



2012
UDFCD FLASH FLOOD PREDICTION
PROGRAM - ANNUAL REPORT

Submitted by
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1.0 Introduction

The Urban Drainage and Flood Control District (District or UDFCD) has used the forecasting and notification services of a private sector meteorologist for the Flash Flood Prediction Program (F2P2) since 1979. The services of a Private Meteorological Service (PMS) supplement the forecast and warning services of the National Weather Service (NWS) in Boulder, Colorado for the seven-county District area. This is the 34th year the UDFCD has funded the F2P2.

The UDFCD forecast area supported by the PMS is shown in Figure 1 and contains a population of approximately 2.8 million people. The forecast area of approximately 3,000 square miles includes the upper basin areas of watercourses that flow into the District. Terrain in the forecast area varies in elevation of around 5,000 feet above sea level to as high as 10,500 feet above sea level.

A team comprised of Genesis Weather Solutions, a Highlands Ranch, Colorado based company and Skyview Weather, a Castle Rock, Colorado based company was selected as the 2012 PMS.

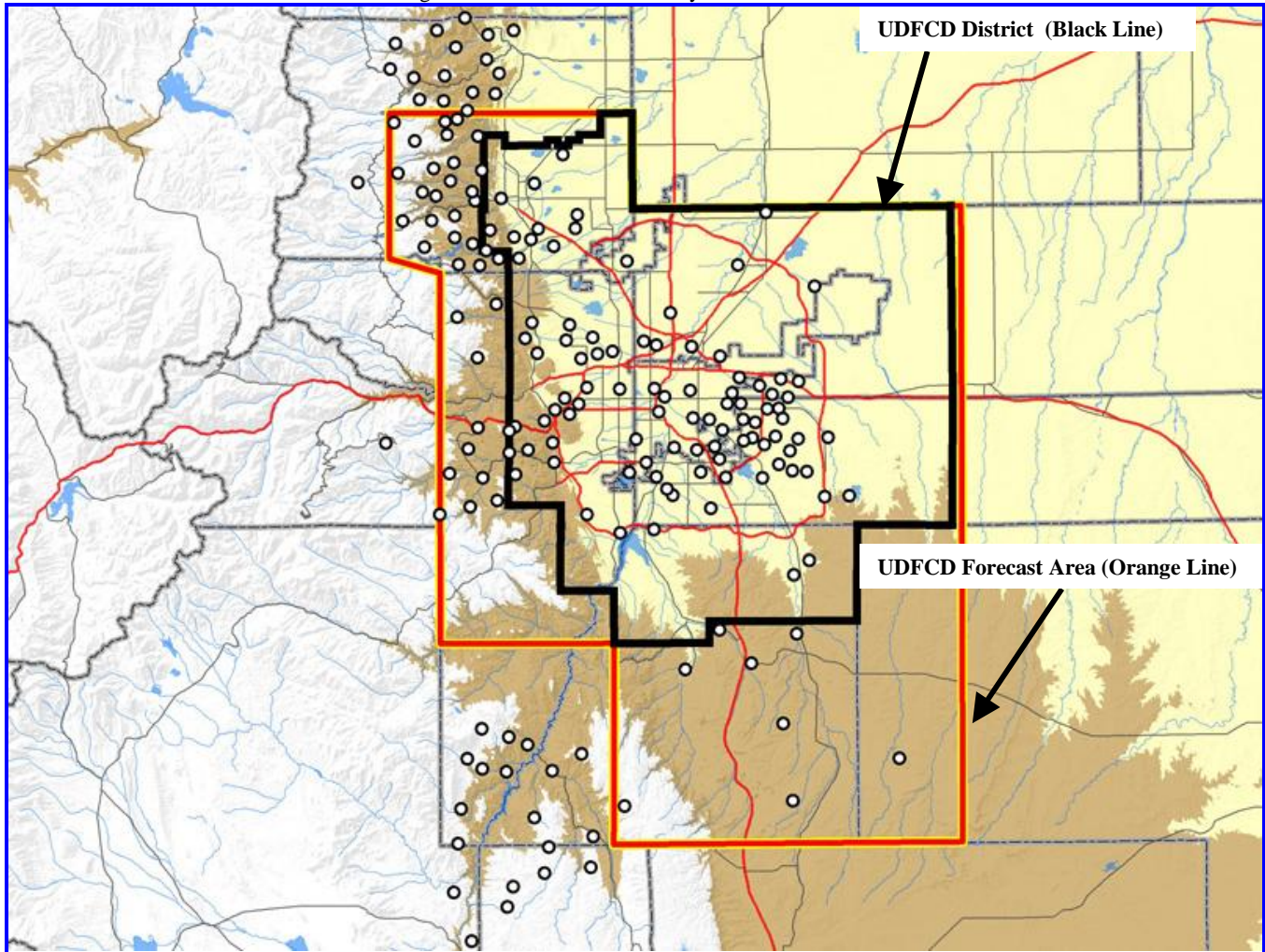
Weather prediction personnel Bryan Rappolt, Tim Tonge, Brad Simmons, Jeffrey Auger, Chris Brinson, and Jorel Torres provided the F2P2 prediction and notification services. Bryan Rappolt was as the Project Manager and Chief Operational Meteorologist.

Bryan Rappolt worked his 19th season on the F2P2 while Tim Tonge worked his 7th, Brad Simmons his 6th, Jeffrey Auger his 1st, Chris Brinson his 1st season and Jorel Torres his 1st season.

2.0 2012 Operational Season

The 2012 F2P2 season began on April 15, 2012 and concluded on September 15, 2012 for a total of 154 operational days. Normal operational hours were from 7:00 AM to 10:00 PM. A total of **1249** man-hours were expended by the PMS providing support of the F2P2 during normal operational hours. During the time period from 10:00 PM to 7:00 AM the PMS provided an additional **211** man-hours of operational support.

Figure 1: The UDFCD boundary and forecast area.



3.0 2012 Operational Products

The F2P2 is designed to provide rainfall prediction and notification services of urban flooding and flash flooding threats to the seven District counties and the cities and towns within those counties. Direct support is provided to the District basin-specific flood warning plans, which include the Westerly Creek, Boulder Creek, Toll Gate Creek, Lena Gulch, Ralston Creek, Goldsmith/Harvard Gulch, and the Bear Creek drainage basins.

Five specific F2P2 products were produced by the PMS. The products included the Heavy Precipitation Outlook (HPO), the Internal Message Status (IMS), the Quantitative Precipitation Forecast (QPF), Storm Track (ST), and Messages. Table 1 provides a description of the first four products and Table 2 provides a description of Messages. Table 3 depicts the number of F2P2 products that were produced and the number of communication contacts made or received by the PMS in 2012.

The Red Flood Alert (RFA) product that has been used within the program for the last five years, was replaced this year with a Low Impact Flood (LIF) product. The LIF is issued when Message 1 level flooding has a high probability (90% or greater) of occurring within the District.

Table 1. F2P2 product descriptions.

Heavy Precipitation Outlook (HPO)/Internal Message Statement (IMS). This HPO is available by 11:00 AM every day during our primary flood season as noted above. It provides a weather forecast for the District with emphasis on possible rainfall amounts and where storms are most likely to occur. When flood potentials threaten the District, the HPO will be revised and renamed "Internal Message Status" or IMS. This report will indicate the message status for each primary contact point within the District. The contact points include the counties of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas and Jefferson, and the City of Aurora.

Quantitative Precipitation Forecast (QPF). This text product is only available on days when the rainfall potential exceeds 1.5 inches in one-hour or less. The QPF product contains more basin-specific information than the HPO or IMS, and requires some knowledge of the regional major drainage basins, streams and associated flood hazards that impact the District. Storm types, expected rainfall totals, storm duration, peak intensities and associated probabilities of occurrence are presented in this forecast product.

Storm Track (ST). This combination map/text product is a short lead-time forecast showing where a storm has formed or is forming, the approximate size of the storm(s), the direction (or track) of the storm(s), and the estimated arrival times along the forecast track(s). This is probably the most-anticipated hard copy product of the F2P2, but keep in mind that generally it is only available within an hour or less of storm impact. Also, the Storm Track is not prepared for storms that do not pose a flood threat.

All of the above products were produced and delivered to F2P2 participants using the UDFCD F2P2 Internet-based Product Generator Interface (PGI). All F2P2 products were made available on the PGI in both HTML and PDF format, with exception of the Storm Track product which is only available in PDF format.

Voice communication is the principal method of disseminating information within the F2P2. Two hundred eighty-five (285) telephone contacts were made to F2P2 communication points by the PMS.



URBAN DRAINAGE AND FLOOD CONTROL DISTRICT FLASH FLOOD PREDICTION PROGRAM (F2P2) MESSAGE DEFINITIONS

MESSAGE 1 (*Street Flood Potential*)

This message is to inform key people that weather conditions are such that low impact street flooding may occur later in the day. Streets, low-lying areas, normally dry gulches, small urban streams, and recreational trails located along streams are areas most likely to be affected. Mud, debris and rock slides are the primary concern in the mountains and foothills.

MESSAGE 2 (*Flash Flood Watch*)

This message is to inform key people that a Flash Flood Watch has been issued by NWS indicating that weather conditions are such that a life-threatening flash flood may occur later in the day. Significant stream flooding and property damage is possible. PMS will add any additional information available.

MESSAGE 3 (*Flash Flood Warning*)

This message will be issued to inform key people that a Flash Flood Warning has been issued by NWS or PMS feels that a life-threatening flash flood is imminent or occurring. Significant stream flooding and property damage is expected. PMS will add any additional information available. This warning message should be disseminated as quickly as possible.

MESSAGE # UPDATE

This message will be used by PMS to update any of the previous messages. For example, this message can be used to narrow a watch or warning area as more information becomes available, or to provide more site-specific data and direction during an event.

(Low Impact Flooding)

This language will be included as a sub-title to either a MESSAGE 1, MESSAGE 1 UPDATE, or MESSAGE 2 UPDATE to inform key people that low impact flooding is either imminent or occurring. Streets, low-lying areas, normally dry gulches, small urban streams, and recreational trails located along streams are areas most likely to be affected. Mud, debris and rock slides are the primary concern in the mountains and foothills. This product is comparable to the NWS Urban and Small Stream Flood Advisory.

MESSAGE 4 (*All Clear*)

This message cancels the flood potential status. It is issued by PMS after consultation with NWS and other entities involved with direct PMS communications.

SUPPLEMENTAL: *F2P2 messages are used to notify local governments of potential (MESSAGES 1 and 2) and imminent (MESSAGE 3 and Low Impact Flooding) flood threats. All F2P2 messages are designed for internal use and not intended for the general public. Standard message forms completed by the meteorologist are sent by fax or email to designated communication fan-out points prior to making contact by telephone. Each county warning point or designated recipient should follow their respective protocol for subsequent dissemination of messages.*

ABBREVIATIONS: NWS...National Weather Service PMS...Private Meteorological Service

Table 2: Message definitions.

Table 3: 2012 product/communication summary.

Product/Communication	Number
Heavy Precipitation Outlook (HPO)	168
Messages and Red Flood Alerts	309
Internal Message Status (IMS)	75
Basin-Specific Quantitative Precipitation Forecasts (QPF)	14
Storm Tracks (ST)	53
PMS Initiated Telephone Contacts	285
F2P2 Participant Initiated Telephone Contacts	34
Total	938

One hundred sixty eight (**168**) emails identifying daily Message potential were disseminated to F2P2 participants.

4.0 2012 Message Statistics

The primary service provided to F2P2 participants is early prediction and notification of the potential for flash flooding, urban and small stream flooding, and locally heavy rainfall events that can initiate nuisance flooding. The PMS indicated the potential for these events in a series of products issued to F2P2 participants by phone, facsimile, email and Internet.

4.1 Message Verification

A Message day is defined as any day in which a Message 1, Message 2 or Message 3 is issued based on the criteria depicted in Table 4. Messages were issued on **26** days during the 2012 F2P2 between April 15, 2012 and September 15, 2012. There was one day of the 26 Message days where only Message 2's were issued. There were four days of the 26 Message days where a combination of Message 2's and Message 1's were issued for portions of the District. There was a **100%** verification rate of Message days on a District-wide basis.

Table 5 depicts the number of Message days and the number of Messages issued and verified for each month of the 2012 F2P2.

Table 4: Message Criteria.

Message 1 “Nuisance Flood Advisory” Criteria	
• Message-1 (Street or gutter flooding): 0.50"/10 minutes or 1.00"/60 minutes	
• Message-1 (Significant urban street and stream flooding): 1.00 to <3.00"/ 60 minutes	
• Low Impact Flooding (LIF) : Rainfall intensity: 0.50"/10 minutes or 1.00"/60 min AND occurrence is imminent	
Message 2 Flash Flood Watch Criteria	
• Option A: National Weather Service issues a Flash Flood Watch affecting the District	
• Option B: PMS predicts rainfall that will equal/exceed 3.00"/hour (No NWS Flash Flood Watch exists)	
Message 3 Flash Flood Warning Criteria	
• Option A: National Weather Service issues a Flash Flood Warning affecting the District	
• Option B: PMS issues a Flash Flood Warning for a specific District river/stream/drainageway (No NWS Flash Flood Warning exists)	
Message 4	
• Message 4 (“All Clear”) is issued whenever Messages are rescinded before their expiration time.	

Table 5: Monthly Message verification.

Month	Number of Message Days	Verified Message Days	Verifying Message Days	Messages Issued	Verified Messages	Verified Messages
April	1	1	100%	5	5	100%
May	2	2	100%	12	7	58%
June	7	7	100%	51	30	59%
July	12	12	100%	92	69	75%
August	3	3	100%	18	13	72%
September	1	1	100%	1	1	100%
Total	26	26	100%	179	125	70%

There was **0** “nearby hit” days where a Message was issued for a portion of the District and Message-level rainfall was not observed within the District.

Of the **26** Message days, **26** of the days had Message level rainfall observed within either the forecast area or nearby.

There was **1** day (July 9) where Message level rainfall was observed within a portion of the District and a Message was issued with short lead-time (< 30 minutes).

There were **0** days where Message level rainfall was observed within a portion of the District and no Message was issued.

A Low Impact Flood (LIF) product is issued when the PMS felt that there is a 90% or greater probability that Message level rainfall would be observed within a portion of the District. There were a total of **12** LIF days, of which all **12** of these LIF days verified; resulting in a verification rate of **100%**.

4.2 County/City Message Statistics

Each Message issued within the F2P2 is disseminated to a primary contact point in which flooding potential has been predicted. The counties and cities that receive Messages are listed in Table 6.

A Message is verified as a "hit" when a rainfall event meeting the Message criteria depicted in Table 4 is observed in the District-portion of that City/County or in the drainage area of a watercourse that flows into the jurisdiction. Table 6 contains the results of the Message verification on a City/County basis.

Verification of Messages issued for the City of Aurora and Denver International Airport (DIA) are included in the County statistics because Aurora is a primary contact point and Denver County is segmented into two sections which includes the City and County of Denver and northeast Denver County, DIA. The Four Mile burn area was added as a new forecast zone due to its high potential for flooding from minimal rainfall caused by a wildfire in the fall of 2010.

The cities of Arvada, Lakewood and Wheat Ridge receive Message 1 notifications from Jefferson County dispatch, but also receive LIFs, Message 2's and Message 3's directly from the PMS.

Table 6: County/City Message Verification.

Primary Message Contact Points	Messages Issued	Message Hits	% Message Hits	LIFS Issued	LIF Hits	% LIF Hits	Events Missed	Event < 30 min Lead Time
Adams	15	11	73%	3	3	100%	0	0
Arapahoe	17	12	71%	6	6	100%	0	0
Aurora	18	11	61%	6	6	100%	0	0
Boulder	20	15	75%	3	3	100%	0	0
Broomfield	15	7	45%	1	1	100%	0	0
Denver	14	8	57%	4	4	100%	0	1
DIA	15	7	47%	2	2	100%	0	0
Douglas	22	20	91%	6	6	100%	0	0
Jefferson	24	22	92%	5	5	100%	0	0
Four Mile	19	12	63%	5	5	100%	0	0
TOTAL	179	125	70%	41	41	100%	0	1
Red Flood Alert Contact Points	Messages Issued	Message Hits	% Message Hits	LIFS Issued	LIF Hits	% LIF Hits	Events Missed	Event < 30 min Lead Time
Arvada	N/A	N/A	N/A	1	1	100%	0	0
Lakewood	N/A	N/A	N/A	2	2	100%	0	0
Wheat Ridge	N/A	N/A	N/A	1	1	100%	0	0
TOTAL	N/A	N/A	N/A	4	4			
GRAND TOTAL	179	125	70%	45	45	100%	0	1

A total of **179** Messages were issued within the District. Of the **199** Messages that were issued, **125** Messages verified, resulting in a verification rate of **70%**. Jefferson County had the highest verification rate, **91%**, while Broomfield County had the lowest verification rate, **45%**.

A total of **45** LIF's were issued. Of the **45** LIF's issued, **45** of them verified, resulting in a verification rate of **100%**.

The PMS identified cloud-to-ground lightning days that covered the forecast period of April 15, 2012 through September 15, 2012. A cloud-to-ground lightning day was identified as any day that a thunderstorm cell produced cloud to ground lightning within the District. Archived cloud-to-ground lightning data was reviewed for each of the 154 operational days of the F2P2. Of the 154 operational days, **84** of the days (**55%** of the total days) cloud-to-ground lightning was observed within or near the District. Of the **84** "thunderstorm days" within the District, **31%** of the days had Messages issued.

5.0 Notable Weather Events

The 2012 F2P2 season was below normal with respect to the number of thunderstorms, Message-days and flooding that was observed within the District. Some of the notable weather events observed during the 2012 F2P2 are described below:

June 6th: A large slow moving thunderstorm complex developed over northern Douglas County and central Arapahoe County during the afternoon. Heavy rain of up to 4.5 inches initiated a Flash Flood Warning and a Message 3 for the area. Accumulating large hail of up to 10 inches in depth exacerbated the flooding and caused some roofs to collapse in Castle Rock and Parker.

Figure 2: Flooding in Aurora on 6/6/12.



Figure 3: Accumulating hail in Parker on 6/6/12.



July 6th: Multiple thunderstorms tracked across portions of the District producing severe weather, heavy rain and street and urban flooding across a good portion of the Denver Metropolitan area. Rainfall amounts of over 2 inches were common in Douglas and Boulder Counties. The heavy rain prompted a Flash Flood Warning for the Four Mile burn area in Boulder County and south central Douglas County.

July 9th: Early morning slow moving thunderstorms produced heavy rain across portions of the Metro area. A narrow northwest to southeast line of training thunderstorm cells produced heavy rain of up to 3.50” in 3 hours. Isolated, but significant, urban flooding was experienced across northwest Denver and northeast Jefferson Counties.

Figure 4: Metro area (Sloan Lake) urban flooding on 7/9/12.



6.0 Recommendations

Storm Track Product

It is recommended that the GIS-based Storm Track application used to produce Storm Track products within the program be upgraded. Currently it is rather cumbersome to add text, shapes and lines, which are all used to create the product. It is felt that the current application could be improved in how text, shapes and lines are added to the product, allowing the user to produce and disseminate the Storm Track product in a more efficient and timelier manor.