

**2004
URBAN DRAINAGE AND FLOOD
CONTROL DISTRICT FLASH FLOOD
PREDICTION PROGRAM ANNUAL
REPORT**



Photo of car overtaken by a combination of rain and hail on June 8th, 2004
in the Denver West area of Lakewood. Image courtesy of KUSA-TV Channel 9, Denver.

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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 District contracts the unique, basin/storm-specific weather prediction services of a Private Meteorological Service (PMS) to augment the traditional forecast and warning services of the National Weather Service (NWS) for the seven-county District area.

The District is outlined in Figure 1 and includes over 60 percent of Colorado's population. The forecast area of responsibility includes the actual District in addition to drainage basins that flow into the District, which are primarily to the west and south of the area. The District is approximately 1,600 square miles and the forecast area is about 3,000 square miles that includes the upper basins of streams that flow into the District. Terrain in the forecast area varies from the rolling populated prairies of Arapahoe, Adams and Broomfield 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 dramatically over the last few years with most notable increases occurring within the city of Aurora and Douglas County. Douglas County has been one of the fastest growing counties in the United States over the last ten years.

HDR Hydro-Meteorological Services of Denver was selected as the 2004 F2P2 PMS. HDR operational meteorologists Robert Rahrs, John Henz, Bryan Rappolt and William Badini provided the F2P2 forecast services with the assistance of Junior Meteorologist, Daniel Henz. William Badini acted as Project Manager with Bryan Rappolt and John Henz providing quality control and quality assurance on F2P2 products. Mr. Rappolt and Mr. Henz also provided guidance to the on-duty operational meteorologist, based on their vast experience with the F2P2.

This season marked the 3rd for Robert Rahrs working within the F2P2. William Badini worked his 6th while Daniel Henz operated in his 4th as a member of the program with the first three as a Meteorological Technician but, this year the combination of his experience and the completion of his technical coursework in Atmospheric Sciences at the University of Arizona allowed him to participate as a Junior Meteorologist. This role allowed for him to perform independent analyses and forecast production of Heavy Precipitation Outlooks (HPO) under the direct supervision of another HDR meteorologist. Daniel's participation was primarily conducted between May 15th and August 15th, which is the 'peak season' for heavy rain events in the area. John Henz's participation in the program this season marked his 26th year being involved with the F2P2 along with Bryan Rappolt's 13th.

2.0 2004 Operational Season

The 2004 F2P2 season began on April 15th and concluded on September 15th for a total of 154 operational days. Normal operational hours were defined as from 700 AM to 1000 PM. A handful of days required active monitoring and support of the program outside of this timeframe during the course of the season, however this is typical for the history of the program.

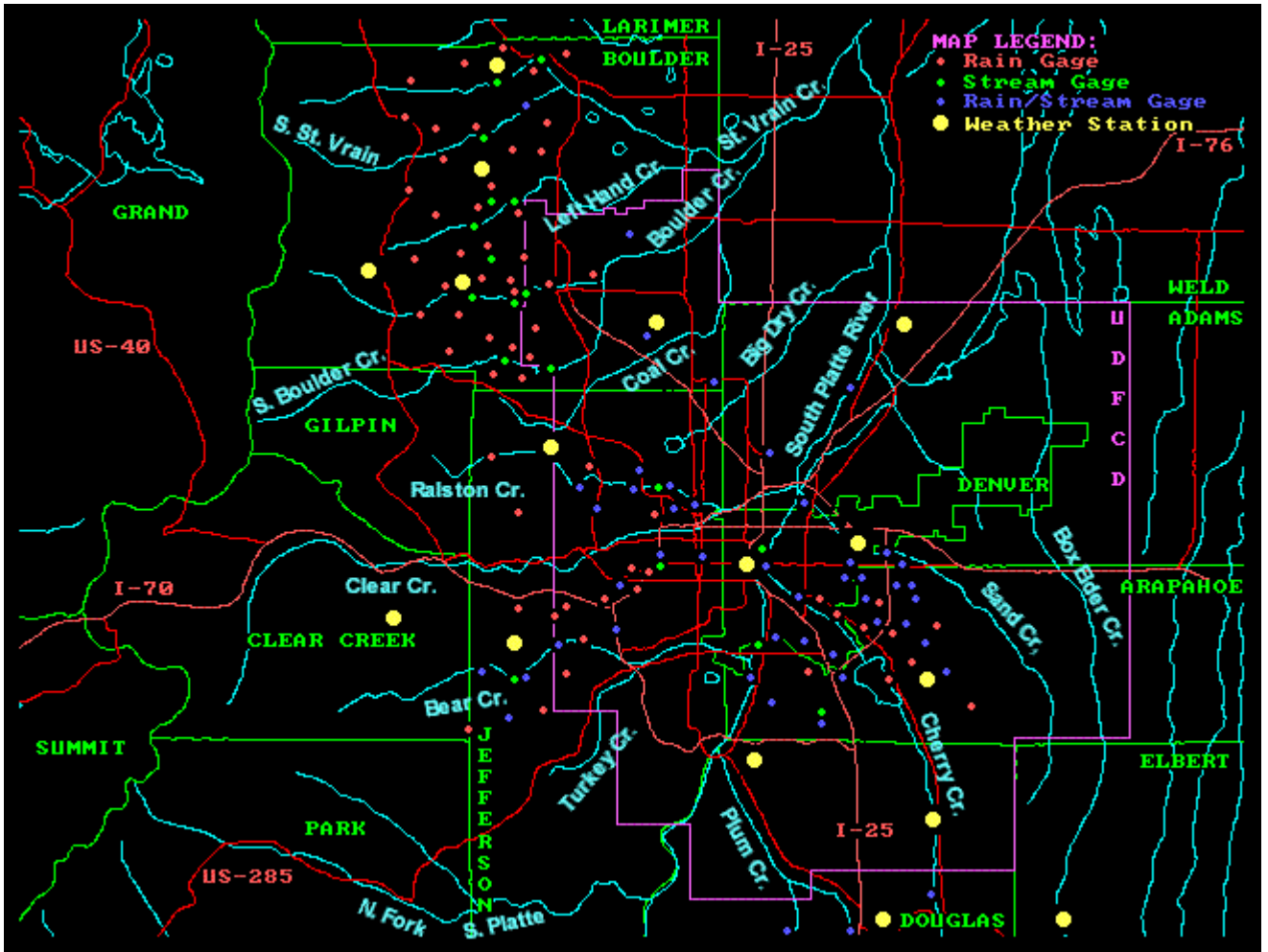


Figure 1. The UDFCD and the flood detection network.

3.0 2004 F2P2 Operational Products

The F2P2 provides a unique, urban flooding and flash flooding prediction and warning service to the seven District counties and the cities and towns within those counties and inside of the District. Direct support is rendered to the District basin-specific flood warning plans identified below:

Boulder Creek Flood Warning Plan, which serves Boulder/South Boulder Creeks in Boulder County, which impacts the City of Boulder and portions of un-incorporated Boulder County.

Lena Gulch Flood Warning Plan, which serves the Lena Gulch basin and impacts Jefferson County, Golden, Lakewood and Wheat Ridge.

Goldsmith/Harvard Gulch Flood Warning Plan which serves south-central Denver.

Westerly Creek Flood Warning Plan, which serves eastern Denver and western Aurora.

Toll Gate Creek Flood Warning Plan, which serves central and southern Aurora.

Ralston Creek Flood Warning Plan, which serves Arvada and Jefferson County.

Bear Creek Flood Warning Plan, which impacts western Lakewood, the Town of Morrison and portions of central Jefferson County.

Five specific F2P2 products were produced within the F2P2. These products included the Heavy Precipitation Outlook (HPO), Messages (1-4), Internal Message Status (IMS), Quantitative Precipitation Forecasts (QPF) and StormTrak. During the 2004 F2P2 season HDR produced the following number of F2P2 products:

Table 1: 2004 F2P2 Product Summary

Product	Number issued
Heavy Precipitation Outlook (HPO)	193
Message and Message Updates	444
Internal Message Status (IMS) reports	62
Basin-Specific Quantitative Precipitation Forecasts	32
StormTraks	45
Total	776

All products were delivered to F2P2 participants using Xpedite Internet-based broadcast fax and new e-mail dissemination service. A majority of these products were also uploaded and available from UDFCD's ALERT web site, <http://alert.udfcd.org>. Message forms were the only F2P2 product not available on the UDFCD's ALERT web site due to the fact that Messages (internal alerts) are only intended to be utilized by F2P2 participants and are not intended for the public.

Voice communication continues to be the primary form of communication within the F2P2. Four hundred sixty-two (**462**) telephone interactions were logged by HDR, between HDR meteorologists/meteorological technicians and F2P2 participants. This statistic indicates that verbal communications remains a key component of the F2P2 to ensure proper communications of products and maintaining a 'personal touch' to the program.

Denver Office of Emergency Management and Denver Wastewater received notification of the issuance of Messages and StormTraks through pagers. InfoRad software was used to disseminate the text information to the pagers. There were a total of 101 information disseminations to the Denver F2P2 pager network.

4.0 2004 F2P2 Operational Verification

The primary service rendered by the F2P2 to participants is the issuance of forecasts and warnings of flash flooding potential, urban and stream flooding, and locally heavy rainfall events that cause nuisance flooding. HDR indicates the potential for these events in a series of products issued directly to the users by phone, fax and Internet.

The definition and criteria associated with each Message is given in Table 2. This criteria is essentially unchanged from the criteria of the program from recent seasons.

The issuance of F2P2 Messages is quantitatively linked to rainfall criteria established by the District.

Table 2: UDFCD Flash Flood Prediction Program Message Criteria

**UDFCD FLASH FLOOD PREDICTION PROGRAM
MESSAGE CRITERIA**

Message 1: (M-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 significant. 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	Issued to identify storm events, which fall just short of producing life-threatening rainfall, but produce significant runoff.
RED FLAG Rainfall intensity:	Rainfall rates are predicted or observed to equal or exceed Message 1 criteria and the storm is considered imminent. <i>(This criteria was changed during this seasons to ANY event that may produce a Message-level rainfall.)</i>
Message 2: (M-2)	Issued when the threat of potential life threatening flooding is predicted or the NWS issues a Flash Flood Watch. An HDR-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 HDR due to antecedent rainfall impacts on soil saturation and/or runoff characteristics.
Message 3: (M-3)	Issued when 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.
Message 4: (M-4)	Issued when the flooding threat has passed.

4.1 2004 F2P2 Message Day, Count and Verification

The verification of the Messages issued by HDR meteorologists is presented in Table 3. A Message day is defined as any day from April 15 to September 15, 2004 on which a Message 1, Message 2 or Message 3 is issued based on the criteria presented in Table

2. Messages were issues on **31** days during the 2004 F2P2. There were **20** days, of the 31 that Message-level rainfall verified, based on the established criteria listed in Table 2. The result was a **65%** verification of messages days on a District-impacted basis.

Table 3: Monthly Message Verification for the 2004 F2P2 Operational Season

Month	Message Days	Message Days Verified	% Verified	County Messages Issued	County Messages Verified
April	N/A	N/A	N/A	N/A	N/A
May	2	0	0%	6	0
June	10	5	50%	64	16
July	10	8	80%	53	36
August	8	5	62%	46	20
September	1	1	100%	7	2
Total	31	20	65%	176	74

Message 1's were issued on 25 days during the 2004 season. In terms of the 31 total Message days, this number is slightly below the long-term average of 35 Message Days during the 26-year history of the F2P2 and ranks as being tied for 15th (out of 26) in terms of the number of Message days during the program.

In terms of Message 2 days, there were 8 days on which Message 2's were issued for either the entire District or portions of the District during the 2004 operational season. This is above normal number when compared to the long-term average of 4. In addition, there were 5 days in which Message 3's were issued for the District which is greater than the long-term average of 2.5.

4.2 County Message Verification and Comparison Statistics

Each Message issued in the F2P2 is disseminated to a specific county or to the City of Aurora in which flooding potential has been forecast. For the purposes of verification, Messages will be verified on only a county-by-county basis given the size and multi-county jurisdiction of Aurora. These counties are listed in Table 4. A Message 1 or 2 indicates to the user that the potential exists for a flooding event later during the day.

A county Message is verified as a "hit" only if a rainfall event meeting the Message criteria in Table 2 occurs in the District-portion of that city/county or in the drainage area of a stream that flows into the District. Table 4 below summarizes the results of the 2004 F2P2 verification by jurisdiction.

On a county-by-county basis, the percentage of verifying hits varied from 62% in Arapahoe County to 15% in Broomfield County. It should be noted that the advent of Broomfield County in 2001, created a fairly small county from a spatial standpoint in terms of forecasting. If one takes out the statistics for Broomfield County in this county cumulative verification, then the cumulative county 'hit' ratio increases to 47% from 44%. Over the previous 25 years of the F2P2, the average verification rate has been 55%, or

8% better than this years' program. The other 6 District counties with territory inside of the UDFCD have been well established since the programs inception and have adequate to excellent coverage of precipitation reporting stations from both the ALERT (Automated Local Evaluation in Real Time) and CoCoRaHS (Community Collaborative Rain and Hail Study) observers. The ALERT system is operated by the UDFCD and the CoCoRaHS is a network of volunteers taking daily precipitation observations coordinated by Colorado State University.

Table 4: County Message Verification for the 2004 F2P2 Operational Season

Primary Contacts	Messages Issued	Message Hits	% Message Hits	Events Missed	Event < 10min Lead Time
Adams	27	9	45	0	0
Arapahoe	29	16	62	0	1
Boulder	22	10	26	0	0
Broomfield	20	5	15	0	0
Denver	27	10	48	0	0
Douglas	27	14	61	0	0
Jefferson	24	14	56	0	0
TOTAL	176	78	44%	0	1

Here is a sampling of how the 2004 F2P2 season ranks against the prior 25 F2P2 seasons:

1. **Tied for 15th with respect to the number of message days that occurred.**
2. **Above average number of Message 2's and National Weather Service Flash Flood Watches (8).**
3. **Above average number of Message 3's and National Weather Service Flash Flood Warnings (5).**

Appendix A contains all of the county-by-county Message issuances and the verification of those Messages. Message statistics for all 26 F2P2 seasons can be found in a table located in Appendix B.

5.0 Synopsis: 2004 Season

The 2004 spring and summer could be best described as a relatively quiet one to start off as there were only two (2) Message days from the start of the program until June 7. This is generally a very dry period for the Denver area, as there were only two storms

events during the April 15 - June 7 period in which there was 'storm total' precipitation amounts in excess of 1.00". This coincided with the overall trend of below normal precipitation across the area for the period and a continuation of the general drought conditions that has affected the area since 2000.

However, beginning with the initial verified Message day of June 8th and onward through late August, the summer portion of the F2P2 would make a dramatic shift in terms of total accumulated precipitation and the number of heavy rainfall events across the area. However, unlike some other wet summertime periods along the Front Range, the primary source of moisture for many of these storms was not directly attributed to our traditional 'monsoon' season where robust mid-level moisture flows directly into Eastern Colorado from the sub-tropics. The Front Range's traditional monsoon season was quite limited as many of the real robust rain events, to be highlighted below, were a combination of 'Pacific' storm systems and events triggered by 'upslope' winds, transporting moist air with origins primarily from the Great Plains rather than the direct transport of moisture from the Gulf of Mexico/Southern Great Plains. The months of June, July, August and September resulted in above normal precipitation at the official Denver recording station at Denver International Airport. This was the first time since 1995 that four (4) consecutive months has registered above normal precipitation and the first time since 1999 that the months of June, July and August had been above normal in terms of precipitation. A brief explanation of this 'pattern' could be shown by Figure 2 (below) which depicts the departure from normal of the 500 millibar height pattern (approximately 18,000' above sea level) for the period from June 8th – August 31st. This figure essentially depicts the long-term departure of the jet-stream from it's long-term average position for this time of year.

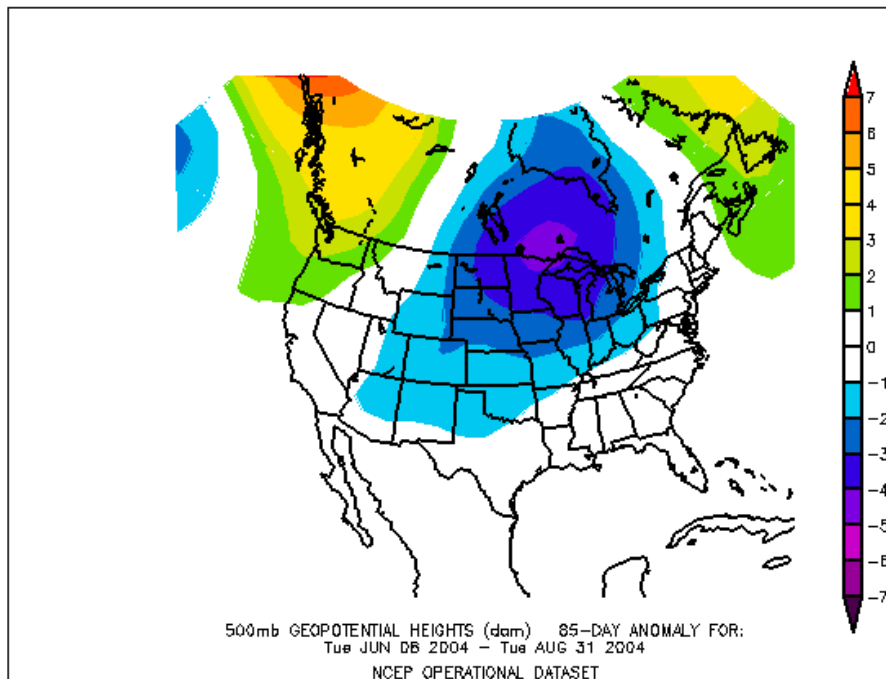


Figure 2. Long-term departure of the 500-Millibar geopotential height pattern from normal for the period of June 8th, through August 31st, 2004. Image courtesy of the NOAA Climate Diagnostics Center.

This multi-day average shows how persistent and strong areas of upper-level low-pressure moved through the north-central U.S.. When this pattern occurs, it is quite common to have persistent and strong surface high-pressure in the Upper Great Plains. Surface high-pressure in the Upper Great Plains frequently results in upslope (easterly) winds in Eastern Colorado. The strength and duration of the monsoon this season was notably repressed as the mid-level flow across the Southwestern US rarely occurred. As a side note, upslope conditions along the Front Range are commonly associated with cooler-than-normal temperatures. This in fact was the case this summer as the official average temperature in Denver for the June-August period was the second coolest value since at least 1948.

5.1 Message 2/Message 3 Days

Given the importance of the threat of flash flooding as a focal point of the F2P2, a detailed account of days when Message 2's and primarily Message 3s' were issued is provided below. Each Message 3 day has a synopsis of the meteorological conditions that occurred and a general description of HDR operations for that day. The first section describes the conditions for days when Message 2's were issued. There was only one (1) day when Message 2 and Message 3's were both issues (August 18th).

5.1.1 Message 2 Days

The 2004 F2P2 was very active in terms of flooding potential in the District. A very high number of Message 2 days were in effect this season. Some of this potential was due to the above average days where robust moisture content was provided from 'upslope' conditions rather than true subtropical monsoonal moisture being brought into the region from the southwest. Another exacerbating factor in Message 2 issuances was on days when Message 1 level rainfall was expected but, due to heavy rainfall from storms in prior days, antecedent moisture content was relatively high. These conditions did contribute to an effective lowering of thresholds that may have otherwise necessitated Message 1 status. The days where Message 2's were issued were June, 28th, 29th, and 30th, July 15th-16th, July 22nd and August 5th and 18th.

5.1.2 Message 3 Days

On five (5) days Message 3's (Flash Flood Warnings) were issued by HDR and the National Weather Service (respectively) during the 2004 operational season. These days were on Tuesday, June 8th, Sunday June 27th, Friday July 23rd, Wednesday August 4th and Wednesday August 18th. The events will be detailed in the section below.

June 8th:

In summary, the large-scale weather pattern that established itself up over eastern Colorado was typical of the conditions described in the Synopsis section above as a modest cold-frontal boundary had passed through the area in the early morning hours. This feature introduced a broad area on east-to-northeasterly winds across the District and a subsequent increase in low-level moisture. The challenge early on this day was determining if the level of low-level moisture and warmth were sufficient to develop into thunderstorm activity given that there was relatively warm air present at mid-levels in the region which could suppress activity. The combination of increasing moisture and an approaching upper-level disturbance from the south led to the issuance of Message 1's at 4:30 PM. All conditions indicated that approximately 1.5" of rain in 30 minutes was

possible at that time. Around 6:00-6:30 PM a cluster of storms developed across Douglas County and moved slowly northward. Around 8:00 PM a large cluster of storms began to develop along the plains-foothills interface of Jefferson County. Over the next 60-90 minutes, these storms produced a very localized area of heavy rain with totals near 3" concentrated in the Lena Gulch basin. Figure 3 (below) shows how localized the heaviest rain was distributed. As a result of the intense rain rates detected by the Lena Gulch ALERT network the National Weather Service issued a Flash Flood Warning at approximately 8:45 PM after which HDR promptly issued a Message 3. The intense rains and their effects were worsened by the impacts of hail, especially in the Denver West area of Lakewood. The impact of hail on drainage helped to create quite a quagmire in the area as a number of car rescues were reported. A somewhat surprising 'side effect' of this event was the relative misplacement of the heaviest portion of the core rainfall analyzed by the Storm Total Precipitation (STP) product by the NWS-KFTG radar that placed the storm precipitation 'core' further to the north of the measure rainfall amounts. The actual cause of this misplacement by the STP is still under investigation.

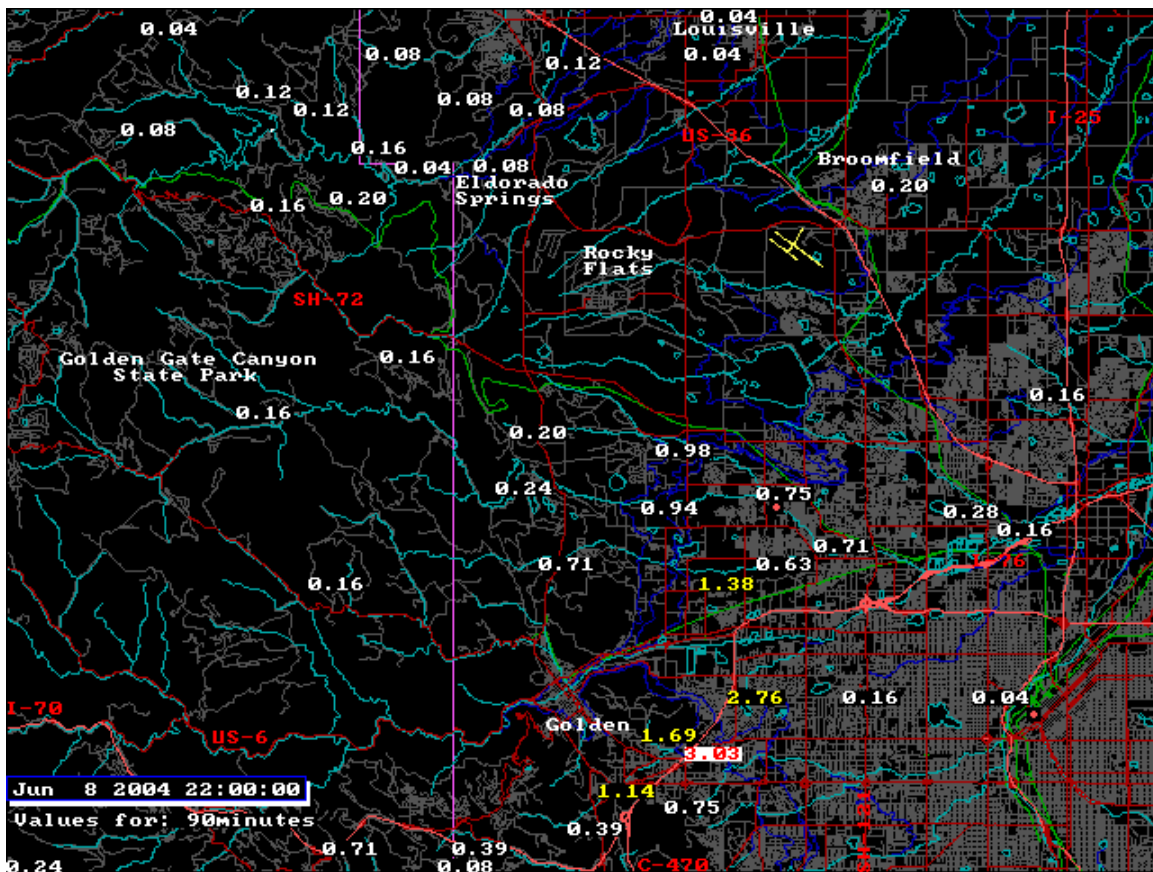


Figure 3. Precipitation recorded by ALERT gauges from 830PM to 1000PM on June 8th, 2004

June 27th: (Message 3)

A primary meteorological cause of this event was anchored around the passage of a cold-frontal boundary draped across Southeastern Colorado during the morning

hours. A typical increase in low-level moisture and strengthening of easterly low-level winds put the components in place for a threat of heavy rainfall with an emphasis on the foothills/plains interface portions of the District. An additional concern for the day was that mid-level winds were forecast to be relatively light which could have led to slower movement of developed storms. Message 1 was issued for the entire District at 12:30 PM given that atmospheric conditions were deemed capable of producing up to 2" of rain in a 30-45 minute period. Between 2:00 and 3:00 PM 'sluggish' daytime warming (temperatures at best approaching the 70 F mark) and a gradual shift of low-level winds to a more east-northeasterly direction helped to generate a line of thunderstorms that were oriented immediately along the foothill/plains interface of Jefferson and Douglas Counties. The sluggish movement of these storms and the effective 'double peaking' of localized cells led to the development of 3" to 4" of rain in a 90-120 minute period in the City of Golden and the Ken Caryl Ranch area. Around 4:00 PM, the NWS issued a Flash Flood Warning (Message 3's) for areas in Jefferson and Douglas Counties. HDR did not initially concur with this warning but, per protocol issued a Message 3, this was primarily spurred by ground truthing of the ALERT system which indicated that storm total amounts were under 2.00". Peak estimates of rainfall produced by the STP product were somewhat reasonable in terms of amounts and by location. The impacts of this event were impressive as evidenced by media coverage of flooding along Massey Draw in Jefferson County and in localized areas in the City of Golden as both locations experienced some flooding of residential structures. A second cluster of storms eventually formed in eastern Boulder Co. with resultant precipitation amounts in the 1.50"-2.25" in the Layfayette area (see Figure 4.)

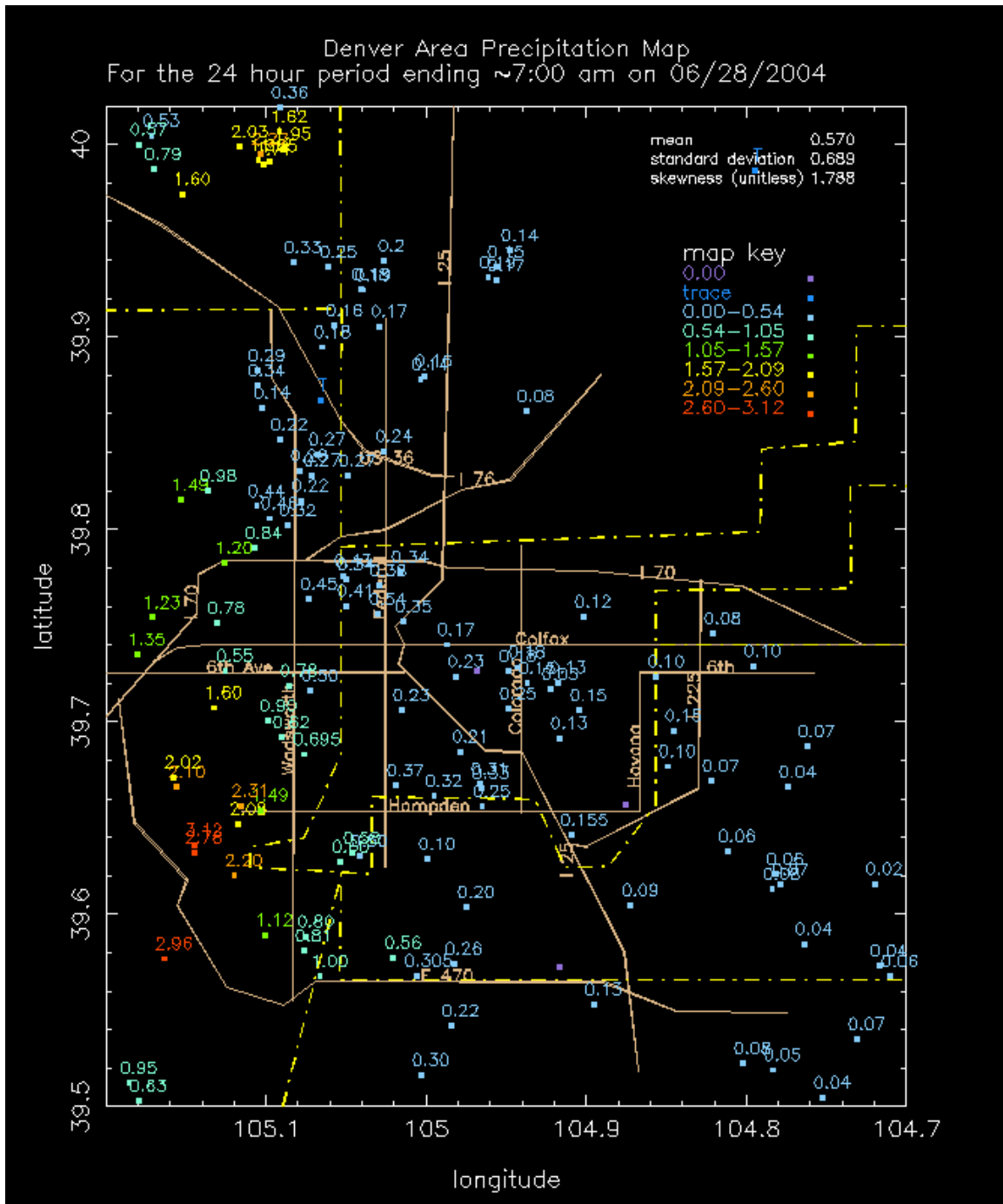


Figure 4. CoCoRaHS 24-hour total rainfall (i.e. storm totals) from ~700 AM to ~700 AM ending June 27th, 2004.

July 23rd: (Message 3)

A extremely moist atmosphere for Eastern Colorado was in place on this morning, partially in response to thunderstorm activity in the area from the night before. The morning analysis also indicated that weak upslope conditions were in place across Eastern Colorado and that a Denver Cyclone was possible later in the day. A final and important ingredient was that upper-level winds were fairly strong which helped to

introduce, a series of upper-level disturbances through the area later in the day. As the early afternoon hours approached storms began to form across Boulder, Broomfield and Adams Counties around 1:00 PM with amounts reaching up to 2" to 2.25" during this period. A second cluster of storms began to form in Aurora along the eastern portions of the Denver Cyclone and these storms also developed a wide swath of 1"-2" of rain in 45-60 minutes (see Figure 5). A second area of thunderstorms formed in the vicinity of the first wave of storms in Broomfield and Adams Counties around 2:30 PM. As a result of this second wave, the NWS issued a Flash Flood Warning for this area and HDR also issued a Message 3 very shortly thereafter. Storm total amounts, between the two 'waves' were in the 2.7" to 3.5" range in portions of extreme Northeastern Jefferson, Broomfield and Western Adams Counties (see Figure 6). In terms of actual flooding, there were sporadic reports of some residential flooding in the Thornton/Northglenn areas and notable flooding of the intersection of 84th and Grant in Thornton. Personal acquaintances reported that there was severe damage of sand volleyball courts in the vicinity of this area and that a major portion of the sand in those courts had actually been washed into the parking lot and needed notable repairs. Some flooding of Sand Creek was reported by Arapahoe County and this flooding persisted well into the evening hours.

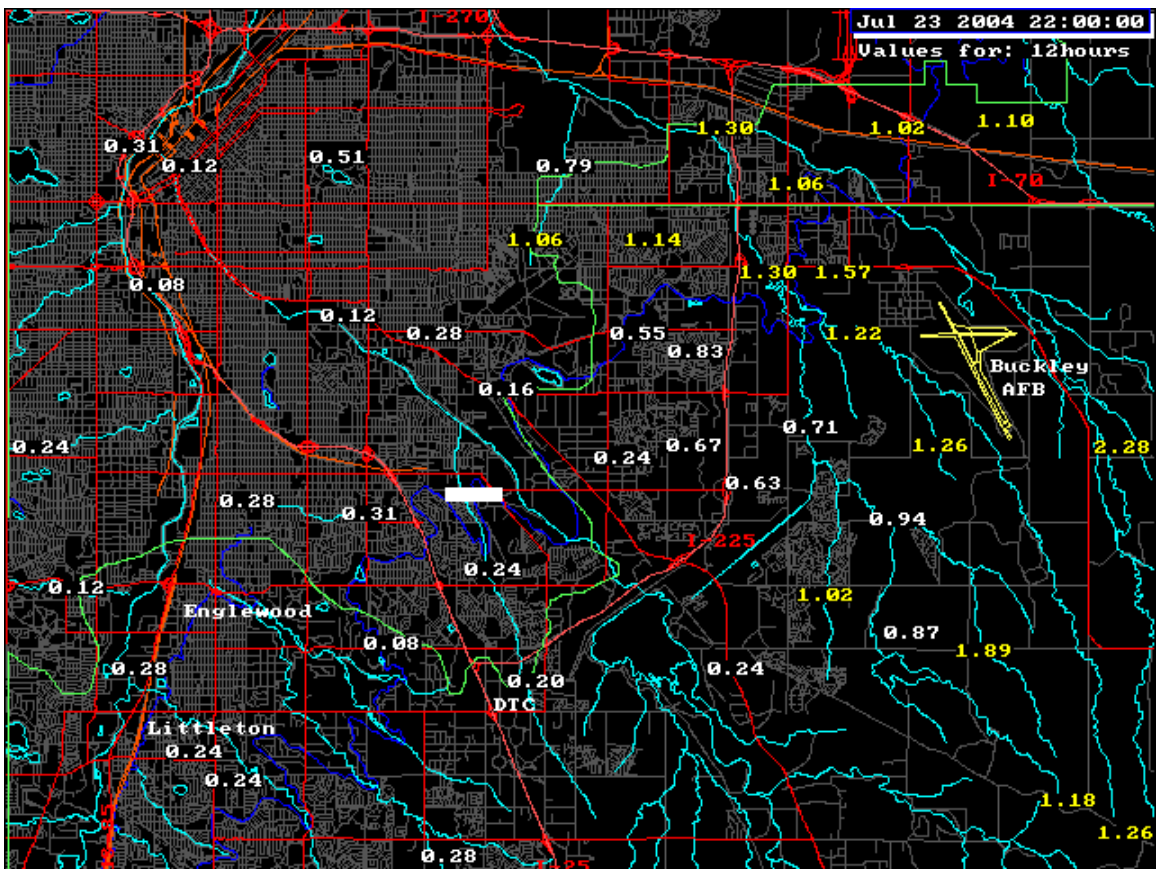


Figure 5. ALERT storm total rainfall for SE Denver/Aurora for July 23rd, 2004 (Period is from 1000 AM to 1000 PM).

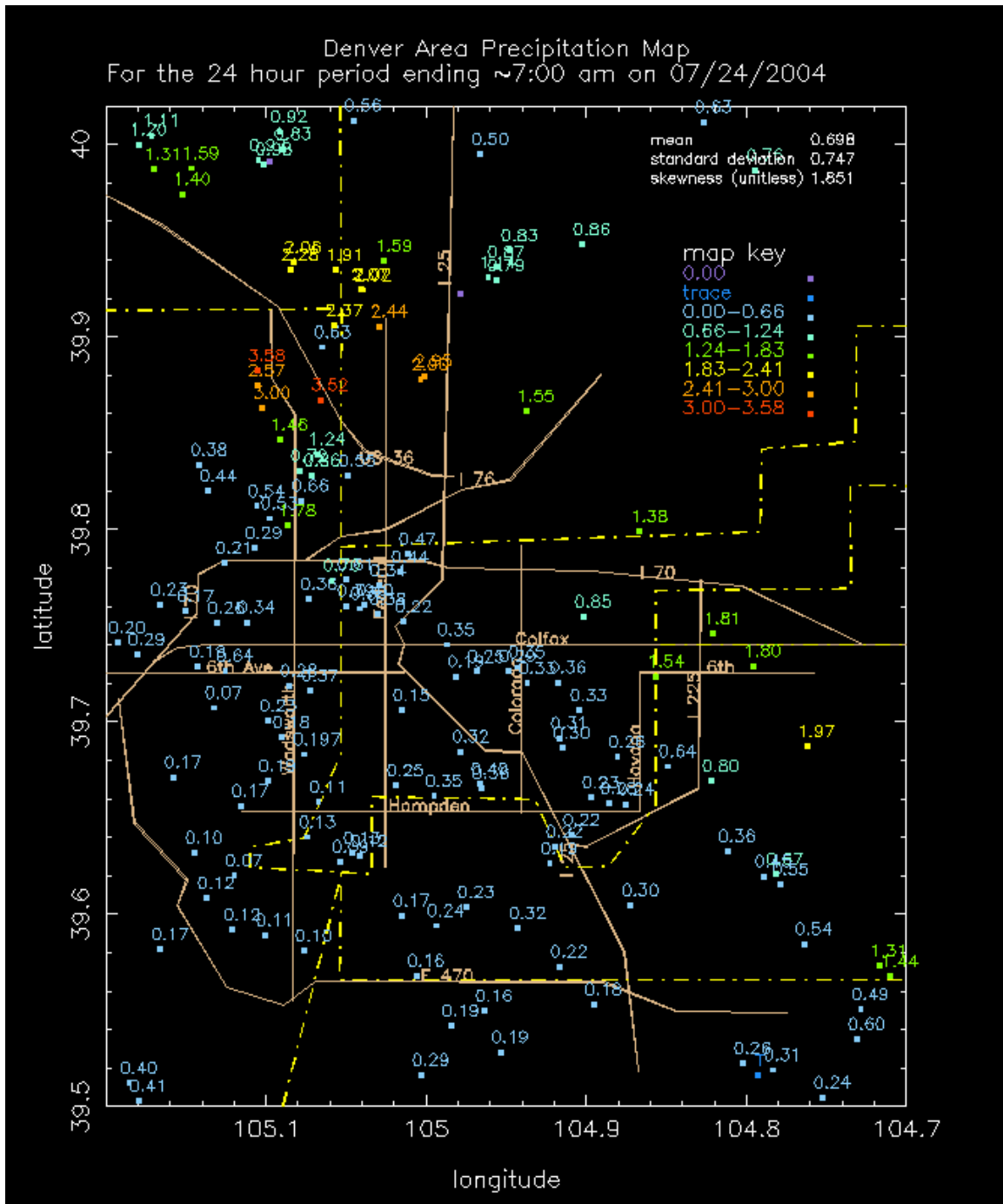


Figure 6. CoCoRaHS storm total rainfall for the Denver area for the 24-hour period of 700 AM to 700 AM ending July 24th, 2004.

August 18th: (Message 2 and 3)

In what could easily be considered the ‘main event’ of the 2004 F2P2 operational season, a very widespread area of heavy rainfall resulted in some very impressive flows in the South Platte River and some of the east bank tributaries. A main contributor of this event was, once again, a modest cold frontal boundary that crossed Eastern Colorado during the morning hours. The increase in low-level moisture in concert with

relatively weak upper level winds and a well defined Pacific-based storm disturbance made the decision to issue a Message 2 (Flash Flood Watch) for the District a prudent decision. By mid-afternoon, strong thunderstorms began to develop across the foothills of Jefferson and Boulder Counties. Around 3:00-3:30 PM the strongest line of storms began to develop across the central portions of the District. The NWS and HDR issued Flash Flood Warning/Message 3 for Denver, Jefferson, Arapahoe and Douglas Counties. The heaviest rainfall amounts were generally in the City/County of Denver most notably at the ALERT gage at the Denver Zoo where ~3" of rain fell in 2 hours with a very impressive total of 4.84" in 6 hours. Storm total amounts in terms of peak amounts and the spatial coverage of 2" and 3" amounts help to explain the high flows that occurred in the South Platte River and in Cherry Creek and Sand Creek. This activity was persistent until after the midnight hour when the widespread moderate rains finally subsided. The rainfall totals from this event can be simply viewed in the following figures (7 and 8). However, high flows across the South Platte River persisted through the night.

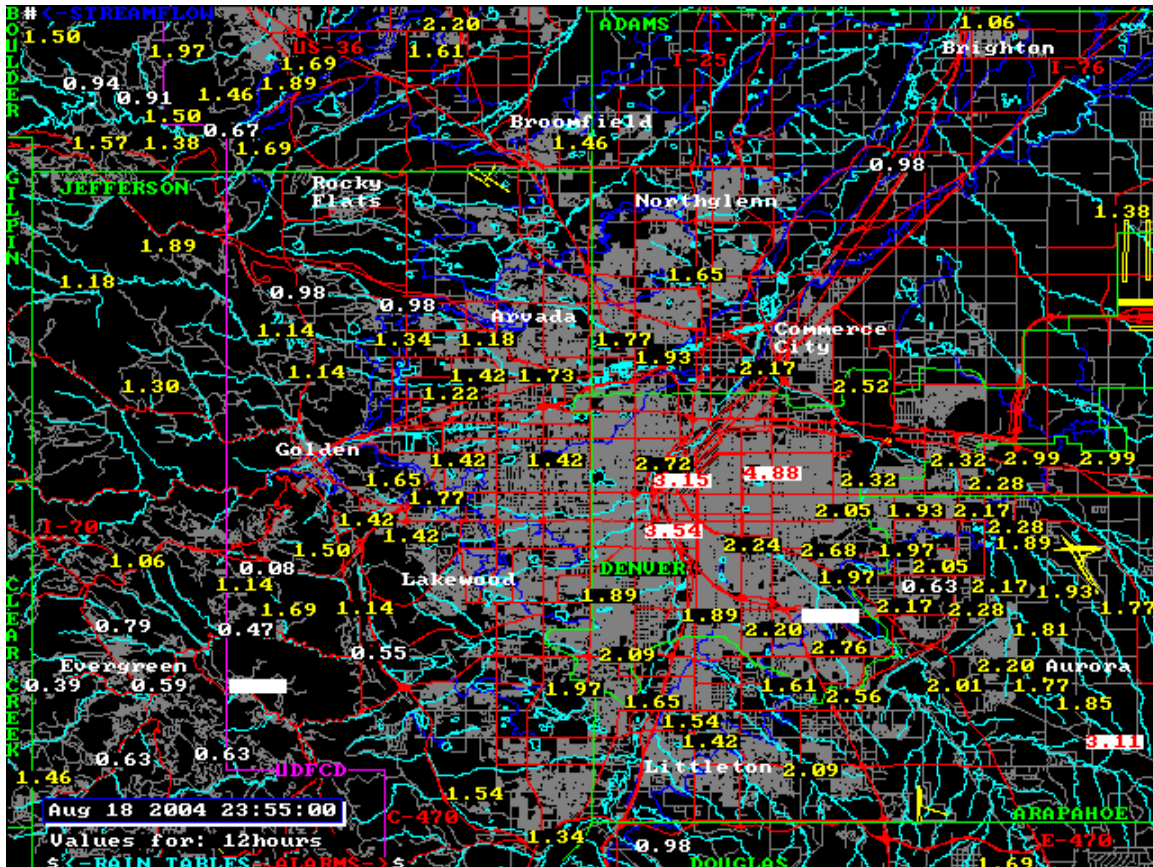


Figure 7. ALERT 12-hour rainfall total from 11:55 AM until 11:55 PM on August 18th, 2004.

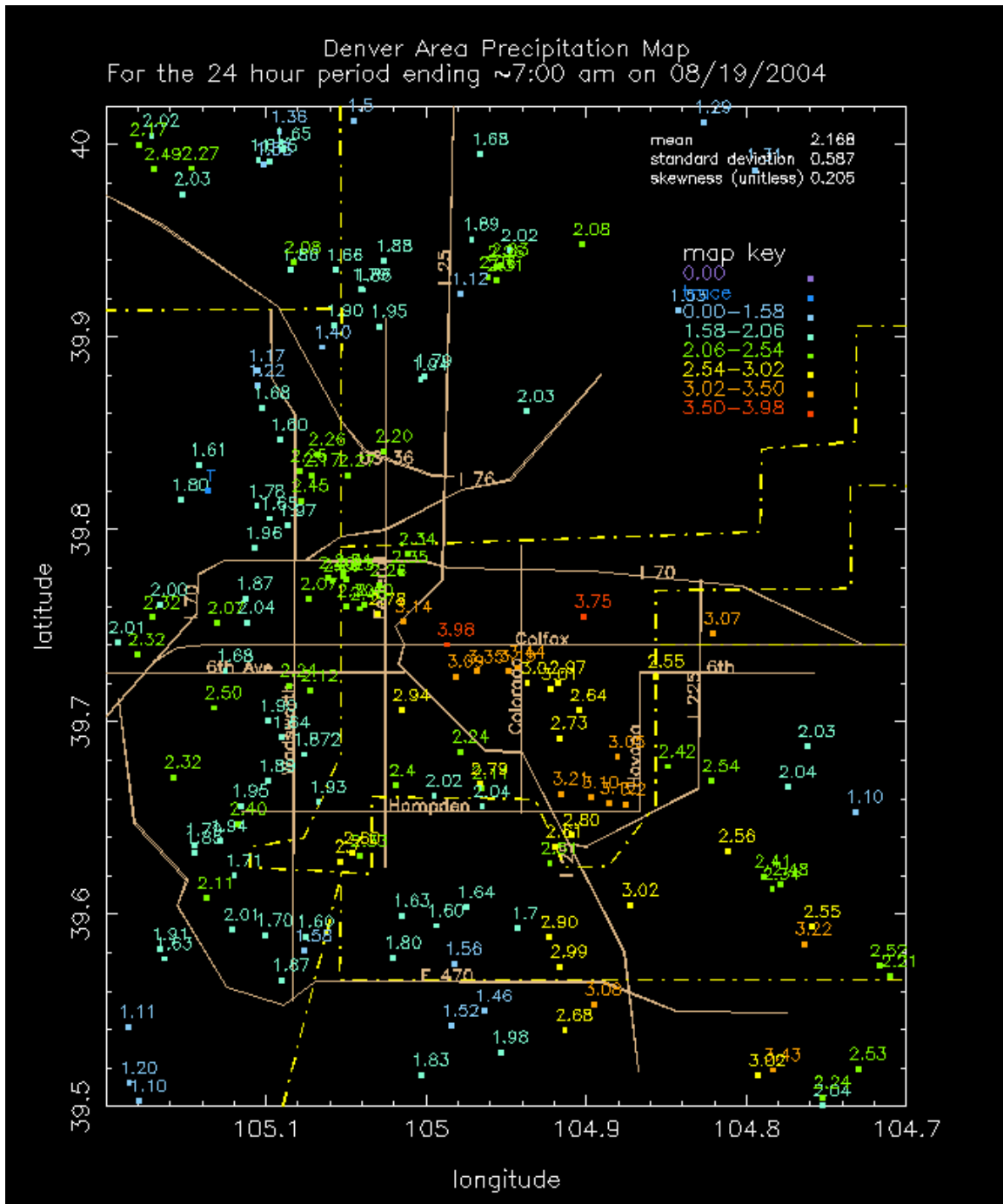


Figure 8. CoCoRaHS 24-hour rainfall total from 7:00 AM until 7:00 AM ending on 7AM August 19th, 2004.

August 4th: (Message 3)

A notable low-level boundary formed along the southeastern boundary of the District this day separating relatively dry surface air from a more moist airmass with dewpoints in the low-to-middle 50's. This situation necessitated the issuance of Message 1's earlier in the day. A cluster of storms formed late in the afternoon near this boundary. Around 4:30 PM one of these storms briefly stalled over north-central Douglas County and the

National Weather Service issued a Flash Flood Warning for this area. HDR promptly issued a Message 3. Verified rainfall totals from this complex of storms generally ranged from 1.25" to 2.00" in Douglas and Elbert Counties as these storms gradually weakened over a 90 minute period.

5.2 Significant Storms of 2004

The five most significant "storm events" in the 2004 F2P2 are listed below in the order of severity of impact in the District:

1) August 18th: Please see section 5.1.2 above.

2) June 27th: Please see section 5.1.2 above.

3) June 8th: Please see section 5.1.2 above

4) July 23rd: Please see section 5.1.2 above

5) July 16th:

An extremely moist low-level atmosphere greeted the District on this morning thanks in large part to a touch of 're-circulated' mid-level moisture that could be identified as monsoonal in origin. However, the lower-levels were, once again, dominated by an upslope regime with a primary cold frontal boundary lingering over the Southern Great Plains. The NWS issued a Flash Flood Watch only for the higher terrain of the foothills portions of the District. Given the high amount of atmospheric moisture/surface dewpoints, the rainfall from a potentially strong storm was extremely high and as a result HDR extended the Message 2 status to the entire District. Thunderstorm activity did start in the early afternoon over the highest portions of the Front Range, east of the Continental Divide, and slowly drifting east and slowly decaying. Subsequent, outflow boundaries produced by this activity was sufficient to generate an area of heavy/moderate rains over eastern sections of Aurora and eventually SE Boulder, Broomfield and western Adams Counties. Fortunately, the subsequent rainfall from these storms was limited to the 1"-1.5" range in a 60-75 minute period in most locations that received the heaviest rain with no observed storm total exceeding 2". However, the impacts were heavy enough to cause numerous lane closures and delays in the freeway system across the area through the evening.

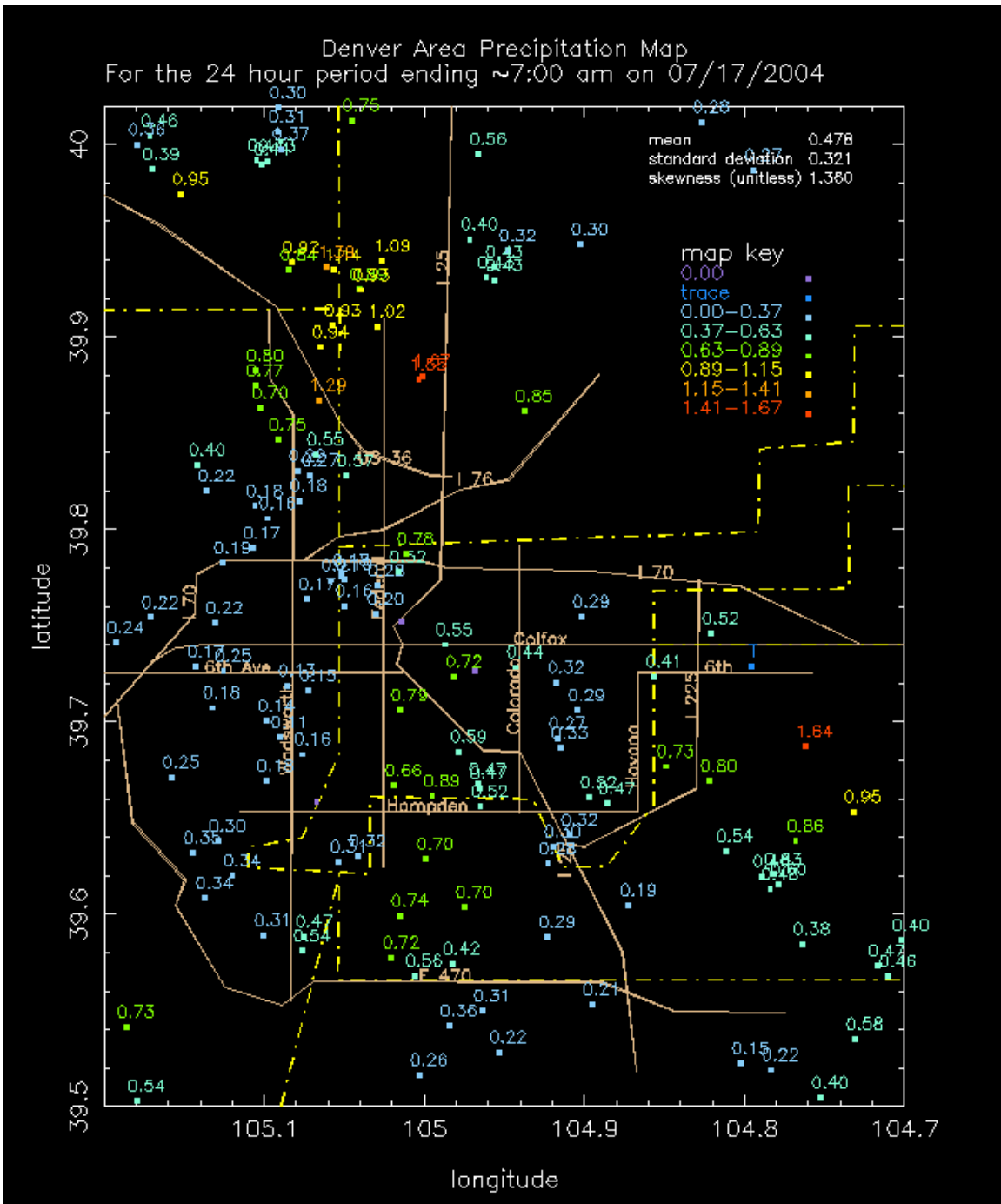


Figure 10. CoCoRaHS 24-hour rainfall total from 7:00 AM until 7:00 AM on July 17th, 2004.

6.0 Recommendations and Comments

ALERT Mesonet

Again, the ALERT Mesonet was deemed a reliable source of forecast and verification information during the 2004 F2P2.

Xpedite Internet-based broadcast fax service

The Xpedite fax delivery service performed optimally during a majority of the F2P2 season. There were very few instances this season where the service was unoperable. HDR would encourage the continued use of Xpedite to the District for the 2005 F2P2 season.

Internet Access/Computing Facilities:

HDR was pleased with the Internet and computing capabilities provided by the UDFCD at the Flood Prediction Center. No recommendations or alterations are being offered in this category. There was a brief period of time when the primary servers in the FPC were unavailable due to computer failure but, due to planning by HDR and UDFCD for such situations the program was able to operate at a level to serve the users effectively. As always, there were a couple of scenarios that made product creation and dissemination difficult but, personal experience during the program has shown that this can and will happen regardless of planning and that direct verbal communications with the users should always take top priority in challenging situations.

Flood Warning Plans

HDR suggests that a preliminary evaluation study be undertaken to assess the potential need and feasibility for enhancing existing Flood Warning Plans (FWP) listed in section 3.0. Such upgrades and enhancements could assist affected counties and communities in maximizing the information provided by the F2P2, the UDFCD ALERT system, and incorporate new technologies including GIS. FRP's would provide pro-active response actions for emergency response agencies in these communities.

Such an evaluation would encompass such tasks as interviewing and information gathering of various agencies involved with flood response and flood related activities. This information would be utilized in generating recommendations for enhancements and cost estimates to enhance the FWP's and upgrade FWP's to FRP's. In addition, the role and utility of the F2P2 to the response organizations will be assessed along with a recommendation for future enhancements to that program.

Additional Meteorological Data Sets

ACARS

HDR was very pleased that the District was able to acquire real-time access to the ACARS datastream. This data set was very helpful on a number of occasions in determining the vertical stability of the atmosphere and real-time middle and upper

atmospheric wind information. HDR would like to strongly encourage the District to continue to make this data source available for the F2P2 in 2005.

Mesonet Data (non-ALERT stations)

HDR is aware of the District's efforts to incorporate real-time mesonet information from the FSL MADIS database into a real-time easy-to-view product. We would like to strongly encourage the District to continue forward on these efforts for the 2005 season.

GIS-Based Products

1) STORMTRAK

The current use of Stormtrak was optimal for the 2004 season although there were a couple of occasions where the application locked up and delayed a timely release of the product. Also, some form of formalized backup procedure maybe implemented if the primary CPU that the Stormtrak resides encounters a failure. The reason for this is that the 'backup' method for Stormtrak issuance is also tied to this CPU and caused a temporary concern in the production and availability of the product.

2) QCP2 and QRPM

Unfortunately, these products were not implemented in the program during the 2004 season. The primary concern was the use of the Meteorologix 'multi-site' GIS-based radar feed which raised concerns about product accuracy. The need for single-site based radar (KFTG) was identified as being critical. It is hoped that alterations and/or alternative method could be developed with the developed architecture in place to implement these products.

3) Other GIS-Information

The use of the Meteorologix MxAnalyst for the display of radar data was deemed useful in terms of identifying precise storm location with respect to certain geographical boundaries. Given the technique that Meteorologix utilizes in their composite technique it is difficult at times to achieve a timely radar depiction that corresponds to the data available in the single site radar. However, it should be noted that use of this product did help HDR identify UDFCD District boundaries, county boundaries and major and minor highways relative to storm location and in Stormtrak issuance.

7.0 Summary

The 2004 UDFCD F2P2 operated from April 15th to September 15th for the 26th consecutive year. This year's program was conducted by HDR Engineering Inc.. Overall, there were 31 Message days in the F2P2, which is below the long-term average of 35 while there were 5 days with Message 3s' and 8 days with Message 2's. These numbers are above average in terms of both Message 2's and Message 3's.

The overall statistics indicate that the verification of Message Day 'hits', as scored on a District-wide basis, registered at 65%, which is lower than the longer-term average of 83%. Many of these 'false-alarm' days occurred relatively early in the season with 6 of 11 these days occurring by June 30th. While June 30th is the 'midpoint' of the program in terms of the program, the second half of the season is typically acknowledged as a much more active period in terms of storm activity. When the verification statistics are calculated on a county-by-county basis, the statistics indicate a relatively low number of hits (44%), which is lower than the long-term average of 55%.