Name: Maidment

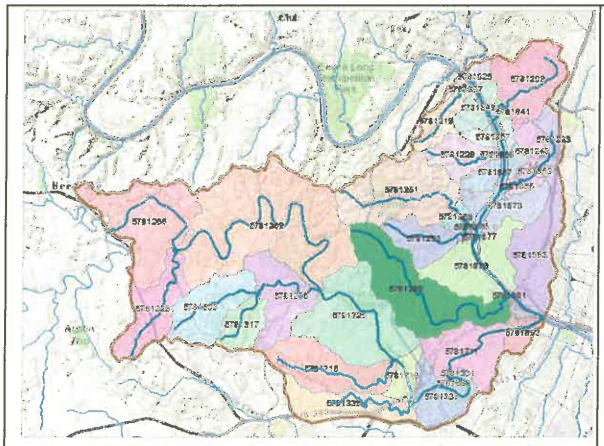
CE 397 Flood Forecasting **Midterm Exam** **Spring 2015**

There are three questions on this exam. Please do all three questions.

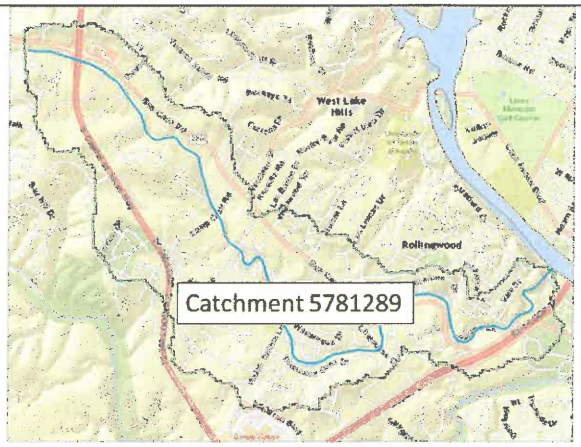
1. Flood Forecasting in Rollingwood

The maps and photographs below show Eanes Creek in Rollingwood, Texas, and its junction with Bee Caves Rd, a significant regional road in this area. The drainage pipes shown each have a flow capacity of about 150 cfs, the upstream drainage area is about 3 square miles, and the flow during a flood event is of the order of 1000 cfs or more.

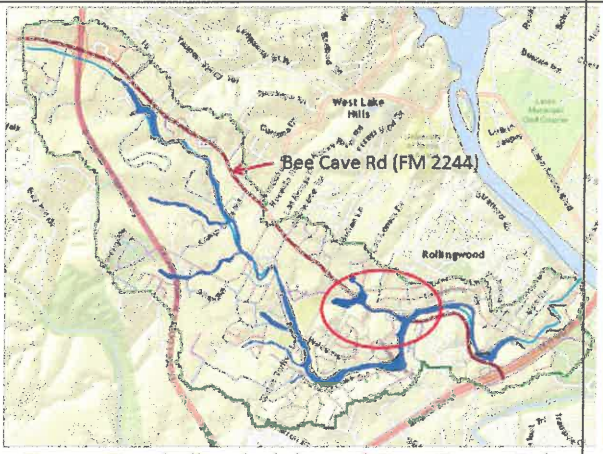
On the night of Sept 18, 2014, a flash flood happened in Travis County. A first responder attempting to set up a barrier across Bee Caves road to prevent cars driving through the overflow waters was swept off the road into the creek and nearly lost his life.



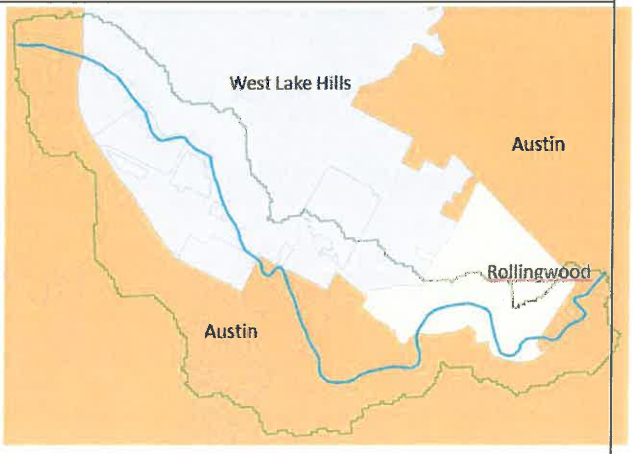
Huc12 Subwshed Lake Austin-Town Lake



Reach Catchment 5781289



Eanes Creek flood plain and Bee Caves Rd



Jurisdictions in this catchment

Upstream view of culvert

Downstream view of culvert

Eanes Creek Upstream of Bee Caves Rd

Culvert Pipe under the road (4 ft diameter)

Let's imagine some years into the future that the National Flood Interoperability Experiment is now fully operational. Describe how it could work to better inform the emergency response community in Rollingwood of the flood conditions they can expect to occur at this location during an impending storm. Describe each of the five components of the National Flood Interoperability Experiment and how it contributes information to help illuminate this situation.

(a) NFIE-Geo

(i) What is NFIE-Geo?

(5) A national geospatial framework for hydrology. This needs to include landscape description and streamflow description (ie. include Geogrid as well)

(ii) What information could NFIE-Geo contribute?

(5) Definition of the catchment boundary for Eanes Creek and the main flowline of Eanes Creek. Definition of the Submetershed within which Eanes creek lies. Definition of the cells by which the atmospheric and land surface modeling will be done for this catchment.

(b) NFIE-Hydro

(i) What is NFIE-Hydro?

(5) A continental scale hydrologic simulation framework operating on NFIE-Geo linking weather forecasts, land-atmosphere modeling and channel flow routing to produce probabilistic flood forecasts.

(ii) What information could NFIE-Hydro contribute?

A rainfall forecast for 15 hours ahead for Eanes Creek catchment. A flow forecast for the discharge in Eanes Creek. Hopefully these will be ensemble forecasts as for GloFAS. Assessment of state of soil moisture when a storm is impending.

(c) NFIE-River

(i) What is NFIE-River?

(5) A database of river channel information and associated flood hydraulic models that can be used to support flood inundation mapping.

(ii) What information could NFIE-River contribute?

A translation of flow forecast to water level forecast on Eanes Creek.

5 This should apply at all critical locations on the stream reach eg low water crossings of all roads crossing the creek. A flood inundation map for the creek. This means we need a structure rating curve for each road crossing

(d) NFIE-Response

(i) What is NFIE-Response?

(5) A plan for flood response action developed by a local emergency response community

(ii) What information could NFIE-Response contribute?

Once the forecast information is known, a response plan for road closures could be defined with enough lead time to get the appropriate staff in place before flood conditions are critical — the capacity to be "proactive" rather than "reactive"

(e) NFIE-Services

(i) What are NFIE-Services?

A set of standardized web services for water and weather observations and forecasts.

(5)

(ii) What information could NFIE-Services contribute?

A service for - rainfall forecast for Eanes Creek catchment
- flow forecast for Eanes Creek
- probability forecast for overflow of Bee Caves Rd

What Actually Happened

The Police Chief of Rollingwood attended a City Council meeting that evening, which concluded about 10PM. He had been watching the weather radar for three days knowing that a storm could be coming but decided that the threat wasn't large. As he was driving home to Dripping Springs, heavy rain started to fall. Around midnight, after he arrived home, he got a call saying his youngest officer, handling a flood for the first time, had been washed into Eanes Creek. This officer was fortunately able to hang onto a tree until other first responders rescued him.

What Could Have Happened

Describe how you think a better informed decision and set of actions could have been made to deal with this situation.

(8)

Information: In an ideal situation, there would be a probabilistic forecast of rainfall in the catchment, flow in the creek, and probability of overflow at each of the critical low water crossings.

Better response: This would enable pre-staging of response personnel & equipment before flood conditions become acute. Taking actions ahead of time rather than in response to events. Having enough people with experience on hand.

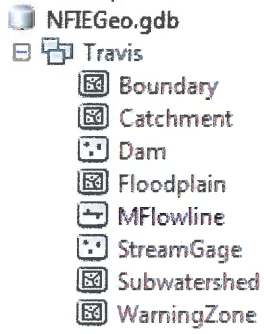
Mitigating: Ideal solution is to replace all low water crossings with proper flow conveyance. So that there is no need to close roads during flood events.

2. Flood Forecasting at the National Water Center

Now, let's suppose we go to the other end of the problem and assume that you are a forecast hydrologist at the National Water Center who is trying to produce high resolution flood forecasts for the 2.67 million reach catchments covering the continental United States.

(a) NFIE-Geo

The feature classes in the NFIE-Geo geodatabase for Travis County are listed below. Describe the content of each of these feature classes and how it interacts with the others to provide the geospatial information base for the NFIE.



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① Boundary – outer county boundary selected from natural feature service of county boundaries. Defines spatial scope of problem.

② Catchment – catchment boundary for each stream reach. Uniquely labeled. Used to determine local runoff into the reach.

③ Dam – dam location information from USGS – needs more information on dam characteristics to be useful for flow routing.

④ Floodplain – flood inundation map for base flood (100 yrs) from FEMA National Flood Hazard Layer

⑤ MFlowline – stream reach flowline for catchments. Uniquely labelled in U.S. Carries the flow computation & forecast.

⑥ Streamgage – Streamgage information from USGS (point locations). Gives observed flow information

⑦ Subwatershed – 12-digit HUC subwatersheds from USGS – collection for Catchments

⑧ Warning Zone – intersection of ② & ④ – gives flood warning zone for stream reach

(b) NFIE-Hydro

Describe the process of constructing a flow forecast at the reach catchment scale including the following elements:

(i) High Resolution Rapid Refresh Model

A fifteen hour ahead forecast is obtained from the High Resolution Rapid Refresh model – radiation, humidity, temperature, wind and precipitation. The data are in a net cdf framework over the continental US & have a 1-hr time step

(ii) WRF-Hydro framework

The output from HRRR is used as input to the NOAH-MP land-atmosphere to compute the surface water and energy balance. The outputs of this process include soil moisture and runoff on the Geogrid cell layout

(9)

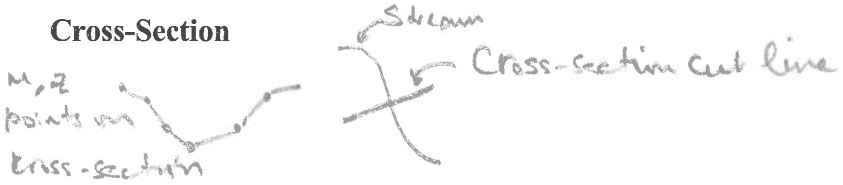
(iii) RAPID model

Runoff from the WRF-Hydro Geogrid cells is converted to catchment level runoff using a weighted area calculation. It is routed through the rivers using a Muskingum scheme with K, X computed for each stream reach.

(d) NFIE-River

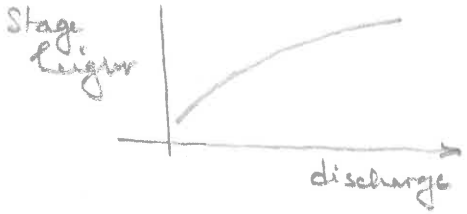
Hydraulic information at a point in a river can be described using a cross-section and a rating curve. Use a diagram to illustrate each of these and explain how their combination can be used to transform a flow forecast into a forecast of water level above geodetic datum at that location.

Cross-Section



(3)

Rating Curve



(3)

Computing the water level forecast from the flow forecast

(2) Given the forecast discharge, read off the corresponding stage height. Determine from this the corresponding geodetic elevation of water surface

3. Information Model for the National Flood Interoperability Experiment

(a) Observations and Measurements Standard

The ISO Observations and Measurements Standard has the framework statement: "An Observation is an action whose *Result* is an estimate of the value of some *Property* of the *Feature of Interest*, obtained using a specified *Procedure*".

Take five elements of National Flood Interoperability Experiment and for each describe how this standard could be applied to that element.

(i)	Feature of Interest	Property	Procedure	Result
	Stream gage	Water level (stage height)	Float recorder	Time series of water level or storage height

(ii)	Feature of Interest	Property	Procedure	Result
	Catchment	Precipitation rate	HRRR & WRF Hydro	Time series of forecast precipitation

(15)

(iii)	Feature of Interest	Property	Procedure	Result
	Flowline	Discharge	RAPID model	Time series of stream discharge

(iv)	Feature of Interest	Property	Procedure	Result
	Road Crossing	Water level	Transform from flow using rating curve	Forecast of possible road overflow

(v)	Feature of Interest	Property	Procedure	Result
	my House	Water level	Flood inundation map forecast	Probability I will be flooded!

(b) Web Services

(i) Streamflow – describe the web services used to obtain real-time streamflow data from the USGS

The USGS uses the WaterML2 language to distribute its data as Web Services using a REST call that gets a time series for a particular gage at a particular location for a specified time period.

(5)

(ii) Time

Write 2PM Central Daylight Time on 11 March 2015 in the ISO Time format

2015-03-11T 14:00:00 – 05:00

(4)

(iii) Values

Write 563.45 cfs as at the above time as a time-value pair in WaterML2 format.

```
<wml2:measurementTVP>
<wml2:time> 2015-03-11T 14:00:00 – 05:00 </wml2:time>
<wml2:value> 563.45 </wml2:value>
</wml2:measurementTVP>
```

(3)

(c) Flood Inundation Mapping

Once a water level forecast has been computed, it is useful to create the corresponding flood inundation map.

Describe a procedure for creating such a map in a single stream reach

Have a library of flood inundation maps indexed to stage height and select the one that's closest to the forecast stage height

(3)

How would the inundation maps be combined for multiple reaches in a stream network?

(3)

① Translate the stage height to return period & select maps for a common return period

② linearly interpolate along the flowline for water surface elevation and construct the flood inundation map from that information

Average = 88.8

95–100 (3)

90–94 (3)

87–89 (3)

83–86 (2)

<83 (2)

Five roles

Command

Operations

Planning

Logistics

Finance

Ideal

P(Q)

Flow levels

Safety

PIO – Public Info Officer

Incident Management System

discharge

forecasts

Response