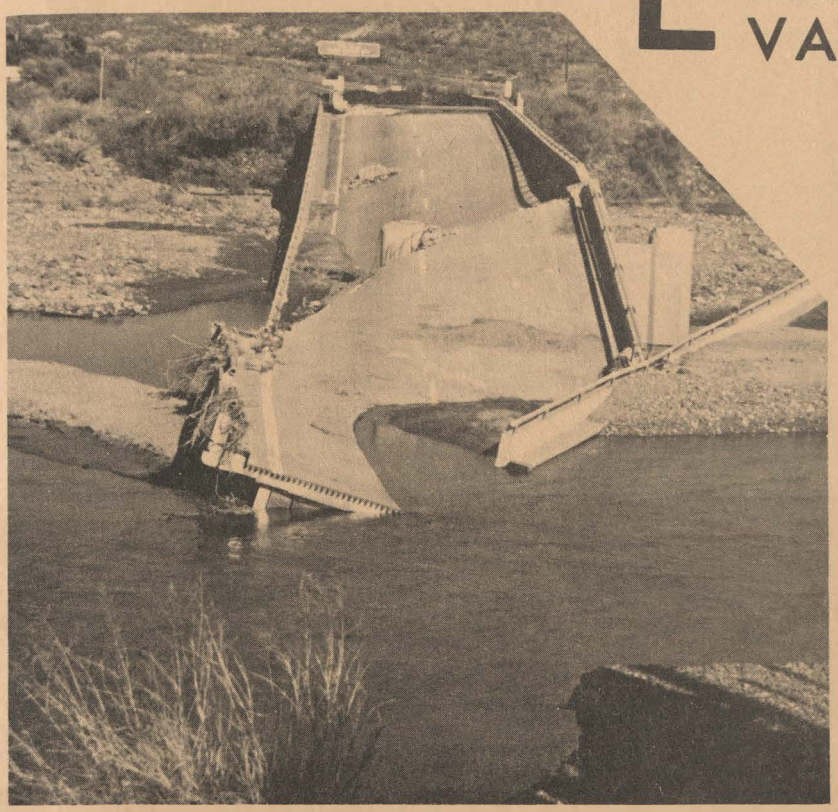
AUTOMATED LOCAL EVALUATION IN REAL TIME



A COOPERATIVE FLOOD WARNING SYSTEM FOR YOUR COMMUNITY

NATIONAL WEATHER SERVICE
WESTERN REGION
BOX 11188 FEDERAL BUILDING
SALT LAKE CITY, UTAH 84147

Notice: This is the second printing of this publication providing information about cooperative flood warning systems. The first printing was titled: "An Automated Flood Warning For Your Community?"

Prepared by
Hydrologic Services Division
National Weather Service
Western Region

Second Printing, February 1981

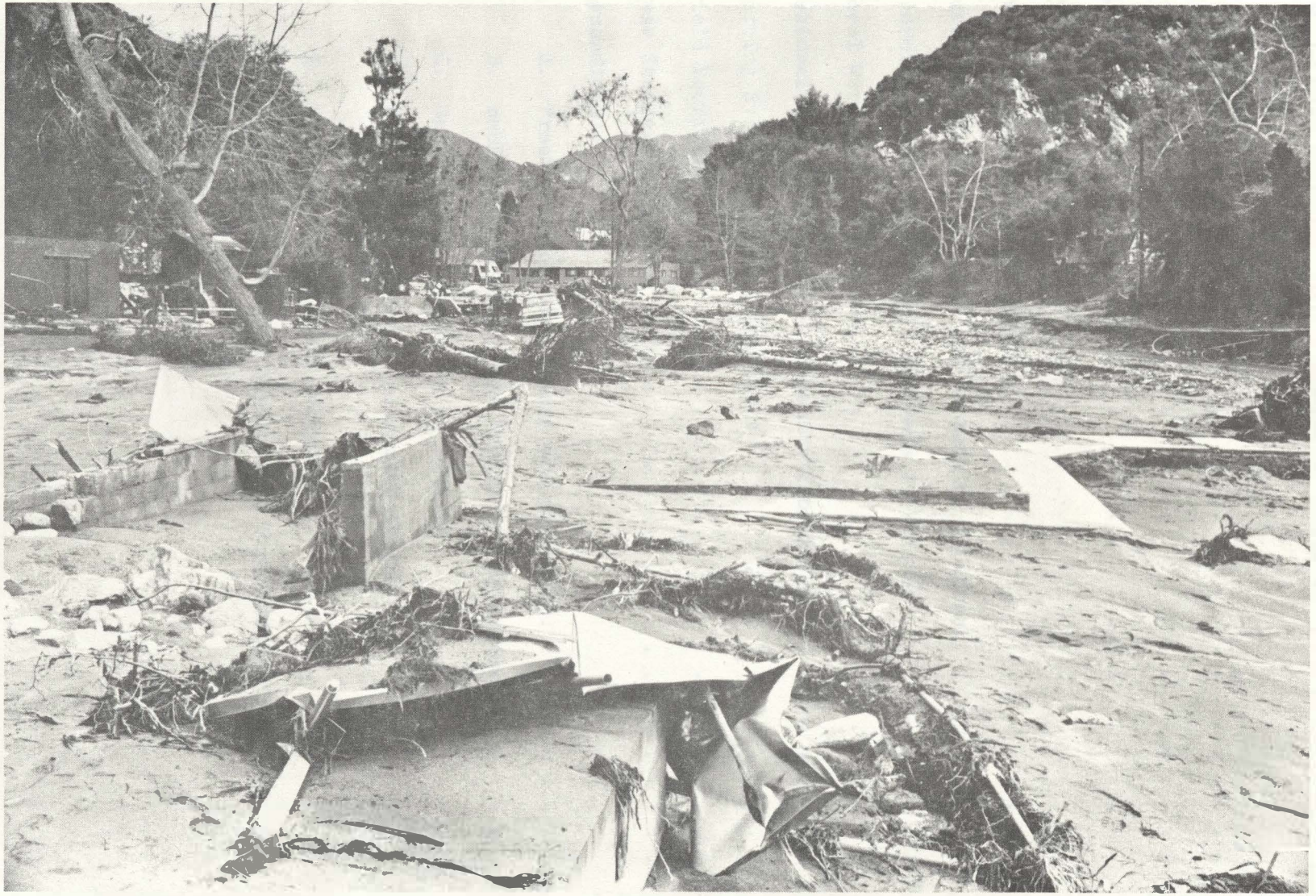


Figure 1. Flood damage, Hidden Springs on Mill Creek, San Gabriel Mountains, Los Angeles, California (Los Angeles Times Photo).

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FOREWORD

Flooding of rapidly responding rivers continues to exact a heavy toll on life and property. The tragic floods at Rapid City, South Dakota; Johnstown, Pennsylvania; and Big Thompson Canyon, Colorado; are examples of the loss of life that occurs without local flood warnings. The flooding in southern California and Arizona in 1978 and again in 1980 reemphasizes the need for effective local flood warning systems.

The Western Region of the National Weather Service, through its California-Nevada River Forecast Center, has implemented a new cooperative flood warning system. This system, now installed in a number of California communities, is based upon Automated Local Evaluation in Real Time. These systems have already demonstrated a highly cost-effective capability to protect life and property.

This publication describes the cooperative flood warning system and the ALERT (Automated Local Evaluation in Real Time) concept for handling data, which has produced these benefits and which has the potential for aiding many additional flood-threatened areas.

H. H. Bedke
Director, Western Region
National Weather Service

A COOPERATIVE FLOOD WARNING SYSTEM FOR YOUR COMMUNITY

INTRODUCTION

Flash floods are a frequent visitor to many areas of the western United States. The topography of much of the West tends to enhance rainfall from Pacific storms and thunderstorm activity. Rainfall, at times, is of such intensity that minor streams and even dry canyons are rapidly transformed into torrents of water which can sweep away man and his possessions. The potential for loss of life is steadily increasing due to spreading urbanization and flood plain encroachment.

Cooperative flood warning systems, utilizing ALERT, can provide the necessary time so that action to save life and property can be taken. Essentially, two critical elements are needed: one is an effective warning process which clearly identifies the area and magnitude of hazard, and the second is a response plan which provides for timely reaction. Owing to the brief time period before heavy upstream rains generate damaging downstream flows, the maximum time advantage can be gained by:

1. real-time monitoring of upstream precipitation gages;

2. evaluating from meteorological conditions, satellite and radar information, expected duration and amount of rain; and

3. using hydrologic techniques to assess the runoff threat.

Satellite imagery and radar data are useful to help assess the short-term precipitation outlook during critical flash flood situations. They cannot, however, provide the data required for generation of timely, discrete, site-specific flood warnings.

The California-Nevada River Forecast Center, located in Sacramento, has spent many years in developing the technology required for automated flood warning systems in order to provide the most effective warnings. Systems of this type are currently providing warnings on several streams in California. These systems are available, in cooperation with the National Weather Service, to any community having a flood problem.

SYSTEM COMPONENTS

The basic components of the automated flood warning system consist of:

1. automated precipitation and river gages,

2. automated data collection and processing equipment,

3. computerized hydrologic and meteorologic analysis techniques, and

4. the warning distribution.

1. PRECIPITATION AND RIVER GAGES

Precipitation gages which adequately measure high intensity rainfall capable of producing flash floods must frequently be located at remote sites in the headwaters of basins (Figure 2). The remote rain gage in the flood warning system is a modular, self-contained, self powered, event-reporting unit (Appendix A). Each 1 mm (.04 inch) increment of precipitation measured by a tipping bucket mechanism (Figure 3) causes the electronics and radio package (Figure 4) to transmit a station identification and a precipitation accumulation value. A similar gage utilizing the displacement of a solution of ethylene glycol and methyl alcohol is available for snow locations.

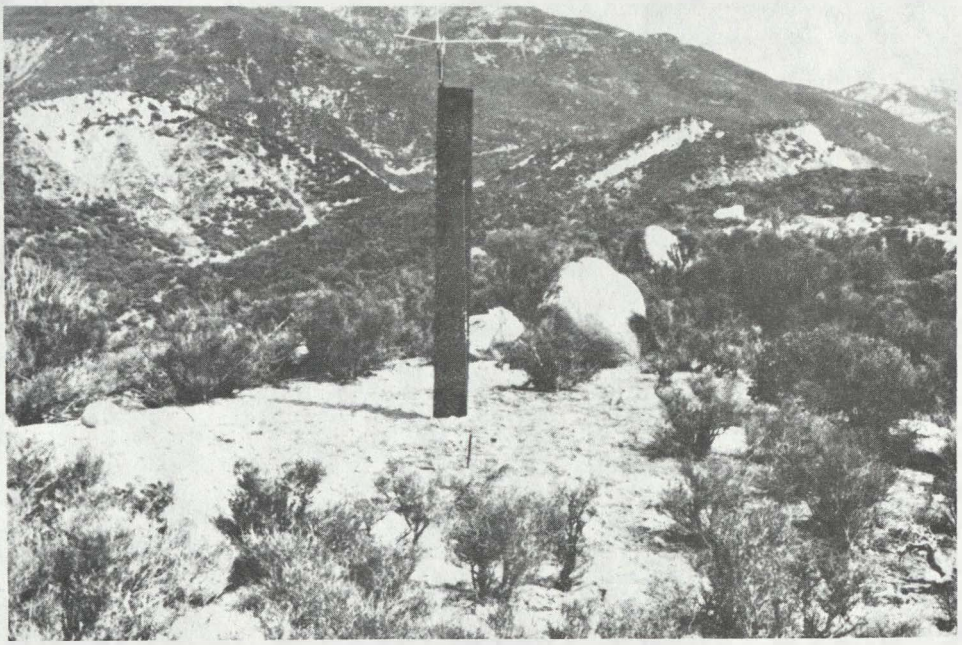

Figure 2. Rain Gage at Field Site

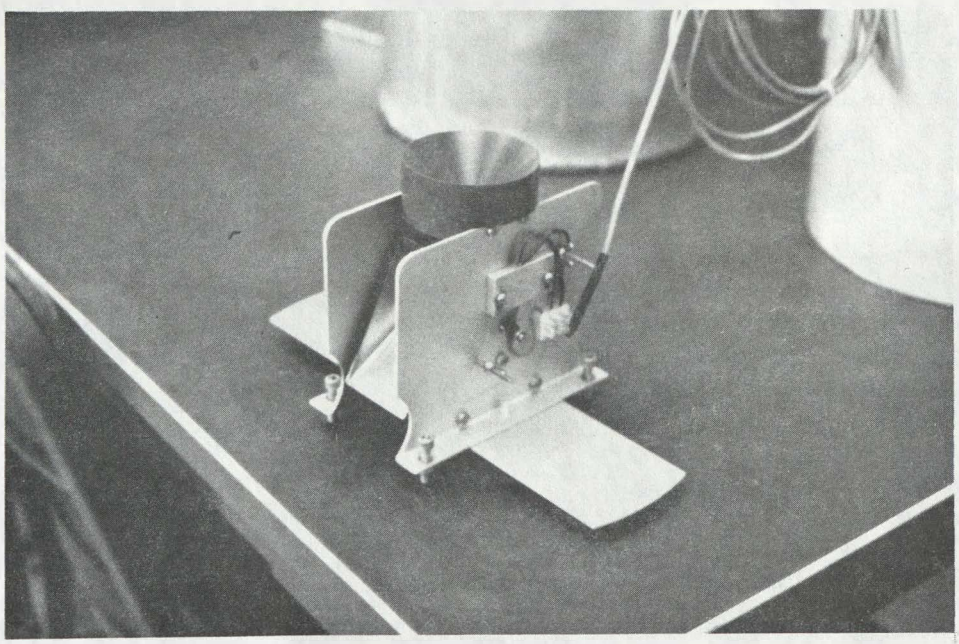

Figure 3. Tipping Bucket Mechanism

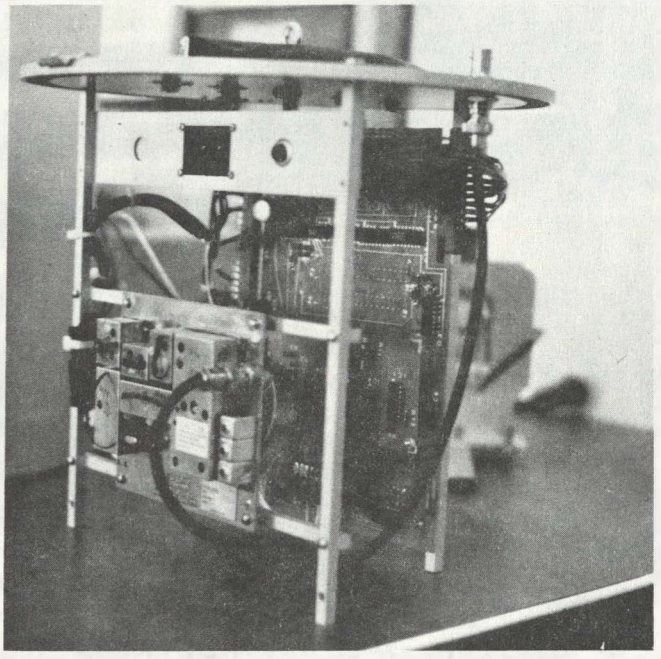

Figure 4. Electronics and Radio Package

Two types of river gages are available as part of the system. One for use where a stilling well is available, is a simple event-reporting water level sensing unit (Figure 5). A preselected incremental change in river elevation causes the transmission of a station identification and river elevation value. The other is a bubbler type gage (Figure 6), designed for use at remote locations where a stilling well would be impracticable to use (see Appendix B).

Both types use the same electronics and radio package as the precipitation gage. The bubbler type river gage and the precipitation tipping bucket mechanism may be collocated in the same structure and use only one transmitter.

The gages have been especially engineered to provide the maximum level of dependable data collection, independent of the status of local utilities and at the lowest possible cost associated with acquisition, operation and maintenance.

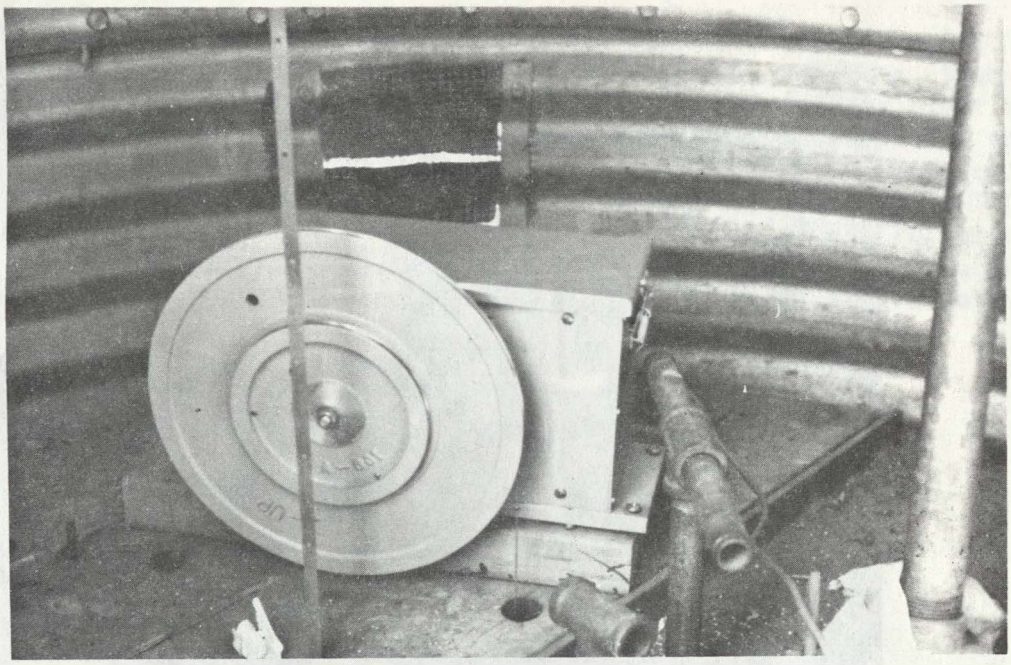

Figure 5. Water Level Sensor Type River Gage

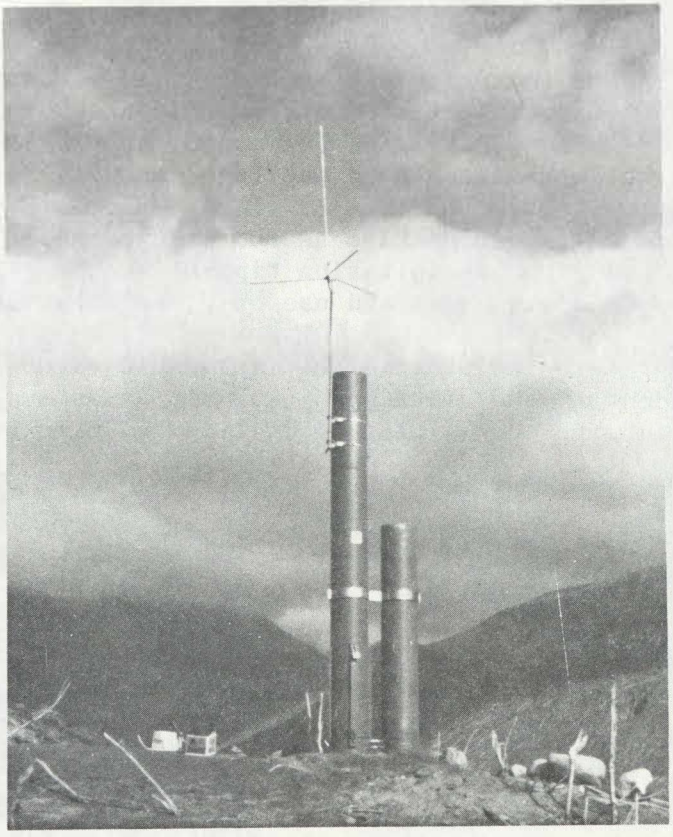

Figure 6. Bubbler Type River Gage

2. AUTOMATED DATA COLLECTION AND PROCESSING EQUIPMENT

Radio transmissions from the remote gages to the local agency are line-of-sight. Topography between the gaging sites and the receiving site may necessitate a radio relay installation at sufficient elevation for line-of-sight receipt and retransmission of signals (Figure 7).

The data collection and processing equipment are located at the local agency responsible for the flood warning program. The components consist of 1) a radio receiver for receipt of the event-reported radio signals, and 2) a dedicated inexpensive microcomputer or minicomputer system for collection and display of the data (Figure 8).

The local data collection site operates in a fully automatic mode, continuously receiving, processing and making available for display precipitation and streamflow data. This insures that the local group has full knowledge of current conditions in the river basin.

3. HYDROLOGIC AND METEOROLOGIC ANALYSIS TECHNIQUES

The local agency data system has a store and forward capability, allowing transmission of data and messages between it and the National Weather Service office having warning responsibilities. The data base may also be relayed automatically to the River Forecast Center or the River Forecast Center may call the local data system at appropriate intervals to obtain the data (Figure 9).

Using a hydrologic streamflow model, the River Forecast Center analyzes the data and provides flood threat potentials in the form of advisories (Appendix C). These advisories are displayed on the local system's CRT and at the River Forecast Center.

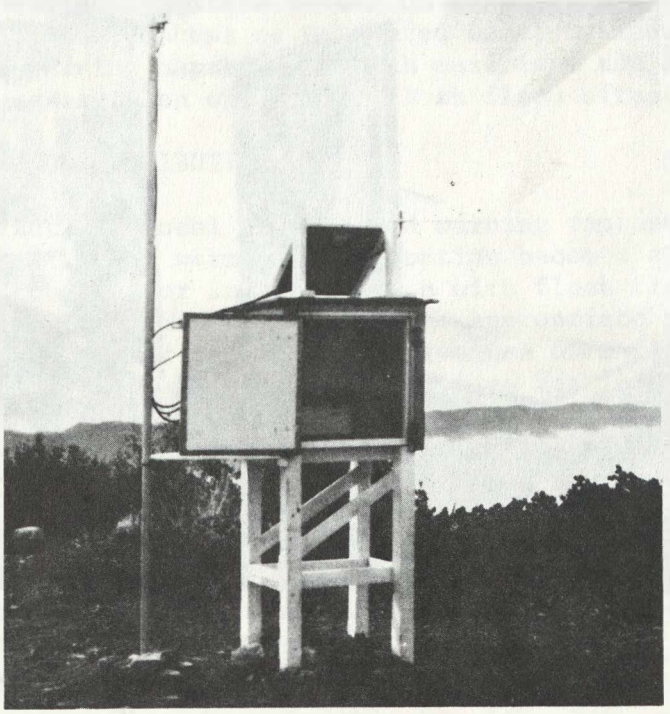

Figure 7. Repeater Installation (Sisar Peak)

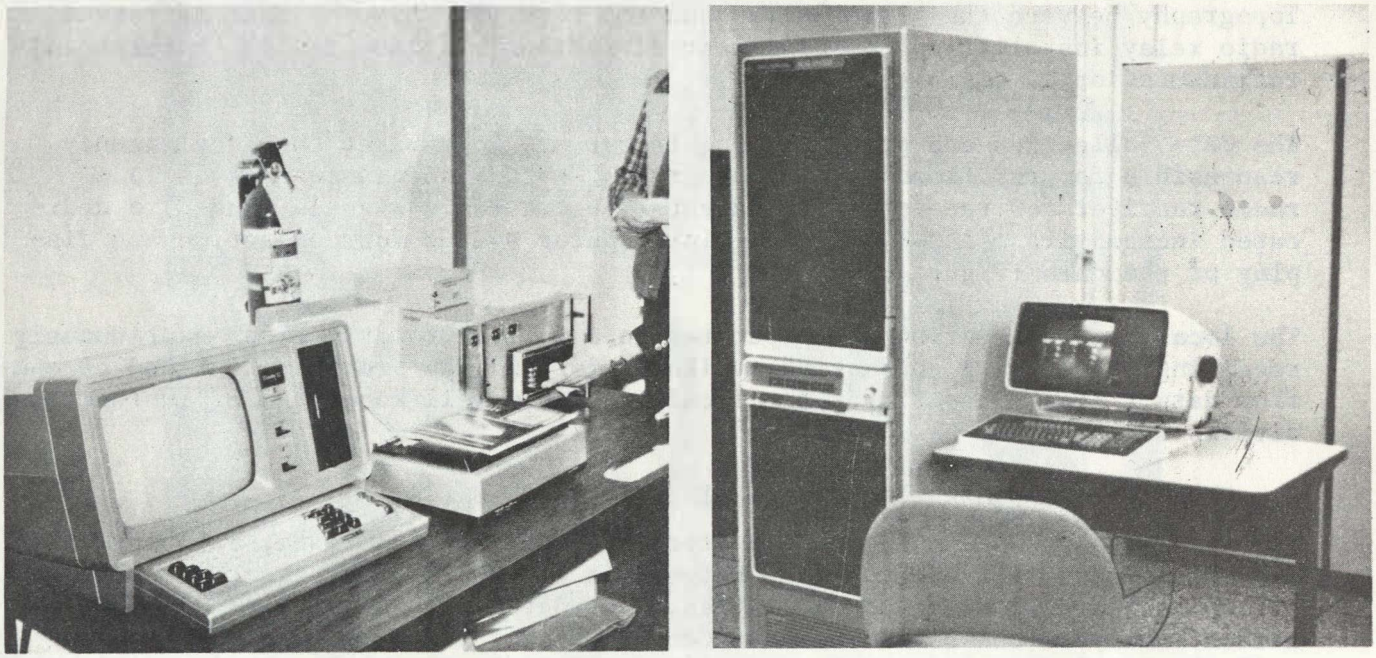

Figure 8. Local Microcomputer System (left) - Minicomputer System (right).

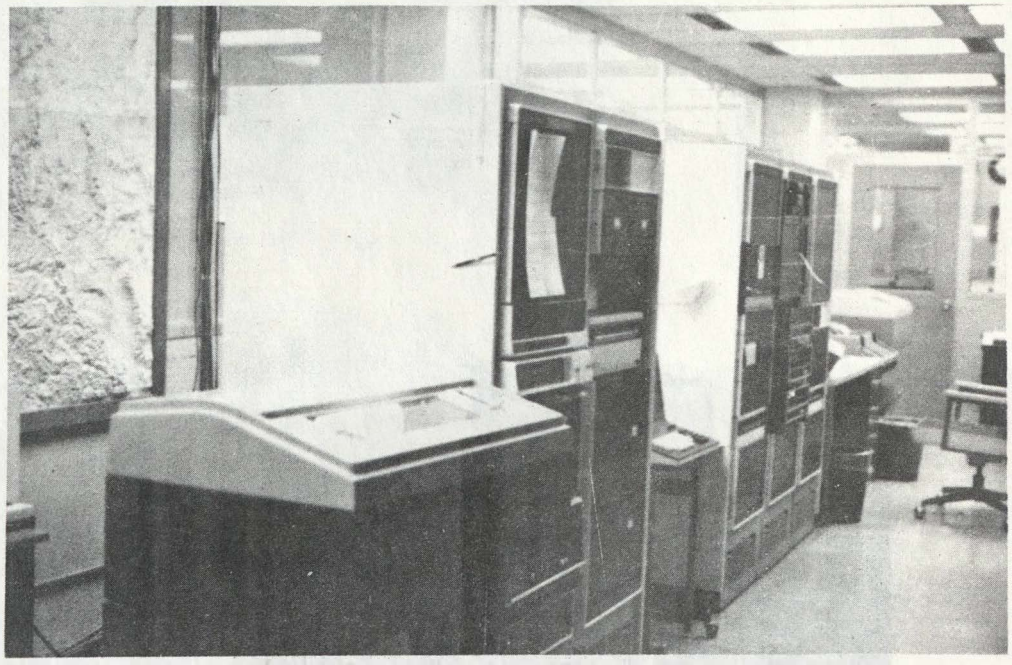

Figure 9. California-Nevada River Forecast Center Computer Equipment

The local automatic data collection system utilizes a CRT which can 1) display the compiled data base (Appendix D), 2) display the basic advisory material (Appendix E), and 3) store and forward messages between the local unit and the Central Network Weather Service Automatic Data Processing system. This approach, ALERT (Automated Local Evaluation in Real Time), allows the local group to assess the potential problem and--where dangerous conditions appear to be developing--to confer with the National Weather Service.

A computerized forecast routine which can be resident in the cooperating local agency's automatic data-collection receiving system is operational. This routine includes a streamflow simulation model of the basin, which reevaluates the anticipated flow conditions each twelve minutes. It is designed to evaluate the precipitation reports from the automated network, and generate the potential streamflow conditions. The streamflow analysis includes a short term (24 minutes) quantitative precipitation forecast (QPF) derived from local reports and National Weather Service guidance. At regular intervals, the responsible Weather Service Office reloads QPF information and the River Forecast Center performs supporting computations to the forecast routine which may allow the system to operate independently for up to five days in the event that communications between the local automatic data-collection system and the National Weather Service office may be temporarily disrupted.

The output from the hydrologic simulation model provides the local agency with a best estimate as to the severity of flooding. With this guidance, the local agency can take the necessary action.

In addition, the system prepares an advisory forecast based on the next six hours of forecast precipitation to provide an assessment of hazard level likely to develop in the near future. This hazard level is intended to provide planning guidance and is not intended for a full scale response unless the time factor or the degree of hazard leaves no reasonable alternative. This ALERT system, based on the concept of Automated Local Evaluation in Real Time, provides discrete warning capability which maximizes the lead time for the response required for preservation of life in flash flood situations.

4. LOCAL WARNING DISTRIBUTION

The community acts as local flash flood warning representative of the National Weather Service. Local warning distribution becomes a responsibility of the local warning coordinator in conjunction with flash flood warning statements issued by the National Weather Service to appropriate media and through NOAA Weather Radio. In order to make effective use of a flood warning system, a community needs a response plan that provides for levels of action necessary for minimizing threat to life and property damage. (For a guide to flash flood and flood preparedness planning see Appendix F.)

NATIONAL WEATHER SERVICE - COMMUNITY COOPERATION

The National Weather Service River Forecast Center will cooperate with any local agency in implementing an automated flood warning system.

The responsibilities of local government are:

1) Purchase of the field equipment and base station equipment.

2) Installation and maintenance of the equipment.

3) Development and operation of a flood response plan.

The National Weather Service will provide:

1) Assistance in site location of the field equipment and training in its installation.

2) A streamflow simulation model for the basin.

3) The software needed for data acquisition and display as well as the advisory service.

4) Meteorological and hydrological forecast service for the river basin.

5) Training in the use of base station equipment and forecast advisory service.

6) System monitoring and forecast model recalibration as required.

WARNING SYSTEM EQUIPMENT AND COSTS

The equipment costs for an automated flood warning system will vary with the size and complexity of the river basin. A small subbasin generally requires three rain gages, while a river basin of 150 to 300 square miles consisting of two or three subbasins will normally require a minimum of six rain gages. The base station equipment is independent of the number of field gages within the framework of a local warning system. Listed below is a summary of the typical costs required to procure equipment for an automated flood warning system. All equipment listed is an example of type only, no recommendation of vendors or guarantee of prices by the National Weather Service is implied.

a) FIELD EQUIPMENT	Approximate Cost/Each
Event Reporting Rain Gage	$2,500.00
Event Reporting Intermediate Gage (moderate snow area)	$2,700.00
Event Reporting Gage (heavy snow area)	$2,900.00
Event Reporting River Gage (for installation in an existing enclosure)	$ 400.00
Radio Repeater (if necessary)	$3,000.00
Enclosure, Antenna and Power Backup for Repeater	$5,000.00
Gage Installation	$ 300.00

b) BASE STATION EQUIPMENT	
Microcomputer/Minicomputer with 64K Bytes Real Time Clock, Communications Interface Diskette, CRT	$4,000.00/$9,000.00
Radio Receiver	$2,700.00
Auto Answer Modem	$ 300.00

The equipment costs for the average quick responding basin with little snow in winter would consist of a six rain gage network, radio repeater and enclosure equaling a field equipment cost of $23,000. The base station equipment cost ranges from $7,000 to $12,000. Total local system equipment costs range from $30,000 to $35,000. Installation costs for this network would be approximately $3,000 with annual maintenance costs of about $1,000. It should be noted that once a system is installed in one basin, additional basins can be added to the system with the additional costs of only field equipment. The base station data acquisition equipment has the capability of handling up to 100 gages.

A precipitation gage can be installed by 2 people in 2-4 hours. With reasonable site access, a 2-man team can install 2 gages per day. The installation cost per gage, including labor, material and transportation, is approximately $300 per gage. River gage installation costs are similar, assuming installation in an existing stilling well.

Routine maintenance is done annually, primarily for exchange of a freshly recharged battery and in the case of the snow gages, replacement of the ethylene glycol and methyl alcohol solution. Experience with existing systems indicates that routine annual maintenance will average approximately $100 per gage.

The system as described allows for the most cost effective continuous review of the hydrologic situation of a river basin on a real time basis. It provides the maximum effective warning time when integrated with meteorologic and hydrologic input through communications links with the servicing River Forecast Center.

If your community is interested in a cooperative venture with the National Weather Service in implementing an automated flood warning system, call or write:

Regional Hydrologist
National Weather Service, Western Region
P.O. Box 11188, Federal Building
Salt Lake City, Utah 84147
Phone: (801) 524-5137

APPENDIX A

PRECIPITATION GAGE DESIGN AND OPERATION

The precipitation gage entails a modular design comprised of components for precipitation measurements, structural support and data transmission. The structural component of the gage is fabricated from 12-inch aluminum irrigation pipe of sufficient height to provide a buried well for shielding on-site electronics and stabilizing battery and electronics. The 12-inch pipe provides a 30.5 mm orifice while simultaneously serving as a support for the antenna system. This configuration was chosen on the basis of many years of experience in testing equipment under particularly severe storm conditions in the Sierra Nevada mountains. Precipitation is caught in an aluminum funnel assembly and measured by a tipping bucket mechanism (Figure 10). Each 1 mm increment of precipitation causes the radio transmitter contained in the electronic package (Figure 10) to transmit a two-digit gage identification number and a two-digit rainfall accumulation value on an appropriate hydrologic radio frequency. Configurations appropriate to snow areas use a modified version of the design which causes incoming precipitation to displace an antifreeze mix through the tipping bucket mechanism. Considerations in the design of the basic rain gage unit include:

1. A whip antenna with ground plane mounted to eliminate drip into the orifice.

2. A straight-sided gage to reduce the vertical lift over the orifice induced by slope-sided or shouldered gages.

3. A large orifice diameter, 30.5 mm, to compensate for the pressure jump effect at the leading edge of the orifice which tends to carry precipitation across the throat of smaller gages.

4. A stainless steel non-corrosive strainer set deeply into the throat to prevent debris from choking the tipping bucket mechanism.

5. An enclosed tipping bucket mechanism which requires a full throw and alternating tips for signal transmission.

6. A tipping bucket sized at 1 mm to provide good resolution while preventing wind flutter and precipitation balancing frequently found in buckets of .25 mm or less.

7. A self-contained leveling device to assist in proper placement of the tipping unit.

8. Electronics located below ground for temperature stabilization and protection from vandalism.

9. No ground level doors or openings, in order to discourage vandalism.

10. A clock which sends regular check signals for verification of system operation.

11. A transmission interval of less than 150 milliseconds to minimize battery drain and reduce contention problems between gages operating on the same radio frequency.

12. An integral accumulator which prevents loss of volumetric data if transmissions are occasionally blocked.

13. Modular electronic components for simplified maintenance.

14. A switch-selectable station ID to simplify installation and maintenance.

15. Rechargeable gel cell battery supply with adequate power for over two years of data transmission between charges.

16. A high orifice level to discourage pranksters.

17. A simple cylindrical container to provide a gage enclosure, electronic security and antenna support with minimum environmental impact.

18. Elimination of every function from the field site which can reasonably be performed by the local receiving site.

19. Gages are designed for nominal servicing on an annual basis.

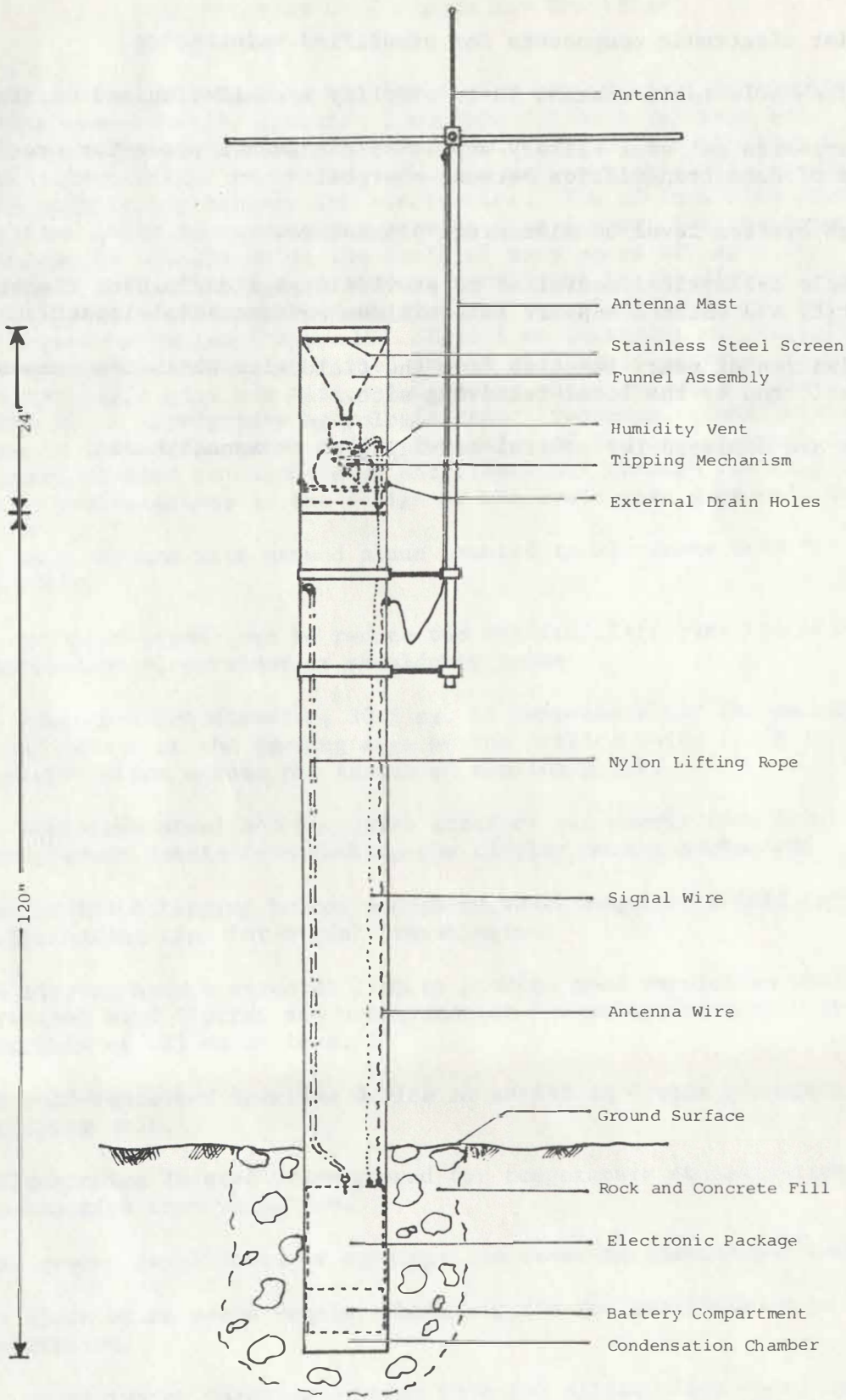

Figure 10. Schematic Diagram of Installed Precipitation Gage

APPENDIX B

BUBBLER TYPE RIVER GAGE DESIGN AND OPERATION

The bubbler type event reporting river gage equipment is used in rough terrain where access is limited, and where a stilling well is impracticable. The structural component and installation of the gage is similar to the precipitation gage (Appendix A), allowing the gages to be collocated and use the same transmitter. The gage consists of four major parts (Figure 11): 1) The gas purge system, 2) the manometer assembly, 3) the liquid level, and 4) the radio transmitter.

During operation, a length of three-eights inch plastic tubing leading from the bubbler orifice is anchored to the streambed. Air from a dry nitrogen supply is metered through the bubbler orifice. The changing head above the bubble orifice causes a corresponding pressure change which results in the manometer fluid level changing. Preselected incremental changes in river elevation are stored in the accumulator of the transmitter. A two-digit gage identification number and a four-digit accumulated river elevation value is transmitted on an appropriate hydrologic radio frequency. Considerations in the design of the bubbler type river gage include:

1. Stilling wells are not required
2. Equipment can be located several hundred feet from the stream
3. Range is 0-40 feet with accuracy $\pm$ 0.1 feet (approximately)
4. Electronics located below ground for temperature stabilization and protection from vandalism
5. A clock which sends regular check signals for verification of system operation
6. A transmission interval of less than 150 milliseconds to minimize battery drain and reduce contention problems between gages operating on the same radio frequency
7. An integral accumulator which prevents loss of data if transmissions are occasionally blocked
8. Modular electronic components for simplified maintenance
9. A switch-selectable station identification to simplify installation and maintenance
10. Rechargeable gel cell battery supply
11. A simple cylindrical container to provide a gage enclosure, electronic security and antenna support with minimum environmental impact

12. Elimination of every function from the field site which can reasonably be performed by the local receiving site.

13. Gages are designed for nominal servicing on an annual basis.

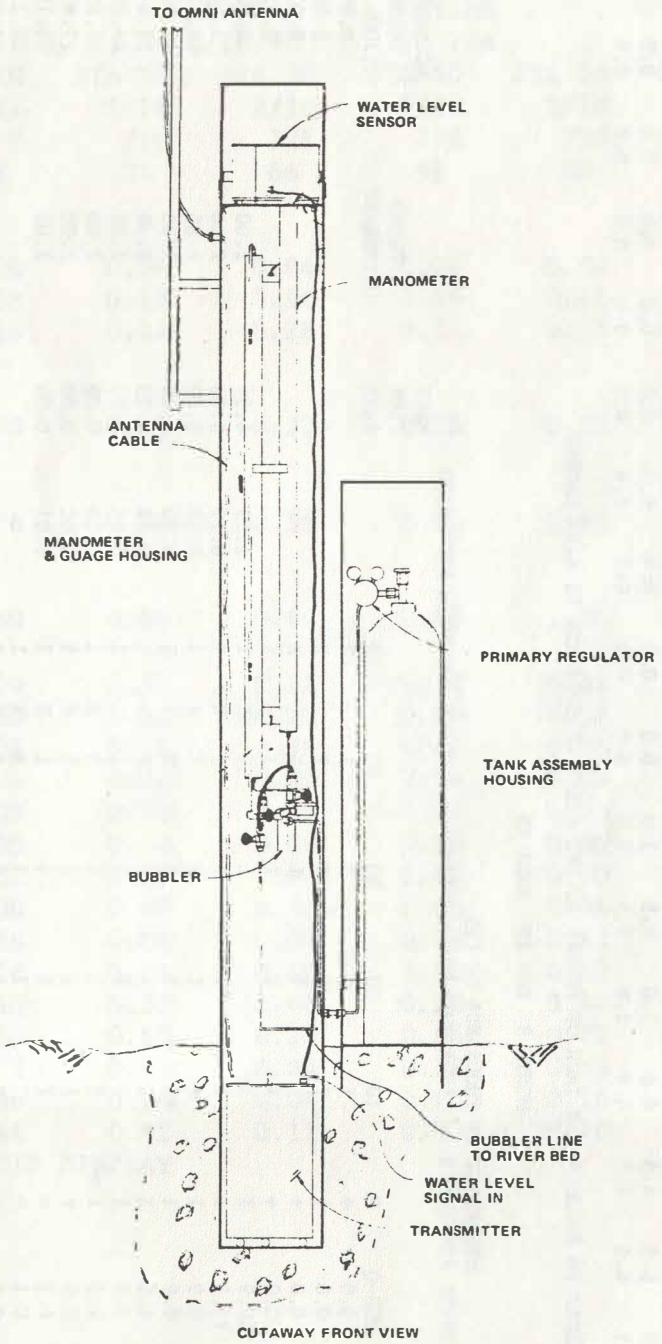

Figure 11. Schematic Diagram of Installed Bubbler Type River Gage.

FORECAST BASED ON 5 INCH GAGE CATCH IN THE LAST SIX HOUR PERIOD

SESPE CR NO FILLMOR — RIVER FORECAST MODEL PARAMETERS

	UZTWC	UZFWC	LZTWC	LAFSC	LZFPC	ADIMC
STORAGE CAPACITIES	2.50	1.40	6.19	3.40	7.50	8.69
INITIAL CONTENTS	0.00	0.00	1.03	0.00	6.36	0.42

UZK	LZSK	LZPK	LPERC	REXP	SIDE	PCTIM	RSERV	ADIMP	PFREE	VOL-1	VOL-2	VOL-3	RC-1	RC-2	RC-3	RC-4
0.372	0.041	0.0007	31.7	1.05	0.00	0.00	0.50	0.01	0.09							

UNITGRAPH ORDINATES

DOWNSTREAM	5.5	6.5	4.5	4.0	3.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NORMAL	5.5	6.5	4.5	4.0	3.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UPSTREAM	5.5	6.5	4.5	4.0	3.0	1.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THE AMOUNT OF RAIN NEEDED TO PRODUCE ONE INCH OF RUNOFF AT THE START OF THIS RUN IS 6.25 INCHES

BASE FLOW 0.0 — MONTH 8 DAY 20 HOUR 10

AUG 80 — DISCHARGE IN THOUSANDS OF CFS

\+ FOR ADJUSTED FORECASTS *FOR MACHINE FORECASTS = FOR OBSERVED FORECASTS

DAY	HR	ADJ-Q	MCH-Q	0	10	20	30	40	50		MELT PLUS RAIN	APPLIED UNITGRAPH	ACCUMULATED VOLUME (1000 AF)
20	10	0.0	0.0	+	I	I	I	I	X				0.000
20	16	0.0	0.0	+	I	I	I	I	X				0.008
20	22	0.0	0.0	+	I	I	I	I	X				0.017
21	4	0.0	0.0	+	I	I	I	I	X				0.025
21	10	10.9	10.9	I	I+	I	I	I	X	I	1.99	6.36	2.00	0.034
21	16	13.5	13.5	I	I +	I	I	I	X	I	0.11	0.00	2.00	5.446
21	22	9.9	9.9	I	+	I	I	I	X	I	0.05	0.00	2.00	12.125
22	4	8.9	8.9	I	+I	I	I	I	X	I	0.03	0.00	2.00	17.021
22	10	6.8	6.8	I	+ I	I	I	I	X	I	0.02	0.00	2.00	21.415
22	16	3.7	3.7	I	+ I	I	I	I	X	I	0.01	0.00	2.00	24.804
22	22	2.5	2.5	I	+ I	I	I	I	X	I	0.01	0.00	2.00	26.659
23	4	0.4	0.4	+	I	I	I	I	X	I	0.01	0.00	2.00	27.918
23	10	0.2	0.2	+	I	I	I	I	X	I	0.01	0.00	2.00	28.121
23	16	0.1	0.1	+	I	I	I	I	X	I				28.236
23	22	0.1	0.1	+	I	I	I	I	X	I				28.307
24	4	0.1	0.1	+	I	I	I	I	X	I				28.354
24	10	0.1	0.1	+	I	I	I	I	X	I				28.390
24	16	0.1	0.1	+	I	I	I	I	X	I				28.418
24	22	0.0	0.0	+	I	I	I	I	X	I				28.444
25	4	0.0	0.0	+	I	I	I	I	X	I				28.468
25	10	0.0	0.0	+	I	I	I	I	X	I				28.492
25	16	0.0	0.0	+	I	I	I	I	X	I				28.515
25	22	0.0	0.0	+	I	I	I	I	X	I				28.539
				50	40	30	20	10	0		2.18	6.36		

X = TOTAL EFFECTIVE BASIN RAIN

SESPE CR NR FILLMORE

APPENDIX D

NWS HYDROLOGIC DATA COLLECTION SYSTEM

VENTURA COUNTY

DATE 2/16/80 TIME 726

	STA 10	STA 20	STA 30	STA 40	STA 50	STA 60	STA 80	STA 90
DATE,TIME,VALUE	2/16	2/16	2/16	2/16	2/16	2/16	0/ 0	0/ 0
OF LAST TRANSMIT	7 7	726	721	719	724	718	0 0	0 0
	73	21	66	91	38	32	0	0
PRECIPITATION								
LAST 10 MIN	0.00	0.04	0.04	0.04	0.04	0.04	0.00	0.00
LAST 30 MIN	0.08	0.12	0.16	0.16	0.12	0.16	0.00	0.00
LAST 60 MIN	0.16	0.24	0.28	0.24	0.32	0.32	0.00	0.00
FOR 6 HOURS								
ENDING AT 700	0.28	0.44	0.32	0.28	0.52	0.52	0.00	0.00
FOR 24 HOURS								
ENDING AT 700	0.76	0.60	0.56	0.60	0.96	0.80	0.00	0.00
SINCE 0800								
YESTERDAY	0.80	0.68	0.64	0.68	1.04	0.96	0.00	0.00
SINCE 700	0.04	0.12	0.12	0.12	0.12	0.16	0.00	0.00
600 THRU 700	0.20	0.28	0.20	0.20	0.32	0.28	0.00	0.00
500 THRU 600	0.04	0.08	0.08	0.04	0.08	0.12	0.00	0.00
400 THRU 500	0.04	0.08	0.04	0.04	0.08	0.08	0.00	0.00
300 THRU 400	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00
200 THRU 300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SINCE 400	0.32	0.56	0.44	0.40	0.60	0.64	0.00	0.00
2200 THRU 400	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00
1600 THRU 2200	0.16	0.08	0.00	0.08	0.12	0.00	0.00	0.00
1000 THRU 1600	0.28	0.04	0.08	0.12	0.12	0.08	0.00	0.00
400 THRU 1000	0.40	0.32	0.40	0.28	0.40	0.32	0.00	0.00
2200 THRU 400	0.40	0.60	0.28	0.84	0.72	0.48	0.00	0.00
1600 THRU 2200	0.72	0.52	0.24	0.52	0.52	0.40	0.00	0.00
1000 THRU 1600	0.36	0.16	0.04	0.28	0.16	0.00	0.00	0.00
400 THRU 1000	0.44	0.32	0.12	0.32	0.40	0.28	0.00	0.00

??ENTER 11 TO OBTAIN PRECIP DISPLAY

APPENDIX E

V E N T U R A C O U N T Y F L O O D A D V I S O R Y

ISSUED AT 558 HOURS ON 2/16/80.

FORECAST PEAK FLOWS IN THOUSAND CFS RESULTING FROM PRECIPITATION FALLING AFTER 400 ON 2/16:

PRECIPITATION IN INCHES	SESPE CR NR FILLMORE	PRECIPITATION IN INCHES	SANTA PAULA CR NR SANTA PAULA
1	7.02	1	1.06
2	15.84	2	2.40
3	24.83	3	3.76
4	33.85	4	5.13
5	42.89	5	6.50

CALIBRATION EFFECTIVENESS IS LIMITED BY THE SHORTNESS OF THE OPERATIONAL PRECIPITATION RECORDS

APPENDIX F

GUIDE FOR FLOOD AND FLASH FLOOD PREPAREDNESS PLANNING

Purpose:

1. To assess the adequacy of the community's existing flood warning system and preparedness plan;

2. Decide what actions will be needed to write preparedness plans that have content and detail appropriate to the community's needs; and

3. Develop an adequate flood preparedness plan.

Scope:

To assist development of flood preparedness plans at the community level. However, coordination with flood preparedness planning at the county and state level and more detailed flood preparedness planning for specific sites are necessary.

Use:

This guide does not contain nor constitute a model plan. It identifies the range of matters to be considered and suggests procedures.

The analysis of the flood hazard should cover the sources, causes, area affected as well as who lives there and the types and severities of potential floods. The needs of the community and the flood hazard analysis determine the characteristics and capability of the warning system and the preparedness plan details the community response to the flooding.

I. Available Federal Assistance

Numerous federal agencies provide funding, technical assistance or information useful for flood preparedness planning. The following table shows those agencies having the most directly applicable programs.

Available Federal Assistance for
Flood Preparedness Plan Development

Element	Financial Assistance	Planning & Technical Assistance	Useful Information
Warning	NWS FEMA CPA	NWS USCE SCS WPRS	NWS USCE USGS SCS WPRS
Evacuation & Rescue	FEMA CPA	NWS USCE FEMA SCS	NWS USCE SCS FIA

Element	Financial Assistance	Planning & Technical Assistance	Useful Information
Evacuation & Rescue (continued)		RC ES WPRS	RC USGS PHS ES WPRS
Damage Reduction	FEMA CPA SCS	USCE SCS ES WPRS	USCE SCS USGS ES RC WPRS
Recovery	FEMA CPA SCS RC	FEMA USCE SCS RC ES WPRS	USCE SCS FEMA RC PHS ES WPRS
Public Information	FEMA CPA	NWS USCE FEMA SCS RC ES WPRS	NWS USCE SCS USGS RC PHS ES WPRS
Plan Implementation	FEMA CPA	NWS USCE FEMA SCS RC ES WPRS	NWS USCE SCS FEMA RC ES WPRS
Plan Maintenance	FEMA CPA	NWS FEMA SCS ES	NWS FEMA ES SCS

CPA - Comprehensive Planning Assistance Program (701)
ES - Extension Service
FEMA - Federal Emergency Management Administration
FIA - Flood Insurance Administration
NWS - National Weather Service
PHS - Public Health Service
RC - Red Cross and other volunteer agencies
SCS - Soil Conservation Service
USCE - United States Corps of Engineers
USGS - United States Geological Survey
WPRS - Water and Power Resources Service

II. Planning Guidance

The numerous aspects of flood preparedness plans are organized into seven elements titled Warning, Evacuation and Rescue, Damage Reduction, Recovery, Public Information, Plan Implementation and Plan Maintenance.

A. Warning Element

Objective: To define systems for early recognition of floods and dissemination of warnings which are accurate, timely and reliable.

1. Flood Recognition and Warning Dissemination

a. Select a suitable local warning point (e.g. emergency operation center, police or fire station).

b. Establish operational procedures at the warning point.

c. Establish operational procedures to be followed by river and rainfall observers.

d. Establish procedures for issuing warning.

e. Establish procedures for disseminating information concerning potential flood threats to special warning recipients.

f. Establish procedures for the dissemination of warnings to the general public.

B. Evacuation and Rescue Element

Objective: To prevent the loss of life due to flooding or to flood related causes.

1. Evacuation Area Identification

a. Identify areas which will be inundated at each potential level of flooding.

b. Identify areas which will be inundated due to internal drainage or ponding unrelated to flood height.

c. Identify areas requiring evacuation for reasons other than inundation.

2. Evacuation Procedures Development

a. Select evacuation destinations for each area to be evacuated.

b. Identify best available evacuation routes.

c. Establish priorities for evacuation.

d. Establish procedures for carrying out evacuation which are consistent with the warning time.

3. Reception Center Operations

a. Estimate the duration, damage and population affected in case of a severe flood and determine reception center requirements.

b. Select reception center(s).

c. Establish procedures for the operation of reception centers.

4. Emergency Action

a. Evaluate the areas subject to flooding or isolation with respect to the types of emergency activities which may be required.

b. Determine requirements for conducting emergency actions.

c. Establish procedures for carrying out emergency actions.

C. Damage Reduction

Objective: To reduce public and private property damages from flooding or flood related causes.

1. Flood Fighting

a. Identify needed flood fighting actions to reduce overflows, seepage and other types of flooding as well as erosion due to flood waters.

b. Establish flood fighting procedures to control overflow, seepage, or other types of flooding.

c. Establish procedures for the evacuation or temporary removal and relocation of automobiles, furniture, valuables, clothes, business and personal records, machinery and other movable property to reduce damage.

D. Utility Management

1. Establish procedures for the curtailment of utility services to flooded areas.

2. Establish utility operation procedures to be used immediately prior to and during floods.

E. Traffic Control

1. Identify needs for traffic control prior to, during and immediately after floods.

2. Establish procedures for traffic control.

F. Maintenance of Vital Services

1. Identify police, fire, medical and other vital community services and facilities.

2. Establish operational procedures for police, fire, utility repair, rescue, medical and other services prior to and during floods.

3. Establish procedures for evacuation or protection of important records and documents located in areas subject to flooding.

G. Recovery Element

Objectives: To initiate and carry out post flood actions to maintain public health, return community services to normal at the earliest possible time and to provide aid and assistance in recovery.

1. Maintenance of Public Health

a. Establish procedures for handling of dead.

b. Establish procedures for actions to preserve public health.

c. Establish procedures for actions to resume provision of utility services.

d. Establish procedures for returning to normal traffic patterns.

2. Rehabilitation and Repair

a. Establish procedures for post-flood clean-up.

b. Establish procedures for management of damaged structures.

3. Mobilization of Assistance

a. Identify the sources and programs of recovery assistance and the means of obtaining each.

b. Establish procedures for mobilizing assistance from each available source.

H. Public Information Element

Objectives: To develop community awareness and understanding of the flood hazard and to prepare for the accurate and timely provision of information during flood emergencies.

1. Community Education and Emergency Information

a. Prepare the materials for and carry out a continuing public information program including letters to residents in evacuation areas, to increase community awareness of floods and evacuation area residents' knowledge.

b. Prepare and carry out a continuing program to provide technical information to those wishing to employ temporary flood-proofing measures or needing to develop more detailed subplans for warning dissemination, evacuation, and damage reduction.

c. Identify the types of emergency information to be conveyed to the public in the period prior to, during and immediately following a flood.

d. Identify the means and procedures to be used in communicating each type of information.

e. Prepare warning announcements for use in various potential circumstances and expected flood heights.

I. Plan Implementation

Objectives: To develop the administrative arrangements necessary for effective implementation of the flood preparedness plan.

1. Resource Identification, Responsibility Allocation and Coordination

a. Identify type and amount of resources required for implementing the plan.

b. Identify the sources of personnel, equipment, supplies and facilities for implementing the plan.

c. Evaluate each aspect of plan implementation.

d. Assign responsibility for implementation of each aspect of the plan.

e. Establish procedures for coordination of local governmental actions through an emergency operations center, if available, or other mechanisms.

f. Establish necessary arrangements, including mutual aid agreements, for use of facilities, equipment and personnel, and services necessary for implementation of the plan.

g. Establish procedures to coordinate the plan fully with state and other local plans for emergency operations.

h. Establish procedures to guide and coordinate more detailed site-specific planning for warning dissemination, evacuation and damage reduction in public and private buildings.

J. Plan Maintenance

Objectives: To update, extend and improve the flood preparedness plan and to insure readiness for executing the plan.

1. Plan Updating, Plan Improvement and Plan Practice

a. Establish procedures and schedules for plan contents subject to rapid obsolescence.

b. Establish procedures for updating of plan contents based on specific events.

c. Describe needed and planned extensions of the warning system and preparedness plan.

d. Describe needed and planned refinements to the warning system and preparedness plan.

e. Establish procedures for the critical evaluation of performance in real and simulated implementation of the plan.

f. Establish procedures and schedules for testing those aspects of the flood warning system and preparedness plan which are susceptible to periodic use.

g. Establish procedures and schedules for the periodic simulation of those aspects of the warning system and preparedness plan not susceptible to direct testing.

III. Preparation of the Plan and Organization of the Planning Document

A. Effect of Warning Time

The time required to carry out various actions like warning dissemination and evacuation depends on the size, population and other characteristics of the affected area.

B. Effect of Flood Characteristics

Floods differ significantly from place to place and sometimes seasonally with respect to depth, velocity, duration, rate of rise in water levels, or other characteristics. These characteristics may individually or jointly affect the content and execution of preparedness plans.

C. Effect of Resources Availability

The ability to carry out the plan depends heavily on the resources available including people and equipment. Some tasks require a far greater input of resources for their accomplishment than do others.

D. Communications

The means by which flood warnings and other messages should be or can be communicated depend on their urgency, means available for transmission and receipt, and the content of the warning message. Multiple means of communication are generally required to reach all warning recipients and handle the variety of messages necessary.

Particular attention should be given to reliability in designing procedures and means of communication. Electrical power and telephone services frequently fail during floods. Unless telephone and power systems are adequately flood-proofed, alternative means of communication are essential.

E. Special Warning Recipients

The intended audience for flood warnings may vary depending upon the stage of warning, warning time available and general approach taken to warning dissemination. When time permits, flood potential statements to those individuals and organizations having subsequent responsibilities in warning dissemination or having special needs requiring unusual amounts of warning time can be crucial.

F. Preparation of Maps

Much of the information needed for development and implementation of flood preparedness plans is best presented in map form. Much of the needed information may, in fact, be available in map form but in various scales, coverage, and levels of detail. An effective approach to mapping increases planning efficiency considerably and should be carefully laid out when the Plan of Study is prepared.

G. Organization of the Planning Document

The criteria for effectiveness in organizing the materials comprising the preparedness plan is ready availability and convenient use in emergencies. Achieving these purposes may require preparing the materials in several forms according to their intended need.

Where short warning times put a high value on rapid reference to the planning documents, sections of the planning documents which are dependent upon considerations such as time of day or flood height can be separately prepared and indexed for each potential circumstance.

IV. Sources of Information and Assistance

Local, state and federal agencies provide a ready source of much of the information required to analyze the flood hazard and to develop warning systems and preparedness plans. Some agencies (e.g. National Weather Service) also provide technical and financial assistance for preparedness planning.

Identifying and accessing sources of information and assistance requires a determination of what is needed and where it may be available. The search should begin with those agencies and organizations most closely involved with flood preparedness planning. Usually, this includes the National Weather Service, civil defense agencies, Red Cross and others.

A. Non-federal

1. Municipal Departments

2. County Departments

3. Conservation Districts, etc.

4. Volunteer Organizations (e.g. Red Cross)

5. State Agencies

6. River Basin Commissions, etc.

B. Federal

1. Cooperative Extension Service

2. U. S. Army Corps of Engineers

3. Federal Emergency Management Agency

4. Federal Insurance Administration

5. National Weather Service
6. Office of Community Planning and Program Coordination (HUD 701)
7. Soil Conservation Service
8. U. S. Geological Survey
9. Water and Power Resources Service
10. American Red Cross (Federally chartered)