SKUNK CREEK FLOOD RESPONSE PLAN

TECHNICAL MEMORANDUM

Prepared For:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009
(602) 506-1501

Prepared By:

Tetra Tech, Inc.
Infrastructure Southwest Group
4801 E. Washington Street, Ste. 260
Phoenix, AZ 85034
(602) 682-3300

In association with:

JE Fuller/ Hydrology & Geomorphology, Inc.
6101 S. Rural Road, Suite 110
Tempe, AZ 85283
(480) 752-2124

August 2001

SKUNK CREEK FLOOD RESPONSE PLAN

TECHNICAL MEMORANDUM

Prepared For:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009
(602) 506-1501

Prepared By:

Tetra Tech, Inc.
Infrastructure Southwest Group
4801 E. Washington Street, Ste. 260
Phoenix, AZ 85034
(602) 682-3300

In association with:

JE Fuller/ Hydrology & Geomorphology, Inc.
6101 S. Rural Road, Suite 110
Tempe, AZ 85283
(480) 752-2124

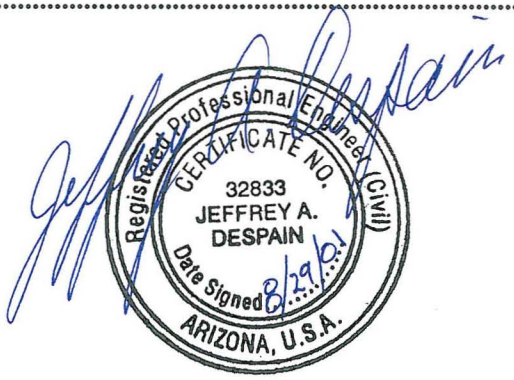
August 2001

NOTE:

THE USER SHOULD READ THE ENTIRE FRP CAREFULLY AND SHOULD BE AWARE OF ALL ELEMENTS OF THIS PLAN, INCLUDING STRENGTHS AND WEAKNESSES, AND INDIVIDUAL RESPONSIBILITIES. THE FLOOD WARNING/ RESPONSE PLAN PRESENTED HEREIN, AND IN THE FIELD BOOK AND FRP RESIDENT MENUS, IS USEFUL AS ONE STEP IN DEVELOPING A FLOOD WARNING SYSTEM FOR THE RESIDENTS WITHIN THE SKUNK CREEK WARNING AREA. HOWEVER, THE POSSIBILITY OF INADVERTENT ERROR IN DESIGN OR FAILURE OF EQUIPMENT TO FUNCTION EXISTS AND MAY PREVENT THE SYSTEM FROM OPERATING PERFECTLY AT ALL TIMES. THEREFORE, NOTHING CONTAINED HEREIN MAY BE CONSTRUED AS A GUARANTEE OF THE SYSTEM OR ITS OPERATION, OR CREATE ANY LIABILITY ON THE PART OF ANY PARTY OR ITS DIRECTORS, OFFICERS, EMPLOYEES OR AGENTS FOR ANY DAMAGE THAT MAY BE ALLEGED TO RESULT FROM THE OPERATION, OR FAILURE TO OPERATE, OF THE SYSTEM OR ANY OF ITS COMPONENT PARTS. THIS CONSTITUTES NOTICE TO ANY AND ALL PERSONS OR PARTIES THAT THE NATIONAL WEATHER SERVICE, FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, MARICOPA DEPARTMENT OF EMERGENCY MANAGEMENT, MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION, MARICOPA COUNTY SHERIFF'S OFFICE, DAISY MOUNTAIN FIRE DEPARTMENT, RURAL METRO FIRE DEPARTMENT, TETRA TECH, INC., AND JE FULLER/ HYDROLOGY & GEOMORPHOLOGY, INC. OR ANY OFFICER, AGENT OR EMPLOYEE THEREOF, SHALL NOT BE LIABLE FOR ANY DEATHS, INJURIES, OR DAMAGES OF WHAT EVER KIND THAT MAY RESULT FROM RELIANCE ON THE TERMS AND CONDITIONS OF THIS SYSTEM.

TABLE OF CONTENTS

TABLE OF CONTENTS, continued



LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

FILES ON CD-ROM

DESCRIPTION	FORMAT
Skunk Creek Watershed Map	AutoCAD R14 drawing
Hydraulic Analysis Work Map	AutoCAD R14 drawing
Hydraulic Analysis Files	HECRAS
Hydrologic Analysis Files	HEC-1
FRP Technical Memorandum	Word document
FRP Field Book	PDF format

SECTION 1: INTRODUCTION

1.1 Purpose

One component of the implementation strategy for the Skunk Creek Watercourse Master Plan (WCMP), a project authorized by the Flood Control District of Maricopa County (District or FCDMC) FCD 99-23, is the establishment of a flood warning system for Skunk Creek. The purpose of this system is early detection of flooding events that could damage the existing residences within the FEMA 100-year floodway and Severe Erosion Hazard Zone. This information could be used to warn residents of impending floods and trigger evacuation notices.

This flood warning plan and system would be considered only an interim measure because it is to be phased-out by a buy-out/ relocation program. Any proposed buy-out program will be voluntary. If buy-out offers are made, it is anticipated that the flood warning system for individual residences would be terminated after those accepting the offer are moved out.

1.2 Project Location

The Skunk Creek study area is located in northern Maricopa County, Arizona. Residences included in the FRP warning area are located in unincorporated areas, but portions of the downstream study area are within the City of Phoenix corporate boundary. See Figure 1-1 for a location map and Figure 1-2 for a vicinity map.

1.3 Flood Response Plan Components

This document contains the Flood Response Plan (FRP) and supporting technical documentation. Hydrologic and hydraulic models are provided on CD-ROM. Two exhibit maps are also provided on the CD as AutoCAD files. These include a watershed map that shows the HEC-1 subbasins and concentration points, and a hydraulic work map with HECRAS cross-section locations.

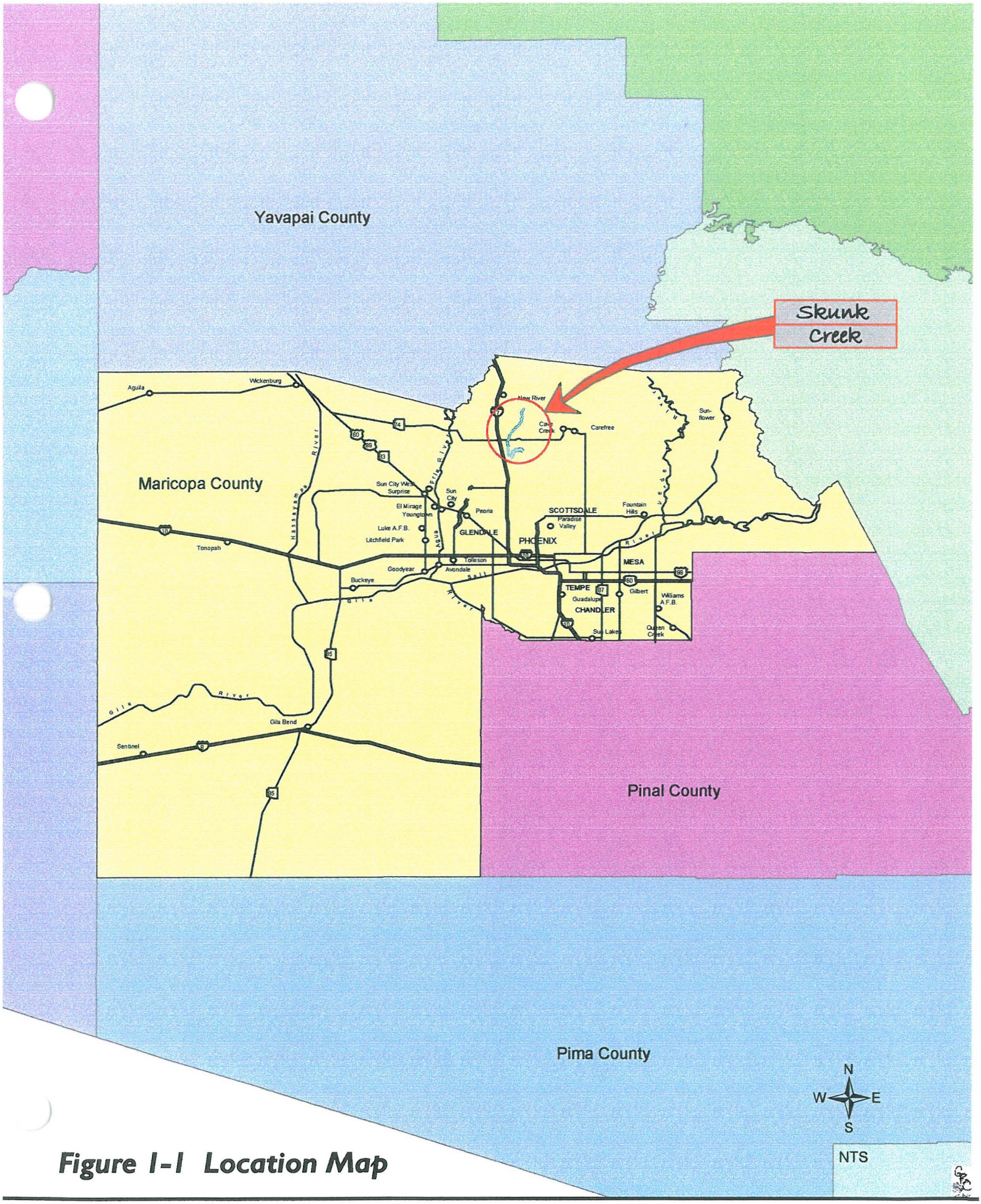


Figure 1-1 Location Map

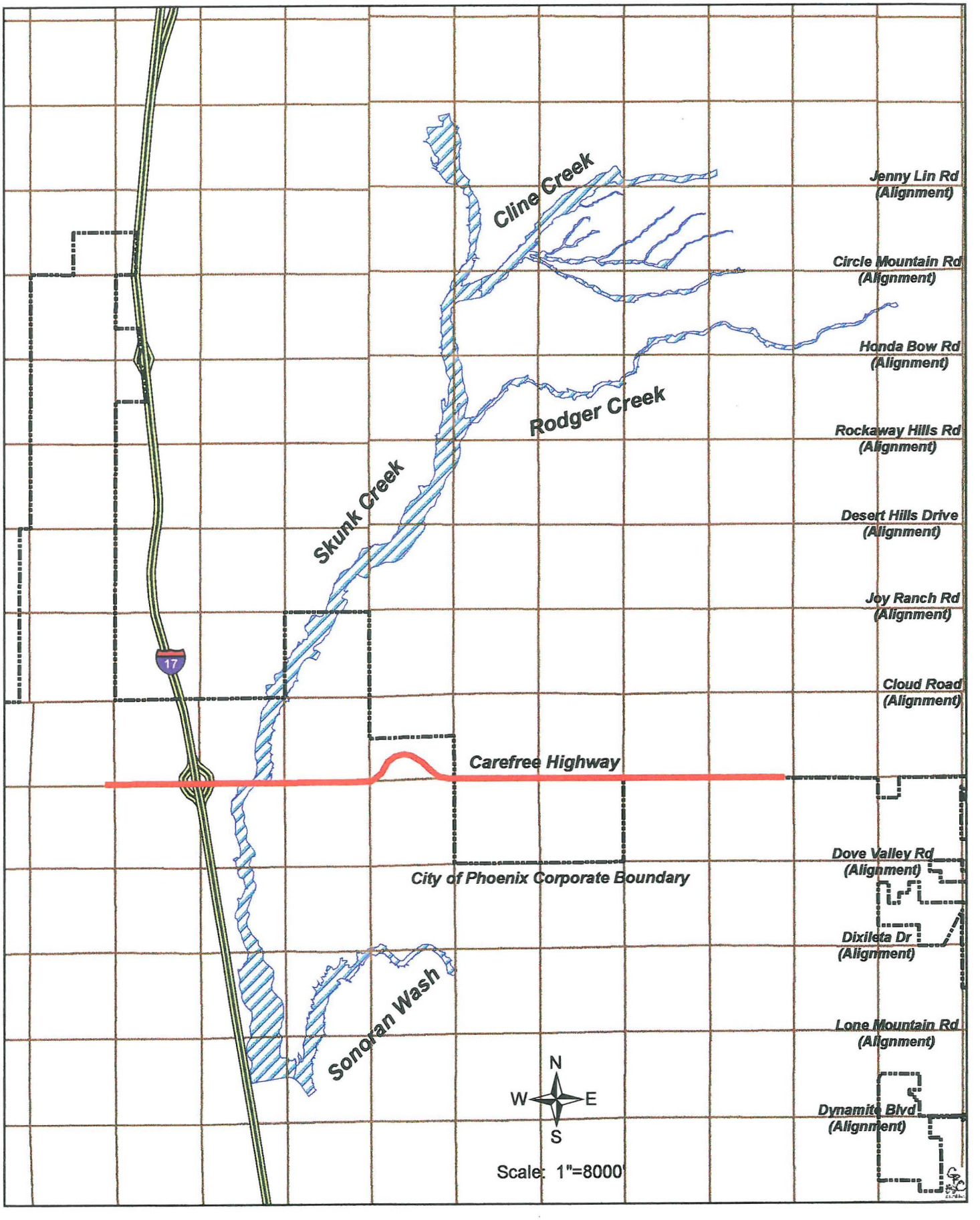


Figure 1-2 Vicinity Map

The FRP is intended to stand on its own and to be added as an Appendix to the District's Flood Emergency Response Manual. The Flood Response Plan is comprised of three primary components, including a Technical Memorandum, FRP Field Book, and FRP Menus.

Technical Memorandum

This document is the Technical Memorandum and is intended for use by District Flood Warning Branch and Meteorological Services Program (MSP) personnel to support decisions regarding dissemination of flood alert messages and implementation of the flood response action plans during flood events in the Skunk Creek watershed.

Sections 2 through 5 include summaries of the hydrologic and hydraulic modeling and results as they relate to the estimation of flood vulnerability of structures and roadway crossings, the determination of flood detection criteria for establishing minimum rainfall and streamflow threshold alarms for sensors in the watershed, and the estimation of hydrologic lead times for the watercourse. The hydrology and hydraulics analyses used for this study were developed as part of the WCMP. Refer to Skunk Creek Watercourse Master Plan, Attachment 3: Hydrology Report, and Attachment 4: Hydraulics and Sediment Report, for complete supporting documentation.

Section 6 of this Technical Memorandum provides information regarding the development of the FRP including the estimation of effective lead times, the selection of the information dissemination option for the Skunk Creek FRP, the flood warning message suite, the emergency response and post-flood action plans for the participating agencies and the residents included in the warning area, and recommendations regarding training, exercises, and FRP updates. Portions of the FRP data and information provided in Section 6 of the Technical Memorandum are also presented in the FRP Field Book.

Flood Response Plan Field Book

The FRP Field Book is provided under separate cover. The material contained herein in Section 6, in part, comprises the information presented in the Field Book. The Field Book contains a description of the components of the flood warning system, flood detection criteria, warning message sequence and content, communication flowchart, effective lead times, agency action plans, resident FRP menus, contact information, and other pertinent emergency information. In addition, digital files for the FRP field book are provided to the District to facilitate future updates to the plan.

The FRP Field Book is intended for use by the District and emergency response agencies to coordinate flood response roles and activities. The FRP Field Book will be distributed to the FCDMC, National Weather Service (NWS) Phoenix Office, Maricopa County Department of Emergency Management (MCDEM), Maricopa County Department of Transportation (MCDOT), Maricopa County Sheriff's Office (MCSO), Daisy Mountain Fire Department (DMFD), and the Rural Metro Fire Department.(RMFD).

Flood Response Plan Menus

The FRP menus include identified potential trouble areas in the flood vulnerable zones, the flood warning messages which trigger each level of emergency response activities, and stepped action plans listing emergency actions required by the affected residents in the warning area. The menus also include aerial photographs showing evacuation routes and destination sites. The menus are intended for use by the individual residents in the Skunk Creek warning area within the floodway and Severe Erosion Hazard Zone.

SECTION 2: FLOOD VULNERABILITY

2.1 Types of Hazards

Two types of flooding hazards are present in the project area. First, a number of homes, both site-built and mobile, are located in the FEMA 100-year floodway and/or the Severe Erosion Hazard Zone and are at risk for inundation during flood events. The District intends for the warning area for the Skunk Creek FRP to include occupied structures in the floodway and/or the Severe Erosion Hazard Zone. Second, Skunk Creek, Cline Creek, and Rodger Creek all cross at least one roadway where overtopping may be hazardous. Skunk Creek crosses many roadways at-grade which are inundated frequently. Both types of hazards were analyzed for the FRP.

2.2 Identification of At-Risk Structures

Initially, structures in the floodway were identified from aerial photographs of the project area taken in July 1999. Using information provided by the Maricopa County Assessor's Office, owners of those parcels were contacted by phone or mail in order to obtain permission to conduct a field survey of their property. The surveyors obtained the finished floor elevation of each residence and the elevation of the ground adjacent to each residence. In addition, field inspection revealed that some of the structures identified in the photos were uninhabited barns, sheds, or other outbuildings. The study focused on occupied structures (houses and mobile homes), although finished floor elevations of some outbuildings were also obtained. This information was used to determine the depth of flooding during the 100-year flood and the threshold flow required to just reach the finished floor elevation.

After the initial evaluation of floodway structures, the study was expanded to include all homes within the Severe Erosion Hazard Zone. These homes were initially identified from

the aerial photographs. A field reconnaissance study verified that the structures were, indeed, occupied residences. Homes within the Severe Erosion Hazard Zone, but outside of the floodway, were not surveyed for finished floor elevations. Instead, the WCMP topographic mapping was used to estimate the elevation of the adjacent ground. For flooding analysis, the estimated ground elevation plus one foot was assumed for the finished floor elevation of these homes.

2.3 Flood Hazard Groups

The at-risk structures were divided into four groups, based on geographical location along the creek. The creation of groups was necessary to customize the flood response action plan menus for the residents of each area. See Figure 2-1 for a map of the group locations. Appendix A contains a listing of homeowners included in the flood warning system. The purpose of creating groups was two-fold. First, because the travel time of peak flow from the rain gages to each group varies, the lead time available to warn residents of flood danger also varies. Clearly, the farther downstream from the gage a structure is located, the more lead time is available. Second, due to overtopping of New River Road and associated secondary roads, not all residents in the project area will be able to go to the same evacuation site. Residents living between the New River Road bridge at Skunk Creek and Rodger Creek will not be able to leave the area due to roadway overtopping.

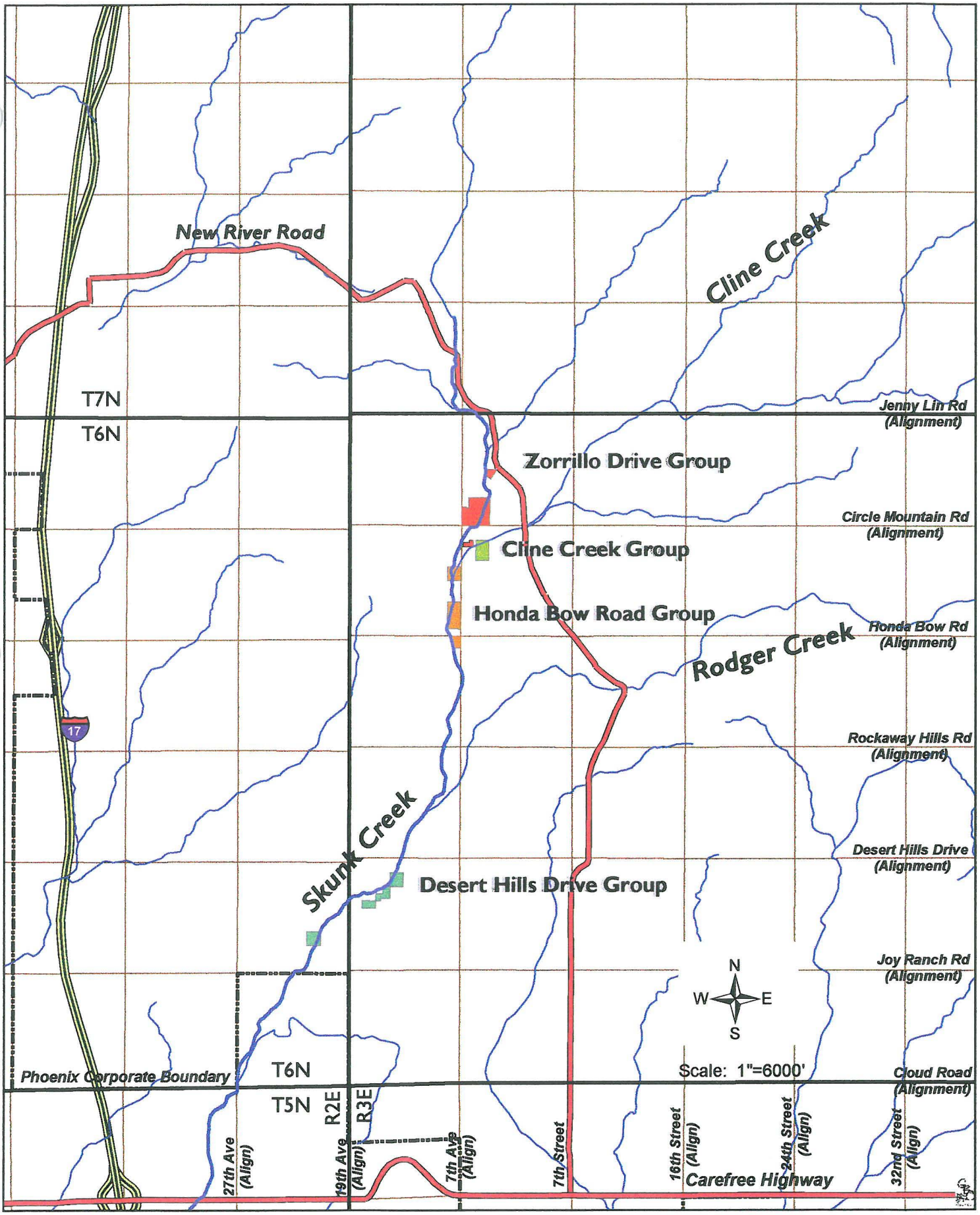


Figure 2-1 Map Of Flood Hazard Group Locations

2.4 Roadway Overtopping

Table 2-1 summarizes the roadway crossings that have been analyzed for this study. The relationship between flow, depth, and velocity at each crossing was determined using HECRAS or HEC-2 hydraulic models, except for the bridge over Cline Creek. As-built drawings were obtained for this bridge that show that it passes the 100-year event without overtopping. Thus, the Cline Creek bridge was assumed to provide 100-year capacity for the purposes of this FRP. The Rodger Creek crossing was analyzed using the effective Flood Insurance Study (FIS) HEC-2 model. The Skunk Creek crossings were modeled using a modified version of the effective FIS HECRAS model. A more detailed discussion of the hydraulic modeling of roadway overtopping is contained in Section 5.4, Hydraulic Analysis.

TABLE 2-1: ROADWAY CROSSING SUMMARY

Watercourse	Roadway	Type
Skunk Creek	New River Road north of the bridge	At-grade
	New River Road at the bridge	Bridge
	Shangri La Lane	At-grade
	Circle Mountain Road	At-grade
	Honda Bow Road	At-grade
	Desert Hills Drive	At-grade
	19th Avenue	At-grade
	Cloud Road/27th Avenue	Culverts
Cline Creek	New River Road	Bridge
Rodger Creek	New River Road	Culverts

The criteria for determining when a flooded roadway becomes too hazardous to cross was adopted from the USBR (1988). Figure 4 in that report is a graph that shows the flood danger level for passenger vehicles as it relates to flow depth and velocity. See Appendix B for Figure 4 and additional excerpts from the report (USBR, 1988). The flood danger levels are shown on the graph as High Danger, Low Danger, and an intermediate Judgment Zone, in which the danger level is based upon engineering judgment. For the FRP, the lower boundary of the Judgment Zone was used to define the point at which a flooded roadway becomes too hazardous to cross.

SECTION 3: FLOOD DETECTION

3.1 Existing Flood Detection System

The primary use of the existing rain and stream gages in the Skunk Creek watershed has been to provide data for the safe operation of Adobe Dam, located downstream, and to provide advisory information in support of road closure decisions during flood events. Additionally, the data are incorporated into the rainfall and streamflow databases maintained by the District. The existing flood detection system used in Maricopa County includes the following major features:

- *ALERT System and MSP* – The District operates and maintains the ALERT (Automated Local Evaluation in Real Time) system comprising, in part, the flood detection network (FDN) for Maricopa County. The FDN contributes to the early detection of flooding by measuring rainfall and streamflow using gage sensors at critical locations in the basins. Rainfall depth and rate alarms and/or streamflow stage and discharge thresholds are preset to notify District personnel when a flood threat is detected. These data are used by the District Meteorological Services Program (MSP) to forecast and monitor significant rainfall events, and to issue weather information and flood warning messages to agencies participating in the program via broadcast fax.

  The District's current ALERT system gages in the Skunk Creek watershed include:

  - ALERT 1 mm Tipping Bucket Rain Gages
    - Upper Skunk Creek (#5580) – installed 08/01/81
    - Skunk Creek at I-17 (#5565) – installed 11/08/89
  - Real-time Streamflow Gages
    - Skunk Creek near New River (#5583) – installed 06/21/95
    - Skunk Creek at I-17 (#5568) – jointly operated with the USGS, installed by USGS 10/01/67, by FCDMC 10/26/89

- *Weather Station Network* – The District utilizes data from a weather station network comprised of 23 stations distributed throughout Maricopa County and vicinity. Those weather data are used to assess the rainfall potential of the air mass covering the County and contributing basins. These weather station data are used in conjunction with other information by the NWS in the issuance of flash flood watches and flash flood warnings. The District also uses this data to issue flood alert messages as part of its Meteorological Services Program (MSP).

- *Radar* – The NWS WSR-88D Doppler radar located at Williams Gateway Airport provides a valuable short-term prediction and detection tool to track thunderstorm systems and other rain-producing cloud systems, measure their intensity, and estimate storm potential. The information obtained from the WSR-88D radar is useful in identifying basins with immediate flash flood threat and in issuing flash flood warnings.

- *Internet Weather and Water Data Sites* – In combination with the preceding sensor networks and radar, other weather and real-time water data are available via the Internet. In effect, the availability of these data expands the temporal and spatial extent of the FDN for use by the FCDMC and the MSP in detecting and monitoring rainfall-producing storms. An exhaustive listing of weather sites available on the Internet is not provided here; however, the following list contains the addresses of key web sites:
  - http://www.fcd.maricopa.gov/alert/alert.htm FCDMC real-time ALERT data
  - http://www.nws.noaa.gov/data.html NWS information about current weather conditions, forecasts, and flash flood watches/ warnings
  - http://water.usgs.gov/data.html Streamflow data from USGS gages
  - http://www.afws.org/ The web site of the Arizona Flood Warning System, owned by the Arizona Department of Water Resources (ADWR) and operated by the Salt River Project (SRP), provides 24 hour hydrological and meteorological information and links to other weather- and water-related sites.

3.2 Proposed FDN Enhancements

The effectiveness of the FRP in providing inundation/evacuation warnings to residents within the Skunk Creek floodplain depends upon the ability to monitor conditions upstream in the watershed. Currently, there is one stream gage on Upper Skunk Creek near Fig Springs Road and one rain gage located near Cline Creek. Additional gaging stations are proposed as follows: add a rain sensor to the Upper Skunk Creek stream gage, one rain gage and one stream gage co-located on lower Cline Creek and one rain gage in each of the upper watersheds of Skunk and Cline Creeks. See Figure 3-1 for a map of the proposed gage locations. A co-located rain and stream gage was proposed for Rodger Creek, but was subsequently eliminated from the plan because the property owners declined to allow the District to install the gage on their property.

The gage locations were chosen to provide additional lead time to implement flood response action plans. Once installed, the proposed stations will be added to the existing ALERT system. Calculation of the lead time available for dissemination of flood warning information to agencies and residents was based upon the assumption that the gages are installed as planned.

Additional recommended enhancements to the FDN include the following:

- It is recommended that a real-time hydrologic model be developed for the Upper Skunk Creek basin. Such a model would facilitate estimation of streamflow at key locations along the watercourse using rainfall data inputs obtained in real-time from the ALERT sensors in the basin.

- The effective lead times available for emergency response were computed for the Upper Skunk Creek flood hazard groups (Section 6.2). Those lead times are

minimal, and in some cases negative, implying the need for strong predictive capabilities for flooding in the basin. Incorporation of radar-based rainfall forecasts, currently available from private vendors, would augment the existing FDN predictive capabilities and lengthen the effective lead time available for emergency response. It is recommended that these forecast products be obtained.

- The FDN for the Skunk Creek watershed could also be supplemented by reports of storms, rainfall, and flooding by citizens and the emergency response community in the area. These observations can be valuable in the verification of sensor data and/or in "spotting" potentially hazardous situations missed by the detection network. No formal "spotter" network exists in the Skunk Creek basin, however, the development of one is encouraged.

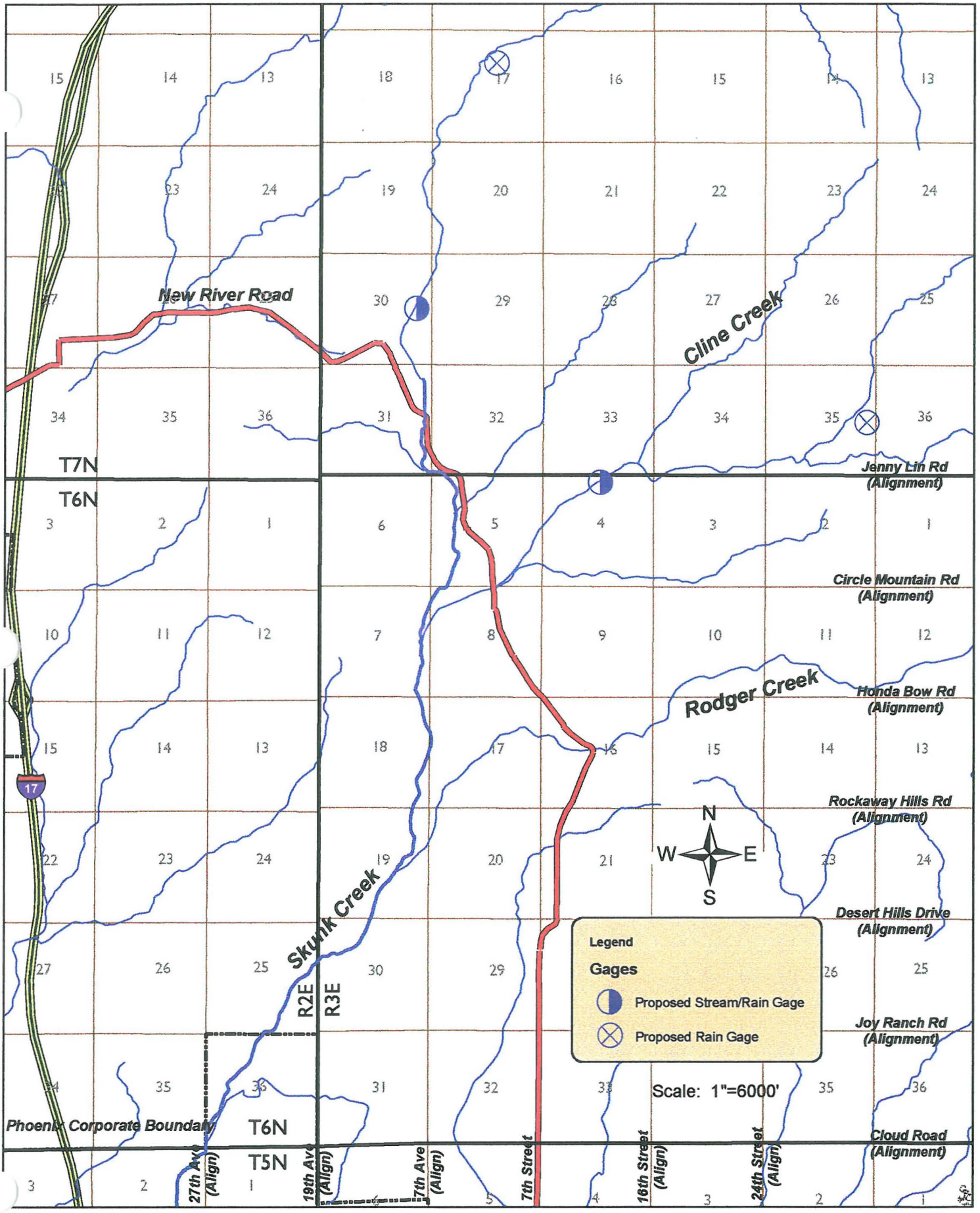


Figure 3-1 Proposed FDN Gage Locations

3.3 Flood Detection Criteria

Flood detection criteria were developed based upon the results of the hydrologic and hydraulic analyses and the assumption that the additional gages are installed as proposed in Section 3.2. The detection criteria are based upon the rainfall intensities required to produce the critical threshold stages or discharges that inundate at-grade crossings at impassable levels and/or reach the finished floor elevations of the floodway structures.

These criteria are recommended for use by the District and NWS to disseminate flood warning messages (Section 6.4) to the residents in the warning area and to appropriate emergency response agencies, thereby triggering implementation of the FRP action plans (Section 6.5). Table 3-1 summarizes detection criteria including rainfall intensities and discharge values for each level of flood alert in the warning message suite.

TABLE 3-1: FLOOD DETECTION CRITERIA

Group	Warning Message	Rainfall Depth (in)	Rainfall Duration (hours)	Rainfall Depth (in)	Rainfall Duration (hours)	Discharge at 5588 (cfs)	Discharge at 5583 (cfs)	Critical Discharge (cfs)
Zorrillo Drive (S13C)	1	1.00	2.5	1.50	5.0	-------	-------	
	2	1.65	2.5	2.25	5.0	1,300		
	3	-------	-------	-------	-------	2,000		4,400
Cline Creek (CCC)	1	1.00	2.5	1.50	5.0	-------	-------	
	2	2.22	2.5	3.30	5.0	-------	4,700	
	3	-------	-------	-------	-------	-------	7,000	10,600
Honda Bow (SC-CC)	1	1.00	2.5	1.50	5.0	-------	-------	
	2	1.48	2.5	1.92	5.0	1,300 or 4,700		
	3	-------	-------	-------	-------	(1,500 and 2,400) or 5,500		8,000
Desert Hills (S16C)	1	1.00	2.5	1.50	5.0	-------	-------	
	2	1.45	2.5	1.87	5.0	1,300 or 4,700		
	3	-------	-------	-------	-------	(1,600 and 3,000) or 6,000		9,000

SECTION 4: HYDROLOGIC ANALYSIS

4.1 General

The base hydrologic data used for the development of the FRP were taken from three existing floodplain delineation studies, as follows:

- Skunk Creek Floodplain Delineation Study, June 1997 by Montgomery Watson Americas, Inc. (Montgomery Watson) for the Flood Control District of Maricopa County, FCD 95-16. This study models the Skunk Creek watershed above the Central Arizona Project (CAP) Canal.

- Rodger Creek Floodplain Delineation Study, December 1989 by Michael Baker, Jr., Inc. for the Flood Control District of Maricopa County, FCD 89-15. Revised by the Flood Control District of Maricopa County in February 1996. This study models the watershed of Rodger Creek above its confluence with Skunk Creek.

- Cline Creek Floodplain Delineation Study, December 1989 by Michael Baker, Jr., Inc. for the Flood Control District of Maricopa County, FCD 89-15. Revised by the Flood Control District of Maricopa County in February 1996. This study models the watershed for Cline Creek above its confluence with Skunk Creek.

The results of all three of these models were combined and used as the base hydrology for the Skunk Creek Watercourse Master Plan. The rainfall-runoff models were run using the U.S. Army Corps of Engineers HEC-1 computer program, version 4.0.1E, September 1990, as implemented by Dodson and Associates. The results of the modeling have been summarized in this report for the

convenience of the user. Please refer to Skunk Creek Watercourse Master Plan, Attachment 3: Hydrology Report for the complete supporting documentation.

4.2 WCMP Hydrology Results

Tables 4-1 and 4-2 summarize the results of the WCMP hydrologic modeling. This modeling used the 24-hour SCS Type II rainfall distribution. HEC-1 results are listed for individual subbasins and concentration points. Refer to the Skunk Creek Watershed Map (digital file provided on the attached CD-ROM), for the locations of subbasins and concentration points.

Table 4-1 shows peak discharge and time to peak. Table 4-2 shows rainfall volume results. These values are for existing conditions in the watershed at the time the FIS studies were completed.

TABLE 4-1: SUMMARY OF SKUNK CREEK PEAK DISCHARGES

HEC-1 ID	Existing Drainage Area [sq. mi.]	Time of Peak			Peak Discharge		
		2-Year [hours]	10-Year [hours]	100-Year [hours]	2-Year [cfs]	10-Year [cfs]	100-Year [cfs]
Subbasin Operations							
S1	2.08	12.17	12.17	12.17	673	1,610	2,911
S2	1.17	12.17	12.17	12.17	472	1,000	1,738
S3	1.03	12.17	12.17	12.17	293	764	1,415
S4	0.97	12.17	12.17	12.17	242	686	1,295
S5	1.85	12.33	12.25	12.25	359	1,043	2,007
S6	0.94	12.25	12.17	12.17	319	744	1,339
S9	1.02	12.25	12.17	12.17	232	658	1,254
S10	1.80	12.25	12.25	12.17	438	1,236	2,350
S7	0.68	12.17	12.17	12.17	306	623	1,061
S8	1.12	12.17	12.17	12.17	323	885	1,650
S13	1.27	12.17	12.17	12.17	388	956	1,734
S11	0.92	12.25	12.17	12.17	214	611	1,161
S12	0.91	12.25	12.25	12.25	368	760	1,307
S14	0.83	12.08	12.08	12.08	340	762	1,336
X1SUB	0.61	12.00	12.00	12.00	406	748	1,216
X2SUB	0.43	12.08	12.00	12.00	256	496	824

TABLE 4.1: SUMMARY OF SKUNK CREEK PEAK DISCHARGES, cont'd

HEC-1 ID	Existing Drainage Area [sq. mi.]	Time of Peak			Peak Discharge		
		2-Year [hours]	10-Year [hours]	100-Year [hours]	2-Year [cfs]	10-Year [cfs]	100-Year [cfs]
X3SUB	0.56	12.08	12.08	12.08	321	632	1,054
X4SUB	0.28	12.00	12.00	12.00	214	382	613
X5SUB	0.38	12.08	12.00	12.00	186	419	727
SUBC1	1.26	12.00	12.00	12.00	484	1,291	2,369
SUBC2	2.19	12.17	12.08	12.08	514	1,575	3,033
SUBC3	1.24	12.08	12.08	12.08	356	1,055	1,990
SUBC4	2.54	12.08	12.08	12.08	696	2,090	3,948
SUBC5	3.39	12.08	12.08	12.08	1,034	2,919	5,426
SUBC7	1.20	12.08	12.00	12.00	734	1,407	2,311
SUBC8	1.42	12.08	12.08	12.08	862	1,583	2,543
SUBC9	0.58	12.17	12.17	12.17	210	510	915
S15	0.99	12.17	12.17	12.17	426	903	1,564
R1	1.56	12.17	12.17	12.17	911	1,638	2,636
R2	1.98	12.17	12.17	12.17	1,003	1,892	3,120
R3	1.59	12.25	12.25	12.25	609	1,208	2,074
S16	1.32	12.17	12.08	12.08	309	1,000	1,930
S21	2.22	12.33	12.25	12.25	868	1,746	2,946
S17	1.03	12.25	12.25	12.25	378	813	1,422
S18	1.71	12.25	12.25	12.25	789	1,529	2,537
S19	0.77	12.08	12.08	12.08	429	827	1,368
S20	1.27	12.25	12.25	12.25	600	1,150	1,900
S22	1.47	12.17	12.17	12.17	348	1,044	1,987
S23	1.72	12.42	12.42	12.42	556	1,184	2,027
S24	0.64	12.08	12.08	12.08	281	642	1,113
Concentration Points							
S2C	3.25	12.42	12.33	12.33	836	2,035	3,760
S3C	4.28	12.25	12.25	12.25	1,036	2,633	4,899
S5C	2.82	12.25	12.25	12.25	564	1,653	3,169
S6C	8.04	12.67	12.58	12.58	1,463	4,063	7,840
S8C	1.80	12.17	12.17	12.17	616	1,491	2,685
S10C	12.66	12.50	12.50	12.50	1,674	4,919	9,741
S12C	1.83	12.33	12.33	12.33	499	1,230	2,246
S13C	15.76	12.50	12.50	12.50	2,070	6,010	11,811
S14RC	16.59	12.67	12.58	12.67	2,083	6,044	11,863
XCO-1	1.04	12.08	12.08	12.08	617	1,174	1,933
XCO-2	1.60	12.17	12.17	12.17	741	1,486	2,500
XCO-3	1.88	12.08	12.08	12.08	856	1,718	2,890
XCO-4	2.26	12.08	12.08	12.08	1,031	2,109	3,571
CCO-1	5.93	12.17	12.08	12.08	1,185	3,921	7,632
CCO-2	10.62	12.42	12.25	12.25	1,460	5,405	10,883
CCO-3	2.62	12.17	12.17	12.17	894	1,684	2,818

TABLE 4.1: SUMMARY OF SKUNK CREEK PEAK DISCHARGES, cont'd

HEC-1 ID	Existing Drainage Area [sq. mi.]	Time of Peak			Peak Discharge		
		2-Year [hours]	10-Year [hours]	100-Year [hours]	2-Year [cfs]	10-Year [cfs]	100-Year [cfs]
CCO-4	15.50	12.42	12.50	12.50	2,144	7,055	13,884
CCO-5	16.08	12.58	12.67	12.67	2,149	6,975	13,747
S14C	32.67	12.67	12.67	12.67	3,845	12,307	24,427
CO-1	3.54	12.25	12.25	12.25	1,519	2,901	4,800
CO-2	5.13	12.58	12.58	12.58	1,699	3,308	5,624
S16C	40.11	12.83	12.92	12.92	4,868	14,001	27,332
S21C	42.33	13.25	13.33	13.33	4,728	13,642	26,688
S18C	2.74	12.33	12.33	12.33	943	1,947	3,343
S19C	3.51	12.25	12.25	12.25	1,222	2,478	4,239
S20C	4.78	12.42	12.42	12.42	1,500	3,070	5,257
S21C2	47.11	13.25	13.33	13.33	4,948	14,049	27,733
S22C	48.58	13.50	13.58	13.58	4,872	13,837	27,283
S23L	50.29	14.08	14.17	14.17	4,712	13,417	26,513
C010	50.29	13.33	13.00	12.83	2,098	4,852	9,825
CAP	63.68	13.50	14.00	14.08	5,413	14,606	28,467
S24C	64.32	13.75	14.17	14.33	5,314	14,436	28,227

TABLE 4-2: SUMMARY OF SKUNK CREEK RUNOFF VOLUMES

HEC-1 ID	Existing Drainage Area [sq. mi.]	Rainfall Excess			Runoff Volume		
		2-Year [in]	10-Year [in]	100-Year [in]	2-Year [ac-ft]	10-Year [ac-ft]	100-Year [ac-ft]
Subbasin Operations							
S1	2.08	0.391	0.925	1.816	43.4	102.6	201.5
S2	1.17	0.490	1.053	1.998	30.6	65.7	124.7
S3	1.03	0.319	0.843	1.669	17.5	46.3	91.7
S4	0.97	0.242	0.749	1.544	12.5	38.7	79.9
S5	1.85	0.237	0.746	1.543	23.4	73.6	152.2
S6	0.94	0.375	0.898	1.793	18.8	45.0	89.9
S9	1.02	0.241	0.748	1.543	13.1	40.7	83.9
S10	1.80	0.243	0.744	1.533	23.3	71.4	147.2
S7	0.68	0.501	1.076	2.043	18.2	39.0	74.1
S8	1.12	0.252	0.752	1.545	15.1	44.9	92.3
S13	1.27	0.535	1.163	2.085	36.2	78.8	141.2
S11	0.92	0.241	0.748	1.542	11.8	36.7	75.7
S12	0.91	0.457	1.013	1.959	22.2	49.2	95.1
S14	0.83	0.656	1.317	2.320	29.0	58.3	102.7
X1SUB	0.61	0.697	1.364	2.447	22.7	44.4	79.6
X2SUB	0.43	0.540	1.143	2.151	12.4	26.2	49.3
X3SUB	0.56	0.461	1.030	1.995	13.8	30.8	59.6
X4SUB	0.28	0.545	1.192	2.282	8.1	17.8	34.1
X5SUB	0.38	0.333	0.831	1.695	6.7	16.8	34.4
SUBC1	1.26	0.202	0.705	1.451	13.6	47.4	97.5
SUBC2	2.19	0.194	0.694	1.431	22.7	81.1	167.1
SUBC3	1.24	0.203	0.716	1.469	13.4	47.4	97.1
SUBC4	2.54	0.192	0.691	1.426	26.0	93.6	193.2
SUBC5	3.39	0.281	0.820	1.610	50.8	148.3	291.1
SUBC7	1.20	0.686	1.384	2.506	43.9	88.6	160.4
SUBC8	1.42	0.718	1.469	2.682	54.4	111.3	203.1
SUBC9	0.58	0.392	0.957	1.882	12.1	29.6	58.2
S15	0.99	0.582	1.180	2.164	30.7	62.3	114.3
R1	1.56	0.775	1.489	2.647	64.5	123.9	220.2
R2	1.98	0.675	1.331	2.397	71.3	140.6	253.1
R3	1.59	0.741	1.385	2.419	62.8	117.4	205.1
S16	1.32	0.180	0.699	1.468	12.7	49.2	103.3
S21	2.22	0.490	1.099	2.120	58.0	130.1	251.0
S17	1.03	0.419	0.954	1.871	23.0	52.4	102.8
S18	1.71	0.512	1.126	2.159	46.7	102.7	196.9
S19	0.77	0.541	1.153	2.174	22.2	47.3	89.3
S20	1.27	0.593	1.239	2.310	40.2	83.9	156.5

TABLE 4.2: SUMMARY OF SKUNK CREEK RUNOFF VOLUMES, cont'd

HEC-1 ID	Existing Drainage Area [sq. mi.]	Rainfall Excess			Runoff Volume		
		2-Year [in]	10-Year [in]	100-Year [in]	2-Year [ac-ft]	10-Year [ac-ft]	100-Year [ac-ft]
S22	1.47	0.210	0.723	1.503	16.5	56.7	117.8
S23	1.72	0.473	1.109	2.170	43.4	101.7	199.1
S24	0.64	0.367	0.920	1.863	12.5	31.4	63.6
Concentration Points							
S2C	3.25	0.416	0.956	1.853	72.1	165.7	321.2
S3C	4.28	0.384	0.918	1.787	87.7	209.5	407.9
S5C	2.82	0.229	0.735	1.520	34.4	110.5	228.6
S6C	8.04	0.304	0.812	1.621	130.4	348.2	695.1
S8C	1.80	0.338	0.863	1.711	32.4	82.8	164.3
S10C	12.66	0.265	0.758	1.528	178.9	511.8	1,031.7
S12C	1.83	0.340	0.867	1.724	33.2	84.6	168.3
S13C	15.76	0.276	0.772	1.540	232.0	648.9	1,294.4
S14RC	16.59	0.289	0.790	1.562	255.7	699.0	1,382.1
XCO-1	1.04	0.631	1.271	2.321	35.0	70.5	128.7
XCO-2	1.60	0.565	1.174	2.186	48.2	100.2	186.5
XCO-3	1.88	0.558	1.171	2.188	55.9	117.4	219.4
XCO-4	2.26	0.515	1.106	2.092	62.1	133.3	252.2
CCO-1	5.93	0.230	0.745	1.494	72.7	235.6	472.5
CCO-2	10.62	0.189	0.679	1.387	107.0	384.6	785.6
CCO-3	2.62	0.690	1.409	2.564	96.4	196.9	358.3
CCO-4	15.50	0.292	0.813	1.599	241.4	672.1	1,321.8
CCO-5	16.08	0.292	0.812	1.598	250.4	696.4	1,370.4
S14C	32.67	0.267	0.764	1.514	465.2	1,331.2	2,638.0
CO-1	3.54	0.707	1.381	2.472	133.5	260.7	466.7
CO-2	5.13	0.705	1.363	2.424	192.9	372.9	663.2
S16C	40.11	0.300	0.800	1.560	641.8	1,711.4	3,337.1
S21C	42.33	0.303	0.803	1.566	684.1	1,812.9	3,535.4
S18C	2.74	0.467	1.045	2.021	68.2	152.7	295.3
S19C	3.51	0.476	1.057	2.033	89.1	197.9	380.6
S20C	4.78	0.499	1.090	2.079	127.2	277.9	530.0
S21C2	47.11	0.310	0.808	1.575	778.9	2,030.1	3,957.2
S22C	48.58	0.304	0.801	1.564	787.6	2,075.3	4,052.2
S23L	50.29	0.304	0.801	1.565	815.4	2,148.4	4,197.5
C010	50.29	0.110	0.239	0.457	295.0	641.0	1,225.7
CAP	63.68	0.320	0.806	1.573	1,086.8	2,737.4	5,342.3
S24C	64.32	0.320	0.805	1.572	1,097.7	2,761.5	5,392.6

4.3 Rainfall Distribution

The hydrologic modeling completed for the WCMP used the 24-hour, SCS Type II distribution. For the FRP study, the HEC-1 models were run using various rainfall distributions in order to compare the effect each distribution had on basin response time, travel time, and the relationship between rainfall depth and the resulting peak discharge through the flood hazard areas.

The following rainfall distributions were used during the FRP hydrologic analysis:

- 24-hour SCS Type II distribution
- 6-hour Maricopa County distribution (from Drainage Design Manual for Maricopa County: Hydrology, 1992)
- Hypothetical distribution
- 4 historical rainfall distributions from FCDMC database (Dates: July 7, 1990; August 14, 1990; February 28, 1991; August 31, 1993)

The effect that using various rainfall distributions had on basin response time and the selection of rainfall trigger levels for the ALERT system is discussed in subsequent sections. Plots of each distribution are included in Appendix C-1.

4.4 Basin Response Time

Basin response time is defined for purposes of the FRP study as the lag time between the time of peak rainfall intensity and the time of peak discharge at the concentration point(s) nearest to the ALERT gage location(s). The calculated basin response time varied according to gage location and the rainfall distribution being used. Table 4-3 shows a comparison of the basin response time calculations. Appendix C-1 contains plots of each rainfall distribution and the resulting

hydrograph at each gage station. Based on these results, a basin response time of 20 minutes was selected for calculation of the hydrologic lead time for implementation of the action plan.

TABLE 4-3: COMPARISON OF BASIN RESPONSE TIME RESULTS

	BASIN RESPONSE TIME [min]	
RAINFALL DISTRIBUTION	**SKUNK CREEK GAGE (CP* S3C)**	**CLINE CREEK GAGE (CP CC0-2)**
24-hour SCS Type II	20	20
6-hour Maricopa County	25	25
Hypothetical	35	35
Historical 7-7-90	20	20
Historical 8-14-90	20	20
Historical 2-28-91	20	20
Historical 8-31-93	20	20

*CP = HEC-1 concentration point

4.5 Travel Time

Travel time is defined for purposes of the FRP study as the time period between peak discharge at the ALERT gage site and peak discharge at the downstream flood hazard area. The total hydrologic lead time is the sum of the basin response time and the subsequent travel time. Travel time to each flood hazard area was calculated using the results of hydraulic modeling.

Average travel time is a HECRAS output variable that is calculated by dividing the reach length by the flow velocity. Travel time from the Skunk Creek gage was

taken directly from the hydraulic model output. Travel time from the Cline Creek gage to Skunk Creek had to be calculated from the HEC-2 model flow velocities, because it is not a HEC-2 output variable.

Table 4-4 shows the travel times used in calculating the total hydrologic lead time for the FRP. The table also shows which watercourses contribute to the total flow through each flood hazard area.

TABLE 4-4: SUMMARY OF TRAVEL TIME CALCULATIONS

FLOOD HAZARD GROUP	FROM GAGE SITE	TRAVEL TIME [min]
Zorrillo Drive	Skunk	23
Cline Creek	Cline	17
Honda Bow Road	Skunk	37
	Cline	22
Desert Hills Drive	Skunk	57
	Cline	44

4.6 Threshold Alarm Levels

The threshold rainfall intensities and streamflow discharges that will trigger each level of alert in the FRP were selected by the District. These threshold values are based upon the results of hydrologic models of the Skunk Creek basin using rainfall distributions derived from historical data for two storm events of 2.5- and 5-hour duration. Threshold precipitation depth plots are shown in Appendix C-2. The resulting flood detection criteria are provided in Table 3-1.

4.7 Storm Recurrence Interval Estimation

In order to estimate the probability of flooding for each structure, storm recurrence interval curves were plotted from HEC-1 modeling results. The curves are shown in Appendix C-3. Each flood hazard area has a separate curve, plotted from data for the nearest concentration point. Peak flows during the 2-year, 10-year, and 100-year storms were plotted on 2-cycle log normal graph paper (Figure 9-4 in the ADOT Highway Drainage Design Manual, Hydrology) and a smooth curve was drawn through the points.

The curves were used to estimate the return interval of the storm that would cause flooding to reach the finished floor elevation of each structure (or the ground adjacent to mobile homes). The probability of flooding for each structure is included in the hydraulic modeling results, shown in Tables 5-1 through 5-4.

SECTION 5: HYDRAULIC ANALYSIS

5.1 General

The base hydraulic data used for this study was developed as part of the WCMP. Refer to Skunk Creek Watercourse Master Plan, Attachment 4: Hydraulics and Sediment Report, for the complete supporting documentation. The effective FIS model for Skunk Creek is a HEC-2 model prepared by Montgomery Watson for the Skunk Creek Floodplain Delineation Study, June 1997. This model was converted to HECRAS format and used as the base WCMP model.

The effective FIS models for Cline Creek and Rodger Creek were also used in this study. Those HEC-2 models were prepared in December 1989 by Michael Baker, Jr., Inc. and revised by the Flood Control District of Maricopa County in February 1996.

HEC-2 models were run using the U.S. Army Corps of Engineers HEC-2 computer program, as implemented by Dodson & Associates, Inc. in their ProHEC2 Plus software, Version 4.6.2PD, July 1995. HECRAS models were run using the U.S. Army Corps of Engineers HECRAS (River Analysis System) program, Version 3.0.1, March 2001. Refer to the FRP work map (digital file provided on the attached CD-ROM), which shows the location of cross-sections used in hydraulic modeling.

5.2 Analysis of Flood Hazards for Floodway Structures

The base WCMP 100-year storm model was modified to include a cross-section for each home in the floodway. This was done in order to obtain, as accurately as possible, the 100-year water surface elevation at each structure. Model results were used in conjunction with the surveyed finished floor elevations to determine the depth of flooding at each structure.

The flow required to just reach the finished floor elevation of each structure was also determined using the HECRAS model. This information was used to estimate the probability of flooding for each structure. The storm recurrence interval curves discussed in Section 4.7 were used to estimate the return interval of the storm that would cause flooding to reach the finished floor elevation.

For mobile homes, the probability of flooding was calculated using the adjacent ground elevation in lieu of the finished floor elevation. Most of the mobile homes are not flooded, because they are set up on foundation piers that raise the finished floor a few feet above the adjacent ground. However, floodwaters flowing underneath a mobile home will likely erode the soil under the foundation piers and cause the structure to fall into the water. For this reason, the adjacent ground elevation was used for mobile home flood hazard calculations.

The threshold inundation frequency data is summarized in Section 5.6.

5.3 Analysis of Flood Hazards for Residences Not Surveyed

Most of the homes that are located in the Severe Erosion Hazard Zone, but outside of the floodway, were not surveyed for finished floor and adjacent ground elevations. Elevations for these structures were taken from the WCMP topographic mapping. For calculating the probability of flooding, it was assumed that finished floor elevations were one foot above the estimated ground elevation. The flow required to reach this elevation was determined using the HECRAS model. Cross-sections were not added to the model for these structures; instead, the water surface elevation was interpolated between the two cross-sections bordering the structure. The storm recurrence interval curves discussed in Section 4.7 were used to estimate the return interval of the storm that would cause flooding to reach the assumed finished floor elevation.

For mobile homes in the floodplain, the probability of flooding was calculated in the same manner as it was for mobile homes in the floodway. The estimated ground elevation was used for mobile home flood hazard calculations.

5.4 Roadway Overtopping

The roadway crossings listed in Table 2-1 were analyzed for overtopping during the 100-year event. The WCMP HECRAS model was used to determine the relationship between discharge, flow depth, and flow velocity at each Skunk Creek crossing. The roadway elevations were estimated from WCMP topographic mapping. The New River Road bridge at Skunk Creek was already included in the WCMP model. For the 19th Avenue and Desert Hills Drive crossings, cross-sections were added to the model. The Cloud Road/ 27th Avenue culverts were assumed to be full and roadway overtopping was calculated using cross-sections 17.95 through 18.29. Overtopping of the remaining Skunk Creek dip crossings was estimated using adjacent cross-sections.

Approximately 900 feet north of the New River Road bridge, breakout flow from Skunk Creek overtops the roadway when flow in the channel exceeds approximately 3,000 cfs. The flow that breaks out of Skunk Creek and overtops the road at that location was estimated using the HECRAS split flow routine. To model this crossing, the roadway elevation of New River Road from the Skunk Creek bridge north to the floodplain boundary was surveyed at 50-foot intervals. The discharge/ flow depth/ velocity relationship at a dip in that section of road was calculated using Manning's equation and the roadway profile.

As-built drawings were obtained for the New River Road bridge over Cline Creek. These plans show that the bridge passes the 100-year event without overtopping. The Cline Creek bridge was assumed to have 100-year capacity for the purposes of this FRP. Rodger Creek

crosses New River Road through two 8-foot diameter culverts. This crossing is modeled in the effective FIS HEC-2 model, which was used to analyze overtopping at that location.

Appendix D-2 contains a plot for each crossing showing the flow depth versus flow velocity. These plots were used to determine the threshold flow, velocity, and depth for each crossing. The threshold values represent the point where the depth/ velocity curve intersects the lower boundary of the Judgment Zone. Table 5-5 shows the threshold values for each crossing.

5.5 Split Flows

Two split flow analyses were prepared as part of the FRP study; one each at the New River Road bridge crossing and in the area of Desert Hills Drive. HECRAS, version 3.0.1, was used to conduct the split flow analyses. Since no structures were determined to be located in the floodway or Severe Erosion Hazard Zone in the vicinity of the New River Road bridge, this area was not included in the FRP. The split flow near Desert Hills Drive potentially impacted residential structures; therefore, this area was further investigated.

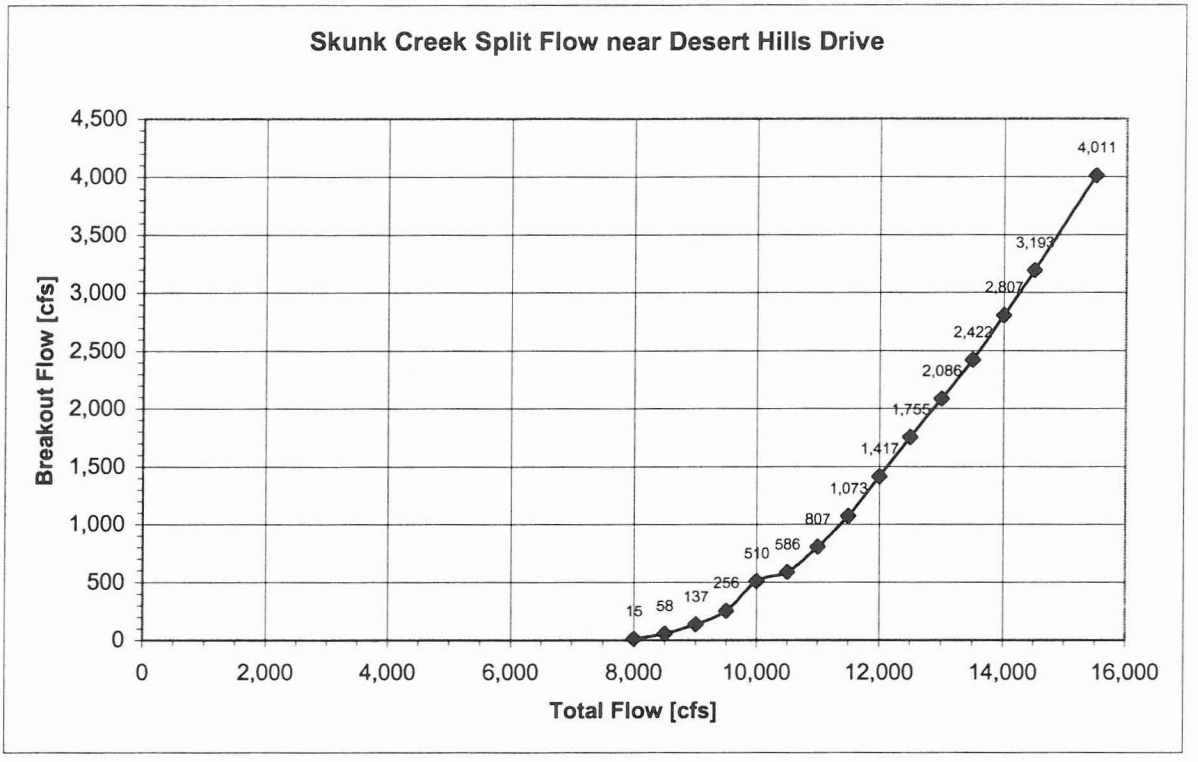
Figure 5-1 shows the area where the flow split affects homes located on the left overbank, downstream of Desert Hills Drive. A small secondary channel on the left overbank begins near cross-section 21.41 and continues downstream, ultimately leading into a section of braided channel near cross-section 20.16. In order to estimate the probability of flooding for homes along the secondary channel, a split flow analysis was performed. Floodwaters reach the homes in this area via the secondary channel well before flow in the main channel reaches an elevation high enough to overtop the left channel bank. For the purposes of this study, the ridge of high ground on the left overbank between cross-sections 20.79 and 21.41 was modeled as a broad-crested lateral weir with a coefficient of 2.6.

A rating curve, shown in Figure 5-2, was developed to show the relationship between breakout flow and the total flow in the channel. The secondary channel is small enough and close enough to the main channel that flow submerges the "weir" and becomes one unbroken flow during storms much less severe than the 100-year event. For this reason, the rating curve was only used for total flows of 15,500 cfs or less. The storm recurrence interval associated with flows higher than 15,500 cfs was estimated using results from the WCMP HECRAS model without the split flow option.

Figure 5-1

Desert Hills Drive Split Flow Area

FIGURE 5-2: RATING CURVE FOR DESERT HILLS DRIVE FLOW SPLIT



5.6 Modeling Results

Summaries of the hydraulic modeling results for homes in the floodway and Severe Erosion Hazard Zone are shown in Tables 5-1 through 5-4. The tables are presented by flood hazard groups described in Section 2.3. Supporting data is included in Appendix D-1. Roadway overtopping results are shown in Table 5-5, with supporting data in Appendix D-2.

TABLE 5-1: PROBABILITY OF FLOODING FOR ZORRILLO DRIVE GROUP

Parcel #	Tag ID	Name	Structure	HECRAS Q_{100} [cfs]	Q_{FFE} (or Q_{ground}, mobiles) [cfs]	Return Frequency to FFE/EGE	FW	FP
202-21-008T	579	Kraus Investmnt	Mobile	11,800	4,400	6-yr		X
202-21-008T	579	Kraus Investmnt	Mobile	11,800	5,000	8-yr		X
202-21-150	826	Parry	Mobile	9,700	5,000	13-yr		X
202-21-031Q	639	Sartain	House 1	11,800	>11,800	>100-yr	X	

*FFE = finished floor elevation (houses), EGE = estimated ground elevation (mobile homes)

TABLE 5-2: PROBABILITY OF FLOODING FOR CLINE CREEK GROUP

Parcel #	Tag ID	Name	Structure	HECRAS Q_{100} [cfs]	Q_{FFE} (or Q_{ground}, mobiles) [cfs]	Return Frequency to FFE/EGE	FW	FP
202-21-031C	634	Selleys	House	16,700	10,600	40-yr	X	
202-21-032A	647	Caldwell	House	16,700	13,300	91-yr	X	

TABLE 5-3: PROBABILITY OF FLOODING FOR HONDA BOW ROAD GROUP

Parcel #	Tag ID	Name	Structure	HECRAS Q_{100} [cfs]	Q_{FFE} (or Q_{ground}, mobiles) [cfs]	Return Frequency to FFE/EGE	FW	FP
211-22-002B	5	McKeag	House	24,400	8,000	5-yr	X	
202-21-169	847	Hines	House	24,400	8,000	5-yr	X	
202-21-024B	616	Albert	House	24,400	12,200	13-yr	X	
211-22-002J	6	Geraci	Mobile	24,400	13,500	16-yr	X	
202-21-013R	585	Eller	House	24,400	18,000	34-yr	X	
202-21-013M	584	Funk	House	24,400	19,000	42-yr		X

TABLE 5-4: PROBABILITY OF FLOODING FOR DESERT HILLS DRIVE GROUP

Parcel #	Tag ID	Name	Structure	HECRAS Q_{100} [cfs]	Q_{FFE} (or Q_{ground}, mobiles) [cfs]	Return Frequency to FFE/EGE	FW	FP
211-50-022	62	Hopwood Trust	Mobile 3	27,300	9,000	5-yr	X	
211-50-022	62	Hopwood Trust	Mobile 2	27,300	11,700	8-yr	X	
211-50-016J	84	Harper	Mobile 1	27,300	13,000	11-yr	X	
211-50-037C	104	Mathis	Mobile	27,300	13,600	12-yr	X	
211-50-016J	84	Harper	Mobile 3	27,300	13,500	12-yr	X	
211-50-016J	84	Harper	Mobile 2	27,300	14,250	13-yr	X	
211-50-022	62	Hopwood Trust	Mobile 1	27,300	15,000	15-yr	X	
211-50-037C	104	Mathis	House	27,300	19,600	31-yr	X	
211-50-016H	929	Birdsell	Mobile	27,300	25,000	71-yr	X	
211-50-022	62	Hopwood Trust	House 2	27,300	25,000	71-yr		X
211-50-022	62	Hopwood Trust	House 1	27,300	27,300	100-yr	X	
203-32-006	148	Parks*	Mobile	27,300	n/a	n/a		

*The Parks residence is located in the Severe Erosion Hazard Zone, but outside of the 100-year floodplain.

TABLE 5-5: ROADWAY CROSSING MODELING RESULTS

Watercourse	Roadway	Type	Threshold Depth [ft]	Threshold Flow [cfs]	Threshold Velocity [ft/s]
Skunk Creek	New River Road north of the bridge	At-grade	1.7	5,800	3.8
	New River Road at the bridge	Bridge	N/A	N/A	N/A
	Shangri La Lane	At-grade	1.7	250	3.0
	Circle Mountain Road	At-grade	1.7	350	4.0
	Honda Bow Road	At-grade	1.9	200	3.8
	Desert Hills Drive	At-grade	1.6	400	4.2
	19th Avenue	At-grade	1.7	1,250	3.3
	Cloud Road/27th Ave	Culvert	1.8	16,000	2.0
Cline Creek	New River Road	Bridge	N/A	N/A	N/A
Rodger Creek	New River Road	Culvert	1.8	2,500	1.6

N/A = Bridge is not overtopped during the 100-year event

SECTION 6: FLOOD RESPONSE PLAN

6.1 General Background

The District has maintained and operated a rain gage and a stream gage in the Phase 2 study reach of upper Skunk Creek since 1981 and 1995, respectively. Those gage data, in combination with rainfall and streamflow data from gages located downstream at the I-17 crossing at Skunk Creek, are used by the District to support the following functions:

- Flood Warning - The primary flood warning use of the Skunk Creek gages has been to provide data for evaluation of the performance and safety of Adobe Dam located downstream. Additionally, the collected data provide advisory information in support of road closure decisions during flood events.

- Data Collection/ Archive - The data continue to be incorporated into rainfall and streamflow databases maintained by the District. These databases provide critical data for the design and evaluation of engineered structures in the Skunk Creek watershed as well as elsewhere around Maricopa County and the State of Arizona.

District staff report that the existing flood warning system has been adequate thus far to meet the flood warning needs in the Skunk Creek watershed as described above. However, since June 1995 when the "Skunk Creek near New River" stream gage was installed, no extreme flood events have occurred. In consideration of the potential impacts of larger floods to structures and roadway crossings in the Phase 2 study area, an assessment of the need for flood warning for this area was justified.

6.1.1 Flood Warning System (FWS) Needs Assessment

The necessary elements and objectives of the Skunk Creek FWS were assessed by:

- Considering the information provided by the District's existing Automated Local Evaluation in Real Time (ALERT) sensor detection network in the watershed;
- Comparing the flow rate at which overbank flooding occurs with the precipitation necessary to produce that flow rate;
- Determining the locations of structures and road crossings in the floodway, floodplain, and Severe Erosion Hazard Zone; and
- Examining the travel time to these locations from existing and planned stream gages as well as the approximate frequency of the beginning of inundation at these locations.

The results of the assessment indicated that the primary need for flood warning in the Skunk Creek watershed is for closure of at-grade road crossings. A secondary need for larger floods is the warning and evacuation of structures which are located within the Skunk Creek floodway and those structures located outside the floodway, but within the Severe Erosion Hazard Zone. The rapid basin response time of streams in the Skunk Creek watershed and the somewhat remote location of the area limit the nature of, and means for, flood warning. Finally, development within the downstream portions of the study area may change the flood warning needs as future development proceeds. Flood warning needs should be re-evaluated as development occurs.

6.1.2 Flood Warning System Components

An effective flood warning system combines several vital elements. The first element is the ability to detect and evaluate a flood threat in its early stages and make a decision to warn the public before flood damages or personal injuries occur. The second element is the

dissemination of the warning to the public at risk. The third element is the public response to the warning. The fourth element is the post-flood action plan. The following is a brief description of each of these components relative to the Skunk Creek FWS.

6.1.2.1 Flood Detection

The earliest recognition of a potential flood threat for the Skunk Creek basin will be the forecast products available from the District and NWS. The Precipitation Outlook (PO) forecast provided by the Flood Control District of Maricopa County Meteorological Services Program (MSP) provides an initial daily assessment of the flooding potential of the atmosphere and a basin-specific quantitative precipitation forecast (QPF). The MSP provides, via broadcast fax, a series of flood alert messages of increasing severity and urgency to agencies participating in the program. The MSP service supplements standard NWS forecast products and the flash flood watch and flash flood warning messages issued by the NWS. MSP forecasts and messages are more site-specific to the Skunk Creek watershed. District MSP messages are coordinated with the NWS Weather Forecast Office at Phoenix. Depending on staffing and personnel assigned by the District, FCDMC flood alert messages and NWS flash flood watches and flash flood warnings could be issued in an agreed upon sequence to residents in areas impacted by flooding along Skunk Creek. The flood warning message suite is described in more detail in Section 6.4.

The automated rain gages and stream gages in the Skunk Creek basin and adjacent watersheds transmit rainfall data and real-time streamflow measurements to District personnel and the NWS. The effectiveness of the Skunk Creek FWS is highly dependent upon adequate rainfall and streamflow data collected by the sensors comprising the flood detection network for the Skunk Creek watershed. Therefore, one new stream gage and three new rain gages are scheduled to be installed to supplement the existing rain and stream gages on Skunk Creek near New River (#5580 and #5583, respectively). The new stream gage is planned on Cline Creek, a major tributary that joins Skunk Creek downstream of the existing stream gage. In addition, a new rain gage will be co-located at

this site. One new rain gage is planned for each of the upper watersheds of Skunk and Cline Creeks. These new gages should substantially improve the hydrologic data available for the District to support decisions concerning road closures and trigger the flood response plan action protocols based upon pre-determined flood detection criteria and sensor threshold alarms. More information about the flood detection network and detection criteria is provided in Section 3.

6.1.2.2 Information Dissemination

An interim program to disseminate flood warning messages to the public and to emergency response agencies is recommended to the District, and could be accomplished using NOAA weather radios and pagers. Notification via multiple paths is provided for redundancy and robustness of the FWS. The NWS will issue warning messages to the public via:

- Emergency Alert System (EAS) – The system consists of radio and television broadcast stations in the Phoenix operational area that are responsible for disseminating emergency information and warnings to the public. EAS broadcasts by commercial media are voluntary, but experience shows that the stations regularly transmit NWS messages.

- NOAA Weather Radio (NWR) – NWS issues flash flood watch and flash flood warning messages via NOAA Weather Radio according to standard protocol using tone alarms followed by voice messages.

The District's program could then send text flood alert messages via pager to residents in the Skunk Creek floodway and Severe Erosion Hazard Zone, as appropriate. The District's flood alert messages would be sequenced with the NWS flash flood watch and flash flood warning message suite. Information dissemination and communication means and paths are described in Section 6.3.

6.1.2.3 Emergency Flood Response

Once a potentially hazardous flood event is detected and this information is communicated to appropriate agencies and affected individual parties, those entities must implement emergency response activities. The recommended response component of the FWS for the Skunk Creek warning area consists of three primary components: Technical Memorandum, Flood Response Plan Field Book, and the Flood Response Plan Menus. These are described in Section 1.3 of this document and in the FRP Field Book Introduction.

6.1.2.4 Post-Flood Action Plan

Post-flood actions include, but are not limited to, criteria for re-occupation of structures, an After-Action Report, relations with the news media, and government assistance for flood victims (both private and agencies). The Skunk Creek Flood Response Plan is intended to be added as an Appendix to the FCDMC Flood Emergency Response Manual and the MCDEM Emergency Operations Plan. Post-flood action protocols, as addressed in both the FCDMC and MCDEM documents, are incorporated by reference herein to the Skunk Creek Flood Response Plan Report, Technical Memorandum, and FRP menus. Refer to the FCDMC and MCDEM documents for further information.

6.2 Lead Time Estimation

The methodology for estimation of lead time for the Skunk Creek Flood Response Plan was adopted from the Wickenburg Flood Response Plan (FCDMC, 1999). The following definitions and descriptions of procedures for the determination of hydrologic, decision, action, and effective lead times are replicated below in italics from those respective sections of the FCDMC Wickenburg Flood Response Plan Technical Addendum (1999). Modifications to that text relative to the Skunk Creek FRP are shown in normal font.

> *The design of an effective flood response plan is driven by the amount of lead time available for response agencies to mobilize and implement*

emergency response efforts. The hydrologic lead time is set by the basin response to rainfall. The travel time of the runoff to flood vulnerable areas is set by hydraulic characteristics of the conveyance channels to those areas. The sum of basin response time and hydraulic travel time constitutes the hydrologic lead time. The emergency response time is determined by the decision time needed to assess the flood event and issue warnings, and by the readiness of the local emergency response agencies to implement the appropriate action plans.

The balance of hydrologic lead time relative to emergency response time comprises the effective lead time. The magnitude of the resulting effective lead time determines whether the flood response plan for a particular watershed is ***proactive*** *– triggered by the prediction of the runoff-producing rainfall – or* ***reactive*** *– relying on the detection of the event by watershed instrumentation – or a* ***combination of both****.*

The FRP for the Skunk Creek warning area is divided into groups, or clusters, of at-risk structures according to geographic location along the watercourse. For each group, the travel time increases with increasing downstream distance, thereby increasing hydrologic lead time and effective lead time. Decision makers in a flood emergency **must exercise caution** in the use of, and reliance upon, the lead times provided in Table 6-1. These lead times are **estimates only**, based upon the best available technical information, and **should not be strictly interpreted. They should only be used as an indicator of the urgency of the necessary response actions and as a decision-making tool for prioritization of the response activities.**

6.2.1 Hydrologic Lead Time

Hydrologic lead time refers to the response time of a watershed to runoff-producing rainfall. This ***basin response time*** *is defined as the lag time from the occurrence of the highest rainfall intensity to the time of peak discharge. Basin response times are estimated for the* Skunk Creek groups of flood vulnerable structures (as described in Section 4.4). *Hydraulic* ***travel time*** *is the estimated time the flood takes to travel from an upstream location to the identified flood vulnerable areas downstream.* Section 4.5 *addresses the calculation of hydraulic travel time to* each of the Skunk Creek groups. Those findings are presented in Columns (3) and (4) of Table 6-1, respectively. *The sum of the basin response and travel lead times constitutes the* ***hydrologic lead time*** *for those watercourses.*

The optimal use of the hydrologic lead time period is to place the emergency response agencies on a heightened level of awareness to the potential flooding problem. Depending on the severity of the potential flooding problem, varying degrees of awareness and action may be evoked. In effect, the hydrologic lead time should provide enough time to avoid flooding surprises to the response agencies and afford them the opportunity to prioritize response in an orderly fashion. The hydrologic lead time may be provided by weather prediction, radar observation of the storm, or the alarm response of a flood detection network's rain or stream gages to observed rainfall or steam flow (as described in Section 3).

6.2.2 Decision/ Action Lead Time

The emergency response time is determined by the decision time needed to assess the flood event and issue warnings, and by the readiness of the local emergency response agencies to implement the appropriate action plans.

*The **decision lead time** refers to the amount of time required by the meteorologist and/or hydrologist to:*

1. *verify that a flash flood or flooding problem is imminent based on prediction tools or that flooding is occurring based on detection data;*
2. *identify the relative magnitude of the flooding event based on pre-determined criteria; and*
3. *issue the appropriate alert warning to local response agencies so that the applicable FRP action plans may be triggered.*

In effect, the decision lead time is a measure of the amount of time required by technical experts to verify that a problem exists and to issue a warning. Decision lead times are estimated for Skunk Creek warning area, as shown in Columns (5) and (6) of Table 6-1. The decision lead time component was estimated by interviews with staff of the District Flood Warning Branch and National Weather Service Phoenix Office. A range of values is included to account for variation in the degree of complexity in interpreting data and information from incoming sources.

*The **action time** component is the sum of the time required by the response agencies to acknowledge and respond to the flood alert messages, commit resources to the various components of the action plans, and to implement the appropriate response action.*

The action lead time values for the selected information dissemination method (Option E as described in Section 6.3.2) are shown in Columns (7) and (8) of Table 6-1. They were

obtained by interviewing appropriate staff of the City of Phoenix 911 Central Alarm, Maricopa County Department of Emergency Management, and Daisy Mountain Fire Department. A range of values is provided to account for unforeseen difficulties in flood response activities inherent to any given flood event.

6.2.3 Effective Lead Time

> *The **effective lead time** available for the implementation of a flood response plan is the time period afforded* to the residents of the floodway and Severe Erosion Hazard Zone to evacuate *before a flood reaches inescapable proportions. The estimate of that critical evacuation window, the comparative balance of the hydrologic lead time to the emergency response lead time, is evaluated.*

The evaluation of the effective lead time for the flood vulnerable areas of the Skunk Creek floodway indicates that those values vary considerably, as shown in Columns (9) and (10) of Table 6-1. Those lead times range from negative values – implying the need for strong predictive capabilities for flooding in the Skunk Creek basin – to relatively small positive values – signifying that the project team must focus on minimizing the emergency response times with the most efficient information dissemination tools possible. This approach will minimize reliance upon prediction of precipitation and flood events as much as possible.

TABLE 6-1: LEAD TIME FOR FLOOD VULNERABLE AREAS BY GROUP

Group (1)	Location (2)	Hydrologic Lead Time		Emergency Response Time				Effective Lead Time	
				Decision Time		Action Time (Option E)			
		Basin Response [min] (3)	Travel Time [min] (4)	Minimum [min] (5)	Maximum [min] (6)	Minimum [min] (7)	Maximum [min] (8)	Minimum [min] (9)	Maximum [min] (10)
Zorrillo Drive	First inundated home: Kraus Invest. mobiles	20	23	10	15	10	40	-12	23
	Shangri La Lane	20	23	10	15	10	40	-12	23
Cline Creek	First inundated home: Selleys house	20	17	10	15	10	40	-18	17
Honda Bow Road	First inundated home: McKeag house	20	20	10	15	10	40	-15	20
	Honda Bow Road	20	20	10	15	10	40	-15	20
	Circle Mountain Road	20	20	10	15	10	40	-15	20
	Rodger Creek crossing	20	20	10	15	10	40	-15	20
Desert Hills Drive	First inundated home: Hopwood Trust mobile	20	42	10	15	10	40	7	42
	Desert Hills Drive	20	42	10	15	10	40	7	42
	19th Avenue	20	42	10	15	10	40	7	42
	Cloud Rd / 27th Ave.	20	42	10	15	10	40	7	42

6.3 Information Dissemination

The range of effective lead times from negative to positive values directly influences the options available for dissemination of District flood alert messages and NWS flash flood watches and flash flood warnings to the emergency response agencies and to the public. First, a highly reliable and efficient, almost instantaneous, means of communicating flood warning messages to the emergency response agencies is necessary to minimize the action time required to implement the agency emergency response plans. Second, due to minimal effective lead time and the wide spatial distribution of the property owners in flood vulnerable areas of the floodway, those property owners need to be warned of impending and/or occurring flood events on an individual basis in order to minimize the time required for implementing individualized emergency action plans and for evacuating to the destination sites.

6.3.1 Information Dissemination Options

Initially, four information dissemination options (A through D) were evaluated. Option E evolved after sirens were not favorably considered for inclusion in the Skunk Creek FWS and pagers were substituted as viable alternatives to provide redundancy for warning messages transmitted via the NOAA Weather Radio system. The options considered are listed below:

A Emergency Notification Program (ENP) Telephone System/ Sirens
B Tone Alert Receiver/ Sirens
C NOAA Weather Radio/ Sirens
D Traditional Door-to-Door Notification
E NOAA Weather Radio/ Pagers

A summary matrix is provided in Table 6-2 of action times, effective lead times, key features, cost, implementation, and viability for side-by-side comparison of each option.

TABLE 6-2: SUMMARY MATRIX OF INFORMATION DISSEMINATION OPTIONS

DECISION CRITERIA	A ENP TELEPHONE SYSTEM/ SIRENS	B TONE RECEIVER/ SIRENS	C NOAA RADIO/ SIRENS	D TRADITIONAL	E NOAA RADIO/ PAGERS
Action Time Range (minutes)	5 to 35	5 to 35	10 to 40	30 to 60	10 to 40
Effective Lead Time Range (minutes)	-16 to 47	-16 to 47	-21 to 42	-41 to 22	-21 to 42
Key Features	▪ Turn-key system ▪ Remote activation ▪ Multiple messages ▪ Instantaneous action time ▪ Siren redundancy	▪ Turn-key system ▪ Remote activation ▪ Multiple messages ▪ Instantaneous action time ▪ Siren redundancy	▪ Existing system ▪ Remote activation ▪ Multiple messages ▪ ~ Instantaneous action time ▪ Siren redundancy	▪ FCDMC contacts MCDOT for barricades ▪ Individuals contact response agencies via 911 system	▪ Existing system ▪ Remote activation ▪ Multiple messages ▪ ~ Instantaneous action time ▪ Pager redundancy
Cost	▪ Set-up - $16,500 ▪ Monthly - $0.05/ line/ month ▪ Event-specific - $0.23/ 30 sec of connect time ▪ Sirens – 3 @ $12,000 ea., in place ▪ MCDEM sirens may be available	▪ Receivers - $221 ea. ▪ Sirens – 3 @ $12,000 ea., in place ▪ MCDEM sirens may be available ▪ Encoder - $495 ▪ Portable 2-way radio	▪ Radios - $20-60 ea. ▪ Sirens – 3 @ $12,000 ea., in place ▪ MCDEM sirens may be available ▪ Unknown costs for MCDEM siren installation and encoder hardware	▪ None beyond current funding	▪ Radios - $20-60 ea. ▪ Pagers - $10.95-13.95 ea./ month lease OR $139 ea. to purchase ▪ Paging Service - $3.50/ month/ pager w/ purchase option only ▪ Group Paging Service - $1.50/ month/ pager
Implementation	▪ 6 – 8 weeks for study area ▪ County-wide implementation planned in about 1 year	▪ Requires County license to operate select frequencies ▪ Orders must be placed by June 11, 2001	▪ Requires timely coordination between agencies ▪ Potential FEMA grant program to fund radio distribution	▪ Currently in place	▪ Requires timely coordination between agencies ▪ Requires timely procurement of radios and pagers ▪ Signal strength and transmission issues may exist
Viability	Long-term viability, but not before August 2001	Viable by August 2001	Viable by August 2001	Least effective lead time of four options evaluated	Viable by August 2001 w/ timely procurement

The Skunk Creek WCMP Steering Committee met on June 5, 2001 to evaluate information dissemination options A through D, among other agenda items. The Steering Committee directed the project team to proceed with Option C - NOAA Weather Radio/ Sirens. Justification for this decision included the following:

- **Option A:** The Emergency Notification Program (ENP) telephone system offers the most expedient information dissemination method evaluated. It offers turn-key implementation, instantaneous action time, expandability to other geographic areas, message flexibility, and after-event reporting, but it is expensive to deploy at such a small scale. Current plans by the Maricopa County 911 Oversight Committee include county-wide implementation of this system in about one year. The immediate flood warning needs of the Skunk Creek watershed require shorter-term solutions. In addition, sirens were not favorably considered for reasons described under Option C below.

- **Option B:** While the Tone Alert Receiver/ Siren system satisfies key decision criteria, it is costly to implement in the short-term given the pending county-wide launch of the ENP telephone system. In addition, sirens were not favorably considered for reasons described under Option C below.

- **Option C:** The NOAA Weather Radio/ Siren system offers similar advantages compared to Option B and utilizes the existing Weather Radio notification system. Option C minimizes short-term investment in equipment, while providing almost instantaneous flood warning capabilities with proper advance preparations of warning message formats. Sirens were included in Options A, B, and C to provide redundancy and robustness to the FWS, but the District elected to not use sirens at a subsequent meeting on June 26, 2001. This was due to District concerns about false alarms and the potential for confusion on the part of residents between siren alarms for flood warning and siren alarms for other types of emergencies that require

response from the Maricopa County Sheriff's Office, Rural Metro Fire Department, and Daisy Mountain Fire Department. Some residents also indicated at the Public Open House held on June 28, 2001 that they would prefer not to have sirens disturbing the rural quiet that they had moved to Skunk Creek to enjoy.

- **Option D:** The current Traditional Door-To-Door Notification for the Skunk Creek study area is reliable, but it does not provide the necessary effective lead times due to the flashy basin response to rainfall and rapid travel times in the channels.

6.3.2 Recommended Option

A June 8, 2001 meeting was held to discuss the necessary steps required to implement information dissemination Option C, using the existing NOAA Weather Radio Service and fixed outdoor sirens, to provide weather alert and flood warning to residents located in the Skunk Creek warning area. The agencies represented at that meeting included the Flood Control District of Maricopa County (FCDMC), National Weather Service (NWS), Maricopa County Department of Emergency Management (MCDEM), and Arizona Division of Emergency Management (ADEM).

The group consensus was that the use of NOAA Weather Radio for this purpose was feasible; however, it was not possible to install the sirens in time to meet the August 2001 implementation deadline. In addition, other concerns about potential confusion on the part of residents as to the significance of siren alarms for floods versus other, more common, emergencies were discussed. The consensus was that sirens would not be preferred for use for flood warning in Skunk Creek. The use of a group paging system was identified as a viable alternative to the sirens. Under this scenario, residents at risk due to Skunk Creek flooding would be equipped with a pager, a NOAA Weather Radio, and a Flood Response Plan "menu" describing their individualized action plan in the event of a flood emergency. This program could be launched on or about the August 2001 deadline, depending upon timely procurement of the pagers and radios.

The group discussed the inter-agency coordination and warning message sequence and content. It was agreed that both the District and NWS would initiate messages in an alternating sequence to Skunk Creek residents as listed below and as described in detail in Section 6.4:

- FCDMC would send text weather alert and flood warning messages via pager; and
- NWS would issue flash flood watch and flash flood warning tone alarms followed by voice messages via the NOAA Weather Radio Service.

Some concerns were expressed about interference of pager and radio messages in the Skunk Creek basin and NWS agreed to investigate the signal strength for NOAA Weather Radio reception in the study area. A field test of a text message pager and a weather radio was subsequently conducted on July 6, 2001 during weather conditions typical of that to be expected during a flood event with full cloud cover and moderate rain. The pagers performed very well, even when positioned in the bottom of the Skunk Creek channel. In every location tested, the pagers received the flood warning message text encoded using the Internet.

The NOAA Weather Radio (NWR) performed less well with static reception in certain locations. The NWR seemed more susceptible to signal interference due to topography, with reception ranging from marginal to good depending upon location. It was decided that the District would proceed with the use of NWR as a means of transmitting NWS flash flood watch and flash flood warning messages to Skunk Creek residents. The pager will provide the means for transmitting the more site-specific, District-generated flood alert messages. It is recommended that a house-to-house evaluation of NWR reception be conducted and documented once the radios are distributed to the residents. If NOAA Weather Radio reception proves to be an ongoing problem, then additional transmitting capacity may need to be acquired for this system to function with full reliability. Issues of transmitter power, location, and cost will need to be addressed at that time. Alternatively, a weather paging service offered by private vendors is also an option. A weather paging

service could automatically dial-up pagers encoded with a 6-digit code for Phoenix and Maricopa County when NWS flash flood watch and flash flood warning messages are issued for that specific area.

In consideration of the above, the **Option E** NOAA Weather Radio/ Pager information dissemination system is recommended for implementation in the Skunk Creek warning area. The preparation of the flood response plan is predicated upon the final selection by the District of this information dissemination option at a Steering Committee meeting on June 26, 2001. Appendix E contains an overview sheet summarizing the products, contact information, features, costs, and important considerations for Option E.

6.3.3 Communications Schematic

The flow of information and communications in the FRP among personnel within the participating agencies will be by normal methods now in operation. MCDEM is the central contact for all communications concerning the Skunk Creek watershed. FCDMC and NWS are responsible for relaying weather and flood information to other participant agencies and to the public, most importantly the Skunk Creek residents in the flood warning area. During emergency operations, personnel from one agency wishing to communicate with personnel with another agency should follow their own jurisdiction's incident command system.

Primary communication between FCDMC, NWS, and MCDEM will be by telephone. The Maricopa County response agencies, including MCDEM, MCDOT and MCSO, will use assigned frequencies within the County's internal radio communication system to communicate with field personnel and the FCDMC Flood Warning Branch.

Figure 6-1 is a visual representation of the communication path between the sources of flood information and the end users of that information. The following is a brief description of the intended internal communication flowpaths:

1. FCDMC and NWS hydrologists and meteorologists will monitor incoming weather, rainfall, and streamflow data from various sources, including the observations of local spotters, as shown in Figure 6-1. Given indications of potential runoff-producing storms in the Skunk Creek watershed, the FCDMC or NWS will initiate, and both will maintain, communication with each other for the duration of the storm event.

2. The FCDMC will contact MCDOT and MCDEM via telephone or using Maricopa County's internal radio communications system. MCDEM will also be included in the pager call list for FCDMC weather alert and flood warnings.

3. During emergency operations, MCDEM, MCDOT, and MCSO will maintain communication with each other and the FCDMC via the County internal radio system or telephone according to the protocol established by Maricopa County Emergency Operations Plan (1999).

4. MCDEM will contact Daisy Mountain Fire Department (DMFD) directly via telephone. MCDEM will also maintain contact with FCDMC and NWS and monitor evolving weather conditions. When school is in session, MCDEM will contact the Deer Valley Unified School District to inform them of flood potential so that the school district may make decisions about student dismissal and bus transportation.

5. MCDOT Traffic Operations will dispatch barricade crews via the County internal radio system or telephone.

6. MCSO may contact DMFD and/or Rural Metro Fire Department (RMFD) depending upon the particular needs of the flood situation and the jurisdictional boundaries of the fire departments. A map showing the fire department response areas in the Skunk Creek watershed is provided in Figure 6-2. While these

boundaries are generally followed, DMFD and RMFD will support emergency response needs across jurisdictional boundaries when the immediate situation warrants.

7. FCDMC will send weather alert and flood warning messages to Skunk Creek floodway and Severe Erosion Hazard Zone residents via pager. The message suite is described in Section 6.4.

8. NWS will issue flash flood watches and flash flood warnings according to standard protocol. Those message shall be transmitted via NOAA Weather Radio Service to the public, including the Skunk Creek residents in the flood warning area. Those messages shall also be transmitted voluntarily via the Emergency Alert System (EAS) over commercial radio and television networks.

9. Any incoming emergency calls relative to flooding in the Skunk Creek watershed received from the public via the 911 emergency dial-up system will automatically be dispatched by Phoenix Central Alarm to MCSO, Rural Metro, and/or Daisy Mountain Fire Department according to an existing computer-based routing system for emergency response.

In the interim period until the weather radios and pagers are distributed and all components of the Skunk Creek FWS are in place, a short-term measure is established to provide flood warning to residents. The FCDMC and NWS will conduct the weather monitoring and flood warning activities as described above. The NWS will continue to issue standard weather forecast products and flash flood watches and warnings via the EAS and NOAA Weather Radio. However, in lieu of FCDMC-issued flood alert messages via pager, MCDEM will provide telephone dial-up services to individually contact residents in the Skunk Creek floodway and Severe Erosion Hazard Zone. Emergency response agencies including MCDOT, MCSO, Rural Metro, and DMFD will function as described above.

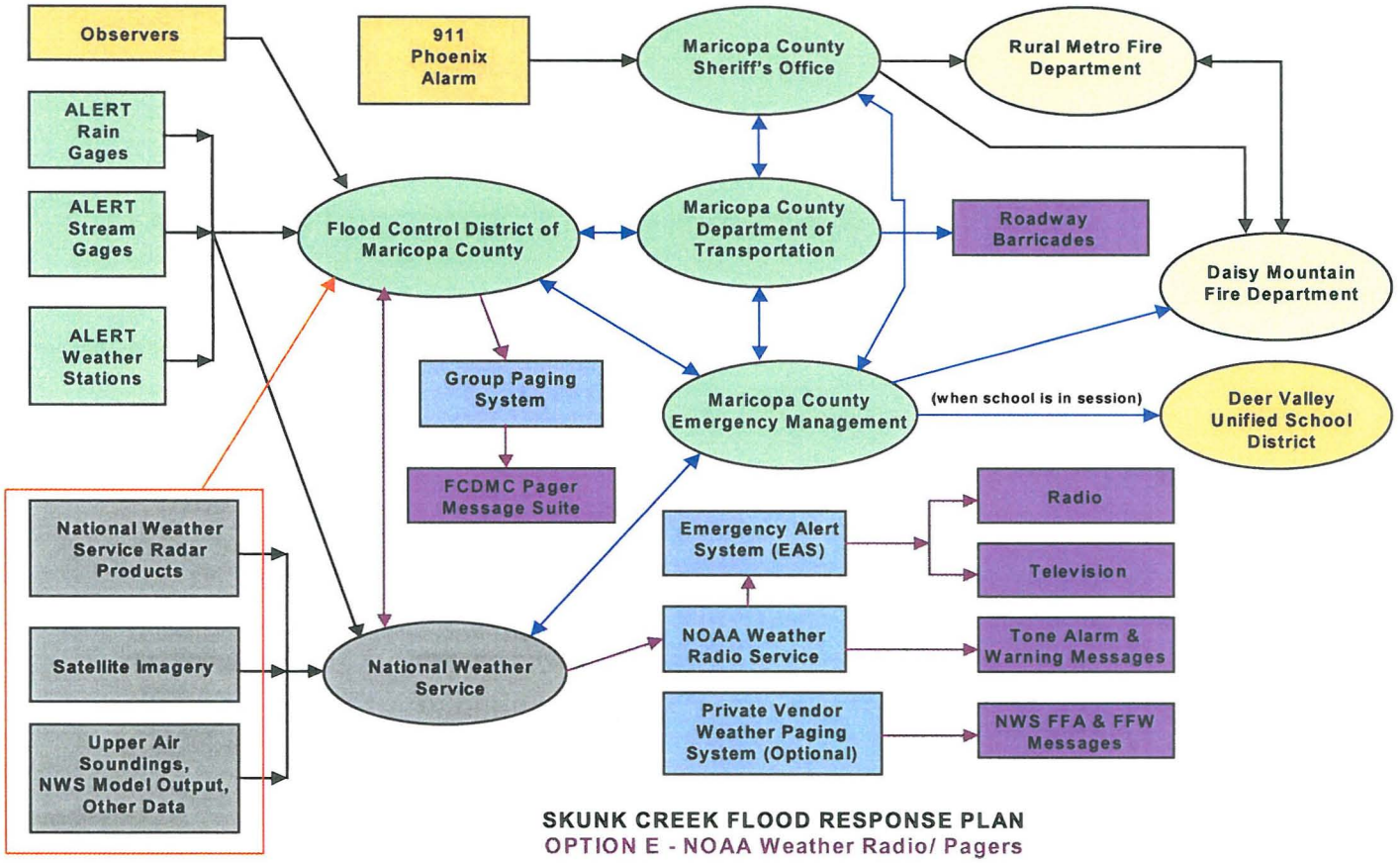


FIGURE 6-1: COMMUNICATIONS FLOWCHART

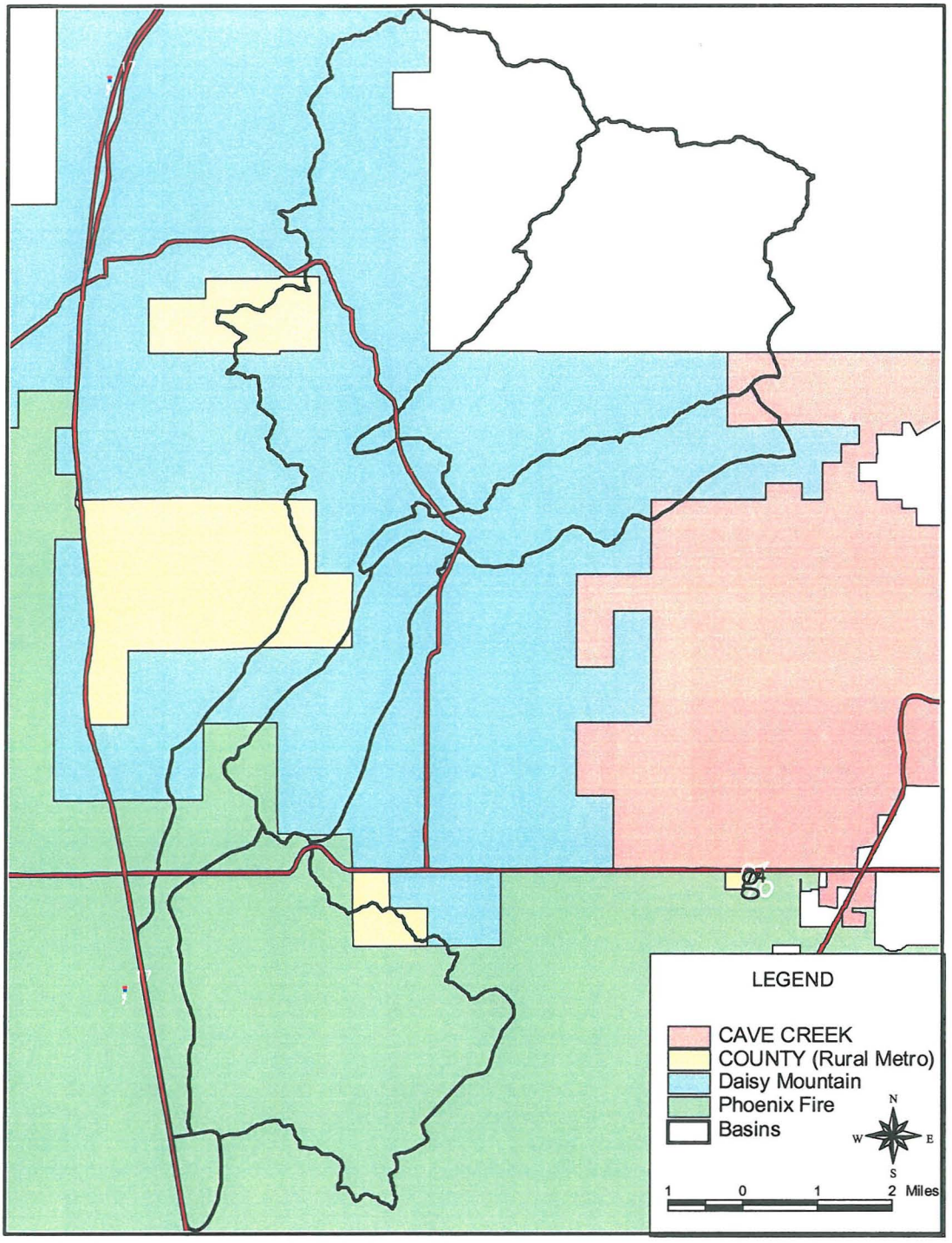


FIGURE 6-2: FIRE DEPARTMENT RESPONSE AREAS IN THE SKUNK CREEK WATERSHED

6.4 Flood Warning Message Suite

At a June 8, 2001 meeting, the NWS and FCDMC agreed to work jointly on providing a suite of flood alert, flash flood watch, and flash flood warning messages to the participants in the Skunk Creek FRP. These warning messages will be provided in a sequence of increasing urgency as flood threat intensifies and response time diminishes. It was agreed that both the FCDMC and NWS will initiate messages in an alternating sequence to Skunk Creek residents as itemized in Table 6-3:

- FCDMC will send text weather alert and flood warning messages via pager.
- NWS will issue flash flood watch and flash flood warning tone alarms followed by voice messages via NOAA Weather Radio Service.

Table 6-3 presents the message sequence, source agency, communication means, message content, and corresponding rainfall/runoff condition status. The flood detection criteria described in Section 3.3 trigger the progression of the message sequence to increasing **or** decreasing levels of alert as evolving flood conditions warrant. The emergency action plans of the Skunk Creek FRP for individual residents of the Skunk Creek warning area and by participating agencies are described in Section 6.5. The implementation of those action plans is linked directly to the dissemination of the various flood alert messages (Table 6-3) as triggered by the flood detection criteria (Table 3-1).

TABLE 6-3: SKUNK CREEK FRP MESSAGE SEQUENCE AND CONTENT

MESSAGE SEQUENCE	SOURCE AGENCY/ COMMUNICATION MEANS	MESSAGE CONTENT (effective times)	FLOOD CONDITION STATUS
NWS FFA	National Weather Service/ **NOAA Weather Radio** (voice message, tone alarm optional) **EAS Commercial radio/ TV**	National Weather Service **Flash Flood Watch** (begin time/ end time)	➢ Flash flooding is possible in north-central Maricopa County, including Skunk Creek or Cline Creek.
FCDMC 1	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 1 **Weather Alert** (begin time/ end time)	➢ Flash flooding is possible in north-central Maricopa County, especially in the upper Skunk Creek and Cline Creek areas.
FCDMC 2	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 2 **Flash Flood Alert** (begin time/ end time)	➢ Heavy rainfall detected in the upper Skunk Creek or Cline Creek watersheds. ➢ Moderate flow volumes detected by stream gages ➢ Potential for life-threatening flooding exists
NWS FFW	National Weather Service/ **NOAA Weather Radio** (tone alarm followed by voice message) **EAS Commercial radio/ TV**	National Weather Service **Flash Flood Warning** (begin time/ end time)	➢ Flash flooding is imminent or occurring in north-central Maricopa County, including Skunk Creek or Cline Creek.
FCDMC 3	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 3 **Severe Flood Warning** (effective time/ all clear)	➢ Extreme rainfall detected in the upper Skunk Creek or Cline Creek watersheds. ➢ Critical flow volumes detected by stream gages. ➢ Severe flash flooding is imminent or occurring. ➢ Many or all roadway crossings in the area are impassable.
FCDMC 4	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 4 **All Clear** (effective time)	➢ Floods on Skunk and Cline Creek have dropped below critical levels. ➢ Potential for additional extreme flooding is minimal.

NOTE: The message progression may shortcut to FCDMC Message 3 or 4 at any point in the sequence as evolving flood conditions warrant. If a NWS Flash Flood Watch is in effect early in the day, the warning message sequence may shortcut to NWS Flash Flood Warning, as appropriate to changing weather conditions.

6.5 Action Plans

Once a rainfall/ runoff event is occurring of sufficient magnitude so as to meet or exceed the established flood detection thresholds (Table 3-1), warning messages are issued (Table 6-3) using the information dissemination tools (Section 6.3.2) and communication flowpaths (Figure 6-1) previously established. Governmental and emergency response agencies participating in the Skunk Creek FRP, and individual residents in the warning area, must implement their respective emergency response action plans. Participating agencies will follow the action plans described herein within the context of their own jurisdiction's incident command system. Individual residents will follow the action plans described herein and as provided on their FRP menus.

6.5.1 Agency Action Plans

Each FCDMC weather alert and/or flood warning, NWS flash flood watch, and flash flood warning message is related to a different degree of flood threat and consequently requires a different associated response by the emergency response agencies. The message sequence is structured in a manner of increasing urgency triggered by imminent or occurring flooding in the floodway and in the Severe Erosion Hazard Zone. This graduated flood warning message suite is associated with a similarly stepped action plan comprised of emergency response activities of increasing urgency. Table 6-4 presents the emergency action plans for each agency. Table 6-5 provides contact information for each agency.

The agency action plans do not contain detailed operational procedures; rather, they provide an overview of technical support activities, communications, emergency operations and general responsibilities of each participating organization. Specific task assignments and responsibilities are described in these agencies' emergency operations plans and supplemental documents. Similarly, the technical support organizations (NWS and FCDMC) routinely update their own internal operating procedures, policies, and duty manuals.

TABLE 6-4: SKUNK CREEK FRP AGENCY ACTION PLANS

MESSAGE SEQUENCE	NWS National Weather Service	FCDMC Flood Control District of Maricopa County	MCDEM Maricopa County Department of Emergency Management	MCDOT Maricopa County Department of Transportation	MCSO Maricopa County Sheriff's Office	DMFD Daisy Mountain Fire Department	RMFD Rural Metro Fire Department
NWS FFA	➢ Monitor incoming weather, rainfall, streamflow data ➢ **Issue Flash Flood Watch** ➢ Establish communication with FCDMC	➢ Monitor incoming weather, rainfall, streamflow data ➢ Establish communication with NWS and MCDEM	➢ Monitor incoming weather, rainfall, streamflow data ➢ Establish communication with FCDMC				
FCDMC 1	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with FCDMC ➢ Establish communication with MCDEM	➢ Monitor incoming weather, rainfall, streamflow data ➢ **Issue Weather Alert** ➢ Maintain communication with NWS and MCDEM ➢ Establish communication with MCDOT	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with FCDMC ➢ Establish communication with NWS, MCDOT, MCSO, RMFD, and DMFD	➢ Monitor incoming weather information ➢ Establish communication with FCDMC and MCDEM ➢ Ready barricade crews	➢ Monitor incoming weather information ➢ Establish communication with MCDEM ➢ Ready district command office	➢ Monitor incoming weather information ➢ Establish communication with MCDEM and RMFD ➢ Ready local station crews	➢ Monitor incoming weather information ➢ Establish communication with MCDEM and DMFD ➢ Ready local station crews
FCDMC 2	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with FCDMC and MCDEM	➢ Monitor incoming weather, rainfall, streamflow data ➢ **Issue Flash Flood Alert** ➢ Maintain communication with NWS, MCDEM, and MCDOT ➢ Trigger MCDOT barricade crews	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with NWS, FCDMC, MCDOT, MCSO and DMFD ➢ Establish communication with evacuation sites and school district office	➢ Monitor incoming weather information ➢ Maintain communication with FCDMC and MCDEM ➢ Dispatch barricade crews to Skunk Creek road crossings. ➢ Monitor area road conditions	➢ Monitor incoming weather information ➢ Maintain communication with MCDEM ➢ Establish communication with DMFD and RMFD ➢ Alert district personnel in area	➢ Monitor incoming weather information ➢ Maintain communication with MCDEM and RMFD ➢ Establish communication with MCSO ➢ Maintain local station crews on alert	➢ Monitor incoming weather information ➢ Maintain communication with DMFD ➢ Establish communication with MCSO ➢ Maintain local station crews on alert
NWS FFW	➢ Monitor incoming weather, rainfall, streamflow data ➢ **Issue Flash Flood Warning** ➢ Maintain communication with FCDMC and MCDEM	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with NWS, MCDEM, and MCDOT	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with NWS, FCDMC, MCDOT, MCSO and DMFD ➢ Maintain communication with evacuation sites and school district office	➢ Monitor incoming weather information ➢ Maintain communication with FCDMC and MCDEM ➢ Complete roadway barricade activities. ➢ Maintain barricade crews on alert ➢ Monitor area road conditions	➢ Monitor incoming weather information ➢ Maintain communication with MCDEM, DMFD, and RMFD ➢ Maintain district personnel in area on alert	➢ Monitor incoming weather information ➢ Maintain communication with MCDEM, MCSO, and RMFD ➢ Maintain local station crews on alert ➢ Ready evacuation sites	➢ Monitor incoming weather information ➢ Maintain communication with DMFD and MCSO ➢ Maintain local station crews on alert
FCDMC 3	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with FCDMC and MCDEM	➢ Monitor incoming weather, rainfall, streamflow data ➢ **Issue Severe Flood Warning** ➢ Maintain communication with NWS, MCDEM, and MCDOT	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with NWS, FCDMC, MCDOT, MCSO and DMFD ➢ Maintain communication with evacuation sites and school district office	➢ Monitor incoming weather information ➢ Maintain communication with FCDMC and MCDEM ➢ Maintain barricade crews on alert ➢ Monitor road conditions along evacuation routes	➢ Monitor incoming weather information and communication ➢ Monitor evacuation routes for residents in need of assistance ➢ Secure affected areas ➢ Verify that residents have evacuated by checking for sheet hanging on front door	➢ Monitor incoming weather information ➢ Maintain communication with MCDEM, MCSO, and RMFD ➢ Assist in evacuations, as needed ➢ Receive and register residents at evacuation sites	➢ Monitor incoming weather information ➢ Maintain communication with DMFD and MCSO ➢ Assist in evacuations as needed
FCDMC 4	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with FCDMC on as-needed basis	➢ Monitor incoming weather, rainfall, streamflow data ➢ **Issue All Clear** ➢ Maintain communication with NWS and MCDEM on as-needed basis	➢ Monitor incoming weather, rainfall, streamflow data ➢ Maintain communication with FCDMC on as-needed basis ➢ Notify MCDOT to retrieve roadway barricades	➢ Retrieve barricades ➢ Perform roadway clearing and/or repair activities, as required	➢ Provide post-flood assistance to residents returning to properties ➢ Control vehicular and personnel access to affected areas, as required	➢ Provide post-flood assistance to residents returning to properties	➢ Provide post-flood assistance to residents returning to properties

TABLE 6-5: SKUNK CREEK AGENCY CONTACT LIST

AGENCY	CONTACT	PHONE NUMBER
NWS	General	(602) 275-7002
FCDMC	ALERT Room	(602) 506-8701
MCDEM	Duty Officer	(602) 273-1411
MCDOT	Traffic Operations	(602) 506-4180
MCSO	District 4 North	(602) 256-1742
DMFD	Administration Pager	(623) 465-7400 (602) 673-0695
RMFD Cave Creek/ Carefree	Administration Pager	(480) 994-3886 (480) 627-6607
Deer Valley Unified School District	Administrative Services General	(623) 445-4951 (623) 445-5000

6.5.2 Resident Action Plan

A similar action plan, together with an aerial photograph showing evacuation routes and sites, is provided as a "menu" for use by the residents of the Skunk Creek FRP warning area. The menus are customized according to flood hazard group along Skunk Creek (Section 2.3). These groups include Desert Hills Drive, Honda Bow Road, Cline Creek, and Zorrillo Drive. Table 6-6 presents the emergency action plan for the residents in a stepped sequence similar to the graduated warning message suite. Appendix F includes the full FRP menus for each group.

TABLE 6-6: SKUNK CREEK FRP RESIDENT ACTION PLANS

WHICH MESSAGE (likely sequence)	WHO/ HOW Source Agency/ Communication Means	WHAT IT SAYS Message Content (effective times)	WHAT IT MEANS Alert Protocol	WHAT YOU NEED TO DO Actions Required
NWS FFA	National Weather Service/ **NOAA Weather Radio** (voice message, tone alarm optional) **EAS Commercial radio and/or TV**	National Weather Service **Flash Flood Watch** (begin time/ end time)	➢ Flash flooding is possible in north-central Maricopa County, including Skunk Creek or Cline Creek. ➢ Be alert!	➢ Monitor your FCDMC pager and NOAA weather radio continually for updates. Other sources of flood information include: - Some commercial radio and TV stations voluntarily broadcast NWS flash flood watch warning information. - Real-time FCDMC rainfall and flood information is always available by monitoring their web page at *http://www.fcd.maricopa.gov/alert/alert.htm* - 24-hour flood and weather information for the entire state is available at *http://www.afws.org*
FCDMC 1	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 1 **Weather Alert** (begin time/ end time)	➢ Flash flooding is possible in north-central Maricopa County, especially in the upper Skunk Creek and Cline Creek areas. ➢ Be alert!	
FCDMC 2	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 2 **Flash Flood Alert** (begin time/ end time)	➢ Heavy rainfall detected in upper Skunk Creek or Cline Creek watersheds. ➢ Moderate flow volumes detected by stream gages. ➢ Potential for life-threatening flooding exists. ➢ Take necessary precautions!	➢ You MAY be instructed to EVACUATE and will need to do so at a moment's notice. You may only have a few minutes! Get prepared! ➢ Monitor your FCDMC pager and NOAA weather radio continually for updates. ➢ Locate all the residents of your home, pets, and livestock. Collect absolute necessities and load in your vehicle(s). Include a flashlight. Secure the premises. ➢ Find a light-colored sheet or towel to hang on your doorway in case you evacuate.
NWS FFW	National Weather Service/ **NOAA Weather Radio** (tone alarm followed by voice message) **EAS Commercial radio and/or TV**	National Weather Service **Flash Flood Warning** (begin time/ end time)	➢ Flash flooding imminent or occurring in north-central Maricopa County, including Skunk Creek or Cline Creek. ➢ Take necessary precautions!	
FCDMC 3	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 3 **Severe Flood Warning** (effective time/ all clear)	➢ Extreme rainfall detected in the upper Skunk Creek or Cline Creek watersheds. ➢ Critical flow volumes detected by stream gages. ➢ Severe flash flooding is imminent or occurring. ➢ Many or all roadway crossings in the area are impassable. ➢ Residents MUST monitor pagers and NOAA weather radios. ➢ Follow the instructions listed under "What You Need To Do"!	➢ IMMEDIATELY EVACUATE all residents and pets from your home and get to your evacuation site (see map on reverse). Act quickly! ➢ Turn off lights, heating and air conditioning units. ➢ Hang a light-colored sheet or towel over your door to indicate to emergency personnel that you have evacuated. ➢ Monitor your FCDMC pager and NOAA weather radio for updates. ➢ Follow the evacuation route shown on the map. Avoid travel on roadways through wash crossings. DO NOT cross any barricaded roadways! NEVER drive through flooded roadways, especially at night when dangers are harder to recognize. ➢ Report to evacuation site for registration, even if you do not plan to stay. ➢ Seek medical care at the nearest hospital, if needed. Food, clothing, and first aid may be available from emergency aid organizations such as the Red Cross.
FCDMC 4	Flood Control District of Maricopa County/ **Pager**	Skunk Creek Message 4 **All Clear** (effective time)	➢ Floods on Skunk Creek and Cline Creek have dropped below critical levels. ➢ Potential for additional extreme flooding is minimal.	➢ Leave the evacuation site and return to your home using the same route in reverse. ➢ Use flashlights if necessary to examine buildings. Flammables may be inside. ➢ Electrical equipment should be dried and checked before being returned to service. ➢ Boil drinking water before using. Wells should be pumped out and water tested for purity before drinking. ➢ Throw out any fresh food that has come in contact with flood waters.

NOTE: The message progression may shortcut to FCDMC Message 3 or 4 at any point in the sequence as evolving flood conditions warrant. If a NWS Flash Flood Watch is in effect early in the day, the warning message sequence may shortcut to NWS Flash Flood Warning, as appropriate to changing weather conditions

Three evacuation sites are provided. The Desert Hill Drive group, including Hopwood Trust/ Harper/ Mathis/ Birdsell/Parks, reports to:

- Daisy Mountain Fire Department Station
  251 West Desert Hills Drive
  Phoenix, Arizona 85086
  (623) 465-7400 Administration
  (602) 673-0695 Pager

The Honda Bow Road, Cline Creek, and Zorrillo Drive groups, including Albert/ Eller/ Hines/ Funk/ McKeag/ Geraci/ Sartain/ Selleys/ Caldwell/ Parry, report to:

- Desert Valley Baptist Church
  42425 N. New River Road
  New River, AZ 85086
  (623) 465-9461

The Shangri La group are part of the Zorrillo Drive group, but are located on the west side of Skunk Creek. Access to New River Road via Shangri La Drive is cut-off at the dip crossing. Therefore, Shangri La residents are instructed to evacuate to:

- Shangri La Resort Main Office
  46834 N. Shangri La Lane
  New River, AZ 85027
  (623) 465-5959

The FCDMC and NWS will provide timely weather information and flood warning messages to residents to the best of their ability using currently available technology. Residents are advised that prediction of flash floods is complex and conditions can change very rapidly. Residents have a responsibility to do what they can to remain alert for changing flood conditions impacting their residences by using the pagers, weather radios,

commercial radios, television, and/or the Internet. They should also closely monitor local conditions around their residences. When rainfall increases rapidly or flood conditions worsen significantly, residents should follow the instructions provided on their menus even if they have not received pager or weather radio flood warning messages.

6.5.3 Post-Flood Actions

The Skunk Creek Flood Response Plan is intended to be added as an Appendix to the FCDMC Flood Emergency Response Manual and the MCDEM Emergency Operations Plan. Post-flood action protocols, as addressed in both the FCDMC and MCDEM documents, are incorporated by reference herein to the Skunk Creek Flood Response Plan Report, Technical Memorandum, and FRP menus. Post-flood actions include, but are not limited to, criteria for re-occupation of structures, an After-Action Report, relations with the news media, and government assistance for flood victims (both private and agencies). Refer to the FCDMC and MCDEM documents for further information.

6.6 FRP Follow-Up

This section of the FRP describes the training, exercises, and update requirements of the FRP. These requirements, as recommended in this section, should be reviewed annually to take into account future development, changes in land use, changes in population, advances in communication and sensing technology, and the organization of the identified agencies and community. Any changes to the FRP should be communicated to all participating agencies and residents in the warning area.

6.6.1 Training

Training, in this FRP, refers to the water resource agencies responsible for developing flood information, the emergency response agencies responsible for carrying out the action plans,

and the residents in the Skunk Creek floodway warning area responsible for carrying out their individualized emergency action plans.

For the water resource and emergency response agencies, training requirements will be met by participation in annual exercises described in Section 6.6.2. Specialized training may be required for MCSO, DMFD, and/or RMFD personnel to familiarize themselves with the structure of the FRP and to maintain proficiency with any activities unique to carrying out their responsibilities as outlined in the action plan. Listing the training requirements of each agency is beyond the scope of this FRP; however, the identification of the need for this training is not. It is recommended that each agency establish a means of ensuring that any extra training in response to flooding events is provided on a periodic basis and is documented.

The residents included in the Skunk Creek FRP warning area will receive the NOAA Weather Radios, pagers, and menus at a future public meeting. Instructions on the structure of the FRP, use of the equipment, interpretation of the warning messages, and the emergency response activities will be provided at that time.

6.6.2 Flood Exercises

The scope, temporal and spatial extent of flood exercises should be varied to develop and maintain competency in using the decision-making tools and information dissemination equipment, and to maintain interest and communications among the agencies and residents. The agencies that should be represented are those listed in Table 6-5. In addition, representatives from the evacuation sites should also be involved.

- The spatial extent of the exercises should be varied. Flash flood exercises can be conducted on a basin-specific basis or as part of a countywide exercise. The FRP

should be exercised annually on a basin-specific basis and every three years as part of a countywide flood exercise.

- The exercises should vary temporally. The exercise can be held in alternating years during November or December to test the robustness of the FRP for winter storm flooding and during May or June to test the FRP for monsoon thunderstorm flooding.

- The scope of the exercises may vary. A tabletop exercise with all participating agencies in one possible format. Alternatively, a pre-determined exercise could be prepared by the FCDMC and conducted without prior sharing with the participating agencies.

- Residents should receive mailers from the District in advance of summer monsoon season and/or as part of NWS Flash Flood Awareness Week. Local newspapers could include FCDMC press releases about the Skunk Creek FWS in conjunction with the mailers.

6.6.3 FRP Updates

The FRP should be updated annually for changes in procedure and coverage due to communications upgrades, MSP/NWS forecast enhancements, changes in the flood detection network, changes in agency responsibilities, and/or population changes. The update should be conducted annually during April and May to insure necessary changes to the FRP are able to be made before the active summer monsoon season. All FRP updates should be mailed out to agencies and individuals that participate in the FWS.

The following verification activities should be conducted:

- The National Weather Service and District MSP should verify available products.

- Radio frequencies, group pager, telephone, and fax numbers should be tested to see if changes have been made since the last operational season. Agency contact numbers should be verified.

- All spotters should be called to verify their participation.

- The construction of the new Daisy Mountain Fire Department fire stations is scheduled for completion November 2001. Two new stations are being built at the following locations: north of Desert Hills Drive and 11th Avenue, and west of New River Road just south of the Cline Creek bridge crossing. The evacuation sites will move to these new facilities when they are completed. The Technical Memorandum, Field Book, and FRP menus will require revisions to show these new stations as the evacuation sites and to modify the evacuation routes accordingly.

- The condition of the evacuation routes should be verified periodically. This includes the evaluation of the hydraulic capacity of the Cline Creek bridge.

- Development within the downstream portions of the study area may change the flood warning needs as future development proceeds. Flood warning needs should be re-evaluated as development occurs.

6.7 Limitations

The limitations of the technical foundation of the FRP are those common to all hydrologic and hydraulic analyses. There are inaccuracies inherent in watershed modeling to estimate discharge values, and in step-backwater computer models to estimate water surface elevations. Engineering judgment is used in estimating various input parameters to these

models, such as loss parameters, routing variables, and roughness coefficients. Topographic mapping, though prepared to acceptable standards, also introduces error in measurements.

The operation of the FWS is predicated upon accurate measurement of rainfall and stream flow by the gages comprising the flood detection network. Known inaccuracies are introduced in measurements of rain by the gages due to uncontrollable variables such as wind speed and direction. Similarly, measurement of stage at stream gages for the purpose of discharge estimation can be inaccurate due to irregularities in the channel section that render the development of accurate rating curves for the cross sections difficult. The variability of precipitation further complicates the estimation of accurate modeling results.

All of the above combine to produce results that are approximately correct, but exactly inaccurate. The users of this FRP should keep these known limitations in mind.

SECTION 7: REFERENCES

1. Arizona Department of Transportation, Highway Drainage Manual – Hydrology, March 1993.

2. Flood Control District of Maricopa County, Drainage Design Manual for Maricopa County, Arizona, Volume I: Hydrology, June 1992.

3. Flood Control District of Maricopa County, Drainage Design Manual for Maricopa County, Arizona, Volume II: Hydraulics, September 1992.

4. Flood Control District of Maricopa County, Wickenburg Flood Response Plan and Technical Addendum, prepared by Stantec Consulting, Inc., Phoenix, Arizona, March 1999.

5. Maricopa County Department of Emergency Management, Maricopa County Emergency Operations Plan, February 1999.

6. Michael Baker, Jr., Inc., Rodger Creek Floodplain Delineation Study, December 1989, for the Flood Control District of Maricopa County, FCD 89-15. Revised by the Flood Control District of Maricopa County in February 1996.

7. Michael Baker, Jr., Inc., Cline Creek Floodplain Delineation Study, December 1989, for the Flood Control District of Maricopa County, FCD 89-15. Revised by the Flood Control District of Maricopa County in February 1996.

8. Montgomery Watson Americas, Inc., Skunk Creek Floodplain Delineation Study, June 1997, for the Flood Control District of Maricopa County, FCD 95-16. .

9. Tetra Tech, Inc., Skunk Creek Watercourse Master Plan, July 2001, for the Flood Control District of Maricopa County, FCD 99-23.

10. U.S. Department of the Interior, Bureau of Reclamation, 1988, Downstream Hazard Classification Guidelines, Acer Technical Memorandum No. 11, Denver, Colorado.

APPENDIX A

LISTING OF HOMEOWNERS INCLUDED IN THE FRP

Skunk Creek Flood Response Plan

Floodway & Severe Erosion Hazard Zone Homeowner Listing

Zorrillo Drive Group

Parcel #	TAG No.	Name of Owner		Phone Number	e-mail Address	Mailing Address 1	Mailing Address 2	Site Address 1	Site Address 2
		First	Last						
202-21-008T	579	0	Kraus Investments L C	(623) 465-5959	0	0	0	46834 N Shangri La Ln	New River Az 85027
202-21-031Q	639	0	Sartain James P;Wanda A	(623) 465-7749	0	43020 N 3Rd Ave	New River Az 85087	43020 N 3rd Ave	New River Az 85087
202-21-150	826	0	Parry Michael K;Debra T	(623) 465-9340	0	0	0	44833 N Shangri La Ln	Phoenix Az 85027

Honda Bow Road Group

Parcel #	TAG No.	Name of Owner		Phone Number	e-mail Address	Mailing Address 1	Mailing Address 2	Site Address 1	Site Address 2
		First	Last						
202-21-013M	584	0	Funk Donna M;Proulx Bradley E	0	0	43426 N 7Th Ave	New River Az 85087	43426 N 7Th Ave	New River Az 85087
202-21-013R	585	Jeanie	Eller	(623) 465-0195 or 2003	(623) 465-0274 fax	PO Box 4944	Cave Creek AZ 85327	42828 N 7Th Ave	New River AZ 85087
202-21-024B	616	Daniel R. & Kathleen	Albert	(623) 465-5971	0	0	0	42745 N 7Th Ave	Phoenix Az 85027
202-21-169	847	Joe E & Claudia M	Hines	(623) 465-7200	0	43012 N 7th Ave	New River AZ 85087	43012 N 7Th Ave	New River Az 85087
211-22-002B	5	James F & Kasey L	McKeag	H (623) 465-5222, cell (602) 743-5338	0	515 E Carefree Hwy. #3	Phoenix AZ 85085	755 W Honda Bow Rd	New River AZ 85086
211-22-002J	6	Sharon K	Geraci	H (623) 465-2687, cell (623) 363-1395	0	PMB, 47515 E. Carefree	Phoenix AZ 85085	705 W Honda Bow Rd	New River Az 85086

Desert Hills Drive Group

Parcel #	TAG No.	Name of Owner		Phone Number	e-mail Address	Mailing Address 1	Mailing Address 2	Site Address 1	Site Address 2
		First	Last						
211-50-016J	84	Willis E (Bud)	Harper	(623) 465-0366	0	38821 N 17Th Ave	New River Az 85027	38821 N 17Th Ave	New River Az 85027
211-50-022	62	Family Trust	Hopwood	0	0	39030 N. 15th Avenue	New River AZ 85086	39030 N 15Th Ave	New River AZ 85086
211-50-037C	104	Tim & Tammy R	Mathis	(623) 465-8731	timandtam@qwest.net	38640 N 17Th Ave	New River, AZ 85086	38640 N 17Th Ave	New River, AZ 85086
211-50-016H	929	Carl C	Birdsell	0	0	11156 W Mtn View Dr	Sun City Az 85351	*No Site Address*	Az
203-32-006	148	Patricia E	Parks	0	0	3002 W Muriel Dr	Phoenix Az 85053	38210 N 21St Ave	Phoenix Az 85027

Cline Creek Group

Parcel #	TAG No.	Name of Owner		Phone Number	e-mail Address	Mailing Address 1	Mailing Address 2	Site Address 1	Site Address 2
		First	Last						
202-21-031C	634	0	Selleys Charles T Tr	(623) 465-5559	0	0	0	43826 N 3Rd Ave	Phoenix Az 85027
202-21-032A	647	0	Caldwell David L;Carol A	(623) 465-7670	0	0	0	43750 N 3Rd Ave	New River Az 85087

APPENDIX B

DOWNSTREAM HAZARD CLASSIFICATION GUIDELINES (EXCERPT)

ACER TECHNICAL MEMORANDUM NO. 11
ASSISTANT COMMISSIONER - ENGINEERING AND RESEARCH
DENVER, COLORADO

DOWNSTREAM HAZARD CLASSIFICATION GUIDELINES

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
1988

IV. IDENTIFICATION OF HAZARDS

A. Introduction

A dam-break/inundation study is performed for the purpose of determining the impact of a dam failure flood on "possible hazards." A possible hazard is one that has been identified as having the possibility to constitute a hazard, but field work and/or analysis needs to be performed for confirmation.

Possible hazards are identified from topographic maps, photographs, field surveys, and information from "locals." They include any situation that is suspicious of having potential for lives-in-jeopardy or economic loss due to a dam failure. Some examples are listed in section II.

Sometimes, downstream hazard classification is obvious. That is, an analysis is not necessary because lives would be in jeopardy, and/or property damage would occur, with little doubt, due to a dam failure.

Analysis does not always prove a possible hazard to be a confirmed hazard; many "gray areas" exist in hazard classification. Analysis may indicate that a residence could be flooded by 1 foot (0.3 m) of water, but will this result in loss of life? If a failure flood overtops a highway bridge, will the bridge be destroyed? If not, will a vehicle be carried by floodwater or go out of control due to hydroplaning? Or, will a vehicle crash due to a damaged road or bridge after the flood has passed? Questions and gray areas such as these are the underlying reasons for guidelines regarding identification of downstream hazards. Such guidelines are presented in subsections B. through G.

Subsections B. through E. contain curves of depth versus velocity (figs. 2 through 6) that are indicative of dangerous floodflows for various possible hazards. Figure 2 is a modification by the author of a study performed by Black [8]. The curves in figures 3 through 6 were derived theoretically by the author. Figure 4 is in reasonable agreement with a theoretical analysis performed by Simons, Li and Associates [9]. The lower curve in figure 5 is in reasonable agreement with a theoretical analysis performed by David J. Love and Associates, Inc. [10], and a laboratory flume study performed at Colorado State University by Abt and Wittler using monoliths [11]. Very little research has been done on this topic; however, even if this were the case, there would be discrepancies which cannot be avoided due to the

many initial assumptions that have to be made, very large number of variables that have to be considered, and philosophy. This was emphasized by Abt and Wittler [11] who conclude, "Physical tests of human subjects, even in a controlled laboratory environment, indicated that the ability of the subject to adapt to flood flow conditions is difficult to quantify." The relationships presented in figures 2 through 6 are very reasonable for estimating lives-in-jeopardy for downstream hazard classification purposes, and satisfy one of the purposes of these guidelines - to bring consistency and objectivity into downstream hazard classification. In addition, they are logical and easy to use.

The depth-velocity flood danger level relationships are divided into three zones: low danger, judgment, and high danger. An explanation of these zones follows:

Low-danger zone. - If a [redacted] hazard is subject to a depth-velocity combination [redacted] one, then the number of lives-in-jeopardy a[redacted] downstream hazards is assumed to be zero.

High-danger zone. - If a possible hazard is subject to a depth-velocity combination plotting within this zone, then it is assumed that lives are in jeopardy at all possible downstream hazards.

Judgment zone. - The low-danger and high-danger zones represent the two extremes of reasonable certainty regarding the occurrence of no lives-in-jeopardy and some lives-in-jeopardy, respectively. Between these two extremes exists a zone of uncertainty with respect to assessing lives-in-jeopardy. Because every flood situation is unique, it is impossible to account for all of the variables that may result in lives to be in jeopardy if the flood magnitude (depth and velocity) plots in this zone. Thus, in this case, it is left up to the analyst to use engineering judgment for determining lives-in-jeopardy. Whenever possible, several opinions, and a common agreement among analysts should be reached in making this determination. There are many possible factors to consider; examples include:

- A designated campground, attraction, monument, etc. may receive very little visitor use. Such facilities may be visited for a very small total time during a year (e.g., 100 person-hours). Thus, the chance for lives to be in jeopardy due to flood depths and velocity combinations being in the judgment zone of

figure 5 or 6, is very small and lives-in-jeopardy can be considered zero.

- The total time that the flood depths and velocities reach magnitudes within the judgment zone. An example is a dam-break flood from a small reservoir that rapidly reaches a peak discharge, then rapidly decreases. If the only possible hazard is a highway receiving little use, then the chance of a vehicle being exposed to a dam-break flood is very small. On the other hand, vehicles on a heavily traveled highway that could receive flooding from a large reservoir having sustained high flows are likely to be "caught" in a flood situation. Although the effect of the flood on loss of life is uncertain in this zone, the fact that there is a large population involved cannot be ignored, and conservative judgment should be used such that loss of life is considered possible.

- A residence subject to a flood depth-velocity in the judgment zone may be a three-story, well-built, brick home. In such a case, the assumption could be made that the occupants are not in serious danger - especially if the flooding is of fairly short duration. However, occupants of a single-story, poorly constructed home subject to floods of a long duration should be assumed to be in danger.

- Multiple-story [redacted] occupants above the first [redacted] to [redacted] that the occupants will [redacted] (e.g., [redacted] sleeping) and will move to a [redacted]

It is very important to understand that the zones (low-danger, judgment, high-danger) represented in figures 2 through 6 are not "cast in stone." Predicting lives-in-jeopardy is far from being an exact science. If the analyst has sound reason to believe that lives are in jeopardy for conditions in the low-danger zone, or no lives are in jeopardy for conditions in the high-danger zone, then such reasoning can override figures 2 through 6. However, the reasons have to be documented in the hazard classification report.

In many hazard classifications, especially where large dams and catastrophic flooding are involved, reference to figures 2 through 6 is superfluous because of the obvious flood danger. But, for situations where the hazard classification of a dam is solely dependent upon an

isolated flood situation where occupants of a dwelling or vehicle may be in danger, or a person having no protective environment (e.g. house, vehicle) may be in danger, these figures should be used. In such situations, the analyst will have predicted a reasonable maximum depth and velocity, "with confidence" (refer to the following paragraph), at the possible hazard site and needs to make a decision as to the floods effect on the possible hazard so that lives in jeopardy can be assessed. If depths and velocities cannot be predicted with confidence, then a conservative approach should be used that assumes any possible hazard in the path of a dam-break flood is in danger and is considered a downstream hazard. But, for situations where the analyst is confident about the predicted depths and velocities, figures 2 through 6 can be used for estimating the susceptibility of a possible hazard to impacts from the predicted floodwate[illegible]alysts can decide if the possible downstr[illegible] hazard[illegible] as a downstream hazard, and assess live[illegible] jeopard[illegible]

The adequacy of predicted depths and velocities can be ascertained by performing sensitivity analyses on critical breach outflow and channel routing parameters. If predicted depths and velocities at a specific channel site do not change significantly with significant changes in the critical parameters, then the predicted depth and velocity can be used "with confidence." More information regarding sensitivity analysis is contained in appendix A, subsection D.

Extent of economic loss is the decision of the analyst, as previously stated. Thus, depth-velocity-damage relationship curves are not presented in the following sections.

B. Permanent Residences, Commercial and Public Buildings, and Worksite Areas

Permanent residences are considered dwellings attached to foundations, and hooked to utilities. Some mobile homes are not attached to foundations; these are discussed separately in subsection IV.C.

Worksite areas include facilities that contain workers on a daily (work week) basis. This includes farm operations, oil and gas operations, sand and gravel operations, and fish hatcheries.

The lives-in-jeopardy includes all occupants of dwellings located within the inundation boundaries, subject to a combination of flood depth and velocity plotting above the low-danger zone of figure 2. However, but

HIGH DANGER ZONE - Occupants of most houses are in danger from floodwater.

JUDGEMENT ZONE - Danger level is based upon engineering judgement.

LOW DANGER ZONE - Occupants of most houses are not seriously in danger from flood water.

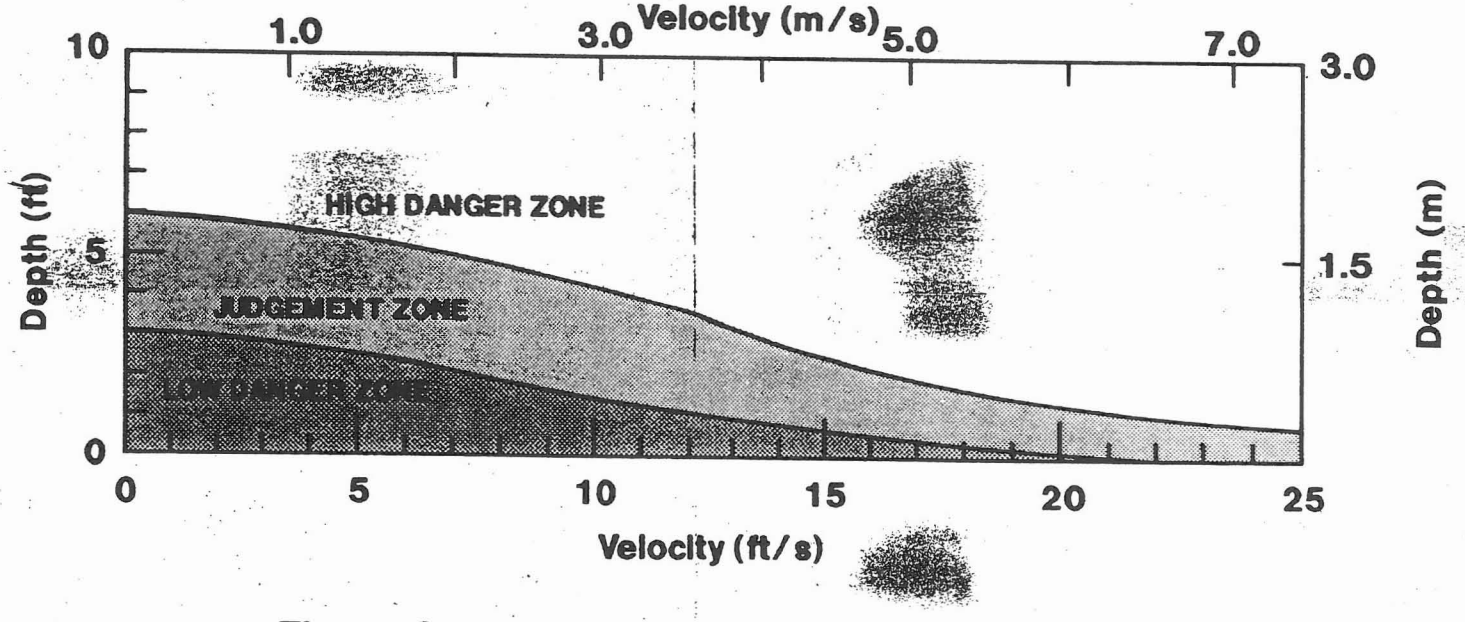


Figure 2. – Depth–velocity flood danger level relationship for houses built on foundations.

only if justifiable, no lives-in-jeopardy has to be associated with occupants of dwellings subject to a flood depth and velocity plotting within the judgment zone. Lives-in-jeopardy is always associated with occupants of dwellings subject to a combination of flood depth and velocity plotting within the high-danger zone except very special cases where the analyst can present strong justification.

If flood depth and velocity cannot be predicted with reasonable confidence, then the lives-in-jeopardy includes all occupants of residences within the inundation boundaries with no reference to depth or velocity, and the downstream hazard classification can be assigned accordingly.

For situations where pedestrians may be a factor in the downstream hazard classification, refer to subsection IV.E.

C. Mobile Homes

Mobile home parks are typical[redacted]od plains due to zoning requirements in ma[redacted] areas. T[redacted] dangerous situation for occupants of mobile homes, as they are very susceptible to movement from relatively small floods. Thus, depth-velocity-flood danger level relationships (fig. 3), other than those for houses on foundations, are used for mobile homes.

The lives-in-jeopardy includes all occupants of mobile homes located within the inundation boundaries, subject to a combination of flood depth and velocity plotting above the low-danger zone of figure 3. However, but only if justifiable, no lives-in-jeopardy has to be associated with occupants of mobile homes subject to a combination of flood depth and velocity plotting within the judgment zone. Lives-in-jeopardy is always associated with occupants of mobile homes subject to a combination of flood depth and velocity plotting within the high-danger zone except very special cases where the analyst can present strong justification.

If flood depth and velocity cannot be predicted with reasonable confidence, then the lives-in-jeopardy includes all persons likely to be in the inundated area with no reference to depth and velocity, and the downstream hazard classification can be assigned accordingly.

HIGH DANGER ZONE - Occupants of almost any size mobile home are in danger from flood water.

JUDGEMENT ZONE - Danger level is based upon engineering judgement.

LOW DANGER ZONE - Occupants of almost any size mobile home are not seriously in danger from flood water.

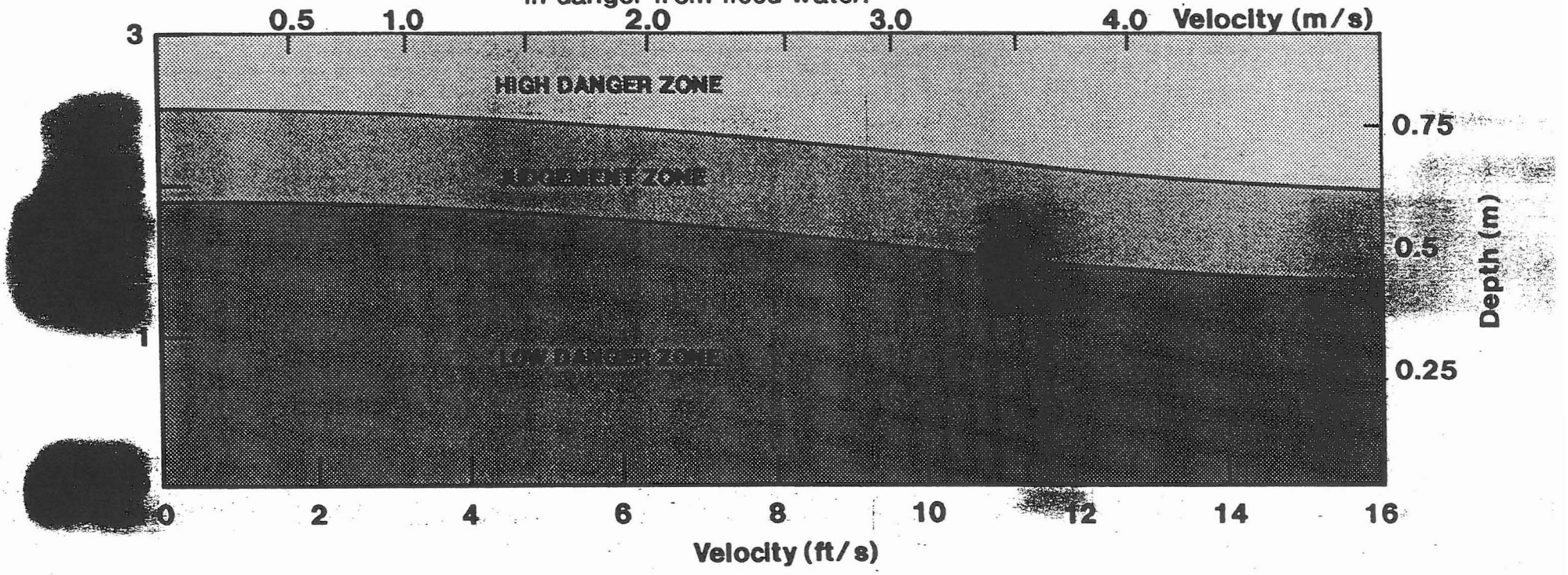


Figure 3. – Depth–velocity flood danger level relationship for mobile homes.

D. Roadways

If a dam-break flood wave inundates a roadway, the possibility for loss of life to motorists and pedestrians (guidance for pedestrians is covered in subsec. IV.E.) should be evaluated. In most cases, a roadway is inundated due to its crossing the channel via a bridge or culvert, or due to its running parallel to the channel such as in a canyon.

Loss of life is possible on a roadway as a result of a dam failure due to several causes. These include:

- A vehicle being carried downstream by floodwater,
- Loss of control and subsequent crash of a vehicle due to its impact with the floodwater, and,
- A vehicle crash resulting from road damage after the flood has passed.

However, because downstream hazard classification is based on the direct impacts from a dam-break flood (subsec. I.A.), situations such as a vehicle crash resulting from road damage after the flood wave has passed are not considered when estimating lives-in-jeopardy. It is assumed that vehicles are already on, or attempting to enter a roadway when it is inundated.

The lives-in-jeopardy includes all occupants of vehicles within the inundation boundaries subject to a combination of depth and velocity plotting above the low-danger [redacted] figure 4. However, but only if justifiable, no lives-in-jeopa[redacted]ssociated with occupants of vehicles subject to a combina[redacted]epth and velocity plotting within the judgment zone. L[redacted]is always associated with occupants of vehicles subject to a combination of flood depth and velocity plotting within the high-danger zone except very special cases where the analyst can present strong justification.

If flood depth and velocity cannot be predicted with reasonable confidence, then the number of lives-in-jeopardy includes all persons likely to be in the inundated area with no reference to depth and velocity and the downstream hazard classification can be assigned accordingly.

A roadway will be a factor in determining the downstream hazard classification of a dam, only when it is paved. This criteria provides a simplified way of accounting for the amount, frequency, and speed of traffic on that particular roadway.

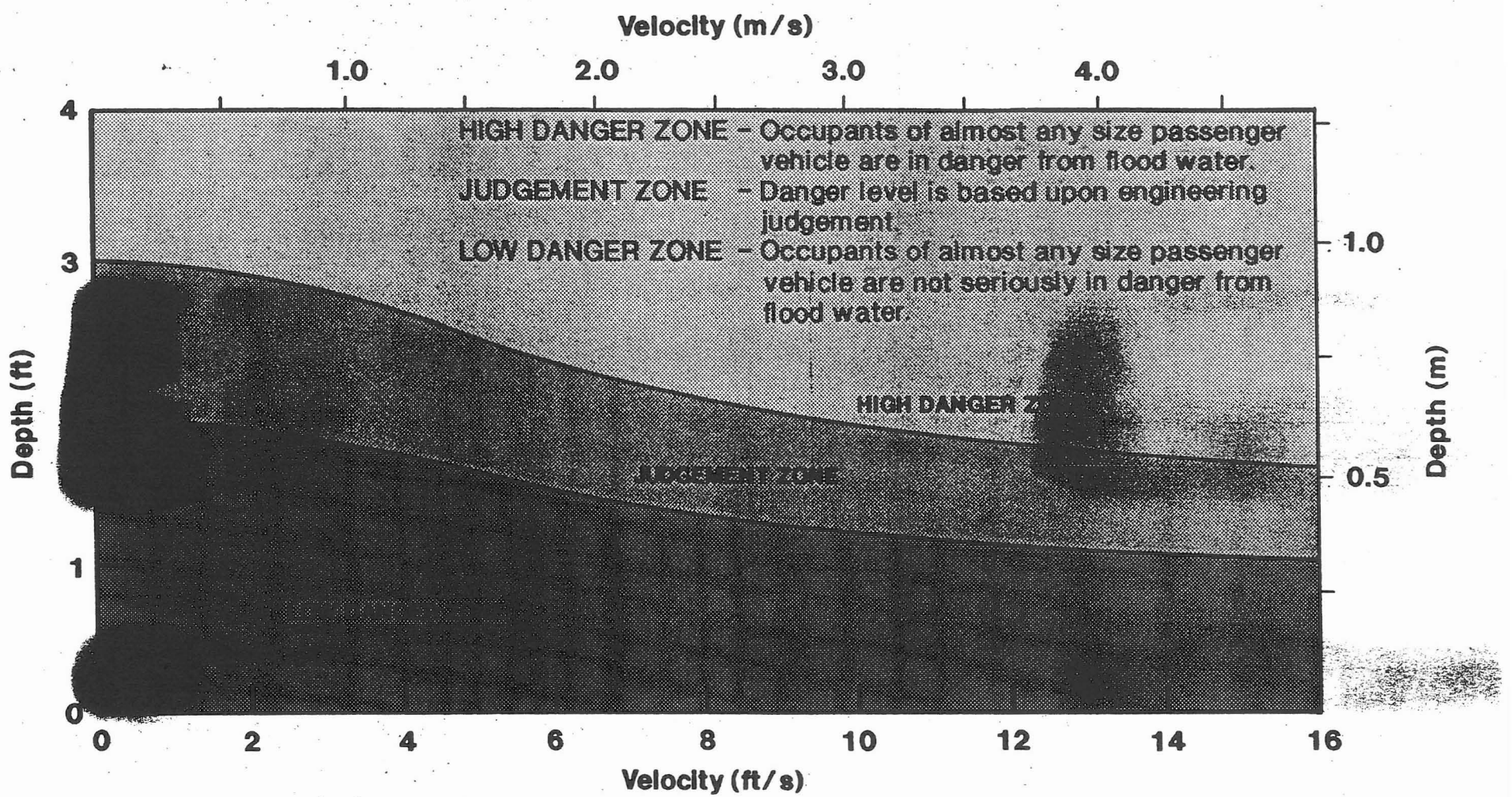


Figure 4. – Depth–velocity flood danger level relationship for passenger vehicles.

The paved road criteria apply unless the analyst can provide reason to the contrary. For example, a paved roadway may be located in a very remote location and rarely traveled. Or a roadway may be closed during the time of year that the dam failure is assumed to occur. Such a case is when a dam failure flood can only endanger a roadway if the failure occurs in combination with a large flood, but, the large flood can only occur in late spring (rain-on-snow flood) when a roadway located in an alpine area is closed.

Conversely, unpaved roads can also present a lives-in-jeopardy situation, thereby resulting in a significant- or high-hazard classification if proper justification can be made. An example is a gravel road in a long narrow canyon with a dam located upstream. This road receives moderate traffic because it is an access to an established recreational area, scenic attraction, residential housing division, etc. However, because the road passes through a long narrow canyon, a dam failure flood could very likely cause loss of life to motorists in the canyon due to the difficulty [illegible] the flood.

Economic loss includes replacement costs of the highway and crossings only.

E. Pedestrian Routes

Pedestrian routes include sidewalks, bicycle paths, and walking/hiking trails. For situations where pedestrian routes are isolated, and/or may influence the hazard classification, the lives-in-jeopardy can be estimated using figures 5 and 6. Figures 5 and 6 are depth-velocity-flood danger level relationships for adults and children, respectively. Separate figures for adults and children (versus one figure for all humans) are included so possible hazards that may not include children can be evaluated differently than mixed populations of both adults and children. Examples of "adult only" populations are worksites and adult-only residential areas. An adult is considered (for the use of figures 5 and 6) any human over 5 feet (150 cm) tall and weighing over 120 pounds (54 kg). The choice of using either figure 5 or 6 is the decision of the analyst based on knowledge and understanding of the population. However, when populations are mixed (i.e., adults and children), figure 6 should be used for conservativeness.

Infants are not treated separately; instead, they are assumed to be safely attended by adults.

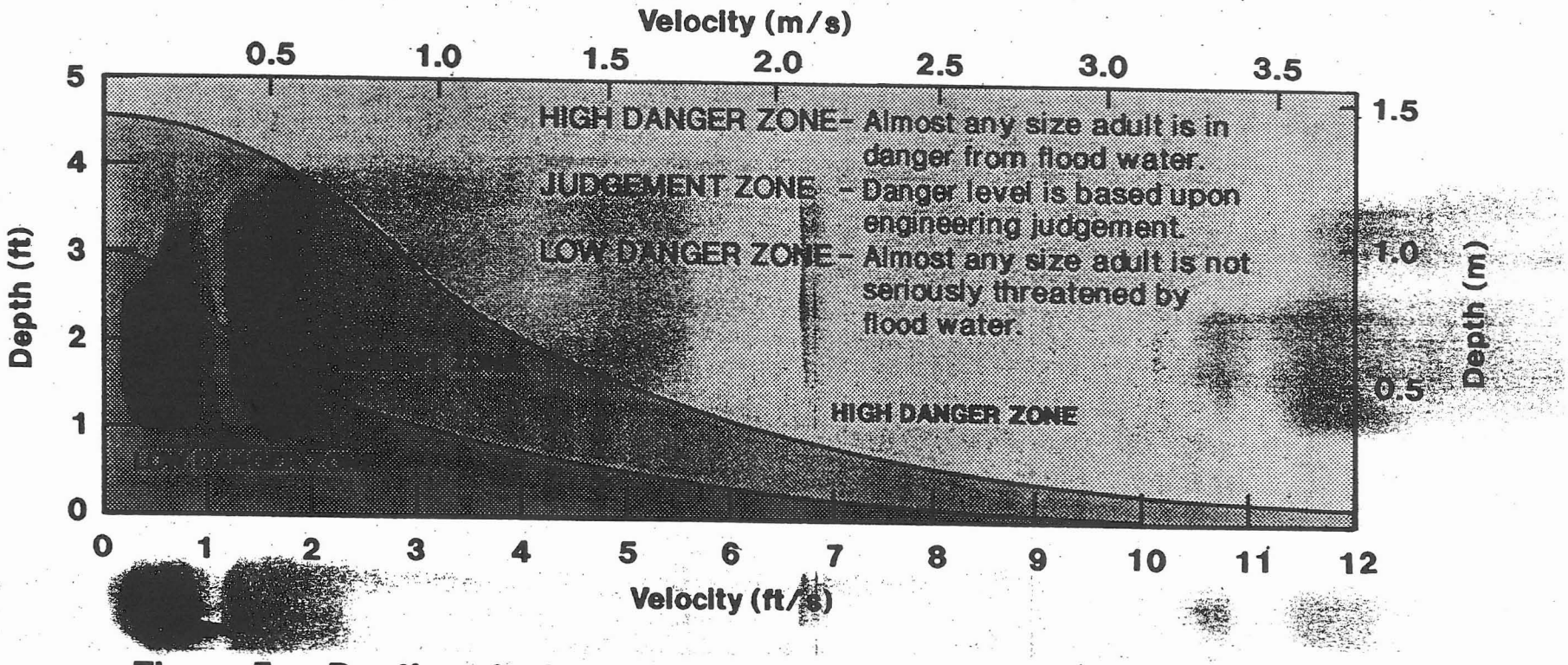


Figure 5. – Depth–velocity flood danger level relationship for adults.

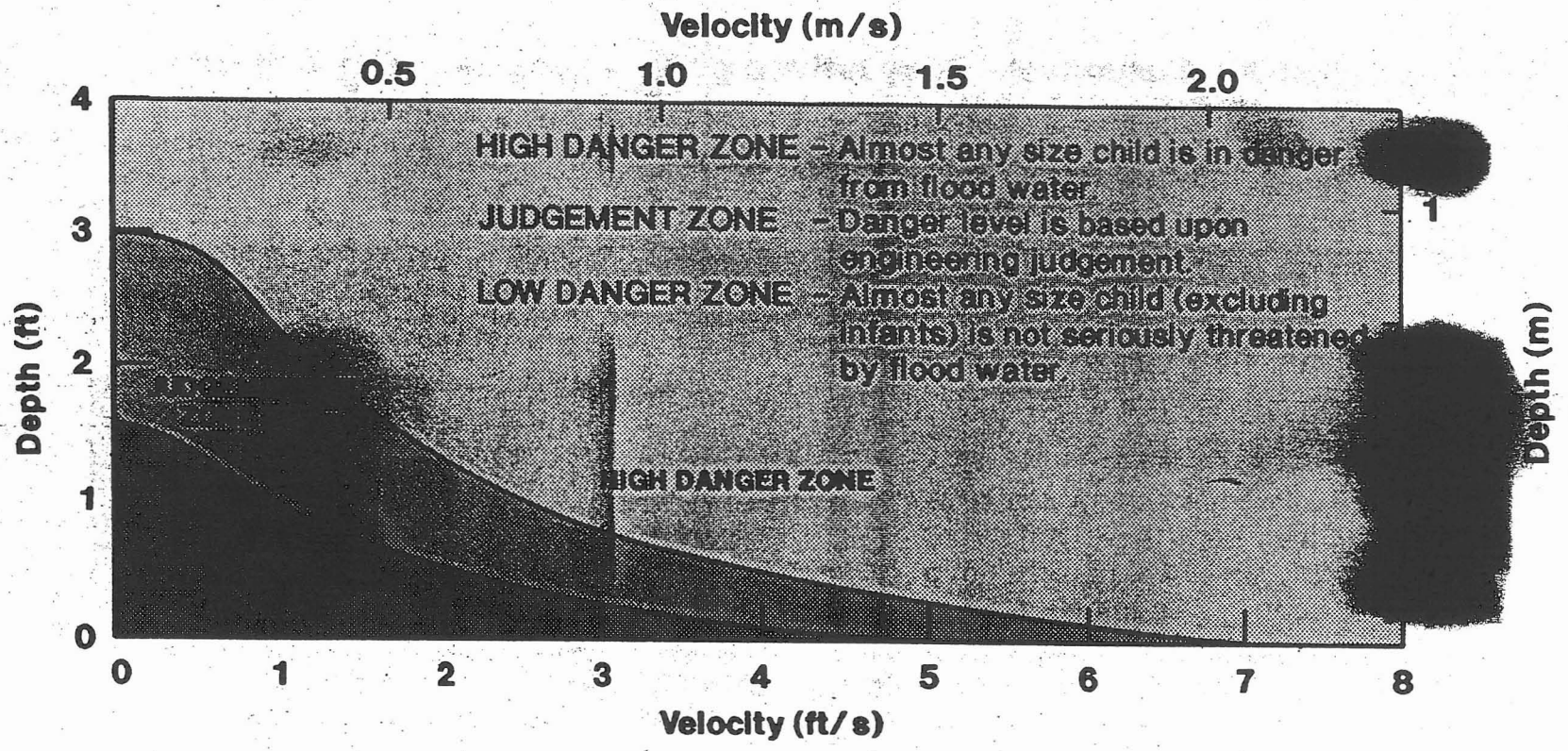


Figure 6. – Depth–velocity flood danger level relationship for children.

VI. REFERENCES

[1] "Federal Guidelines for Dam Safety," prepared by the Ad Hoc Committee on Dam Safety of the Federal Coordinating Council for Science Engineering and Technology, Washington, D.C., June 25, 1979.

[2] "Departmental Manual, Part 753, Dam Safety Program," U.S. Department of the Interior, January 1981.

[3] "Guidelines to Decision Analysis," ACER Technical Memorandum No. 7, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado, 1986.

[4] "Guidelines for Defining Inundated Areas Downstream from Bureau of Reclamation Dams," Bureau of Reclamation, Engineering and Research Center, Denver, Colorado, June 1982.

[5] Wetmore, Jonathan N., and D. L. Fread, "The NWS Simplified Dam Break Flood Forecasting Model for Desk-Top and Hand-Held Microcomputers," Hydrologic Research Laboratory, Office of Hydrology, National Weather Service, National Oceanic and Atmospheric Administration, Silver Spring, Maryland.

[6] Fread, D. L., The NWS - DAMBRK Model, Office of Hydrology, National Weather Service, Silver Spring, Maryland, June 20, 1988.

[7] Trieste, D. J., and R. D. Jarrett, Roughness Coefficients of Large Floods, Proceedings, ASCE Irrigation and Drainage Division Speciality Conference, Irrigation Systems for the Twenty-First Century, Portland, Oregon, July 28-30, 1987.

[8] Black, R. D., Flood Proofing Rural Residences, Department of Agriculture Engineering, Cornell University, A "Project Agnes" Report, prepared for the U.S. Department of Commerce, Economic Development Administration, May 1975.

[9] Ruh-Ming, Li, "Car Floatation Analysis," Simons, Li, and Associates, SLA Project No. CO-CB-05, February 7, 1984.

[10] David J. Love and Associates, Inc., "Analysis of a High Hazard Flood Zone," Prepared for the City of Boulder, Colorado, Department of Public Works, October 1987.

[11] Abt, S. R., and R. J. Wittler, Project Number Flood Hazard Concept Verification Study, Department of Civil Engineering, Colorado State University, Fort Collins, Colorado 80523, Prepared for City of Boulder Flood Utility, Department of Public Works, Boulder, Colorado 80306.

[12] Fread, D. L., "BREACH: An Erosion Model for Earthen Dam Failures," Hydrologic Research Laboratory, National Weather Service, Silver Spring, Maryland, July 1988.

[13] National Bulletin No. 210-6-19, Subject: Eng-Dam Breach Peak Discharges, U.S. Department of Agriculture, Soil Conservation Service, PO Box 2890, Washington, D.C. 20013, September 19, 1986.

[14] Costa, John E., "Floods from Dam Failures," U.S. Geological Survey Open-File Report 85-560, Denver, Colorado 1985.

[15] Mac Donald, Thomas C., and Jennifer Langridge-Monopolis, "Breaching Characteristics of Dam Failures," Journal of Hydraulic Engineering, vol. 110, No. 5, May 1984.

[16] Hagen, V. K., "Re-evaluation of Design Floods and Dam Safety," Transactions, International Commission on Large Dams, vol. 1, May 1982, pp. 475-491.

[17] Froehlich, D. C., 1987: Embankment-Dam Breach Parameters, Proceedings of the 1987 National Conference on Hydraulic Engineering, ASCE, New York, New York, August, pp. 570-575.

[18] Fread, D. L., "Some Limitations of Dam-Breach Flood Routing Models, ASCE Fall Convention, St. Louis, Missouri, October 26-30, 1981.

[19] Wurbs, Ralph A., "Dam-Breach Flood Wave Models," Journal of Hydraulic Engineering, vol. 113, No. 1, January 1987.

[20] Chow, Ven Te, Open-Channel Hydraulics, McGraw-Hill, New York, New York, 680 p., 1966.

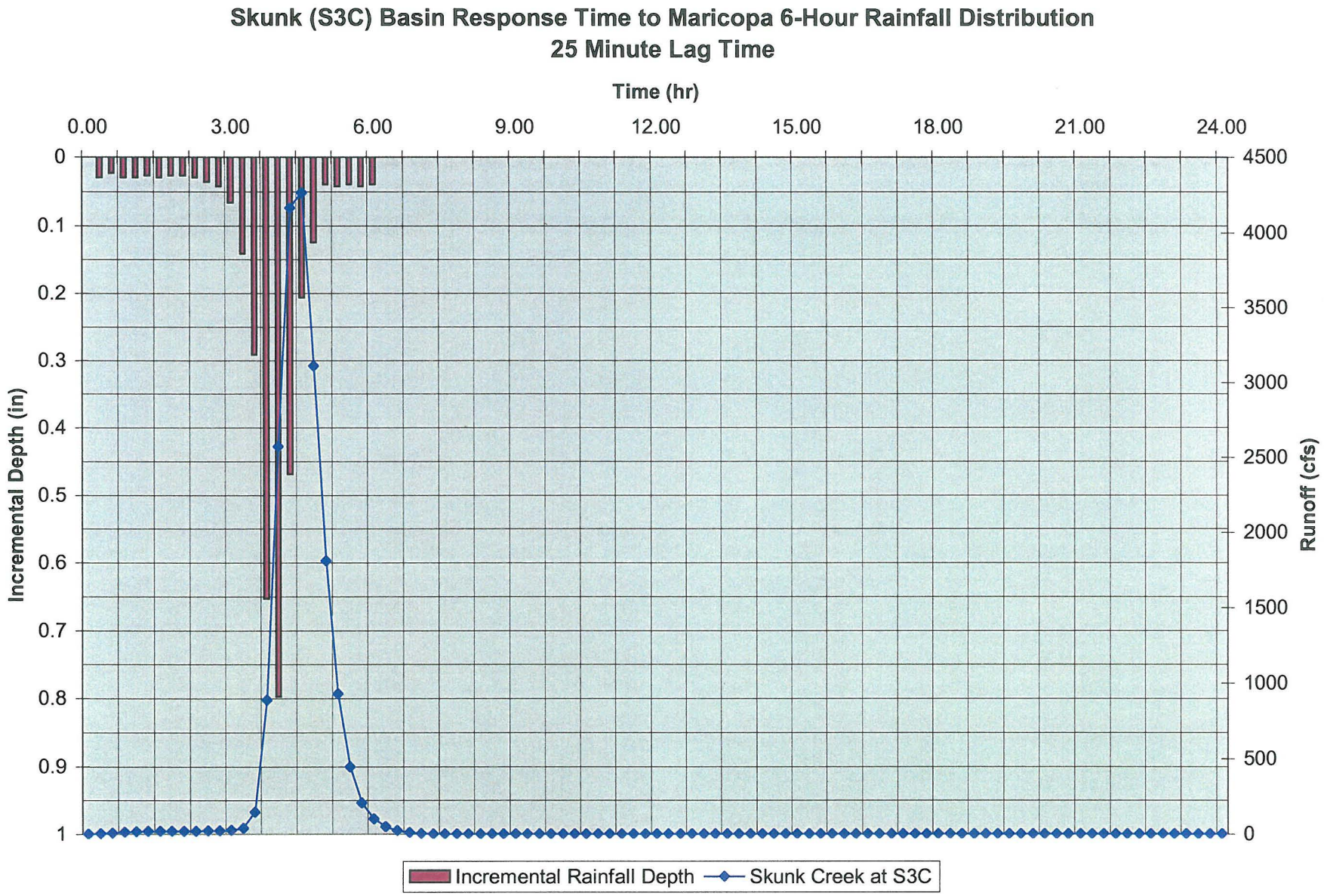
[21] Henderson, F. M., Open Channel Flow, MacMillan Publishing Co., Inc., New York, New York, 522 p., 1966.

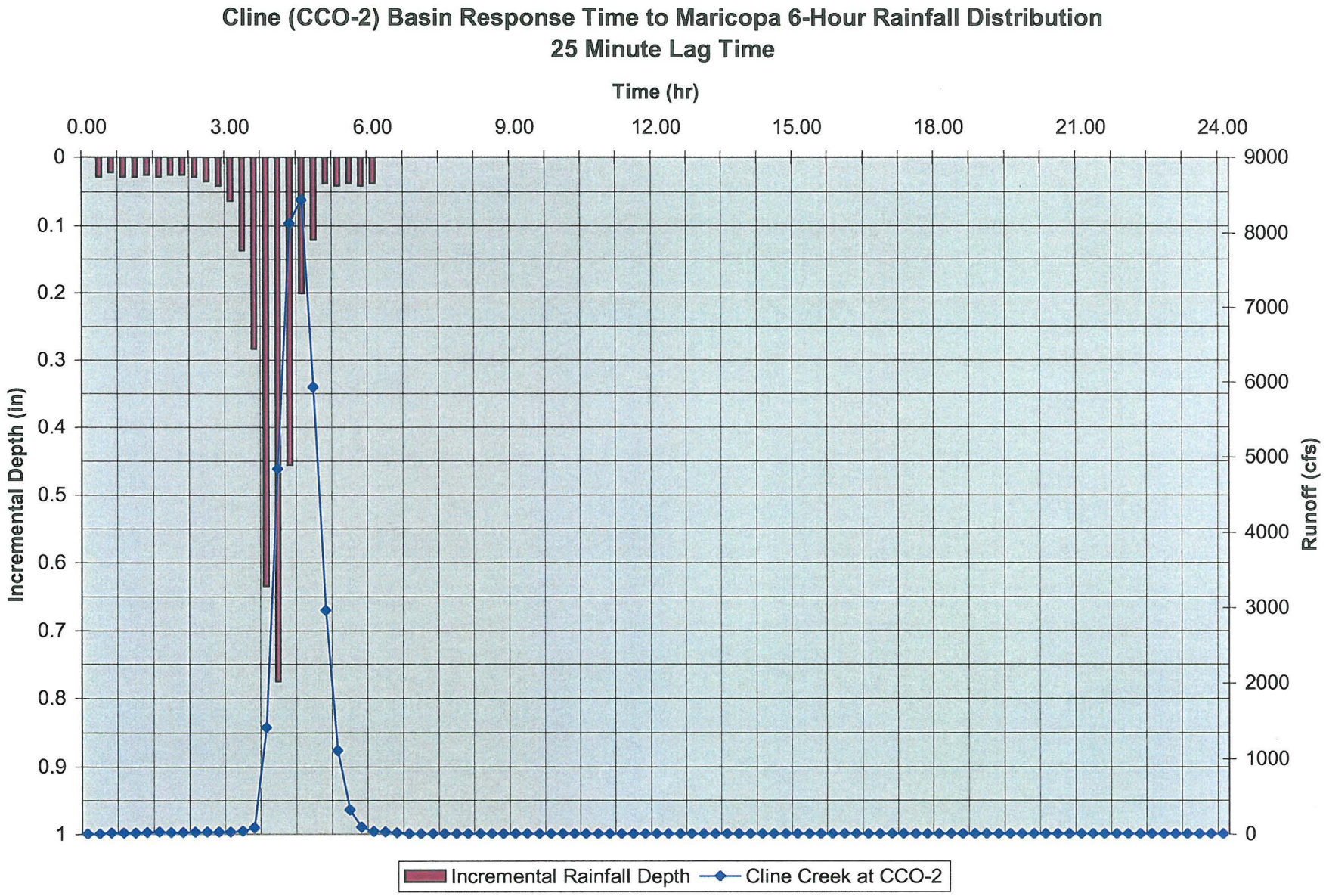
APPENDIX C

HYDROLOGIC ANALYSIS SUPPORTING DATA

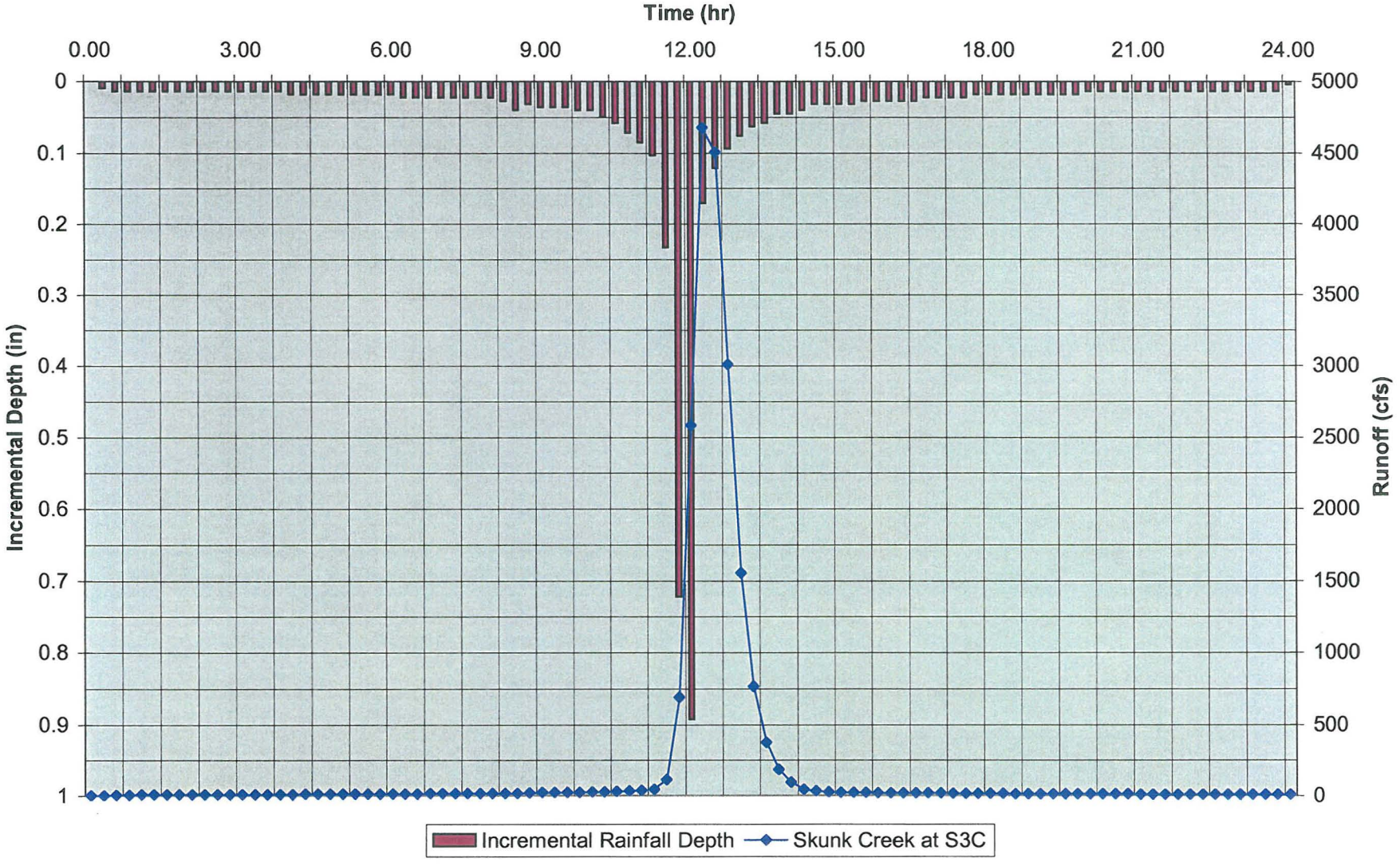
C-1: Rainfall Distribution & Basin Response Time Plots
C-2: Threshold Precipitation Depth Plots
C-3: Recurrence Interval Curves

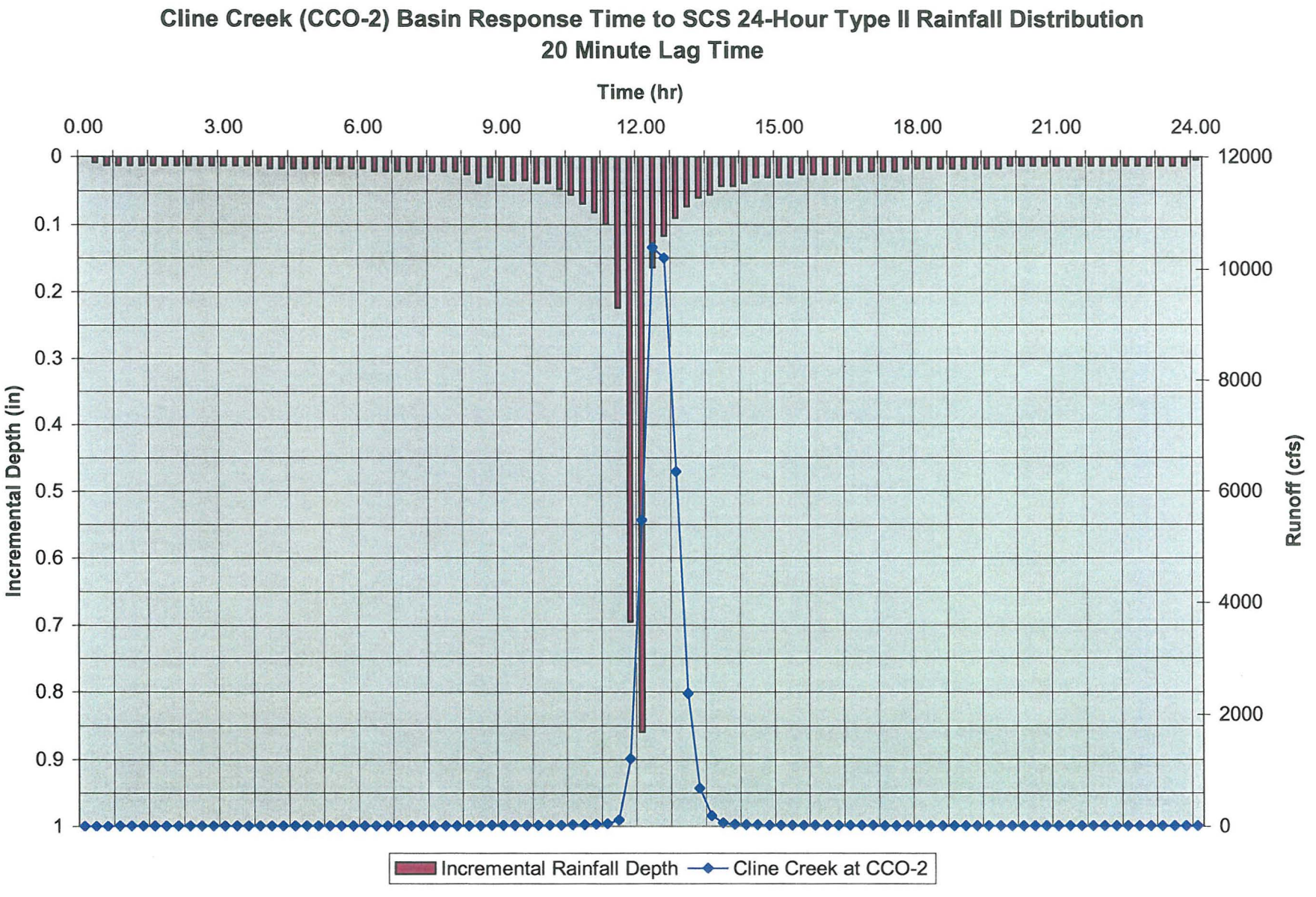
APPENDIX C-1: Rainfall Distribution & Basin Response Time Plots

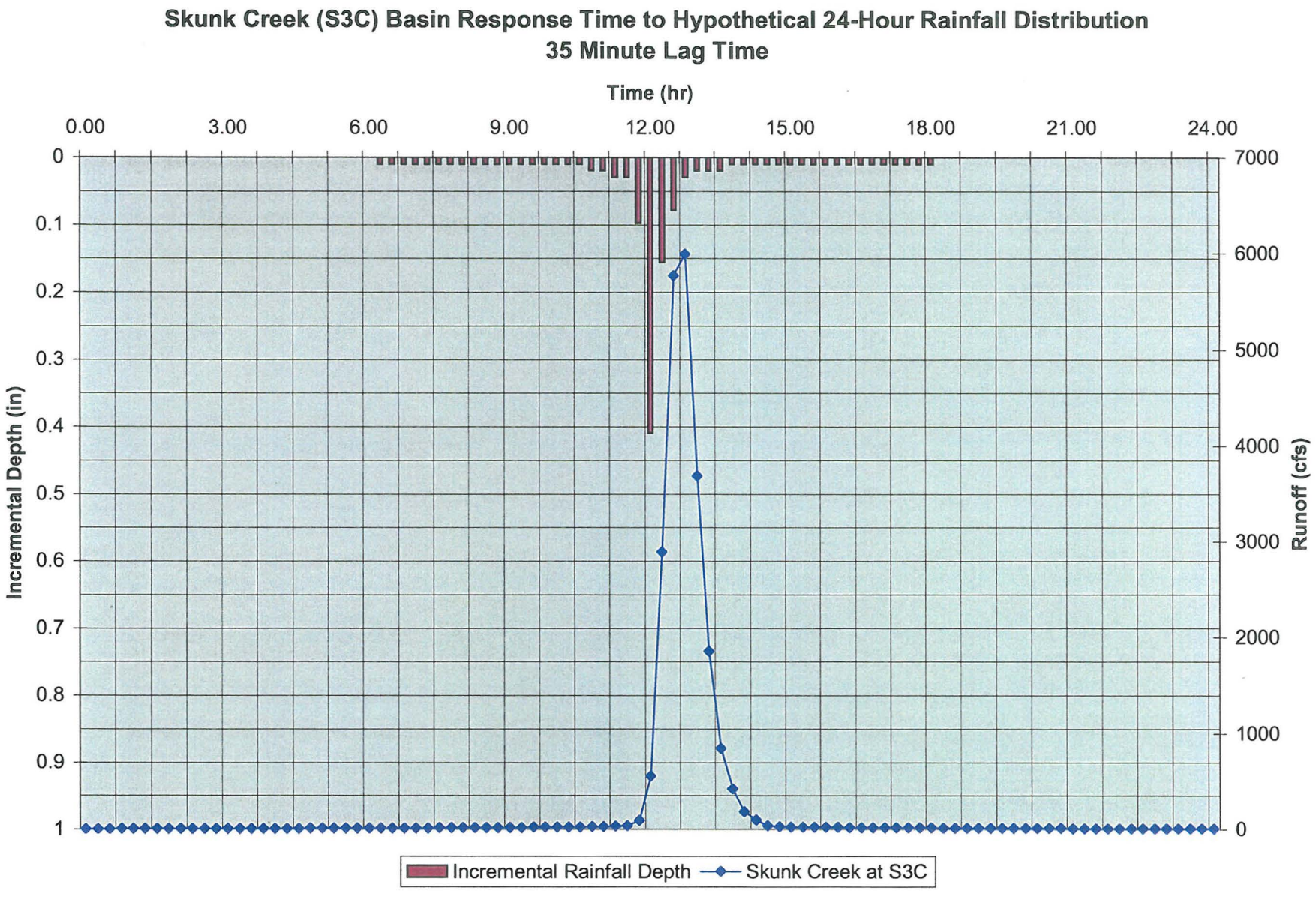

Skunk (S3C) Basin Response Time to Maricopa 6-Hour Rainfall Distribution
25 Minute Lag Time
Time (hr)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
Incremental Depth (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Runoff (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Incremental Rainfall Depth
Skunk Creek at S3C

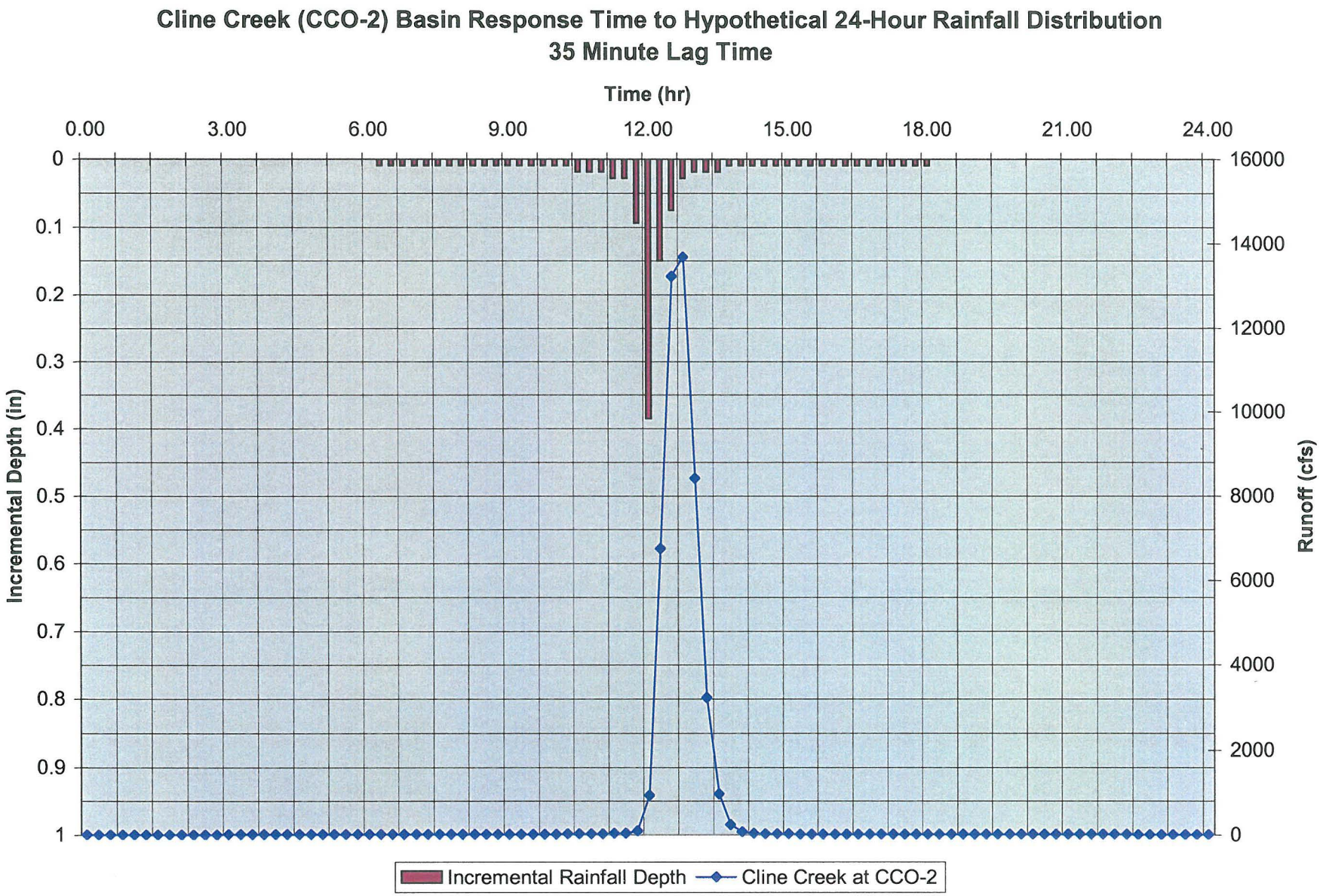

Cline (CCO-2) Basin Response Time to Maricopa 6-Hour Rainfall Distribution
25 Minute Lag Time
Time (hr)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
Incremental Depth (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Runoff (cfs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Incremental Rainfall Depth
Cline Creek at CCO-2

Skunk Creek (S3C) Basin Response Time to SCS 24-Hour Type II Rainfall Distribution
20 Minute Lag Time

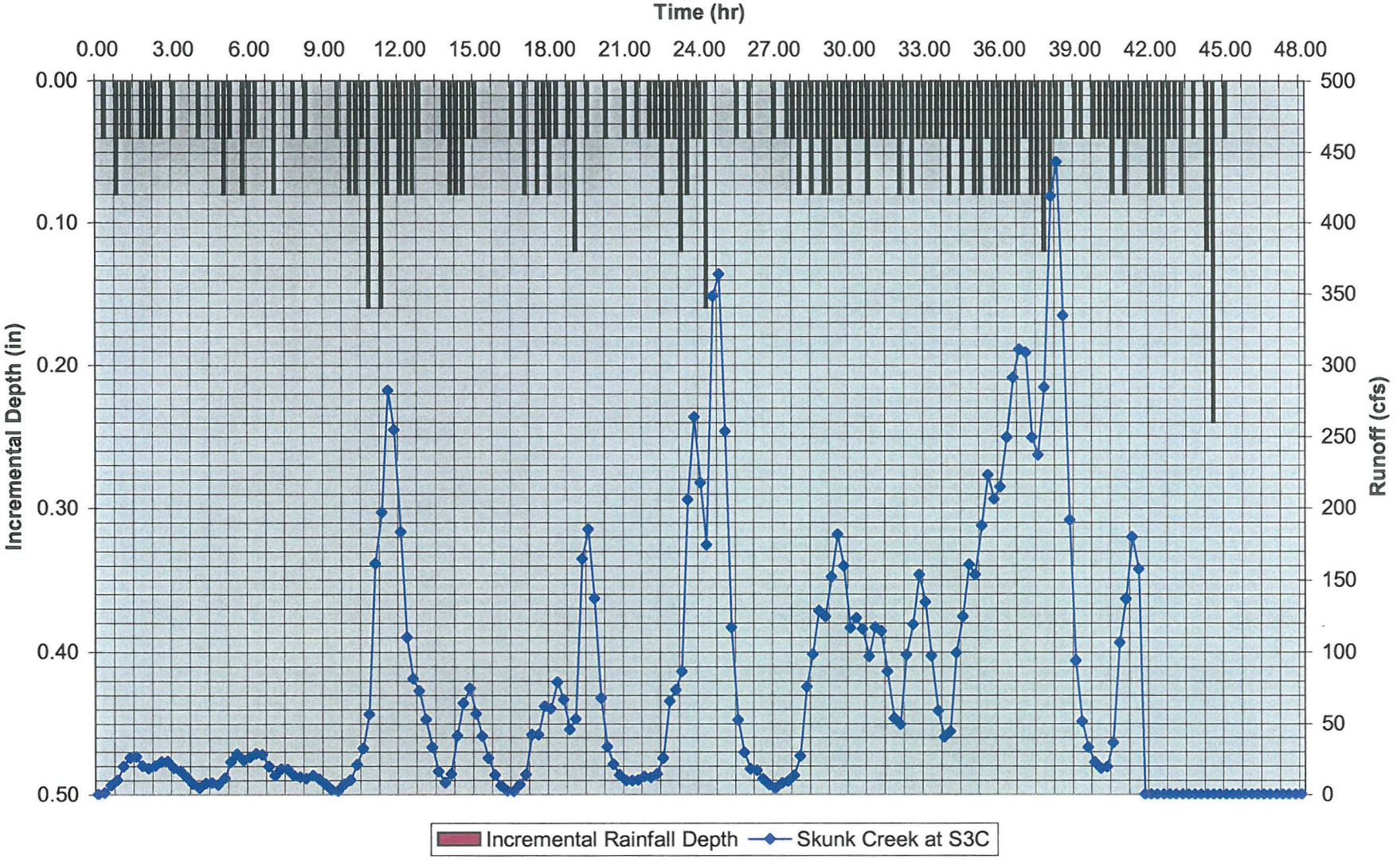


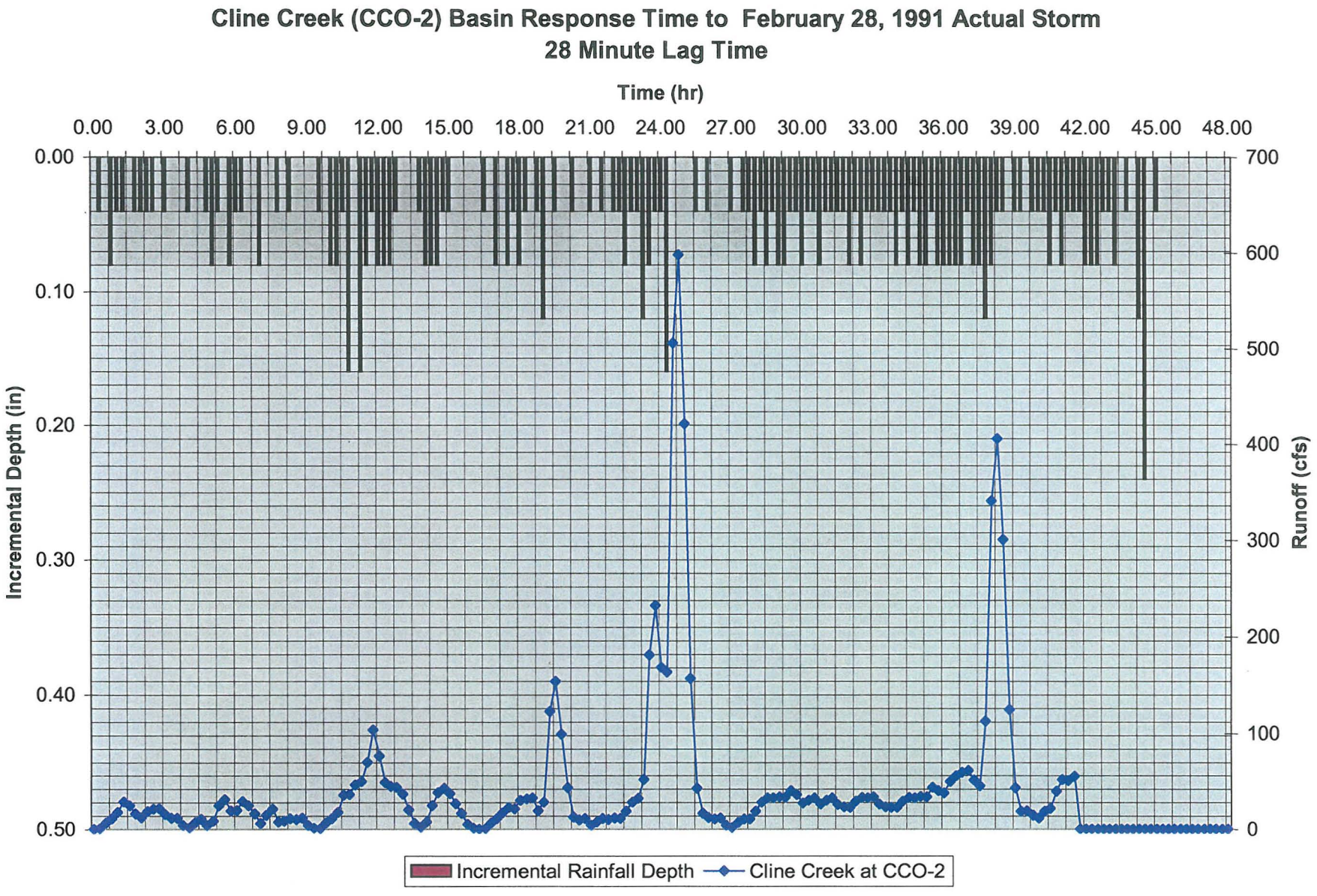

Cline Creek (CCO-2) Basin Response Time to SCS 24-Hour Type II Rainfall Distribution
20 Minute Lag Time
Time (hr)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
Incremental Depth (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Runoff (cfs)
12000
10000
8000
6000
4000
2000
0
Incremental Rainfall Depth
Cline Creek at CCO-2

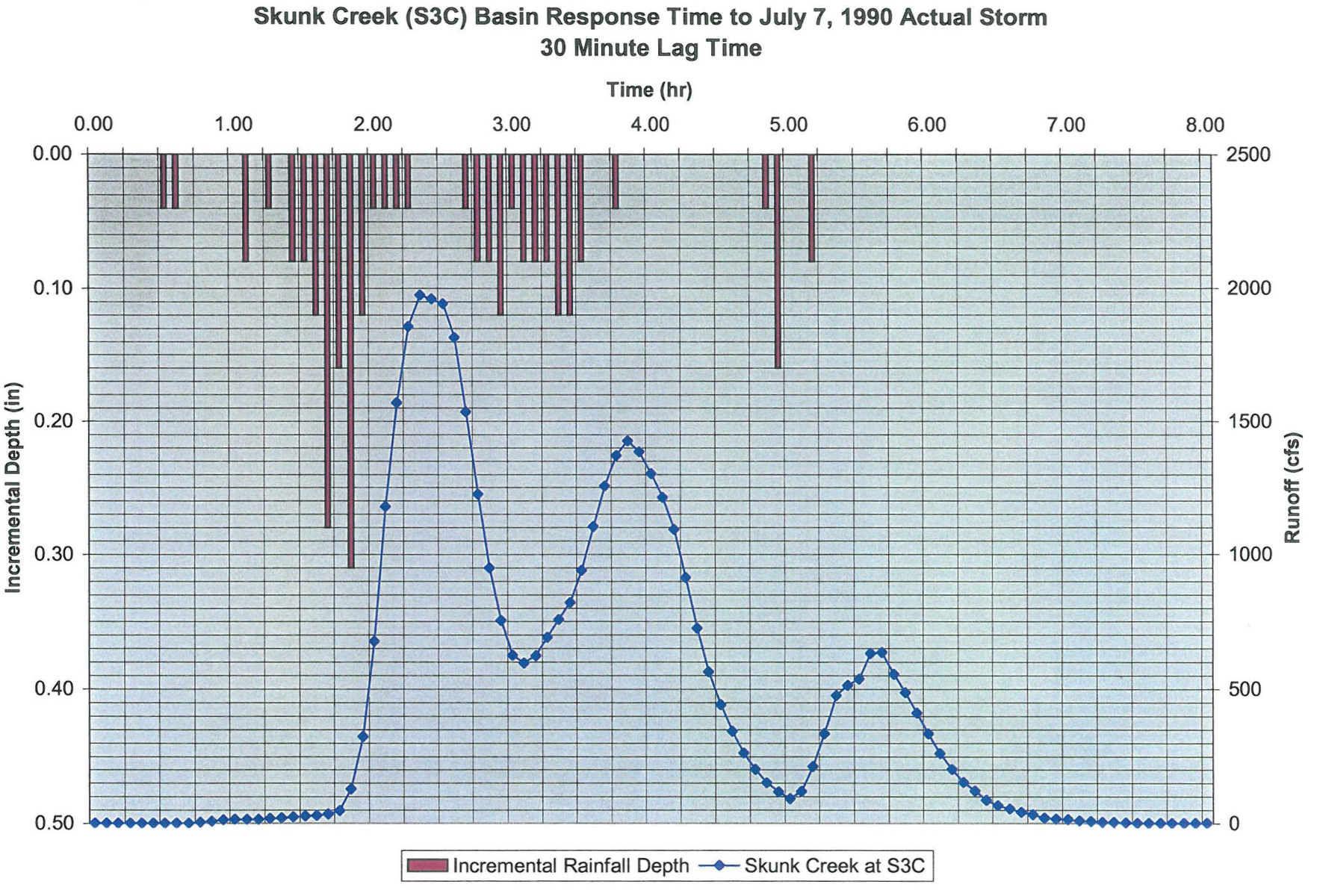

Skunk Creek (S3C) Basin Response Time to Hypothetical 24-Hour Rainfall Distribution
35 Minute Lag Time
Time (hr)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
Incremental Depth (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Runoff (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Incremental Rainfall Depth
Skunk Creek at S3C

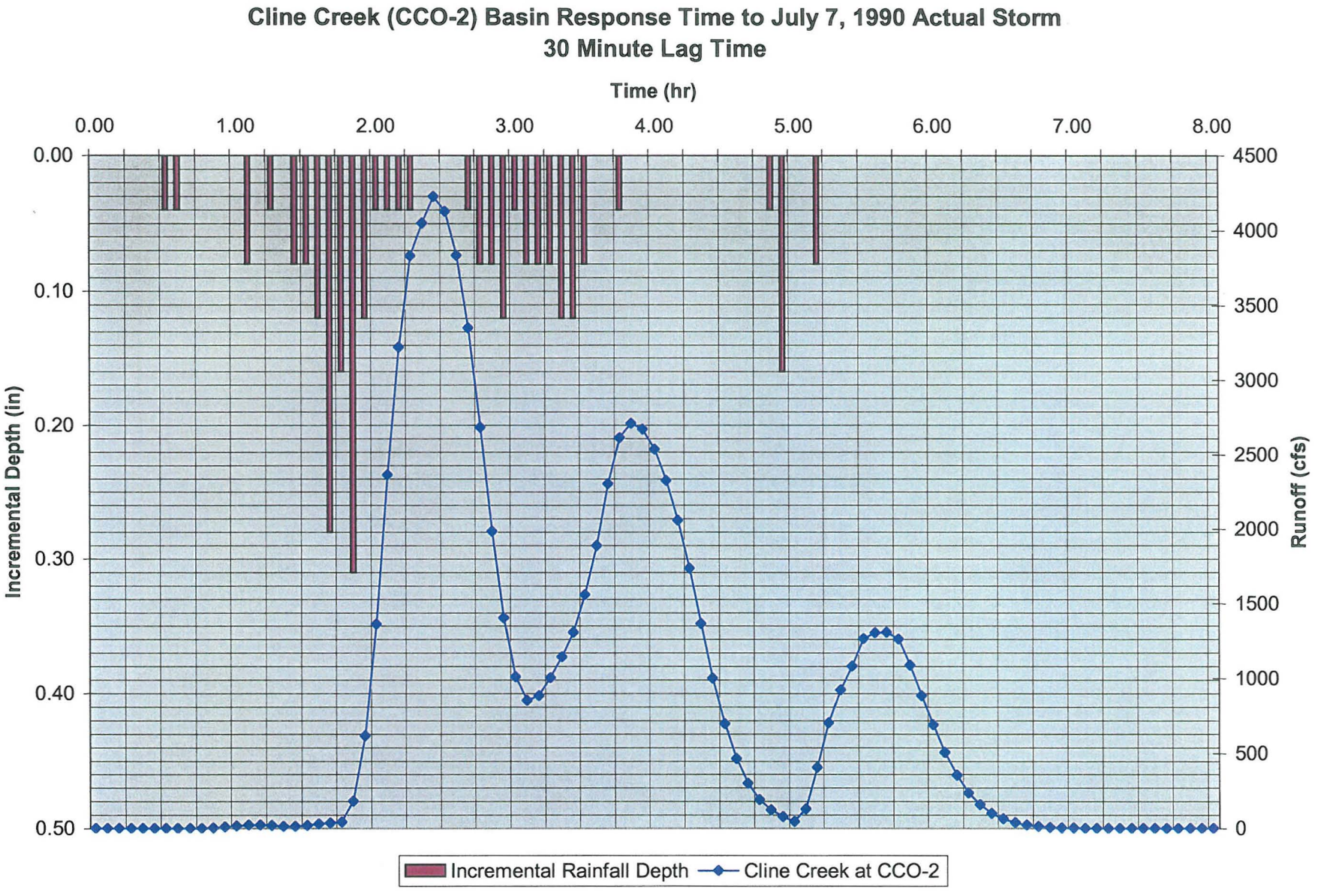

Cline Creek (CCO-2) Basin Response Time to Hypothetical 24-Hour Rainfall Distribution
35 Minute Lag Time
Time (hr)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
Incremental Depth (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Runoff (cfs)
16000
14000
12000
10000
8000
6000
4000
2000
0
Incremental Rainfall Depth
Cline Creek at CCO-2

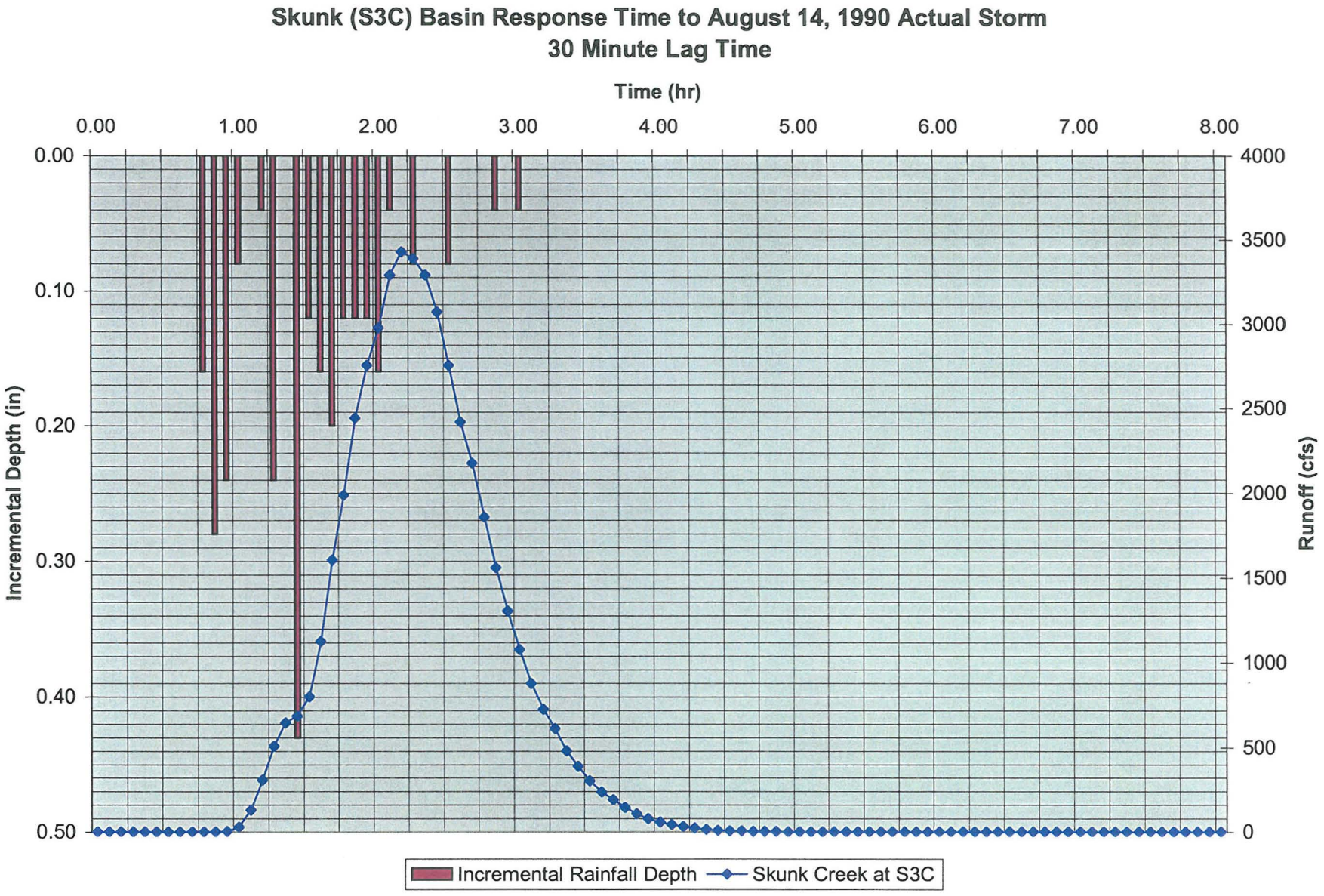
Skunk Creek (S3C) Basin Response Time to February 28, 1991 Actual Storm
22 Minute Lag Time

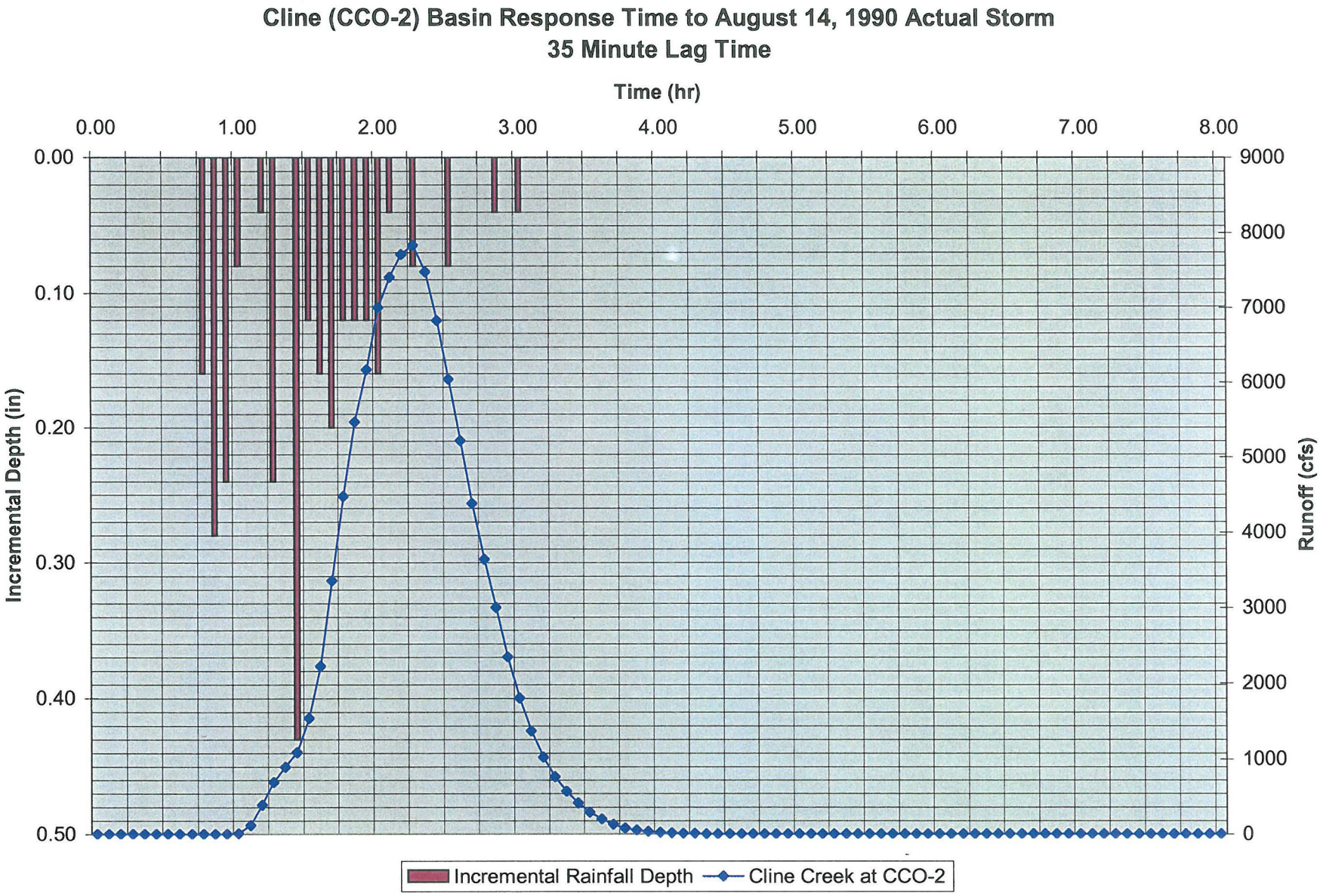


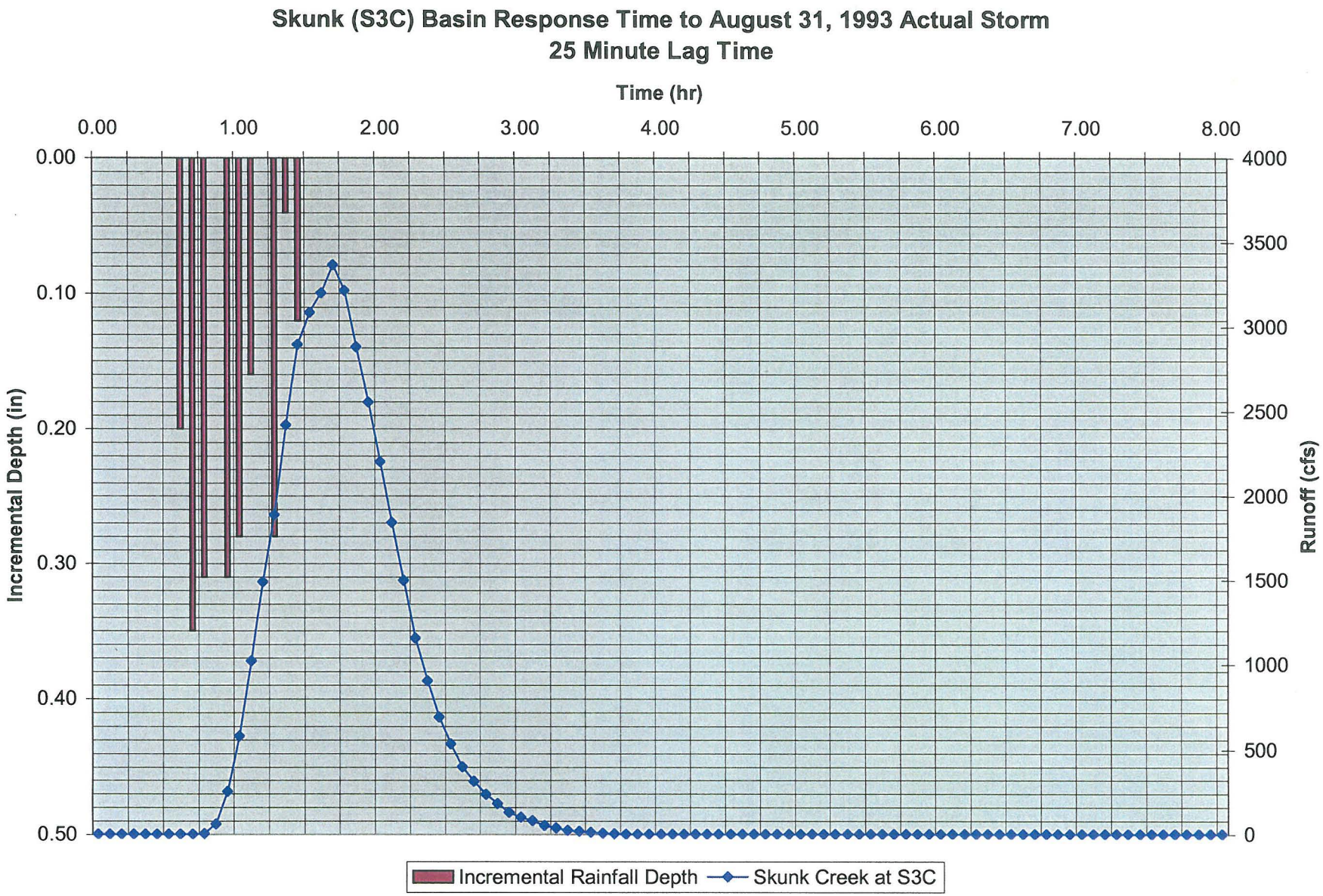

Cline Creek (CCO-2) Basin Response Time to February 28, 1991 Actual Storm
28 Minute Lag Time
Time (hr)
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
30.00
33.00
36.00
39.00
42.00
45.00
48.00
Incremental Depth (in)
0.00
0.10
0.20
0.30
0.40
0.50
Runoff (cfs)
700
600
500
400
300
200
100
0
Incremental Rainfall Depth
Cline Creek at CCO-2

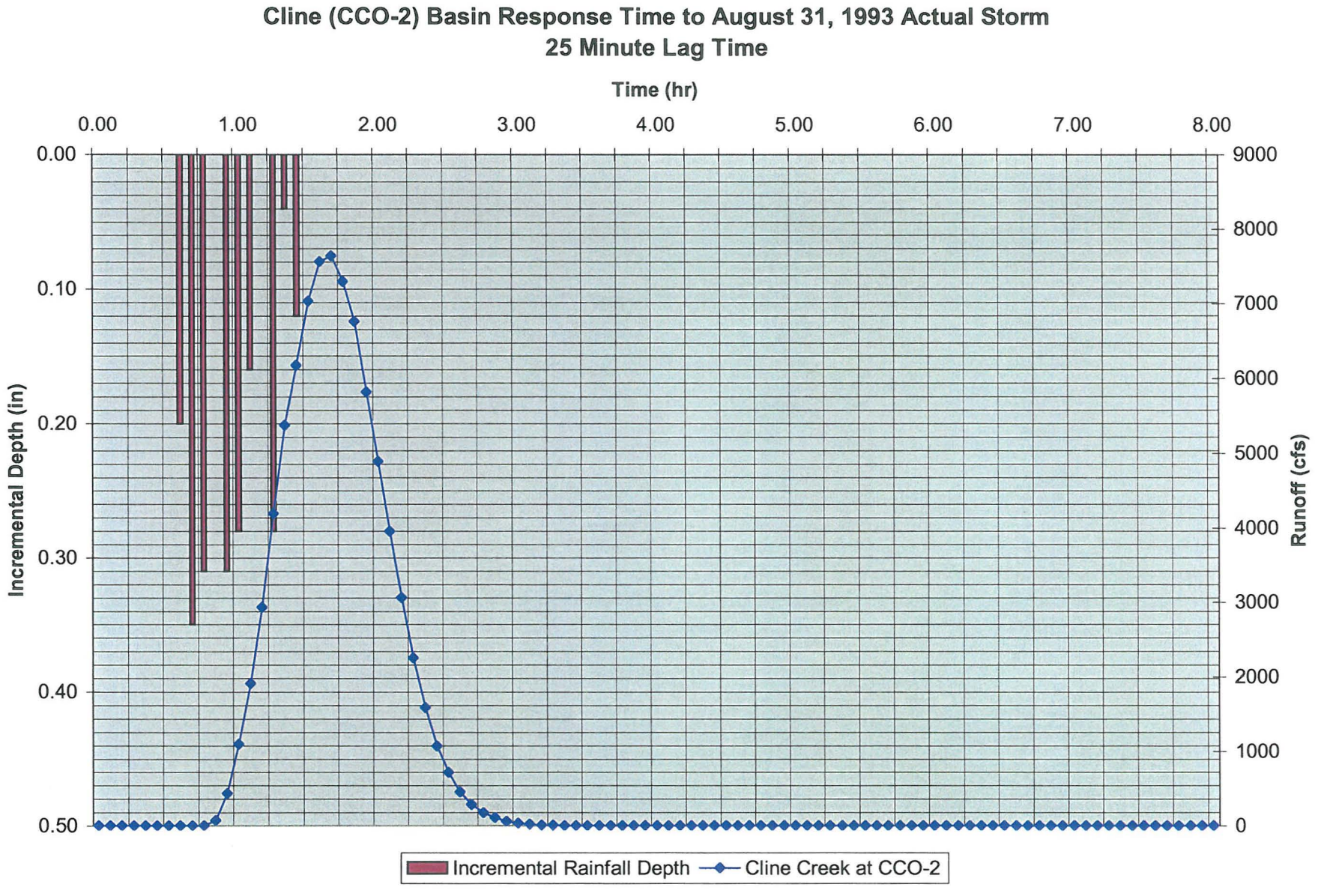

Skunk Creek (S3C) Basin Response Time to July 7, 1990 Actual Storm
30 Minute Lag Time
Time (hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Incremental Depth (in)
0.00
0.10
0.20
0.30
0.40
0.50
Runoff (cfs)
2500
2000
1500
1000
500
0
Incremental Rainfall Depth
Skunk Creek at S3C


Cline Creek (CCO-2) Basin Response Time to July 7, 1990 Actual Storm
30 Minute Lag Time
Time (hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Incremental Depth (in)
0.00
0.10
0.20
0.30
0.40
0.50
Runoff (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Incremental Rainfall Depth
Cline Creek at CCO-2

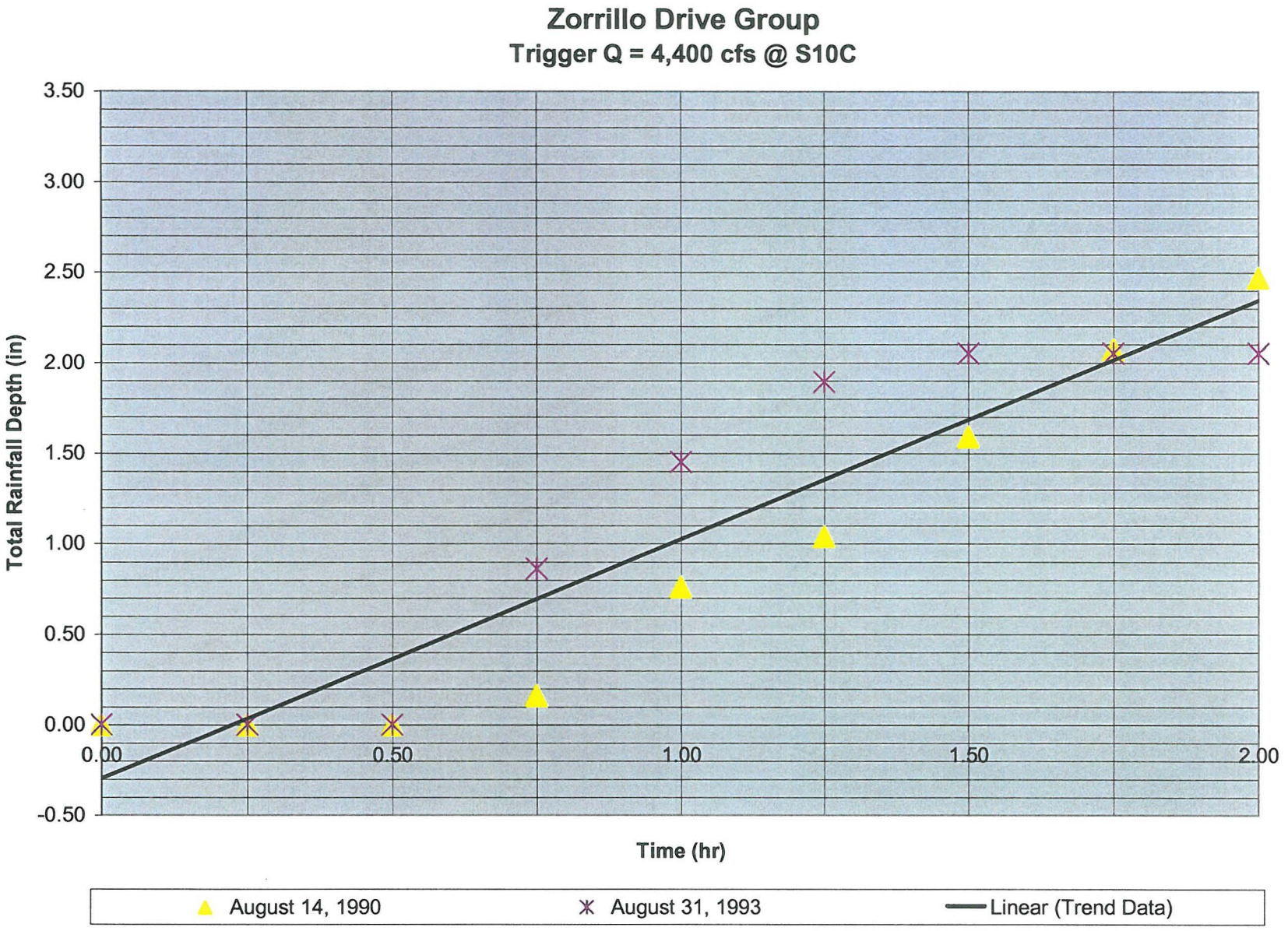

Skunk (S3C) Basin Response Time to August 14, 1990 Actual Storm
30 Minute Lag Time
Time (hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Incremental Depth (in)
0.00
0.10
0.20
0.30
0.40
0.50
Runoff (cfs)
4000
3500
3000
2500
2000
1500
1000
500
0
Incremental Rainfall Depth
Skunk Creek at S3C

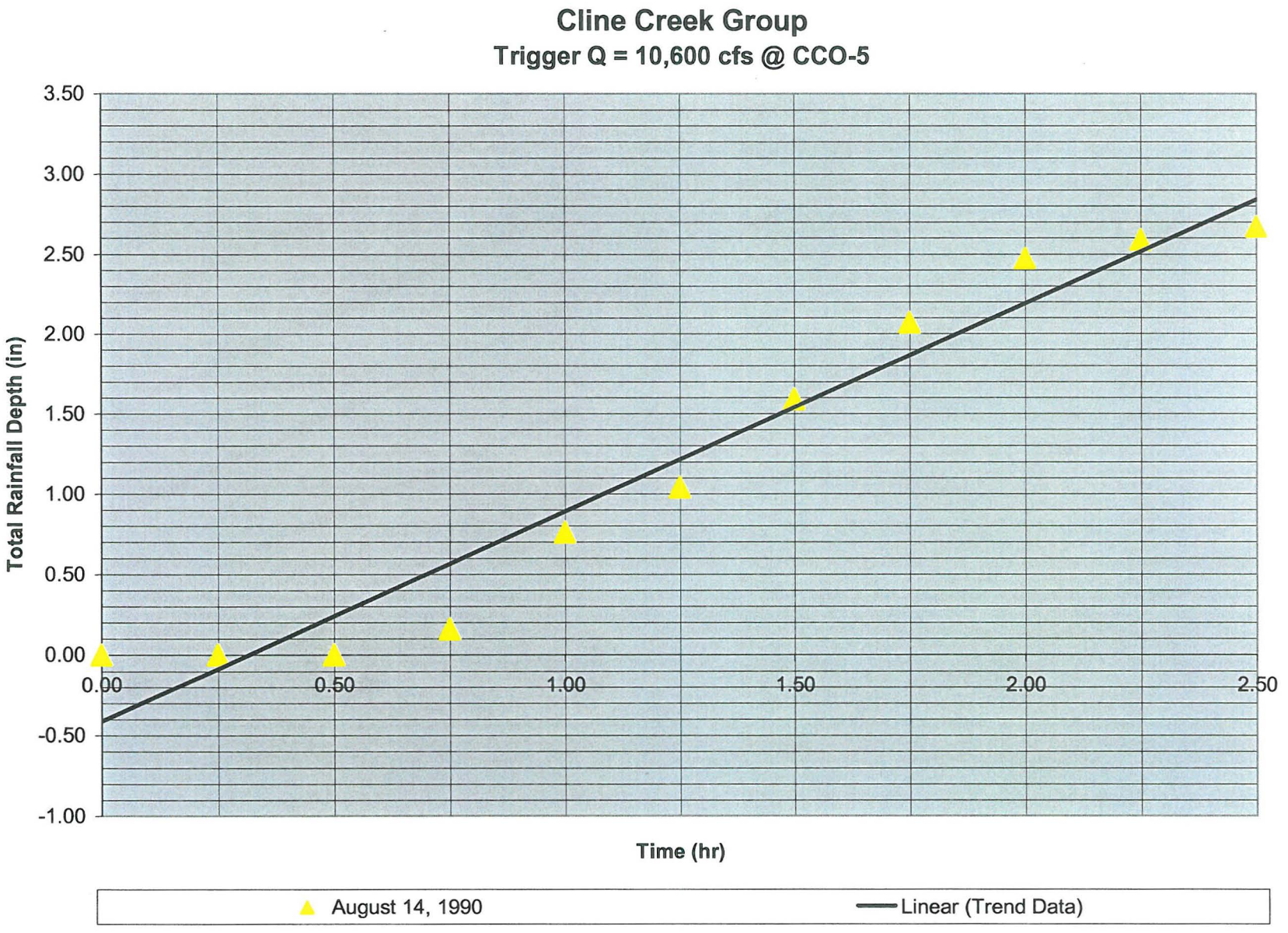

Cline (CCO-2) Basin Response Time to August 14, 1990 Actual Storm
35 Minute Lag Time
Time (hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Incremental Depth (in)
0.00
0.10
0.20
0.30
0.40
0.50
Runoff (cfs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Incremental Rainfall Depth
Cline Creek at CCO-2

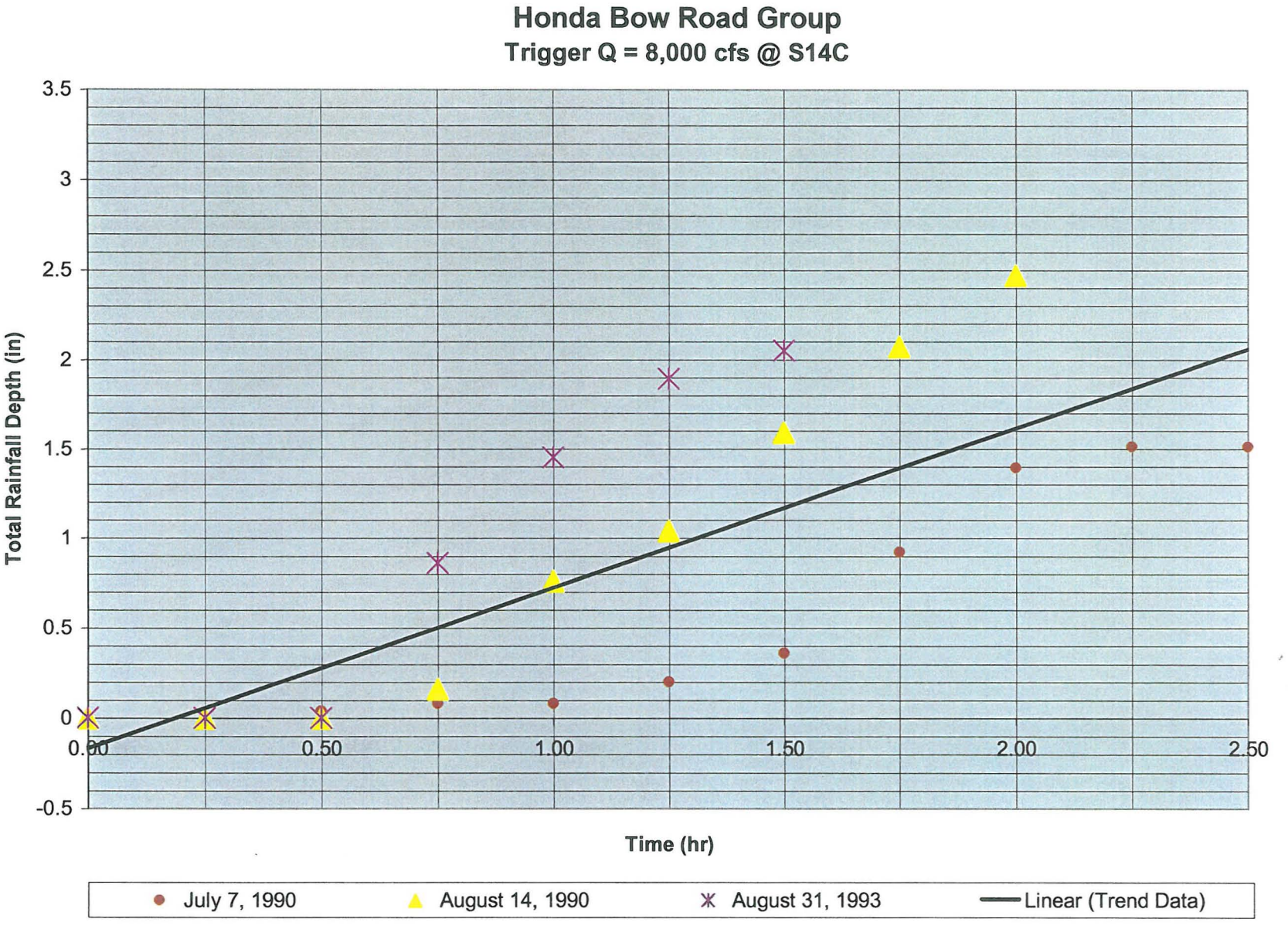

Skunk (S3C) Basin Response Time to August 31, 1993 Actual Storm
25 Minute Lag Time
Time (hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Incremental Depth (in)
0.00
0.10
0.20
0.30
0.40
0.50
Runoff (cfs)
4000
3500
3000
2500
2000
1500
1000
500
0
Incremental Rainfall Depth
Skunk Creek at S3C

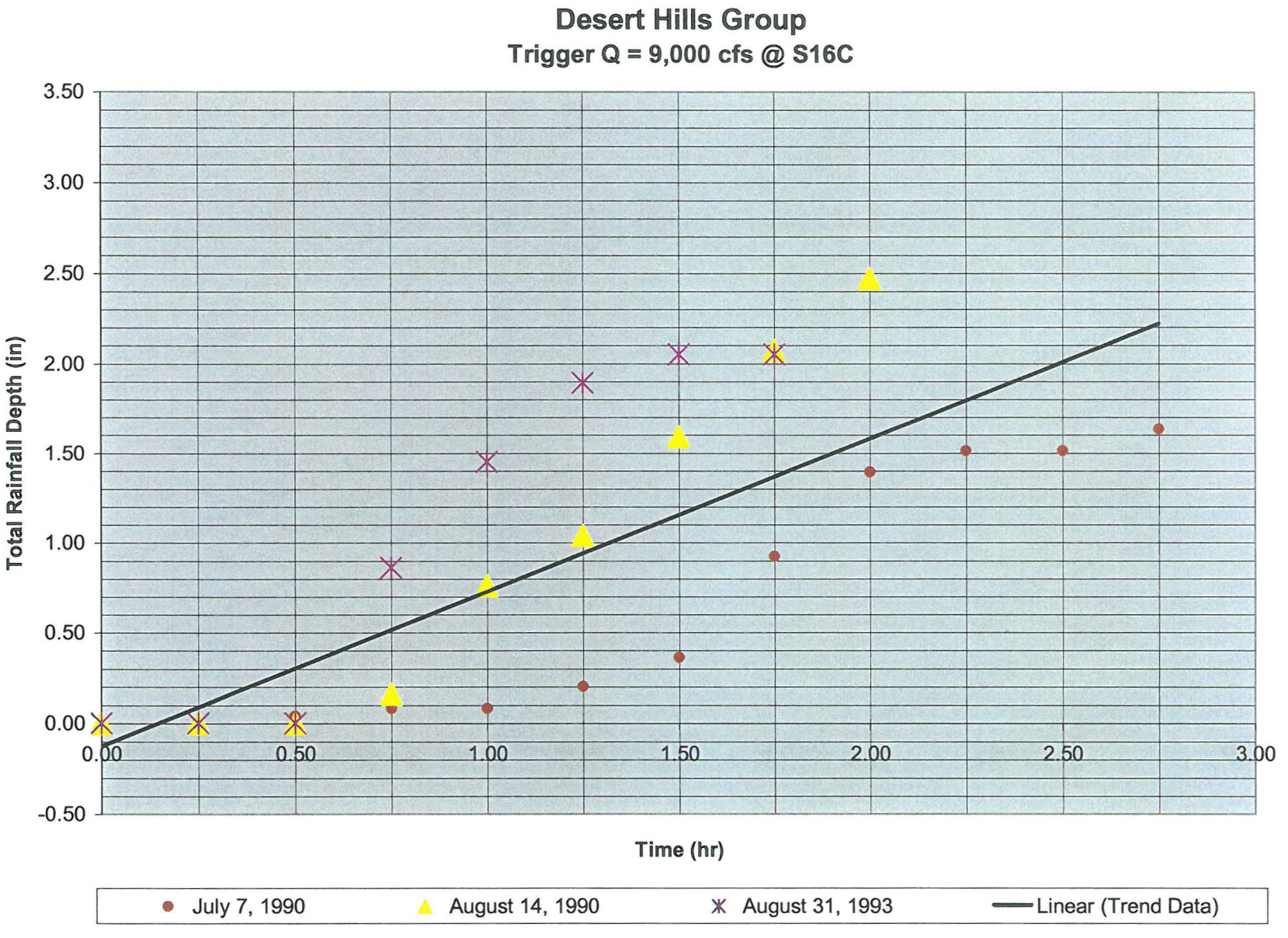

Cline (CCO-2) Basin Response Time to August 31, 1993 Actual Storm
25 Minute Lag Time
Time (hr)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Incremental Depth (in)
0.00
0.10
0.20
0.30
0.40
0.50
Runoff (cfs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Incremental Rainfall Depth
Cline Creek at CCO-2

APPENDIX C-2: Threshold Precipitation Depth Plots


Zorrillo Drive Group
Trigger Q = 4,400 cfs @ S10C
Total Rainfall Depth (in)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
0.00
0.50
1.00
1.50
2.00
Time (hr)
August 14, 1990
August 31, 1993
Linear (Trend Data)


Cline Creek Group
Trigger Q = 10,600 cfs @ CCO-5
Total Rainfall Depth (in)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
0.00
0.50
1.00
1.50
2.00
2.50
Time (hr)
August 14, 1990
Linear (Trend Data)


Honda Bow Road Group
Trigger Q = 8,000 cfs @ S14C
Total Rainfall Depth (in)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0.00
0.50
1.00
1.50
2.00
2.50
Time (hr)
July 7, 1990
August 14, 1990
August 31, 1993
Linear (Trend Data)


Desert Hills Group
Trigger Q = 9,000 cfs @ S16C
Total Rainfall Depth (in)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Time (hr)
July 7, 1990
August 14, 1990
August 31, 1993
Linear (Trend Data)

APPENDIX C-3: Recurrence Interval Curves

sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT Skunk Creek | JOB NO. | PAGE
PROJECT Hydrology DATA | DATE CHECKED | DATE 4/19/0
DETAIL | CHECKED BY | COMPUTED BY 1

		0.5 Existing 2-yr	0.1 Existing 10-yr	0.01 Existing 100-yr	Time to Peak [hrs] SCS 24-hour distribution 2-yr	10-yr	100-yr
At Fig Bd. (gage)	53C	1,036	2,419	4,899	12.25	12.25	12.25
Above Cline	513C	2,070	5,485	11,811	12.50	12.50	12.50
Cline US (gage)	CCO-2	1,460	4,887	10,883	12.42	12.25	12.25
Cline	CCO-5	2,149	6,322	13,747	12.58	12.67	12.67
below Cline	514C	3,845	11,155	24,427	12.67	12.67	12.67
Rodger	CO-2	1,699	3,082	5,624	12.58	12.58	12.58
below Rodger	516C	4,868	12,778	27,332	12.83	12.92	12.92
AT Tank	521C2	4,948	12,807	27,733	13.25	13.33	13.33
	510C	1,674	4,494	9,741	12.50	12.50	12.50
	510-9C	1,458	3,916	8,532		—	—
New Rue Bridge	56C	1,463	3,718	7,840	12.67	12.58	12.58
Rodger Gage	CO-1	1,519	2,713	4,800	12.25	12.25	12.25

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

STATION NAME
Skunk Creek Existing Hydrology
STATION NO. S3C, S13C, S14C, S21C2
DRAINAGE AREA At Fig, Above Cline, Below
PERIOD OF RECORD Cline, Below Tank

PEAK DISCHARGE, IN CFS

S21C2
S14C
S13C
S3C

PROJECT
DATE BY

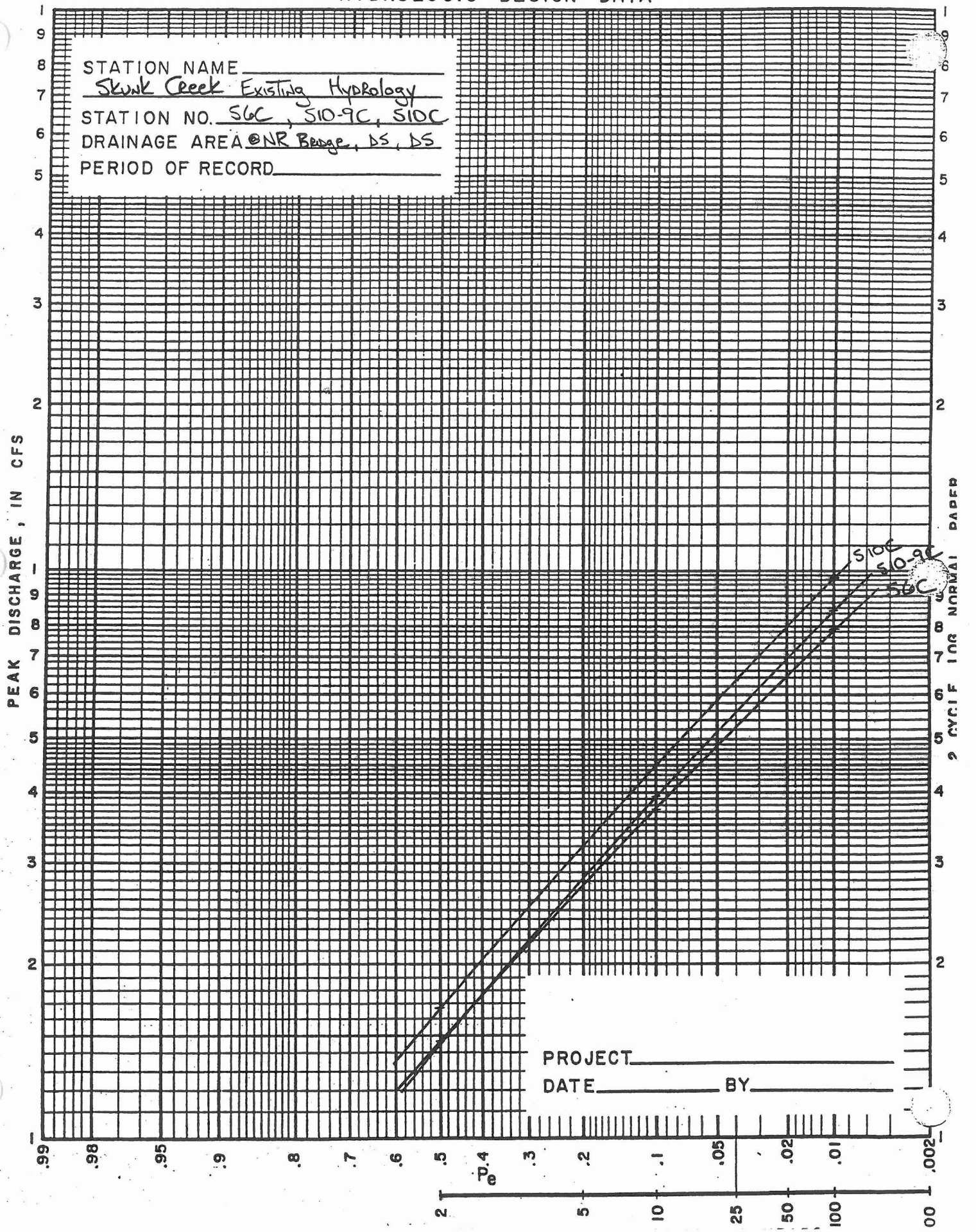
P_e

RETURN PERIOD IN YEARS

2 CYCLE NORMAL PAPER

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

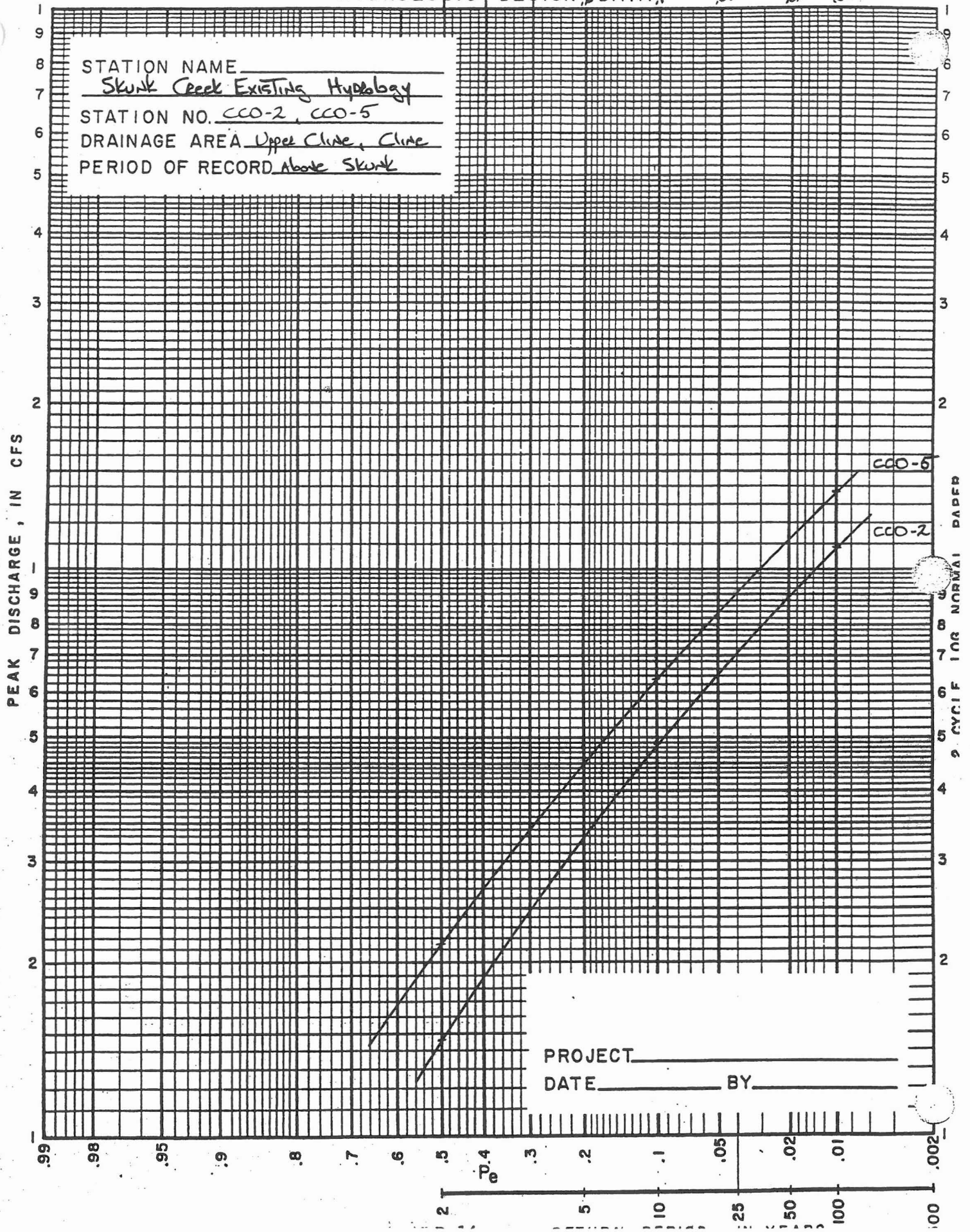
STATION NAME
Skunk Creek Existing Hydrology
STATION NO. S6C, S10-9C, S10C
DRAINAGE AREA @NR Bridge, DS, DS
PERIOD OF RECORD

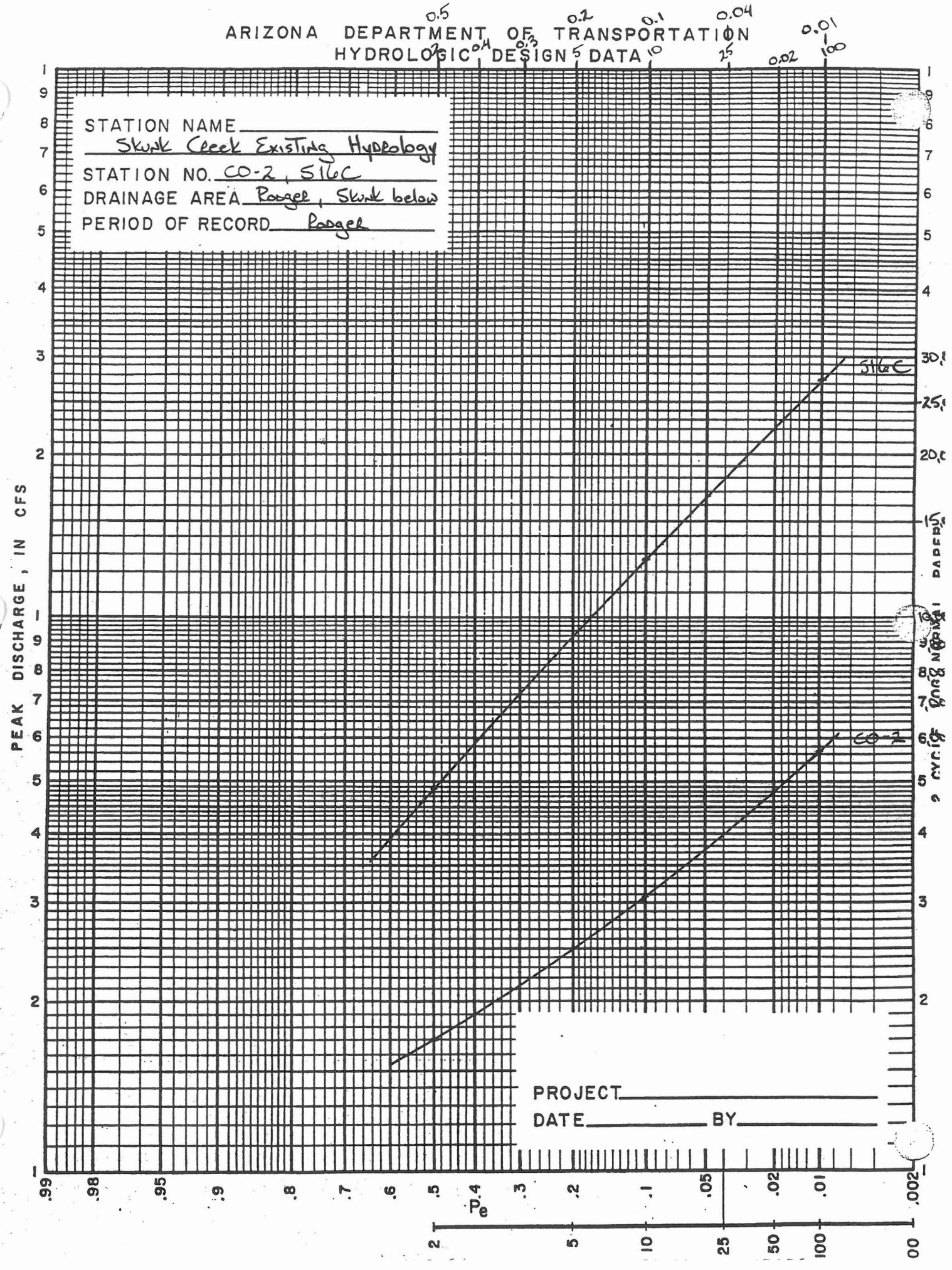


2 CYCLE LOG NORMAL PAPER

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA

STATION NAME Skunk Creek Existing Hydrology
STATION NO. CCO-2, CCO-5
DRAINAGE AREA Upper Cline, Cline
PERIOD OF RECORD Above Skunk



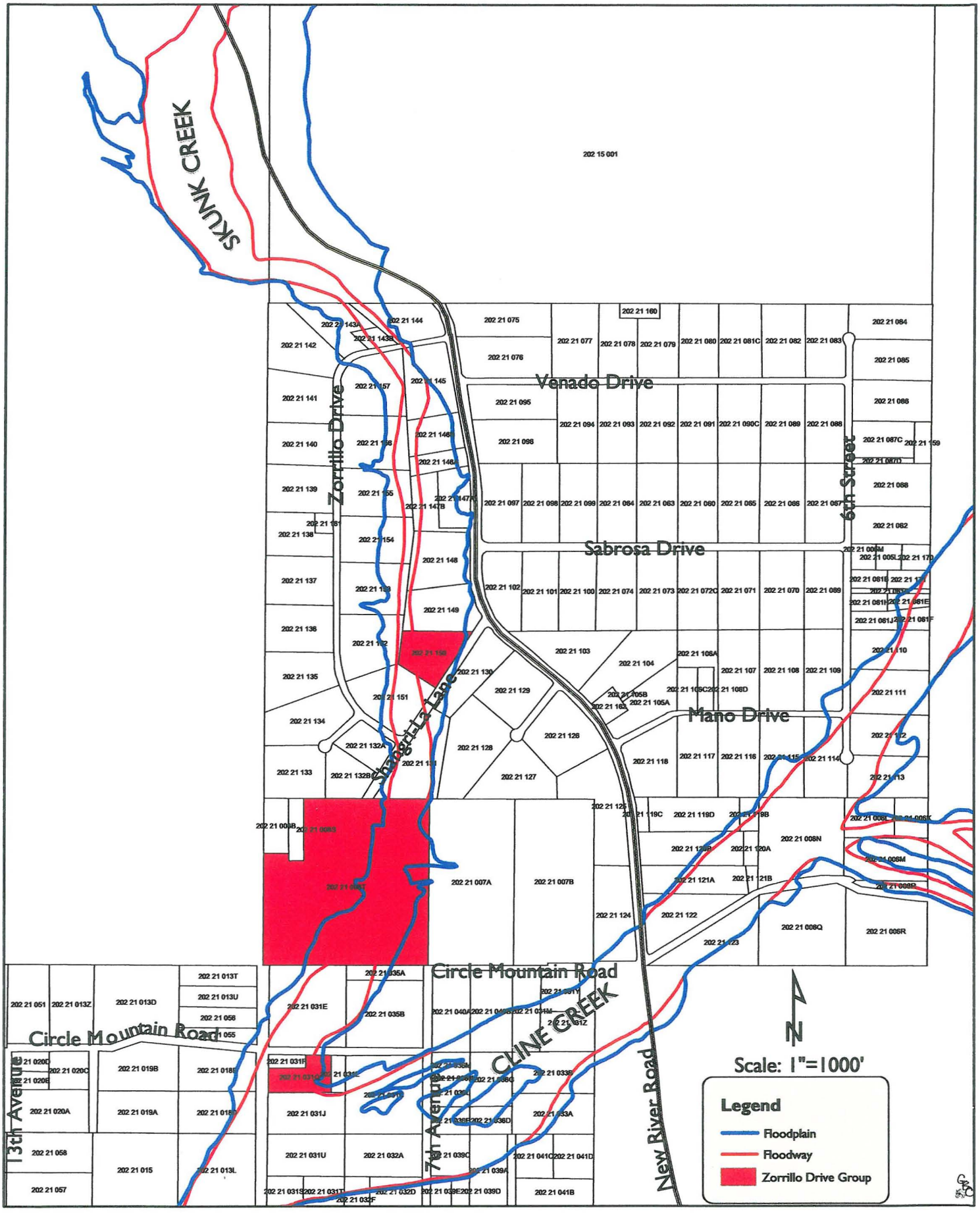

ARIZONA DEPARTMENT OF TRANSPORTATION
HYDROLOGIC DESIGN DATA
STATION NAME
Skunk Creek Existing Hydrology
STATION NO. CO-2, 516C
DRAINAGE AREA Badger, Skunk below
PERIOD OF RECORD Badger
PEAK DISCHARGE, IN CFS
516C
CO-2
PROJECT
DATE
BY
Pe

APPENDIX D

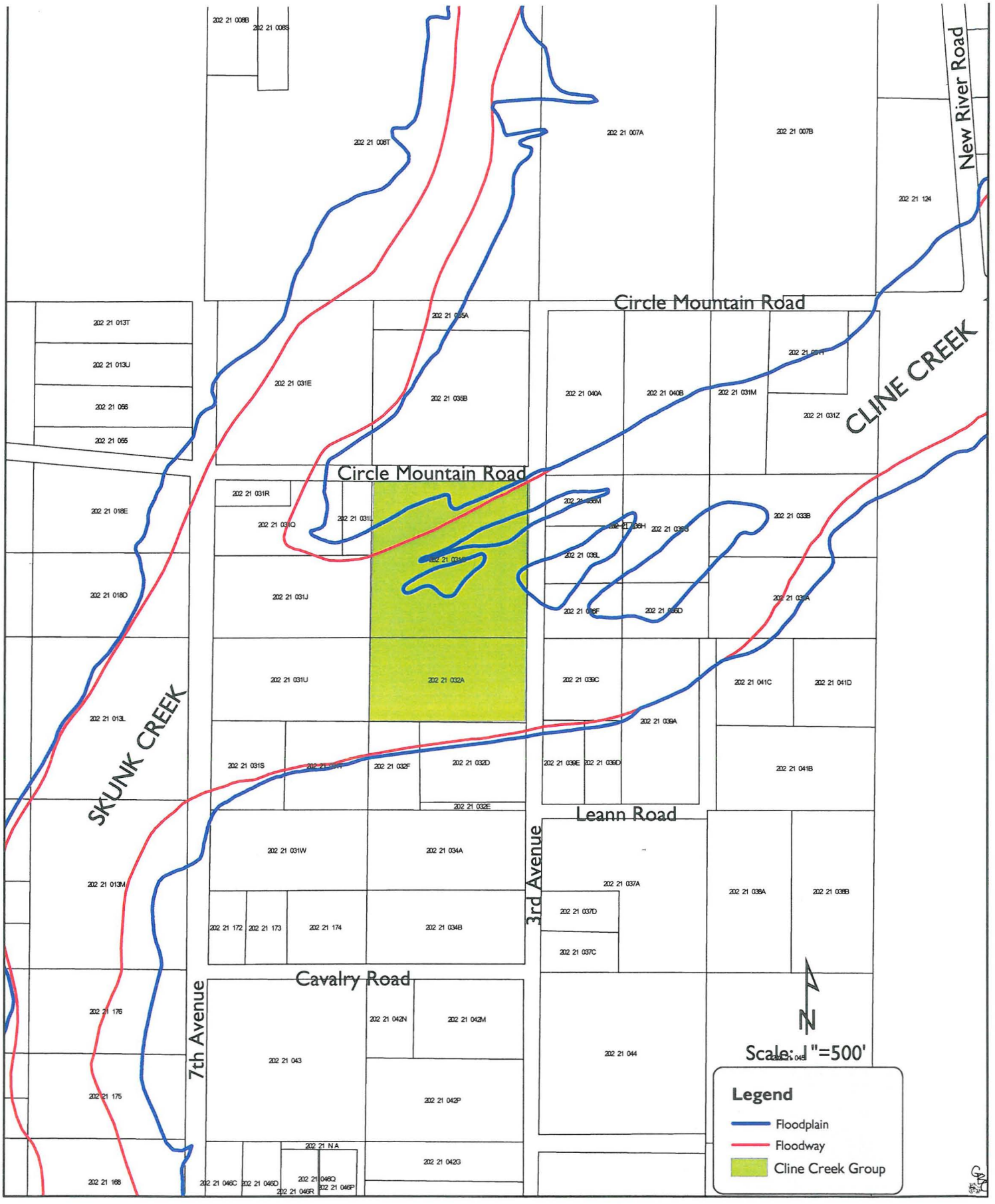
HYDRAULIC ANALYSIS SUPPORTING DATA

D-1: FRP Structure Data
D-2: Roadway Overtopping Plots

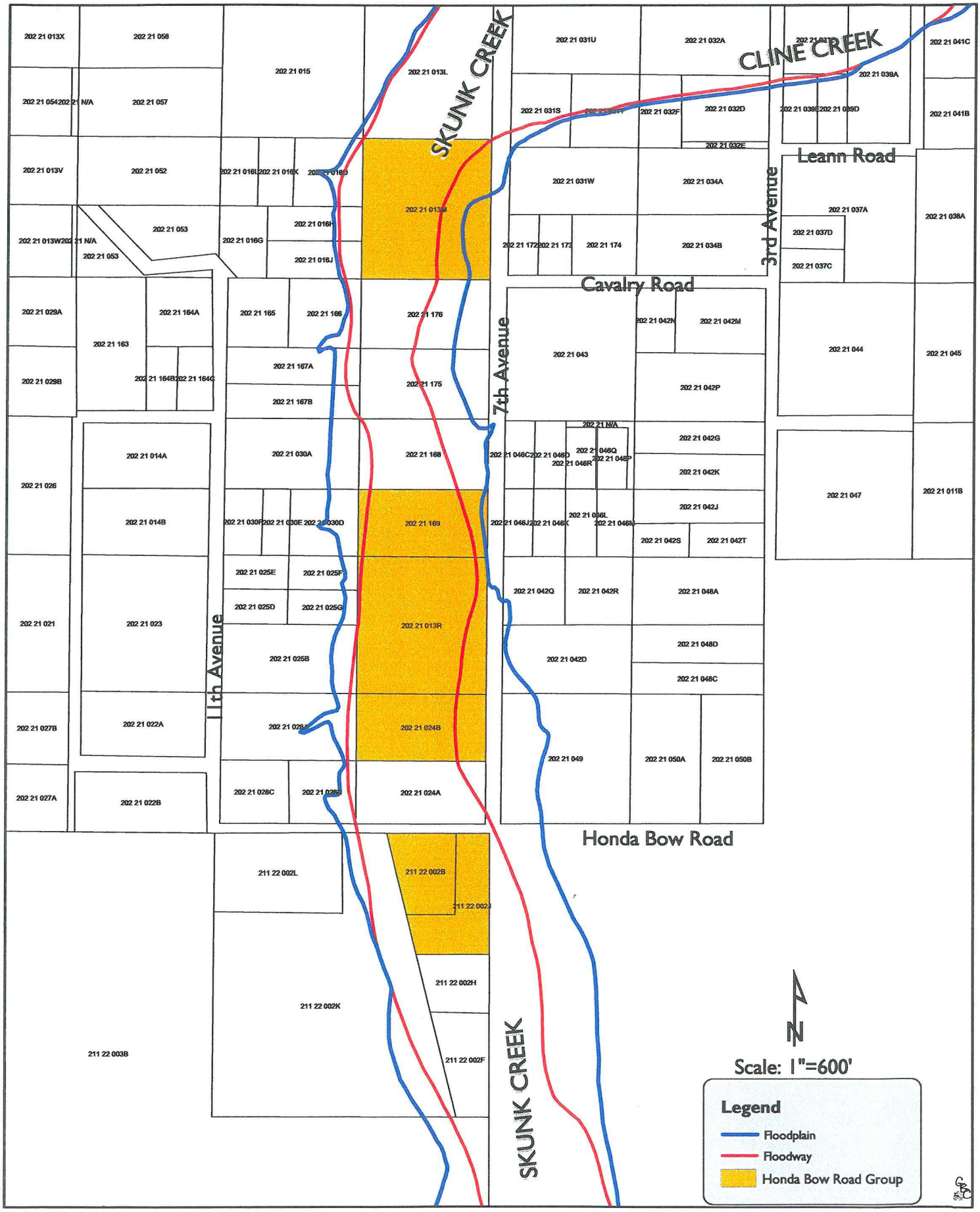
APPENDIX D-1: FRP Structure Data



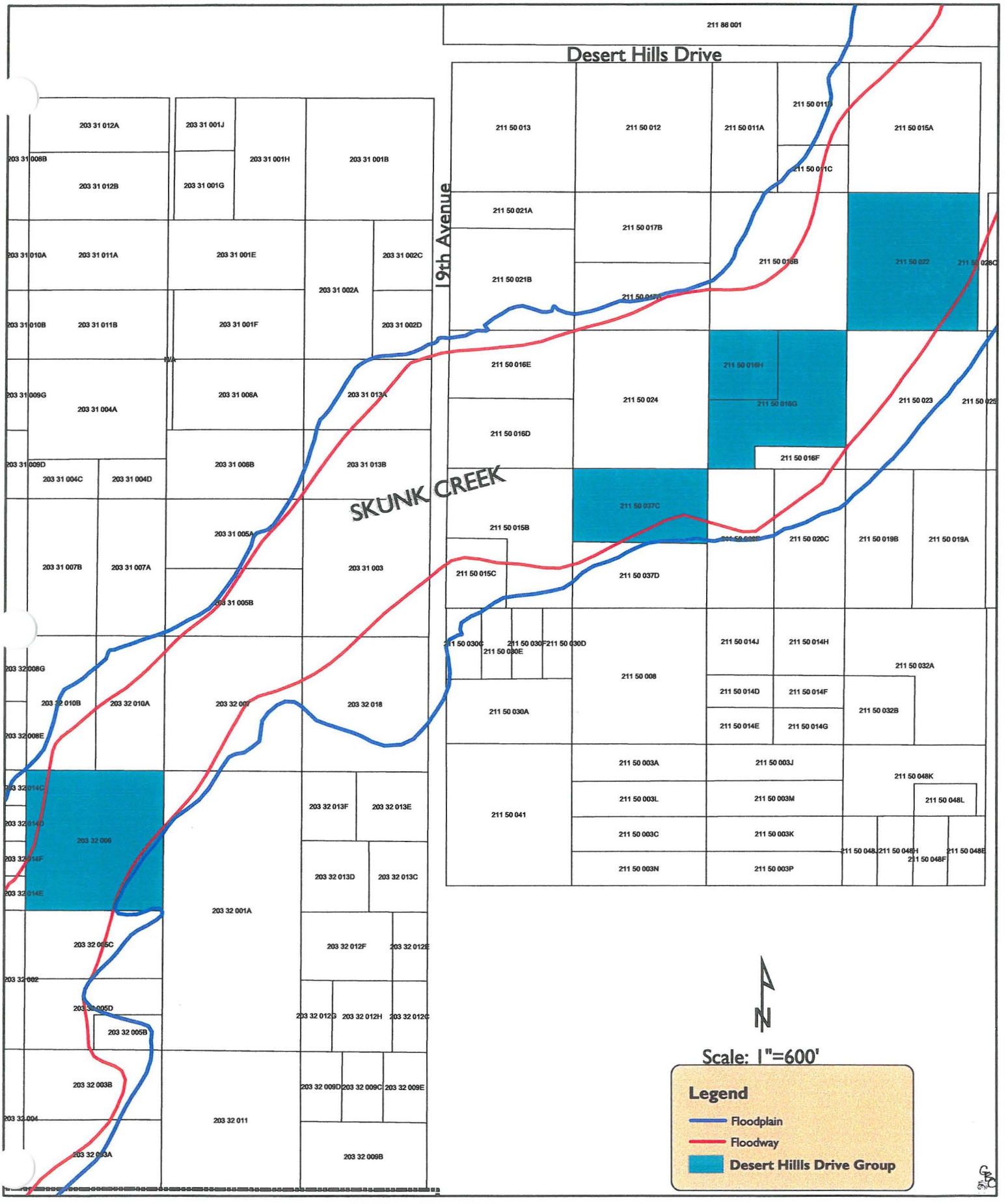
ZORRILLO DRIVE FLOOD HAZARD GROUP



CLINE CREEK FLOOD HAZARD GROUP



HONDA BOW ROAD FLOOD HAZARD GROUP



DESERT HILLS DRIVE FLOOD HAZARD GROUP

SKUNK CREEK FLOOD RESPONSE PLAN

Flow to Reach Finished Floor Elevation and Associated Recurrence Interval

Parcel #	Tag ID	Name	Structure	HEC-RAS Cross Section	100-yr WSEL	FFE Elev	Difference	RAS model Q_{100} [cfs]	Q_{FFE} (or Q_{ground}, mobiles) [cfs]	Approx. Recurrence Interval	Overbank Flow Velocity‡ [fps]
211-50-037C	104	Mathis	Mobile	20.26	1830.65	1831.54	-0.89	27,300	13,600	12	5 to 6
211-50-037C	104	Mathis	House	20.32	1833.30	1832.54	0.76	27,300	19,600	31	5 to 6
211-50-016H	929	Birdsell	Mobile	---	1837.22	?	---	27,300	25,000	71	5 to 6
211-50-016J	84	Harper	Mobile 3	20.45	1839.39	1840.43	-1.04	27,300	13,500	12-yr	5 to 6
211-50-016J	84	Harper	Mobile 2	20.45	1839.39	1840.32	-0.93	27,300	14,250	13-yr	5 to 6
211-50-016J	84	Harper	Mobile 1	20.47	1840.58	1842.17	-1.59	27,300	13,000	11-yr	5 to 6
211-50-022	62	Hopwood Trust	Mobile 2	20.53	1843.80	1844.34	-0.54	27,300	11,700	8-yr	4 to 5
211-50-022	62	Hopwood Trust	House 1	20.55	1844.89	1844.87	0.02	27,300	27,000	100-yr	4 to 5
211-50-022	62	Hopwood Trust	Mobile 3	20.56	1845.66	1845.22	0.44	27,300	9,000	5-yr	4 to 5
211-50-022	62	Hopwood Trust	Mobile 1	20.61	1847.62	1848.55	-0.93	27,300	15,000	15-yr	4 to 5
211-50-022	62	Hopwood Trust	House 2	---	1845.66[1]	1845.48	0.18	27,300	25,000	71-yr	4 to 5
211-22-002J	6	Geraci	Mobile	22.87	1965.40	1965.42	-0.02	24,400	13,500	16	5
211-22-002B	5	McKeag	House	22.90	1968.29	1965.25	3.04	24,400	8,000	5	5
202-21-024B	616	Albert	House	22.95	1973.36	1971.42	1.94	24,400	12,200	13	4 to 5
202-21-013R	585	Eller	House	23.12	1980.24	1979.29	0.95	24,400	18,000	34	4
202-21-169	847	Hines	House	23.20	1984.20	1980.93	3.27	24,400	8,000	5	4
202-21-013M	584	Funk	House	23.44	1997.41	1996.58	0.83	24,400	19,000	42	3 to 7
202-21-032A	647	Caldwell	House	---	2021.74	2021.44	0.30	16,700	13,300	91-yr	2 to 6
202-21-031C	634	Selleys	House	---	2024.80	?	---	16,700	10,600[2]	40-yr	?
202-21-031Q	639	Sartain	House 1	23.83	2016.49	2017.10	-0.61	11,800	>11,800	>100-yr	3 to 4

[1] WSEL set to match neighboring structure from model

[2] Flow interpolated to estimated ground elevation (EGE)

‡By Stantech, from floodplain model

Used "Desert Hills Split Flow" model for these homes; Minimum Breakout Flow = 8,000 cfs

Interpolated WSEL between cross-sections

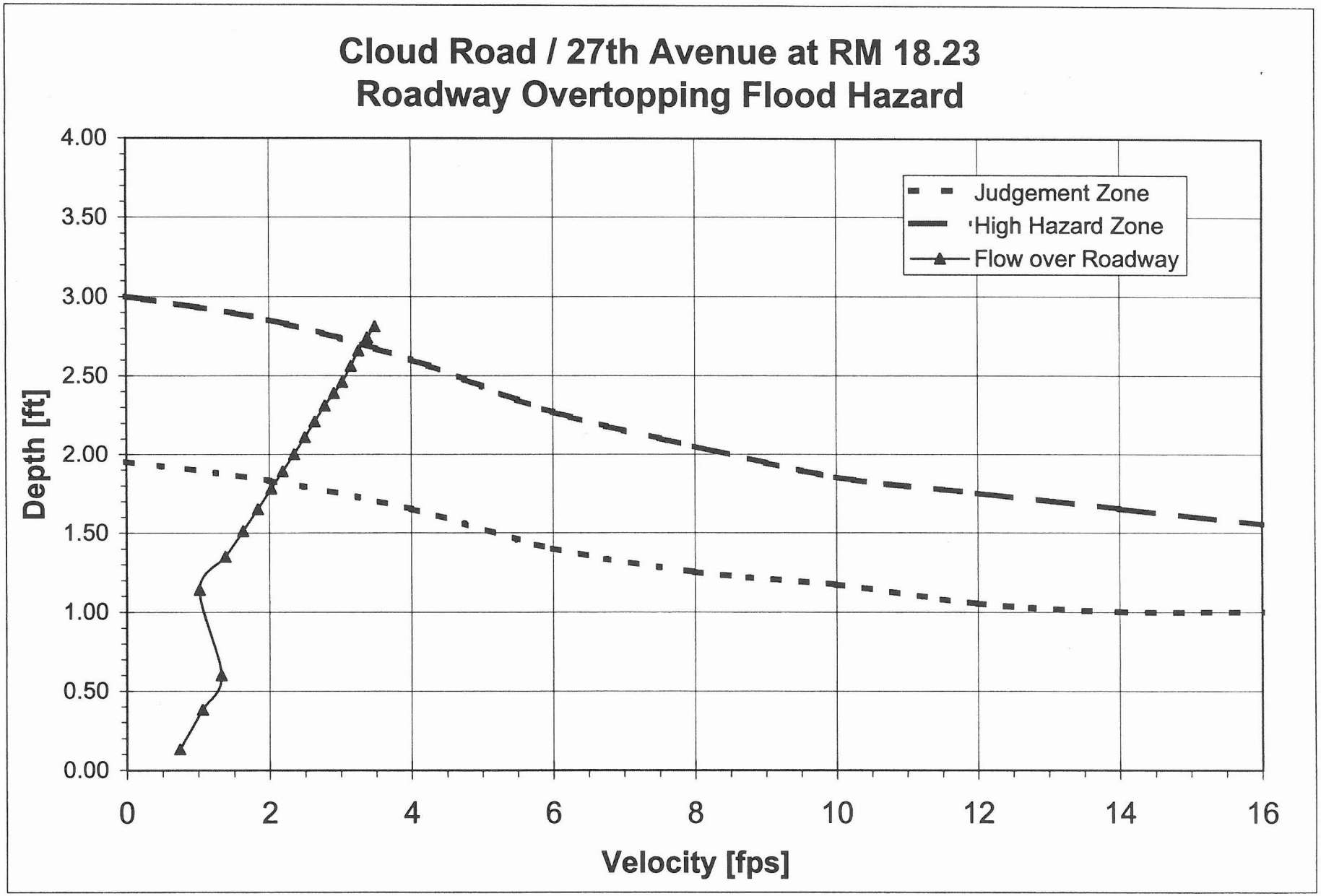
SKUNK CREEK FLOOD RESPONSE PLAN

Flow to Estimated Ground Elevation and Associated Recurrence Interval

Parcel #	Tag ID	Name	Structure	DS Xsec	US Xsec	Estimated Ground Elevation (EGE)	Flow to EGE - 6"	Flow to EGE	Flow to EGE + 6"	Flow to EGE + 12"	HEC-1 Conc. Pt.	HEC-1 100-yr Flow	Return Frequency to EGE - 6"	Return Frequency to EGE	Return Frequency to EGE + 6"	Return Frequency to EGE + 12"
202-21-008T	579	Kraus Investmnt	Mobile	24.03	24.12	2024	3,400	4,400	5,600	7,000	S13C	11,800	4	6	11	19
202-21-008T	579	Kraus Investmnt	Mobile	24.03	24.12	2025	3,800	5,000	6,200	8,000	S13C	11,800	5	8	13	26
202-21-008T	579	Kraus Investmnt	2 Mobiles	24.12	24.25	2029	5,800	7,200	9,000	—	S13C	11,800	11	20	38	—
202-21-008T	579	Kraus Investmnt	Restaurant	24.03	24.12	2026	6,600	8,600	10,200	11,600	S13C	11,800	16	33	62	95
202-21-150	826	Parry	Mobile	24.48	24.61	2045	4,000	5,000	6,400	—	S10C	9,700	8	13	26	—
202-21-150	826	Parry	House	24.48	24.61	2046	5,000	6,200	7,800	>9,700	S10C	9,700	13	24	45	>100
202-21-031C	634	Selleys	House	CL 0.327	CL 0.403	2024		10,600			CCO-5	13,750		40		
202-21-032A	647	Caldwell	House	CL 0.247	CL 0.327	2021.4*		13,300	*to FFE		CCO-5	13,750		91		

*Surveyed finished floor elevation

APPENDIX D-2: Roadway Overtopping Plots

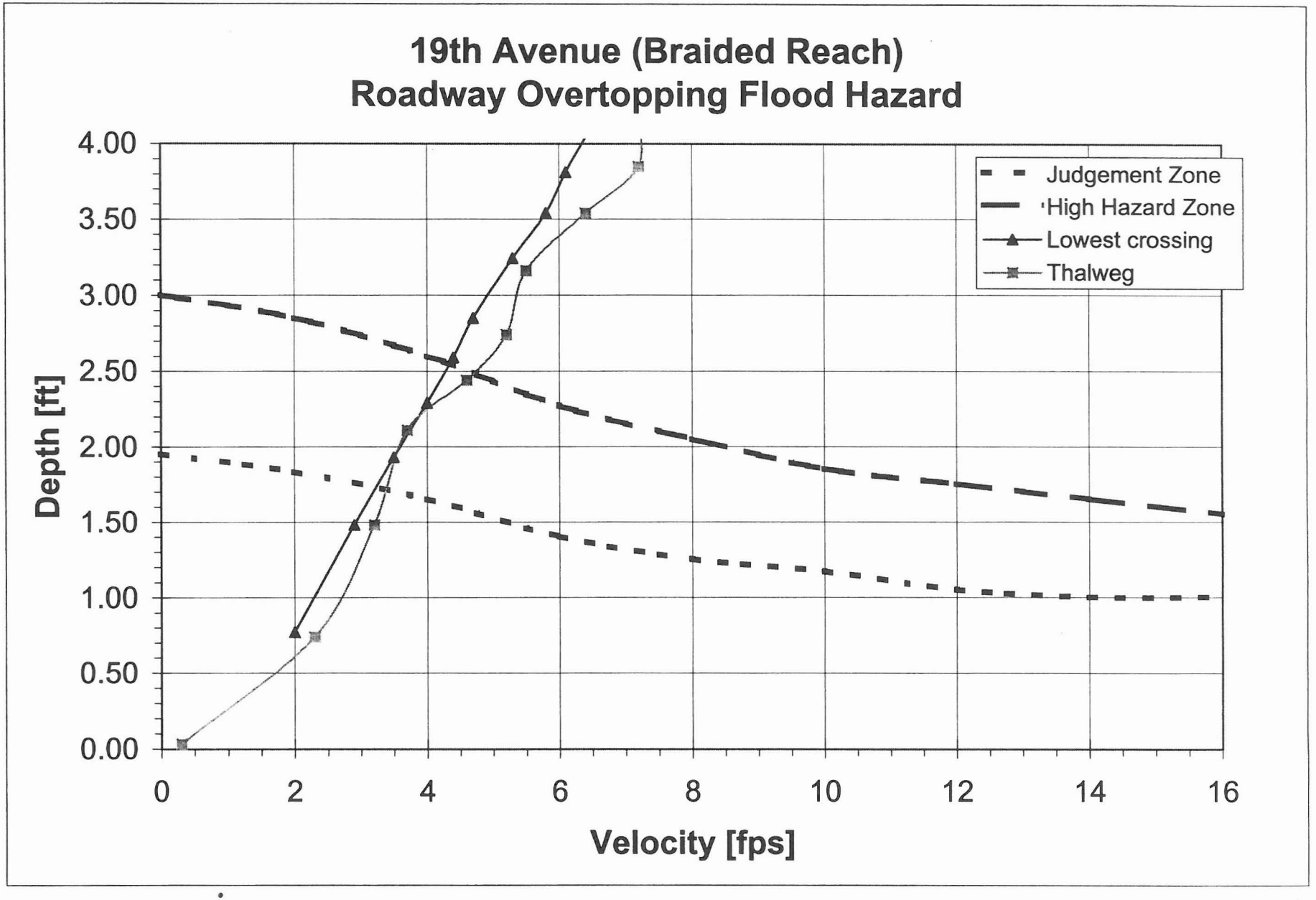

Cloud Road / 27th Avenue at RM 18.23
Roadway Overtopping Flood Hazard
Judgement Zone
High Hazard Zone
Flow over Roadway
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]

Roadway Overtopping Analysis

Graph Data

Cloud Rd / 27th Avenue at RM 18.23
(culvert capacity ignored)

Q Total (cfs)	Depth (ft)	Velocity (ft/s)	Q Overtop (cfs)
9,000	0.13	0.7	8
10,000	0.38	1.1	34
11,000	0.60	1.3	81
12,000	1.14	1.0	244
13,000	1.35	1.4	547
14,000	1.51	1.6	832
15,000	1.65	1.8	1,144
16,000	1.78	2.0	1,463
17,000	1.89	2.2	1,762
18,000	2.00	2.4	2,105
19,000	2.11	2.5	2,454
20,000	2.21	2.6	2,802
21,000	2.31	2.8	3,163
22,000	2.39	2.9	3,517
23,000	2.46	3.0	3,844
24,000	2.56	3.2	4,238
25,000	2.66	3.3	4,657
26,000	2.74	3.4	5,043
27,000	2.81	3.5	5,420


19th Avenue (Braided Reach)
Roadway Overtopping Flood Hazard
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]
Judgement Zone
High Hazard Zone
Lowest crossing
Thalweg

Roadway Overtopping Analysis

Graph Data

19th Avenue, lowest point on topo

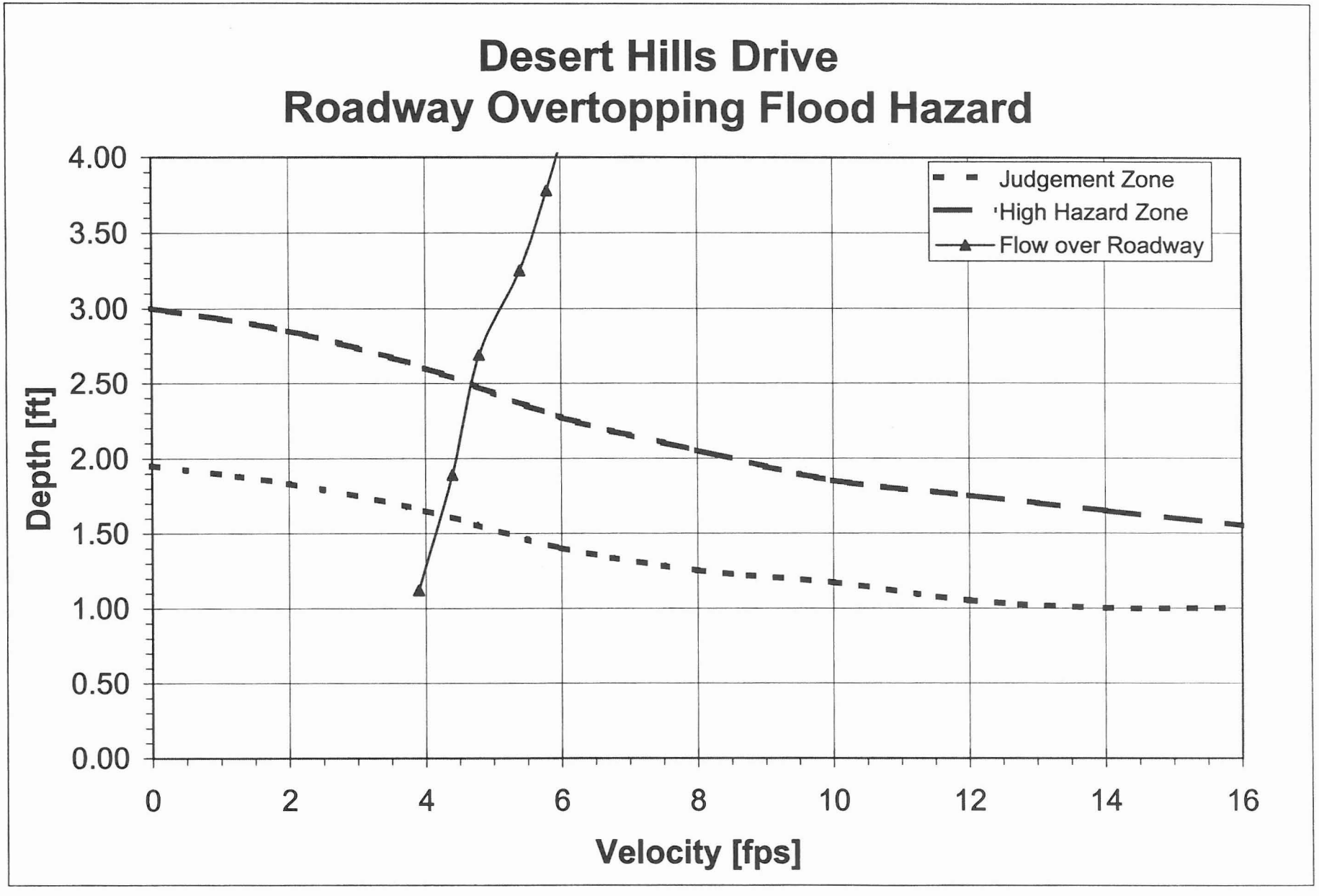
HEC-RAS X-sec	Q Total (cfs)	W.S. Elev (ft)	Depth Chnl (ft)	Vel Chnl (ft/s)	Q Channel (cfs)
20.08	500	1814.77	0.77	2.0	83
20.08	1,000	1815.48	1.48	2.9	293
20.08	1,500	1815.93	1.93	3.5	504
20.08	2,000	1816.29	2.29	4.0	731
20.08	2,500	1816.59	2.59	4.4	944
20.08	3,000	1816.85	2.85	4.7	1,154
20.08	4,000	1817.24	3.24	5.3	1,521
20.08	5,000	1817.54	3.54	5.8	1,851
20.08	6,000	1817.81	3.81	6.1	2,160
20.08	7,000	1818.04	4.04	6.4	2,456
20.08	8,000	1818.24	4.24	6.7	2,709
20.08	9,000	1818.44	4.44	6.9	2,949
20.08	10,000	1818.62	4.62	7.0	3,183
20.08	11,000	1818.79	4.79	7.2	3,411
20.08	12,000	1818.96	4.96	7.4	3,643
20.08	13,000	1819.12	5.12	7.5	3,870
20.08	14,000	1819.27	5.27	7.6	4,079
20.08	15,000	1819.42	5.42	7.7	4,293
20.08	16,000	1819.57	5.57	7.8	4,488
20.08	17,000	1819.72	5.72	7.9	4,681
20.08	18,000	1819.85	5.85	8.0	4,877
20.08	19,000	1819.98	5.98	8.1	5,070
20.08	20,000	1820.10	6.10	8.2	5,273
20.08	21,000	1820.22	6.22	8.3	5,474

Roadway Overtopping Analysis

Graph Data

19th Avenue, thalweg

HEC-RAS X-sec	Q Total (cfs)	W.S. Elev (ft)	Depth Chnl (ft)	Vel Chnl (ft/s)	Q Channel (cfs)
20.13	200	1816.03	0.03	0.3	0
20.13	500	1816.74	0.74	2.3	16
20.13	1,000	1817.48	1.48	3.2	108
20.13	1,500	1818.11	2.11	3.7	294
20.13	2,000	1818.44	2.44	4.6	498
20.13	2,500	1818.74	2.74	5.2	717
20.13	3,000	1819.16	3.16	5.5	977
20.13	4,000	1819.54	3.54	6.4	1,392
20.13	5,000	1819.85	3.85	7.2	1,806
20.13	6,000	1820.25	4.25	7.2	2,151
20.13	7,000	1820.50	4.50	7.4	2,461
20.13	8,000	1820.74	4.74	7.6	2,787
20.13	9,000	1820.93	4.93	7.7	3,065
20.13	10,000	1821.12	5.12	7.9	3,401
20.13	11,000	1821.26	5.26	8.2	3,758
20.13	12,000	1821.36	5.36	8.6	4,071
20.13	13,000	1821.48	5.48	8.8	4,365
20.13	14,000	1821.59	5.59	9.0	4,658
20.13	15,000	1821.69	5.69	9.3	4,950
20.13	16,000	1821.78	5.78	9.6	5,241
20.13	17,000	1821.85	5.85	9.9	5,535
20.13	18,000	1821.97	5.97	10.0	5,805
20.13	19,000	1822.08	6.08	10.1	6,092
20.13	20,000	1822.16	6.16	10.3	6,370
20.13	21,000	1822.25	6.25	10.5	6,639

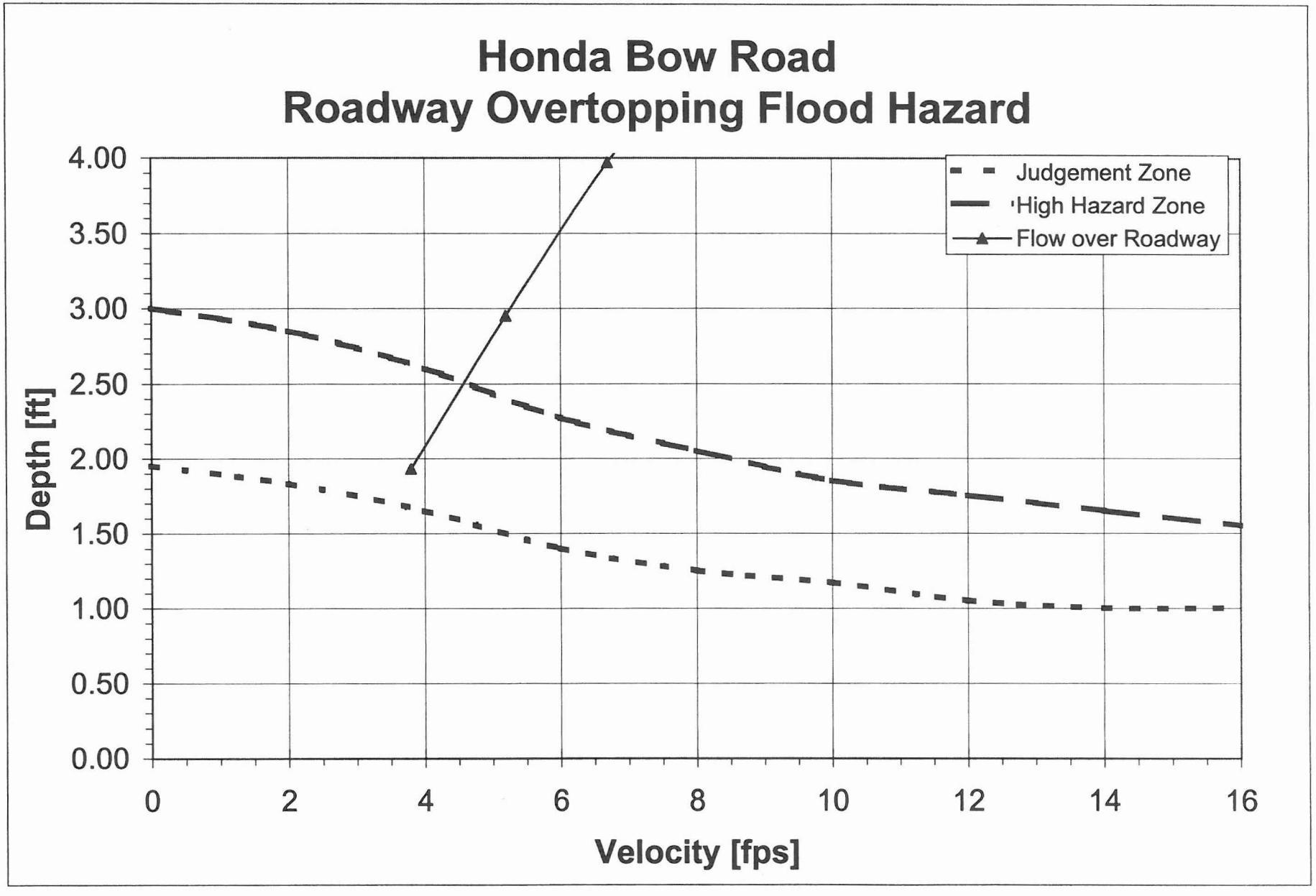

Desert Hills Drive
Roadway Overtopping Flood Hazard
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]
Judgement Zone
High Hazard Zone
Flow over Roadway

Roadway Overtopping Analysis

Graph Data

Desert Hills Drive

HEC-RAS X-sec	Q Total (cfs)	W.S. Elev (ft)	Depth Chnl (ft)	Vel Chnl (ft/s)	Q Channel (cfs)
20.77	200	1847.12	1.12	3.9	200
20.77	500	1847.89	1.89	4.4	500
20.77	1,000	1848.69	2.69	4.8	1,000
20.77	1,500	1849.25	3.25	5.4	1,500
20.77	2,000	1849.78	3.78	5.8	2,000
20.77	2,500	1850.24	4.24	6.1	2,494
20.77	3,000	1850.63	4.63	6.4	2,955
20.77	4,000	1851.32	5.32	6.7	3,768
20.77	5,000	1851.80	5.80	7.1	4,519
20.77	6,000	1851.92	5.92	8.2	5,364
20.77	7,000	1852.19	6.19	9.0	6,243
20.77	8,000	1852.46	6.46	9.3	6,850
20.77	9,000	1852.98	6.98	8.5	6,988
20.77	10,000	1853.18	7.18	8.7	7,422
20.77	11,000	1853.30	7.30	9.1	7,935
20.77	12,000	1853.46	7.46	9.3	8,352
20.77	13,000	1853.59	7.59	9.5	8,763
20.77	14,000	1853.74	7.74	9.7	9,132
20.77	15,000	1853.82	7.82	10.0	9,601
20.77	16,000	1854.13	8.13	9.7	9,772
20.77	17,000	1854.19	8.19	10.0	10,219
20.77	18,000	1854.29	8.29	10.2	10,575
20.77	19,000	1854.43	8.43	10.1	10,766
20.77	20,000	1854.49	8.49	10.4	11,154
20.77	21,000	1854.55	8.55	10.7	11,555

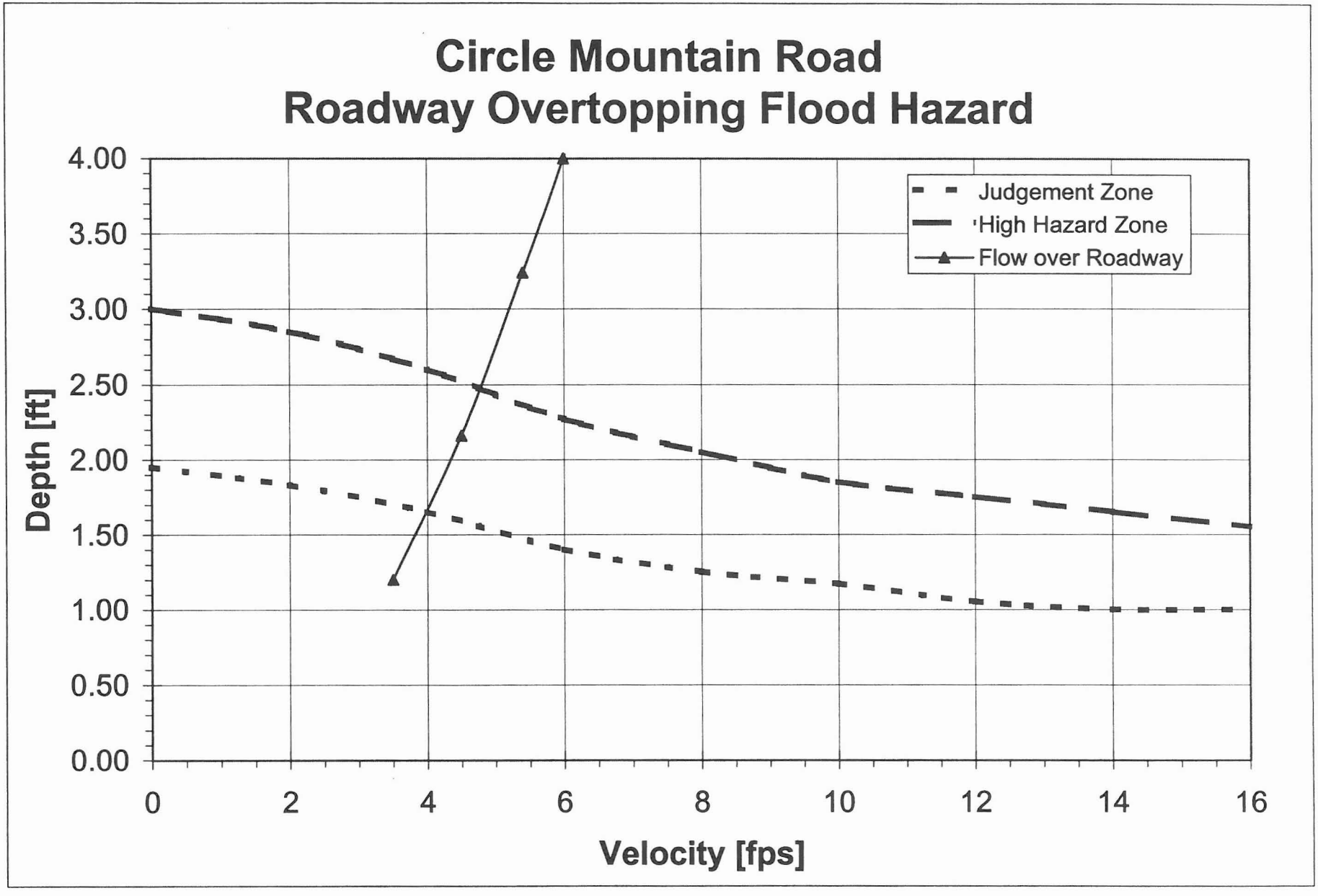

Honda Bow Road
Roadway Overtopping Flood Hazard
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]
Judgement Zone
High Hazard Zone
Flow over Roadway

Roadway Overtopping Analysis

Graph Data

Honda Bow Road

HEC-RAS X-sec	Q Total (cfs)	W.S. Elev (ft)	Depth Chnl (ft)	Vel Chnl (ft/s)	Q Channel (cfs)
22.86	200	1955.43	1.93	3.8	200
22.86	500	1956.45	2.95	5.2	500
22.86	1,000	1957.47	3.97	6.7	1,000
22.86	1,500	1958.16	4.66	8.0	1,498
22.86	2,000	1958.70	5.20	9.0	1,967
22.86	2,500	1959.16	5.66	9.7	2,408
22.86	3,000	1959.56	6.06	10.3	2,827
22.86	4,000	1960.92	7.42	9.0	3,268
22.86	5,000	1961.43	7.93	9.2	3,651
22.86	6,000	1961.78	8.28	9.6	4,033
22.86	7,000	1962.04	8.54	10.1	4,425
22.86	8,000	1962.39	8.89	10.1	4,644
22.86	9,000	1962.68	9.18	10.0	4,789
22.86	10,000	1962.84	9.34	10.3	5,068
22.86	11,000	1963.00	9.50	10.7	5,328
22.86	12,000	1963.13	9.63	11.0	5,598
22.86	13,000	1963.25	9.75	11.3	5,855
22.86	14,000	1963.38	9.88	11.6	6,096
22.86	15,000	1963.49	9.99	11.9	6,335
22.86	16,000	1963.61	10.11	12.1	6,556
22.86	17,000	1963.71	10.21	12.5	6,809
22.86	18,000	1963.80	10.30	12.7	7,041
22.86	19,000	1963.92	10.42	12.9	7,233
22.86	20,000	1963.99	10.49	13.3	7,492
22.86	21,000	1964.06	10.56	13.6	7,743

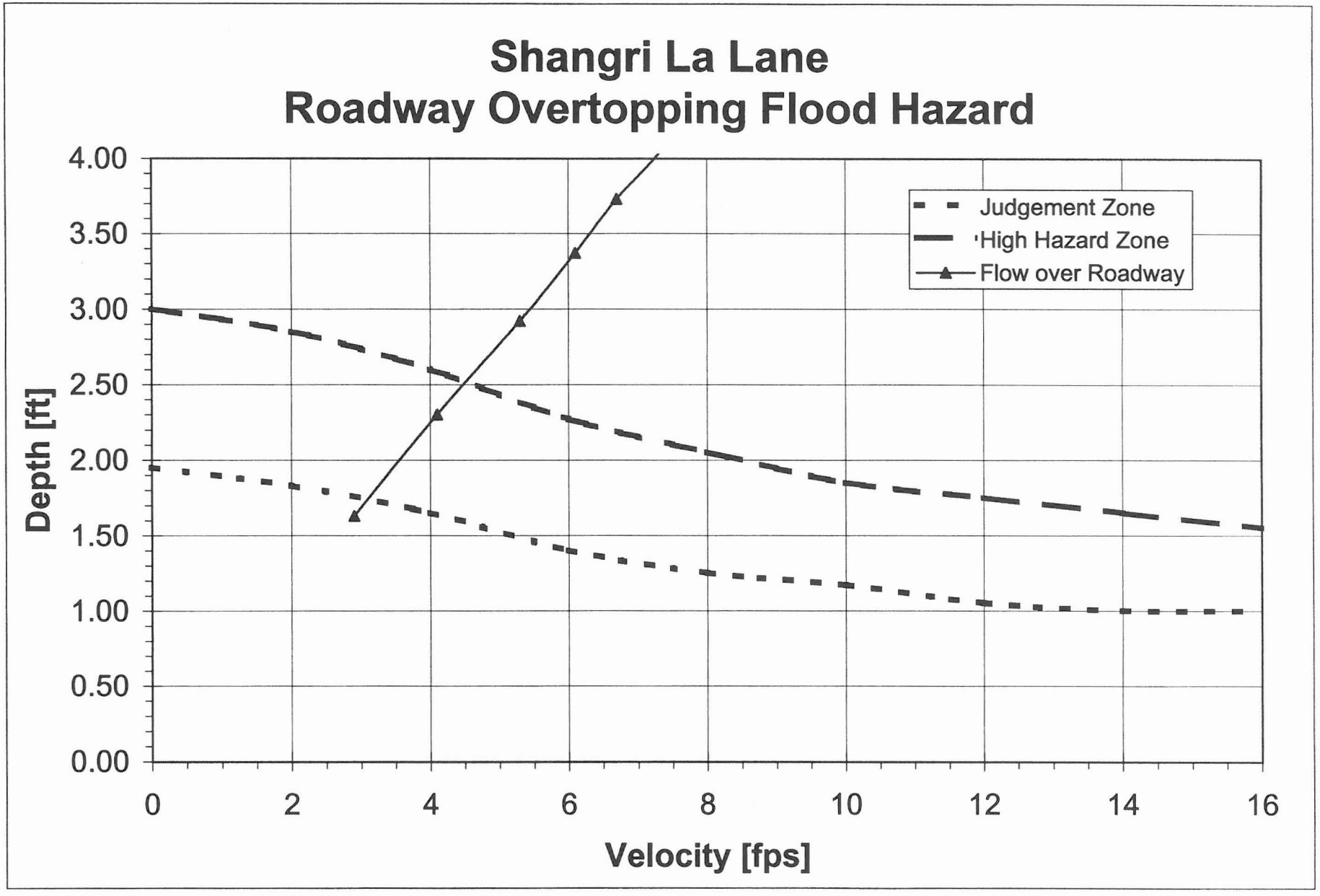

Circle Mountain Road
Roadway Overtopping Flood Hazard
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]
Judgement Zone
High Hazard Zone
Flow over Roadway

Roadway Overtopping Analysis

Graph Data

Circle Mtn Road

HEC-RAS X-sec	Q Total (cfs)	W.S. Elev (ft)	Depth Chnl (ft)	Vel Chnl (ft/s)	Q Channel (cfs)
23.83	200	2009.20	1.20	3.5	200
23.83	500	2010.16	2.16	4.5	500
23.83	1,000	2011.24	3.24	5.4	980
23.83	1,500	2012.00	4.00	6.0	1,420
23.83	2,000	2012.63	4.63	6.4	1,835
23.83	2,500	2013.15	5.15	6.6	2,199
23.83	3,000	2013.57	5.57	6.8	2,526
23.83	4,000	2014.25	6.25	7.2	3,176
23.83	5,000	2014.71	6.71	7.5	3,676
23.83	6,000	2015.11	7.11	7.9	4,156
23.83	7,000	2015.48	7.48	8.2	4,618
23.83	8,000	2015.81	7.81	8.4	5,072
23.83	9,000	2016.16	8.16	8.9	5,656
23.83	10,000	2016.45	8.45	9.1	6,074
23.83	11,000	2016.67	8.67	9.5	6,515
23.83	12,000	2016.93	8.93	9.7	6,915
23.83	13,000	2017.12	9.12	10.0	7,342
23.83	14,000	2017.37	9.37	10.1	7,709
23.83	15,000	2017.59	9.59	10.3	8,091
23.83	16,000	2017.79	9.79	10.6	8,471
23.83	17,000	2017.99	9.99	10.7	8,837
23.83	18,000	2018.19	10.19	10.9	9,203
23.83	19,000	2018.38	10.38	11.1	9,573
23.83	20,000	2018.58	10.58	11.2	9,929
23.83	21,000	2018.77	10.77	11.4	10,310

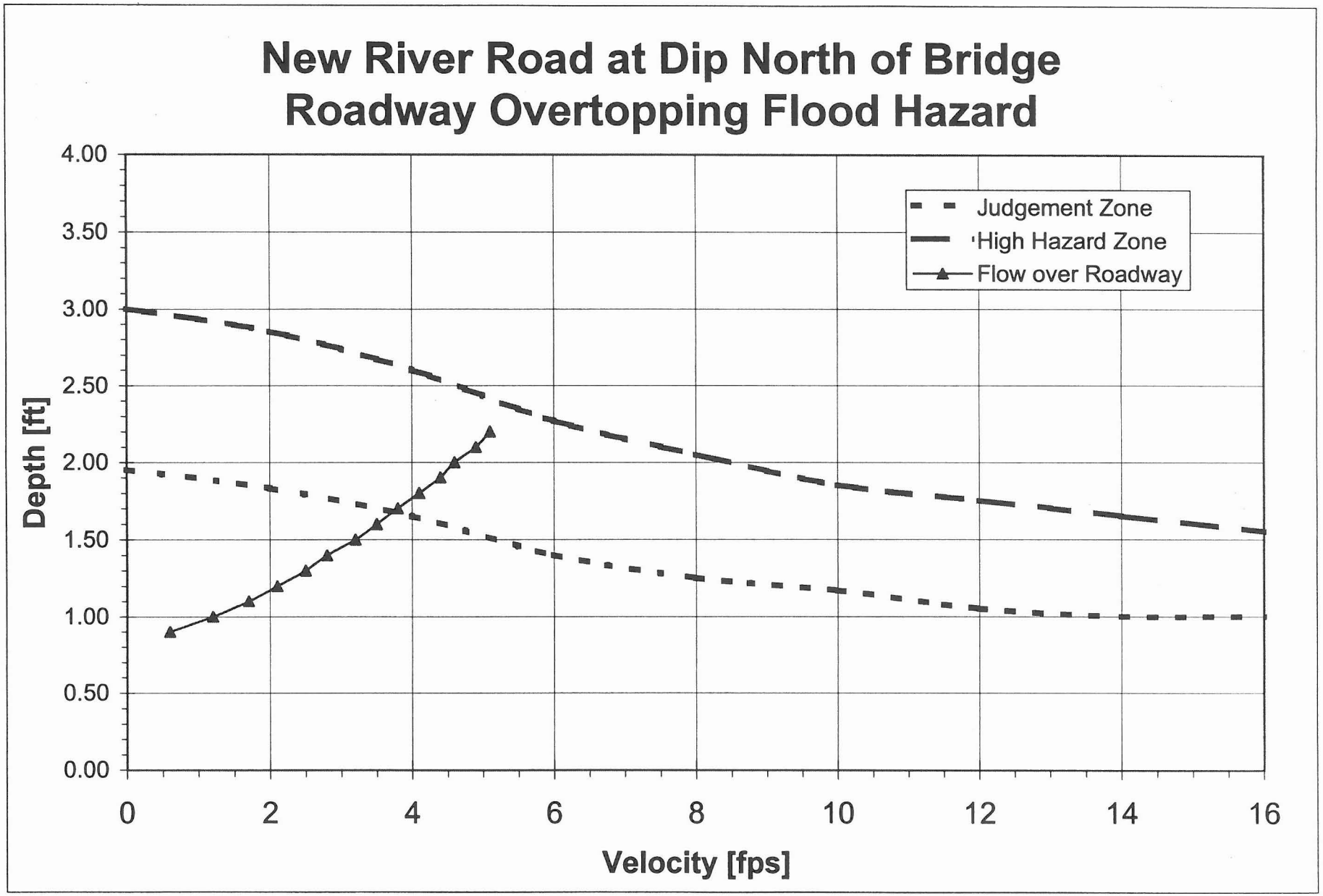

Shangri La Lane
Roadway Overtopping Flood Hazard
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]
Judgement Zone
High Hazard Zone
Flow over Roadway

Roadway Overtopping Analysis

Graph Data

Shangri La Lane

HEC-RAS X-sec	Q Total (cfs)	W.S. Elev (ft)	Depth Chnl (ft)	Vel Chnl (ft/s)	Q Channel (cfs)
24.48	200	2038.43	1.63	2.9	200
24.48	500	2039.10	2.30	4.1	494
24.48	1,000	2039.72	2.92	5.3	926
24.48	1,500	2040.17	3.37	6.1	1,299
24.48	2,000	2040.53	3.73	6.7	1,652
24.48	2,500	2040.83	4.03	7.3	1,977
24.48	3,000	2041.12	4.32	7.7	2,283
24.48	4,000	2041.55	4.75	8.5	2,873
24.48	5,000	2041.94	5.14	9.2	3,448
24.48	6,000	2042.26	5.46	9.7	3,922
24.48	7,000	2042.58	5.78	10.0	4,370
24.48	8,000	2042.83	6.03	10.4	4,811
24.48	9,000	2043.09	6.29	10.7	5,216
24.48	10,000	2043.36	6.56	10.9	5,593
24.48	11,000	2043.56	6.76	11.2	5,970
24.48	12,000	2043.75	6.95	11.5	6,329
24.48	13,000	2043.92	7.12	11.8	6,690
24.48	14,000	2044.11	7.31	12.0	7,021
24.48	15,000	2044.30	7.50	12.2	7,341
24.48	16,000	2044.48	7.68	12.3	7,651
24.48	17,000	2044.66	7.86	12.5	7,955
24.48	18,000	2044.84	8.04	12.6	8,253
24.48	19,000	2045.01	8.21	12.7	8,552
24.48	20,000	2045.18	8.38	12.8	8,841
24.48	21,000	2045.35	8.55	12.9	9,126

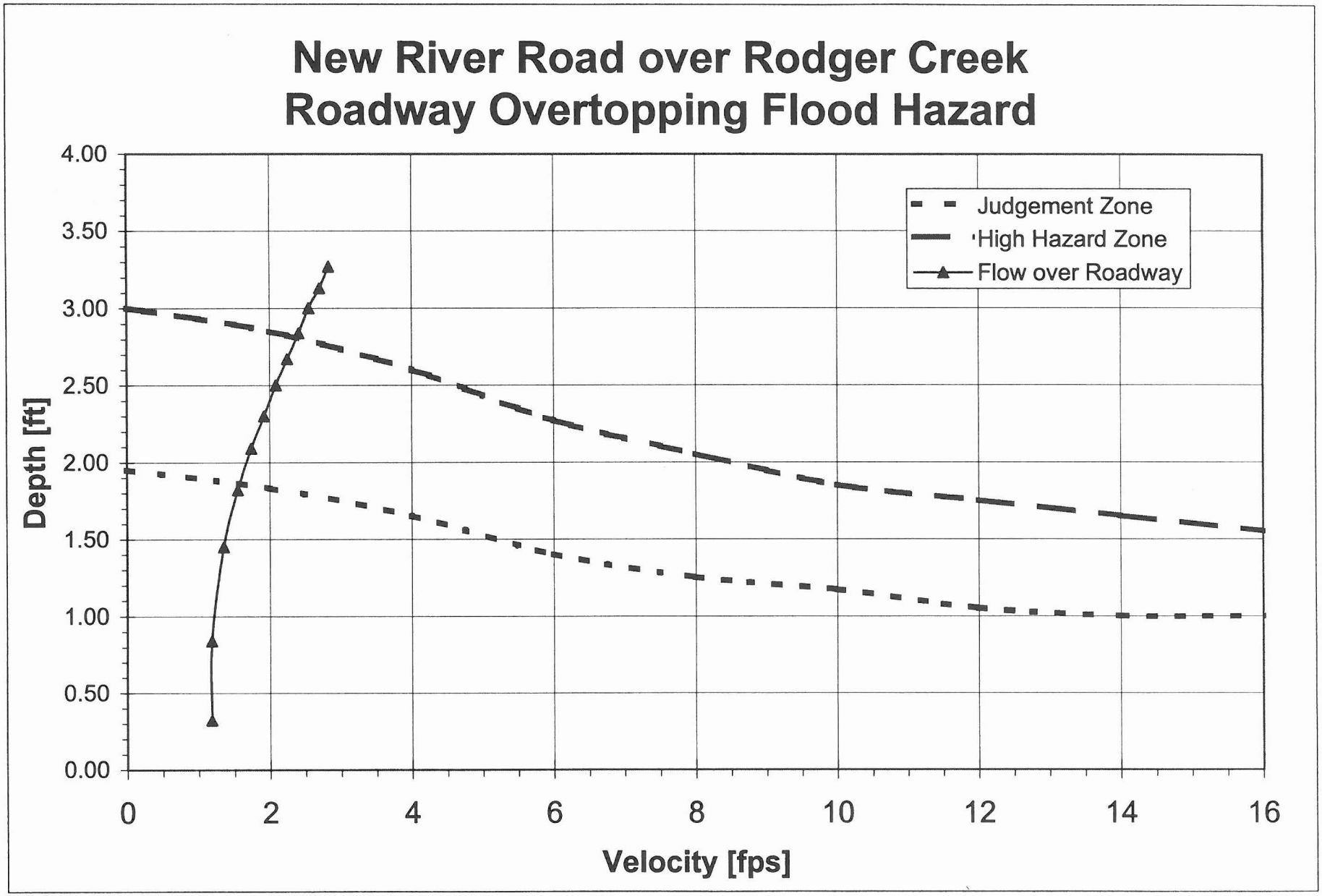

New River Road at Dip North of Bridge
Roadway Overtopping Flood Hazard
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]
Judgement Zone
High Hazard Zone
Flow over Roadway

Roadway Overtopping Analysis

Graph Data

New River Road at dip north of the bridge
(Manning spreadsheet data)

Q Total (cfs)	Depth (ft)	Velocity (ft/s)	Q Overtop (cfs)
7,954	2.2	5.1	3,705
7,446	2.1	4.9	3,259
7,033	2.0	4.6	2,837
6,565	1.9	4.4	2,438
6,181	1.8	4.1	2,063
5,789	1.7	3.8	1,714
5,378	1.6	3.5	1,392
4,995	1.5	3.2	1,096
4,639	1.4	2.8	830
4,300	1.3	2.5	594
3,989	1.2	2.1	391
3,635	1.1	1.7	223
3,233	1.0	1.2	95
3,000	0.9	0.6	15


New River Road over Rodger Creek
Roadway Overtopping Flood Hazard
Depth [ft]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
16
Velocity [fps]
Judgement Zone
High Hazard Zone
Flow over Roadway

Roadway Overtopping Analysis

Graph Data

New River Road over Rodger Creek

(HEC-2 model)

Q Total (cfs)	Depth (ft)	Velocity (ft/s)
1,300	0.32	1.18
1,500	0.84	1.18
2,000	1.45	1.35
2,500	1.82	1.55
3,000	2.09	1.74
3,500	2.30	1.92
4,000	2.50	2.09
4,500	2.67	2.25
5,000	2.84	2.41
5,500	3.00	2.55
6,000	3.13	2.70
6,500	3.27	2.83

APPENDIX E

RECOMMENDED INFORMATION DISSEMINATION OPTION

Skunk Creek WCMP Flood Warning/ Response Plan
OPTION E – NOAA WEATHER RADIO/ PAGER
Overview Information

Products and Services

National Oceanic and Atmospheric Administration (NOAA) Weather Radio Service
NOAA Weather Radios – Radio Shack
Pagers and Group Paging Service – Arch Wireless (formerly PageNet)
Private Vendor Weather Paging Service – I3 Mobile

Contact Information

Steve Waters, FCDMC ALERT Program Manager (602) 506-4694
David Runyan, NWS Meteorologist/ EAS Warning Coordinator (602) 275-7002 x223
Tom Beckett, MCDEM Communications/ Warning Coordinator (602) 273-1411
Mark Rainey - Arch Wireless 1(888) 483-3875
I3 Mobile Customer Service 1(203) 428-3200

Features

- NOAA Weather Radio is currently a NWS warning notification system.
- Phoenix National Weather Service (NWS) office broadcasts weather information 24 hours per day on 162.55 MHz from its transmitter located on South Mountain.
- During severe weather, the routine weather broadcasts are interrupted for special information such as weather warnings.
- FCDMC hydrologists currently monitor ALERT and Unisys data input on a continual basis. Pre-set alarm thresholds trigger heightened awareness on the part of ALERT group personnel.
- FCDMC Meteorological Services Program (MSP) meteorologist is available to interpret weather data.
- FCDMC will establish dialogue with NWS, MCDOT, and MCDEM via telephone or radio when conditions in proximity to and within the Skunk Creek basin warrant.
- MCDEM Duty Officer available 24 hours per day, 7 days per week. MCDEM establishes contact with Maricopa County Sheriff's Office (MCSO).
- MCDOT crews place barricades across roadway dip crossings.
- NWS issues warning messages to the public via:
    - Emergency Alert System (EAS) – consists of radio and television broadcast stations in the Phoenix operational area which voluntarily disseminate emergency information and warnings to the public

- NOAA Weather Radio Service – tone alarm and voice messages received on special weather radios

- FCDMC sends text flood alert messages via pager to residents at risk in the Skunk Creek floodway and floodplain, as appropriate and in the proper sequence, with the NWS flash flood watch and flash flood warning message suite.

- NWS issues flash flood watch and flash flood warning messages via NOAA Weather Radio according to standard protocol using tone alarms followed by voice messages.

- Notification via multiple paths for redundancy:

  - FCDMC pager tone followed by text messages describing nature of flood alert.
  - NWS initiates NOAA Weather Radio tone alarm followed by voice message describing nature of flash flood watch or flash flood warning.
  - OPTIONAL: Weather paging service offered by private vendor automatically dials-up pagers with NWS flash flood watch and flash flood warning messages for a specified area designated by a 6-digit code for Phoenix and Maricopa County.

Warning Message	Alpha Code	Alpha-numeric Code
Flash Flood Watch	PHXFFAPHX	AZZ023
Flash Flood Warning	PHXFFWPHX	AZC013

  - EAS broadcast radio and television flood watch and warning messages (voluntary)
  - Multiple messages possible

- Pagers provides redundancy for weather radio owners.

- Almost instantaneous action time barring system malfunction or interagency communication problems

- Can be implemented on or about August, 2001 given timely procurement of pagers and radios, and fast resolution of interference and/or transmission problems, if any exist.

Cost

- NOAA Weather Radios range in price from $20-$60 each depending on features
- FEMA grant program exists to fund distribution of NOAA radios to floodprone areas
- Pagers - $10.95-13.95 ea. per month for 1-year lease OR $139 to purchase
- Paging Service - ~$3.50 / month/ pager with purchase option only
- Group Paging Service – additional $1.50/ month/ pager
- OPTIONAL Weather Paging Service – additional ~$2/ month/ pager

Considerations

- FCDMC, MCDEM, and NWS will establish in advance warning protocol and message content specific to Skunk Creek for dissemination via NOAA Weather Radio and EAS to minimize time required for message relay

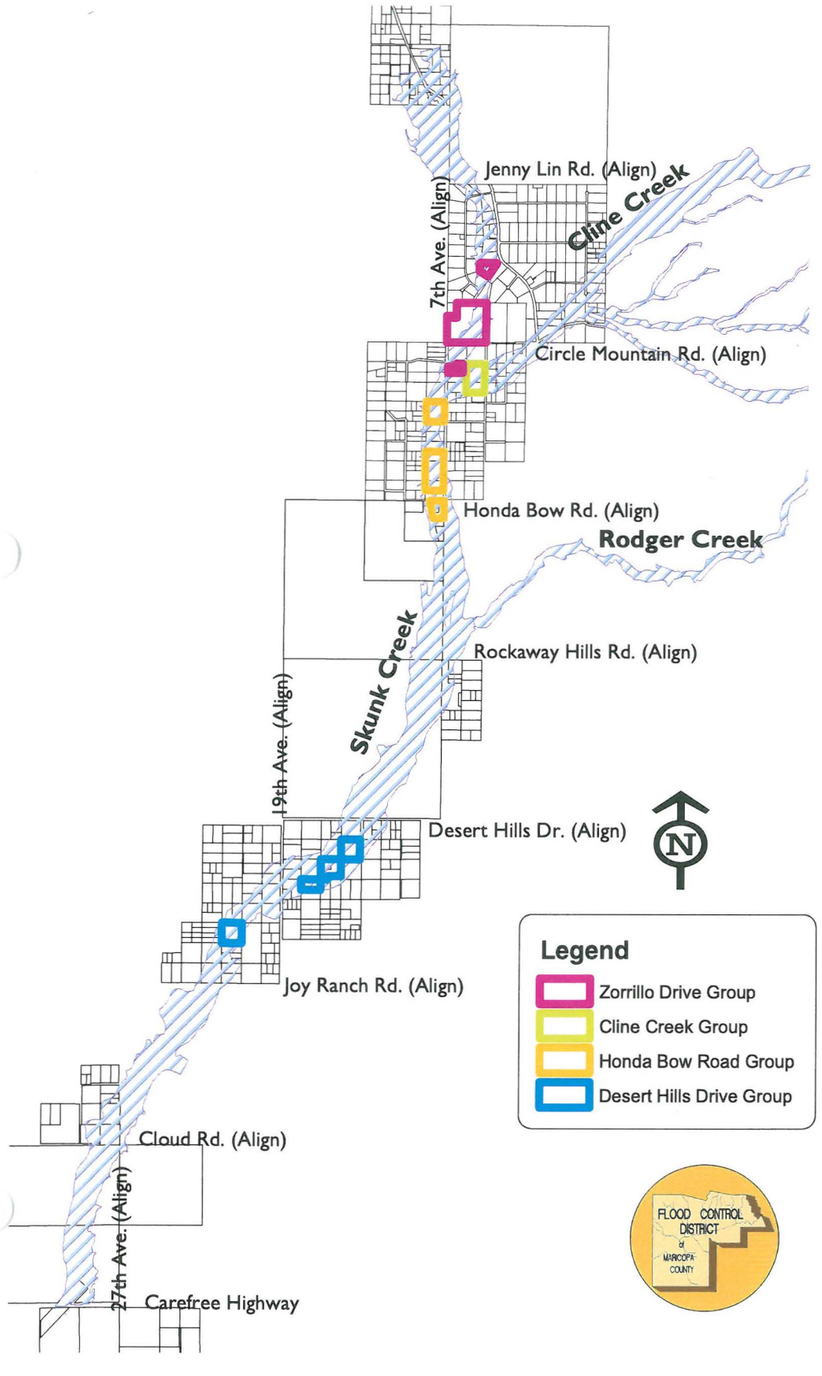
- Meets August, 2001 implementation deadline if timely and successful coordination between FCDMC, MCDEM, and NWS is achieved and timely procurement of equipment is successful.

APPENDIX F

FLOOD RESPONSE PLAN MENUS

SKUNK CREEK FLOOD RESPONSE PLAN

ZORRILLO DRIVE GROUP



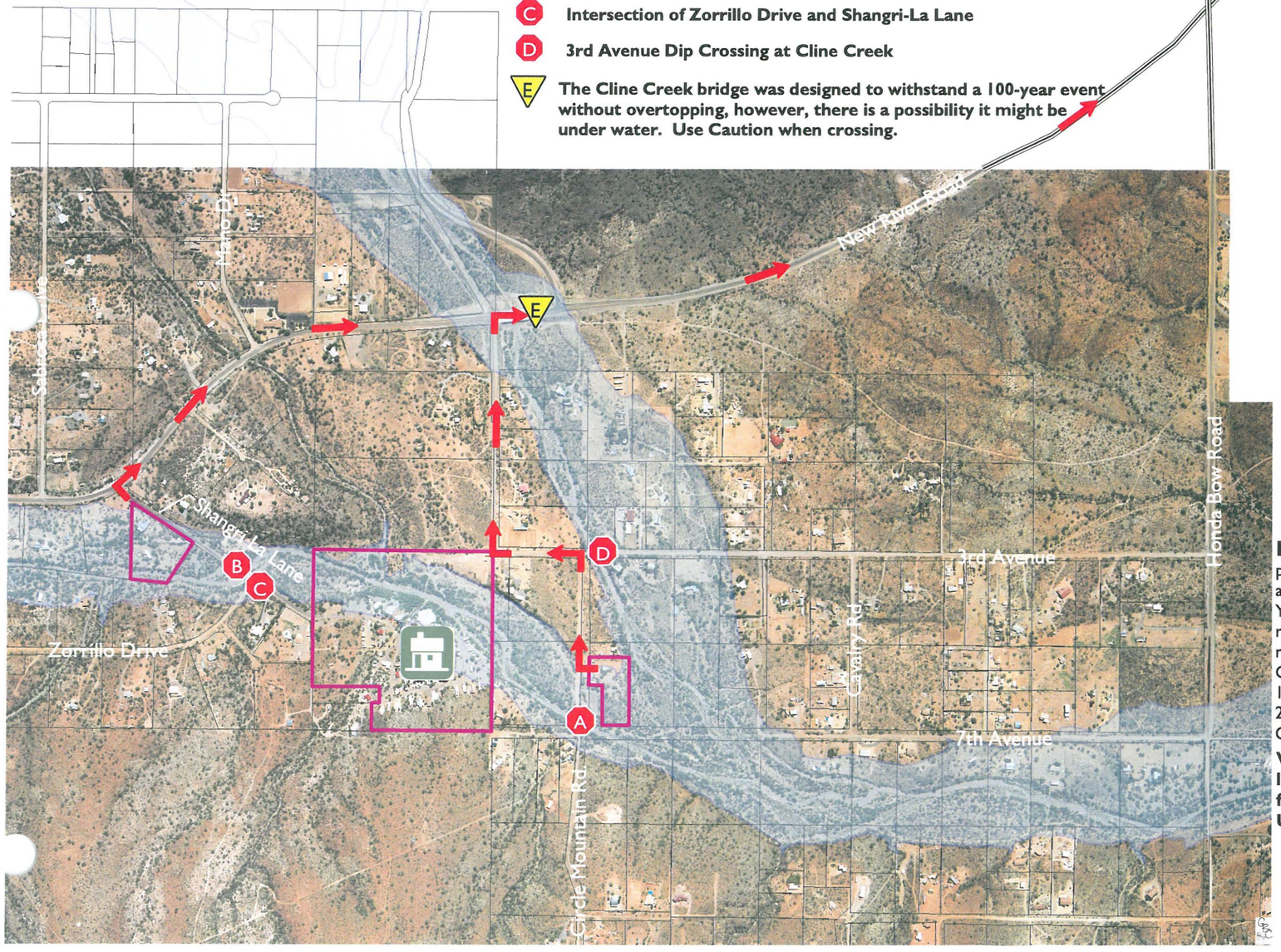
MESSAGE	WHAT IT MEANS	WHAT YOU NEED TO DO
(NOAA Radio) National Weather Service Flash Flood Watch (begin time/end time)	→ Flash flooding possible in north central Maricopa County, including Skunk Creek or Cline Creek → Be alert!	→ Monitor your FCDMC pager and NOAA weather radio continually for updates. Other sources of flood information: - Some commercial radio and TV stations voluntarily broadcast NWS flash flood watch and flash flood warning information - Real-time FCDMC rainfall and flood information is always available by monitoring their web page at: http://www.fcd.maricopa.gov/alert/alert.htm - 24-hour hydrologic and weather information for the entire state is available at: http://www.afws.org
(FCDMC Pager) Skunk Creek Message 1 Weather Alert (begin time/end time)	→ Flash flooding possible in north central Maricopa County, especially in the Upper Skunk Creek and Cline Creek areas → Be alert!	
(FCDMC Pager) Skunk Creek Message 2 Flash Flood Alert (begin time/end time)	→ Heavy rainfall detected in upper Skunk or Cline Creeks Watersheds → Moderate flow volumes detected by stream gages → Potential for life-threatening flooding exists → Take necessary precautions!	→ You MAY be instructed to EVACUATE and will need to do so in a moment's notice. You may only have minutes! Get Prepared! → Monitor your FCDMC pager and NOAA weather radio continually for updates. → Locate all residents of your home, pets and livestock. Collect absolute necessities and load in your vehicle(s). Include a flashlight. Secure premises. → Find a light-colored sheet or towel to hang on your doorway in case you evacuate.
(NOAA Radio) National Weather Service Flash Flood Warning (begin time/end time)	→ Flash flooding imminent or occuring in north central Maricopa County, including Skunk Creek or Cline Creek → Take necessary precautions!	
(FCDMC Pager) Skunk Creek Message 3 Severe Flood Warning (effective time/all clear)	→ Extreme rainfall detected in the upper Skunk Creek or Cline Creek watersheds. → Critical flow volumes detected by stream gages. → Severe flash flooding is imminent or occuring. → Many or all of roadway crossings in the area are impassable. → Residents MUST monitor pagers and NOAA weather radios. → Follow the instructions listed under "What You Need To Do"!	→ IMMEDIATELY EVACUATE all residents and pets from your home and get to the evacuation site (see map on reverse). Act quickly! → Turn off lights, heating and air-conditioning units. → Hang a light-colored sheet or towel over your door to indicate to emergency personnel that you have evacuated. → Monitor your FCDMC pager and NOAA weather radio for updates. → Follow the evacuation route shown on the map. Avoid travel on roadways through wash crossings. DO NOT cross any barricaded roads! NEVER drive through flooded roadways, especially at night when dangers are harder to recognize. → Report to evacuation site for registration, even if you do not plan to stay. → Seek medical care at the nearest hospital, if needed. Food, clothing, and first aid may be available from emergency aid organizations such as the Red Cross.
(FCDMC Pager) Skunk Creek Message 4 All Clear (effective time)	→ Floods on Skunk Creek and Cline Creek have dropped below critical levels. → Potential for additional extreme flooding is minimal	→ Leave the evacuation site and return to your home using the same route in reverse. → Use flashlights to examine buildings. Flammables may be inside. → Electrical equipment should be dried and checked before being returned to service.. → Boil drinking water before using. Wells should be pumped out and water tested for purity before drinking. → Throw out any fresh food that has come in contact with flood waters.

NOTE: The message progression may shortcut to FCDMC Message 3 or 4 at any point in the sequence as evolving flood conditions warrant. If a NWS Flash Flood Watch is in effect early in the day, the warning message sequence may shortcut to NWS Flash Flood Warning, as appropriate to changing weather conditions

SKUNK CREEK FLOOD RESPONSE PLAN
ZORRILLO DRIVE GROUP

POTENTIAL TROUBLE AREAS

- A — Circle Mountain Road Dip Crossing at Skunk Creek
- B — Shangri La Lane Dip Crossing at Skunk Creek
- C — Intersection of Zorrillo Drive and Shangri-La Lane
- D — 3rd Avenue Dip Crossing at Cline Creek
- E — The Cline Creek bridge was designed to withstand a 100-year event without overtopping, however, there is a possibility it might be under water. Use Caution when crossing.



EVACUATION ROUTE

Evacuation Site: Desert Valley Baptist Church
42425 North New River Road
New River, Arizona 85086
(623) 465-9461

Parry
a. South (Right) on New River Road to Honda Bow Road
b. South (Straight) on New River Road a short distance to Desert Valley Baptist Church on East (Left) Side of New River Road Just South of Honda Bow Road

Sartain
c. East (Right) on Circle Mountain Road to 3rd Avenue
d. North (Left) on 3rd Avenue to Circle Mountain Road
e. East (Right) on Circle Mountain Road to New River Road
f. South (Right) on New River Road to Honda Bow Road
g. South (Straight) on New River Road a short distance to Desert Valley Baptist Church on East (Left) Side of New River Road Just South of Honda Bow Road

Evacuation Route Shangri La Residents Only

Evacuation Site: Shangri La Main Office
46834 North Shangri-La Lane
New River, Arizona 85027
(623) 465-5959

Shangri La
a. Evacuate to Shangri La Main Office

NOTE: The Flood Control District of Maricopa County (FCDMC) and National Weather Service (NWS) will provide timely weather information and flood warning messages to you to the best of their abitlity using currently available technology. Be advised that prediction of flash floods is complex and conditions can change very rapidly. You have a responsibility to do what you can to remain alert for changing flood conditions impacting your residence. Closely monitor local conditions around your residence. Use the pager, weather radio, commercial radio, and television to stay informed. You may also contact FCDMC Flood Warning Branch directly for Skunk Creek flood information two ways.

1. Telephone (602) 506-8701
2. Web site http://156.42.96.39/alert/skunk_frp/sc.html

Call 911 if you need emergency assistance during a flood event

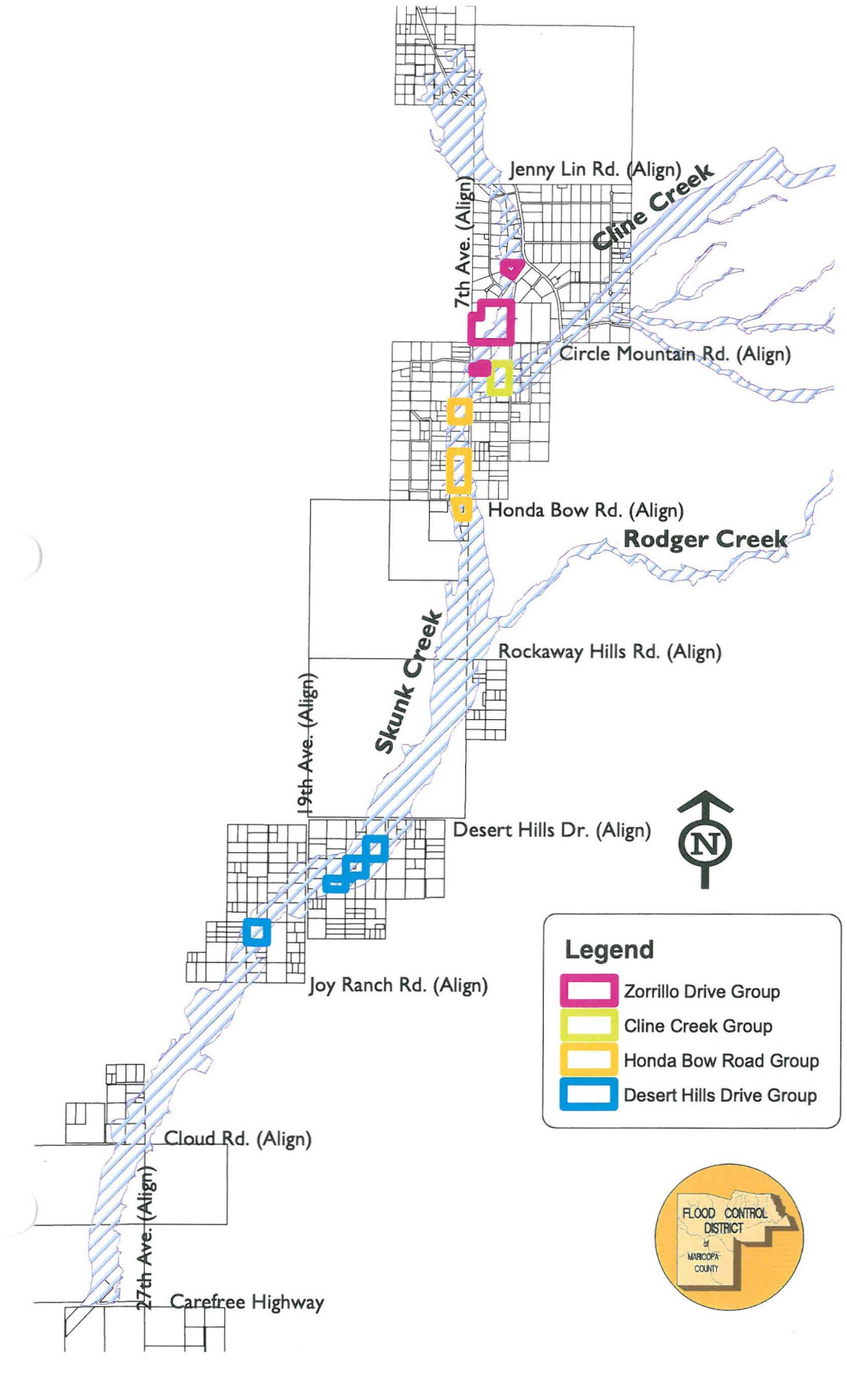
When rainfall increases rapidly or flood conditions worsen significantly, follow the instructions listed under "What You Need To Do" even if you have not received a pager or weather radio flood warning message.
USE COMMON SENSE!

NTS
Aerial Photo Date: 7/1999

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

SKUNK CREEK FLOOD RESPONSE PLAN

CLINE CREEK GROUP



MESSAGE	WHAT IT MEANS	WHAT YOU NEED TO DO
(NOAA Radio) National Weather Service Flash Flood Watch (begin time/end time)	→ Flash flooding possible in north central Maricopa County, including Skunk Creek or Cline Creek → Be alert!	→ Monitor your FCDMC pager and NOAA weather radio continually for updates. Other sources of flood information: - Some commercial radio and TV stations voluntarily broadcast NWS flash flood watch and flash flood warning information - Real-time FCDMC rainfall and flood information is always available by monitoring their web page at: http://www.fcd.maricopa.gov/alert/alert.htm - 24-hour hydrologic and weather information for the entire state is available at: http://www.afws.org
(FCDMC Pager) Skunk Creek Message 1 Weather Alert (begin time/end time)	→ Flash flooding possible in north central Maricopa County, especially in the Upper Skunk Creek and Cline Creek areas → Be alert!	
(FCDMC Pager) Skunk Creek Message 2 Flash Flood Alert (begin time/end time)	→ Heavy rainfall detected in upper Skunk or Cline Creeks Watersheds → Moderate flow volumes detected by stream gages → Potential for life-threatening flooding exists → Take necessary precautions!	→ You MAY be instructed to EVACUATE and will need to do so in a moment's notice. You may only have minutes! Get Prepared! → Monitor your FCDMC pager and NOAA weather radio continually for updates. → Locate all residents of your home, pets and livestock. Collect absolute necessities and load in your vehicle(s). Include a flashlight. Secure premises. → Find a light-colored sheet or towel to hang on your doorway in case you evacuate.
(NOAA Radio) National Weather Service Flash Flood Warning (begin time/end time)	→ Flash flooding imminent or occuring in north central Maricopa County, including Skunk Creek or Cline Creek → Take necessary precautions!	
(FCDMC Pager) Skunk Creek Message 3 Severe Flood Warning (effective time/all clear)	→ Extreme rainfall detected in the upper Skunk Creek or Cline Creek watersheds. → Critical flow volumes detected by stream gages. → Severe flash flooding is imminent or occuring. → Many or all of roadway crossings in the area are impassable. → Residents MUST monitor pagers and NOAA weather radios. → Follow the instructions listed under "What You Need To Do"!	→ IMMEDIATELY EVACUATE all residents and pets from your home and get to the evacuation site (see map on reverse). Act quickly! → Turn off lights, heating and air-conditioning units. → Hang a light-colored sheet or towel over your door to indicate to emergency personnel that you have evacuated. → Monitor your FCDMC pager and NOAA weather radio for updates. → Follow the evacuation route shown on the map. Avoid travel on roadways through wash crossings. DO NOT cross any barricaded roads! NEVER drive through flooded roadways, especially at night when dangers are harder to recognize. → Report to evacuation site for registration, even if you do not plan to stay. → Seek medical care at the nearest hospital, if needed. Food, clothing, and first aid may be available from emergency aid organizations such as the Red Cross.
(FCDMC Pager) Skunk Creek Message 4 All Clear (effective time)	→ Floods on Skunk Creek and Cline Creek have dropped below critical levels. → Potential for additional extreme flooding is minimal	→ Leave the evacuation site and return to your home using the same route in reverse. → Use flashlights to examine buildings. Flammables may be inside. → Electrical equipment should be dried and checked before being returned to service.. → Boil drinking water before using. Wells should be pumped out and water tested for purity before drinking. → Throw out any fresh food that has come in contact with flood waters.

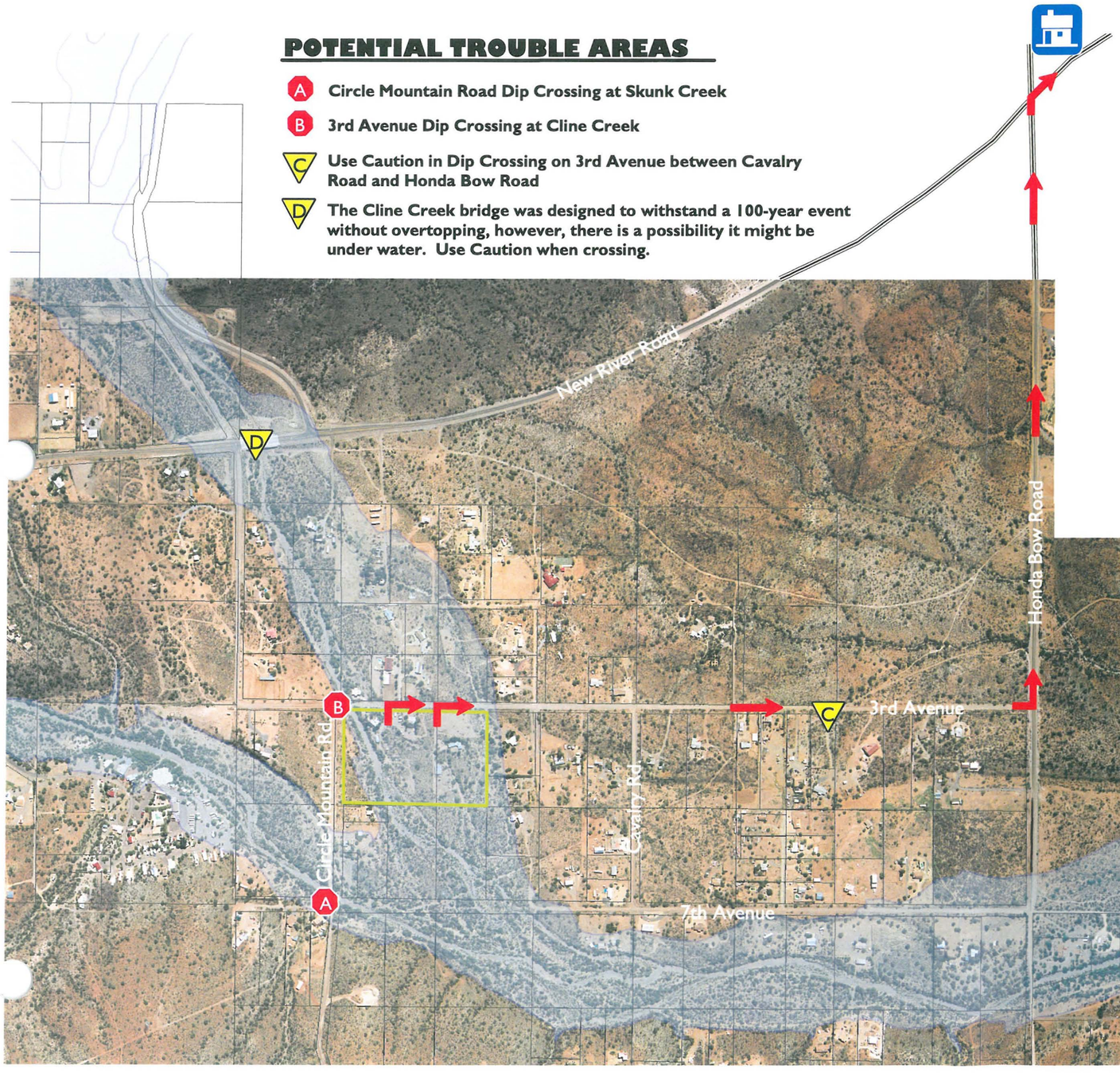
NOTE: The message progression may shortcut to FCDMC Message 3 or 4 at any point in the sequence as evolving flood conditions warrant. If a NWS Flash Flood Watch is in effect early in the day, the warning message sequence may shortcut to NWS Flash Flood Warning, as appropriate to changing weather conditions

SKUNK CREEK FLOOD RESPONSE PLAN

CLINE CREEK GROUP

POTENTIAL TROUBLE AREAS

- **A** Circle Mountain Road Dip Crossing at Skunk Creek
- **B** 3rd Avenue Dip Crossing at Cline Creek
- **C** Use Caution in Dip Crossing on 3rd Avenue between Cavalry Road and Honda Bow Road
- **D** The Cline Creek bridge was designed to withstand a 100-year event without overtopping, however, there is a possibility it might be under water. Use Caution when crossing.



EVACUATION ROUTE

Evacuation Site: **Desert Valley Baptist Church**
42425 North New River Road
New River, Arizona 85086
(623) 465-9461

Selleys/Caldwell

a. **South (Right) on 3rd Avenue to Honda Bow Road (USE CAUTION)**
b. **East (Left) on Honda Bow Road to New River Road**
c. **South (Right) on New River Road a short distance to Desert Valley Baptist Church on East (Left) Side of New River Road Just South of Honda Bow Road**

NOTE: The Flood Control District of Maricopa County (FCDMC) and National Weather Service (NWS) will provide timely weather information and flood warning messages to you to the best of their abitlity using currently available technology. Be advised that prediction of flash floods is complex and conditions can change very rapidly. You have a responsibility to do what you can to remain alert for changing flood conditions impacting your residence. Closely monitor local conditions around your residence. Use the pager, weather radio, commercial radio, and television to stay informed. You may also contact FCDMC Flood Warning Branch directly for Skunk Creek flood information two ways.

1. Telephone (602) 506-8701
2. Web site http://156.42.96.39/alert/skunk_frp/sc.html

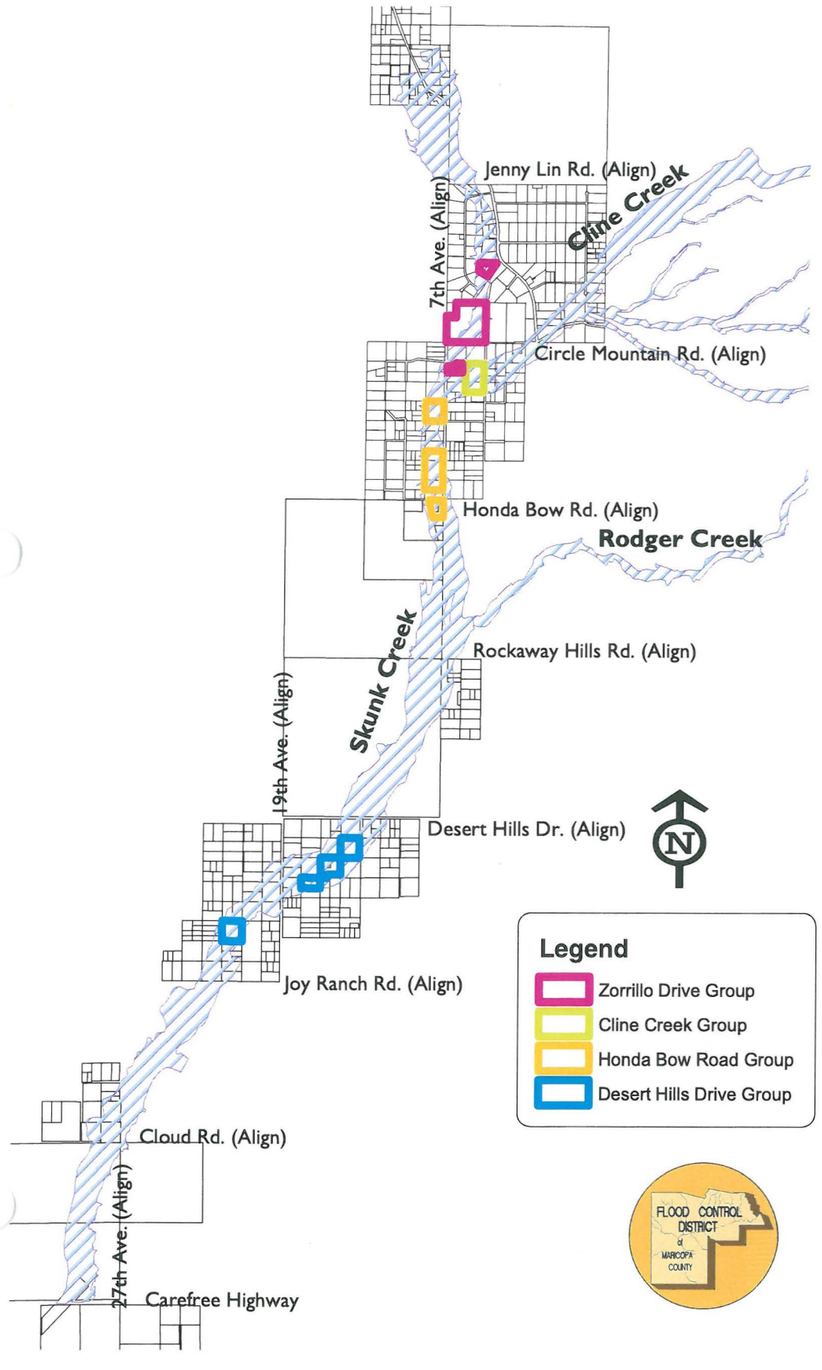
Call 911 if you need emergency assistance during a flood event

When rainfall increases rapidly or flood conditions worsen significantly, follow the instructions listed under "What You Need To Do" even if you have not received a pager or weather radio flood warning message.
USE COMMON SENSE!

NTS
Aerial Photo Date: 7/1999

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

SKUNK CREEK FLOOD RESPONSE PLAN
HONDA BOW ROAD GROUP



MESSAGE	WHAT IT MEANS	WHAT YOU NEED TO DO
(NOAA Radio) National Weather Service Flash Flood Watch (begin time/end time)	→ Flash flooding possible in north central Maricopa County, including Skunk Creek or Cline Creek → Be alert!	→ Monitor your FCDMC pager and NOAA weather radio continually for updates. Other sources of flood information: - Some commercial radio and TV stations voluntarily broadcast NWS flash flood watch and flash flood warning information - Real-time FCDMC rainfall and flood information is always available by monitoring their web page at: http://www.fcd.maricopa.gov/alert/alert.htm - 24-hour hydrologic and weather information for the entire state is available at: http://www.afws.org
(FCDMC Pager) Skunk Creek Message 1 Weather Alert (begin time/end time)	→ Flash flooding possible in north central Maricopa County, especially in the Upper Skunk Creek and Cline Creek areas → Be alert!	
(FCDMC Pager) Skunk Creek Message 2 Flash Flood Alert (begin time/end time)	→ Heavy rainfall detected in upper Skunk or Cline Creeks Watersheds → Moderate flow volumes detected by stream gages → Potential for life-threatening flooding exists → Take necessary precautions!	→ You MAY be instructed to EVACUATE and will need to do so in a moment's notice. You may only have minutes! Get Prepared! → Monitor your FCDMC pager and NOAA weather radio continually for updates. → Locate all residents of your home, pets and livestock. Collect absolute necessities and load in your vehicle(s). Include a flashlight. Secure premises. → Find a light-colored sheet or towel to hang on your doorway in case you evacuate.
(NOAA Radio) National Weather Service Flash Flood Warning (begin time/end time)	→ Flash flooding imminent or occuring in north central Maricopa County, including Skunk Creek or Cline Creek → Take necessary precautions!	
(FCDMC Pager) Skunk Creek Message 3 Severe Flood Warning (effective time/all clear)	→ Extreme rainfall detected in the upper Skunk Creek or Cline Creek watersheds. → Critical flow volumes detected by stream gages. → Severe flash flooding is imminent or occuring. → Many or all of roadway crossings in the area are impassable. → Residents MUST monitor pagers and NOAA weather radios. → Follow the instructions listed under "What You Need To Do"!	→ IMMEDIATELY EVACUATE all residents and pets from your home and get to the evacuation site (see map on reverse). Act quickly! → Turn off lights, heating and air-conditioning units. → Hang a light-colored sheet or towel over your door to indicate to emergency personnel that you have evacuated. → Monitor your FCDMC pager and NOAA weather radio for updates. → Follow the evacuation route shown on the map. Avoid travel on roadways through wash crossings. DO NOT cross any barricaded roads! NEVER drive through flooded roadways, especially at night when dangers are harder to recognize. → Report to evacuation site for registration, even if you do not plan to stay. → Seek medical care at the nearest hospital, if needed. Food, clothing, and first aid may be available from emergency aid organizations such as the Red Cross.
(FCDMC Pager) Skunk Creek Message 4 All Clear (effective time)	→ Floods on Skunk Creek and Cline Creek have dropped below critical levels. → Potential for additional extreme flooding is minimal	→ Leave the evacuation site and return to your home using the same route in reverse. → Use flashlights to examine buildings. Flammables may be inside. → Electrical equipment should be dried and checked before being returned to service.. → Boil drinking water before using. Wells should be pumped out and water tested for purity before drinking. → Throw out any fresh food that has come in contact with flood waters.

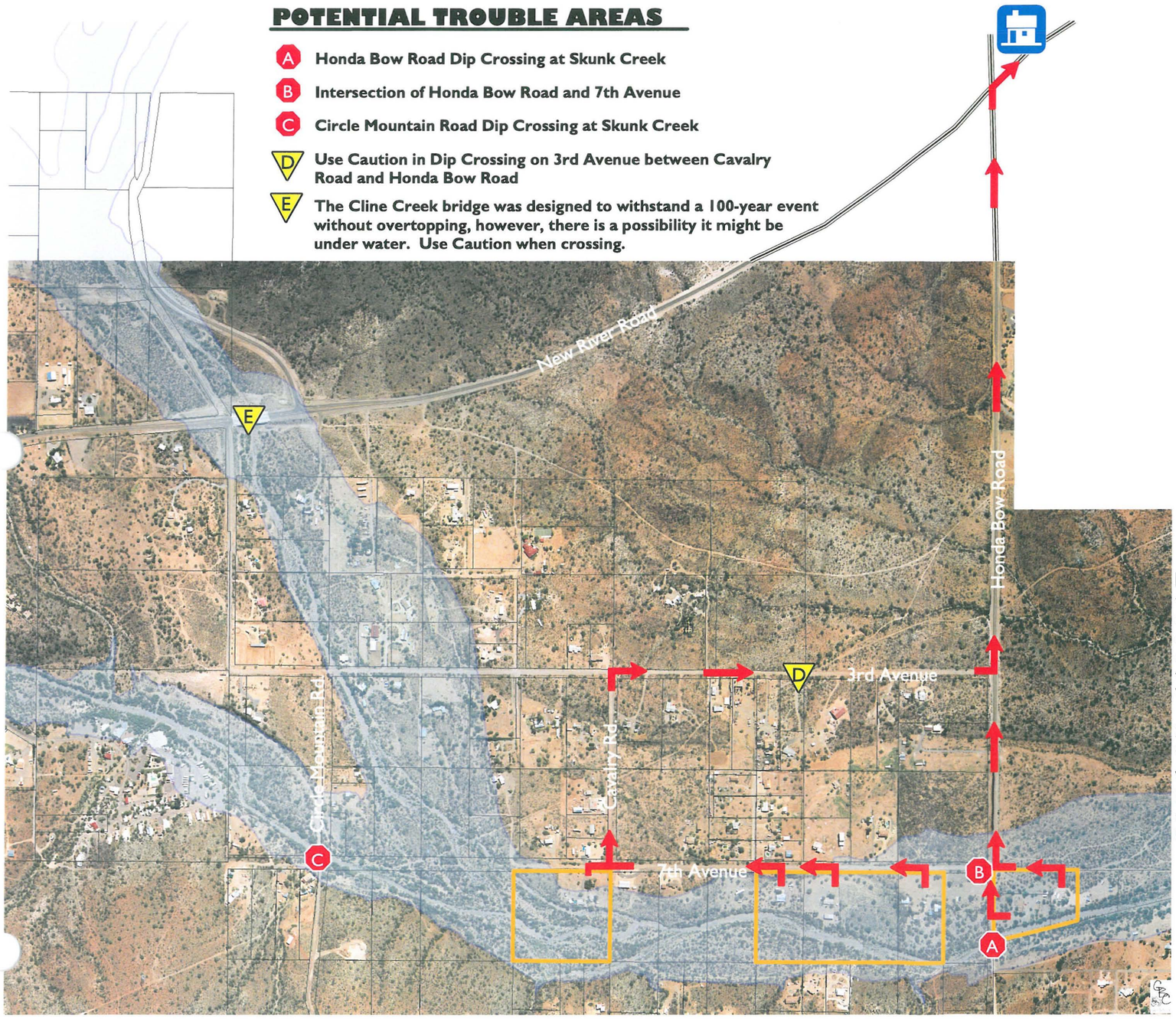
NOTE: The message progression may shortcut to FCDMC Message 3 or 4 at any point in the sequence as evolving flood conditions warrant. If a NWS Flash Flood Watch is in effect early in the day, the warning message sequence may shortcut to NWS Flash Flood Warning, as appropriate to changing weather conditions

SKUNK CREEK FLOOD RESPONSE PLAN

HONDA BOW ROAD GROUP

POTENTIAL TROUBLE AREAS

- **A** Honda Bow Road Dip Crossing at Skunk Creek
- **B** Intersection of Honda Bow Road and 7th Avenue
- **C** Circle Mountain Road Dip Crossing at Skunk Creek
- **D** Use Caution in Dip Crossing on 3rd Avenue between Cavalry Road and Honda Bow Road
- **E** The Cline Creek bridge was designed to withstand a 100-year event without overtopping, however, there is a possibility it might be under water. Use Caution when crossing.



EVACUATION ROUTE

Evacuation Site: Desert Valley Baptist Church
42425 North New River Road
New River, Arizona 85086
(623) 465-9461

Albert/Eller/Hines/Funk

a. North (Left) on 7th Avenue to Cavalry Road
b. East (Right) on Cavalry Road to 3rd Avenue
c. South (Right) on 3rd Avenue to Honda Bow Road (USE CAUTION)
d. East (Left) on Honda Bow Road to New River Road
e. South (Right) on New River Road a short distance to Desert Valley Baptist Church on East (Left) Side of New River Road Just South of Honda Bow Road

McKeag/Geraci

f. East (Right) on Honda Bow Road to New River Road
g. South (Right) on New River Road a short distance to Desert Valley Baptist Church on East (Left) Side of New River Road Just South of Honda Bow Road

NOTE: The Flood Control District of Maricopa County (FCDMC) and National Weather Service (NWS) will provide timely weather information and flood warning messages to you to the best of their abitlity using currently available technology. Be advised that prediction of flash floods is complex and conditions can change very rapidly. You have a responsibility to do what you can to remain alert for changing flood conditions impacting your residence. Closely monitor local conditions around your residence. Use the pager, weather radio, commercial radio, and television to stay informed. You may also contact FCDMC Flood Warning Branch directly for Skunk Creek flood information two ways.

1. Telephone (602) 506-8701
2. Web site http://156.42.96.39/alert/skunk_frp/sc.html

Call 911 if you need emergency assistance during a flood event

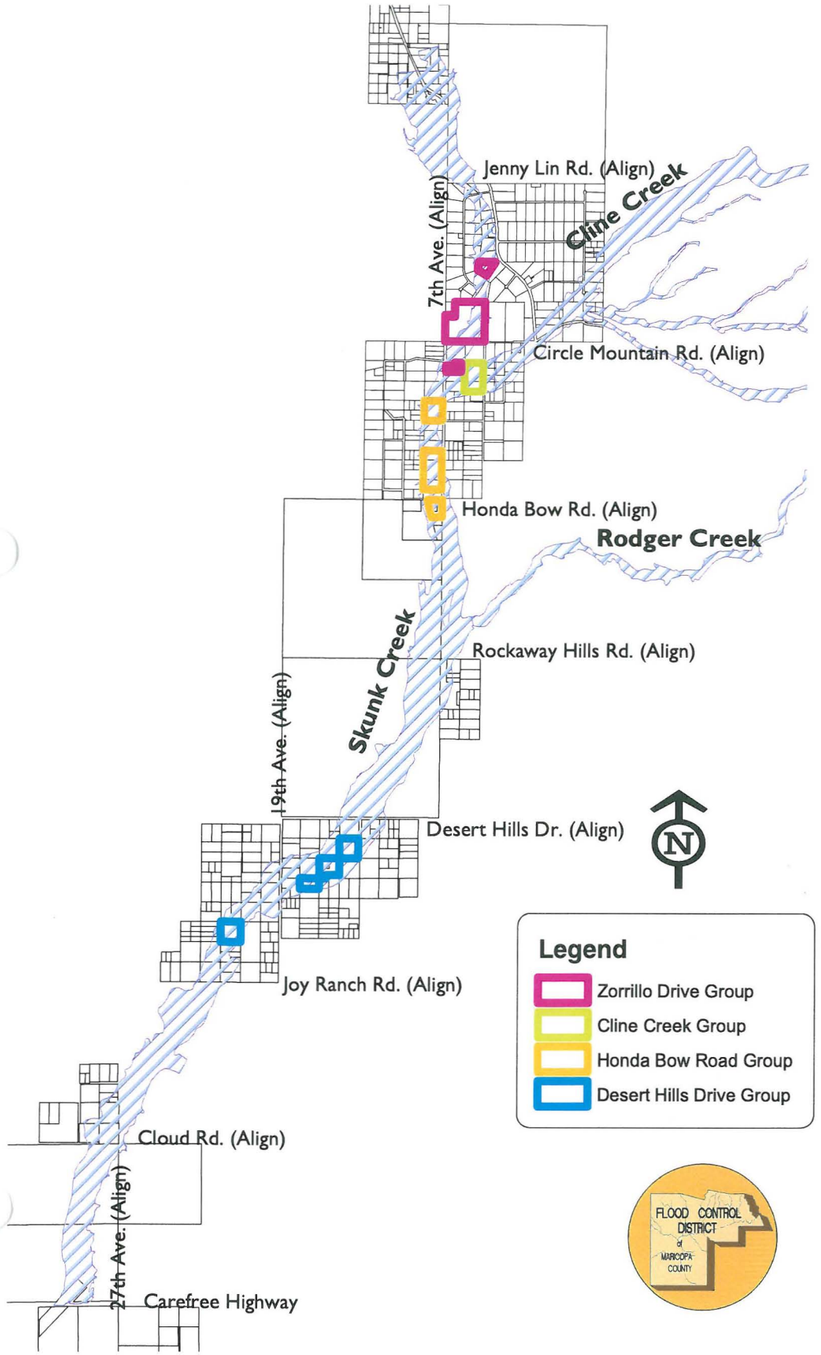
When rainfall increases rapidly or flood conditions worsen significantly, follow the instructions listed under "What You Need To Do" even if you have not received a pager or weather radio flood warning message.
USE COMMON SENSE!

NTS
Aerial Photo Date: 7/1999

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

SKUNK CREEK FLOOD RESPONSE PLAN

DESERT HILLS DRIVE GROUP



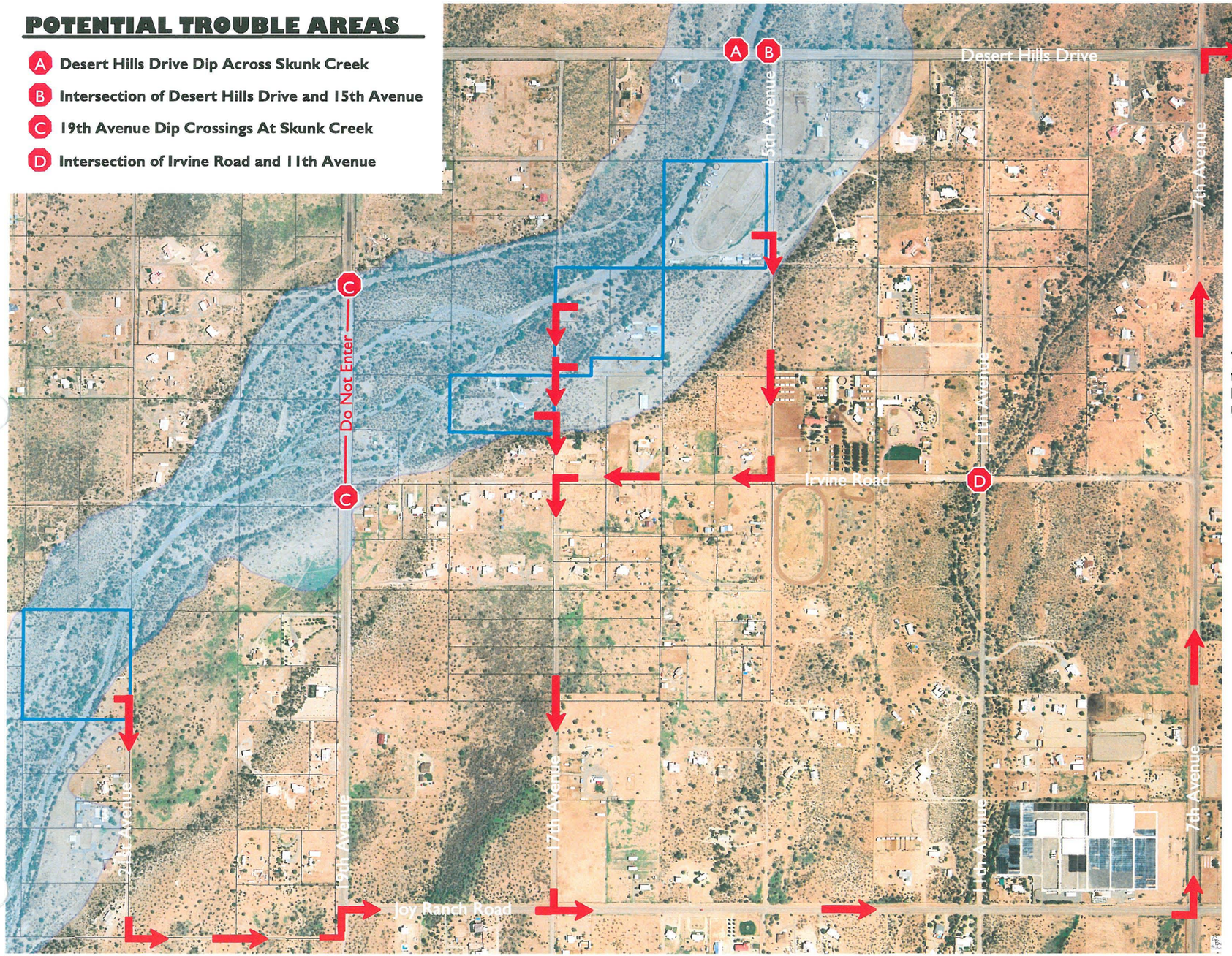
MESSAGE	WHAT IT MEANS	WHAT YOU NEED TO DO
(NOAA Radio) National Weather Service Flash Flood Watch (begin time/end time)	→ Flash flooding possible in north central Maricopa County, including Skunk Creek or Cline Creek → Be alert!	→ Monitor your FCDMC pager and NOAA weather radio continually for updates. Other sources of flood information: - Some commercial radio and TV stations voluntarily broadcast NWS flash flood watch and flash flood warning information - Real-time FCDMC rainfall and flood information is always available by monitoring their web page at: http://www.fcd.maricopa.gov/alert/alert.htm - 24-hour hydrologic and weather information for the entire state is available at: http://www.afws.org
(FCDMC Pager) Skunk Creek Message 1 Weather Alert (begin time/end time)	→ Flash flooding possible in north central Maricopa County, especially in the Upper Skunk Creek and Cline Creek areas → Be alert!	
(FCDMC Pager) Skunk Creek Message 2 Flash Flood Alert (begin time/end time)	→ Heavy rainfall detected in upper Skunk or Cline Creeks Watersheds → Moderate flow volumes detected by stream gages → Potential for life-threatening flooding exists → Take necessary precautions!	→ You MAY be instructed to EVACUATE and will need to do so in a moment's notice. You may only have minutes! Get Prepared! → Monitor your FCDMC pager and NOAA weather radio continually for updates. → Locate all residents of your home, pets and livestock. Collect absolute necessities and load in your vehicle(s). Include a flashlight. Secure premises. → Find a light-colored sheet or towel to hang on your doorway in case you evacuate.
(NOAA Radio) National Weather Service Flash Flood Warning (begin time/end time)	→ Flash flooding imminent or occuring in north central Maricopa County, including Skunk Creek or Cline Creek → Take necessary precautions!	
(FCDMC Pager) Skunk Creek Message 3 Severe Flood Warning (effective time/all clear)	→ Extreme rainfall detected in the upper Skunk Creek or Cline Creek watersheds. → Critical flow volumes detected by stream gages. → Severe flash flooding is imminent or occuring. → Many or all of roadway crossings in the area are impassable. → Residents MUST monitor pagers and NOAA weather radios. → Follow the instructions listed under "What You Need To Do"!	→ IMMEDIATELY EVACUATE all residents and pets from your home and get to the evacuation site (see map on reverse). Act quickly! → Turn off lights, heating and air-conditioning units. → Hang a light-colored sheet or towel over your door to indicate to emergency personnel that you have evacuated. → Monitor your FCDMC pager and NOAA weather radio for updates. → Follow the evacuation route shown on the map. Avoid travel on roadways through wash crossings. DO NOT cross any barricaded roads! NEVER drive through flooded roadways, especially at night when dangers are harder to recognize. → Report to evacuation site for registration, even if you do not plan to stay. → Seek medical care at the nearest hospital, if needed. Food, clothing, and first aid may be available from emergency aid organizations such as the Red Cross.
(FCDMC Pager) Skunk Creek Message 4 All Clear (effective time)	→ Floods on Skunk Creek and Cline Creek have dropped below critical levels. → Potential for additional extreme flooding is minimal	→ Leave the evacuation site and return to your home using the same route in reverse. → Use flashlights to examine buildings. Flammables may be inside. → Electrical equipment should be dried and checked before being returned to service.. → Boil drinking water before using. Wells should be pumped out and water tested for purity before drinking. → Throw out any fresh food that has come in contact with flood waters.

NOTE: The message progression may shortcut to FCDMC Message 3 or 4 at any point in the sequence as evolving flood conditions warrant. If a NWS Flash Flood Watch is in effect early in the day, the warning message sequence may shortcut to NWS Flash Flood Warning, as appropriate to changing weather conditions

SKUNK CREEK FLOOD RESPONSE PLAN
DESERT HILLS DRIVE GROUP

POTENTIAL TROUBLE AREAS

- A Desert Hills Drive Dip Across Skunk Creek
- B Intersection of Desert Hills Drive and 15th Avenue
- C 19th Avenue Dip Crossings At Skunk Creek
- D Intersection of Irvine Road and 11th Avenue



NOTE: The Flood Control District of Maricopa County (FCDMC) and National Weather Service (NWS) will provide timely weather information and flood warning messages to you to the best of their abitlity using currently available technology. Be advised that prediction of flash floods is complex and conditions can change very rapidly. You have a responsibility to do what you can to remain alert for changing flood conditions impacting your residence. Closely monitor local conditions around your residence. Use the pager, weather radio, commercial radio, and television to stay informed. You may also contact FCDMC Flood Warning Branch directly for Skunk Creek flood information two ways.

1. Telephone (602) 506-8701
2. Web site http://156.42.96.39/alert/skunk_frp/sc.html

Call 911 if you need emergency assistance during a flood event

When rainfall increases rapidly or flood conditions worsen significantly, follow the instructions listed under "What You Need To Do" even if you have not received a pager or weather radio flood warning message.
USE COMMON SENSE!

EVACUATION ROUTE

Evacuation Site: Daisy Mountain Fire Department Station
251 West Desert Hills Drive
Phoenix, Arizona 85086
(623) 465-7400

Hopwood Trust

a. South (Right) on 15th Avenue to Irvine Road
b. West (Right) on Irvine Road to 17th Avenue

Hopwood Trust/Harper/Mathis/Birdsell

c. South (Left) on 17th Avenue to Joy Ranch Road
d. East (Left) on Joy Ranch Road to 7th Avenue
e. North (Left) on 7th Avenue to Desert Hills Drive
f. East (Right) on Desert Hills Drive to Daisy Mountain Fire Station on South (Right) Side of Desert Hills Drive Just West of Central Avenue

Parks

g. South (Right) on 21st Avenue to Joy Ranch Road
h. East (Left) on Joy Ranch Road to 7th Avenue
i. North (Left) on 7th Avenue to Desert Hills Drive
j. East (Right) on Desert Hills Drive to Daisy Mountain Fire Station on South (Right) Side of Desert Hills Drive Just West of Central Avenue

N

NTS
Aerial Photo Date: 7/1999

FLOOD CONTROL DISTRICT of MARICOPA COUNTY