III. DECISION AIDS

GENERAL

A private meteorological service (PMS) retained by the Urban Drainage and Flood Control District (UDFCD) will use decision aids for issuing appropriate messages in accordance with standard operating procedures and the supplemental information contained in this flood warning plan. Site-specific decision aids and flash flood guidance for urban areas and mountain canyons are provided to help anticipate flood conditions from forecast and measured rainfall. The decision aids in this section will be updated as experience is gained and more data becomes available.

An automated flood detection network known as the ALERT System has been installed for the Boulder Creek drainage basin and other watersheds in Boulder County. It consists of self-reporting rain gages, stream gages and weather stations that relay data using battery-powered VHF radios. The Boulder County gages are part of a much larger network operated by UDFCD. ALERT base stations located at UDFCD's main office, the UDFCD Flood Prediction Center (FPC), and the Boulder Public Safety Building (PSB) collect and display data from the gaging network in real-time. The base stations also host web services that allow users to view information over the Internet and via city and county local area networks (PSB base only). Rainfall and stream level alarms will alert users of threatening conditions. Alarm notifications can be emailed automatically to warning plan participants. Data from the gaging network is used to update flood peak forecasts, estimate flow arrival times and predict flood impacts at specific locations.

PMS is responsible for monitoring the FPC base station, evaluating the real-time data and updating forecasts with use of available decision aids. Simplified charts, tables, computer graphics and hydrologic models are the principle decision aids for forecasting floods. Sections IV through VIII contain additional information concerning PMS operations and responsibilities.

City of Boulder and Boulder County personnel have access to the current PMS forecast (pager, email, fax, or Internet…http://f2p2.udfcd.org). ALERT gage data may be accessed from Internet websites maintained by UDFCD (http://alert.udfcd.org and http://alert2.udfcd.org), and from the PSB base station via both city and county LAN connections. Technical personnel should make their own assessments of the flood threat by using the gage data, the PMS forecasts and any observations obtained from field personnel (police, Sheriff, fire, public works, etc.) or other reliable sources. Close coordination with emergency management and other public safety agencies should be maintained throughout this process.

The following decision aids are contained in this section of the warning plan:

1. **Figure III-1, Mountain Canyon Flash Flood Guidance.** This graph and corresponding map provide very basic guidance to help estimate an expected flood flow frequency on Boulder Creek and other mountain streams using either forecast or observed rainfall. The map shows drainage

basin boundaries and ALERT gaging station locations. The red elliptical shape on the map covers an area of 10 square miles to illustrate how average storm rainfall for that area may be estimated.

2. **Table III-1, Urban Flash Flood Guidance**. This table provides very basic rule-of-thumb guidance to associate forecast or measured rainfall amounts with the type of flooding that can be expected from heavy rainstorms that occur over urban areas.
3. **Table III-2, Convective Storm Characteristics**. This table is used to associate forecast or measured rainfall amounts with a return period or annual probability of occurrence. Guidance is provided on how to predict flood magnitude/frequency from rainfall amounts.
4. **Tables III-3 to III-5, Flood Detection Networks for Boulder Creek/South Boulder Creek, Boulder County Plains, and Left Hand Canyon & Saint Vrain Creek**. These tables provide basic information about the ALERT gaging stations located in the respective drainage basins. It is important to understand the location of the gages in relation to the basin boundaries and associated flood hazards (see Figure III-2).
5. **Figure III-2, Boulder County Flood Detection Network**. This figure shows the approximate location of the ALERT gaging stations that comprise the Boulder County FDN.
6. **Figure III-3, Typical ALERT Stream Gage Graphics.** Real-time displays showing current water levels, flow rates, and basin rainfall have been developed. These displays update automatically as data is received and provide information regarding local problem areas, historic floods, flood frequency data, alarm levels, elevation data and site details.
7. **Table III-6, Estimated Flow Travel Times for Various Flood Return Periods.** This table can be used to predict flooding at points downstream from stream gages (see Item 6 above).
8. **Figure III-4, Approximate Flood Hazard Areas—North Boulder.** This map shows the approximate boundary of the regulatory (i.e. 100-year) floodplains for Boulder Creek and other tributary streams that impact the northern portion of the City of Boulder.
9. **Figure III-5, Approximate Flood Hazard Areas—South Boulder.** This map shows the approximate boundary of the regulatory (i.e. 100-year) floodplains for Boulder Creek and other tributary streams that impact the southern portion of the City of Boulder. Additional Internet-based floodplain information can be obtained from a number of websites. The UDFCD website http://www.udfcd.org/svg/svg_mapping.htm was used to develop Figures III-4 and III-5.

THE DECISION MAKING PROCESS

The earliest indication of a potential problem will likely be the forecast from PMS or NWS. When the threat of heavy rainfall exists, PMS will provide a Quantitative Precipitation Forecast (QPF) that estimates probabilities for various precipitation amounts and identifies where the greater amounts are most likely. If the Boulder Creek or South Boulder Creek watersheds are included in the heavy precipitation forecast area, check Figure III-1 and Tables III-1 and III-2 for an indication of the event frequency and the type of problems to expect. If no problems are anticipated based on this review, a normal level of vigilance should be maintained. However, if the decision aids indicate that a flood potential exists, a higher level of awareness should be maintained.

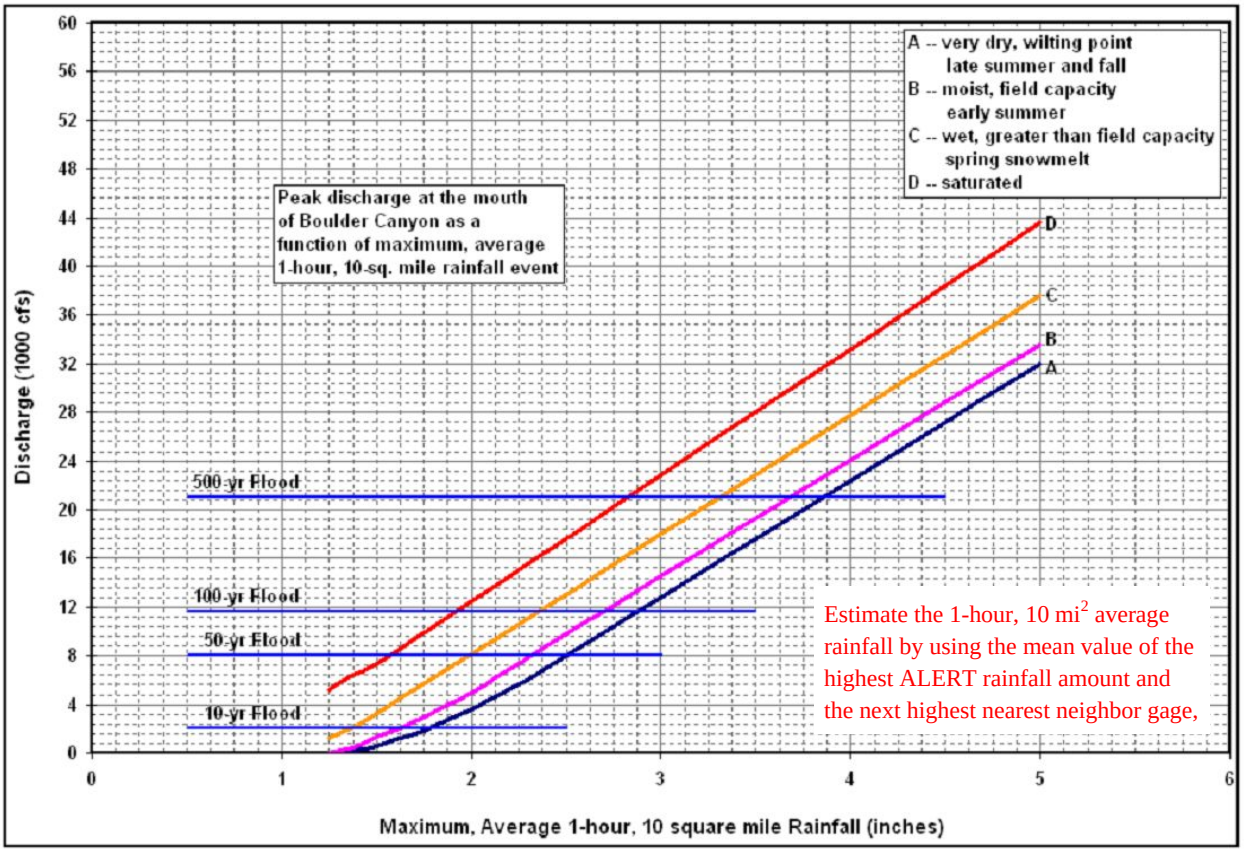
Once rainfall has begun and the gages are reporting rainfall amounts, a further analysis of the flood potential can be made. By determining the heavier rainfall amounts (both measured and projected), estimating the size of the basin area affected and calculating the maximum average 1-hour/10-square mile basin rainfall (Figure III-1); updated projections of the flood threat can be made. Periodic projections should be made until the storm has passed and problems have either occurred or the threat no longer exists. Figures III-4 and III-5 show the approximately flood hazard areas for a 100-year magnitude event and can be used to help direct field operations (road closures, evacuations, etc.).

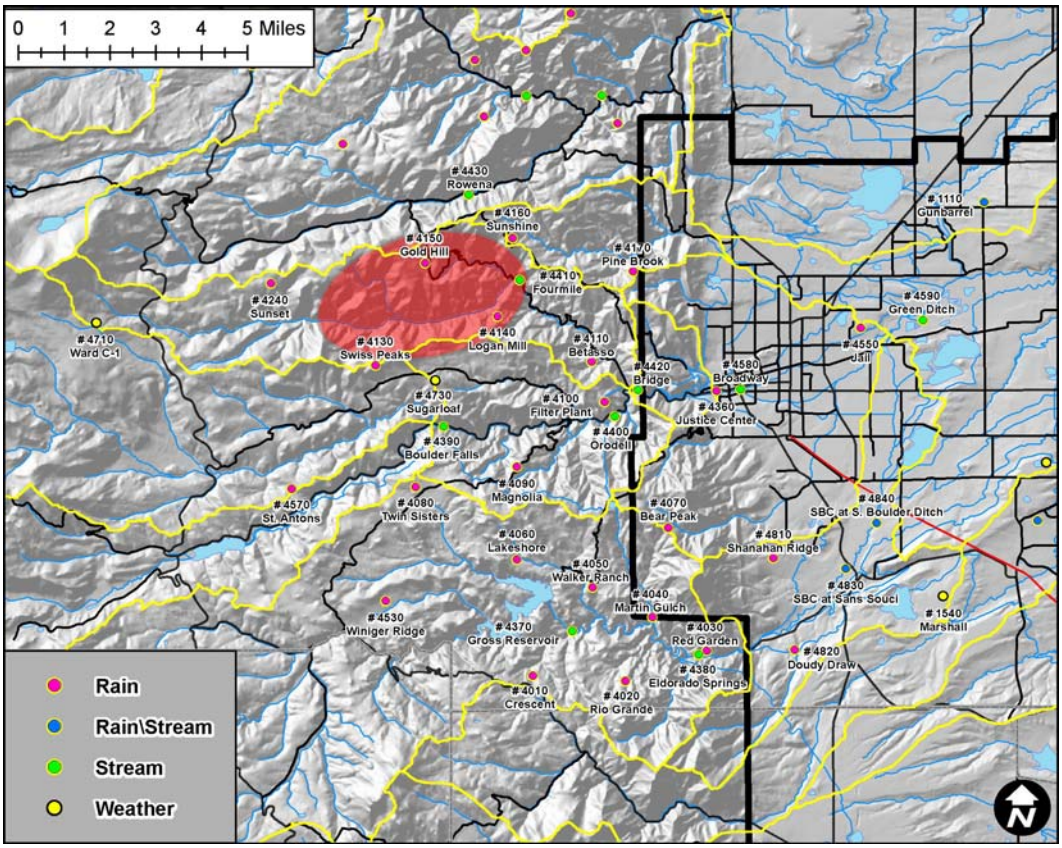
Real-time hydrologic models have been developed for Boulder Creek. Output from one or more of these models may assist with predicting flood magnitudes and timing. Hydrologists may use these models along with the decision aids in this section to further evaluate the flood threat.

The final confirmation that the drainage basin is indeed responding to significant rainfall is the rising stage measured by the ALERT stream gages and field reports from police, fire, public works personnel or other reliable sources. Although it is tempting to wait for this final confirmation, doing so will severely limit the time available to warn floodplain occupants and dispatch emergency personnel to critical areas. Use Table III-6 to estimate flood travel times from each ALERT stream gage at downstream locations.

Once the decision has been made that a significant flood threat exists, it is imperative that the warning and response elements of this plan be implemented.

Figure III-1
Mountain Canyon Flash Flood Guidance





NOTE: The red-shaded ellipse above represents a 10 square mile area.

Table III-1
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
URBAN FLASH FLOOD GUIDANCE

FORECAST RAINFALL	FLOOD POTENTIAL	RECOMMENDED ACTIONS
Total Amt less than 1.0”	Streets, low-lying areas, intersections	Prepare for routine nuisance
Total Amt = 1.0 to 2.0”	All of the above plus small streams, bankfull	Prepare for flooding of frequent problem areas
Total Amt = 2.0 to 3.0”	All of the above plus floodplain inundation	Prepare for street closures
Total Amt more than 3.0”	Major overbank flooding expected	Prepare for floodplain evacuations
Note: Rainfall amounts and guidance information apply to short duration storms (<= 1-hour)	Note: refer to basin flood warning plans for site specific data	Note: use judgement on when to warn public, maintain contact with meteorologist

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Table III-2
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
CONVECTIVE STORM CHARACTERISTICS

(All depths in inches)

Rainfall Frequency / Probability	10-minute Rainfall Depth	30-minute Rainfall Depth	1-hour Rainfall Depth	2-hour Rainfall Depth
2-year / 50%	0.4	0.8	1.0	1.2
5-year / 20%	0.5	1.0	1.4	1.6
10-year / 10%	0.6	1.2	1.6	1.9
25-year / 4%	0.7	1.4	1.9	2.2
50-year / 2%	0.8	1.6	2.2	2.6
100-year / 1%	1.0	1.9	2.6	3.0

NOTES:

1) For "rainfall frequency" to equal "flood frequency," the coverage of rainfall must be over the entire upstream basin.
2) Tables III-1 and III-2 were developed to provide generalized guidance for estimating flood conditions in urban areas and for small streams draining less than 10 square miles. Site-specific guidance should be used where appropriate.

Table III-3
FLOOD DETECTION NETWORK
BOULDER CREEK & SOUTH BOULDER CREEK

Station ID	Station Name	Gage Type	Install Date	Elevation	Location (Lat. / Long.)
SOUTH BOULDER CREEK					
4010	Crescent	RAIN	1979-80	7760	39:55:27 N 105:21:50 W
4020	Rio Grande	RAIN	1979-80	7330	39:55:21 N 105:19:33 W
4030	Red Garden	RAIN	1979-80	6360	39:55:55 N 105:17:32 W
4040	Martin Gulch	RAIN	1979-80	6520	39:56:34 N 105:18:53 W
4050	Walker Ranch	RAIN	1979-80	7320	39:57:08 N 105:20:21 W
4060	Lakeshore	RAIN	1979-80	7700	39:57:40 N 105:22:13 W
4070	Bear Peak	RAIN	1979-80	6920	39:58:16 N 105:18:29 W
4080	Twin Sisters	RAIN	1979-80	8120	39:59:03 N 105:24:43 W
4530	Winiger Ridge	RAIN	1984-85	8130	39:56:53 N 105:25:27 W
4373	Gross Reservoir	STREAM	1997/06/04	6800	39:56:18 N 105:20:51 W
4383	Eldorado Springs	STREAM	1997/04/17	6060	39:55:51 N 105:17:44 W
4810	Shanahan Ridge	RAIN	2002/09/19	5840	39:57:41 N 105:15:55 W
4820	Doudy Draw	RAIN	2002/09/20	5740	39:55:56 N 105:15:25 W
4830 [+3]	SBC at San Souci	RAIN & STREAM	2002/09/24	5470	39:57:28 N 105:14:09 W
4840 [+3]	SBC at S. Boulder Ditch	RAIN & STREAM	2002/10/09	5400	39:58:21 N 105:13:23 W
BOULDER CREEK & FOURMILE CREEK					
4090	Magnolia	RAIN	1978-79	7320	39:59:26 N 105:22:13 W
4100	Filter Plant	RAIN	1978-79	6360	40:00:40 N 105:20:03 W
4110	Betasso	RAIN	1978-79	6480	40:01:26 N 105:20:22 W
4130	Swiss Peaks	RAIN	1978-79	8600	40:01:22 N 105:25:42 W
4140	Logan Mill	RAIN	1978-79	7200	40:02:18 N 105:22:41 W
4150	Gold Hill	RAIN	1978-79	8120	40:03:19 N 105:24:28 W
4240	Sunset	RAIN	1981-82	8680	40:02:56 N 105:28:17 W
4360	Justice Center	RAIN	1981-82	5400	40:00:52 N 105:17:17 W
4393	Boulder Falls	STREAM	1997/04/03	6820	40:00:12 N 105:24:01 W
4403	Orodell	STREAM	1997/04/03	5825	40:00:18 N 105:19:51 W
4413	Fourmile	STREAM	1997/04/17	6520	40:03:00 N 105:22:08 W
4423	Bridge	STREAM	1997/04/03	5700	40:00:54 N 105:19:11 W
4550	Jail	RAIN	1997/06/02	5290	40:02:04 N 105:13:43 W
4570	St. Antons	RAIN	1984-85	8350	39:59:01 N 105:27:46 W
4583	Broadway	STREAM	2006/02/07	5348	40:00:54 N 105:16:43 W
4593	Green Ditch	STREAM	2006/05/07	5154	40:02:12 N 105:12:13 W
4710	Ward C-1	WEATHER	1997/07/22	9700	40:02:11 N 105:32:35 W
4730	Sugarloaf	WEATHER	1997/06/23	7860	40:01:05 N 105:24:13 W
4750	Louisville Lake	WEATHER	1998/07/26	5580	39:59:32 N 105:09:12 W
FOURMILE CANYON CREEK					
4160	Sunshine	RAIN	1978-79	7560	40:03:47 N 105:22:19 W
4170	Pine Brook	RAIN	1981-82	6920	40:03:09 N 105:19:20 W

Table III-4
BOULDER COUNTY PLAINS

Station ID	Station Name	Gage Type	Install Date	Elevation	Location (Lat. / Long.)
PLAINS STATIONS					
1100 [+3]	Louisville Rec Center	RAIN & STREAM	1988/05/06	5464	39:58:23 N 105:09:22 W
1110 [+3]	Gunbarrel	RAIN	1991/12/01	5225	40:04:27 N 105:10:40 W
1540	Marshall Test Site	RAIN	2006/09/27	5717	39:56:57 N 105:11:43 W

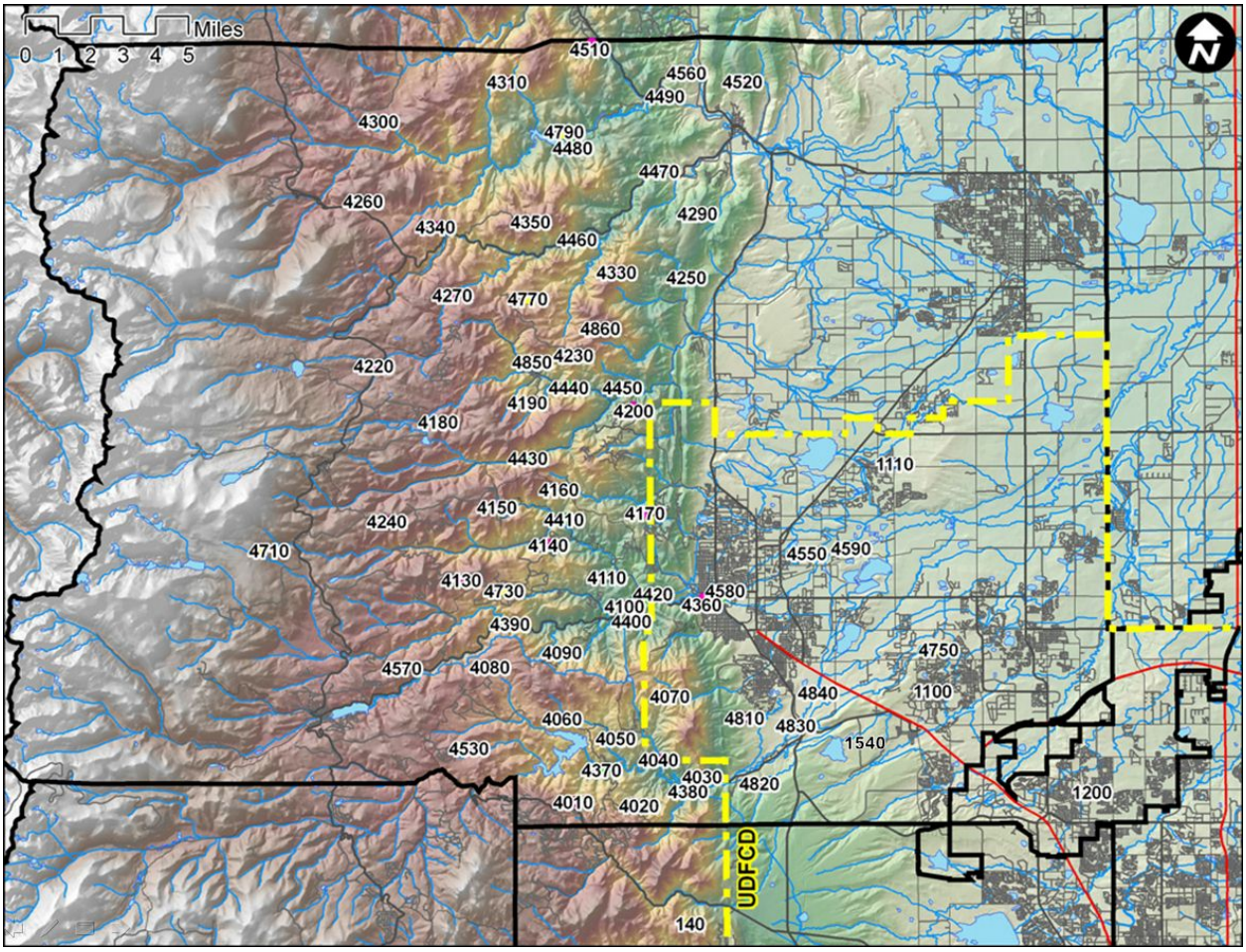
Weather Station IDs: +0 Rain, +1 Relative Humidity, +2 Air Temperature, +4 Barometric Pressure, -6 Peak Wind Gust, -3 Average Wind Speed & Wind Direction

Table III-5
FLOOD DETECTION NETWORK
LEFT HAND CANYON & SAINT VRAIN CREEK

Station ID	Station Name	Gage Type	Install Date	Elevation	Location (Lat. / Long.)
LEFT HAND CREEK & JAMES CREEK					
4180	Gold Lake	RAIN	1981-82	8560	40:05:35 N 105:26:30 W
4190	Slaughterhouse	RAIN	1981-82	7400	40:06:06 N 105:23:01 W
4200	Lazy Acres	RAIN	1981-82	7020	40:05:58 N 105:19:43 W
4230	Golden Age	RAIN	1981-82	8160	40:07:22 N 105:21:58 W
4250	Geer Canyon	RAIN	1981-82	6080	40:09:26 N 105:17:52 W
4330	Indian Ruins	RAIN	1981-82	7790	40:09:34 N 105:20:18 W
4433	Rowena	STREAM	1997/05/06	7170	40:04:37 N 105:23:24 W
4443	James Creek	STREAM	1997/05/05	6680	40:06:30 N 105:21:58 W
4453	Lower Left Hand	STREAM	1997/04/30	6230	40:06:30 N 105:20:06 W
4850	Porphyry Mountain	RAIN	2004/07/07	7347	40:07:11 N 105:23:16 W
4860	Fairview Peak	RAIN	2004/08/11	8260	40:08:04 N 105:20:54 W
SOUTH ST. VRAIN CREEK					
4220	Fling's	RAIN	1981-82	8590	40:07:05 N 105:28:44 W
4270	Cannon Mountain	RAIN	1981-82	8120	40:08:58 N 105:26:00 W
4290	Red Hill	RAIN	1981-82	6590	40:11:08 N 105:17:29 W
4463	SSV at Berry Ridge	STREAM	1997/04/21	6495	40:10:27 N 105:21:40 W
4470 [+3]	Little Narrows	RAIN & STREAM	1997/04/21	5620	40:12:16 N 105:18:49 W
4770	Cal-Wood Ranch	WEATHER	1997/06/20	7760	40:08:52 N 105:23:23 W
NORTH ST. VRAIN CREEK					
4260	Taylor Mountain	RAIN	1981-82	8425	40:11:28 N 105:29:06 W
4300	Big Elk Park	RAIN	1981-82	8600	40:13:36 N 105:28:34 W
4310	Johnny Park	RAIN	1981-82	7680	40:14:39 N 105:24:06 W
4340	Riverside	RAIN	1981-82	8340	40:10:47 N 105:26:36 W
4350	Conifer Hill	RAIN	1981-82	8120	40:10:55 N 105:23:17 W
4480	Button Rock Lake	RAIN	1996/06/03	6200	40:12:57 N 105:21:49 W
4490	Apple Valley	RAIN	1984-85	5920	40:14:18 N 105:18:37 W
4510	Pinewood Springs	RAIN	1984-85	6850	40:15:40 N 105:21:08 W
4520	Eagle Ridge	RAIN/REPEATER	1996/06/01	6280	40:14:39 N 105:15:54 W
4563	Lyons Diversion	STREAM	1997/07/11	5560	40:14:53 N 105:17:51 W
4790	Button Rock	WEATHER	1992/05/11	6500	40:13:15 N 105:22:07 W

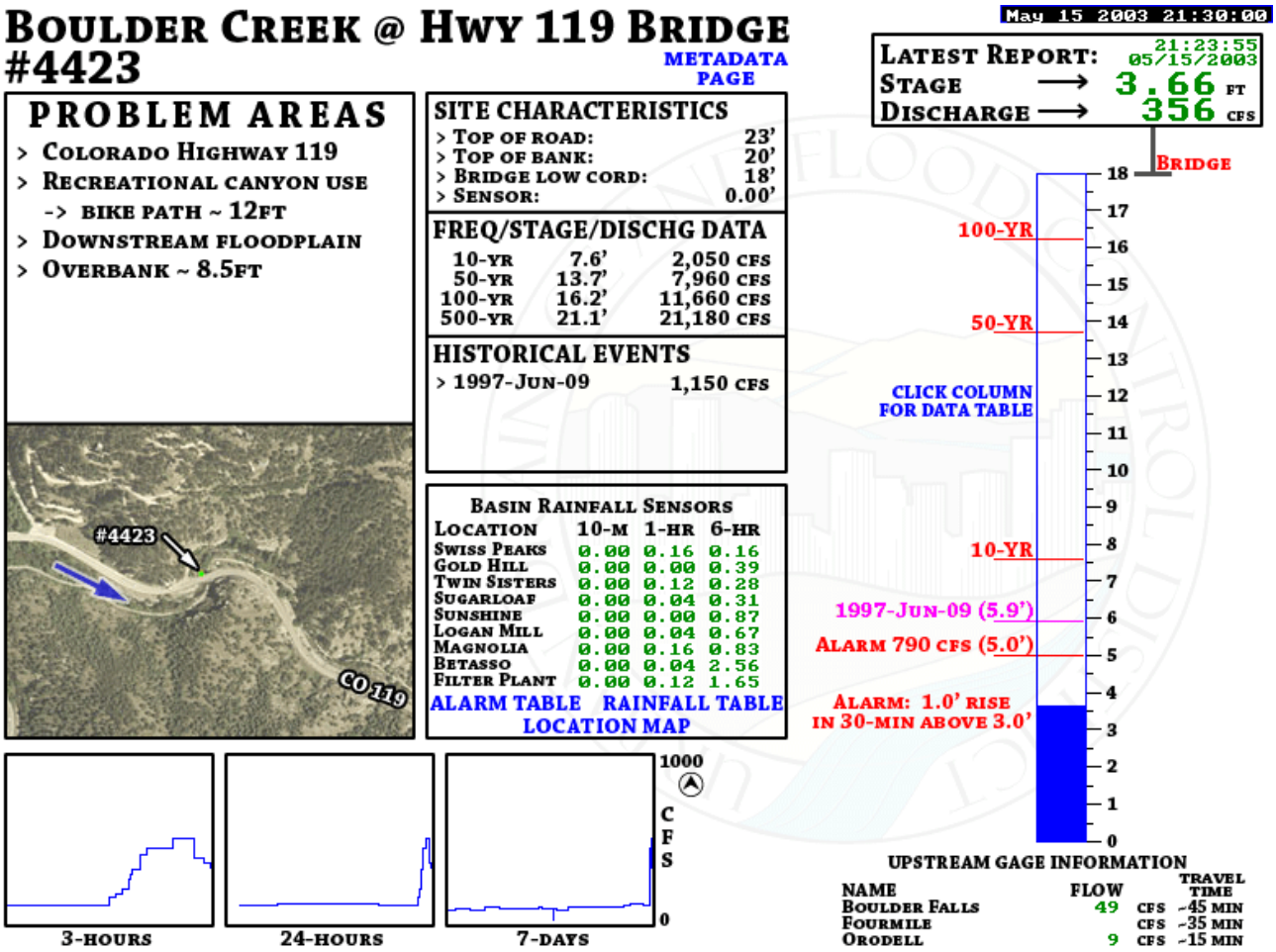
Weather Station IDs: +0 Rain, +1 Relative Humidity, +2 Air Temperature, +4 Barometric Pressure, -6 Peak Wind Gust, -3 Average Wind Speed & Wind Direction

Figure III-2
BOULDER COUNTY FLOOD DETECTION NETWORK



Note: The numbers on the map represent ALERT gaging station ID's. For device ID numbers (i.e. rain gages, stream gages, and weather sensors) refer to Tables III-3, III-4 and III-5.

Figure III-3
Typical ALERT Stream Gage Graphics



Note: Graphic displays like the one above for ALERT stream gages may be viewed by clicking on flow rate or water level values on the streamflow map – http://alert2.udfcd.org/cgi-bin/gdview?tpt=map21qweb

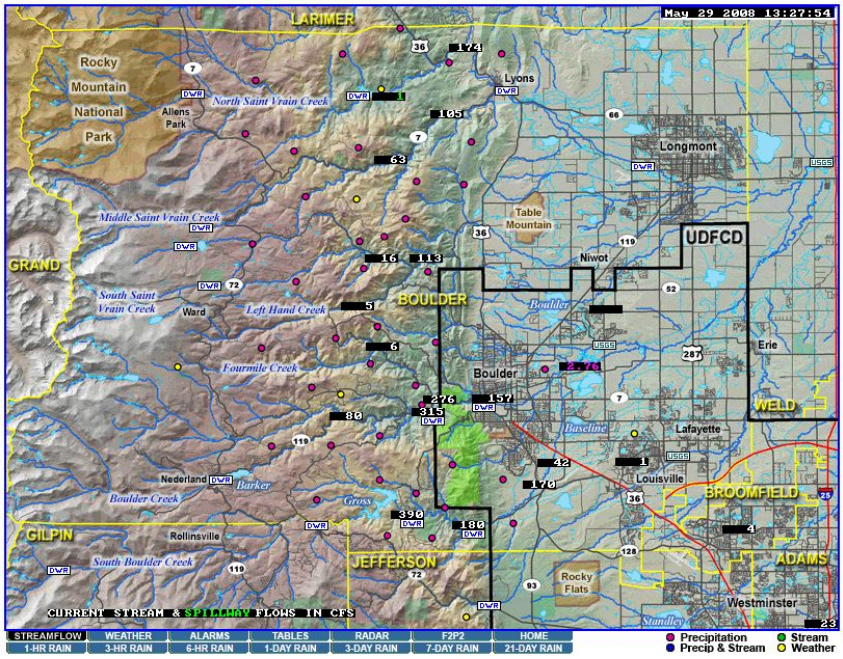


Table III-6
Flow Travel Times for Various Flood Return Periods

from Gross Reservoir (Gage No. 4373)

To:	10-Year	50-Year	100-Year	500-Year
Eldorado Springs	72 minutes	48 minutes	40 minutes	31 minutes
Colorado Highway 93	109 minutes	74 minutes	62 minutes	51 minutes

from Eldorado Springs (Gage No. 4383)

Colorado Highway 93	37 minutes	26 minutes	22 minutes	20 minutes

from Boulder Falls (Gage No. 4393)

Orodell Gage #4403	46 minutes	35 minutes	33 minutes	24 minutes
Bridge Gage # 4423	64 minutes	47 minutes	46 minutes	32 minutes
Boulder	79 minutes	58 minutes	53 minutes	40 minutes

from Orodell (Gage No. 4403)

Bridge Gage # 4423	16 minutes	13 minutes	12 minutes	8 minutes
Boulder	33 minutes	23 minutes	20 minutes	16 minutes

from Fourmile at Salina (Gage No. 4413)

Bridge Gage # 4423	38 minutes	36 minutes	29 minutes	26 minutes
Boulder	53 minutes	43 minutes	40 minutes	34 minutes

from Bridge (Gage No. 4423)

Boulder	15 minutes	11 minutes	7 minutes	8 minutes

Figure III-4
APPROXIMATE FLOOD HAZARD AREAS

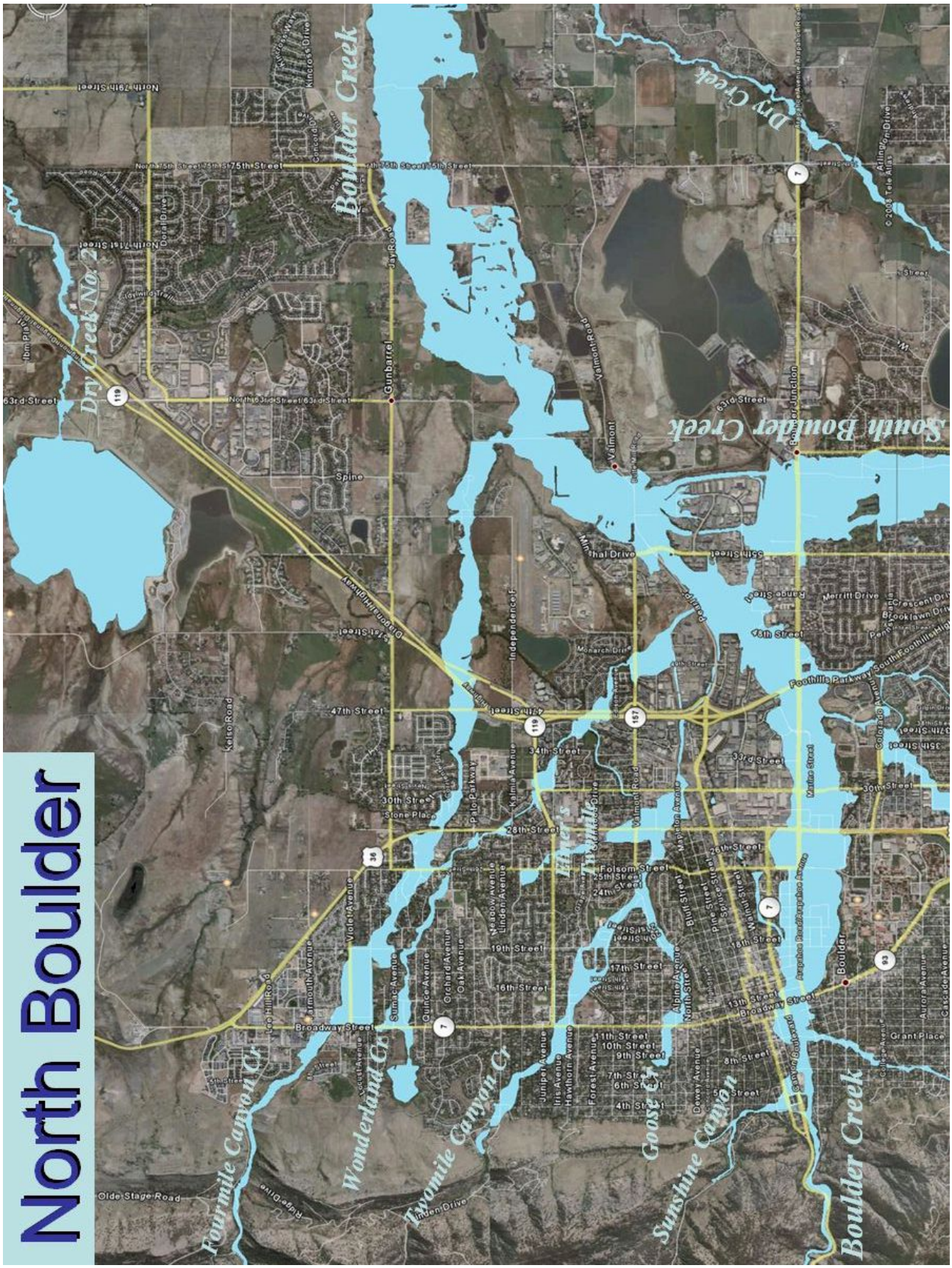


Figure III-5
APPROXIMATE FLOOD HAZARD AREAS