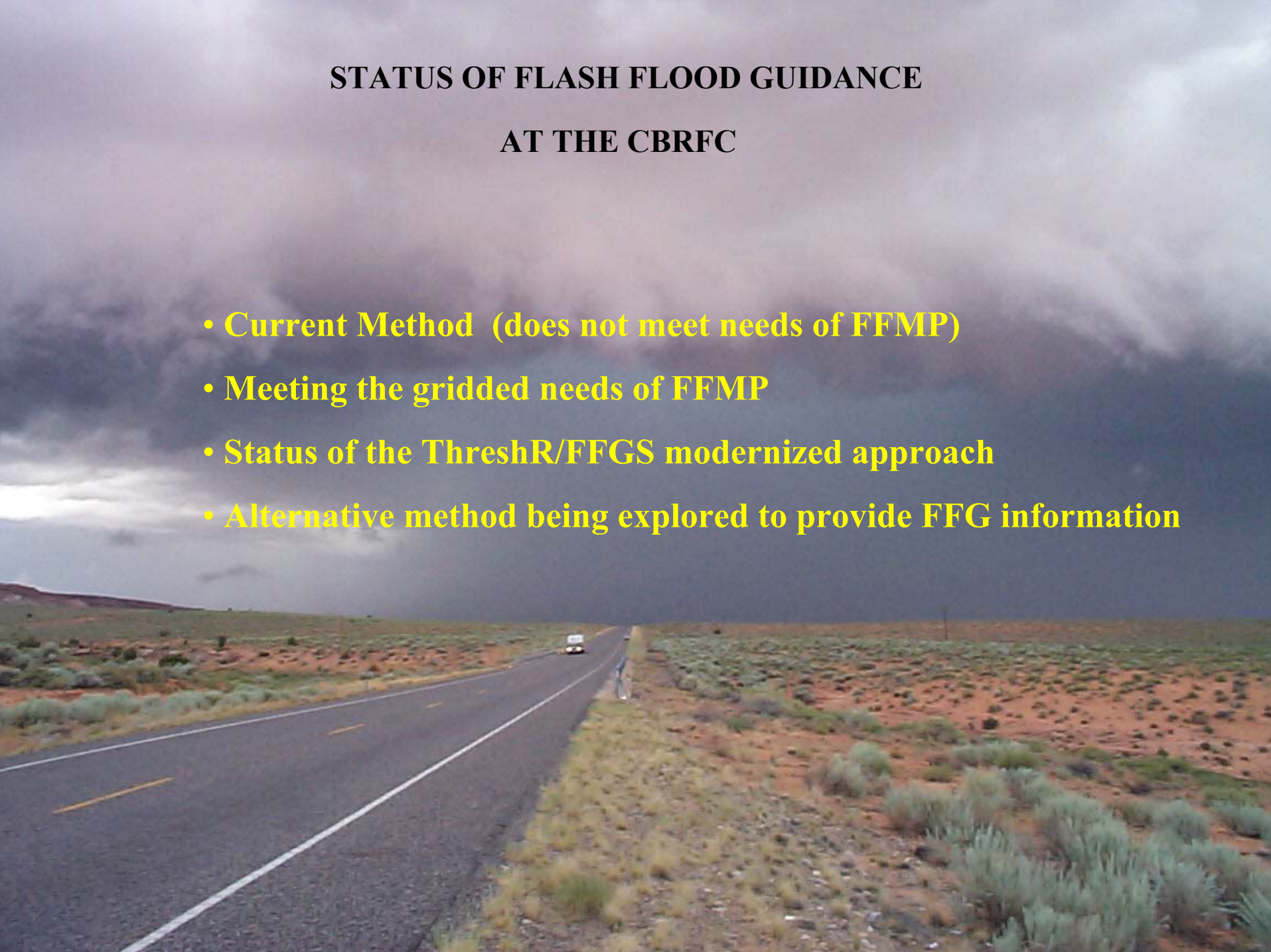
STATUS OF FLASH FLOOD GUIDANCE

AT THE CBRFC

- Current Method (does not meet needs of FFMP)
- Meeting the gridded needs of FFMP
- Status of the ThreshR/FFGS modernized approach
- Alternative method being explored to provide FFG information



How Do We Calculate FFG Now ?

Empirical In Nature – Based On Historical Observations

Input:

8-10 YR 1, 3, 6 hour return period precip amounts

Palmer Drought Index – Skew Values (soil moisture effect)

Output:

1, 3, 6, hour flash flood guidance by WFO forecast zone

FLASH FLOOD GUIDANCE PRODUCT

ZCZC SLCFFGAZ CSW
FOUS65 KSR 220825
FFGAZ
ZONE FLASH FLOOD GUIDANCE
COLORADO BASIN RIVER FORECAST CENTER…SALT LAKE CITY UT

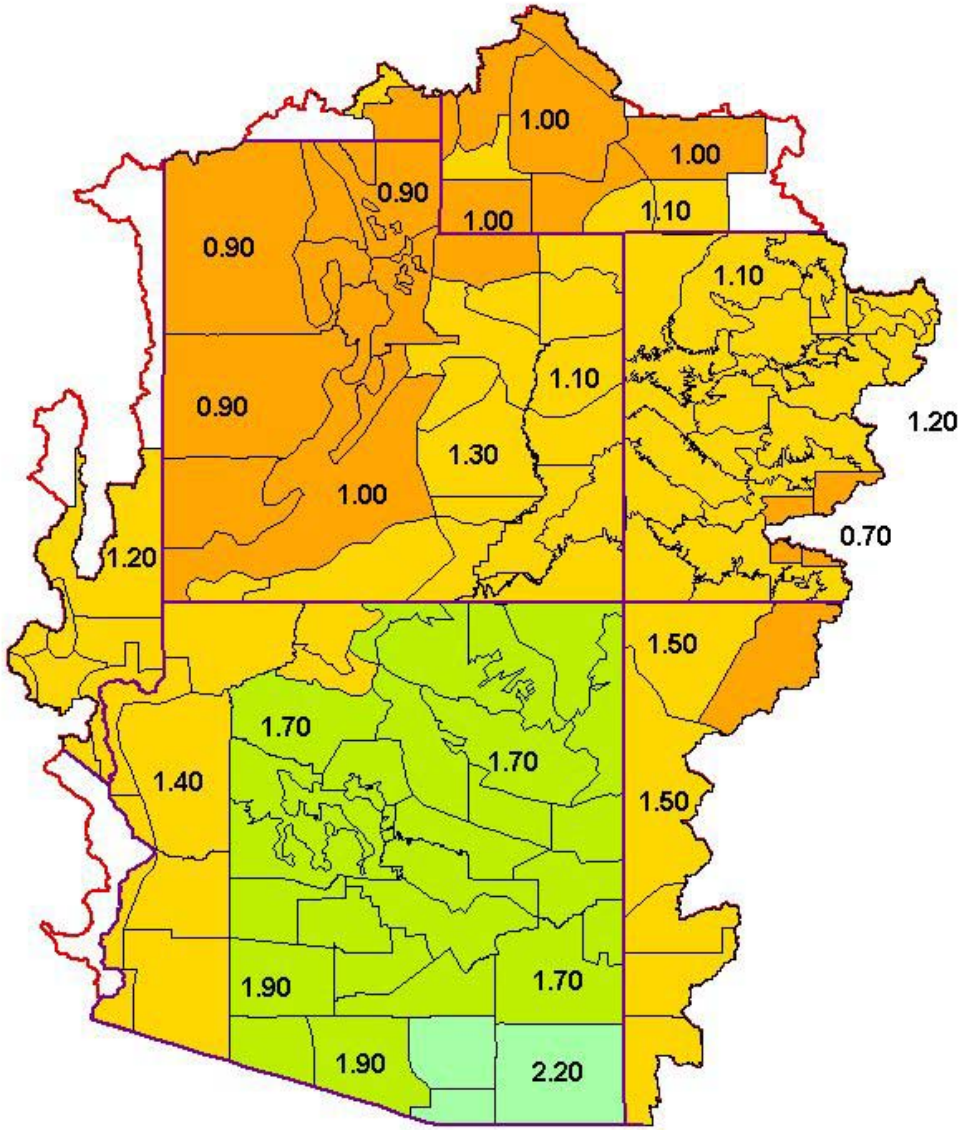
ISSUED 0800 AM MDT TUE MAY 22 2001

Flash Flood Guidance is primarily dependent upon terrain and rainfall intensity. Flash Flood Guidance for urban areas and steep mountainous terrain may be less than indicated.

.B SLR 20010522 Z DH12/DC200105220825 /DUE/PFH/PFT/PFQ

:IDENT	1HR	3HR	6HR
:======	====	====	====
AZZ001	1.4/	1.5/	2.0
AZZ002	1.4/	1.5/	2.0
AZZ003	1.4/	1.5/	2.0
AZZ004	1.6/	2.1/	2.3

1-Hour CBRFC Flash Flood Guidance



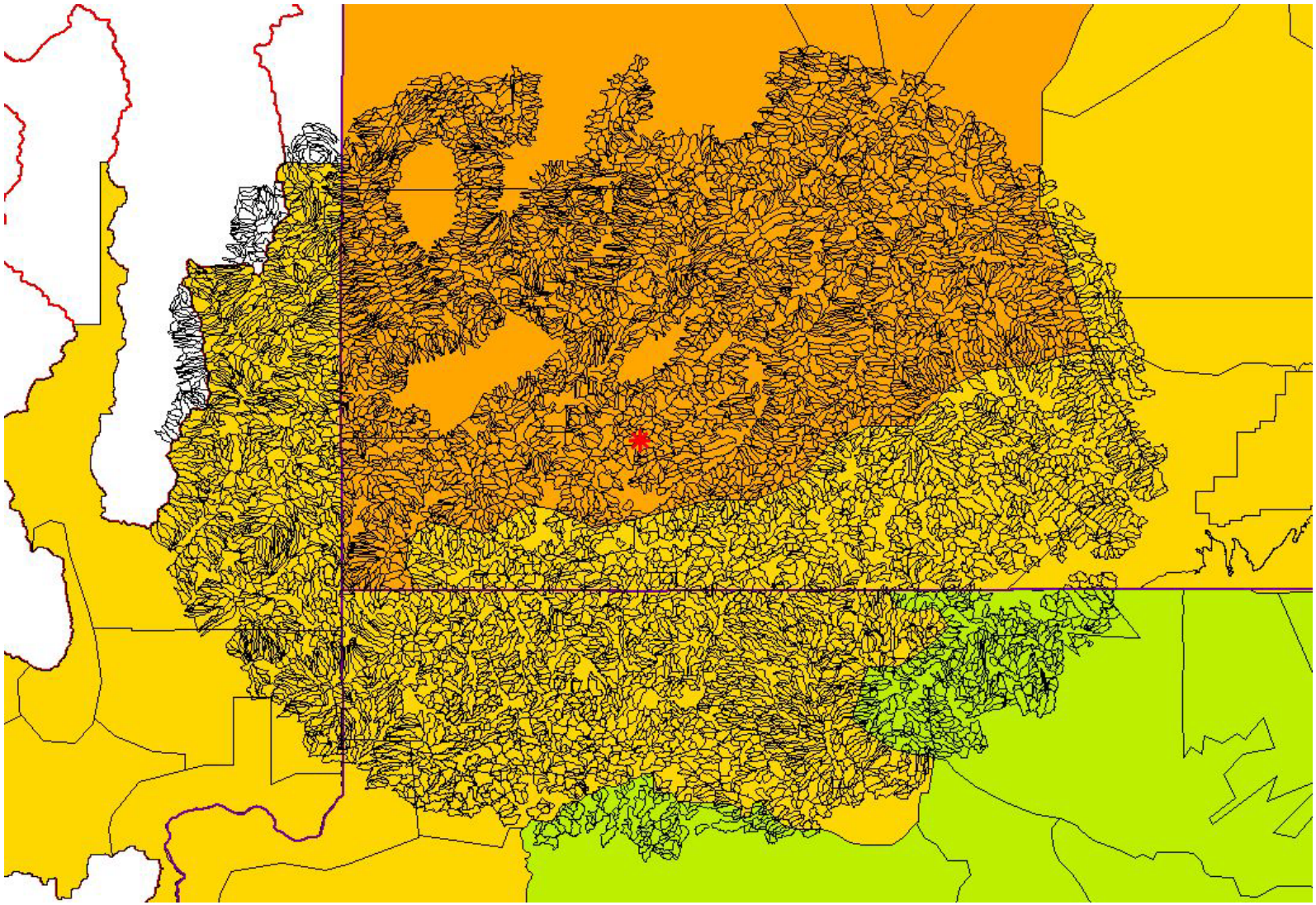
Flash Flood Guidance Inches

- 0.01 - 0.50
- 0.51 - 1.00
- 1.01-1.50
- 1.51 - 2.00
- 2.01 - 2.50

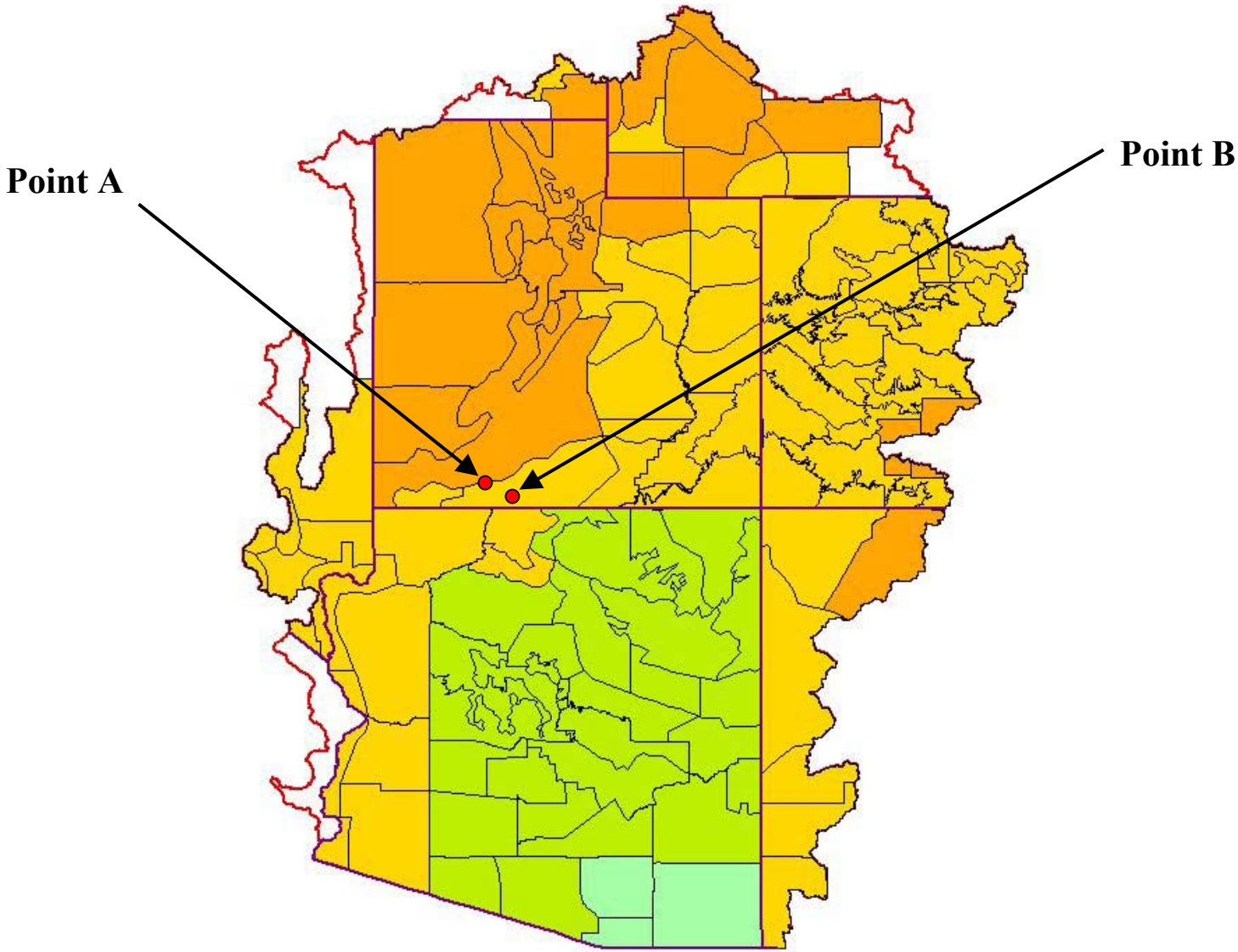
August 2001

KICX FFMP basins overlayed with current zone guidance

Tools like this emphasize the need for greater spatial detail flash flood potential or guidance information



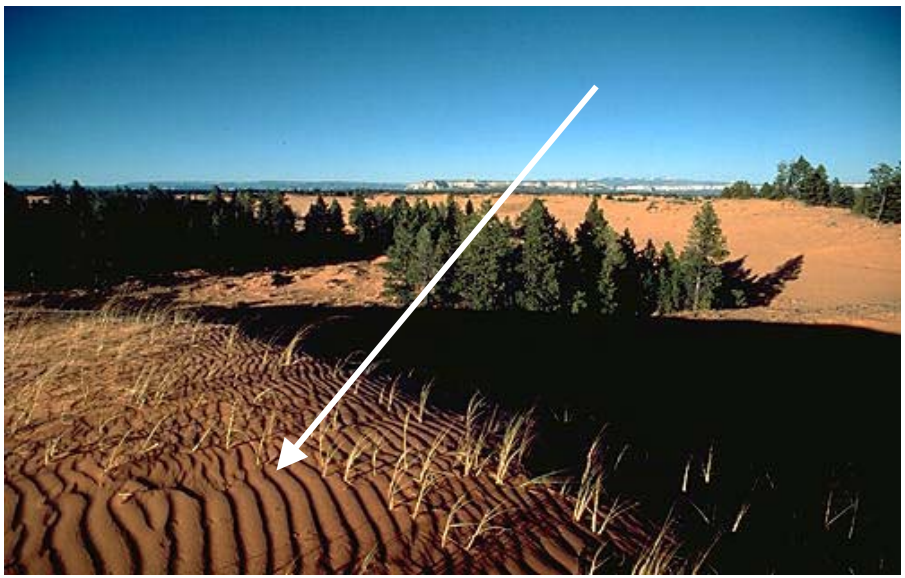
A Comparison of Flash Flood Guidance



POINT A

Parunuweap Canyon on the East Fork of the Virgin River – well known classic flash flood canyon about 10 miles northwest of point B.

Current Method Implies Similar Hydrologic Response



POINT B

Sand dunes near Moquith Mountain.

1-Hour Flash Flood Guidance on this date = 1.10” for both point A and B.

Modernized Guidance – ThreshR/FFG System

The modernized program attempted to provide a standard methodology for creating FFG. Guidance created on a 4km HRAP Grid in order to effectively use WSR-88D radar estimates.

Threshold Runoff:

A fixed value of runoff required to initiate flooding. It is based on geographic and hydrologic features of the stream channel and basin.

Flash Flood Guidance System:

Threshold Runoff

Definition: **R = Qp / qp * A**

R = Threshold Runoff in inches

Qp = Bankfull discharge in cfs (select a return frequency)

qp = Unit HG peak flow in cfs per unit area in sq. miles (cfs/sq. mi)

A = Area in square miles

ThreshR values are desired for thousands of small watersheds

Modernized Guidance – ThreshR/FFG System

UTAH: USGS Regression for Northern Mountain Elevation Region A

$$Q10 = .071A^{0.815}E^{2.70}$$

Q10 = 10 yr peak discharge A = Area E = Elevation

Snyder Unit Hydrograph Method

$$qp = 640\ Cp\ A / t_p$$

$$t_p = C_t (LL_c)^{0.3}$$

What is Bankfull ?

USGS Regions

UTAH: Northern Mountain Elevation Region A

$Q10 = .071A^{0.815}E^{2.70}$

A = Area E = Elevation

COLO: Mountain Region

$Q10 = 86.1A^{0.699}SB^{0.635}$

A = Area
SB = Mean Basin Slope

Snyder Unit Hydrograph Method

$$qp = 640\ C_p\ A / t_p$$

$$t_p = C_t\ (\ LL_c\ )^{0.3}$$

C_p and C_t coefficients are usually derived from gaged watersheds in the same region – this is a problem in much of our remote areas – gaged streams are not representative of the flash flood scale

The coefficients are usually inversely related with C_p ranging from 0.4 – 0.8 and C_t in extreme terrain ranging from 0.4 to 8.0

How do we get these for our basins ?

Modernized Guidance – ThreshR/FFG System

The modernized program attempted to provide a standard methodology for creating FFG. Guidance created on a 4km HRAP Grid in order to effectively use WSR-88D radar estimates.

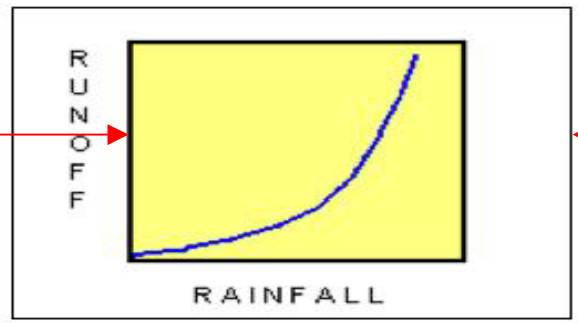
Threshold Runoff:

A fixed value of runoff required to initiate flooding. It is based on geographic and hydrologic features of the stream channel and basin.

Flash Flood Guidance System:

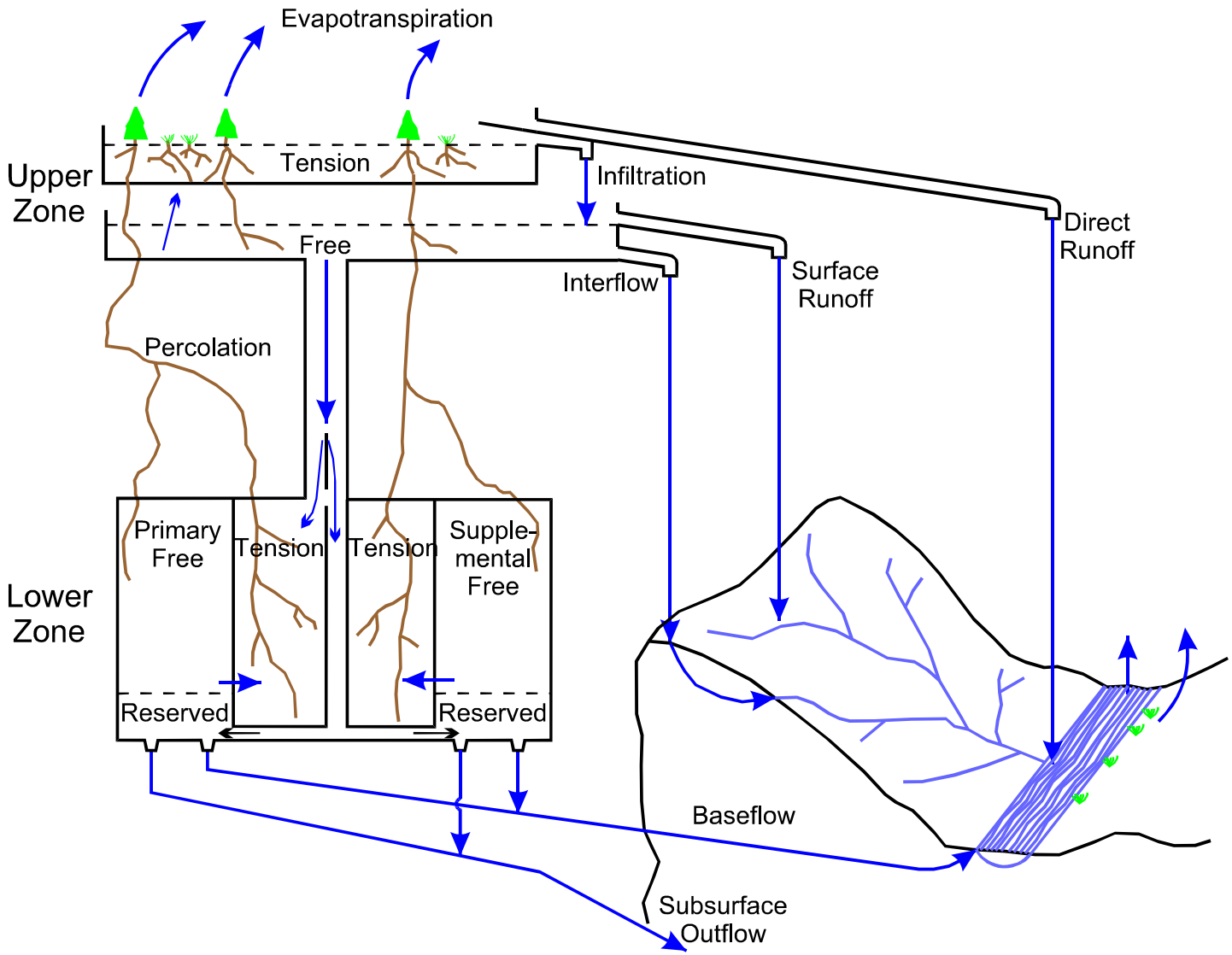
Derives an amount of rainfall that is controlled by soil moisture state from the SAC-SMA model at the RFC and the threshold runoff value.

threshold runoff
(Input to FFG System)

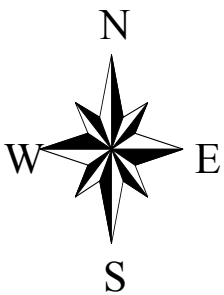


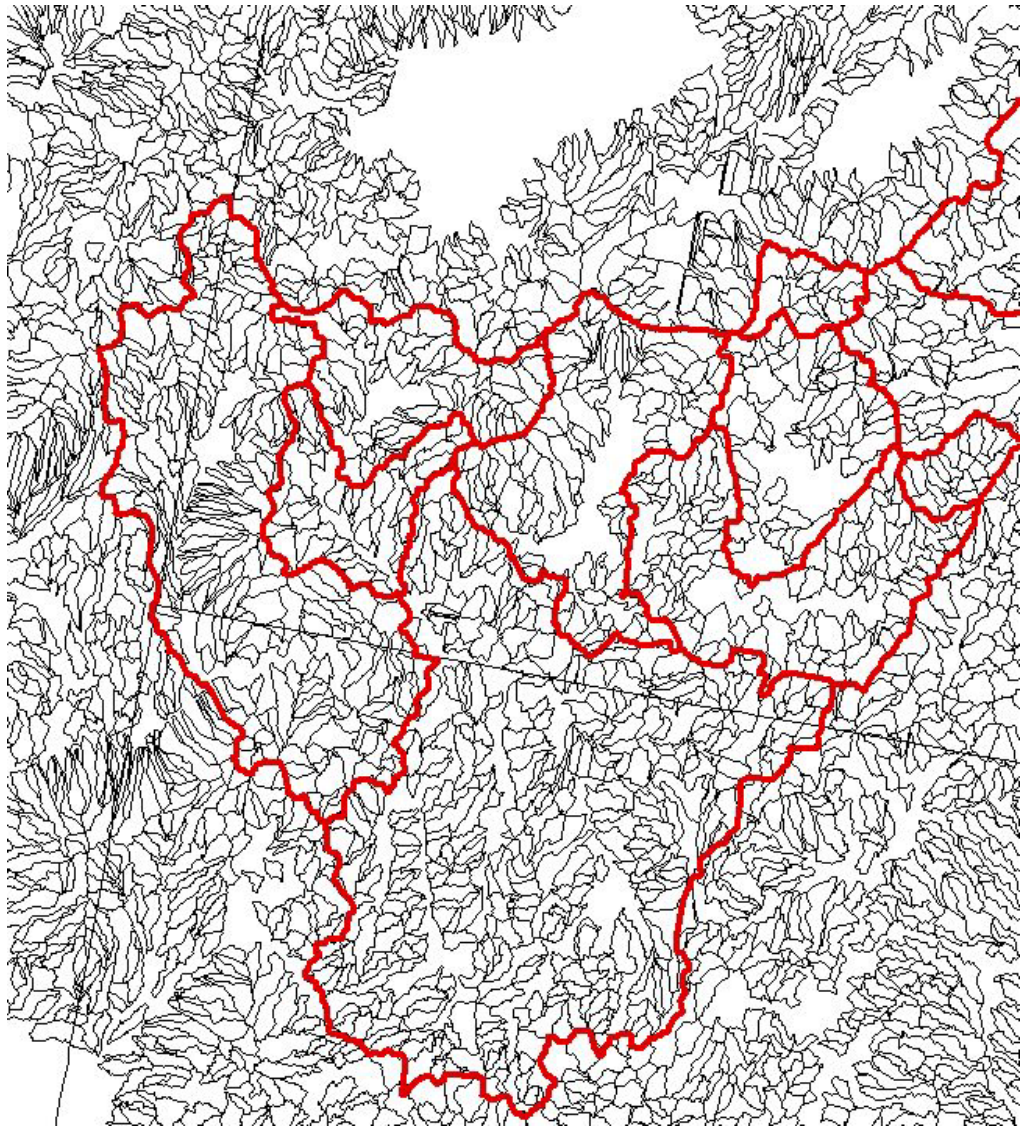
rainfall-runoff curve generated by sac-sma model independent of threshr value.

Limitation: Use of SAC-SMA model at a flash flood scale



FFMP (flash flood) basin size vs. NWSRFS calibrated basins





SAC-SMA Issues

Calibrations for this model are typically for large basins (frequently exceeding 100 sq. miles) vs. flash flood basins that occur on basins as small as 5 sq. miles.

Calibrations are based on historical 6 hour precipitation and temperature data (much of it derived from daily data) as well as mean daily streamflow. The model executes on 6 hour time steps - unrepresentative of western flash flood events.

Many calibrations are primarily developed for seasonal events such as snowmelt, volumetric water supply and synoptic scale events and do not produce realistic runoff values for short duration precipitation input.

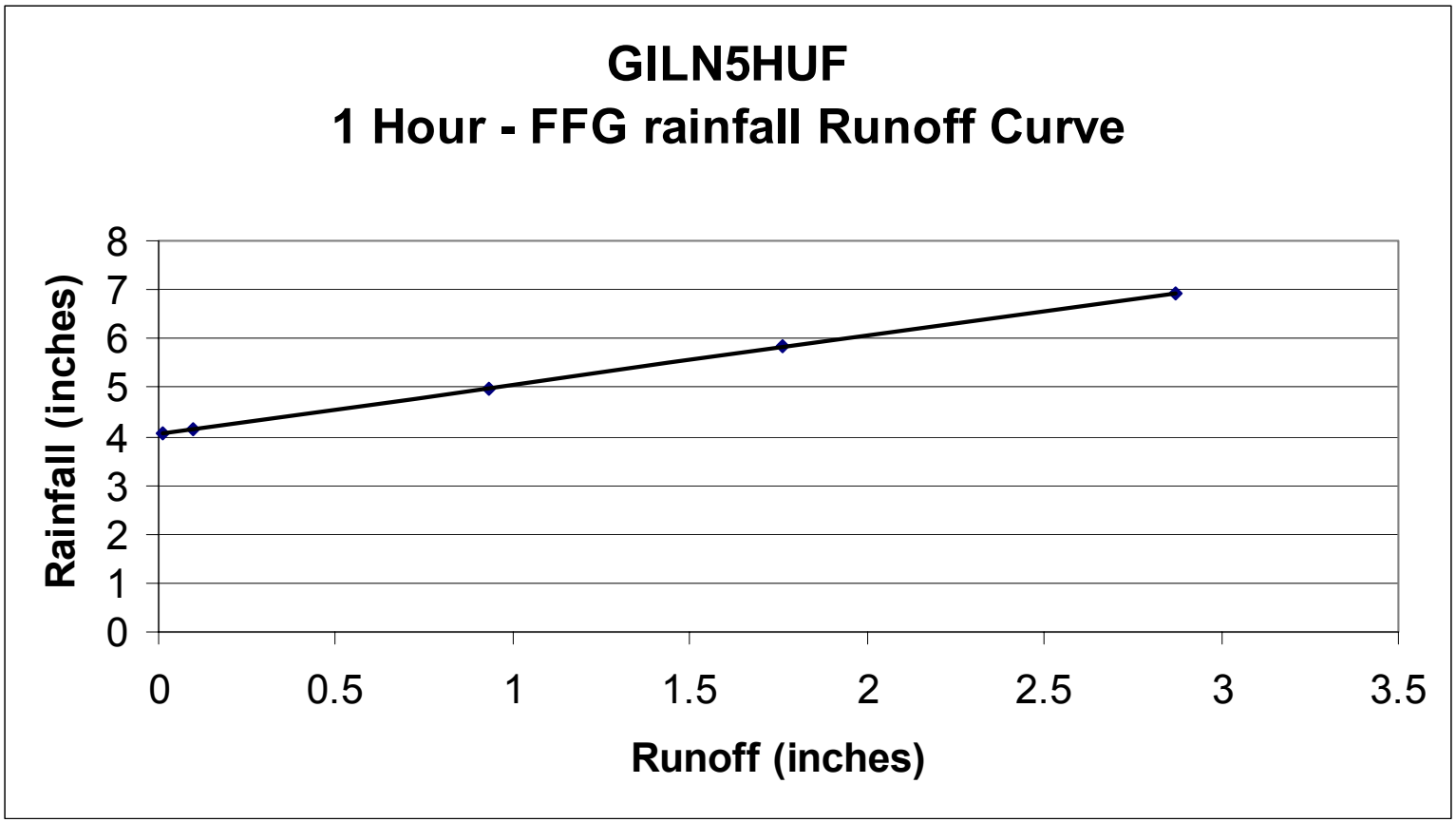
Precipitation catchment and intensity will be underrepresented due to the time scale and spatial scale of MAP areas that are much larger than individual convective cells.

Upper zone tension water tanks that are required to fill before generating runoff will not react properly to high intensity short duration rainfall. Deficits are frequently high in semi-arid areas and following extended periods of dry weather.

SAC-SMA rainfall-runoff curve in the Gila River Basin

Due to tension water deficits 4” of precipitation is required before runoff is generated

Even with Threshold Runoff set to zero !



Modernized vs. Current Flash Food Guidance Output

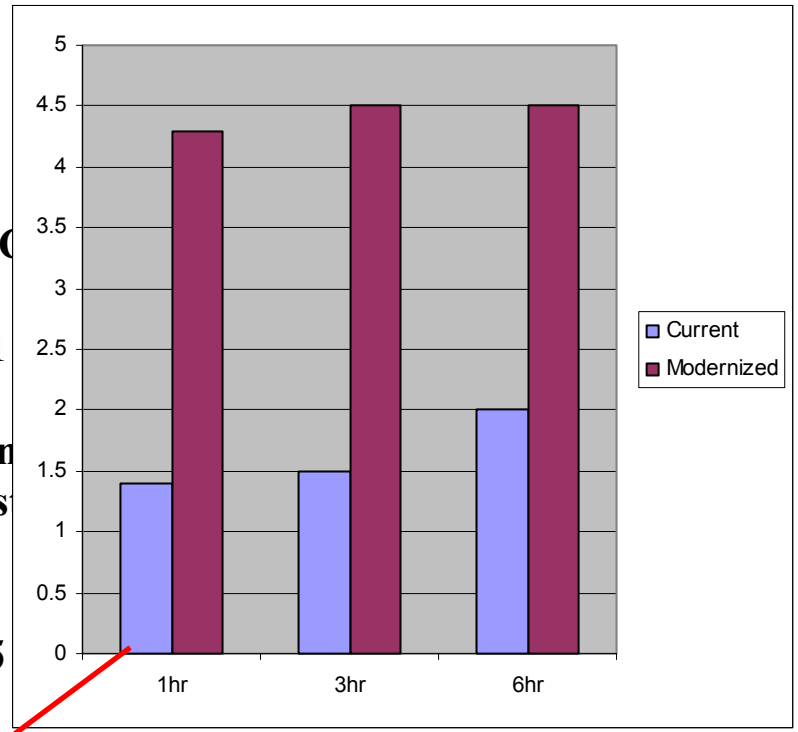
Threshold Runoff is set to zero

ZCZC SLCFFGAZ CSW
FOUS65 KSR 220825
FFGAZ
ZONE FLASH FLOOD GUIDANCE
COLORADO BASIN RIVER FORECAST C

ISSUED 0800 AM MDT TUE MAY 22 2001

Flash Flood Guidance is primarily dependen
Flash Flood Guidance for urban areas and s
indicated.

.B SLR 20010522 Z DH12/DC200105220825



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:======	====	====	====
AZZ001	3.4/	3.6/	3.7
AZZ002	4.3/	4.5/	4.5
AZZ003	4.3/	4.5/	4.5
AZZ004	3.4/	3.6/	3.7

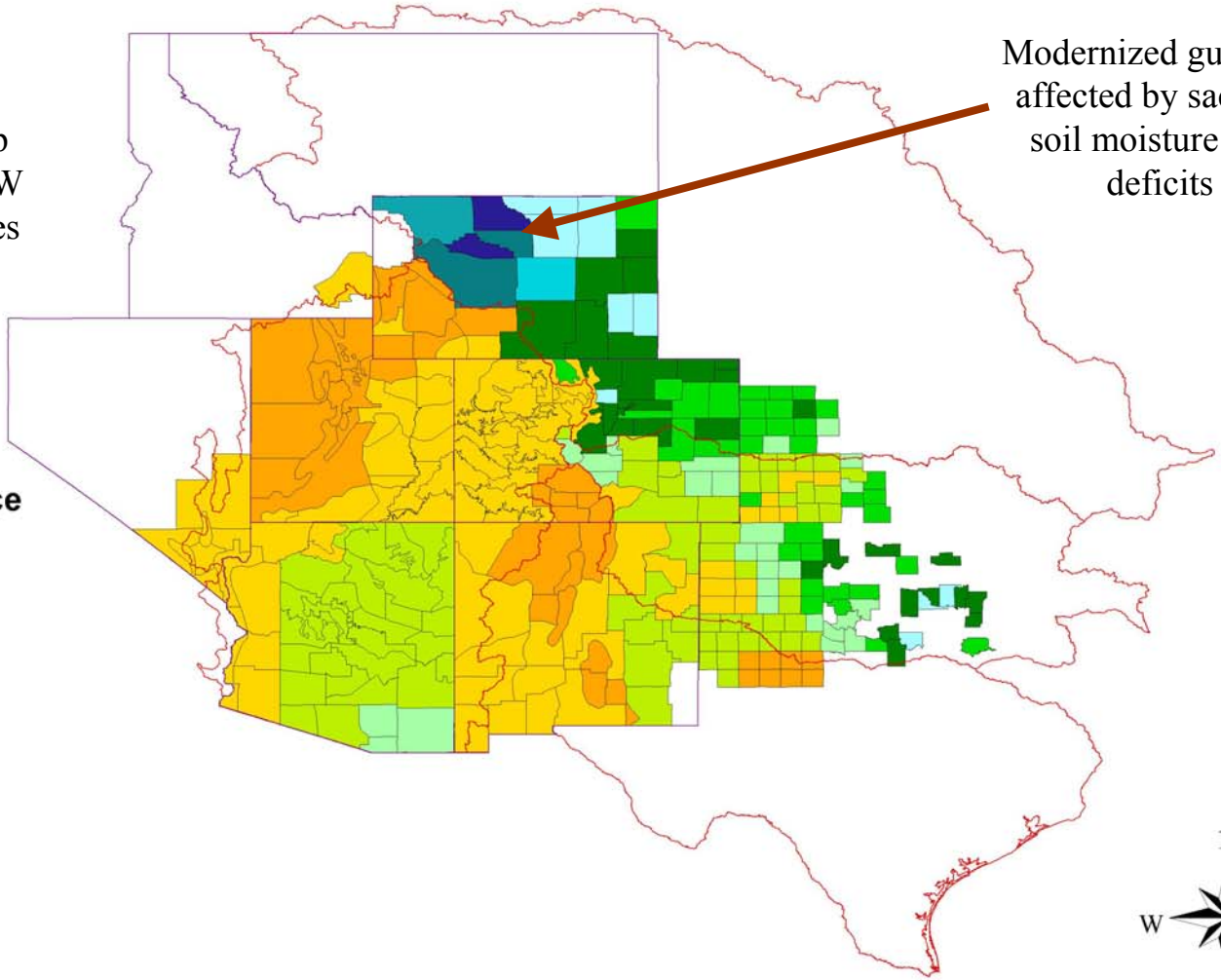
:IDENT	1HR	3HR	6HR
:======	====	====	====
AZZ001	1.4/	1.5/	2.0
AZZ002	1.4/	1.5/	2.0
AZZ003	1.4/	1.5/	2.0
AZZ004	1.6/	2.1/	2.3

Flash Flood Guidance Comparison

current vs. modernized method

100 year 1-hour precip return frequency for NW Wyoming is ~1.5 inches

Modernized guidance affected by sac-sma soil moisture tank deficits



Flash Flood Guidance Inches

- 0.01 - 0.50
- 0.51 - 1.00
- 1.01-1.50
- 1.51 - 2.00
- 2.01 - 2.50
- 2.51 - 3.00
- 3.01 - 3.50
- 3.51 - 4.00
- 4.01 - 4.50
- 4.51 - 5.00
- 5.01 - 5.50
- > 5.51

National Flash Flood Team Recommendations

Existing (modernized) approach is viewed to be at the end of it's life span

"Patches" proposed to the current system for generating FFG

Development on alternate approaches

FFG Quotes:

"For some of the Narrower canyons, as little as a 30 cfs flow can cause significant difficulties. In 1993, two people drowned in Kolob Creek when the stream was flowing at less than 40 cfs. And, many of the narrowest canyons are located in areas where their entire drainage is made up of slickrock.

We have a lot of flash floods that we consider significant because they cause flows through tributaries of the North Fork yet do not show up as a large rise on the North Fork river gauge."

Ray O'Neil, Backcountry permit office supervisor, Zion Nat'l Park

CBRFC/Western Region
Flash Flood Analysis Project

Take a big step back – View from a flash flood potential perspective

Is it even possible to consistently create accurate guidance values ?

- **What physiographic properties make an area susceptible to flash flooding – can we identify these ?**
- **What changes in these features or properties increase/decrease an area's susceptibility to flash flooding.**
- **Identify areas susceptible to flash flooding, relative to one another, based solely on these properties.**

Static Layers


Soil Type


Forest Cover


Land Use

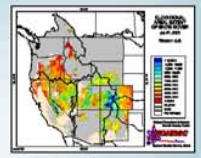

Slope


Vegetation Type

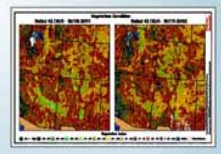
Dynamic - Event Layers


Fire

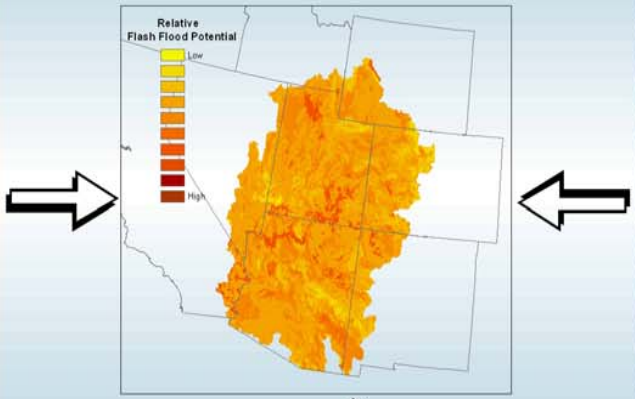
Dynamic - Seasonal Layers

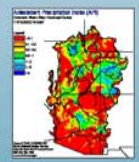



Snow Cover - Frozen Ground




Vegetation State



Precipitation
(Grid API Model from MPE Output)

Dynamic - Daily or Hourly Layers

API
Antecedent Precipitation Index

A measure of soil moisture based on recent precipitation and a time based recession constant

MPE
Multisensor Precipitation Estimator

Generates hourly gridded precipitation field by creating a multi-radar mosaic, mean field bias adjustment, and merging this information with gage observations

CBRFC/Western Region Flash Flood Analysis Project

Example

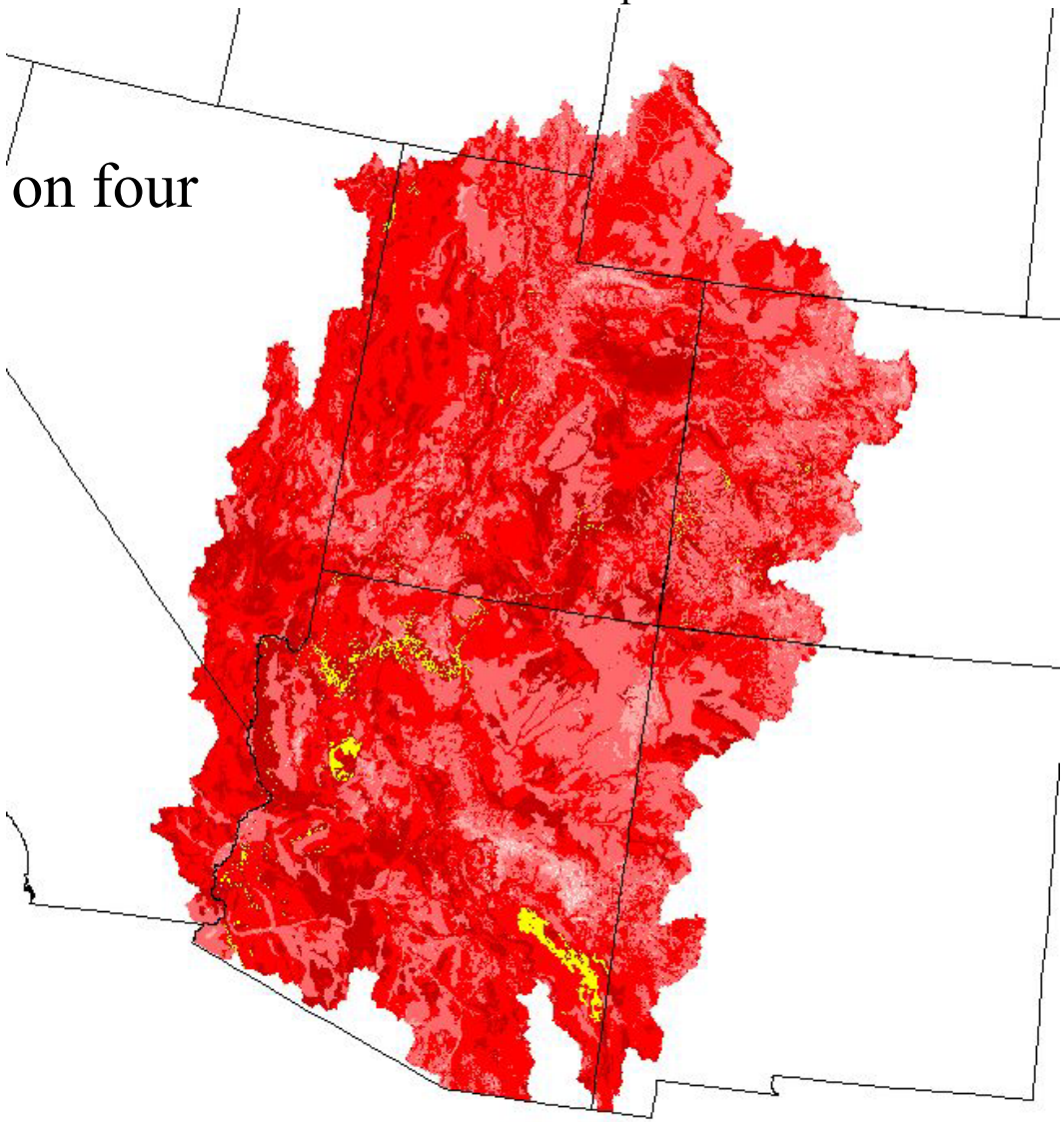
- **A first shot analysis for the CBRFC area using readily available data**
  - **Four raster data layers used – (re-sampled to 400 meter grid – coarse)**
    - **Percent Slope Grid (terrain steepness factor)**
    - **Rock Volume Grid (% rock fragments – affecting infiltration) - STATSGO**
    - **Fractional Soil Grid (% clay, sand etc.) – USGS STATSGO**
    - **Forest Density Grid - NOAA AVHRR**
  - **Datasets were all geo-registered prior to manipulation**
  - **Datasets re-sampled to consistent resolution – Bilinear method**
  - **Equal weighting given to each data layer**
  - **Flash Flood Indicators assigned (1-10) – equal interval re-classification**
  - **Utilized Arc-Info map algebra routines to output a single gridded layer**

Flash Flood Potential Indicators

static relative flash flood potential

Analysis based on four themes:

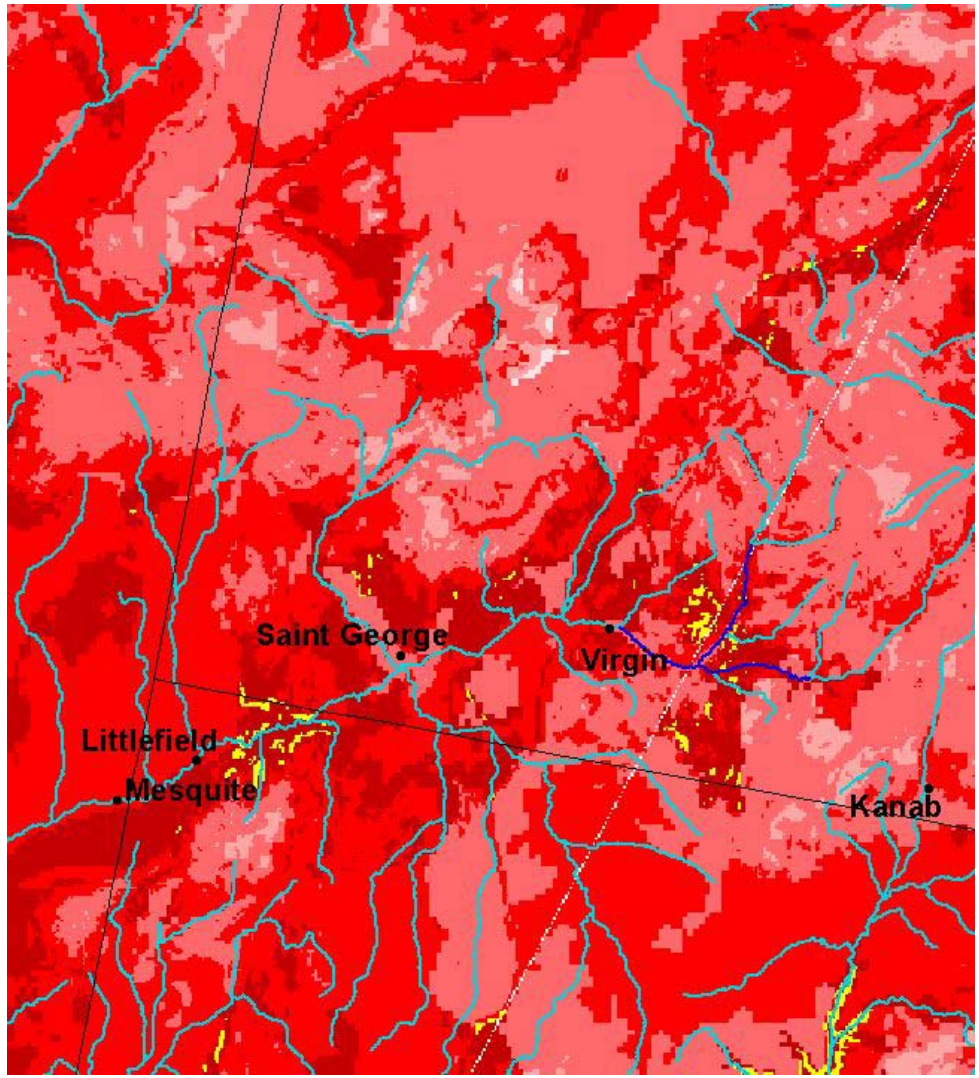
Volume of rock
Fractional Soil
Slope
Forest Density



Flash Flood Potential Indicators

static relative flash flood potential

North and East Fork
Virgin River



FFI_CBRFC
- 1- Low
- 2- Low
- 3- Low
- 4- Moderate
- 5- Moderate
- 6- High
- 7- High

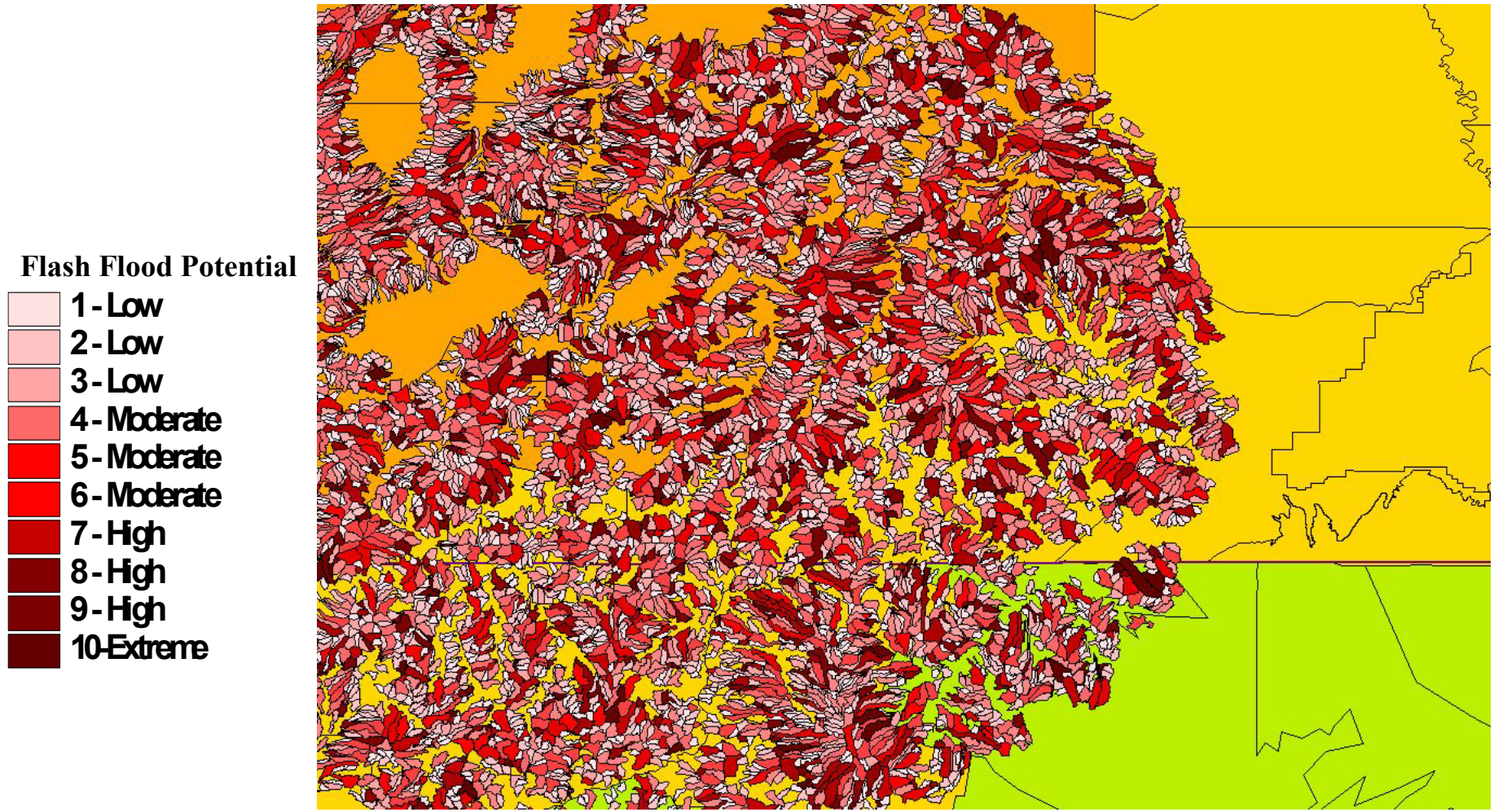
CBRFC/Western Region
Flash Flood Analysis Project

Output – Thematic layer of relative flash flood potential

- **A data layer for spatial variation of current FFG**
- **Initial output is gridded**
- **Interpolate to FFMP basin or other geographic layer**
- **Add basin geometry component to FFG output weighting**

KICX FFMP Basin Flash Flood Potential

hypothetical example



CB
Flash

Move from a stati

- **Seasonal bas**
  - **Vegetation**
  - **Snowpack**
- **Event based**
  - **Fire effects**
  - **Land use o**
- **Daily based on:**
  - **Precipitation component**
  - **Modeled soil moisture index**

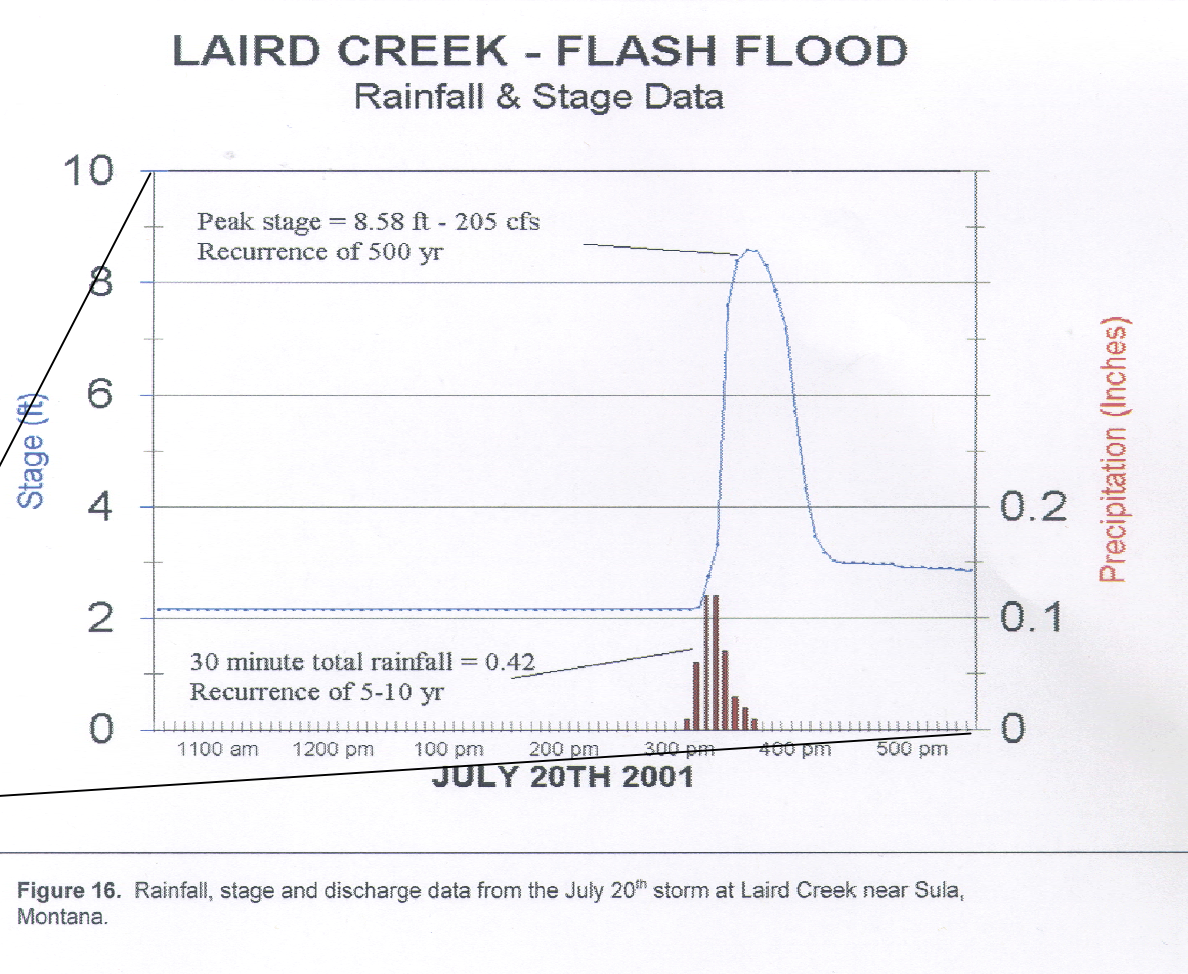
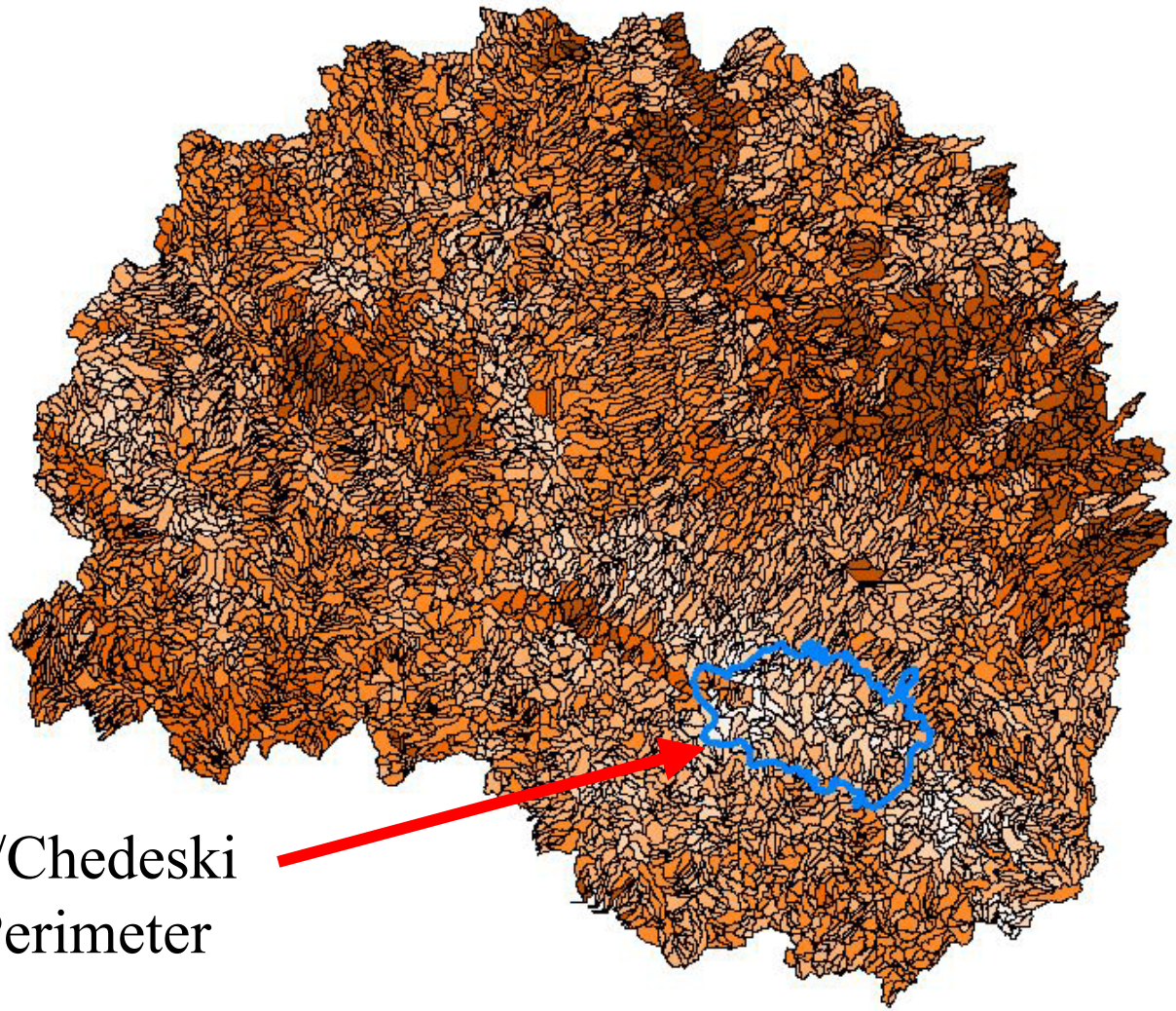


Figure 16. Rainfall, stage and discharge data from the July 20th storm at Laird Creek near Sula, Montana.

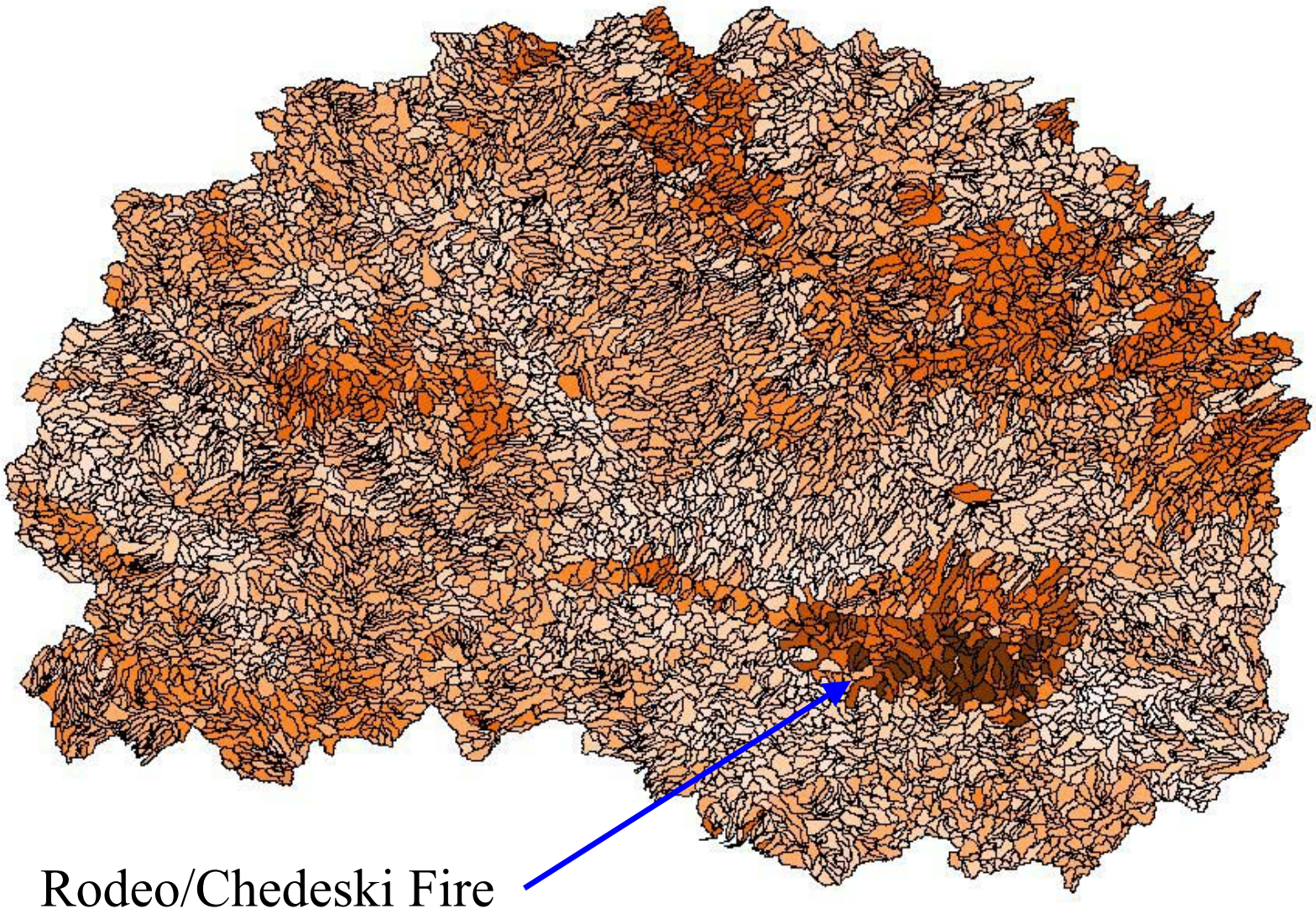
Flagstaff FFMP/AMBER Basins – Flash Flood Potential Layer



Rodeo/Chedeski
Fire Perimeter

Flagstaff FFMP/AMBER Basins – Flash Flood Potential Layer

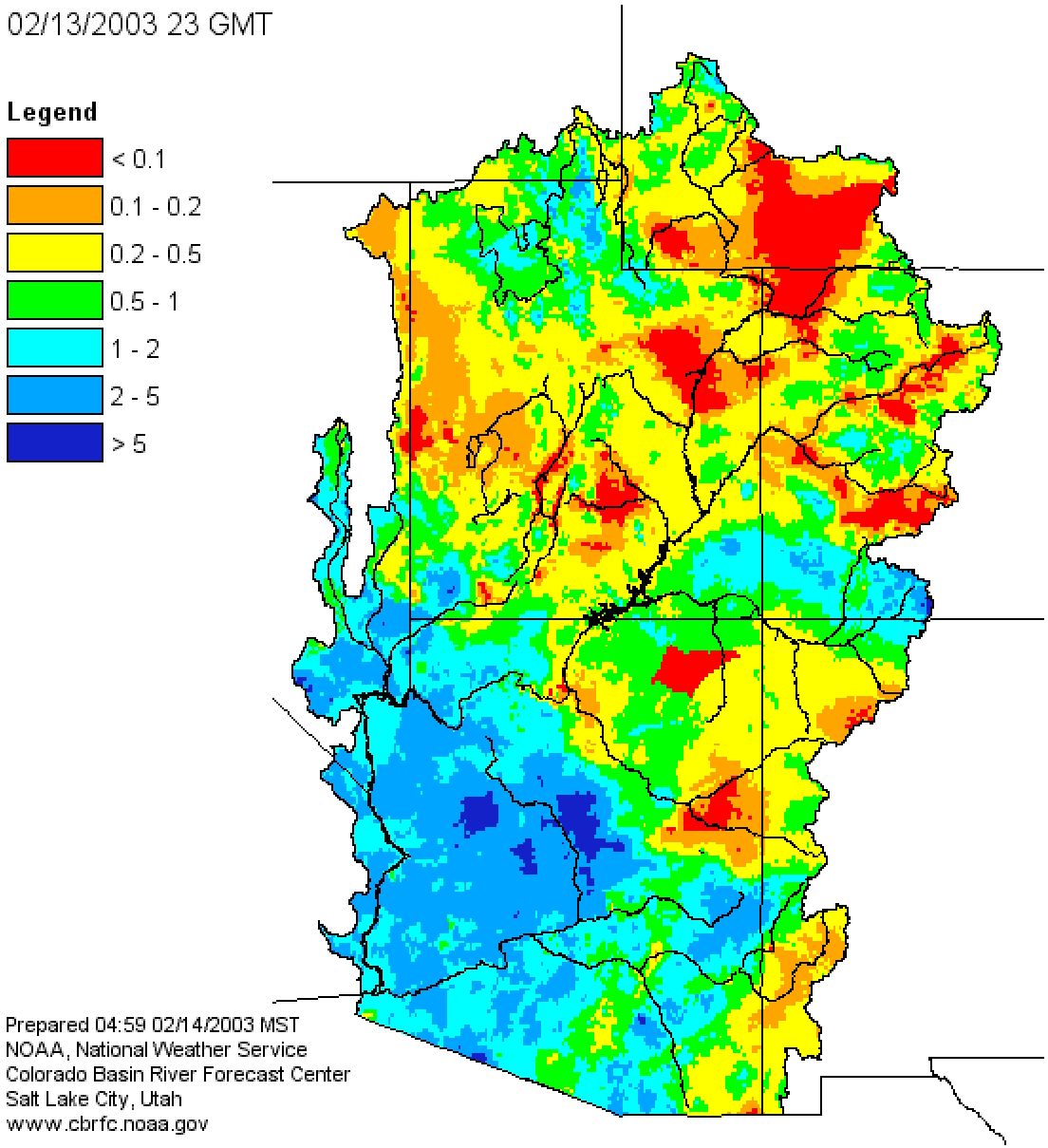
Fire Event Included (3 levels of burn intensity)



Antecedent Precipitation Index (API)

Colorado Basin River Forecast Center

02/13/2003 23 GMT

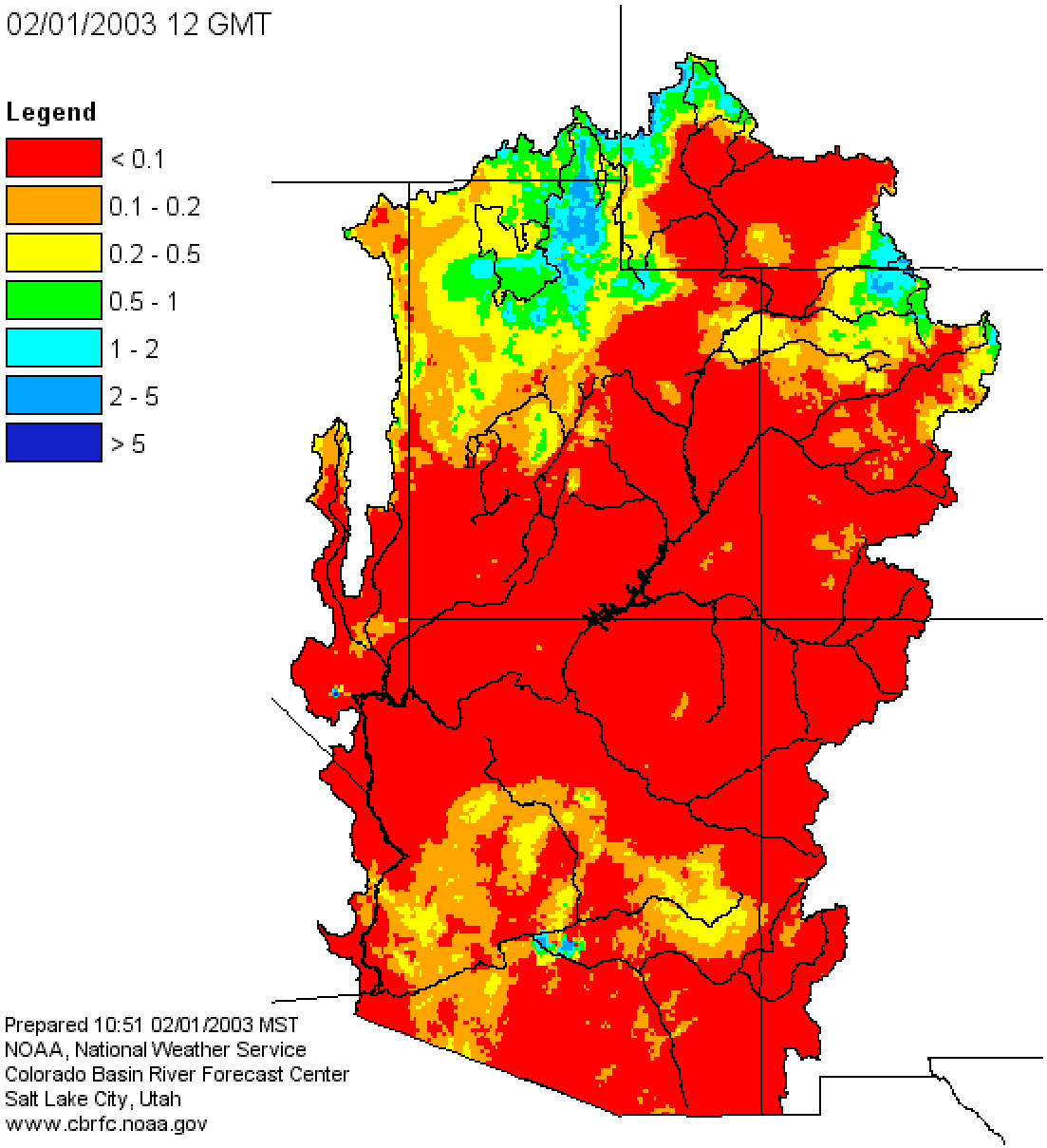


Prepared 04:59 02/14/2003 MST
NOAA, National Weather Service
Colorado Basin River Forecast Center
Salt Lake City, Utah
www.cbrfc.noaa.gov

Antecedent Precipitation Index (API)

Colorado Basin River Forecast Center

02/01/2003 12 GMT



Prepared 10:51 02/01/2003 MST
NOAA, National Weather Service
Colorado Basin River Forecast Center
Salt Lake City, Utah
www.cbrfc.noaa.gov

CBRFC/Western Region
Flash Flood Analysis Project

Develop ability to generate FFG guidance values

- **Assign a FFG value to each of the FF Potential categories**
  - **Simple assignment**
  - **Regression approach using layer info and observed info**
  - **Other?**
- **Incorporate precipitation return frequency information**
  - **May vary by physiographic characteristics**
  - **May vary regionally by climate, etc.**
- **Incorporate distributed model component**
- **Incorporate observed flash flood event information**
  - **Important to ground in observational truth**

CBRFC/Western Region
Flash Flood Analysis Project

How do you verify output ?

- **Based on documented flash flood events**
- **Based on local knowledge of flash flood prone areas**
  - **Create thematic data layers of observed events and known areas**
  - **Determine common characteristics re-apply elsewhere**

Important to ground analysis in observational truth

What's Next

- Initial gridded coverage of flash flood potential complete for the CBRFC area
- Reviewing existing and incorporating new datasets and layer weighing methods
- Process of obtaining and incorporating burn area data layers
- Analyzing MPE gridded output for use as a dynamic soil moisture layer
- Creating a database of observed event data for use in verification and FFG creation
- Virgin River study area using finer resolution datasets