NOAA Precipitation-Frequency Atlas 14 V-11: USDA - NRCS Implementation in Texas



Hong Wang, Ph.D, P.E.
State Hydraulic Engineer
NRCS, Temple TX

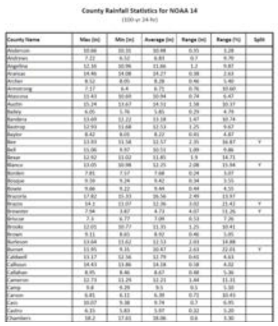
Outline

- Creating TX Rainfall Database
- Generating Rainfall distribution zoning map
- Developing rainfall distribution curves and tables
- Determine Runoff Peak Rate Factors
- Developing type.rf files for EFH2 software
- Developing ArcGIS tool to calculate areal-averaged rainfall intensity using NOAA 14 data
- Updating software/tools and documents

implementation: Rainfall Database

- develop a GIS tool to generate rainfall statistics (maximum, minimum, range, and areal-average) of 100-year 24-hour by county in Texas;
- if the rainfall varies more than 15% within a county, the county is split into two or more sections along some boundary such that the range of the 100-year 24-hour rainfall of each section is less than or equal to 15%;
- generate the statistics for each county/section. The statistics include min, max, range, and areal-average of 1-year through 100-year, 5-minute through 10-day rainfall.
- Develop an ACCESS database which contains above rainfall data with a user-friendly interface so that users can retrieve rainfall data easily.

implementation: County Statistics

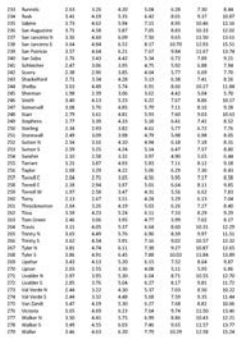


implementation: County Split

36 counties were split into 2 or more sections;
split boundary will be adjusted along township lines

implementation: County Average RF Tables

implementation: County Average RF Tables



Outline

- ~~Creating TX Rainfall Database~~
- Generating Rainfall distribution zoning map
- Developing rainfall distribution curves and tables
- Determine Runoff Peak Rate Factors
- Developing type.rf files for EFH2 software
- Developing ArcGIS tool to calculate areal-averaged rainfall intensity using NOAA 14 data
- Updating software/tools and documents

implementation: Rainfall Distribution

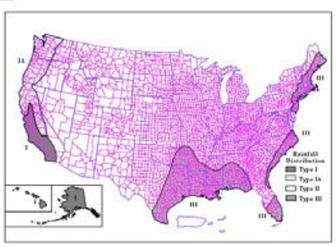
- Rainfall Distribution is the variability of the intensity throughout a storm..... although the overall depth for a storm will be the same for a given duration no matter which Distribution is chosen.
- Distributed in a "reasonable manner"
- Two commonly used methods:
  - Statistical analysis of a gage network
  - Nested intensity method

implementation: Rainfall Distribution

- Uniform
- Yen-Chow
- Alternating Block
- Keifer & Chu (Chicago Method)
- Pilgrim-Cordery distribution
- SCS Distributions
- Huff's Quartile Distributions
- NOAA Atlas 14 Temporal Distributions

implementation: Rainfall Distribution

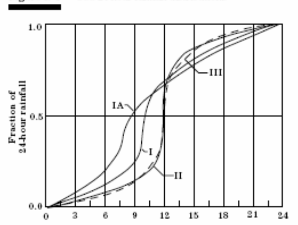
Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Texas is located within Type II and III Rainfall Distribution

implementation: SCS Rainfall Distribution

Figure B-1 SCS 24-hour rainfall distributions



more than 50% of the rainfall occurs between the 11th and 13th hour.

implementation: SCS Distribution

- Nested Intensity Method (synthetic)
- Developed by SCS using rural rain gages
- expanded on work by Hershfield.
- NRCS proposing to discontinue use

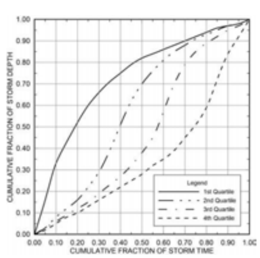
NRCS actually aren't proposing discontinuing use, but acknowledge that those distributions were developed from TP-40 and other old rainfall data studies. Therefore, they are not necessarily appropriate for use with updated NOAA Atlas 14 data. The point is to use appropriate distributions with appropriate data.

implementation: Nested Intensity Method

- Nested intensity hyetographs contain the desired AEP intensity for any given duration within the storm.
- Example: for a 24-hour storm, 100-year event, use 5-min, 10-min, 15-min, 30-min, . . . , 100-year intensities and so on…

implementation: Huff's Quartile Distributions

- Statistical analysis of a gage network
- Derived from 49 gage network in Illinois
- Events > 0.5"
- 11 year period of record, 1955-1966
- Revisited in 1990 to add 5 urban gages and Results included in Bulletin 71.



implementation: SCS Distributions

Advantages
- Applicable to various durations

Disadvantages
- Yields high peak discharge rates
- Significantly "over-predicts" frequent events
- Observed rainfall events do not occur in this manner

implementation: Huff's Quartile Distributions

Advantages
- Derived from regional data
- Produces results "consistent" with observed data
- Distribution varies by duration

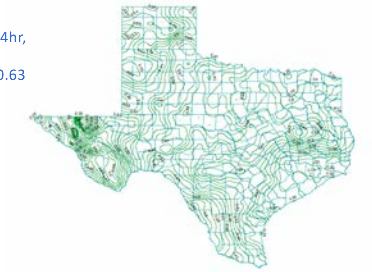
Disadvantages
- requires a substantial amount of analysis to determine the shape parameters of the distribution
- Requires duration sensitivity analysis

Development: NRCS Temporal Distributions

- The NRCS WQQT developed a procedure Using ArcGIS for deriving temporal storm distributions for a wide range of climate conditions (tropical to arctic) which occur in the US.
- Based on ratios of the Atlas 14 (25-yr, 1-hr)/(25-yr, 24-hr) precipitation depths.
- Simplifying to follow County Boundaries for use in NRCS Hydrology Computer Programs…

Development: NRCS Temporal Distributions

- 25-year event:
  Ratio of 1-hr/24hr,
- Range: 0.32 – 0.63

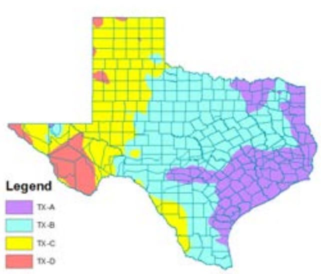


Development: NRCS Temporal Distributions

Ratio Thresholds of 60-min/24-hour Rainfall for 4 Distribution Regions

Rainfall Distributions	Ratio of 60-min/24-hour rainfall
TX-A	0.32 – 0.40
TX-B	0.40 – 0.47
TX-C	0.47 – 0.55
TX-D	0.55 – 0.63

Development: NRCS Temporal Distributions



Development: NRCS Temporal Distributions

implementation: NRCS Temporal Distributions

Adjusted along county lines

implementation: NRCS Temporal Distributions

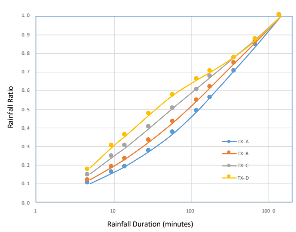
Figure 4.1.2: Climate regions delineated for NOAA Atlas 14 Volume 11.

Outline

- ~~Creating TX Rainfall Database~~
- ~~Generating Rainfall distribution zoning map~~
- Developing rainfall distribution curves and tables
- Determine Runoff Peak Rate Factors
- Developing type.rf files for EFH2 software
- Developing ArcGIS tool to calculate areal-averaged rainfall intensity using NOAA 14 data
- Updating software/tools and documents

implementation: NRCS Temporal Distributions

Ratio of 5 min/24hr through 12hr/24hr for 25year event



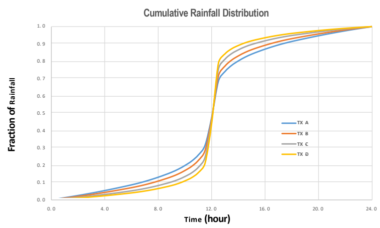
Non-Smooth Ratios for Texas NOAA 14 Distributions

implementation: NRCS Temporal Distributions

Summary of Non-Smooth Ratios for Each Rainfall Distribution

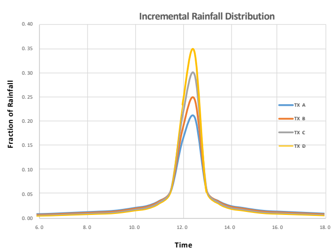
Duration(min)	TX-A	TX-B	TX-3	TX-D
5	0.0994	0.1200	0.1517	0.1845
10	0.1588	0.1927	0.2458	0.3019
15	0.1983	0.2386	0.2994	0.3634
30	0.2776	0.3293	0.4026	0.4747
60	0.3713	0.4310	0.5097	0.5783
120	0.4893	0.5465	0.6129	0.6578
180	0.5682	0.6196	0.6736	0.7004
360	0.7078	0.7459	0.7786	0.7808
720	0.8497	0.8700	0.8844	0.8793
1440	1.0000	1.0000	1.0000	1.0000

implementation: NRCS Temporal Distributions



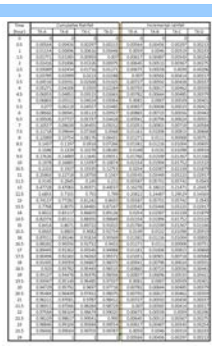
smoothed

implementation: NRCS Temporal Distributions



smoothed

implementation: NRCS Temporal Distributions



Outline

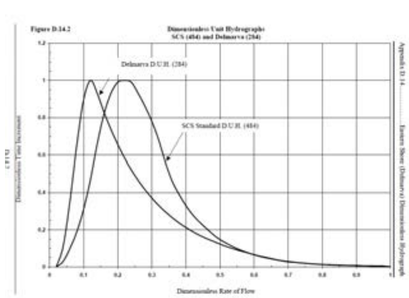
- ~~Creating TX Rainfall Database~~
- ~~Generating Rainfall distribution zoning map~~
- ~~Developing rainfall distribution curves and tables~~
- Determine Runoff Peak Rate Factors
- Developing type.rf files for EFH2 software
- Developing ArcGIS tool to calculate areal-averaged rainfall intensity using NOAA 14 data
- Updating software/tools and documents

implementation: Peak Rate Factor(PRF)

Dimensionless Unit Hydrograph Peak Rate Factor

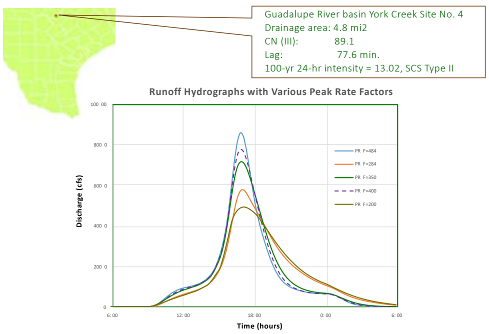
- NRCS runoff modeling/calculation procedures utilize a dimensionless unit hydrograph in the computation of runoff rate and volume.
- Currently, the hydrograph officially used by NRCS in Texas is the "Standard" unit hydrograph, with a PRF = 484 which represents "average" conditions.
- PRF has been known to vary from about 600 in steep terrain to 100 or less in flat, swampy country" (USDA-NRCS, 2007)
- Standard PRF = 484; Delmarva PRF = 284

implementation: Peak Rate Factor(PRF)



NRCS (2007)

implementation: Peak Rate Factor(PRF)



implementation: Peak Rate Factor(PRF)

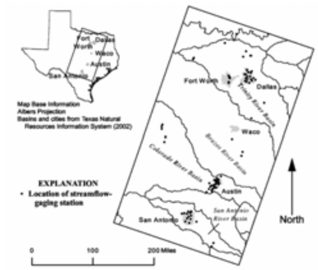
numerous reports indicate that PRF are governed by watershed characteristics.

- rural, rolling hills, PRF is ~300 (NOAA NWS, 2005);
- row crops PRF is ~300, and pasture land PRF is ~200 (Greenvillle County, SC, 2002);
- a study of 10 sites in Illinois resulted in the PRF average of 331 and median value of 320 (Melching and Marquardt, 1997);
- Study of 8 sites in Southeastern U.S. resulted in the PRF average of 329 and median value of 333 (Sheridan et al, 2002).

implementation: Peak Rate Factor(PRF)

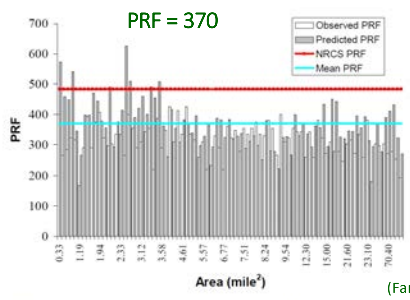
- The most significant studies of PRF for Texas were conducted by Asquith et al (2003) and Fang et al (2005).
- In Asquith's study, 1600 recorded rainfall-runoff data sets from 90 USGS (US Geological Survey) gage stations in central Texas watersheds were collected and analyzed. The unit hydrographs were developed by linear programming for all rainfall-runoff events and all watersheds.
- Fang, based on Asquith's study, further determined PRF for each watershed. As reported by Fang, the average PRF for watersheds in central Texas is 370 with standard deviation of 76.

implementation: Peak Rate Factor(PRF)



(Asquith et al, 2003)

implementation: Peak Rate Factor(PRF)

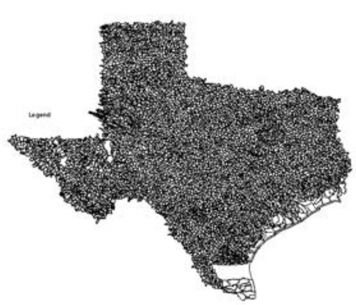


(Fang, 2007)

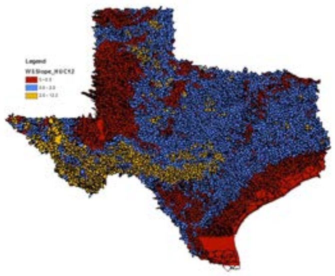
Figure 10. Peak rate factors of synthetic unit hydrographs for central Texas watersheds.

implementation: Peak Rate Factor(PRF)

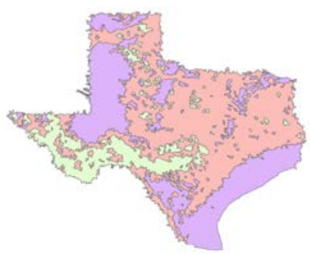
- HUC-12 file from USGS Watershed Boundary Database



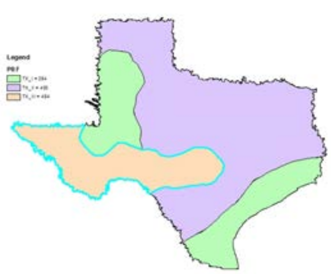
implementation: Peak Rate Factor(PRF)



implementation: Peak Rate Factor(PRF)



implementation: Peak Rate Factor(PRF)



implementation: Peak Rate Factor(PRF)

- Region I – coastal plain and/or extreme flat land with average watershed slope less than or equal to 0.5%, low relief, and significant surface storage in swales and depressions; use Delmarva Unit Hydrograph with PRF = 284;
- Region II – flat to gentle sloped land with average watershed slope higher than 0.5% and less than or equal to 2.0%, use reduced Unit Hydrography with PRF = 400;
- Region III – gentle to steep sloped land with average watershed slope higher than 2.0%, use standard unit hydrograph with PRF = 484.
- When supported by detailed watershed studies, other unit hydrographs may be used. Study procedures should follow Chapter 16 of National Engineering Handbook Part 630, Hydrology.

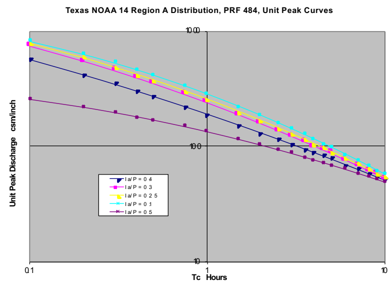
Outline

- ~~Creating TX Rainfall Database~~
- ~~Generating Rainfall distribution zoning map~~
- ~~Developing rainfall distribution curves and tables~~
- ~~Determine Runoff Peak Rate Factors~~
- Developing type.rf files for EFH2 software
- Developing ArcGIS tool to calculate areal-averaged rainfall intensity using NOAA 14 data
- Updating software/tools and documents

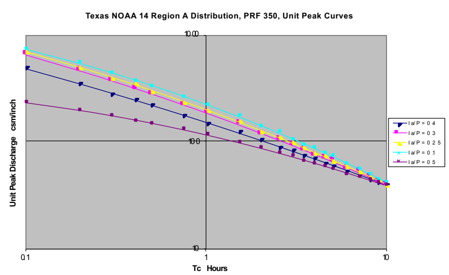
Implementation: EFH2 Coefficient

- Since the dimensionless unit hydrograph (DUH) may not be entered directly in EFH2 in the same way as it can be entered in WinTR-20 and WinTR-55, a type.rf file must be developed for a combination of rainfall distribution and DUH.
- A type.rf file has coefficients for computing peak discharge based on rainfall distribution. Explanations of what the coefficients mean and how they are used to compute peak discharge are included in an appendix to TR-55 (1986).

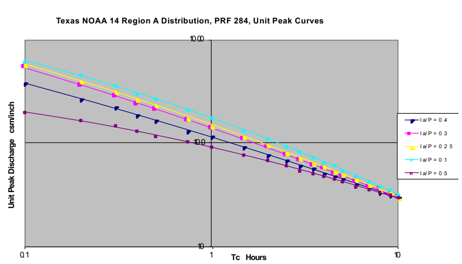
Implementation: EFH2 Coefficient



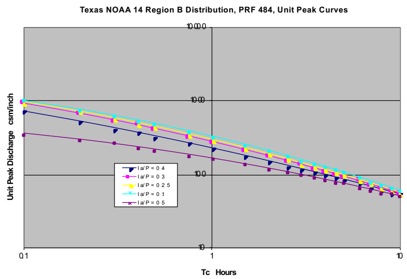
Implementation: EFH2 Coefficient



Implementation: EFH2 Coefficient



Implementation: EFH2 Coefficient

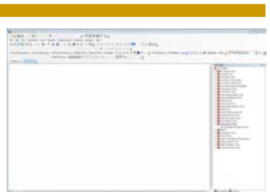


Outline

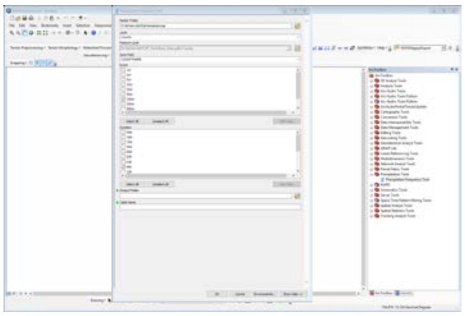
- ~~Creating TX Rainfall Database~~
- ~~Generating Rainfall distribution zoning map~~
- ~~Developing rainfall distribution curves and tables~~
- ~~Determine Runoff Peak Rate Factors~~
- ~~Developing type.rf files for EFH2 software~~
- Developing ArcGIS tool to calculate areal-averaged rainfall intensity using NOAA 14 data
- Updating software/tools and documents

implementation: Texas ArcGIS Tool

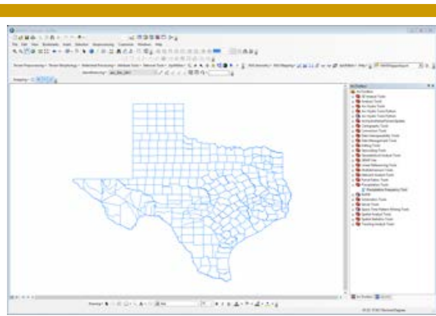
- areal average rainfall intensity
- duration: 5 minutes – 60 days
- return Periods: 1 – 1000 years



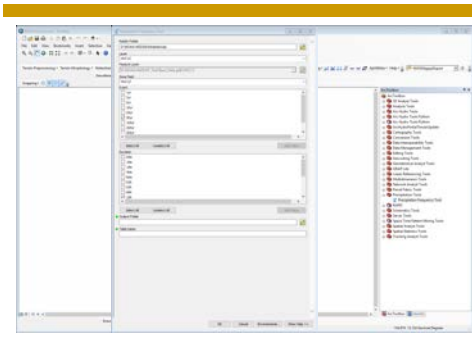
Application: Using Texas ArcGIS Tool



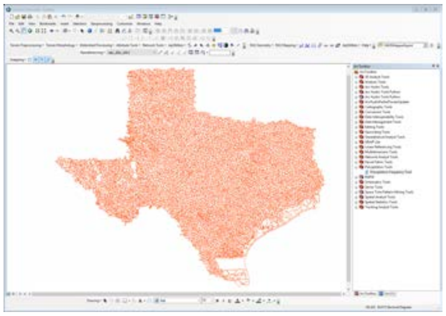
Application: Using Texas ArcGIS Tool



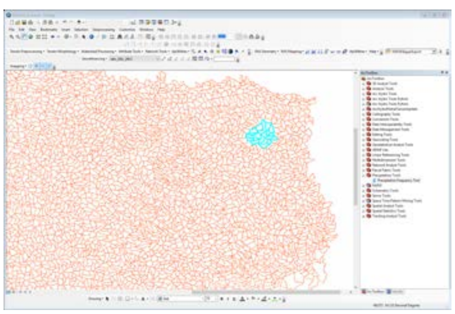
Application: Using Texas ArcGIS Tool



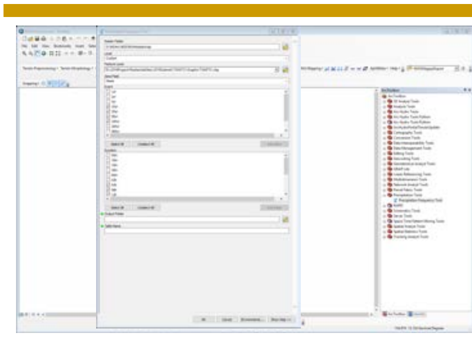
Application: Using Texas ArcGIS Tool



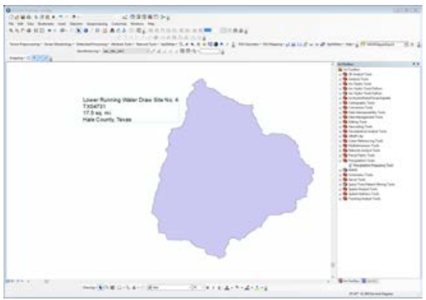
Application: Using Texas ArcGIS Tool



Application: Using Texas ArcGIS Tool



Application: Using Texas ArcGIS Tool



Application: Using NOAA 14 V 11 data

- NOAA Website (point precipitation),
- County-averaged Precipitation Database (county averaged precipitation),
- Texas Precipitation ArcGIS Tool (areal averaged precipitation).

Outline

- ~~Creating TX Rainfall Database~~
- ~~Generating Rainfall distribution zoning map~~
- ~~Developing rainfall distribution curves and tables~~
- ~~Determine Runoff Peak Rate Factors~~
- ~~Developing type.rf files for EFH2 software~~
- ~~Developing ArcGIS tool to calculate areal-averaged rainfall intensity using NOAA 14 data~~
- Updating software/tools and documents

Questions/Comments?

hong.wang@usda.gov
254.742.9914