From: John Henz <henz@hmsweather.com>
To: Kevin Stewart <kstewart@udfcd.org>
Date: Wednesday, December 30, 1998 4:11 PM
Subject: Re: Annual Report due 12/31

Hope you enjoy the new format. I eliminated the hard to read tables from the report but will be happy to give you copies if you want them. The 1997 report is directed at each of your suggestions and they were 90% accepted. Have a Happy New Year! We'll have to catch that lunch early next year.
Jack
-----Original Message-----
From: Kevin Stewart <kstewart@udfcd.org>
To: Jack Henz <henz@hmsweather.com>
Date: Tuesday, December 29, 1998 11:56 AM
Subject: Annual Report due 12/31

>Will this be on time or late?
>
>
>

1998

UDCFD FLASH FLOOD PREDICTION PROGRAM ANNUAL REPORT

Henz Meteorological Services
2480 W. 26th Avenue, Suite 310B
Denver, Colorado 80211

December 1998

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1.0 Introduction

Urban Drainage & Flood Control District (UDFCD or **District**) has funded a Flash Flood Prediction Program (**F2P2**) since May 1979. The F2P2 was established as a response to the disastrous Big Thompson Flash Flood of July 31, 1976 in Larimer County. The F2P2 contracts the unique with basin-/storm-specific weather forecasts of a Private Meteorological Service (PMS) to augment the traditional forecast services of the National Weather Service (NWS) for the six county District region.

The forecast area supported is shown in **Figure 1** and includes over 60 percent of Colorado's population in a roughly 1600 square mile area. Terrain in the region varies from the rolling populated prairies of Arapahoe and Adams Counties to highly urbanized Denver County to the rugged plains-foothills-mountain interfaces of Jefferson, Boulder and Douglas Counties. The population in this area has increased 11.8 percent in the period of 1990 to 1996 and prediction service requests have increased noticeably in the past two years in Boulder, Douglas and Arapahoe Counties.

Henz Meteorological Services (HMS) of Denver was selected as the 1998 F2P2 Private Meteorological Service. HMS provided similar services for the 1990 - 1998 F2P2's. HMS forecast services were provided by **John Henz, Bryan Rappolt and Lisa Morrison**.

2.0 1998 Operational Season

The F2P2 season began on 15 April 1998 and continued through 15 September 1998 for **154 operational days**. Normal operational hours were from 0700L to 2200L and covered **2,322 hours**. During the period from 1000PM to 1200AM HMS meteorologists added an **additional 108 hours** of support time as storms in eastern Adams, eastern Arapahoe and northern Douglas Counties persisted in newly populated areas near Denver International Airport, Parker and eastern Aurora. Overnight forecasting from midnight to 700 AM added an **additional 92 hours** for a total of **2,522 hours of F2P2 activity**. The increase in operational hours past 2200 is due to population increase in eastern portions of the District in Adams, Arapahoe and Douglas Counties.

The F2P2 required a continuous **Metwatch** of the District for the entire period using the NWS WSR-88D Doppler radar, satellite, conventional surface and upper air observations and local ALERT and mesonet networks. These observations were used by HMS meteorologists to prepare in-house analyses, predictions and specialized F2P2 products. These products included daily **Heavy Precipitation Outlooks (HPO), MESSAGE 1, 2, 3 and 4's, Message updates, Quantitative Precipitation Forecasts (QPF) and Storm Traks.** The HPO's were issued at least once daily to describe the potential for heavy precipitation in each of the District counties. Messages were issued on those days when the potential of heavy rainfall capable of producing some form of flooding in the District or a portion of the District was deemed possible. QPF's and Storm Traks were issued on Message days to provide additional weather support to the F2P2 user community.

3.0 1998 F2P2 Operational Product Production

The F2P2 is designed to offer a unique, basin-specific weather information source concerning heavy precipitation, urban flooding and flash flooding threats to the six participating District Counties and the cities within those counties. Direct basin specific support is rendered to the District basin-specific warning plans identified below:

1. **Boulder Creek Warning Plan** which serves Boulder/South Boulder Creeks in Boulder County which impacts the City of Boulder.
2. **Lena Gulch Warning Plan** which serves the Lena Gulch Basin and impacts Jefferson County, Golden, Lakewood and Wheat Ridge.
3. **Goldsmith/Harvard Gulch Warning Plan** which impacts south central Denver.
4. **Westerly Creek Warning Plan** which impacts eastern Denver and western Aurora.
5. **Toll Gate Creeks Warning Plan**, which impacts central and southern Aurora.
6. **Ralston Creek Warning Plan** which impacts central Arvada.
7. **Bear Creek Warning Plan**, which impacts Jefferson County and southern Lakewood.

Five specific F2P2 products exist as expert-to-user support. These products are **Heavy Precipitation Outlooks (HPO), Messages, Internal Message Status's (IMS), Quantitative Precipitation Forecasts (QPF) and HMS Storm Trak Predictions (FAX Map).** During the 1998 season HMS delivered the following quantities of the identified F2P2 Fax Products:

Table 1 1998 F2P2 Production Summary

Product	Number issued
Heavy Precipitation Outlook (HPO)	7,402
Message Forms, Updates and Faxes	876
Internal Message Status (IMS)	1,608
Basin-Specific Quantitative Precipitation Forecasts (QPF)	222
StormTraks	3,014
Total	**13,122**

These products were delivered via fax to participating agencies. The majority of the faxes were sent on either the HMS Communications fax machine, the internal fax card on the HMS F2P2 Communications workstation or on the US West Broadcast Fax service network. Broadcast fax was used to send high impact products with a short "shelf life" such as Storm Traks and IMS's.

While fax service dominated the "hard copy" F2P2 products, significant electronic copy service was provided to the F2P2 via **the District's Electronic Bulletin Board (EBB)**. All HPO, IMS and QPF products were sent to the District EBB for either re-dissemination or dial-in customer support. HMS sent an estimated **212 HPO products, 126 IMS and 22 QPF** products through the District's EBB. The on-demand access of the EBB products to decision-makers using office and home computer systems is a desirable asset of the EBB service. HMS logged over **2,100 storm-related**

telephone interactions during the program, emphasizing the **strong technical "touch"** of the program in the local community. HMS used three dedicated telephone lines: two for voice and one for fax products. These three lines were adequate to handle the volume of communications generated during peak storm periods. User input indicates that the quality of the faxed Storm Traks has improved sufficiently to supplant event verbal "hand-holding" to some degree.

4.0 1998 F2P2 Operational Verification

The **primary service rendered by the F2P2** to participating local governments and associated emergency response agencies **is the issuance of value-added weather forecasts of flash flooding potential, urban and stream flooding, and locally heavy rainfall**. HMS indicates the potential for these events in a series of Messages issued directly to the users by phone, fax and EBB. The definition of each Message is given below in **Table 2**.

Table 2 Message Definitions used in the District Flash Flood Prediction Program (F2P2)

MESSAGE 1 (*Internal Alert*)

A Message 1 is an advisory message meant to inform key people in local emergency response community that weather conditions are such that flood producing storms could develop later in the day. It is issued after forecast discussions between HMS and National Weather Service (NWS). The advisory is preceded by the statement, " THIS IS A RED FLAG MESSAGE", when HMS deems priority handling by communications dispatchers is required.

MESSAGE 2 (*Flash Flood Watch*)

This Message indicates that a Flash Flood Watch has been issued by the NWS **and/or** HMS feels that the risk is high that a life-threatening flood may occur later in the day. This Message requires priority handling by communications dispatchers.

MESSAGE 3 (*Flash Flood Warning*)

This Message indicates that a Flash Flood Warning has been issued by the NWS **and/or** HMS feels that the risk is high that a life-threatening flood is imminent. This Message requires priority handling by communications dispatchers.

MESSAGE UPDATE

This Message is used by HMS to provide additional information to any of the above Messages on the developing weather situation. For example, this Message has been used to narrow a NWS Watch or Warning area, as more information becomes available or to provide more site-specific information during an event. If HMS feels that this Message requires priority handling by a communications dispatcher, it is preceded by the statement, " THIS IS A **RED FLAG** MESSAGE ".

MESSAGE 4 (*All Clear*)

This Message cancels the flood potential status. HMS issues it after consultation with NWS and other entities involved with direct HMS communications.

The issuance of F2P2 Messages is quantitatively linked to both the rainfall potential of the weather events and the response of the District basins to the rainfall. **Table 3** shows the criteria for Message issuance based on both the rainfall potential and the anticipated response of the District basin.

Table 3: UDFCD Flash Flood Prediction Program Message Criteria

UDFCD FLASH FLOOD PREDICTION PROGRAM
MESSAGE CRITERIA

Message 1:	Issued primarily to alert local governments to the threat of nuisance flooding of streets and low lying areas due to thunderstorm rainfall when storm total rainfall is 0.50" - 1.00" in one hour or less. When rainfall is 1.00" to < 3.00" in one to three hours, urban street and stream flooding becomes a significant problem. M-1 lead-times of >1 hour are desirable.

Message 1 Rainfall Intensity Criteria:	**Any of the forecast rainfall intensities below prompt a Message 1 issuance**
	1.00"/ 60 minutes
	0.75"/ 30 minutes
	0.50"/ 10 minutes

Message 1: RED FLAG RED FLAG Rainfall intensity:	Issued to identify storm events which fall just short of producing life-threatening rainfall but produce a significant impact on street runoff. Rainfall rates are predicted or observed to **exceed 1.00"/30** minutes **and** the storm is considered **imminent**.

Message 2:	Issued to local governments when the threat of potential life threatening flooding is predicted or the NWS issues a Flash Flood Watch. A HMS-generated M-2 is the equivalent of a Flash Flood Watch. M-2 lead-times of several hours are desirable.
M-2 Rainfall intensity criteria:	**>3.00"/hour or a lower value based on mutual discussion between NWS, District and HMS due to antecedent rainfall impacts on soil saturation and/or runoff characteristics.**

Message 3:	Issued to local governments whenever a life-threatening flash flood is imminent or the NWS issues a Flash Flood Warning. M-3's are issued in accordance with basin-specific warning plans if available or at the discretion of the meteorologist.

4.1 Message Verification

Evaluations of program performance are based on the correct prediction of the rainfall and event occurrences, which verify the criteria presented in Figure 3. An effort has been made to verify all program forecasts by these criteria. **Table 1** presents a monthly verification of all Messages issued in the 1998 F2P2. Three forms of Message verifications are presented. A **Message 1** (**M-1**) **Day** is any day a Message 1 was issued within the District. A **M-1 Day hit** refers to a day when a M-1 verifying event occurred which equaled or exceeded the rainfall criteria in **Table 3** within the County or City for which the Message was issued. Message 1's are issued to both County and City dispatch offices. The **M-1's** column refers to the total number of monthly M-1's which were issued on the M-1 days. The **M-1 hit** column refers to the number of issued M-1's which were verified by the occurrence of a heavy rainfall/flooding event, which met the M-1 criteria in **Table 3**. The **M-1 Red Flags** (RF) refers to the number of M-1's which were "Red Flagged" by HMS meteorologists as meeting the Red Flag rainfall and timing criteria listed in **Figure 3**. **M-1 RF hits** refers to the number of M-1 Red Flags, which were verified by heavy rainfall occurrence. The columns referring to Message 2 verification can be interpreted similarly.

Table 4: Monthly Message Verification for the 1998 F2P2 Operational Season

Month	M-1 Days	M-1 Day Hits	M-1's	M-1 Hits	% M-1 Hits	M-1 Red Flags	M-1 RF Hits	% RF Hits	M-2 Days	M-2 Day Hits	M-2's	M-2 Hits	% M-2 Hits
April	0	0	0	0	0	0	0	0	0	0	0	0	0
May	3	3	16	11	69	0	0	0	0	0	0	0	0
June	3	2	11	2	18	0	0	0	0	0	0	0	0
July	14	13	102	71	70	55	55	100	5	4	35	22	63
August	13	10	72	39	54	24	24	100	0	0	0	0	0
September	1	0	3	0	0	0	0	0	0	0	0	0	0
Totals	**34**	**28**	**204**	**123**	**60**	**78**	78	**100**	**5**	**14**	**35**	**22**	**63**

Message 1's were issued on a total of 34 days near the 19-year average of 35 M-1 days. The 28 observed M-1 days were near the 19-year average of 29 observed M-1 days. In addition to the 34 M1 days, 4 Message 2 (M-2) days occurred in 1998. NWS issued all 4 of the 1998 Message 2's with HMS concurrence. Message 1's were issued preceding Message 2's on 4 of the 5 M-2 days.

In 1998 60 percent of the M1's verified which was 3 percent better than the average. The 123 verified M1 events were about average for the F2P2. A M1 Red Flag was issued 78 times and verified 78 times for a 100 percent verification rate. The improvement in Red Flag (RF) verification marks the third straight year of 98 percent verification or better. In 1994 and 1995 RF verification rates were about 70 percent after three consecutive years of 90 percent or better verification.

Concern existed that RF issuance was over-stimulated by the new NWS|WSR-88D Doppler radar usage and that customer RF expectations were not being met. HMS suggests that the three years of high verification indicate this concern has been addressed and corrected.

Another notable achievement in 1998 was **improved** National Weather Service Flash Flood Watches or **Message 2 verification** in the F2P2. Five Message 2's or flash flood watches were issued in 1998 and flash flooding events were reported on four of the days. **HMS and NWS concurred on all 5 Message 2's.** A total of 22 of 35 county/city combined M-2's verified by NWS criteria for an **accuracy of 60%.** This county/city M2 accuracy level for combined concurrence/non-concurrence days is the **highest** since records have been maintained (1990) by 20 percent. This year marks the second straight year of improved flash flood watch verification.

Message 3's (***Flash Flood Warning or Flood Warning***) were issued by the National Weather Service for **2 storm events and all 4 M3's verified for a 100 percent accuracy**. Close coordination between NWS and HMS meteorologists on storm days kept both organizations "on the same page" to the public's benefit. While day-to-day coordination between HMS and NWS is minimal, very close coordination on flash flood watch days was maintained. No flash floods occurred during the 1998 F2P2 without a timely M3 issuance.

The coordination was very timely during the intense onslaught of monsoon storms from July 29 to August 1. Given the intense and frequent nature of the 1998 F2P2 season storms, anything less than close cooperation between HMS and NWS could have affected the performance of each agency. Instead, both groups benefited from each other's insight and expertise and provided outstanding support to the local populace during trying times.

4.2 County Message Verification and Service Evaluation

Each of the messages issued in the F2P2 is released to a specific county dispatcher in which the flooding potential has been forecast. Some of the Messages are issued for a portion of a county while others are issued for a specific basin supported by a Flood Detection Network (FDN). A County M-1 is verified as a **"hit"** only if a rain/flooding event meeting the M-1 criteria in Table 3 occurs in the **District portion** of that county. Verification for the City of Aurora was added to the County statistics this year. The same criteria apply for a Message issued for a basin-specific FDN. Messages are designed to support both the unique District flood warning plans associated with Flood Detection Networks (FDN) and other portions of the counties and cities in the District which do not have a FDN. Verification of each Message 1 by county provides a means of assessing the accuracy of the support given to these areas.

No **improvement** was noted in the accuracy of the County Message 1's issued during 1998 as seen in **Table 5.** Less than two-thirds **(60%)** of the **County Messages verified but no events occurred without a prior Message and no Messages were issued this year with less than 30 minutes lead-time.** Last year one event was missed and 5 events occurred with less than a 10 minute Message 1 lead-time. This result was attained at the loss of 12% in M1 accuracy from 1997.

Table 5: County M1 Verification for the 1998 F2P2 Operational Season

Month	M-1 Days	M-1 Day Hits	M-1	M-1 Hits	Cnty % Hits	Events Missed	Event< 10min Lead
April	0	0	0	0	0	0	0
May	3	3	16	11	69	0	0
June	3	2	11	2	18	0	0
July	14	13	102	71	70	0	0
August	13	10	72	39	54	0	0
September	1	0	3	0	0	0	0
Totals	**34**	**28**	204	**123**	**60**	**0**	**0**

Note: **Table 2 does not include the 11 M-2 day statistics**

The overall 1998 improvement was also evident in **Message 1-Red Flag** issuance as evidenced in **Table 6**. A **Message 1 indicates** to the user that **the potential exists for a flooding event** later during the day. A **Red Flagged Message 1 indicates that a flooding event is imminent**. In other words the RED FLAG means rapid information dissemination and response action is needed. **One hundred percent of the 1998 Message 1's Red Flagged verified compared to 99 percent in 1997**. The Red Flag verification rebound to pre-1994 levels for three straight years indicates that **users can rely on it.**

Table 6: Verification for 1998 Red Flagged Message 1's

Group	M-1's	M-1 Hits	% M-1 Hits	Red Flags	RF Hits	% RF Hits	% RF M-1's
			County				
ARAP	28	17	61	13	13	100	46
ADM	27	20	74	7	7	100	26
DUG	27	19	70	12	12	100	44
BOU	28	8	29	4	4	100	14
JEF	28	16	57	9	9	100	32
AUR	24	11	46	10	10	100	42
DEN	27	18	67	9	9	100	33
TOTAL	**189**	**107**	**57**	**64**	**64**	**100**	**32**
			FDN	PLANS			
ARV	4	4	100	4	4	100	100
LAK	7	7	100	6	6	100	100
WHT	4	4	100	4	4	100	100
TOTAL	15	15	100	14	14	100	100

5.0 Significant 1998 Storms

The 1998 F2P2 season was very different from the record setting Summer of 1997 in that fewer Message 1 days were observed and 22 percent few Message 1's were issued. The biggest change was noted in the relatively few Message days in May and June 1998. Only five M1 days were observed in those two months compared to 14 in 1997 and a 19-year average of 15 M1 days. The late start was balanced to some degree by the almost daily occurrence of storms from July 22 to August 21st. In many respects the 1998 F2P2 season resembled a storm pattern similar to the one observed during an Arizona monsoon season only six weeks shorter.

While strong storms were noted in May and June none of these storms were especially significant. The first of the nasty summer storms occurred on the night of July 8 in Jefferson and Boulder Counties between 700PM and 1000PM. Heavy rainfall was noted at Red Rocks Park from a small westward-moving storm as a gust front moved off the plains into the Jefferson County foothills. This storm was followed by a fortuitously small but intense storm in Boulder County. This storm formed over Eldorado Springs and moved northwestward slowly into the Boulder County foothills. It dropped a measured 2.76"/45 min and an estimated 5 inches of rain on portions of Eldorado Canyon State Park while doing $25,000 damage to the Windtower, Streamside and West Ridge Trails.

A savage series of monsoon storms hit almost daily from July 22 to August21. It started with a series of gust front generated storms over the Denver metro area causing rush hour slow downs from July 22-24. This surge culminated on July 25 with a 3-6 inch deluge from 500Pm until 700PM, which brought most of the metro area to a crawl. Ten Red Flags and three Flash Flood Warnings verified in this two-hour period. Most of the heaviest rainfall focussed on Denver, Douglas and Arapahoe Counties.

The next nasty period began with a 5.25"/75 min deluge in Larkspur just outside the District on July 29. The next day the Parker area was hit by **"the storm of the summer" as the Denver cyclone spun up an incredible 90-minute storm. District gauges measured an incredible 0.96"/5min and 3.11"/28 min rainfall the likes of which had previously been observed by ALERT gauges in the tropics.** Serious flash flooding occurred in Parker and surrounding areas of northeastern Douglas County. Timely Messages, Watches and warnings were issued and saved lives according to local county officials. On July 31 the Buffalo Creek drainage basin in southern Jefferson County was hit by a damaging flash flood once again. For a brief period the monsoon rested.

The monsoon resumed on August 10 by dropping an intense "pillar of water" storm over Lakewood where Bob Jarrett of USGS measured an unofficial but believable 3.26"/55 min over a small area. A particularly strong storm hit lower portions of Westerly Creek in Denver and west Aurora with 1.41"/22 min as a gust front collision developed storms right over the Westerly Creek Flood Detection Network. Daily nuisance flooding events followed until August 21. On this day the northwest corner of Elbert County was hit over the Coal Creek drainage basin by an estimated 4-7 inches of "train-echo" rainfall between 500PM and 900PM. Serious flooding developed in downstream portions of the basin in eastern portions of the District in Arapaho County. This event

and the preceding event in Parker on July 30 point out the dangers facing the population growth areas in the District.

Table 7 Notable 1998 Storm Days

July 10 On the night of July 8 in Jefferson and Boulder Counties between 700PM and 1000PM, heavy rainfall was noted at Red Rocks Park from a small westward moving storm as a gust front moved off the plains into the Jefferson County foothills. This storm was followed by a fortuitously small but intense storm in Boulder County. This storm formed over Eldorado Springs and moved northwestward slowly into the Boulder County foothills. It dropped a measured 2.76"/45 min and an estimated 5 inches of rain on portions of Eldorado Canyon State Park while doing $25,000 damage to the Windtower, Streamside and West Ridge Trails.

July 30 **The next day the Parker area was hit by "the storm of the summer" as the Denver cyclone spun up an incredible 90 minute storm. District gauges measured an incredible 0.96"/5min and 3.11"/28 min rainfall the likes of which had previously been observed by ALERT gauges in the tropics. Serious flash flooding occurred in Parker and surrounding areas of northeastern Douglas County. Timely Messages, Watches and warnings were issued and saved lives according to local county officials.**

August 10 Slow moving waves of "training" monsoon storms resumed on August 10 by dropping an intense "pillar of water" storm over Lakewood where Bob Jarrett of USGS measured an unofficial but believable 3.26"/55 min over a small area. Serious street flooding occurred

August 18 A particularly strong storm hit lower portions of Westerly Creek in Denver and west Aurora with 1.41"/22 min as a gust front collision developed storms right over the Westerly Creek Flood Detection Network. Daily nuisance flooding events followed until August 21

August 21 Rapidly forming thunderstorms formed along a convergence line in the northwest corner of Elbert County. The Coal Creek drainage basin was hit by an estimated 4-7 inches of "train-echo" rainfall between 500PM and 900PM. Serious flooding developed in downstream portions of the basin in eastern portions of the District in Arapahoe County.

These storms were the most notable of the 1998 F2P2 in the opinion of the HMS staff. It is certain that other storm days could have been included based on peak stream flows reported, intensity of attendant severe weather, vicious lightning or the potential for a major flooding event. Note the predominance of strong storms the past two years in the rapidly populating areas of the eastern District in Adams, Arapahoe and Douglas Counties. The significant increase in overnight hours the past two years has been the concern of HMS meteorologists for newly populated areas during periods of monsoonal nocturnal storms. We believe that a review of the population in newly develop subdivisions would assist forecasters in supporting these eastern areas of the District.

6.0 Concerns and Recommendations

HMS utilizes this portion of the report to identify important operational developments, operational problem areas and matters of concern, which became apparent during the operational season.

Mesonet

HMS had relied very heavily on the ERL Mesonet and the District ALERT weather stations for its ability to provide basin specific flash flood prediction. The loss of the ERL Mesonet on October 1, 1996 cast a shadow over the future of HMS forecast techniques based on the mesonet and led to a significant degradation in the short term, basin-specific forecasting capability of the F2P2 in 1997. The results of the mesonet loss on F2P2 operations were covered in a separate HMS report.

HMS meteorologists have been very pleased with continued upgrading of weather station coverage by the District during the 1998 F2P2. The addition of weather station sites in Douglas, Adams and Boulder County has vastly improved HMS capability to issue basin-specific products such as QPF and StormTraks. The Boulder weather stations were especially helpful the night of the Eldorado State Park flash flood. The addition of the Brighton weather station address partially the exposed northern flank of the District. HMS supports a weather station addition at DIA to address concerns.

Training

HMS continues to note the need for training of both dispatchers and other emergency response personnel in the understanding and utilization of F2P2 products within Flood Warning Plans and in emergency situations. HMS feels strongly that the training issue is a very necessary component of a successful flash flood warning program. Once again, HMS suggests that the District consider funding a three-month pre- operations period (PRE-OPS) from mid-January to mid-April. The PRE-OPS could have the following objectives:

1. **Provide direct person-to-person contact between dispatchers and decision-makers and HMS meteorologists to discuss communications and decision-making issues.**

2. **Exercise existing flood warning plans, and making suggestions on how they can be improved.**

HMS meteorologists have not visited the supported agencies en-masse for several years and planned F2P2 user days and Media F2P2 days have been poorly attended. HMS feels that the personal contact is needed to keep emergency response agencies motivated and able to respond in case of a major urban or foothills flash flood. Additionally HMS recommends that exercises based on the Fort Collins and Big Thompson events should be developed for the urban and foothills areas respectively.

Flood Warning Plans

HMS suggests that the District consider assisting local communities without flood detection networks to develop and exercise community-specific flood warning response plans. The need would appear most acute in the Jefferson and Boulder County foothills where many new communities are developing. Additional need areas are located in rapidly developing and previously rural land around DIA and in unincorporated portions of Douglas, Arapahoe and Adams Counties.

Recommendations

HMS offers the following recommendations for consideration by the District in 1998:

1. **HMS recommends that the District consider funding a pre-operational period (PRE-OPS) which enhances user training and exercises flood warning plans.**

2. **HMS recommends that the District consider the development of flood warning response plans for urban and foothills areas of Jefferson, Douglas, Boulder, Adams and Arapahoe Counties where rapidly growing communities have formed and flood detection networks and flood warning plans do not yet exist.**

3. **HMS recommends the continued effort to expand the District ALERT Mesonet to assist in the production of basin-specific Message, StormTrak and QPF products.**