New Flood Risk Products for Flood Forecasting and Warning Systems in Colorado

Dr. Shane Parson, AECOM
Thuy Patton, Colorado Water Conservation Board
Remmet DeGroot, AECOM

ASFPM 2016 Annual Conference “GREAT LAKES – GREAT PARTNERS”

Grand Rapids, Michigan, June 18–24
Agenda

– Project Summary
– Flood Forecasting Overview
– Existing Colorado Systems
– Adapting Risk MAP Products for Flood Forecasting
Project Summary
2013 Colorado Flooding
South Platte River along State Highway 144 near Orchard, Morgan County, CO
Approximately 2 days after the flood peak
2013 Colorado Flooding
South Platte River along State Highway 144 near Orchard, Morgan County, CO

June 17, 2015
Source: AECOM

June 24, 2015
Source: CDOT Region 4

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
Project Goals

– Literature review: Flood Forecasting, Risk MAP Non-regulatory Flood Risk Products (FRPs)

– Prototype enhancements to FRPs for specific use for flood forecasting

– Address known issues: Near-real time models, Risk communication
Flood Forecasting Overview
Flood Forecasting and Warning System

Typical Riverine Floodplain Modeling

1. Hydrologic Analysis
   - Hydrologic models
   - Preliminary and effective FEMA floodplain data
   - Watershed data
   - Peak Runoff

2. Hydraulic Analysis
   - Hydraulic models
   - Preliminary and effective FEMA floodplain data
   - Terrain data
   - Flood Elevations

3. Floodplain Mapping Analysis
   - Floodplain mapping models
   - Preliminary and effective FEMA floodplain data
   - Terrain data
   - Floodplain boundaries and flood depths
Flood Forecasting Systems are a Balancing Act

- 3-legged stool
- Each flood forecasting system has to balance how to use available dollars to fund staff and models

![Diagram](Diagram of a 3-legged stool with arrows pointing to "People", "Models", and "$$$$$$")
Existing Colorado Systems
Existing Systems in Colorado

- National Weather Service (NOAA)
- Colorado Water Conservation Board
- Denver Metro Area (Urban Drainage and Flood Control District)
- Fort Collins
NWS Rainfall Gauges in Colorado

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
NWS Stream and River Gauges in Colorado

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
NWS Flood Stage Information

- NWS Stages usually include more frequent events than FEMA studies.

- In this location, 10-yr event (10% annual chance) around 33,000 cfs (about same as Major Flood Stage of 14.5 ft).
Impacts of More Frequent Flooding

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
NOAA/NWS Guidelines for Flood Inundation Mapping

- NOAA and USGS have begun to address need for more detailed flood inundation data
- Guidelines developed in 2011 for creation of flood depth rasters to be posted to NWS websites
NWS Flood Inundation Mapping in Kansas

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
NWS Flood Inundation Mapping in Kansas

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
NWS Flood Inundation Mapping in Kansas

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
NWS Flood Inundation Mapping in Kansas

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
Statewide service based on WSR-88D and MADIS weather observations and forecasting

Provides Bulletin, Outlook, and Total Precipitation Estimates
Mapping on the Colorado Flood Threat Bulletin

Today's Flood Threat Map

For more information on today's flood threat, see the map below (hover over threat areas for more details). For Zone-Specific forecasts, jump below the map.

Summary

An old snowpack surge and a large scale trough aloft to produce light to moderate rainfall for many areas across Colorado. With limited stability, and very fast steering winds, heavy rainfall was effectively ruled out. Instead, we expect up to 0.2 inches per hour, with the highest totals concentrated over the Urban Corridor. Front Range, Central Mountains, and Western Slope.

Today's Flood Threat Level

- Low
- Moderate
- High
- High-Impact

Event #1: Friday (9/4) – Saturday (9/5)

The apparent flood threat

A large scale trough will aid in enhanced moisture advection in shower and thunderstorm activity across southern and western Colorado on Friday and Saturday. Over the course of the period, up to 1.0 inches of rainfall will be possible in the San Juan and Central Mountain Areas, with isolated embedded thunderstorms progressing with moist SE flow. Additional rainfall to 0.5 to 1.0 inches may also occur across the Northeast Plains on Friday as the disturbance moves away.

Zone-Specific Forecasts

Urban Corridor, and Northeast Plains:

Scattered showers and thunderstorms are expected, producing mainly gusty winds and lightning, with brief bouts of moderate rainfall. With an inverted-V atmospheric profile in place, maximum rain rates will stay below flash flooding thresholds so no flood threat is warranted. Maximum rain rates will be 0.7-0.8 inches/hour over the Urban Corridor, and 0.3-0.5 inches/hour over the Northeast Plains.

Timing: 1 PM – 10 PM along the Urban Corridor, and 3 PM – midnight across the Northeast Plains.

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
Urban Drainage ALERT System

- Includes a range of flood data links including forecasts, mapping, and gauge data
- Covers a majority of the Denver Metro Area

https://udfcd.onerain.com/home.php
Mapping on Urban Drainage ALERT System
Gauge data on Urban Drainage ALERT System

New Flood Risk Products for Flood Forecasting and Warning System in Colorado
Detailed Model Data on Urban Drainage ALERT System

Boulder Creek Hydromodel Interface

Go to [GRAPHS](#) of Boulder Creek Model Output.

View Larger Map
City of Fort Collins Flood Warning System

- Similar system with range of flood data links including forecasts, mapping, and gauge data
- Works with local E911 for real-time data access and warnings

Mapping on Fort Collins Flood Warning System

Gauge Data on Fort Collins Flood Warning System

POUDRE RIVER FLOOD WARNING

The National Weather Service has issued a Flood Warning for the Poudre River, and expects discharge to rise to 7700 cubic feet per second by Friday afternoon June 12, with additional flooding of low lying areas near the river. Please take appropriate precautions to ensure personal life safety, remove any hazardous/flammable materials and secure floatable objects. DO NOT DRIVE THROUGH FLOODWATERS. Please do not call 9-1-1 unless you have an emergency.
Adapting Risk MAP Products for Flood Forecasting
Flood Forecasting and Warning System

Typical Riverine Floodplain Modeling

1. Hydrologic Analysis
   - Peak Runoff
   - Hydrologic models
   - Preliminary and effective FEMA floodplain data
   - Watershed data

2. Hydraulic Analysis
   - Flood Elevations
   - Hydraulic models
   - Preliminary and effective FEMA floodplain data
   - Terrain data

3. Floodplain Mapping Analysis
   - Floodplain boundaries and flood depths
   - Floodplain mapping models
   - Preliminary and effective FEMA floodplain data
   - Terrain data

People → $$$$$$ → Models
### FEMA Data Availability: Risk MAP (Regulatory and Non-Regulatory)

<table>
<thead>
<tr>
<th></th>
<th>Flow</th>
<th>Profiles</th>
<th>Boundaries</th>
<th>Depth</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>1%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>0.2%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Default Non-Regulatory Datasets:

- Flood Depth and Analysis Grids: Flood depth and Percent Annual Chance
- Flood Risk Assessment: Flood Loss for Buildings (and contents)
New Flood Risk Products for Flood Forecasting and Warning System in Colorado
Adapting Risk MAP Products for Flood Forecasting

<table>
<thead>
<tr>
<th></th>
<th>Flow</th>
<th>Profiles</th>
<th>Boundaries</th>
<th>Depth</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>20%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>1%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>0.2%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>0.1%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>0.05%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>PMF</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

More percent annual chance events (more and less frequent than default)
Adapting Risk MAP Products for Flood Forecasting

<table>
<thead>
<tr>
<th>Event</th>
<th>Flow</th>
<th>Profiles</th>
<th>Boundaries</th>
<th>Depth</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>20%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>1%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>0.2%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>0.1%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>0.05%-ann. chance</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>PMF</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Additional “Composite” raster datasets: Flow, Gauge stage, Loss
Creating Composite Datasets

- Percent annual chance raster and “rating” curve can be used to produce other composite rasters like peak flow.
Flood forecasting questions: Flood inundation for a certain peak flow amount

- Rainfall-runoff model may produce a peak flow estimate for a future event

- Peak Flow Composite Raster can quickly show inundation limits
Flood forecasting questions: Flood inundation for a certain gauge stage

- Predicted maximum stage for river gauge for current ongoing event

- **Gauge Stage Composite Raster** can show inundation limits associated with each stage
Flood forecasting questions: Flood inundation for flood damage thresholds

- How much flooding will cause $10M of damage?

- **Flood Loss Composite Raster** can show for a particular reach flood inundation limits associated with flood losses.
Flood forecasting questions: Flood inundation for flood damage to specific assets

- How severe will flooding need to be to significantly impact railroad?

- **Custom Asset Loss Raster** can show flood inundation limits for damage to specific asset types
Next Steps

- Create datasets for different CO watersheds
- Nationwide prototyping
- Establish standards
- Identify limitations
Questions?

Dr. Shane Parson, shane.parson@aecom.com
Thuy Patton, thuy.patton@state.co.us
Remmet DeGroot, remmet.degroot@aecom.com