



Flood Hazard News

An annual publication of the Urban Drainage and Flood Control District

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December, 2008

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Montclair Storm Drainage Project

*Colorado Association of Stormwater and Floodplain Managers
Grand Award Winner for 2008*

By Mike Galuzzi, WH Pacific
Tom Blackman, City of Denver
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Project Background

The Montclair Storm Drainage Project was a \$25 million endeavor by the City of Denver to improve the drainage in the Montclair Basin and to improve Ferril Lake in City Park. The project includes the conversion of Ferril Lake into a dual use facility (stormwater detention and recreation), associated park improvements, installation of a new storm sewer system in 17th Avenue, and a new storm sewer/road reconstruction on the City Park Esplanade in front of East High School.

The Montclair Basin consists of 9 square miles of fully developed urban land located east of downtown Denver. The basin is approximately 8.2 miles long, extending north from Fairmont Cemetery at its southern limit, to the outlet at the South Platte River near the Denver Coliseum. There is not a single open channel drainageway in the entire basin. Storm drainage is conveyed entirely in the streets and through the existing storm sewer system, which is predominantly brick and was



Ferril Lake in Denver's City Park

Information Services and Flood Warning Program Notes

Kevin Stewart, PE, Program Manager

2008 Flood Season Marks 30 Years of Service

The year 2008 was noteworthy in many respects, not the least of which being the culmination of 30 years of community service by the District in providing local governments with early notification of flood threats. A program with its origin being the aftermath of the devastating 1976 Big Thompson Canyon flash flood, has matured through its unique partnership with the National Weather Service; local emergency managers and other public safety and public works officials; local news media; and the elected officials that have continually supported the program over that past three decades. The private meteorologists that have provided the District with professional forecast services also deserve much credit for building the program's reputation and advancing the science of hydrometeorology.

Special recognition is given to Bill DeGroot (manager of the District's Floodplain Management Program) and Scott Tucker (former Executive Director) who helped light the spark that led to the development of the program. Credit is also given to Eve Gruntfest and Tom Downing, back then with the University of Colorado at Boulder, who researched what people did that night of July 31, 1976 that resulted in the loss of over 140 precious lives, and what might have happened if that monster storm had been centered 25 miles further south over Boulder Creek instead of the Big Thompson. John Henz, currently with HDR Engineering in Denver, is the flash flood pioneer that first served the District's program in 1979 and continued to do so for over a quarter century. John devoted much of his career as a private meteorologist toward advancing the art of quantitative precipitation forecasting and predicting when and where these flood producing heavy rainfalls are most likely to occur. And finally, tribute is given to the visionaries from Boulder County and the City of Boulder who partnered with the District in 1978 to deploy one of the earliest automated flood detection networks in the United States and helped develop a community-based flash flood warning program that has served as a model for many others dedicated to protecting lives and property.



Few headlines this past year had much to do with floods in the District. Tornadoes seemed to be the primary weather threat that captured media attention starting with the deadly May 22 Windsor Tornado that left a 34-mile path of destruction and ending with the far less damaging August 24 Lemon Gulch Tornado (pictured) in

Douglas County on the eve of Denver's historic Democratic National Convention. One flood event on Cherry Creek in Denver did get some attention when fire departments documented 30 water rescues the evening of August 8. Although not noted at the time, subsequent investigation revealed that this event was Denver's largest flood on Cherry Creek since Cherry Creek Dam was completed in 1950. Looking back even further, 8-8-8 proved itself the largest flood since the 12:10 AM failure of Castlewood Canyon Dam sent a 15-foot wall of water down Cherry Creek through Denver on August 3, 1933.

Heavy rainfall was usually scarce in 2008 with the District's flash flood prediction program recording a record low number of threats. April and September produced no flood threats and the months of May and June only had two periods of concern each. While August 8 produced the most notable flood peak of the year, the general rains that occurred over August 15-16 caused the greatest volume of runoff and the largest number of reports (>2000 per hour) from the ALERT system without triggering a single rainfall rate alarm. These and other notable events are highlighted in the flood season recap section of this article.

A record low 26 days with flood potential

May	7, 22	2
June	2, 4-5*	3
July	6, 8, 17, 18, 23-26	8
August	5, 6-7, 8, 9-10, 14, 15-16*, 17, 23-25	13

Bold dates denote days when rainfall measured by automated gages exceeded alarm thresholds. Blue boxes designate NWS flash flood watch days and the red box signifies a flash flood warning. An asterisk (*) indicates a single multi-day storm period.

Meteorological Support

The team of Genesis Weather Solutions and Skyview Weather was selected by the District for a second consecutive year of providing local governments with heavy precipitation forecasts and flood threat notifications. Project manager and chief meteorologist Bryan Rappolt completed his 15th year of service to District's flash flood prediction program (a.k.a. F2P2). Bryan is the president and founder of GWS. Prior to forming GWS, he gained his F2P2 experience working for Henz Meteorological Services and HDR Engineering. Skyview Weather is headed by Tim Tonge of Castle Rock. Brad Simmons with Skyview served his second operational flood season as one of the team's lead forecasters. The met support team was rounded out nicely by the employment three students of meteorology – Dann Cianca, Chris Anderson and Nick Tarantola who proved themselves worthy technicians well on their way to promising careers in meteorology. The F2P2 operates during the flood

season from 15 April to 15 September. Information about the F2P2 can be found at f2p2.udfcd.org.

CoCoRaHS Update

The Community Collaborative Rain, Hail and Snow network is operated by the Colorado Climate Center at Colorado State



University in Fort Collins. The network's popularity continues to expand nationally with daily precipitation measurements being made by an army of volunteers from 37 states. Nine additional states will likely be added in 2009 with 20,000 observers being projected by 2010. There are currently over 300 active observers from the seven District counties.

The District continues to support CoCoRaHS as a sponsor and routinely makes use of this valuable data source. Creative new ways are being developed by the District for viewing and comparing CoCoRaHS measurements with precipitation data from other sources including the ALERT system (see article by Chad Kudym). In 2009 Kevin Stewart will begin serving on a newly formed coordinating committee established under the auspices of the Western Association of Agricultural Experiment Station Directors. This committee is tasked with addressing needs and opportunities for [managing and utilizing precipitation observations from volunteer networks](#).

CoCoRaHS is truly a community-based initiative that would not be possible without the help of people just like you. So please consider becoming a CoCoRaHS volunteer or sponsor today, and visit www.cocorahs.org for the latest news.

EMWIN-Denver Update

The Emergency Managers Weather Information Network has matured this past year as a reliable source of weather alerts for local governments in the 10-county North Central All-Hazards Region, which includes Adams, Arapahoe, Boulder, Broomfield, Clear Creek, Denver, Douglas, Elbert, Gilpin and Jefferson Counties. Weather alerts from EMWIN-Denver are sent automatically to email distribution lists established by local governments. A subscribe/unsubscribe process developed by the District's GIS Administrator Chad Kudym is available for participants that prefer not to administer their own lists. The District provides further assistance by supporting the EMWIN receiver that sends the notifications.

Each weather alert is county-specific. Users may sign-up to receive alerts affecting one or more counties. Two types of messages are sent: a short message service (SMS) designed for cell phones and pagers, and a long message that includes the entire text originated from the NWS Forecast Office in Boulder.

Other uses for EMWIN include interoperable communications between emergency managers concerning non-weather situations, EAS activation requests to NWS by

authorized local officials, and NWS notifications concerning conference calls about developing dangerous weather situations. EAS is the national public warning system that stands for Emergency Alert System. Some work is still needed on these applications, but completion is expected in 2009. The NWS would also like EMWIN-Denver to extend the email notification process to include all 22 counties in NW Colorado served by their warning and forecast office in Boulder. Summit and Grand Counties have already been added.

EMWIN-Denver area is guided by a steering committee that meets quarterly. Rick Newman from Adams County Emergency Management is the current chair. [ARES](#) Hams provide technical support for the communications equipment and assist their respective jurisdictions with training and other needs. For more information about EMWIN visit emwin.udfcd.org.

ALERT System News

The District's ALERT system currently collects hydrologic data in real-time from 178 rain gages, 90 stream gages and 21 weather stations. Six new stations were added to the network in 2008 including: an hourly-reporting weather station installed by the City of Aurora Water Department at the Aurora Airpark; two rain/stream gages in the Piney Creek basin—one at the Liverpool Road crossing of Piney Creek and



the other at the Aurora Regional Pond on Sampson Gulch (pictured); a rain/stream gage on Cherry Creek downstream of the Bayou Gulch confluence—this station replaces the one previously located at Castle Oaks Road; a stage gage on Ferril Lake at City Park in Denver; a rain gage at the Lakewood Country Club in the Lakewood Gulch drainage basin.

Additional network expansion will occur in Douglas County in 2009. Rain gages and weather stations will be installed in the upper Cherry Creek and Plum Creek watersheds. Locations include: Lehigh Gulch, Douglas County Public Works in Castle Rock; Reed Hollow, Jackson Creek, East Cherry Head (Wx), and County Road 5/SH 67. The repeater at West Creek near the Hayman Burn Area will also be upgraded to full weather station status. Two rain/stream gages will be installed on Cherry Creek near Stroh Road and the Apache

Plume confluence. These stations, located in Parker, were originally planned for 2008.

OneRain, Inc. (formerly DIAD) of Longmont completed their 17th consecutive year of field maintenance services. A change for this year involved adding a second maintenance contractor, Water and Earth Technologies (WET) of Fort Collins, to service the gages in Douglas County. As part of WET's service agreement, they continued to provide the District with monthly system-wide performance reports that now include a useful rainfall-intensity-duration analysis, a monthly total rainfall accumulation map, a timer performance map that rates each individual station, and a plot of average and peak hour data traffic received by the District's base station.

OneRain's role was further expanded in 2008 by deploying new equipment on repeaters and conducting more rigorous field tests of a new protocol being developed for ALERT. Last year's newsletter addressed the concern of system capacity limitations caused by continued use of 1960's data communication technology. Hopefully, ALERT-2 will offer a viable alternative for large systems like the District's.

Leonard Rice Engineers (LRE) continued to assist the District by supporting real-time hydrologic models for Boulder Creek in Boulder County; Lena Gulch in Jefferson County; and Harvard Gulch and Goldsmith Gulch in Denver. A hydro model being developed for the Cherry Creek basin above Cherry Creek Reservoir will be operational in 2009. The models activate automatically whenever flood threat notifications are issued by the F2P2 meteorologist. New innovations for 2009 include developing better ways to recognize and evaluate streamflow information based on a familiar NWS Internet application known as AHPS – Advanced Hydrologic Prediction Service. LRE will also develop and support a "Hydrologic Data Service" to integrate data from various sources and make it easier to accomplish one-stop-shopping web applications.

2008 flood season recap

In retrospect, the 2008 storm behavior was anything but normal. April through July produced very few storms with any flood potential. Then August arrived and tried to make up for the lack of moisture from the previous four months over a 13-day period beginning on August 5. After August 17, it grew quiet again with September closing out the flood season with no threats.

Heavy rainfall caused the ALERT system to set off alarms on only 11 days in 2008 including five days in August (9, 11, 15, 23 & 24) that only impacted the Hayman Burn Area in southwestern Douglas and southern

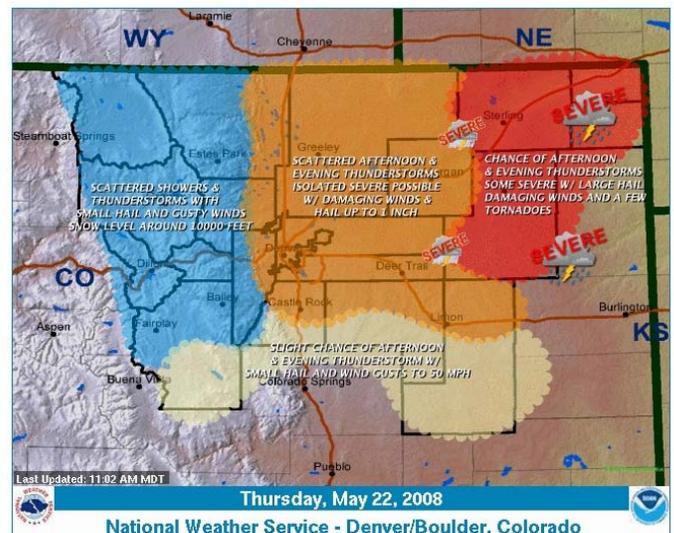
May	7
July	6, 8
August	5, 6, 8

Jefferson Counties. The six days shown in the table were days that affected the District's primary area of interest. Comparing this table to previous years further illustrates just how unusual the 2008 flood season was. The following briefly describes the more notable events:

Wednesday, May 7

The first flood threat day of the year arrived unusually early in the morning without warning or notice by the public, and somewhat indicative of the atypical flood season to come. Heavy rainfall began at about 4:30 a.m. in southwest Denver and three ALERT gages measured rainfall totals that ranged from 1.34" to 1.85", which agreed closely with radar estimates. Rainfall rate alarms were triggered by the Marston Lake and Sanderson at Xavier gages between 5:08 and 5:12. Stream gages also recorded annual peaks for Sanderson Gulch and Bear Creek at Sheridan.

Some minor flooding occurred in Columbine Valley at a District project on Normandy Gulch when stormwater that entered the Nevada Ditch spilled at three locations. The ditch carried debris to its crossing of Fairway Lane. There floodwaters overtopped the road and flowed east to the South Platte River. Fortunately no homes were flooded and the event received little notice due to the early hour.



Thursday, May 22

This was the only other flood threat day in May and it passed by without incident for the District. However, a severe storm that formed just north of Denver International Airport became deadly in Weld County when a large 150 mph/EF3 tornado touched down near the town of Gilcrest and began its 34 mile, one mile-wide path of destruction passing through eastern Windsor and ending just north of Fort Collins near the town of Wellington. Tornadoes of this size, magnitude, duration and direction of movement are quite rare for Colorado—another example of how unusual this severe weather and flood season was looking to become.

Wednesday/Thursday, June 4-5

With the possible exception of some very small hit-and-run storms that occurred on June 2, this storm period was arguably the first and last heavy rain hurrah for the whole month. A general rainfall with embedded thunderstorms began around 3 p.m. on Wednesday lasting overnight and into the afternoon of the second day. Rainfall amounts of up to 2¼ inches occurred across the District over a 36-hour period. The heaviest rains of ¾" to 1.6" occurred during a

2.5-hour period on Wednesday afternoon when three thunderstorms lined-up, each producing between $\frac{1}{4}$ " and $\frac{1}{2}$ " in 10 to 20 minutes over northern Jefferson, SE Boulder, Broomfield and NW Adams Counties. The NWS issued an urban and small stream flood advisory for Boulder and reported 1.5-inch diameter hail near Standley Lake in Jefferson County.

While the ALERT system remained relatively quiet with no rainfall alarm thresholds ($\frac{1}{2}$ " in 10min, 1" in 1hr) exceeded anywhere in the network, June 4 turned out to be Boulder's biggest rain day of the flood season. One more remarkable weather fact to note!

Sunday, July 6

With the summer monsoon's arrival apparently delayed, this storm day produced the only rainfall alarms within the District for the entire month of July. Unbelievable! This may really be a first. It should be noted, however, that a very heavy downpour did skirt the District just two days later when the Castle Rock/Franktown area of Douglas County received over 2 inches. Other "nearby hits" occurred on other days during July, but the District boundary seemed to act like a barrier to heavy rain during this month when flash floods are most likely.

Back to July 6...a small but intense storm in Aurora near C-470 dropped nearly 2 inches in just over 30 minutes. The upper Toll Gage Creek and Murphy Creek basins were affected and the stream gage on No Name Creek at Quincy Ave. recorded its high water mark for the year.

Tuesday, August 5

It took a while, but beginning this day the summer monsoon appeared ready to take a full swing at the District. Messages were issued for six consecutive days with this day having the lowest threat potential of the period, followed by two flash flood watch days, then a flood warning (more on this later), and two more flash flood watch days.

Intense storms accompanied by large hail developed during the afternoon affecting eastern Douglas and central Arapahoe and Adams Counties. Later more storms developed across SE Denver and Aurora, and another line of activity impacted NW Jefferson and SW Boulder Counties. Together the storms caused alarms at 8 ALERT stations including: 2 South Boulder Creek sites upstream of Eldorado Springs; 3 Westerly Creek sites in Denver and Aurora; 1 site on Toll Gate Creek at 6th Avenue in Aurora; and 2 upper Cherry Creek sites in Douglas County. Streets and low lying areas experienced nuisance flooding. No major flood problems were reported.



Wednesday, August 6

With yesterday's storms causing some concern and with 300 acres of Green Mountain blackened from a large grass fire this past Monday, today's heavy rain

threat was elevated causing the NWS to issue its first flash flood watch of the year affecting the District.

Measured rainfall totals exceeded the previous day's rain by about an inch. Alarms thresholds were exceeded at the District's Diamond Hill office at 4:39 p.m. and gages near Brighton were measuring heavy rain between 6 and 7:30 p.m. The largest storms occurred outside the District with some dropping over 3 inches. The flooding impact to the District was once again minor and the Green Mountain burn area was fortunately spared.

Friday, August 8

With yesterday being the third consecutive flood threat day and having nothing of consequence occur (rain <0.2 "), this morning's outlook was less threatening and therefore, the NWS did not issue a flash flood watch. Nuisance flood advisories (a.k.a. Message 1) were issued by the F2P2 meteorologist for Jefferson and Douglas Counties effective from 1 to 8 p.m. calling for the possibility of $\frac{1}{2}$ " to $1\frac{1}{4}$ " in 10-40 minutes and up to $2\frac{1}{2}$ " in 45-60 minutes. The worst case scenario warned that a 60 to 90-minute $3\frac{1}{4}$ -inch rainfall was also possible.

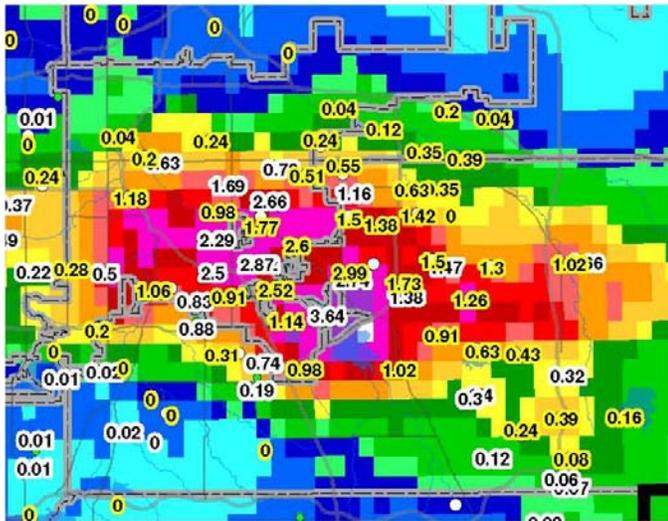
The afternoon passed without incident, but as conditions started to change in the early evening, new messages included Arapahoe County, Aurora and Denver by 6:50 p.m. This set the stage for a somewhat surprising thunderstorm that hit SE Denver very hard at about 7:30 p.m. and lasted approximately one hour. While this storm produced rainfall amounts approaching 4 inches, the most notable consequence...besides the 30 water rescues reported by the media...was that Cherry Creek through downtown Denver experienced its largest flood since the Castlewood Canyon Dam failed on August 3, 1933.

It is also worth noting that in 1933, Cherry Creek Dam did not exist and because of the dam, the effective uncontrolled drainage area of Cherry Creek since 1950 has been just over 25 square miles. The largest floods on Cherry Creek in Denver's 150+ year history date back to 1864 and 1885. Both of these events had estimated flood magnitudes exceeding 20,000 cfs and there were no large dams in the 414 square mile Cherry Creek watershed. The 1933 Castlewood Dam failure had an estimated peak discharge at Denver between 15,000 to 17,000 cfs from a "wall of water" 15 feet deep. By comparison, the maximum water depth for the "8-8-8 flood" was 7 feet at the gage with a peak discharge of 4,100 cfs.

The 8-8-8 flood damaged the stream gage near Champa Street requiring a field survey to determine the peak gage height of 9.97 feet. The USGS performed the survey and estimated that the peak flow was at least 4,100 cfs. This discharge equals the 10-year flood



published in the FEMA Flood Insurance Study. Based on the partial gage record captured by the ALERT system, it is estimated that the Champa gage failed at about 10:10 p.m. with the crest likely occurring within the next 30 minutes.



The storm rainfall totals are shown in the figure. Twenty-six rainfall rate alarms occurred in Denver and Aurora between 7:39 and 8:29 p.m. The storm also caused annual peaks at 13 stream gage locations on Cherry Creek, Westerly Creek, Harvard Gulch, Goldsmith Gulch, Toll Gate Creek and the South Platte River.

Eye witness reports aired by local news stations gave testament to just how quickly floodwaters can rise and how dangerous that can be if trapped within a walled section of channel like Cherry Creek (see the short news clip on District website).

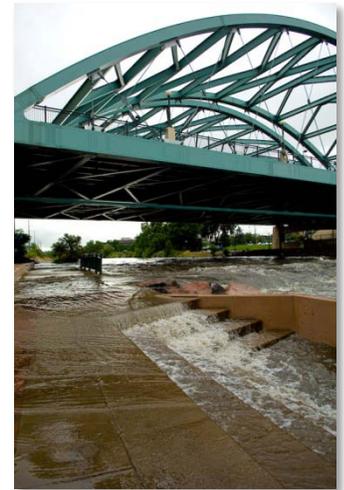
Fortunately, no one was seriously injured thanks to the Denver Fire Department swift water rescue personnel that gave aid to victims caught in floodwaters. It is also remarkable that the Cherry Creek channel did not require any major repairs due to the flood. The District has worked closely with the City and County of Denver over the past four decades to assure the integrity of this channel. It looks like their hard work paid dividends in 2008.



Friday/Saturday, August 15-16

A general rain began falling early Friday morning and continued through Saturday afternoon. Rainfall accumulations over this period ranged from 1¾" to 3½". Rivers and streams were running high by Saturday morning while low lying areas and streets experienced some minor flooding. The NWS issued a flood watch at about 3 p.m. on Friday valid until noon Sunday. A very wet weekend was definitely in store for the District.

During the 24-hour period starting shortly after 3 a.m. on August 16, ALERT stream gages at 28 locations recorded their annual peaks. Affected streams included: Ralston Creek, Leyden Creek and Van Bibber Creek in Arvada; Harvard Gulch, Goldsmith Gulch, Lakewood Gulch, Westerly Creek and Marston Lake North Drainageway in Denver; Granby Ditch and Murphy Creek in Aurora; Lena Gulch in Jefferson County; Broomfield Basin 3207; Slaughterhouse Gulch in Littleton; Englewood Dam on Willow Creek and Holly Dam on Little Dry Creek in Arapahoe County; South Platte River in Littleton, Englewood and Adams County (photo of South Platte River flooding taken by Tim Tonge at Confluence Park showing Speer Blvd. bridge); Sand Creek in Commerce City and Aurora; Niver Creek in Thornton; upper Bear Creek in Jefferson County; Sulphur Gulch in Parker; and upper Cherry Creek through Douglas and Arapahoe Counties. The final alarm occurred at 2:28 a.m. on August 17 from the detention pond at the Louisville Recreation Center.



This widespread event produced the greatest runoff volume of the 2008 flood season, the largest number ALERT reports, and the highest radio traffic loading of the year (>2000 reports/hour between 10 and 11 a.m. on August 16) according to a monthly data analysis report by WET—and all this happened without triggering a single rainfall alarm.

Hungry for more?

Storm summaries for 2008 are available at f2p2.udfcd.org as PDF maps depicting 24-hour gage-adjusted rainfall estimates derived from radar data overlaid by corresponding surface measurements from the ALERT system and CoCoRaHS. By inspecting the single device data from individual ALERT gages, a general sense of storm duration, temporal distribution and time of day can be determined. These maps are routinely prepared by Chad Kudym for every day of the flood season (15 April through 15 September) in which flood threat notifications were issued by the F2P2 meteorologist.

Annual reports by Genesis/Skyview, OneRain and WET are also available from the ALERT System website Bulletin Board page. Broadcast news reports are captured, clipped and available for viewing at the District. Detailed maintenance records are also available for inspection upon request, but please call to make an appointment if you are planning to dig this deep.

Our student intern Stephanie LaCrue continues to assist the IS/FW Program by compiling statistical summaries from the ALERT system and developing a one-stop-shop of historical flood accounts from the seven District counties. This information will eventually be integrated into the

District's electronic data management system, a.k.a. E-library, with easy to use map navigation features.

Tables that summarize annual peak flow measurements and record peaks from the ALERT system are available at alert.udfcd.org. ALERT water level and streamflow records date back to 1986 when data from the Lena Gulch network in Jefferson County was first archived. The entire record is available from the District and most of it can be downloaded from the ALERT system website.

Readers wanting more information about past storms and floods in the Denver region should visit the [Flood Warning Program Bulletin Board](#) webpage.

New look coming soon

Keep an eye on the District's website as some interesting changes will soon be unveiled. Our IT guru and webmaster, Derrick Schauer, has been developing a new look and feel that should greatly simplify finding information.



The homepage is being designed to minimize the need to scroll and will look something like the one above. As the District continues its quest to improve services to local governments, engineering consultants, contractors and the public; this updated website will play a key role.

District Seminar draws 250 attendees, Next one set for February 24, 2009

Check our website for details and to register. We will have room for 300 this year.



Doug Harrison addresses the 2008 seminar on stormwater management issues.

illustrates the new interface by showing a map of 24-hour rainfall totals from August 8, 2008.

The Google Maps ALERT interface is still under development but it will be ready for use for the 2009 flood season. The interface is processor and bandwidth intensive so it does require a relatively new computer and a high speed internet connection to work properly. The latest version of the map can be found on the District website at <http://www.udfcd.org/FWP/LDAD/gmap.html>, as always, we welcome your feedback.

Another development in the Information Services and Flood Warning Program is in the Flash Flood Prediction Program (F2P2). Typically, message products developed by the F2P2 meteorologists are only available in PDF format. In 2009 message products will be available in three different message formats (HTML, full text and short text) for email delivery and posted on the website in PDF and HTML format. F2P2 users will be able to subscribe to the message format that best suits their needs. The short text format will be county specific, concise versions of the full text document and are developed for use with cell phone text messaging. The F2P2 website (<http://f2p2.udfcd.org>) will also include a new tool to search for and view both current and archived messages. The intent for the new F2P2 message generator is to increase the efficiency of producing messages, shorten delivery time and customize the message product to the recipient's device.

Near the end of the 2008 flood season the Information Services and Flood Warning Program staff created ALERT rainfall alarm zones. These zones are used in association with an email list server to allow users to subscribe to their area of interest and limit the number of alarms they receive from other parts of the District ALERT system. If you were already receiving these rainfall alarms, your email has been subscribed to one or more of these zones. If you have not received alarms in the past but would like to, please contact District staff for a link to the subscription page. Figure 2 illustrates the alarms zone boundaries.

District staff from all Programs have also been working with CH2M-HILL to develop a new mapping interface. The interface was initially developed to help users find District

publications such as major drainageway planning reports, flood hazard area delineation reports, as-built drawings and outfall system planning reports but it continues to evolve into a tool to display a variety of District data. The interface uses Google Maps together with an assortment of drop-down lists to help users find documents. The primary goal of the tool is to allow someone to find a document based on either spatial location or properties such as basin name, type, municipality or county. Future developments will involve the inclusion of floodplain data, ALERT station locations, maintenance eligibility and routine maintenance segments along with other data sources that may be useful to users. The interface is still under development and a presentation on the topic will be included in the 2009 District Seminar.

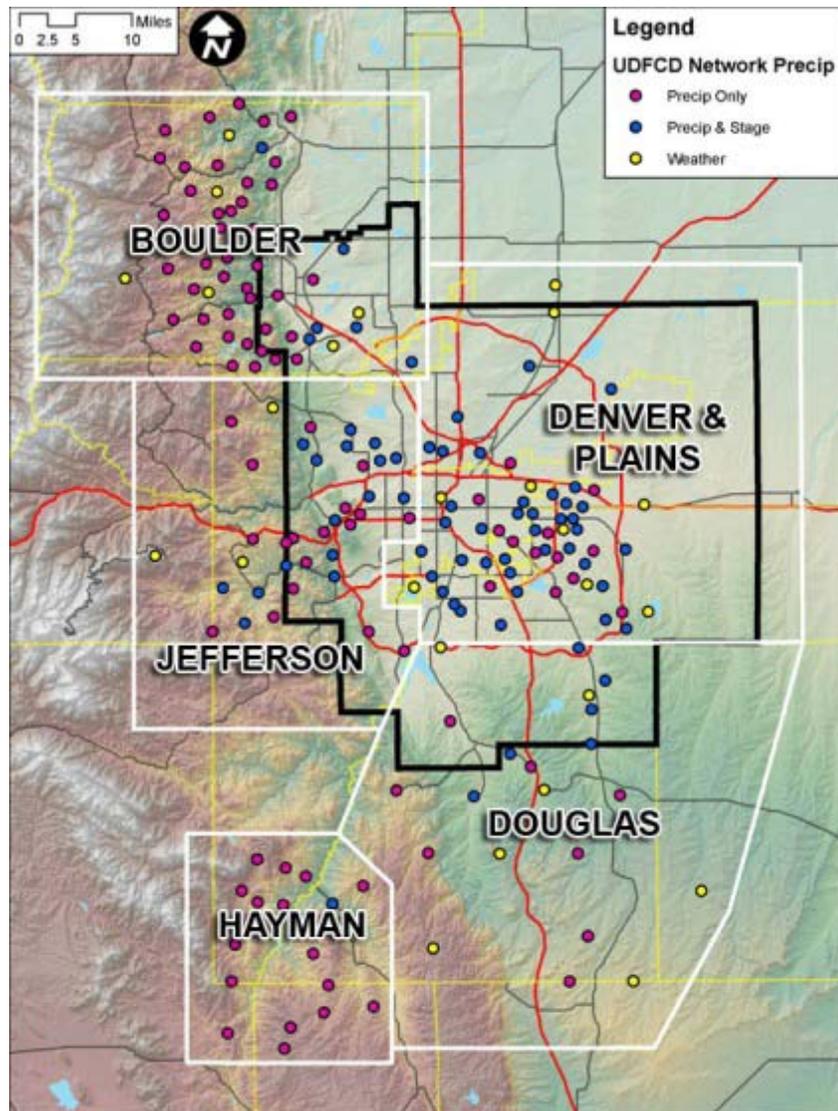


Figure 2 – ALERT Rainfall Alarm Zones