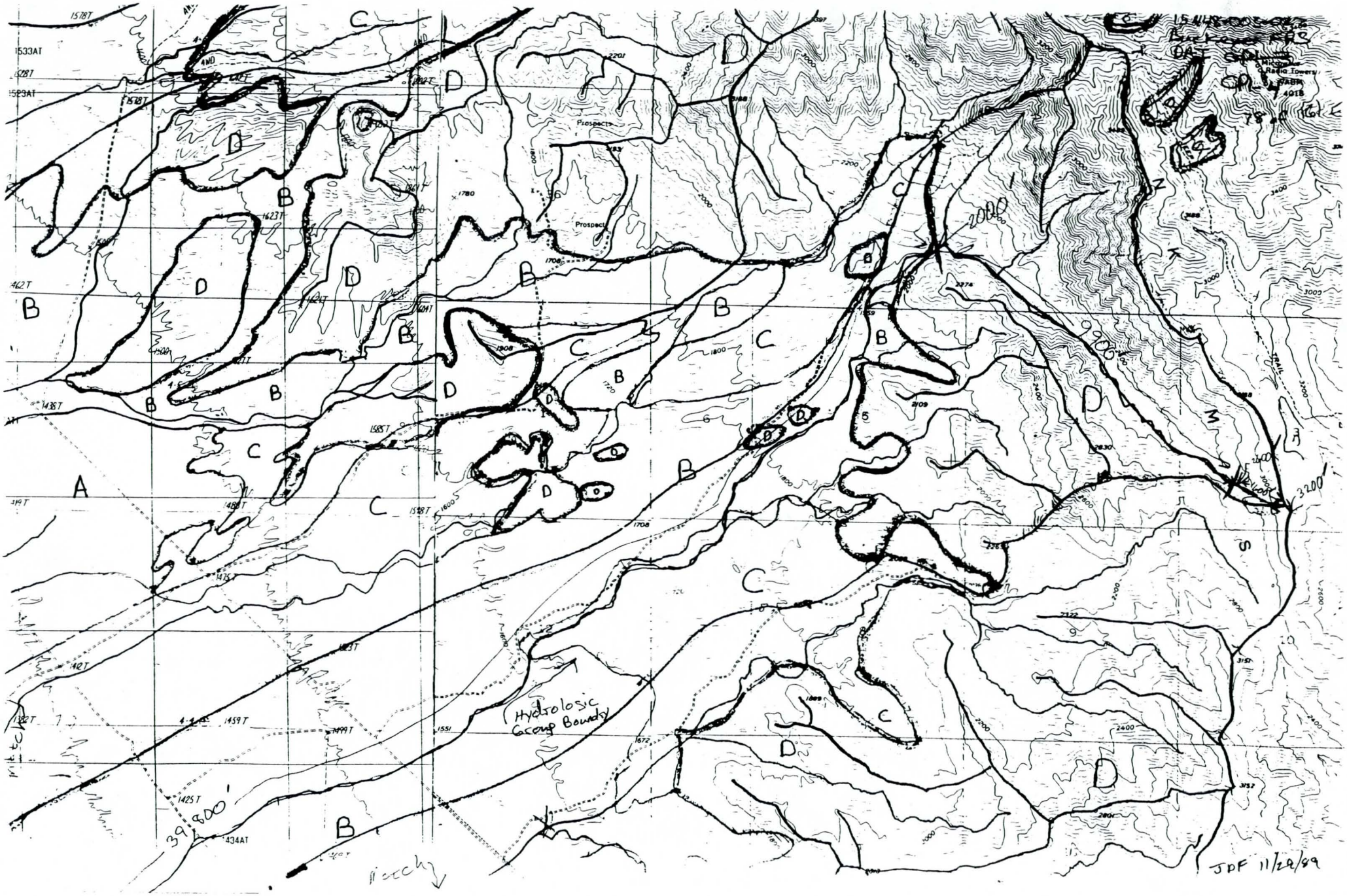
Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	2.7	68	183.6	
B	57.0	79	4503.0	
C	9.0	86	774.0	
D	31.3	89	2785.7	
Total			8246.3	82.5

BY TDF DATE 11/29/89
CHECKED BY ____
COPY TO EO ____

CN Selected [REF 1. for AMC I + III]

AMC I 67
AMC II 83
AMC III 93


Bluebeyer FR
CPI-4
CPI-5
CPI-6
Match Line
DA Boundary
Match Line
1220'
A
B
C
D
JDF 11/29/89


Prospect
Prospect
Radio Towers
Hydrolosic Group Boundry
JDF 11/28/89

FRS #1

DAI CPI-4

Time of Concentration Evaluation

DA = 5.366 acres > 2000 ac

Accuracy decreases for areas > 2000 ac.

Method 1.

$L = 1600 + 9900 + 39,800 = 51,300 \text{ ft} = 9.716 \text{ mi}$

$H = 3200 - 1220 = 1980$

$$T_c = \left[\frac{11.9\,(9.716)^3}{1980}\right]^{0.385} = 1.929$$

$T_c = 1.93$ hrs

Method 2.

Sec No	Description	L ft	Elv_1 ft	Elv_2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600V}$
1	Sm. Gulley	1600	3200	2600	0.375	10.2	0.044
2	Sm. Gulley	9900	2600	2000	0.061	5.0	0.550
3	Sm. Gulley	39,800	2000	1220	0.019	2.8	3.948

$\Sigma T_t = 4.542$

$T_c = 4.54$ hrs

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-89
CHECKED BY ____
COPY TO EO ____

Method 3.

$L = 51{,}300'$

$CN' = 86$

$\bar{S}_{avg} = 3.8\%$

Lag =

From Fig 15.3

$T_c = \frac{\quad}{0.6} =$

$T_c =$

Method 4

A=1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.375	1600	0.040	22.811	0.019
2	0.061	9900	0.040	9.200	0.299
3	0.019	39800	0.040	5.135	2.153

$\Sigma T_t = 2.471$

$T_c = 2.47$ hrs

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-90
CHECKED BY
COPY TO EO

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

HEC-1 Input Parameters

FRS #1

DAI CP1-5

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	71	2.0 ✓
B	3414	98.0 ✓
C	—	
D	—	
Total	3485	100 ✓

Curve Number Estimate

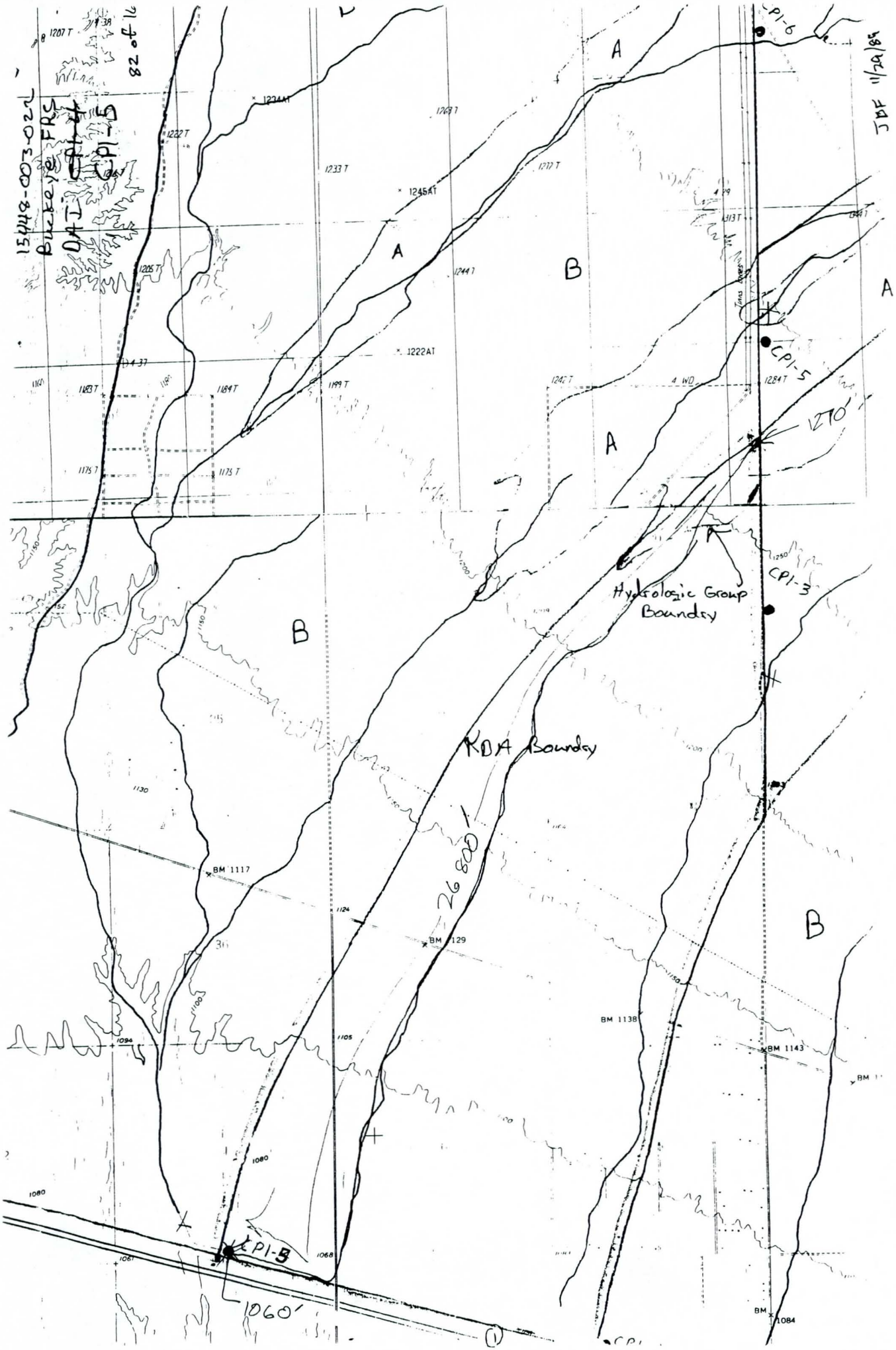
Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	2.0	68	136.0	
B	98.0	79	7742.0	
C				
D				
Total	100		7878.0	78.8 ✓

BY JDF DATE 11/29/89
CHECKED BY ____
COPY TO EO ____

CN Selected [REF 1. for AMC I + III]

AMC I 62
AMC II 79 ✓
AMC III 91

945.1 (12/88) PRINTED IN U.S.A.


15448-003-02L
Buckeye FRC
DATA Sheet
CPI-5
82 of 16
JBF 11/20/85
CPI-6
CPI-5
CPI-3
CPI-8
1210'
1060'
26800'
Hydrologic Group Boundary
KDA Boundary
A
B
BM 1117
BM 1129
BM 1138
BM 1143
BM 1084

FRS #1

DAI CPI-5

~~Time of Concentration Evaluation~~

DA = 3485 acres 2000 ac

Accuracy decreases for areas > 2000 ac.

Method 1.

$L = 26{,}800' = 5.076$ mi =

$H = 1270 - 1060 = 210'$

$$T_c = \left[\frac{11.9\,(5.076)^3}{210}\right]^{0.385} = 2.162$$

$T_c = 2.16$ hrs

Method 2.

Sec No	Discsiption	L ft	Elv_1 ft	Elv_2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600V}$
1	Sm Gulley	26,800	1270	1060	0.008	1.9	3.918
2							
3							

$\Sigma T_t = 3.918$

$T_c = 3.92$ hrs

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-89 CHECKED BY ____ COPY TO EO ____

Dames & Moore

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

Method 3.

$L = 26,800'$

$CN' = 82$

$\bar{S}_{avg} = 0.008$

Lag =

From Fig 15.3

$T_c = \frac{\quad}{0.6} =$

$T_c =$

Method 4

A=1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.008	26800	0.040	3.332	2.234
2			0.040		
3			0.040		

$\Sigma T_t = 2.234$

$T_c = 2.23$

BY JDF DATE 11-29-90
CHECKED BY _____
COPY TO EO _____

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

HEC-1 Input Parameters

FRS # 1

DAI CP1-6

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	379	11.5
B	1279	38.9
C	669	20.4
D	959	29.2
Total	3286	100

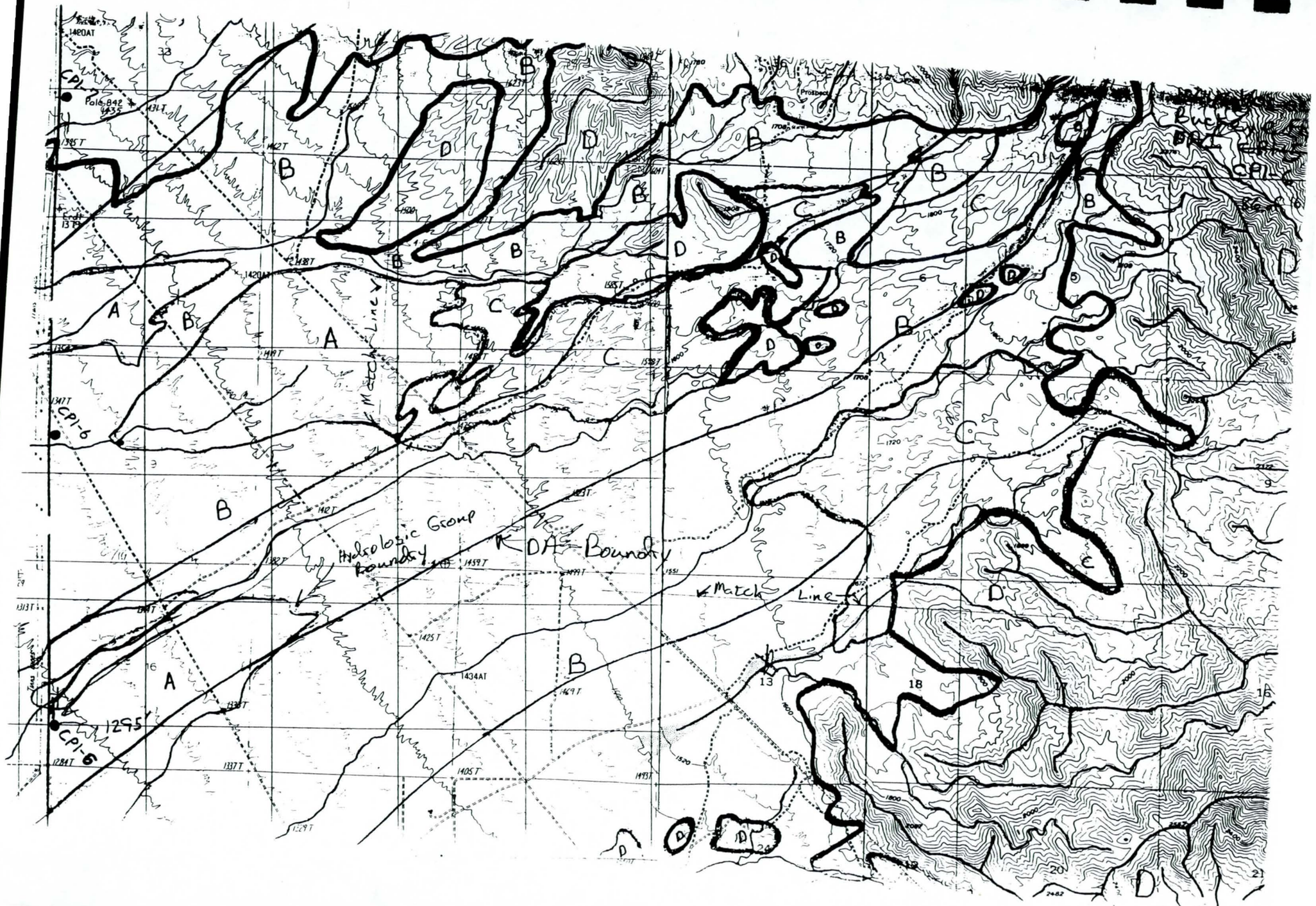
Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	11.5	68	782.0	
B	38.9	79	3073.1	
C	20.4	86	1754.4	
D	29.2	89	2598.8	
Total	100		8208.3	82.1

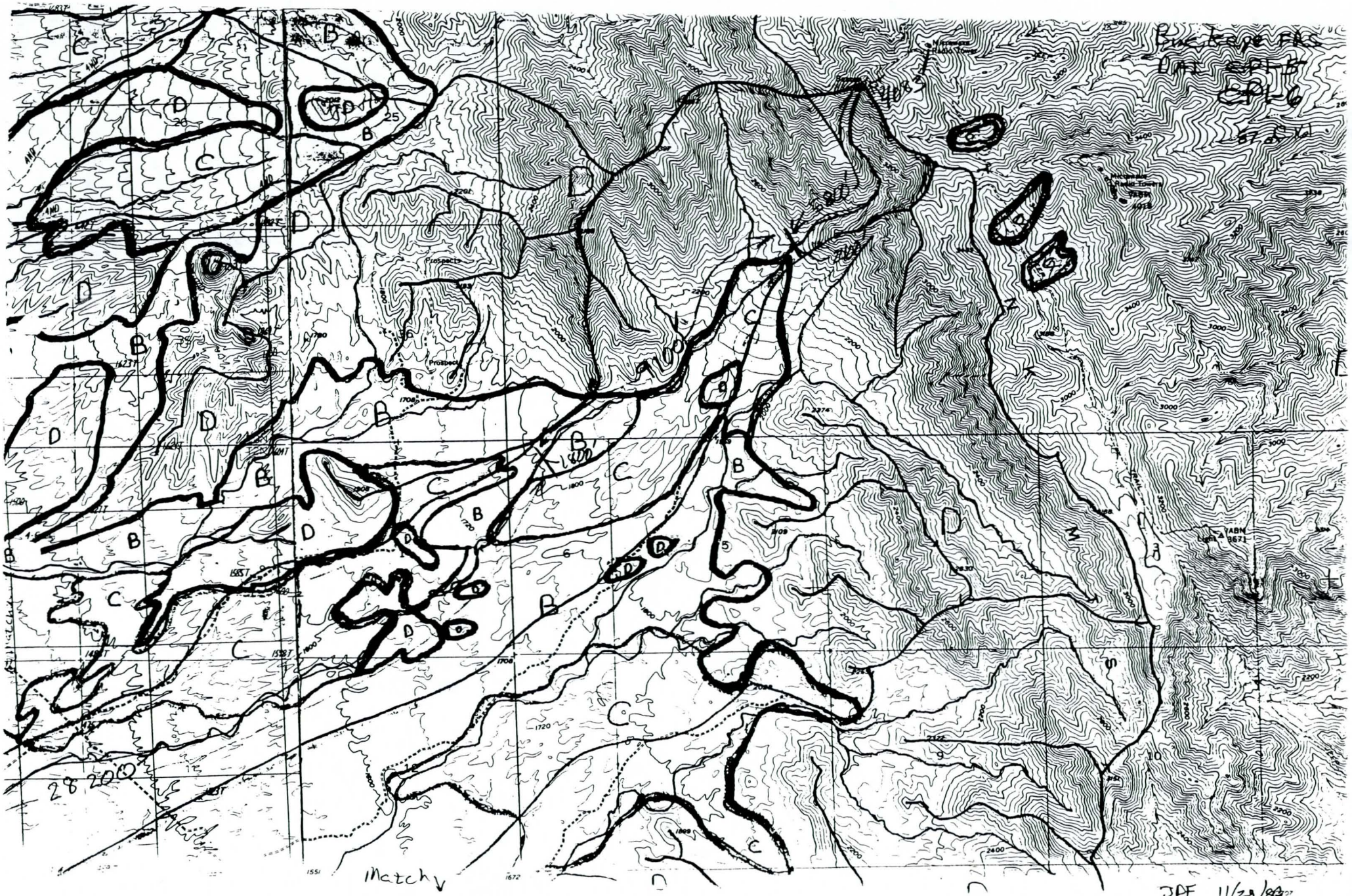
BY JDF DATE 11/29/89
CHECKED BY
COPY TO EO

CN Selected [REF 1. for AMC I + III]

AMC I 66
AMC II 82
AMC III 92


Hydrologic Group Boundary
DA Boundary
Match Line
Match Line
CP1-7
CP1-6
CP1-6
1295
Prospect
Buck Creek
A
B
C
D
E

JDF 11/22/02


Buckeye FIRE
UNIT EPL-6
EPL6
Prospects
Prospect
Microwave Radio Towers
Microwave Radio Towers
ABN 3671
28 200
Match
JDF 11/29/88

FRS #1

DAI CPI-6

Time of Concentration Evaluation

DA = 3.286 acres > 2000 ac.

Accuracy decreases for areas > 2000 ac.

Method 1.

$L = 5800 + 9100 + 28200 = 43,100' = 8.163$

$H = 4083 - 1295 = 2788$

$$T_c = \left[\frac{11.9\,(8.163)^3}{2788}\right]^{0.385} = 1.383$$

$T_c = 1.38$ hrs

Method 2.

Sec No	Discsiption	L ft	Elv₁ ft	Elv₂ ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600V}$
1	Sm Gulley	5800	4083	2400	0.290	10.1	0.160
2	Sm Gulley	9100	2400	1800	0.066	5.2	0.486
3	Sm Gulley	28200	1800	1295	0.018	2.3	3.406
							$\Sigma T_t \doteq 4.052$

$T_c = 4.05$ hrs

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-89 CHECKED BY ____ COPY TO EO ____

Method 3.

$L =$

$CN' =$

$\bar{S}_{avg} =$

Lag = From Fig 15.3

$T_c = \frac{\quad}{0.6} =$

$T_c =$

Method 4

A=1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.290	5800	0.040	20.060	0.080
2	0.066	9100	0.040	9.570	0.264
3	0.018	28200	0.040	4.998	1.567

$\Sigma T_t = 1.911$ hrs

$T_c = 1.91$ hrs

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-90
CHECKED BY
COPY TO EO

HEC-1 Input Parameters

FRS #1

DAI CP1-7

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	824	14.8
B	2147	38.7
C	299	5.4
D	2278	41.1
Total	5548	100

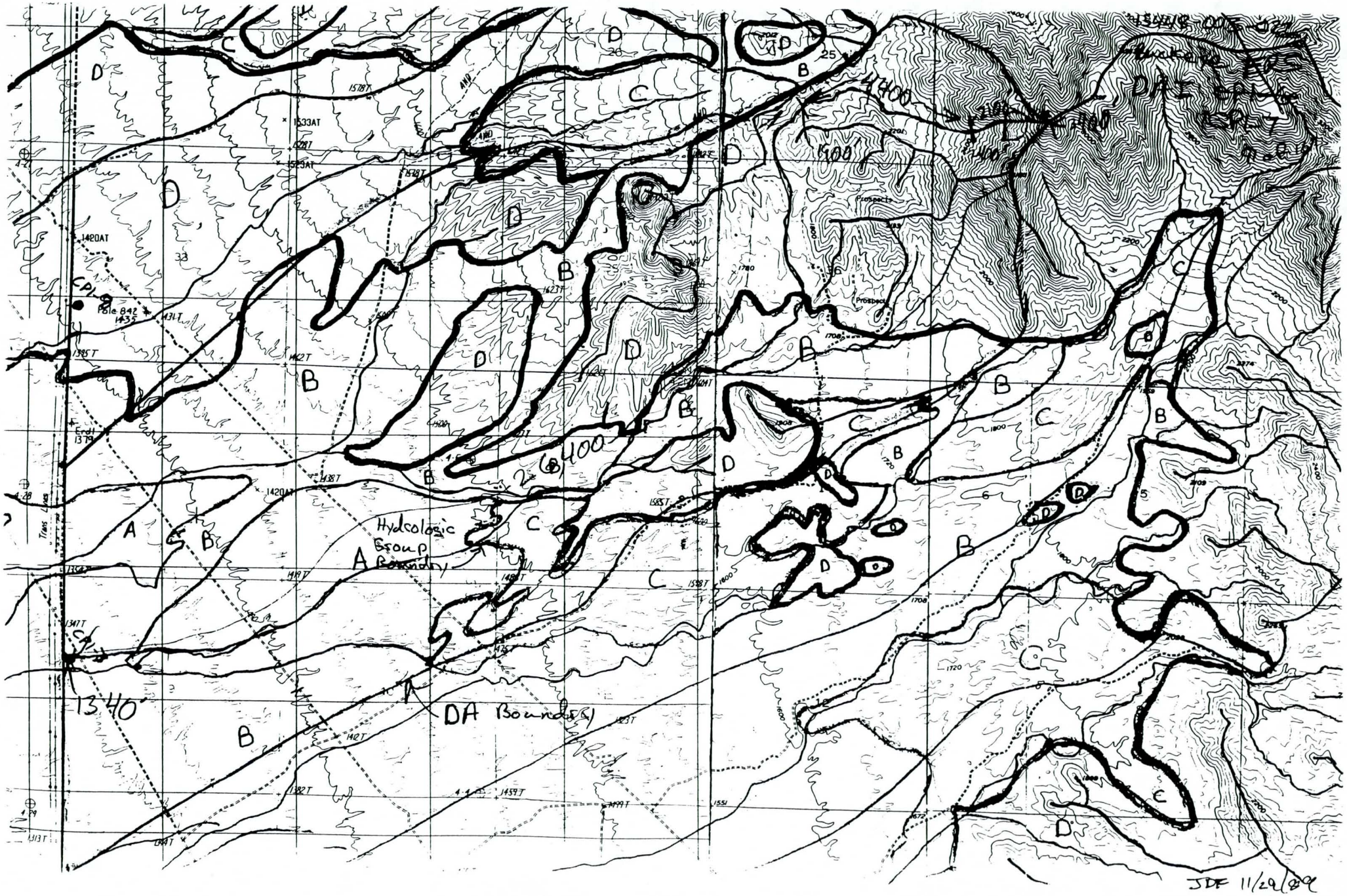
Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	14.8	68	1006.4	
B	38.7	79	3057.3	
C	5.4	86	464.4	
D	41.1	89	3657.9	
Total			8186.0	81.9 ✓

BY JDF DATE 11/29/89
CHECKED BY
COPY TO EO

CN Selected [REF 1. for AMC I + III]

AMC I 66
AMC II 82 ✓
AMC III 92


Hydrologic Group A Boundary
DA Boundary
1340
1400
1500
Prospects
JDF 11/29/89

FRS #1

DAI CPI-1-7

Time of Concentration Evaluation

DA = 5548 acres > 2000 ac

Accuracy decreases for areas > 2000 ac.

Method 1.

$L = 2100 + 4400 + 26400 = 32{,}900' = 6.231$ ✓

$H = 3400 - 1340 = 2060'$ ✓

$$T_c = \left[\frac{11.9\,(6.231)^3}{2060}\right]^{0.385} = 1.138 \text{ hrs}$$

$T_c = 1.14$ hrs

Method 2.

Sec No	Discription	L ft	Elv_1 ft	Elv_2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600V}$ hrs.
1	Sm Gulley	2100	3400	2400	0.476	10.4	0.056
2	Sm Gulley	4400	2400	1900	0.114	6.8	0.180
3	Sm Gulley	26400	1900	1340	0.021	2.9	2.529

$\Sigma T_t = 2.765$

$T_c = 2.76$ hrs ✓

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11-29-89
CHECKED BY ____
COPY TO EO ____

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

Method 3.

$L = 32,900$

$CN' = 86$

$\bar{S}_{avg} = 3.6\%$

$Lag = 2.2$ hrs From Fig 15.3

$T_c = \frac{2.2}{0.6} =$

$T_c = 3.67$ hrs

Method 4

$R = 1$

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.476	2100	0.040	25.700	0.023
2	0.114	4400	0.040	12.577	0.097
3	0.021	26400	0.040	5.398	1.359

$\Sigma T_t = 1.479$

$T_c = 1.48$ hrs

BY JDF DATE 11-29-90
CHECKED BY _____
COPY TO EO _____

Dames & Moore

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

HEC-1 Input Parameters

FRS #1

DAI CP1-8

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	228	13.5
C	292	17.2
D	1176	69.3
Total	1696	100

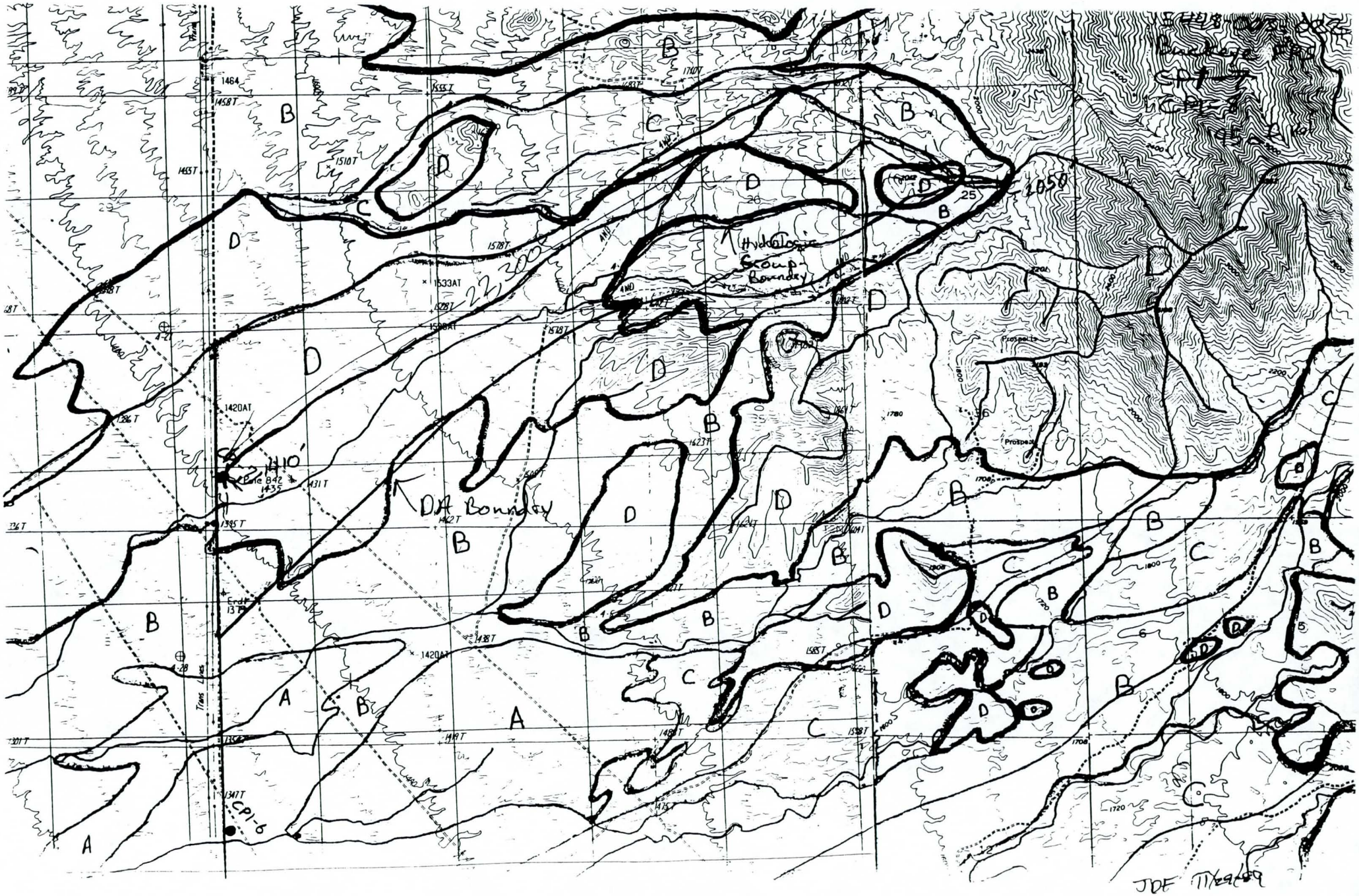
Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A				
B	13.5	79	1066.5	
C	17.2	86	1479.2	
D	69.3	89	6167.6	
Total	100		8713.4	87.1 ✓

BY JDF DATE 11/29/89
CHECKED BY [illegible]
COPY TO EO ____

CN Selected [REF 1. for AMC I + III]

AMC I 73
AMC II 87 ✓
AMC III 95


Hydrologic Group Boundary
DA Boundary
CPI-6
Trans Lines
Prospects
1410
1050
JDF 11/29/89

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

FRS #1

DAI CP1-9

Time of Concentration Evaluation

DA = 1.696 acres < 2000 ac

Accuracy decreases for areas > 2000 ac.

Method 1.

$L = 22{,}300' = 4.223 \text{ mi} =$

$H = 2050 - 1410 = 640$

$$T_c = \left[\frac{11.9\,(4.223)^3}{640}\right]^{0.385} = 1.138$$

$T_c = 1.14$ hrs

Method 2.

Sec No	Discsiption	L ft	Elv₁ ft	Elv₂ ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600\,V}$ hrs
1	Sm Gullies	22,300	2050	1410	0.029	3.4	1.822 ✓
2							
3							

$\Sigma T_t = 1.822$

$T_c = 1.82$ hrs ✓

BY JDF DATE 11-29-89
CHECKED BY ____
COPY TO EO ____

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Method 3.

$L = 22{,}300'$

$CN' = 91$

$\bar{S}_{avg} = 2.9\%$

$Lag = 1.50$ hrs From Fig 15.3

$T_c = \frac{1.50}{0.6} = 2.50$ hrs

$T_c = 2.50$ hrs

Method 4.

A = 1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.029	22,300	0.040	6.343	0.977
2			0.040		
3			0.040		

$\Sigma T_t = 0.977$

$T_c = 0.98$ hrs

BY JDF DATE 11-29-90
CHECKED BY ____
COPY TO EO ____

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

HEC-1 Input Parameters

FRS #1

DAI CP1-9

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	1029	9.8
B	8921	85.1
C	—	—
D	538	5.1
Total	10488	100

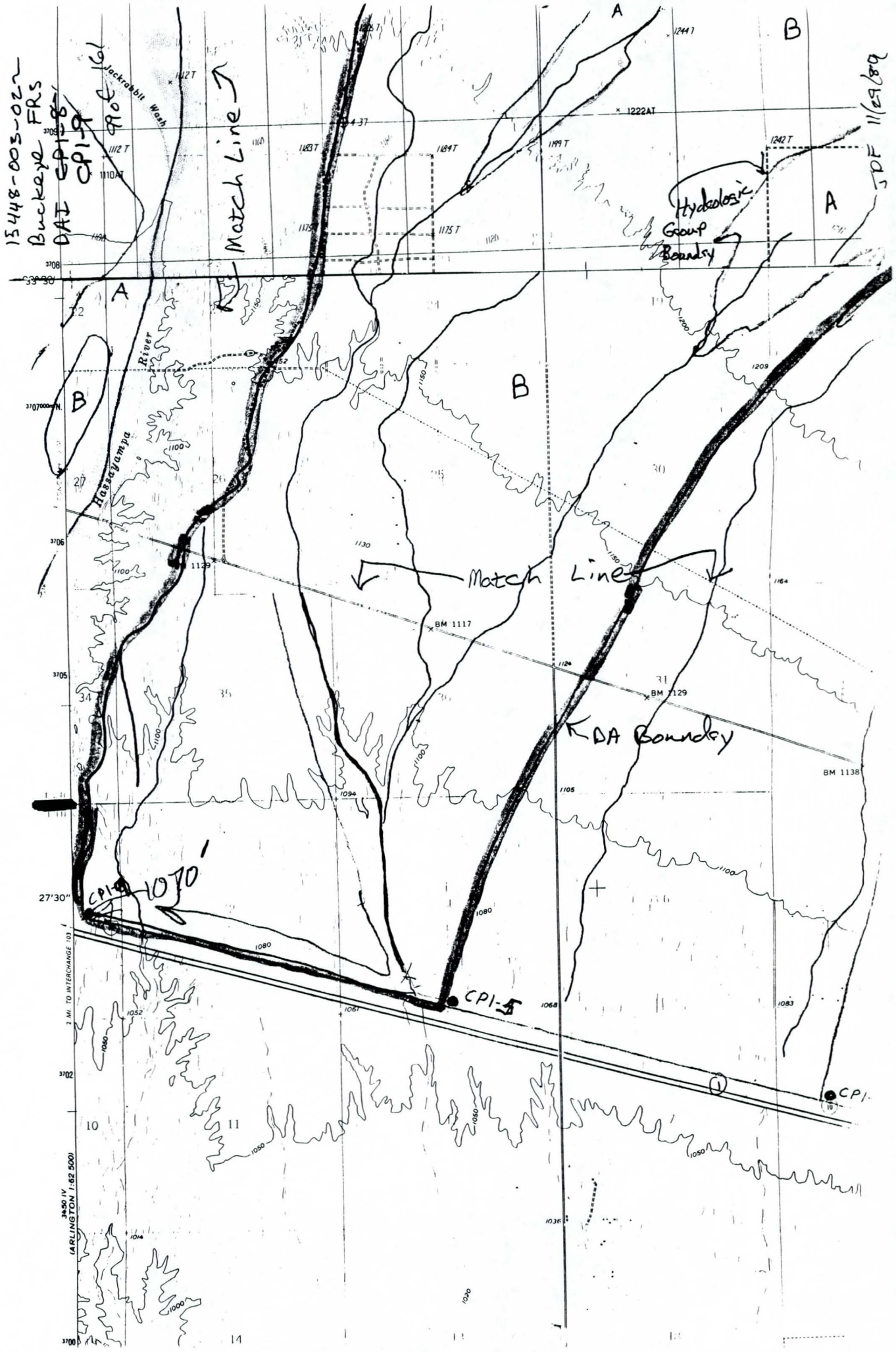
Curve Number Estimate

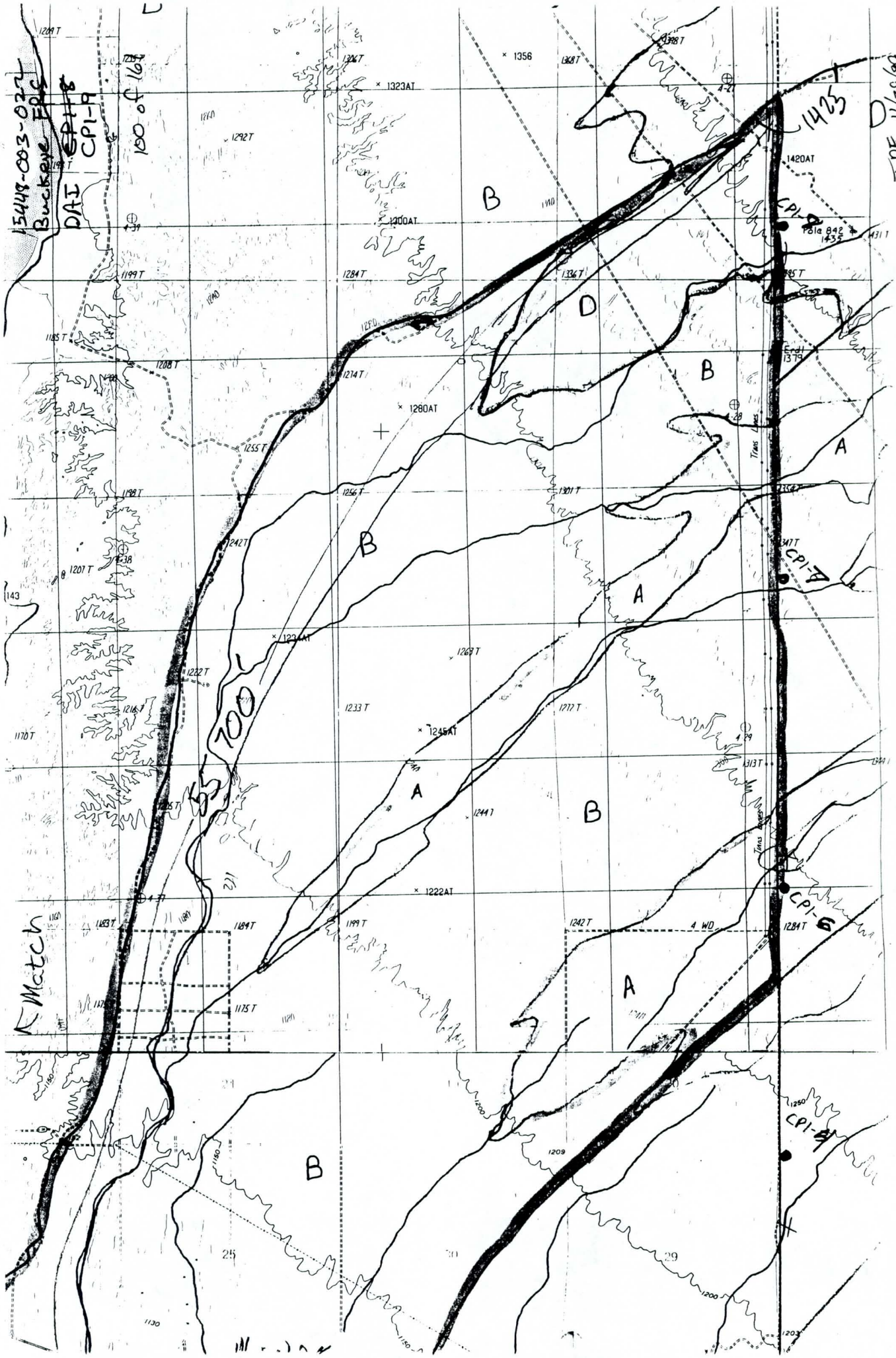
Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	9.8	68	666.4	
B	85.1	79	6722.9	
C				
D	5.1	89	453.9	
Total	100		7843.2	78.4

BY 11/29/84 DATE 11/29/84
CHECKED BY _____
COPY TO EO _____

CN Selected [REF 1. for AMC I + III]

AMC I 60
AMC II 78
AMC III 90


15448-003-02n
Buckeye FRS
DAI CP1-8
CP1-9
90 ft
Jackrabbit Wash
Match Line
Hydrologic Group Boundry
A
B
Hassayampa River
Match Line
BM 1117
BM 1129
BM 1138
DA Boundry
1070'
CP1-10
CP1-5
CP1
27'30"
2 MI. TO INTERCHANGE 103
3450 IV
(ARLINGTON 1:62 500)
JDF 11/29/89


15448-003-027
Buckeye EPC
DAI CP1-8
CP1-9
100 of 167
1423
D
JOE 11/29/88
1420AT
CP1-8
Pole 842
1435
1431T
1356
1323AT
1292T
1200AT
1284T
1336T
1385T
1199T
1185T
1208T
1214T
1280AT
1255T
1379
Erdl
Trans Lines
1301T
1256T
1242T
1201T
1347T
CP1-7
1234AT
1268T
1232T
1233T
1277T
1245AT
1313T
1170T
1244T
1222AT
CP1-6
1242T
1284T
1183T
1184T
1199T
1175T
Match
CP1-5
1209
25
30
29
1130
1200
1203
B
D
A

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

FRS #1

DAI CP1-9

Time of Concentration Evaluation

DA = 10,488 acres > 2000 ac

Accuracy decreases for areas > 2000 ac.

Method 1.

L = 55 700′ = 10.549 mi =

H = 1425 − 1070 = 355

$$T_c = \left[\frac{11.9\,(10.549)^3}{355}\right]^{0.385} = 4.112 \text{ hrs}$$ ✓

T_c = 4.11 hrs

Method 2.

Sec No	Discription	L ft	Elv_1 ft	Elv_2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V From Fig 15.2 fps	T_t $\frac{L}{3600V}$ hrs
1	Sm Gullies	55,700	1425	1070	0.006	1.55	9.982
2							
3							

ΣT_t = 9.982

T_c = 9.98 hrs

BY JDE DATE 11-29-89
CHECKED BY ____
COPY TO EO ____

945.1 (12/88) PRINTED IN U.S.A.

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

Method 3.

L =

CN' =

$\bar{S}_{avg}$ =

Lag = From Fig 15.3

$T_c = \frac{\quad}{0.6} =$

$T_c =$

Method 4

A = 1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.006	55700'	0.040	2.885 ✓	5.363 ✓
2			0.040		
3			0.040		

$\Sigma T_t = 5.363$ hrs

$T_c = 5.36$ hrs ✓

BY JDF DATE 11-29-90
CHECKED BY
COPY TO EO

HEC-1 Input Parameters

FRS #2

DAI CP2-1

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	—
B	781	62.4
C	—	—
D	470	37.6
Total	1251	100

Curve Number Estimate

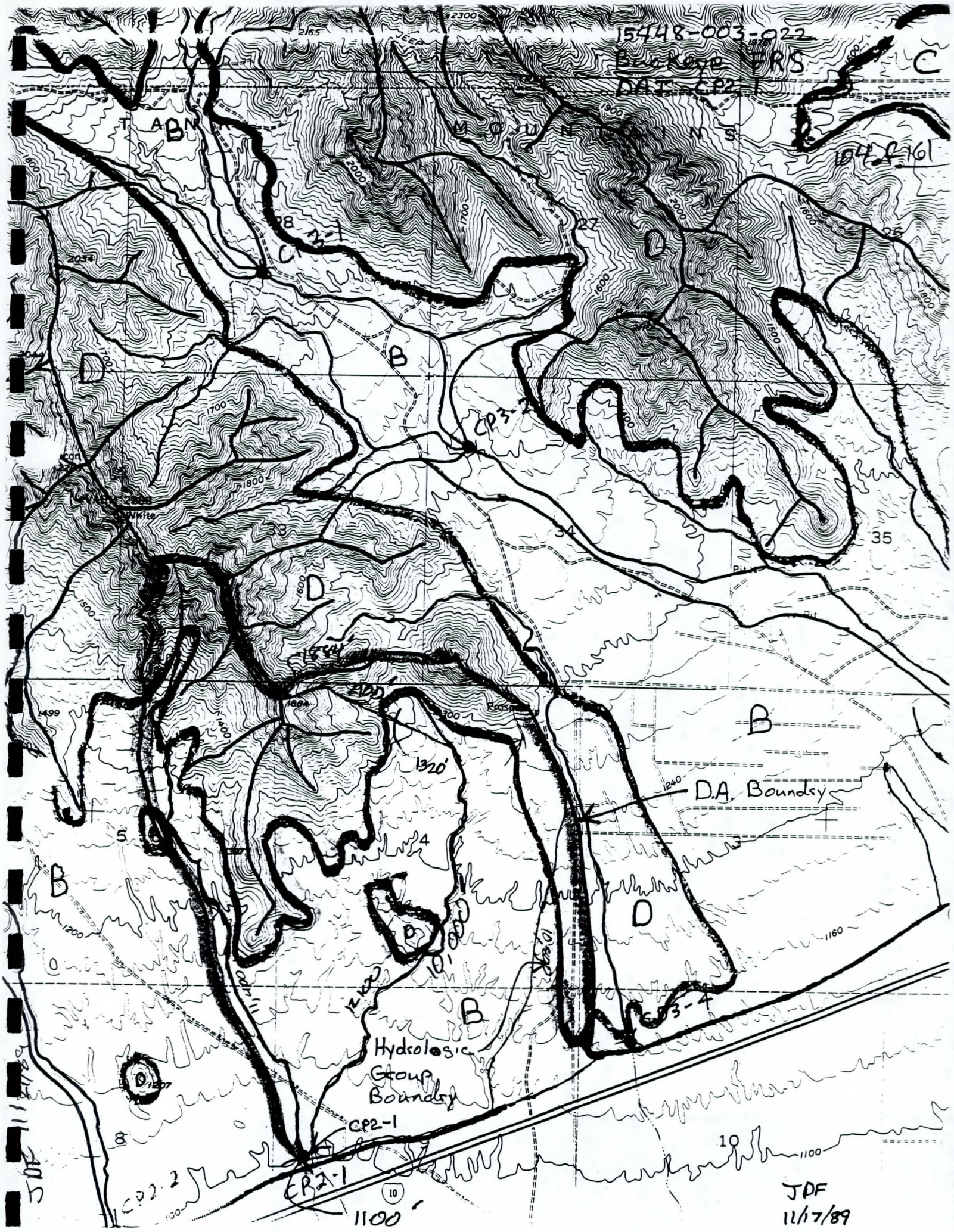
Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—	—		
B	62.4	79	4929.6	
C	—	—		
D	37.6	89	3346.4	
Total	100		8276.0	82.8 ✓

CN Selected [REF 1. for AMC I + III]

AMC I 67
AMC II 83 ✓
AMC III 93

BY JDF DATE 11/21/89
CHECKED BY
COPY TO EO

BY DATE TO EO
BY DATE TO EO


15448-003-022
Buckeye FRS
DAI - CP2-1
104 & 161
CP3-2
D.A. Boundry
Hydrologic Group Boundry
CP2-1
CP2-2
CP3-4
1320'
1100'
JDF
11/17/89

FRS 2

CP 2-1

Tc Evaluation

DA = 1251 acres < 2000 acres

Method 1:

$$L = 11{,}900 = 2.25 \text{ mi}$$

$$H = 1884 - 1100 = 784'$$

$$T_c = \left[\frac{11.9\ (2.25)^3}{784}\right]^{0.385} = 0.509$$

$$\underline{\underline{T_c = 0.51}}$$

Method 2:

Sec No	Description	L ft	Elv_1 ft	Elv_2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V Fig 15.2 fps	T_t $\frac{L}{3600\,V}$
1	Small Gulleys	2100	1884	1320	0.269	10.2	0.057
2	Small Gulleys	10,000	1320	1100	0.022	3.0	0.926

$$\Sigma T_t = 0.983$$

$$\underline{\underline{T_c = 0.98}}$$

BY JDF DATE 11/21/89
CHECKED BY
COPY TO EO

VISIONS
BY DATE TO EO
BY DATE TO EO

Method 3:

$L = 12{,}100$

$CN' = 86$

$\bar{S} = 11.5\%$

Lag time = 0.62 hrs

$T_c = 0.62/0.6 = 1.033$ hrs

$T_c = 1.03$ hrs ✓

Method 4:

R = 1

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$
1	0.269	2100	0.04	19.320	0.030
2	0.022	10 000	0.04	5.525	0.503

$\Sigma T_t = 0.533$ hrs

$T_c = 0.53$ hrs

BY JDF DATE 11/21/89
CHECKED BY
COPY TO EO

VISIONS
BY DATE TO EO
BY DATE TO EO

HEC-1 Input Parameters

FRS #2

DAI CP2-2

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	1051	66.6
C	—	
D	526	33.4
Total	1577	100

Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—			
B	66.6	79	5261.4	
C	—			
D	33.4	89	2972.6	
Total	100		8234.0	82.3 ✓

CN Selected [REF 1. for AMC I + III]

AMC I 66

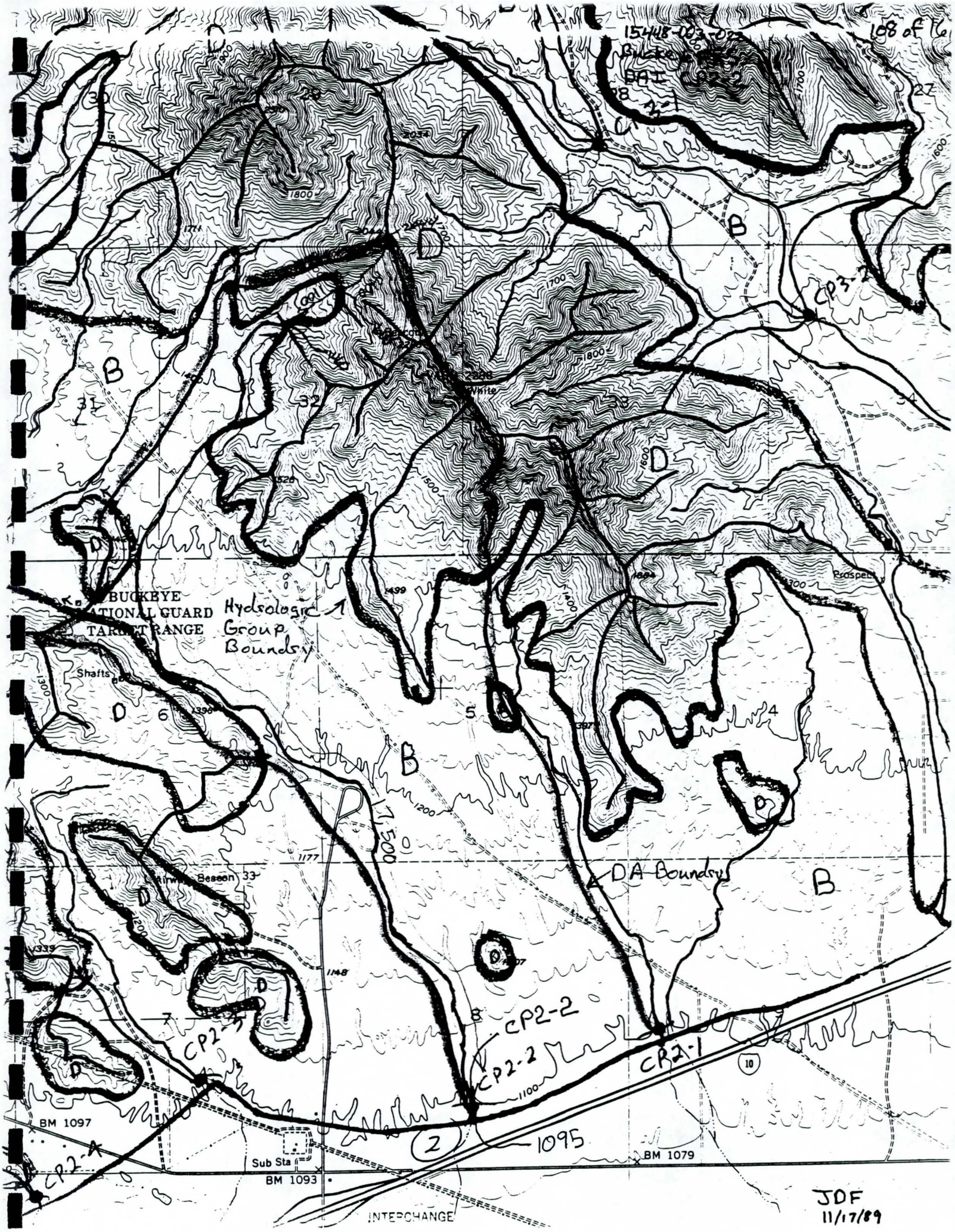
AMC II 82

AMC III 92

BY JDF DATE 11/21/89
CHECKED BY
COPY TO EO

BY DATE TO EO
BY DATE TO EO

15448-003-02


BUCKEYE
NATIONAL GUARD
TARGET RANGE
Hydrologic Group Boundry
DA Boundry
Shafts
Beacon 33
Prospect
White
Sub Sta
BM 1097
BM 1093
BM 1079
INTERCHANGE
CP2-1
CP2-2
CP2-2
CP2-1
CP2-A
CP3-2
1095
JDF
11/17/89

FRS 2
CP2-2
Tc Evaluation

DA = 1577 < 2000 acres

Method 1:

$L = 1400' + 1100' + 17500 = 20{,}000\ ft = 3.79\ mi.$

$H = 2044 - 1095 = 949$

$$T_c = \left[\frac{11.9\ (3.79)^3}{949}\right]^{0.385} = 0.863$$

$T_c = 0.86$ hrs.

Method 2:

Sec #	Discription	L ft	El_1 ft	El_2 ft	$S = \frac{El_1 - El_2}{L}$ ft/ft	V Fig 15.2 fps	$T_t = \frac{L}{3600V}$ hrs
1	Sm Gulley	1400	2044	1600	0.317	11.2	0.035
2	" "	1100	1600	1460	0.127	7.0	0.044
3	" "	17500	1460	1095	0.021	2.9	1.676

$\Sigma T_t = 1.755$

$T_c = 1.76$ hrs

BY JDF DATE 11/21/87
CHECKED BY
COPY TO EO

VISIONS
BY DATE TO EO
BY DATE TO EO

Method 3:

$L = 20{,}000$ ft

$CN' = 86$

$\bar{S} = 8\%$

Lag time $= 0.7$ hrs

$T_c = \frac{0.7}{0.6} = 1.167$ hrs

$T_c = 1.17$ hrs ✓

Method 4:

$R = 1$

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600\,V}$ hrs
1	0.317	1400	0.040	20.973	0.019
2	0.127	1100	0.040	13.275	0.023
3	0.021	17500	0.040	5.398	0.901

$\Sigma T_t = 0.943$ hrs

$T_c = 0.94$ hrs

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDE DATE 11/21/89
CHECKED BY ____
COPY TO EO ____

FILE 15448-003-022
SUBJECT Buckeye FRS
SHEET 111 OF 161

REV NS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

HEC-1 Input Parameters

FRS #2

DAI CP2-3

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	591	66.3
C	—	
D	300	33.7
Total	891	100

Curve Number Estimate

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—			
B	66.3	79	5237.7	
C	—			
D	33.7	89	2999.3	
Total	100		8237.0	82.4

BY JDF DATE 11/21/87 CHECKED BY ____ COPY TO EO ____

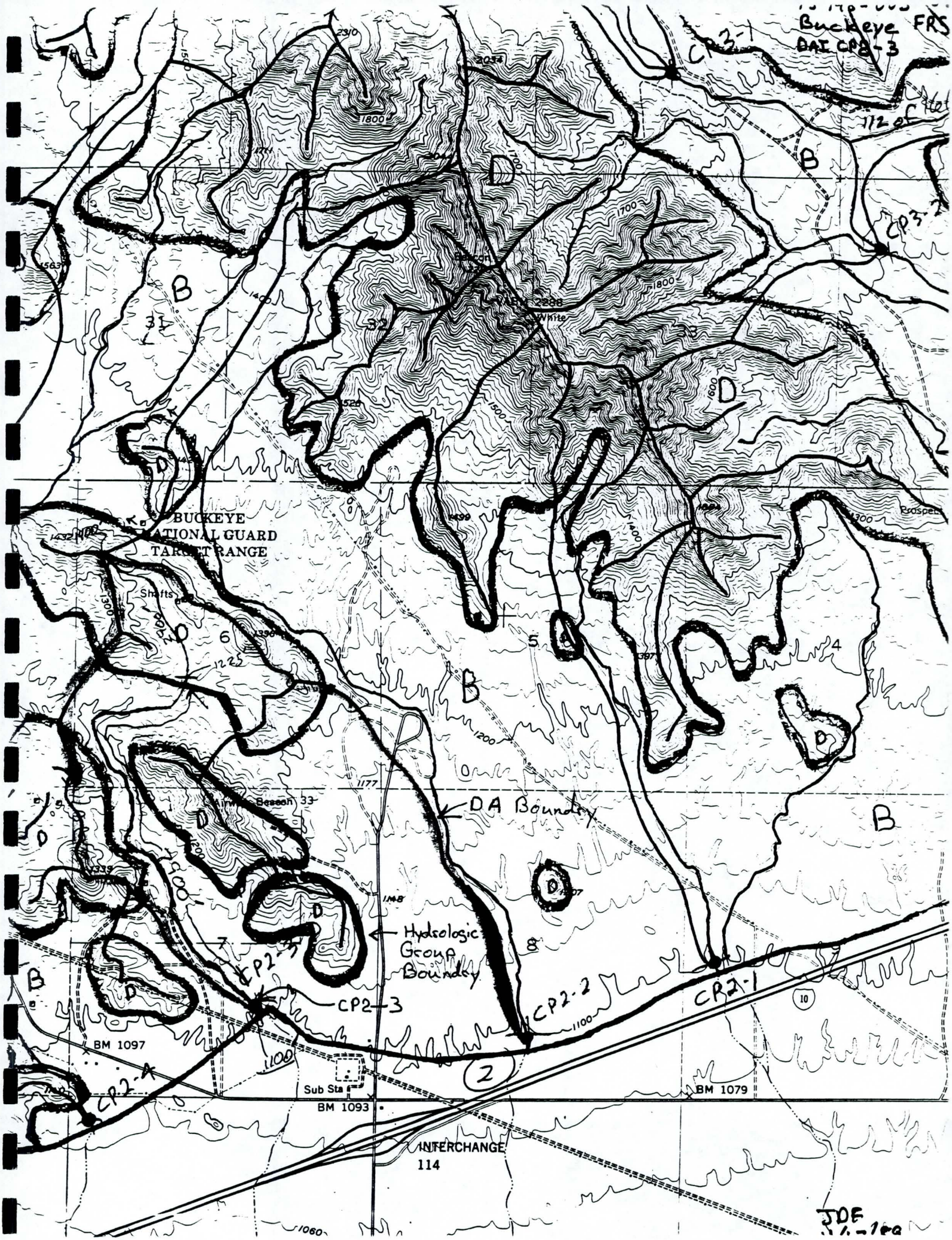
CN Selected [REF 1. for AMC I + III]

AMC I 66

AMC II 82

AMC III 92

Dames & Moore


Buckeye FRS
DAI CP3-3
CP3-1
CP3-2
1/2 of
B
D
BUCKEYE
NATIONAL GUARD
TARGET RANGE
Shafts
Beacon 33
DA Boundry
Hydrologic
Group
Boundry
CP2-1
CP2-3
CP2-2
CP2-A
BM 1097
Sub Sta
BM 1093
BM 1079
INTERCHANGE
114
JDF

FRS 2
CP2-3

DA = 891 acres < 2000 acres

Tc Evaluation

Method 1.

$L = 2900 + 7900 = 10,800' = 2.045$

$H = 1400 - 1100 = 300'$

$$T_c = \left[\frac{11.9\,(2.045)^3}{300}\right]^{0.385} = 0.660$$

$T_c = 0.66$

Method 2.

Sec No	Description	L ft	El_1 ft	El_2 ft	$S = \frac{El_1 - El_2}{L}$ ft/ft	V Fig 15.2 fps	$T_t = \frac{L}{3600\,V}$ hrs
1	Sm. Gulley	2900	1400	1225	0.060	5.0	0.161
2	Sm. Gulley	7900	1225	1100	0.016	2.5	0.878

$\Sigma T_t = 1.039$

$T_c = 1.04$ hrs ✓

BY TDF DATE 11/2/89
CHECKED BY
COPY TO EO

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Method 3.

$L = 10{,}800$

$CN' = 86$

$\bar{S} = 3\%$

$Lag = 0.85$ hrs

$$T_c = \frac{0.85}{0.6} = 1.417 \text{ hrs}$$

$$\underline{\underline{T_c = 1.42 \text{ hrs}}}$$

Method 4

$R = 1$

Sec No	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$	T_t $\frac{L}{3600 V}$
1	0.060	2900	0.040	9.124	0.088
2	0.016	7900	0.040	4.712	0.466

$\underline{\Sigma T_t = 0.554}$ ✓

$$\underline{\underline{T_c = 0.55 \text{ hrs}}}$$

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDE DATE 11/21/89 CHECKED BY ____ COPY TO EO ____

HEC-1 Input Parameters

FRS #3

DAI CP3-1

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	233	25.6
C	—	
D	678	74.4
Total	911	100

Curve Number Estimate

AMC II

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—	—		
B	25.6	79	2022.4	
C	—	—		
D	74.4	89	6621.6	
Total	100		8644.0	86.4

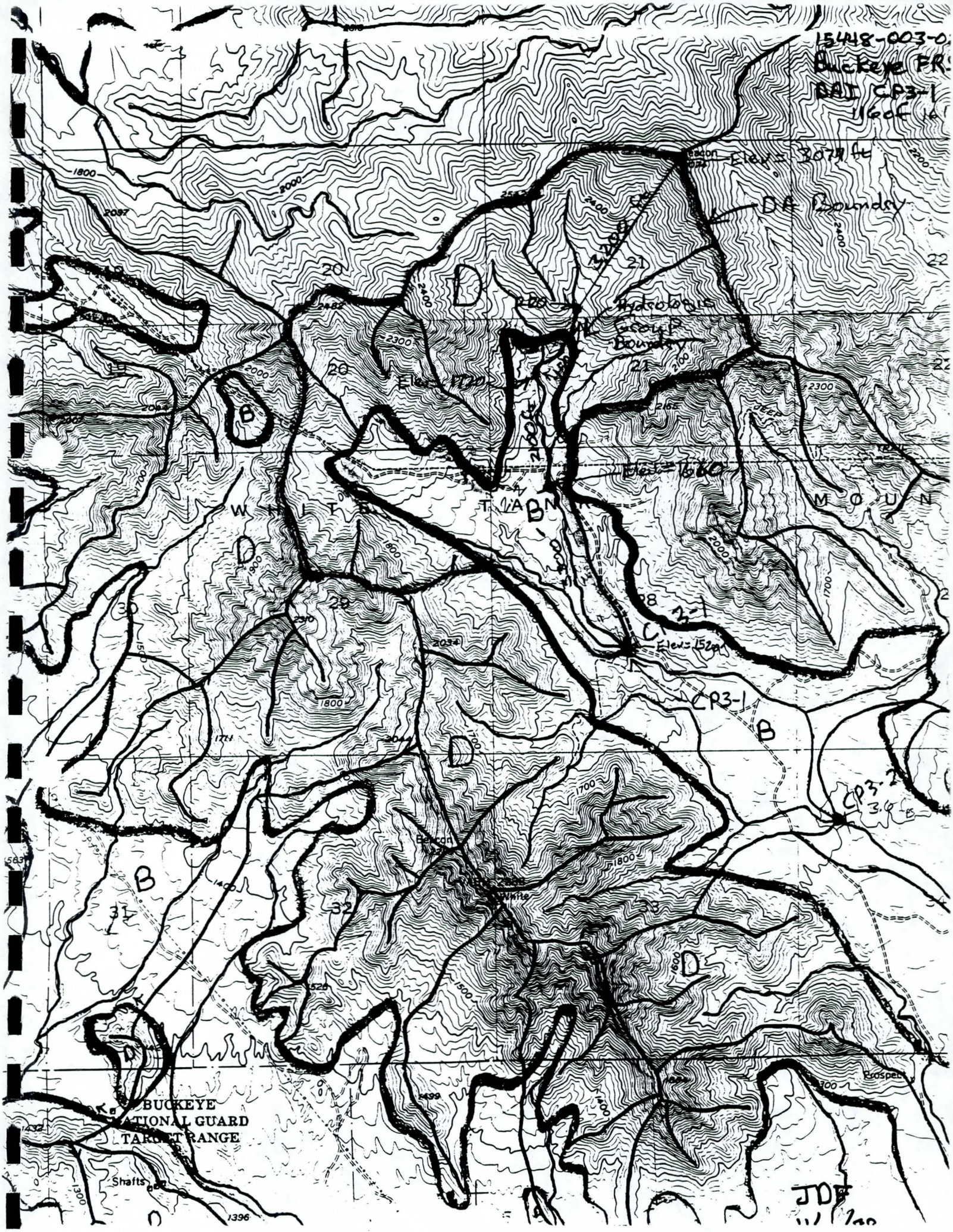
CN Selected [REF 1. for AMC I + III]

AMC I 72

AMC II 86

AMC III 94

REVIEWED BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____
BY DDF DATE 11/21/89
CHECKED BY ____
COPY TO EO ____


15448-003-0
Buckeye FR
BAI CP3-1
Elev = 3077 ft
DA Boundary
Hydrologic Boundary
Elev = 1720
Elev = 1680
Elev = 1520
CP3-1
CP3-2
3.6
WHITE
MOUN
BUCKEYE
NATIONAL GUARD
TARGET RANGE
Shafts
Prospect
JDF

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

FRS: #3

DAI: CP3-1

T_c Evaluation:

Method 1.

From DA Map.

$L = 3200 + 1500 + 2100 + 3300 = 10{,}100' = 1.91$

$H = 3074 - 1520 = 1554'$

$$T_c = \left[\frac{11.9(1.91)^3}{1554}\right]^{0.385} = 0.32 \checkmark$$

$$\underline{\underline{T_c = 0.32 \text{ hrs}}}$$

Method 2.

Sec #	Description	L ft	Elv$_1$ ft	Elv$_2$ ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	Velocity Fig 15.2 fps	T_t $\frac{L}{3600V}$ hrs
1	Overland Flow Nearly Bare	3200	3074	2120	0.298	5.5	0.16
2	Small Gulley	1500	2120	1720	0.267	11	0.04
3	Small Gulley	2100	1720	1660	0.029	3.4	0.17
4	Small Gully	3300	1660	1520	0.042	4.1	0.22

$\Sigma T_t = 0.59 \checkmark$

$$\underline{\underline{T_c = 0.59}} \checkmark$$

BY SDF DATE 11/21/89
CHECKED BY ____
COPY TO EO ____

045-1 (12/88) PRINTED IN U.S.A.

T_c Evaluation Contd.:

Method 3:

Average Slope = 12%
Hydraulic Length = 10100 ft
CN' = 90

From Fig 15.3

Lag = 0.31 hrs

$T_c = \frac{0.31 \text{ hrs}}{0.6} = 0.52 \text{ hrs}$ ✓

$T_c = 0.52$ hrs

Method 4:

Sec #	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{V\,3600}$ hrs
1	0.298	3200	0.040	20.335	0.044
2	0.267	1500	0.040	19.248	0.022
3	0.029	2100	0.040	6.343	0.092
4	0.042	3300	0.040	7.634	0.120

$\sum T_t = 0.278$ hrs ✓

$T_c = 0.28$ hrs ✓

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/21/88
CHECKED BY
COPY TO EO

HEC-1 Input Parameters

FRS #3

DAI CP3-2

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	347	22.8
C	—	
D	1174	77.2
Total	1521	100

Curve Number Estimate
AMC II

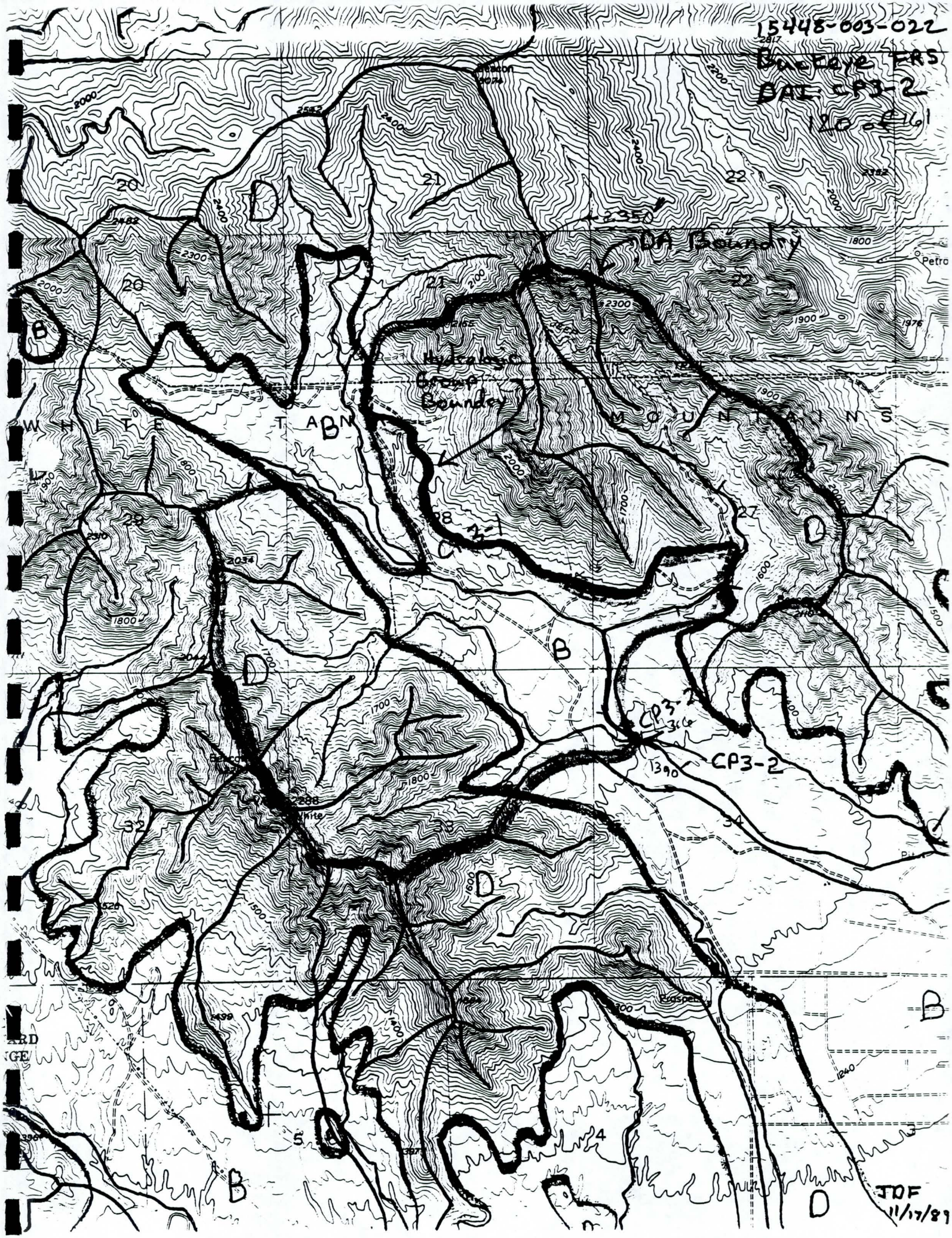
Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—	—		
B	22.8	79	1801.2	
C	—	—		
D	77.2	89	6870.8	
Total	100		8672.0	86.7

CN Selected [REF 1. for AMC I + III]

AMC I 73
AMC II 87
AMC III 95

BY JDF DATE 11/21/88
CHECKED BY
COPY TO EO

REVISIONS BY DATE TO EO
BY DATE TO EO


15448-003-022
Bo-Eye ERS
DAI CP3-2
120 ac
DA Boundary
Hydrology Group Boundary
WHITE MOUNTAINS
CP3-1
CP3-2
CP3-2
JDF
11/17/89

FRS #3

DAI CP3-2

Time of Concentration Evaluation

DA = 1521 acres < 2000 acres

Method 1:

$L = 11500 \text{ ft} = 2.18 \text{ mi}$

$H = 2350 - 1390 = 960'$

$$T_c = \left[\frac{11.9\,(2.18)^3}{960}\right]^{0.385} = 0.45 \text{ hrs}$$

$T_c = 0.45$ hrs

Method 2:

Sec #	Discription	L ft	Elv₁ ft	Elv₂ ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	Velocity Fig 15.2 fps	T_t $\frac{L}{3600V}$ hrs
1	Small gulley	5350	2350	1600	0.140	7.5	0.20
2	Small gulley	1850	1600	1490	0.059	4.8	0.11
3	Small gulley	4300	1490	1390	0.023	3.1	0.38

$\Sigma T_t = 0.69$

$T_c = 0.69$ hrs

BY JDF DATE 11/21/89
CHECKED BY
COPY TO EO

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

045-1 (12/88) PRINTED IN U.S.A.

Method 3:

$L = 11500$ ft

$CN' = 91$

$S_{avg} = 14\%$

From Fig 15.3 $L_{ag} = 0.26$ hrs

$$T_c = \frac{L}{0.6} = 0.43 \text{ hrs.}$$

Method 4:

Sec #	S ft/ft	L ft	n	V fps $\frac{1.49}{n} S^{1/2}$	T_t hrs $\frac{L}{3600V}$
1	0.140	5350	0.040	13.938	0.107
2	0.059	1850	0.040	9.048	0.057
3	0.023	4300	0.040	5.649	0.211

$\Sigma T_t = 0.375$ hrs ✓

$$T_c = 0.38 \text{ hrs.}$$

BY JDF DATE 11/21/89
CHECKED BY
COPY TO EO

REVISIONS
BY DATE TO EO
BY DATE TO EO

HEC-1 Input Parameters

FRS #3

DAI CP3-3

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	
B	877	52.4
C	—	
D	796	47.6
Total	1673	100

Curve Number Estimate

AMC II

Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—	—		
B	52.4	79	4139.6	
C	—	—		
D	47.6	89	4236.4	
Total	100		8376.0	83.8

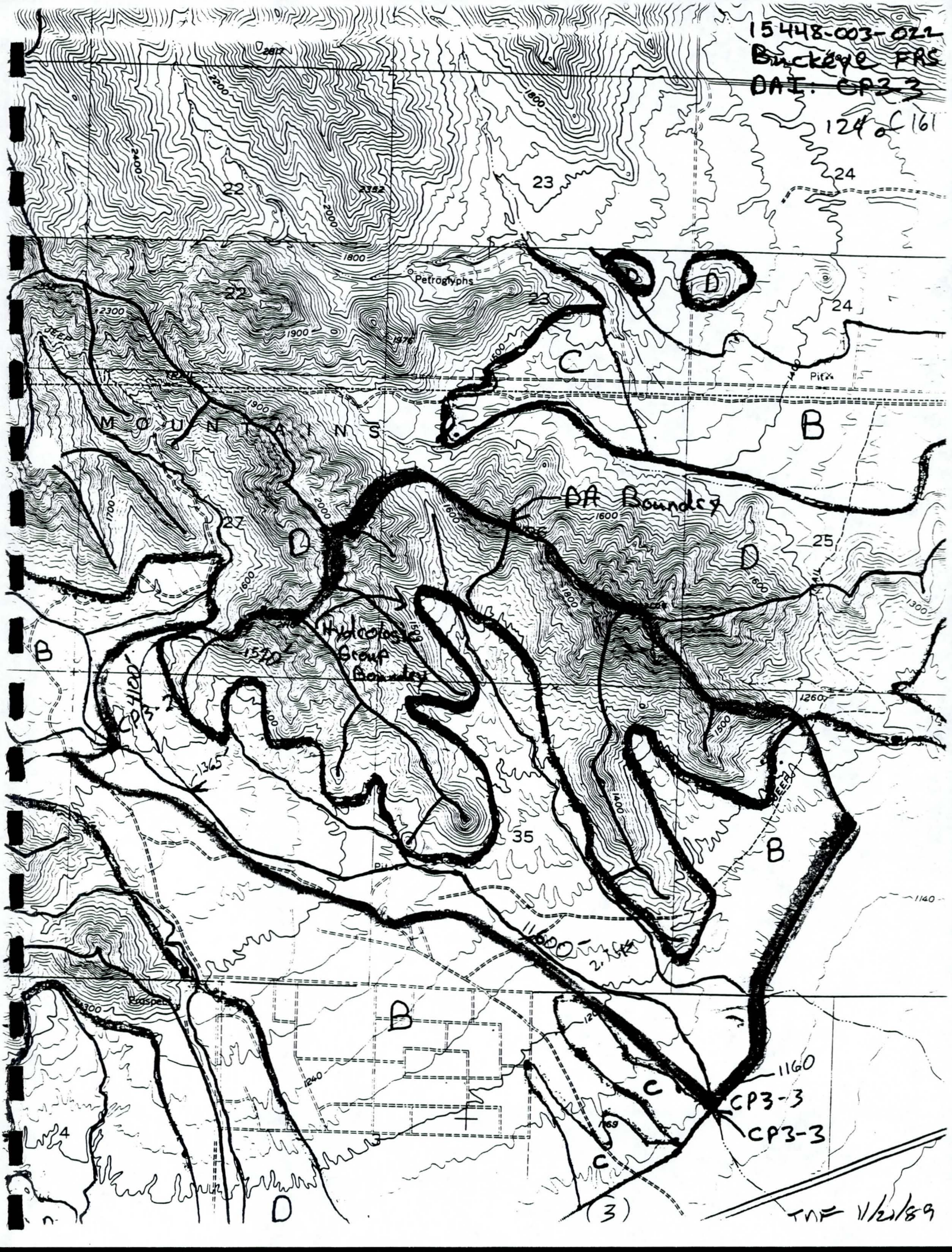
CN Selected [REF 1. for AMC I + III]

AMC I 68

AMC II 84

AMC III 92

REVIEWS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____
BY JDF DATE 11/21/88
CHECKED BY ____
COPY TO EO ____


15448-003-022
Buckeye FRS
DAI: CP3-3
124 of 161
Petroglyphs
MOUNTAINS
DA Boundary
Hydrologic Group Boundary
CP3-3
CP3-3
(3)
TNF 11/21/89

FRS #3
CP3-3
Tc Evaluation
DA = 1673 acres < 2000 acres ✓

Method 1.

$L = 11,600 + 4100 = 15,700' = 2.97$ miles

$H = 1520 - 1160 = 360'$

$$T_c = \left[\frac{11.9\,(2.97)^3}{360}\right]^{0.385} = 0.946 \text{ hrs} \checkmark$$

$$\underline{\underline{T_c = 0.95 \text{ hrs}}}$$

Method 2:

Sec No	Description	L ft	Elv_1 ft	Elv_2 ft	S $\frac{Elv_1 - Elv_2}{L}$ ft/ft	V Fig 15.2 fps	T_t $\frac{L}{3600\,V}$ hrs
1	Overland, Pasc	4000	1520	1365	0.039	2.0	0.55
2	Small Gulley	11,600	1365	1160	0.018	2.7	1.19

$\Sigma T_t = 1.75$ hrs

$$\underline{\underline{T_c = 1.75 \text{ hrs}}} \checkmark$$

BY JDF DATE 11/21/88
CHECKED BY
COPY TO EO

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

945 1 (12/88) PRINTED IN U.S.A.

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Method 3.

$L = 15{,}700'$

$CN' = 87$

$\bar{S} = 18\%$

$Lag = 0.37$ hrs

$$T_c = \frac{0.37}{0.6} = 0.617 \text{ hrs}$$

$$\underline{\underline{T_c = 0.62 \text{ hrs}}} \quad \checkmark$$

Method 4

Sec #	S ft/ft	L ft	n	V $\frac{1.49}{n} S^{1/2}$ fps	T_t $\frac{L}{3600V}$ hrs
1	0.039	4000	0.040	7.356	0.151
2	0.018	11600	0.040	4.998	0.645

$\sum T_t = 0.796$ hrs

$$\underline{\underline{T_c = 0.80 \text{ hrs}}} \quad \checkmark$$

BY TDF DATE 11/21/89
CHECKED BY ____
COPY TO EO ____

945-1 (12/88) PRINTED IN U.S.A.

HEC-1 Input Parameters

FRS # 3

DAI CP3-4

Area Analysis

Hydrologic Group	Area acres	% of Total Area
A	—	—
B	924	63.0 ✓
C	92	6.3 ✓
D	451	30.7 ✓
Total	1467	100

Curve Number Estimate
AMC II

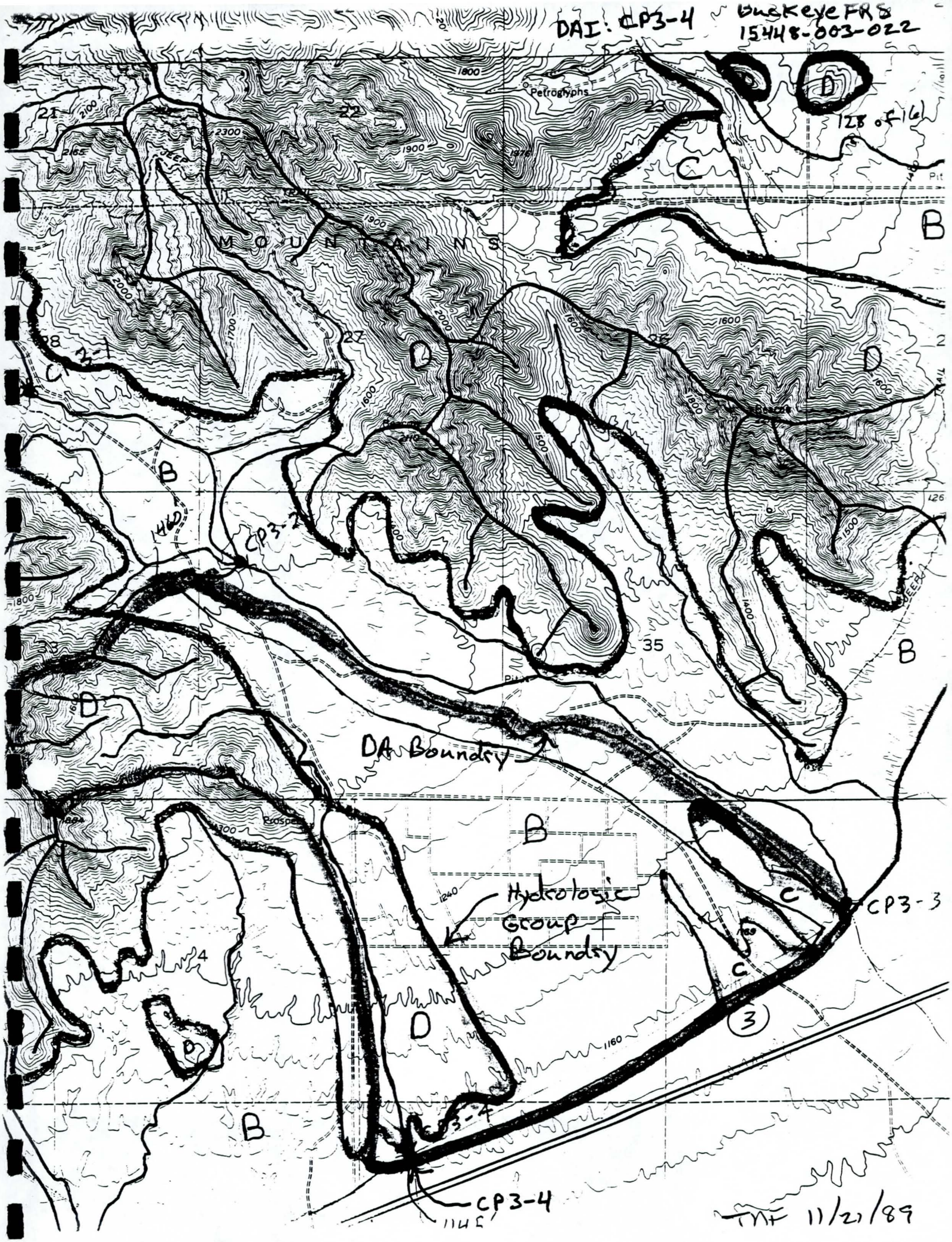
Hydrologic Group	% Total Area	CN [REF. 1]	CN x %	Weighted $CN = \frac{\Sigma CN \times \%}{100}$
A	—	—		
B	63.0	79	4977.0	
C	6.3	86	541.8	
D	30.7	89	2732.3	
Total	100		8251.1	82.5 ✓

CN Selected [REF 1. for AMC I + III]

AMC I 67
AMC II 83 ✓
AMC III 93

BY JDF DATE 11/21/89
CHECKED BY
COPY TO EO

REVIEWS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____


DAI: CP3-4
Buckeye FRS
15448-003-022
128 of 161
Petroglyphs
MOUNTAINS
CP3-1
CP3-2
CP3-3
CP3-4
DA Boundry
Hydrologic Group + Boundry
TMF 11/21/89

FRS #3
CP3-4

Tc Evaluation
DA = 1467 < 2000 acres
Method 1:

$$L = 22,100 = 4.19$$

$$H = 1460 - 1145 = 315'$$

$$T_c = \left[\frac{11.9\,(4.19)^3}{315}\right]^{0.385} = 1.48$$

$$T_c = 1.48 \text{ hrs}$$

Method 2:

Sec #	Discription	L ft	El_1 ft	El_2 ft	S $\frac{El_1 - El_2}{L}$ ft/ft	V Fig 15.2 fps	T_t $\frac{L}{3600V}$ hrs
1	Small Gulleys	22100	1460	1145	0.014	2.4	2.56 hrs

$$T_c = 2.56 \text{ hrs}$$

VISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 11/21/89
CHECKED BY ____
COPY TO EO ____

Method 3:

L = 22,100

CN' =

$\bar{S}$ = 13.9%

Lag = 0.56 hrs

$T_c = \frac{0.56}{0.6} = 0.933$ hrs

$T_c = 0.93$ hrs ✓

Method 4:

Sec #	S	L	n	V $\frac{1.49}{n} S^{1/2}$ cps	T_t $\frac{L}{3600 V}$ hrs
1	0.014	22,100	0.040	4.407	1.393 hrs

$T_c = 1.39$ hrs ✓

VISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 1/12/89
CHECKED BY BJB
COPY TO EO

045-1 (12/88) PRINTED IN U.S.A.

CALCULATIONS COVER SHEET
DAMES & MOORE
DESIGN SERVICES GROUP

PROJECT NUMBER [illegible]
SUBJECT Buckeye FRS
SHEET 131 OF 161

Confining Capacity Data
TITLE OF CALCULATIONS

Buckeye FRS
TITLE OF PROJECT

CALCULATIONS BY: John Fannin
PRINT NAME
John Fannin 12/07/89
SIGNATURE DATE

ASSUMPTIONS CHECKED BY CONSULTANT: George J Geiser
PRINT NAME
G J Geiser 12/19/89
SIGNATURE DATE

CALCULATIONS CHECKED BY: Richard Allen
PRINT NAME
Richard Allen 12/20/89
SIGNATURE DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT OR PM) George J Geiser
PRINT NAME
G J Geiser 12/19/89
SIGNATURE DATE

APPROVAL NOTES:
IF CALCULATIONS ARE ONLY SPOT CHECKED, DO NOT REQUIRE CHECKING OR ARE ASSUMED TO BE CORRECT BY EXPERIENCE OR ENGINEERING JUDGEMENT, IT SHOULD BE NOTED HERE.

REVISION NUMBER	DATE	BY	CHECKED BY (INITIALS)	APPROVAL
1				
2				
3				
4				

BY [illegible] DATE 12/[illegible]/89
CHECKED BY RHA 12/20/89
ORIGINAL TO PROJECT FILE

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

Capacity Chart Check

Purpose: Check Capacity Charts for accuracy for FRS #1, #2, + #3

References:

1. Soil Conservation Service; (1972); "Buckeye Floodwater Retarding Structures 2+3, Buckeye W.P.P., Maricopa County, Arizona"; Drawing No 7-E-23079; U.S. Department of Agriculture.

2. Soil Conservation Service; (1971); "Buckeye Watershed Protection and Flood Prevention Project, Maricopa County, Arizona, Plans for The Construction of Site I Diversion Structure"; Drawing No. 7-E-22084; U.S. Department of Agriculture.

Method

1. Measure Area @ a given Elevation using a planimeter. (Plan views Ref 1+2).

2. Estimate Storage Volume

$$S.V. = \sum \frac{Area_1 + Area_2}{2} \times \Delta Elevation,$$

3. Plot + Compare Values with those shown on the Capacity Charts for each structure.

BY TDF DATE 12/15/89
CHECKED BY _____
COPY TO EO _____

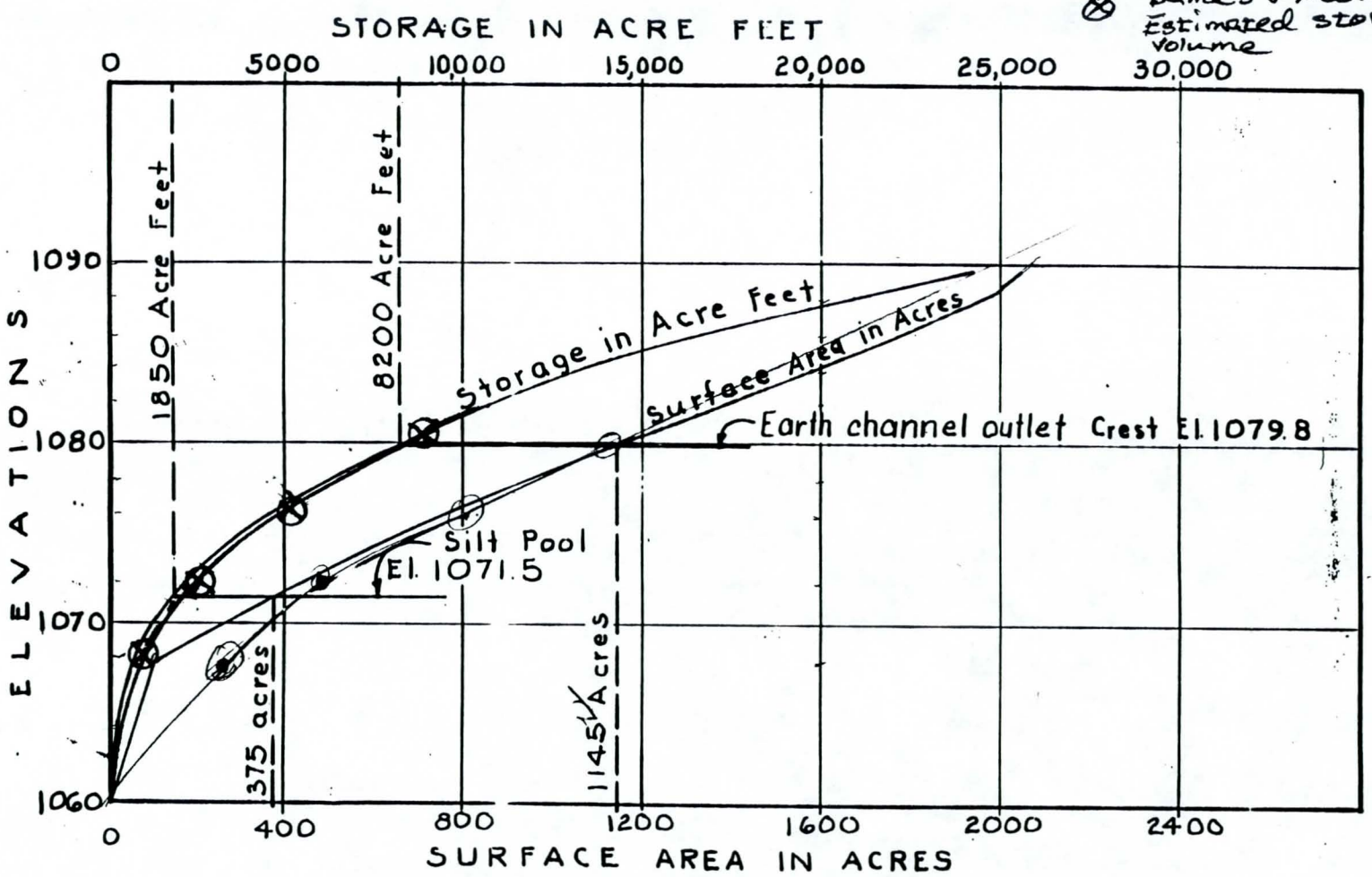
Results:

Estimated Areas and Storage Volume vs. Elevation relationships developed by Dames + Moore compared favorably with the original relationships shown on the Capacity Charts for each structure.

The original rating curves will be used to obtain storage volume vs. elevation data for HEC-1 input.

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____
BY JDF DATE 12/15/89
CHECKED BY BOS
COPY TO EO ____

JDF 12/13/89
checked by RHA 12/20/89



FRS #1

Elevation - Storage - Area Relationships

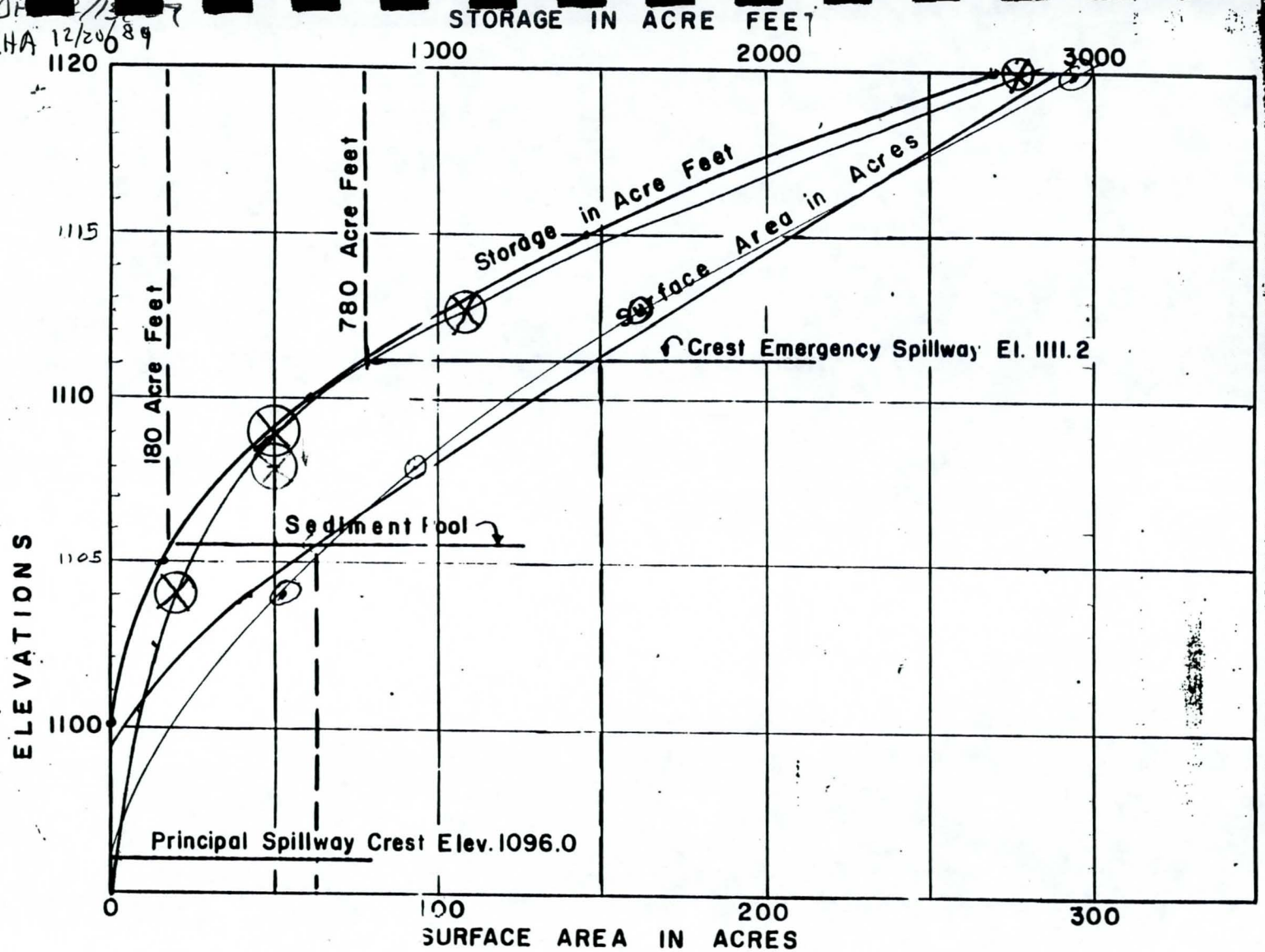
Source: Capacity Charts shown on Plans

	Elevation ft	Storage Volume Ac-ft	Surface Area Ac.
	1060	0	0
	1064	200	50
	1068	750	120
	1072	2000	430
	1076	4500	760
	1078	6300	950
Emergency Spillway Crest Elevation	1079.8	8200	1145
	1082	10400	1390
	1084	13200	1580
	1086	16600	1760
Crest of Dam Sta 876+00 to 931+80	1088	20300	1950
Extrapolated	1090	25000	2060

EVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 12/19/89
CHECKED BY RHA 12/20/89
COPY TO EO ____

Checked by RHA 12/20/89



CAPACITY CHART
FRS #2

⊙ Dames + Moore Estimated Area

⊗ Dames + Moore Estimated storage volume.

B STATION DISTURBED

13+04.58

P.T. Sta. 314+99.20

POWER POLES

PWD BASIN SEE DETAILS SHEET 44

FLOODWAY NO. 2

Page 135 of 161

15448-003-027
Buckeye FAS

FRS #2

Elevation - Storage - Area Relationships

Source: Capacity Chart shown on Plans

	Elevation ft	Storage Volume Ac-ft	Surface Area Ac.
	1100	0	1
	1102	38	21
	1104	113	42
	1106	225	69
	1108	375	98
	1110	625	130
Emergency Spillway Crest Elevation	1111.2	780	150
	1112	900	161
	1114	1250	193
	1116	1650	223
	1118	2125	254
	1120	2712	288
Dam Crest Elevation Sta 230+00 to 324+55	1117	1880	240

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

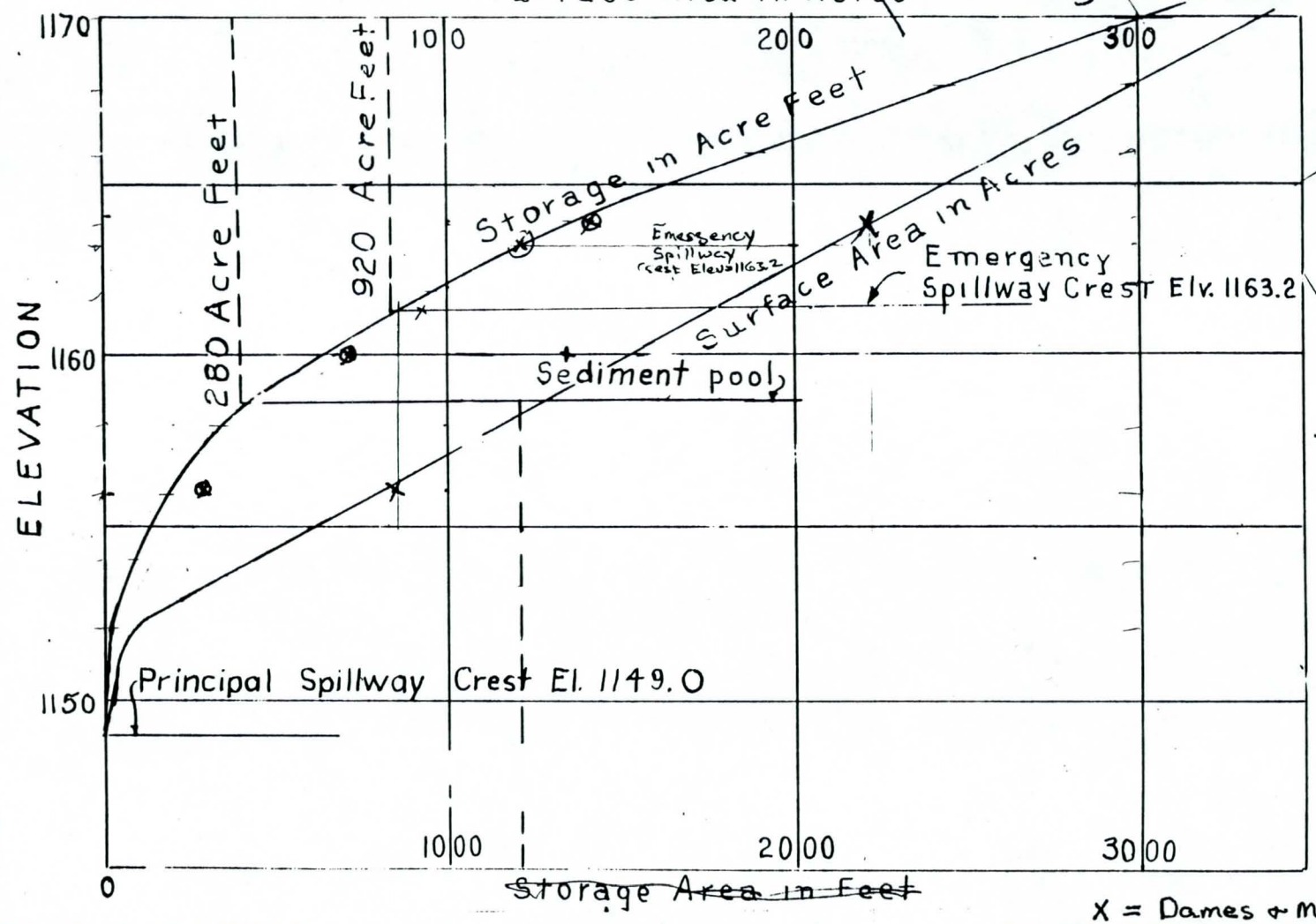
BY JDF DATE 12/19/89
CHECKED BY RHA 12/20/89
COPY TO EO ____

checked by RHA 12/20/89

JDF 12/15/89

15448-003-022
Buckeye FRS
11/30/89 JDF
Page 136 of 161

CAPACITY CHART From Sheet 3
Surface Area in Acres Drawing #7E-23079



Storm Volume In Acre Feet

X = Dames & Moore Area Estimate

⊗ = Dames & Moore Storage Volume Estimate

1180.0

STA. 26+70±
BEGIN DAM NO. 3

FRS #3

Elevation - Storage - Area Relationships

Source: Capacity Chart: shown on Plans

	Elevation ft	Storage Volume Ac-ft	Surface Area Ac.
	1149	0	0
	1150	2	2
	1152	20	9
	1154	90	43
	1156	190	78
	1158	350	115
	1160	630	153
	1162	910	190
Emergency Spillway Crest Elevation	1163.2	1220	210
	1164	1350	223
	1166	1900	264
	1168	2490	298
Crest of Dam	1170	3020	335
Extrapolated	1172	3600	372
	1174	4160	410

EVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 12/19/89
CHECKED BY RWA 12/20/89
COPY TO EO ____

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

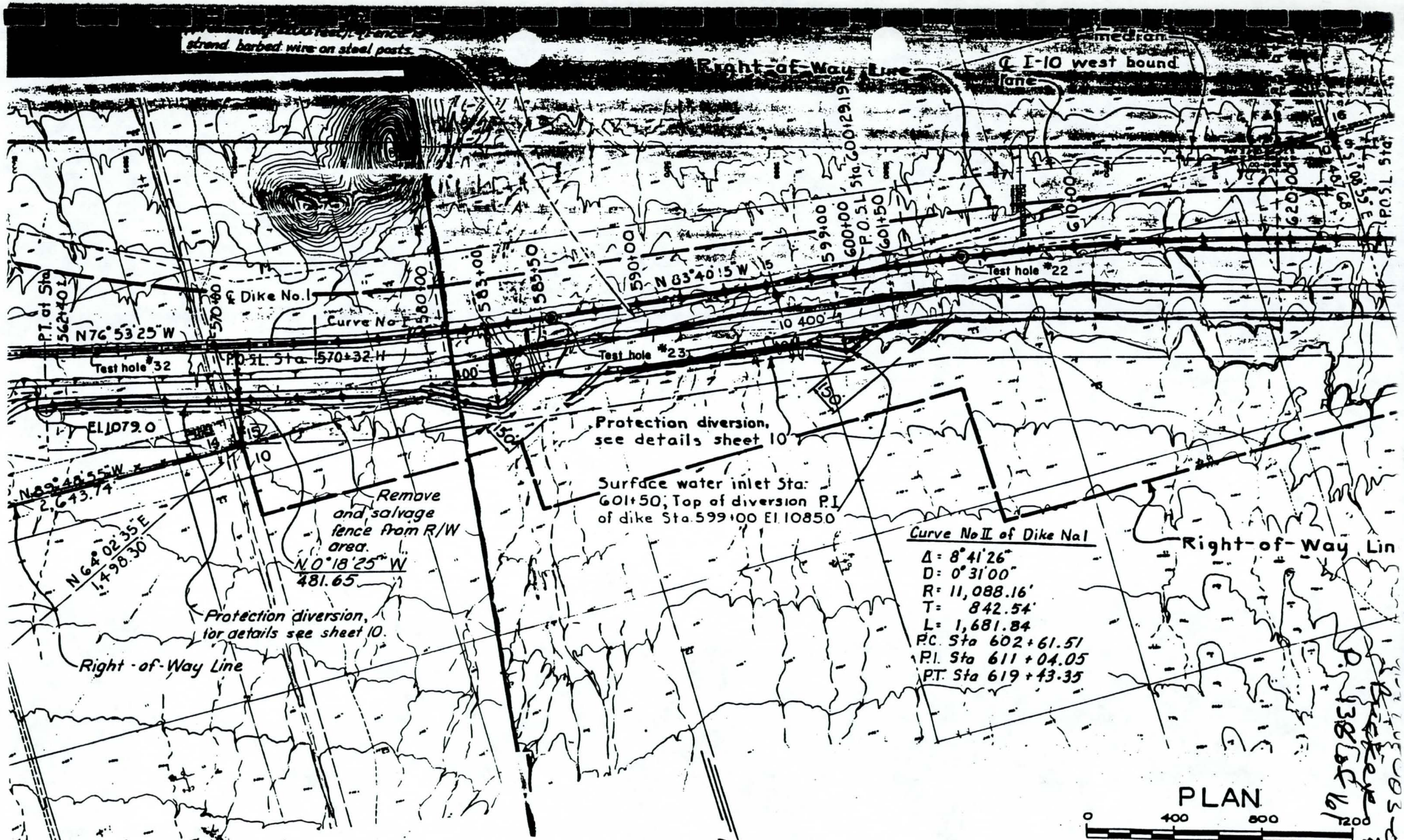
FRS #1, Drawing # 7E-22084
Planimeter Arm Length = 15.7 cm
Set Conversion TO 0.007

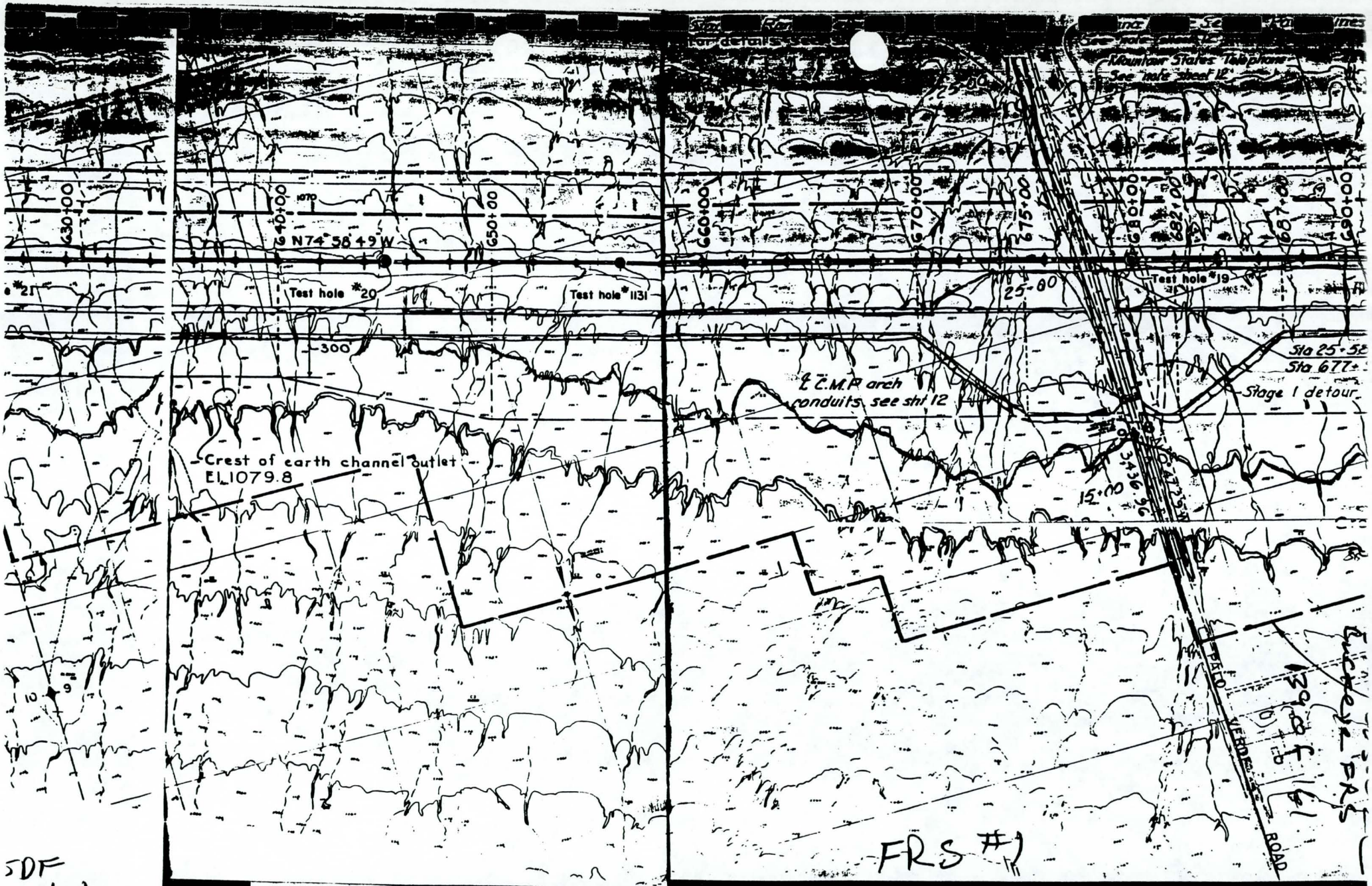
Measured Areas + Estimated Storage Volumes

Elevation ft	Surface Area Acres	Storage Volume = $\sum \frac{Area_1 + Area_2}{2} \times Elv.$ Ac-Ft.
1060.	0	0
1068	272	1088
1072	492	2616
1076	808	5216
1080	1138	9108

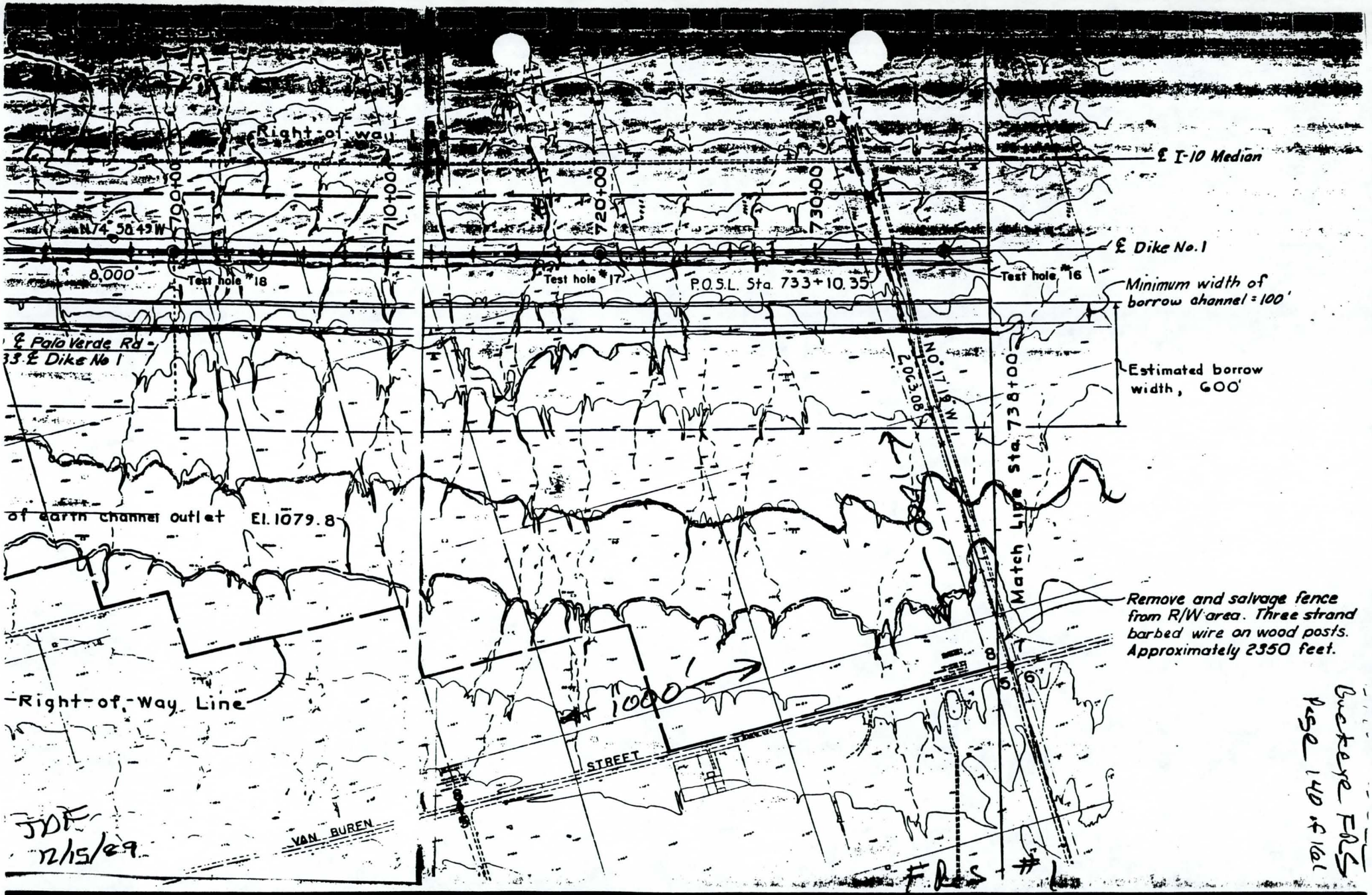
BY JDF DATE 12/13/87
CHECKED BY RHA 12/20/89
COPY TO EO ____

945 1 (12/88) PRINTED IN U.S.A.

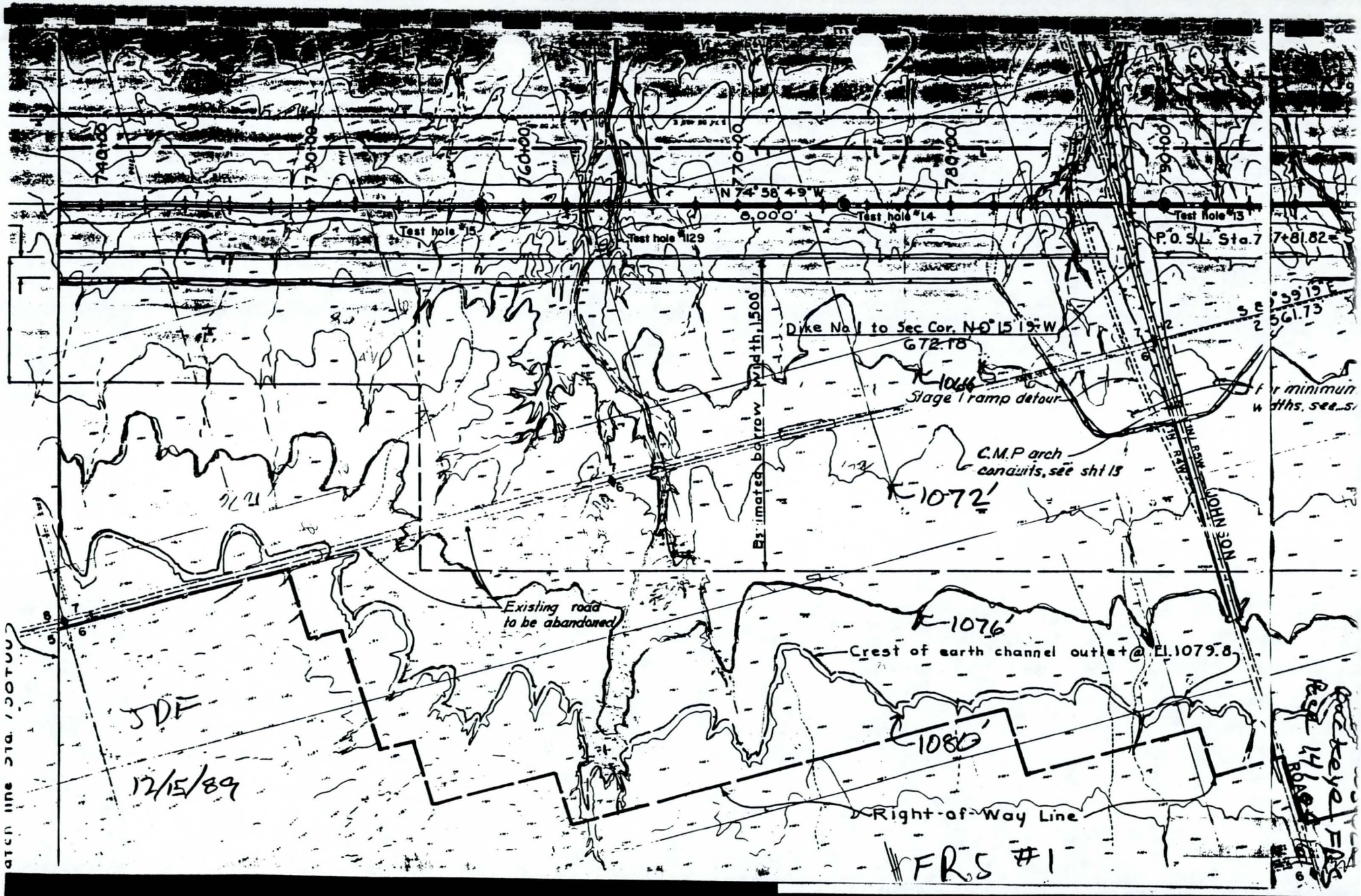

strand barbed wire on steel posts
Right-of-Way Line
median
℄ I-10 west bound lane
℄ Dike No. I
Curve No. I
P.T. of Sta. 562+40.1
N76°53'25"W
Test hole #32
P.O.S.L. Sta. 570+32.11
El. 1079.0
N89°48'55"W
2,643.74'
N64°02'35"E
1,498.30'
Remove and salvage fence from R/W area.
N0°18'25"W
481.65'
Protection diversion, for details see sheet 10.
Right-of-Way Line
N83°40'15"W
Test hole #23
Test hole #22
Protection diversion, see details sheet 10
Surface water inlet Sta. 601+50, Top of diversion P.I. of dike Sta. 599+00 El. 1085.0
Curve No. II of Dike No. I
Δ = 8°41'26"
D = 0°31'00"
R = 11,088.16'
T = 842.54'
L = 1,681.84
P.C. Sta 602+61.51
P.I. Sta 611+04.05
P.T. Sta 619+43.35
Right-of-Way Lin
PLAN
0 400 800 1200
Scale in feet
Borrow Channel Curve Data
Δ = 80° 00'
D = 20° 01' 35"
R = inside curve = 286.02'
T = " " = 240.00'
L = " " = 399.36'
Curve No. I of
Δ = 6° 4
D = 1° 0
R = 4.94
T = 292
L = 585
PT Sta 58
FRS #1

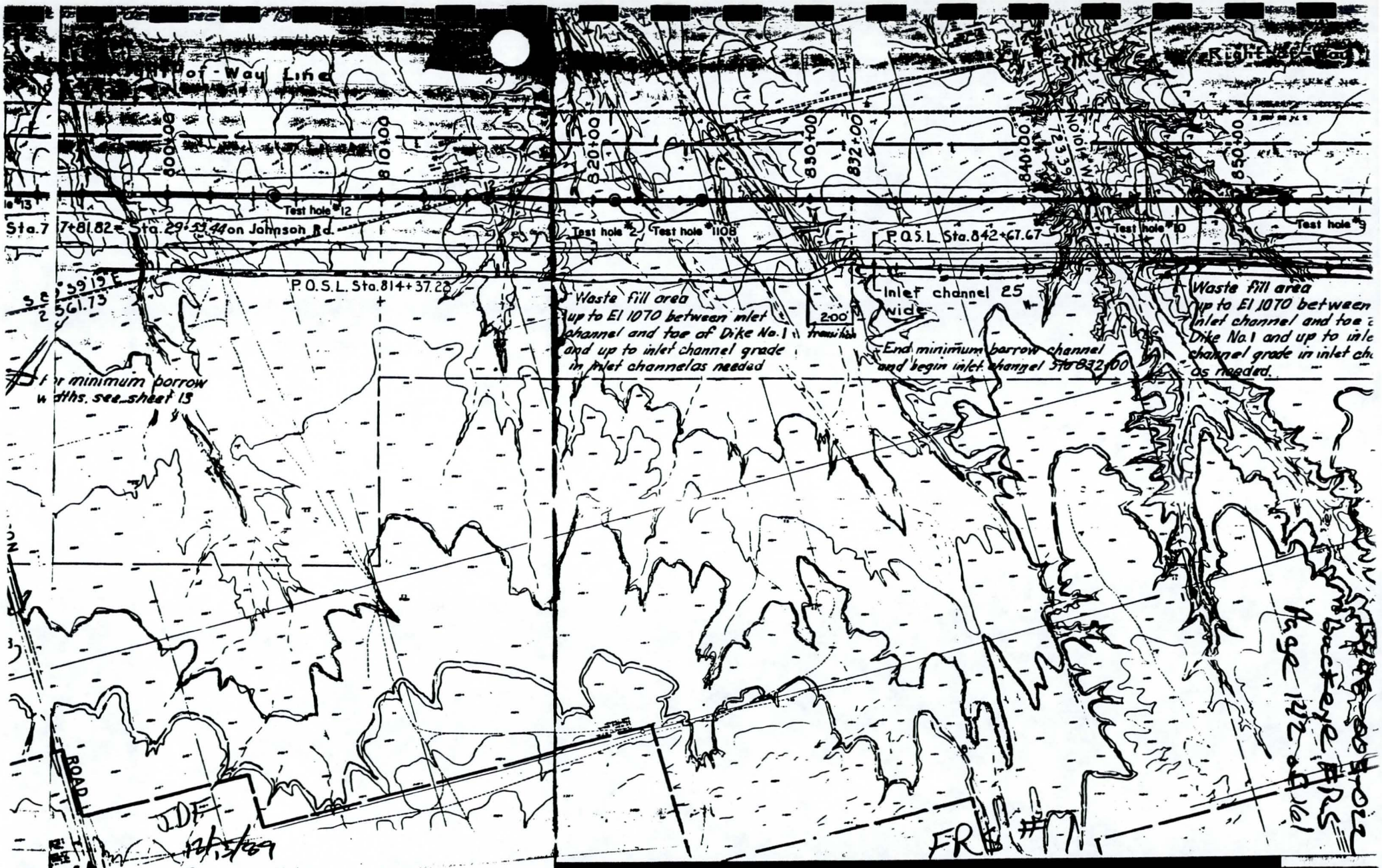

Mountain States Telephone
See note sheet 12
630+00
640+00
650+00
660+00
670+00
675+00
680+00
682+00
687+00
690+00
N74°58'49"W
Test hole #20
Test hole #1131
Test hole #19
25-00
300
℄ C.M.P. arch conduits, see sht 12
Stage I detour
Crest of earth channel outlet
El. 1079.8
15-00
34°36'56"
FIELD VERDE ROAD
FRS #1

SDF
12/15/89

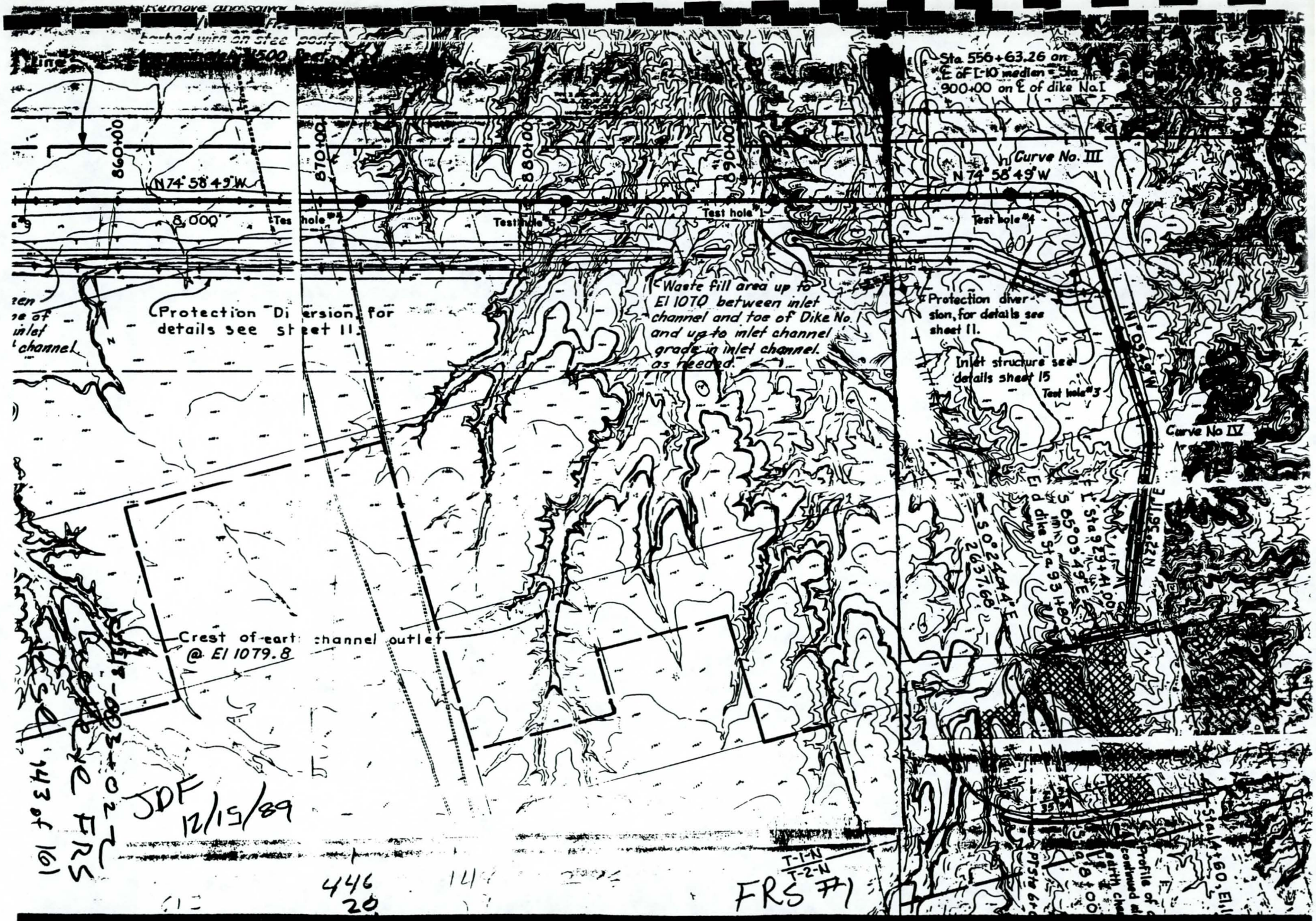


Buckeye FRS
Page 140 of 161


740+00
750+00
760+00
770+00
780+00
790+00
N 74° 58' 49" W
8,000'
Test hole #15
Test hole #129
Test hole #14
Test hole #13
P.O.S.L. Sta. 7+81.82
Dike No. 1 to Sec. Cor. N 0° 15' 19" W
672.18
Borrow Width 1,500'
1066
Stage 1 ramp detour
C.M.P. arch
conduits, see sht 13
1072'
JOHNSON
Existing road
to be abandoned
1076'
Crest of earth channel outlet @ El. 1079.8
JDF
12/15/89
1080'
Right-of-Way Line
FRS #1


of-Way Line
Right of Way
800+00
810+00
820+00
830+00
832+00
840+00
850+00
N 00°14' 39" W
Test hole #12
Test hole #2
Test hole #1108
Test hole #10
Test hole #9
Sta. 7+81.82 = Sta. 29+51.44 on Johnson Rd.
P.O.S.L. Sta. 842+67.67
P.O.S.L. Sta. 814+37.28
S 89°39'19" E
2561.73
Waste fill area up to El 1070 between inlet channel and toe of Dike No. 1 and up to inlet channel grade in inlet channel as needed
200'
Inlet channel 25 wide
End minimum borrow channel and begin inlet channel Sta 832+00
Waste fill area up to El 1070 between inlet channel and toe of Dike No. 1 and up to inlet channel grade in inlet channel as needed.
For minimum borrow widths, see sheet 13
ROAD
JDF
12/15/69
FR #1
Page 122 of 161
Bacteriae #PS

Notes :


Sta. 556+63.26 on ℄ of I-10 median = Sta. 900+00 on ℄ of dike No. I
Curve No. III
N 74° 58' 49" W
860+00
870+00
880+00
890+00
N 74° 58' 49" W
8,000'
Test hole #2
Test hole #5
Test hole #1
Test hole #4
Test hole #3
Protection Diversion for details see sheet 11.
Waste fill area up to El 1070 between inlet channel and toe of Dike No. I and up to inlet channel grade in inlet channel as needed.
Protection diversion, for details see sheet 11.
Inlet structure see details sheet 15
Curve No IV
Crest of earth channel outlet @ El 1079.8
S 0° 24' 44" E
263.68'
S 65° 03' 49" E
Sta 93+80
Sta 93+41.00
El 1095.22
T-1-N
T-2-N
FRS #1
JDF 12/15/89
446
20
14
Sta 4+60 El 1
Profile of earth channel
PT Sta 6+
Sta 8+00
Sta 8+00 El 1
FRS #1
143 of 161

FRS #2

Checking Capacity Chart

Drawing #7E-23079, Sheets 28 + 29 6/72

Planimeter Arm Length = 15.7 cm

Conversion Factor = 0.007

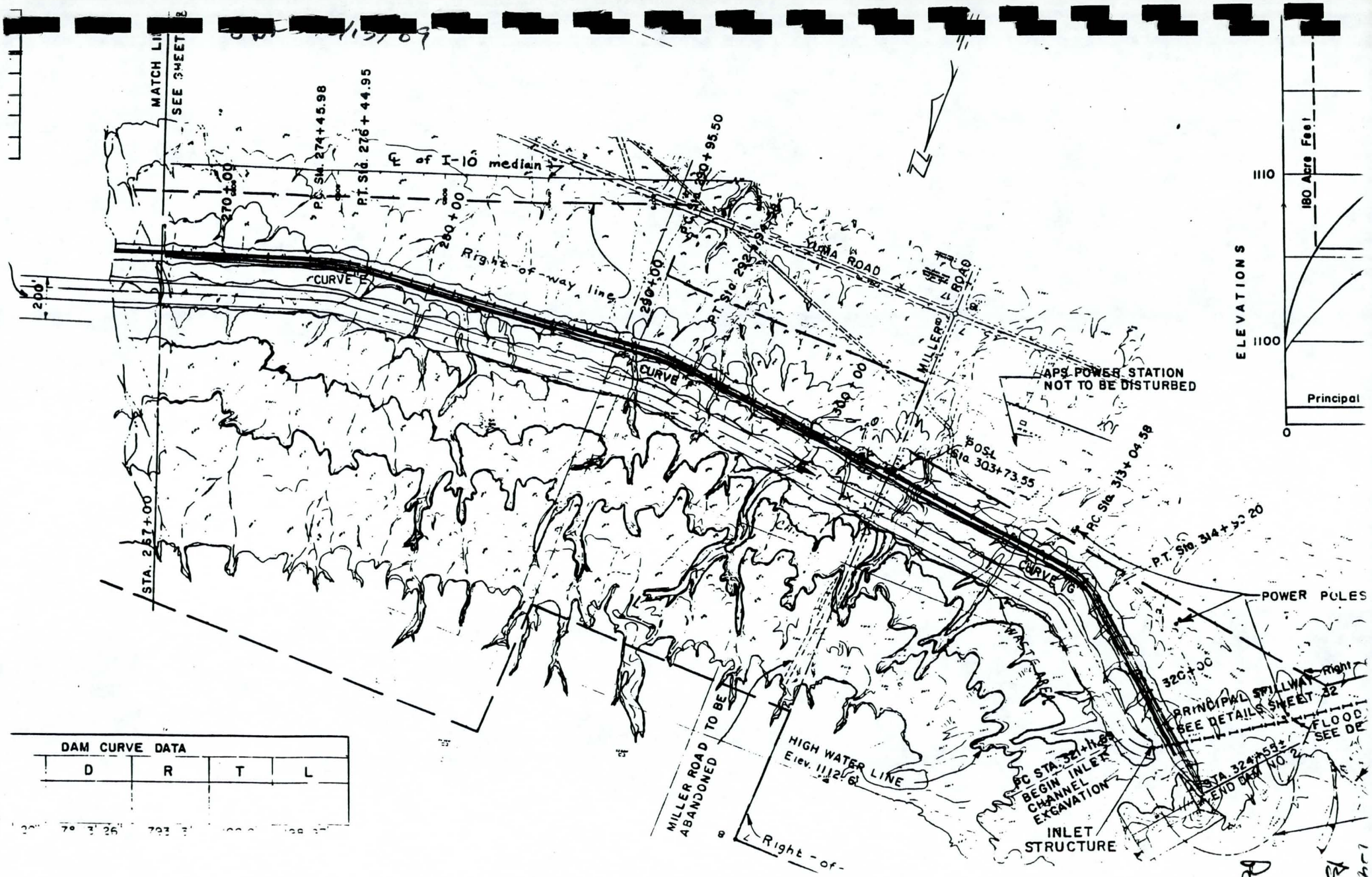
Measured Areas + Estimated Storage Volume

Elevation ft	Surface Area Acres	Storage Volume $= \sum \frac{Area_1 + Area_2}{2} \times \Delta Elv.$ Ac-ft
1096.0	0	0
1104	52	208
1108	94	500
1112.6	161	1086
1120	296	2777

BY JNF DATE 12/15/89
CHECKED BY RHA 12/20/89
COPY TO EO

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

945 1 (12/88) PRINTED IN U.S.A.



DAM CURVE DATA			
D	R	T	L

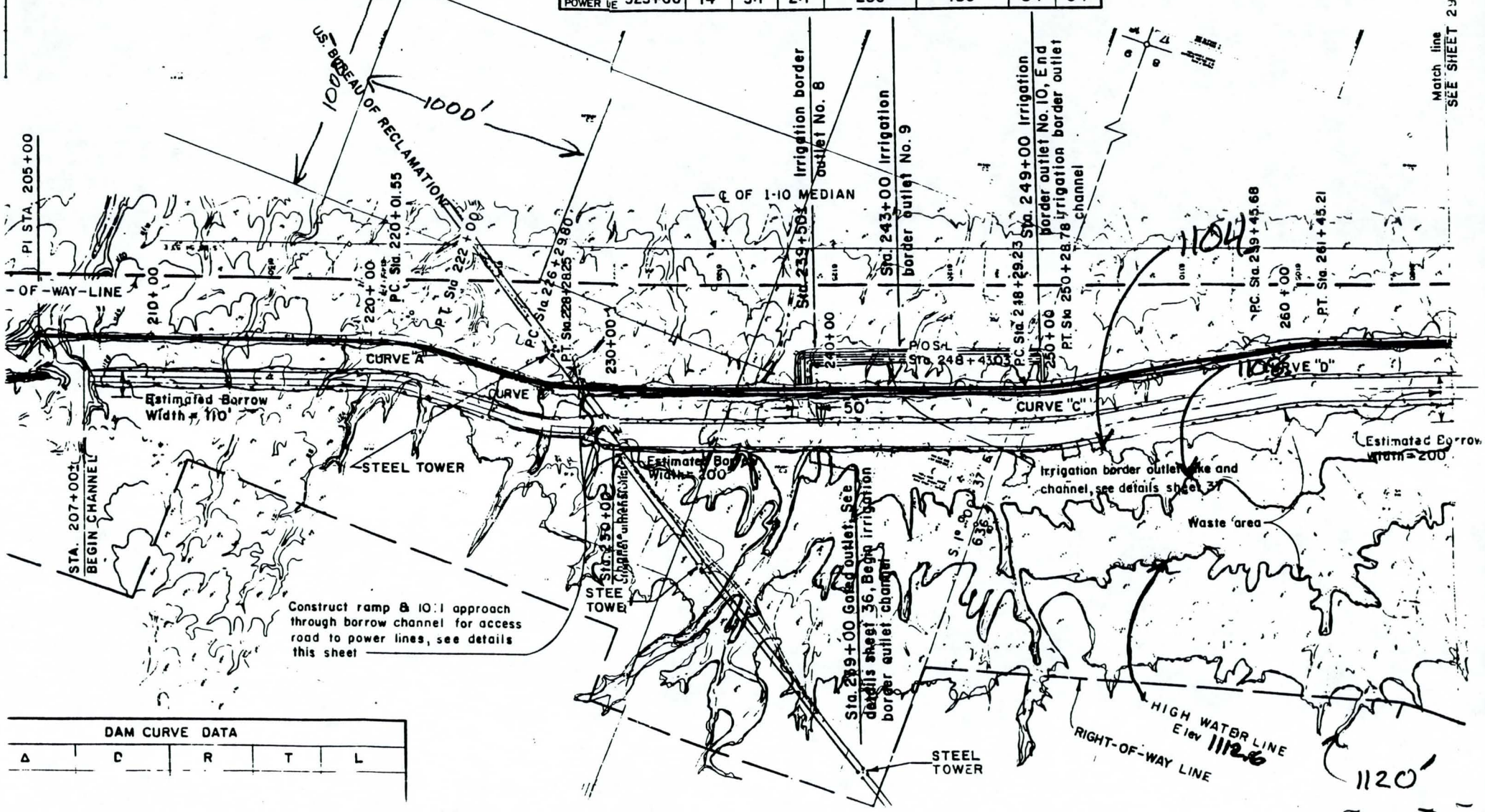
FRS #2
Plan View

Page 45 of 161

Buckeye FRS

JHP 12/3/69

STA.	STA.	TOP WIDTH	SIDESLOPES NORTH	SIDESLOPES SOUTH	℄ CHANNEL	TOP WIDTH	SIDESLOPES NORTH	SIDESLOPES SOUTH
207+0	RAMP ON POWER LINE	14'	3:1	2:1	175'	50'	3:1	3:1
TRANSIT	THRU RAMP	14'	3:1	2:1	VARIABLE	VARIABLE	VARIABLE	
RAMP OF POWER LINE	323+00	14'	3:1	2:1	200'	100'	3:1	3:1



DAM CURVE DATA				
Δ	D	R	T	L

FRS #2
Plan View

15H48-003-002
Buckeye FRS
Page 1 of 1

Checking Capacity Chart

FRS #3, Drawing #TE-23079, Sheet 3,4,+5; 6/72

Planimeter Arm Length = 15.7 cm.

Calibration:

Trial Area = 23.0 acres

	Reading units²	
Trial 1	3281	
Trial 2	3283	Avg = 3283 units²
Trial 3	3285	

Set Conversion Factor to: $\frac{23.0 \text{ ac}}{3283 \text{ units}^2} = 0.007$

Measured Areas + Estimated Storage Volume

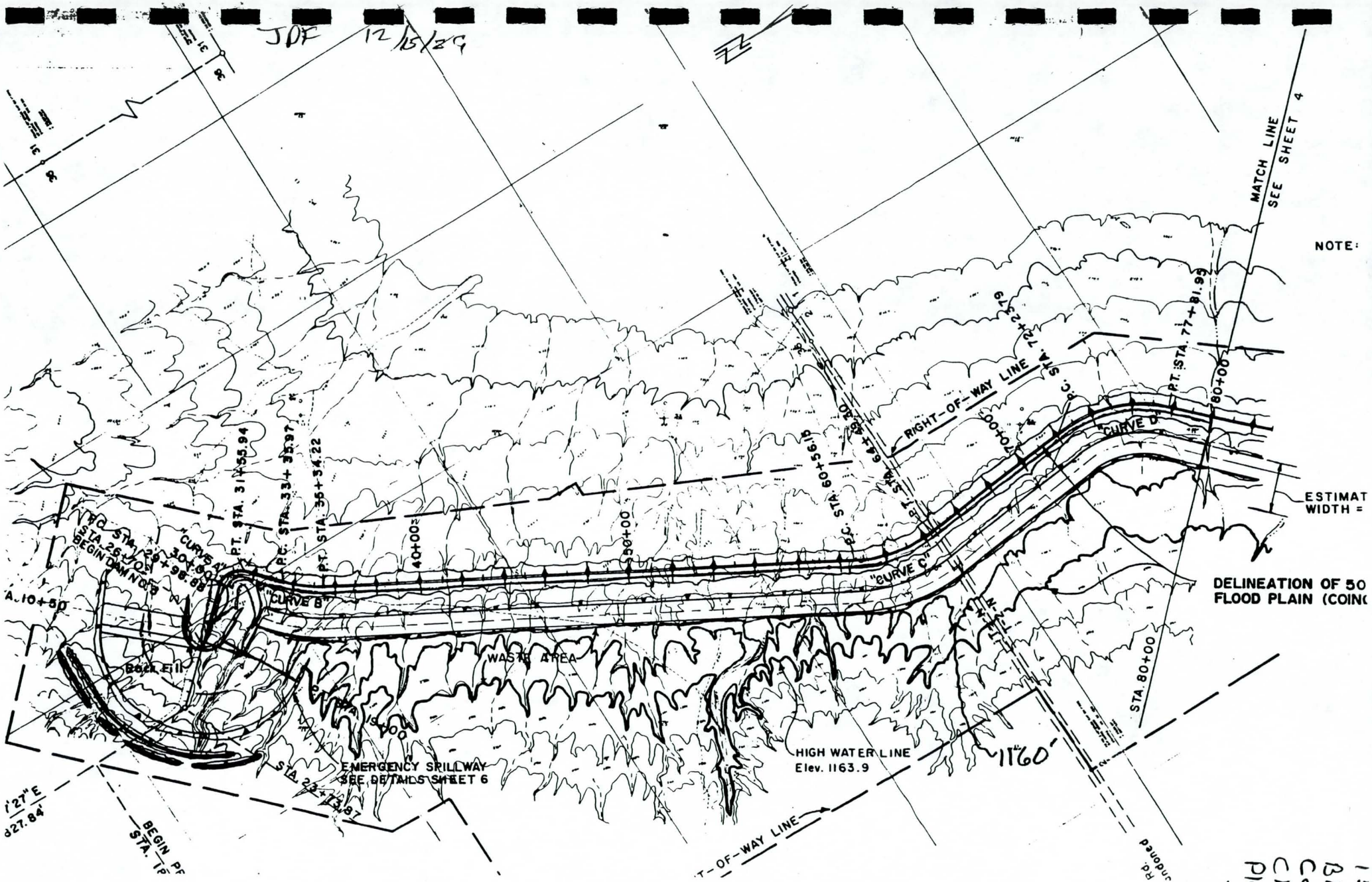
Elevation ft.	Surface Area Acres	Storage Volume Ac-Ft	$\left[\frac{Area_1 + Area_2}{2}\right] \Delta EL$
1149	0	0	
1156	85	298	
1160	135	738	
1163.9	220	1430.25	

BY JDE DATE 11/30/89
CHECKED BY RHA 12/20/87
COPY TO EO

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

045-1 (12/88) PRINTED IN U.S.A.

JDF 12/15/29



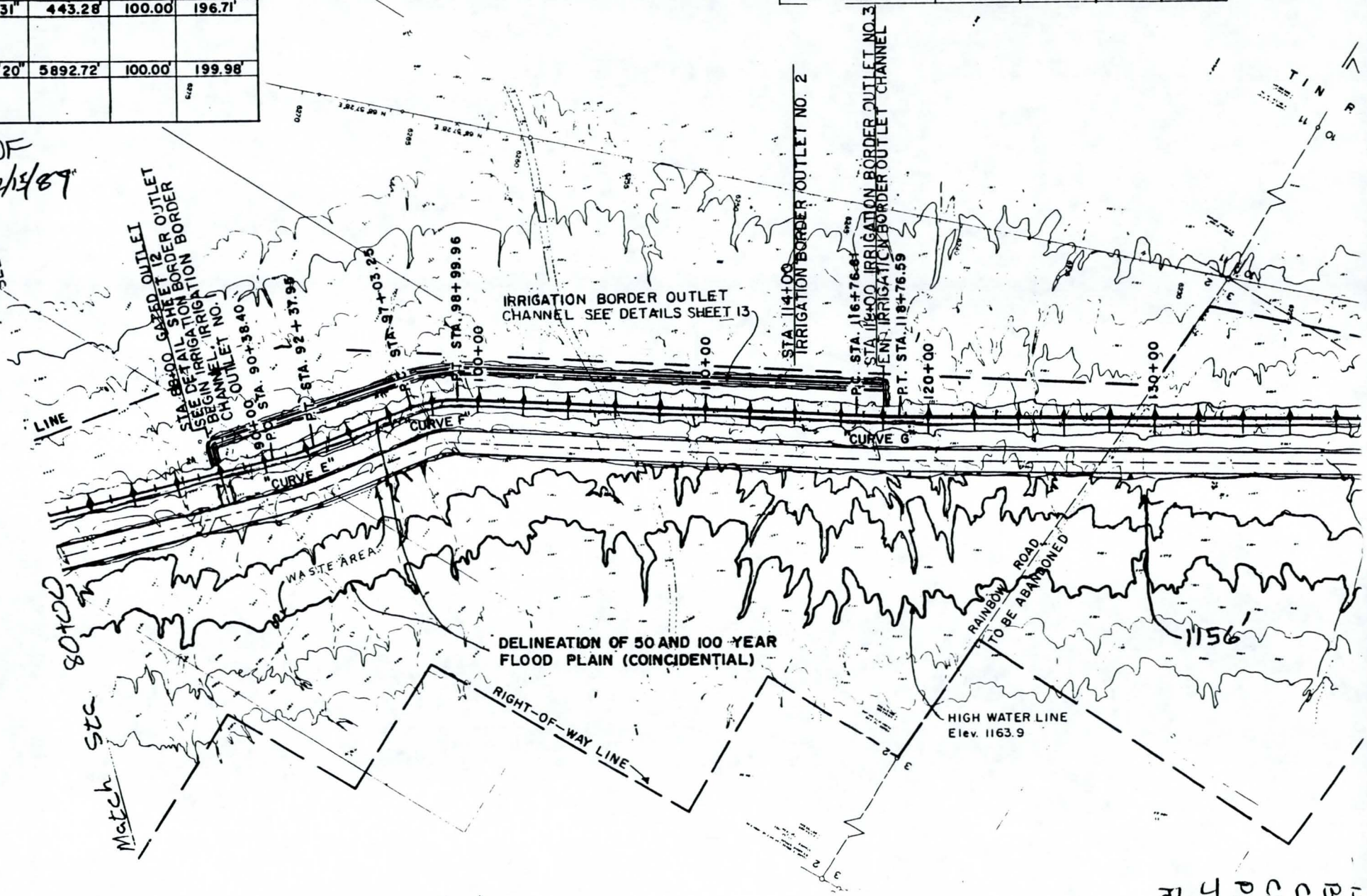
Sheet 3

Buckeye FRS
Capacity Check
Check-- FRS#
Plan View
JDF 11/30
Page 148 of

0'	12°55'31"	443.28'	100.00'	196.71'
	0°58'20"	5892.72'	100.00'	199.98'

	1°56'40"	0°56'25"	6092.72'	103.39'	206.77'

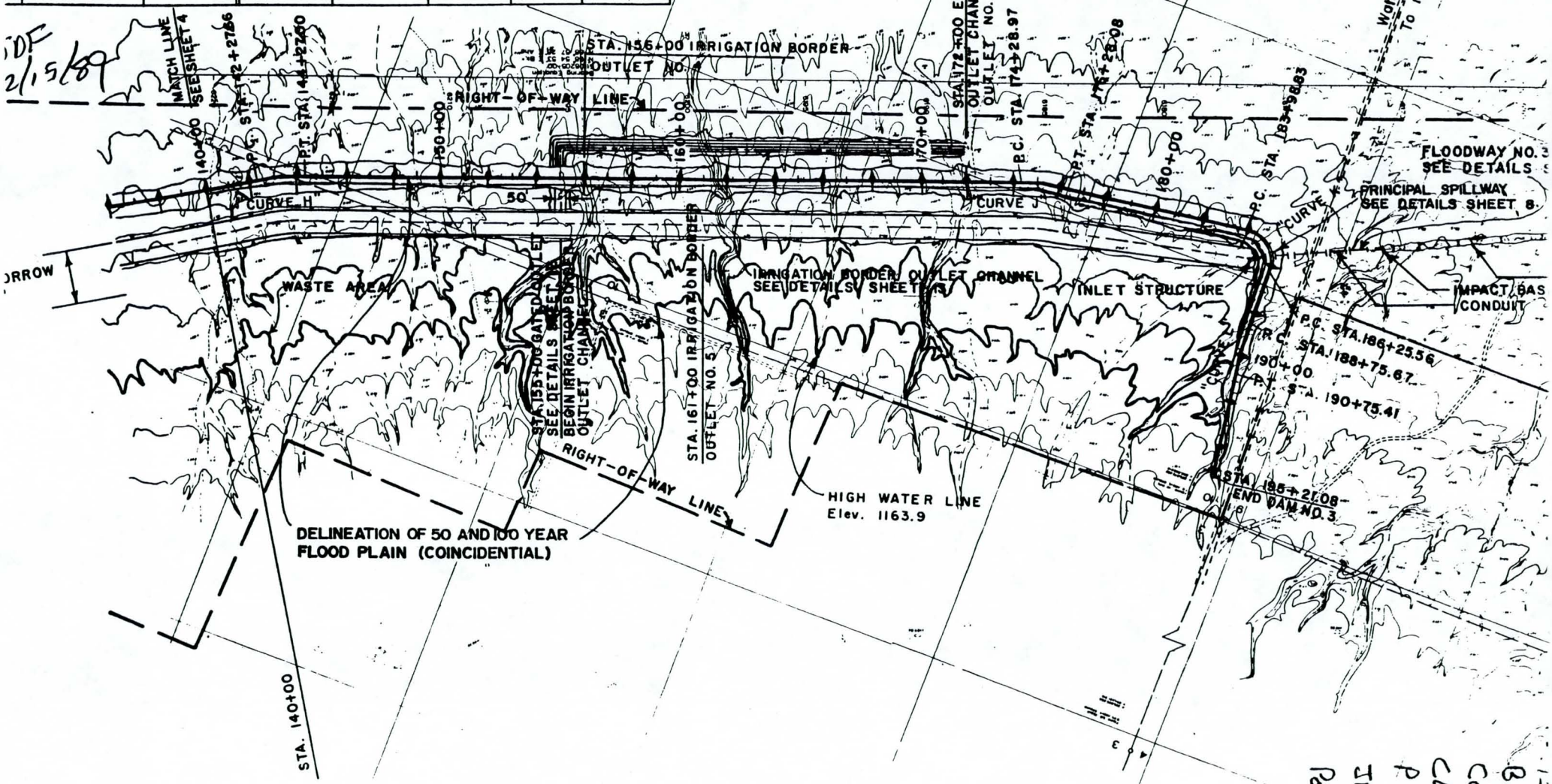
JDF
12/15/89



Sheet 4

1448-003-02
Buckeye FRS
Capacity Chart
Check--FRS #
Plan View
JDF 11/30
Page 49 of 161

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		95°43'55"	42°13'21"	135.70'	150	226.73'
N 2°07'37" W	500.11'					
		7°10'00"	3°35'17"	1596.87'	100.00	199.74'
N 9°17'37" W	545.67'					



Sheet 5

Buckeye FRS
Capacity Chart
Check -- FRS#3
Plan view
IDF. 11/30
Page 150 of 161

CALCULATIONS COVER SHEET
DAMES & MOORE
DESIGN SERVICES GROUP

PROJECT NUMBER [illegible]
SUBJECT Buckeye FRS
SHEET 151 OF 161

Muskingum Channel Routing Parameters
TITLE OF CALCULATIONS

Buckeye FRS
TITLE OF PROJECT

CALCULATIONS BY: John Fannin
PRINT NAME
John Fannin 12/05/89
SIGNATURE DATE

ASSUMPTIONS CHECKED BY CONSULTANT: George J Geiger
PRINT NAME
G J Geiger 12/20/89
SIGNATURE DATE

CALCULATIONS CHECKED BY: Richard Allen
PRINT NAME
Richard Allen 12/20/89
SIGNATURE DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT OR PM) George J Geiger
PRINT NAME
G J Geiger 12/20/89
SIGNATURE DATE

APPROVAL NOTES:
IF CALCULATIONS ARE ONLY SPOT CHECKED, DO NOT REQUIRE CHECKING OR ARE ASSUMED TO BE CORRECT BY EXPERIENCE OR ENGINEERING JUDGEMENT, IT SHOULD BE NOTED HERE.

REVISION NUMBER	DATE	BY	CHECKED BY INITIALS	APPROVAL
1				
2				
3				
4				

BY [illegible] DATE 12/15/89
CHECKED BY RHA 12/20/89
ORIGINAL TO PROJECT FILE

Estimating Muskingum Channel Routing Input Parameters for HEC 1.

Purpose: To develope input modeling parameters for channel routing of flow using Muskingum Routing methods.

References:

1. Linsley, R. K., Jr.; et. al.; (1982); Hydrology For Engineers; McGraw-Hill Book Company; New York, NY.

2. Soil Conservation Service; (1972); National Engineering Handbook, Section 4, Hydrology; U.S. Department of Agriculture; Washington D.C.

3. Linsley, R.K.; Franzini, J.B.; (1972) Water-Resources Engineering; McGraw-Hill Book Company; New York, N.Y.

4. Designated Area Maps included in the Calculations section titled: "Developing HEC 1 Input Parameters"; Dames + Moore (1989).

EVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 12/15/89
CHECKED BY ____
COPY TO EO ____

945 1 (12/88) PRINTED IN U.S.A.

Analysis:

The Muskingum Method for Channel Routing will be used to route flows from an upstream sub-basin through the reach of the downstream sub-basin. The equation use for Channel Routing is as follows:

$$Q_{out_2} = (CA - CB) * Q_{in_1} + (1 - CA) * Q_{out_1} + CB * Q_{in_2}$$

where:

$$CA = \frac{2 * \Delta t}{2 * AMSKK * (1 - X) + \Delta t}$$

$$CB = \frac{\Delta t - 2 * AMSKK * X}{2 * AMSKK * (1 - X) + \Delta t}$$

Q_{in} = Inflow to Routing Reach (cfs)

Q_{out} = Outflow from the Routing Reach (cfs)

AMSKK $\cong$ Travel Time (T_t) through the Reach in hours

X = Dimensionless Constant which indicates the relative importance of the inflow and outflow in determining storage.

Δt = The step time interval. (min)

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/15/89 CHECKED BY ____ COPY TO EO ____

945.1 (12/88) PRINTED IN U.S.A.

For most streams AMSKK and X are determined based on an analysis of recorded stream flow data from gaging stations along a stream. Since this type of data is not available for the small streams in the study area, the following methods & assumptions will be employed.

① X varies from 0 to 0.5 with a value of 0 corresponding to a reservior with no outflow and 0.5 corresponding to a river with little or no storage. [Ref 3]

Assume $X = 0.4$ ✓

② Storage Constant K

Assume $K \cong$ Travel time through reach.

$$T_t \cong K \cong \frac{L}{3600V} \qquad \text{[Ref. 2]}$$

where T_T = Travel Time
L = Length of Reach
V = Velocity of Flow

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____
BY JDF DATE 12/15/89
CHECKED BY ____
COPY TO EO ____

The flow Velocity through a channel Reach will be approximated using Manning's Equation:

$$V = \frac{1.49}{n} \cancel{R^{2/3}}^{\,1} S^{1/2}$$

Where: V = velocity of Flow in fps.

n = Mannings n (Assume n = 0.040)

R = Hydraulic Radius
(Assume Sheet Flow: R = 1)

S = Slope of Energy Grade Line
(Assume ≅ to the channel Slope)

For computational stability and accuracy when using the HEC-1 program, the following limits are placed on K:

$$\frac{1}{2(1-X)} \leq \frac{K*60}{NSTPS*\Delta t} \leq \frac{1}{2X}$$

where: X = Muskingum Weighting Factor

NSTPS = Number of Computational Integer Steps to be used for the Reach

Δt = Integer Number of minutes in tabulation interval. (10 min).

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDE DATE 12/15/89
CHECKED BY ____
COPY TO EO ____

245-1 (12/88) PRINTED IN U.S.A.

Muskingum Channel Routing

Calculations for Approximating the Storage Constant K.

Route FROM	Route TO	Length of Reach ft	Average Slope ft/ft	Manning's n	Velocity $V=\frac{1.49}{n}S^{1/2}$ fps	Travel Time Through Reach fps $T_t=\frac{L}{3600V}$ K hrs
CP3-1	CP3-2	5300 ✓	0.022	0.040	5.5	0.29 ≅ 0.30
CP3-2	CP3-3	13 200	0.017	0.040	4.86	0.75
CP1-8	CP1-9	42,300	0.007	0.040	3.12	3.77
CP1-7	CP1-9	36,200	0.007	0.040	3.12	3.22
CP1-6	CP1-9	31,100	0.007	0.040	3.12	2.77
CP1-4	CP1-5	20,200	0.008	0.040	3.33	1.69

Revised on Page 156A

Checking Numerical Stability of K

Reach From	Reach To	K Assume = 0.30	NSTPS	$\frac{1}{2(1-x)}$ x = 0.40	$\frac{K*60}{NSTPS*10min}$	$\frac{1}{2x}$ x = 0.40	Comment
CP3-1	CP3-2	~~0.29~~ 30	2	0.83	~~0.87~~ 0.98	1.25	ok
CP3-2	CP3-3	0.75	4	0.83	1.13	1.25	ok
CP1-8	CP1-9	3.77	20	0.83	1.13	1.25	ok
CP1-7	CP1-9	3.22	20	0.83	0.97	1.25	ok
CP1-6	CP1-9	2.77	15	0.83	1.11	1.25	ok
CP1-4	CP1-5	1.69	10	0.83	1.01	1.25	ok

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JDF DATE 12/15/89
CHECKED BY RHA DATE 12/20/89
COPY TO EO ____

Checking Numerical Stability of K

100-YR and 6-Hr PMP $\Delta t = 5$ min

Reach FROM	Reach TO	K HRS.	NSTPS	$\frac{1}{2(1-X)}$ X=0.40	$\frac{K*60}{NSTPS*\Delta t}$	$\frac{1}{2X}$ X=0.40	Comment
CP1-4	CP1-5	1.69	24	0.83	0.84	1.25	ok
CP1-6	CP1-9	2.77	39	0.83	0.85	1.25	ok
CP1-7	CP1-9	3.22	46	0.83	0.84	1.25	Ok
CP1-8	CP1-9	3.77	54	0.83	0.84	1.25	Ok
① ~~CP3-1~~	~~CP3-2~~	~~0.27~~	~~3~~	~~0.83~~	~~1.08~~	~~1.25~~	72-HR Failed Lag 15 min
CP3-2	CP3-3	0.75	8	0.80	1.125	1.25	Ok

72-HR PMP $\Delta t = 20$ min

Reach From	Reach To	K HRS	NSTPS	$\frac{1}{2(1-X)}$	$\frac{K*60}{NSTPS*\Delta t}$	$\frac{1}{2X}$	Comment
CP1-4	CP1-5	1.69	6	0.83	0.89	1.25	Ok
CP1-6	CP1-9	2.77	9	0.83	0.92	1.25	Ok
CP1-7	CP1-9	3.22	11	0.83	0.89	1.25	Ok
CP1-8	CP1-9	3.77	13	0.83	0.87	1.25	Ok
① CP3-1	CP3-2	0.27	—	0.83	—	1.25	Reach to Short
CP3-2	CP3-3	0.75	2	0.83	1.12	1.25	Ok

① The Reach is to short for Muskingum Routing. The hydrograph will be lagged 15 to 20 min.

REVISIONS BY ____ DATE ____ TO EO ____ BY ____ DATE ____ TO EO ____

BY JJH DATE 1/5/90 CHECKED BY RHA 1/5/90 COPY TO EO ____

CALCULATIONS COVER SHEET
DAMES & MOORE
DESIGN SERVICES GROUP

PROJECT NUMBER 15448-003-022
SUBJECT Buckeye FRS
SHEET 157 OF 161

Reservior Routing -- Outflow
TITLE OF CALCULATIONS

Buckeye FRS
TITLE OF PROJECT

CALCULATIONS BY: John Fannin
PRINT NAME
John Fannin 12/11/89
SIGNATURE DATE

ASSUMPTIONS CHECKED BY CONSULTANT: GEORGE J GEISER
PRINT NAME
G J Geiser 12/20/89
SIGNATURE DATE

CALCULATIONS CHECKED BY: Richard Allen
PRINT NAME
Richard Allen 12/20/89
SIGNATURE DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT OR PM) GEORGE J GEISER
PRINT NAME
G J Geiser 12/20/89
SIGNATURE DATE

APPROVAL NOTES:
IF CALCULATIONS ARE ONLY SPOT CHECKED, DO NOT REQUIRE CHECKING OR ARE ASSUMED TO BE CORRECT BY EXPERIENCE OR ENGINEERING JUDGEMENT, IT SHOULD BE NOTED HERE.

REVISION NUMBER	DATE	BY	CHECKED BY (INITIALS)	APPROVAL
1				
2				
3				
4				

CHECKED BY RHA DATE 12/20/89

ORIGINAL TO PROJECT FILE

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

Resesvior Routing -- Outflow

Purpose: To develop resesvior routing critesia for outflows.

References:

1. Chow, T. V., Ph. D.; (1959); Open Channel Hydraulics; McGraw-Hill Book Company; New York, NY.

2. Linsley, R. K.; Franzini, J. B.; (1972) Water-Resources Engineering, 2nd ed.; McGraw-Hill Book Company; New York, NY.

3. Barfield, B. J., Warner, R. C.; (1983) Applied Hydrology And Sedimentology For Disturbed Areas; Oklahoma Technical Press; Stillwater Oklahoma.

4. United States Department of the Interior, Bureau of Reclamation; (1973); Design of Small Dams, 2nd ed (Revised 1977); United States Government Printing Office; Washington D.C.

5. Soil Conservation Service; (1971); "Buckeye Watershe Protection and Flood Prevention Project, Maricopa County, Arizona, Plans For The Construction of Site I Diversion Structure", Drawing No. 7-E-22084; U.S. Department of Agriculture.

BY JDE DATE 12/11/89
CHECKED BY ____
COPY TO EO ____

(References contd.)

6. Soil Conservation Service; (1972); "Buckeye Floodwater Retarding Structures 2+3, Buckeye W.P.P., Maricopa County, Arizona"; Drawing No. 7-E-23079; U.S. Department of Agriculture.

7. Dames + Moore; (1989); "Minutes of First Project Milestone Meeting December 8, 1989."

Method:

1. Review References
2. Select Modeling Parameters based on Spillway Configurations and Dam Cross-Sections.

Assumptions:

1. Principal Spillways are not functioning, i.e., Outflow = 0 cfs. (Ref. 7)
2. Dimentions + Elevations obtained from Reference 5+6 accurately represent the as-built structures as they are today. (Ref. 5+6)

REVISIONS BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____

BY JDF DATE 12/11/89
CHECKED BY ____
COPY TO EO ____

945 1 (12/88) PRINTED IN U.S.A.

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

Analysis:

After reviewing the listed references and a site visit, it was decided that flow out of the emergency spillways and over the top of the dams should be modeled using the weir equation:

$$Q = C L H^x$$

Where: Q = Outflow in cfs

C = The weir coefficient of discharge

L = The length of the weir (ft) (Length of Dam being overtopped, and Length of the crest of the emergency spillways perpendicular to center line.

H = Water surface elevation in the Reservior — the crest elevation of the spillway or dam (ft)

X = The exponent of head (H).

BY JDF DATE 12/11/89
CHECKED BY _____
COPY TO EO _____

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

The following table lists the design parameters to be used as input data for the HEC 1 modeling.

Structure	Crest Elevation ft	Length L ft	Coefficient of Discharge C	Exponent of Head X
FRS #3 Emergency Spillway	1163.2	400	2.5 ① ✓	1.5 ✓
Dam	1170.0	16851	2.7 ✓	1.5 ✓
FRS #2 Emergency Spillway	1111.2	350	2.7 ✓	1.5 ✓
Dam ②	1117.0	9455.0 ✓	2.7 ✓	1.5 ✓
FRS #1 Emergency Spillway	1079.8	800	2.7 ✓	1.5 ✓
Dam ②	1089.5	31,800		
	1088.0	5580	2.7 ✓	1.5 ✓

① Includes head losses due to flow in approach channel.

~~② Assumes Flow over top of dams will only occur at the lowest crest elevations of the dams~~

BY JDF DATE 12/11/89
CHECKED BY RHA 12/20/89
COPY TO EO _____

945 1 (12/88) PRINTED IN U.S.A.