0-6824 New Rainfall Coefficients – Including tools for estimation of intensity and hyetographs in Texas

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16. Abstract

Depth-Duration-Frequency coefficients for Texas were updated from findings reported in Asquith (1998) and Asquith and Roussel (2004) and are herein referred to as the 2015—DDF values. The 2015—DDF values were used to estimate the 2015—*ebd* values to parameterize the intensity equation in the Texas Hydraulic Design Manual. Both sets of values are listed as appendices in the report.

A computational tool named EBDLKUP-2015.xlsx was built to replace an earlier tool in common use in Texas. The tool differs from the earlier tool in appearance, and is password protected to reduce unintentional changes to the underlying database. The password and an alternate method to defeat the protection are provided in the Technical Reference Manuals as appendices in the report.

A companion tool named TXHYETO-2015.xlsx was built to enable designers to rapidly generate Texas specific hyetographs for importing into HEC-HMS and similar hydrologic modeling software using an approximation to the tabulations reported in Williams-Sether and others (2004).

Training tutorials, a training video, and a training module are included to facilitate rapid deployment of the tools. These components are listed as appendices in the report.

17. Key Words
Texas Depth-duration-frequency (DDF); Texas Intensity-duration-frequency (IDF); Spreadsheet Tools; Tutorials; Training Module

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Disclaimer

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There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract (to date), including any art, method, process, machine, manufacture, design, or composition of matter, or any new useful improvement thereof, or any variety of plant, which is or may be patentable under the patent laws of the United States of America or any foreign country.

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Contents

1 Introduction

1.1 Overview

Rainfall-runoff estimation is used to design adequate drainage systems for transportation infrastructure in both rural and urbanized watersheds. Growth in impervious areas from urbanization can lower infiltration rates, increase runoff rates, and increase risk of flooding of transportation drainage infrastructure. Engineers frequently use several hydrological methods to estimate peak discharge of rainfall at specific return periods (Annual Recurrence Interval, ARI). Although multiple methods for determining peak discharge from runoff exists, the Rational Method is commonly used in Texas for drainage areas smaller than 200 acres because of its simplicity. Equation 1 is the rational runoff equation from the Hydraulic Design Manual (HDM) (Texas Department of Transportation, 2014),

$$Q = \frac{CIA}{Z} \tag{1}$$

where Q is the maximum rate of runoff (in cubic feet per second for U.S. Customary units), C is a runoff coefficient, I is the average rainfall intensity (in inches per hour for U.S. Customary units), A is the drainage area (in acres for U.S. Customary units), and Z is a conversion factor (1.008 for U.S. Customary units, and 360 for SI units).[1]

Rainfall intensity, I, has an obvious influence on determining the rate of runoff in the rational method, and has similar significance in other methods for estimating runoff from rainfall inputs. Intensity is defined as the depth of the precipitation covering an area over a period of time (in/hr or mm/hr).

Intensity is commonly expressed in the HDM as Equation 2 when using Asquith and Roussel (2004) and also by Equation 3 when using *ebd* empirical factors.

$$I_{ARI} = \frac{P_d}{T_c} \tag{2}$$

where P_d is the depth of rainfall in inches for an Annual Recurrence Interval (ARI) design storm of duration T_c, where T_c is the time of concentration in hours.

[1] The unit convention in use in Texas is U.S. Customary (the term English units is used interchangeably herein). The term metric units is used interchangeably for SI units herein.

The depth of rainfall, P_d, within Texas can be found in the Atlas of Depth-Duration Frequency (DDF) of Precipitation Annual Maxima for Texas (Asquith and Roussel, 2004), more commonly referred to as the DDF Atlas. The DDF Atlas consists of maps of Texas overlain with varying depth of precipitation contours at frequencies of 2, 5, 10, 25, 50, 100, 250, and 500-year storms and at set durations ranging from 15 minutes to 7 days. To use Equation 2 for a project design, an engineer would find the map of the desired storm and duration, locate the county in which the project resides, and typically interpolate to retrieve a rainfall depth. Once the depth is retrieved, the equation is then directly applicable.

Since DDF analyses of rainfall are restricted to the discrete set of durations (Asquith, 1998; Asquith and Roussel, 2004), Intensity-Duration-Frequency (IDF) curves and equations are preferred because they provide a mechanism to estimate rainfall intensity for any arbitrary duration. IDF relationships are often expressed as simple algebraic equations to avoid tabular lookup for design rainfall coefficients.

Many algebraic forms have been used to represent IDF curves and are discussed further in Section 3.3. The form used in the HDM, and historically by TxDOT, to describe the rainfall intensity duration relationship is a power-law model, expressed in Equation 3.

$$I_{ARI;COUNTY} = \frac{b}{(t_c + d)^e} \tag{3}$$

where I is the intensity in inches per hour, T_c is the time of concentration in minutes, b is a scaling value, d is an offset, and e is an exponent.[2]

The subscript on I is to indicate that the function and its corresponding coefficients are a function of frequency (ARI) and location (COUNTY).

The e, b, and d coefficients are available to the public and are necessary to accurately calculate intensity at a given location, duration, and frequency. The coefficients were originally developed from interpreting rainfall depth contours developed by the National Weather Service in the 1960's (Hershfield, 1961) and was further expanded in the 1970's (Fredrick and others, 1977).

The National Oceanic and Atmospheric Administration (NOAA, 2015) operates a web-server that provides point precipitation estimates for most of the United States, except Texas, the Pacific

[2]The values in the equation have dimension, but these are explicitly omitted in the discussion, except for the time of concentration, to prevent confusion and prevent any attempt to associate physical meaning to the e, b, d values – these values are simply fitted values to the power law model to produce intensity estimates that agree with the DDF Atlas or other authoritative sources.

Northwest, and parts of the Atlantic Northeast. These estimates are sometimes referred to as "NOAA Atlas 14 estimates."[3]

The ability to use a single equation over graphical lookup methods for any duration makes Equation 3 especially appealing to design engineers. In addition, there currently exists a computational spreadsheet tool, commonly known as `EBDLKUP.xls`, that calculates intensity using Equation 3 based on a user's input of Texas county name and time of concentration. The spreadsheet is prominent amongst Texas hydrologic engineering practitioners and academics to estimate the rainfall intensity for Texas counties. The current tool uses and includes a database of e, b, and d coefficients that were last examined in 1985, approximately 30 years ago.

Recent TxDOT research has resulted in updated DDF estimates that supersede the earlier estimates of TP-40 (Hershfield, 1961) and HYDRO-35 (Fredrick and others, 1977). The analysis of rainfall data applying certain statistical methods (L-moments) and selection of distributions (GLO and GEV) using L-moment ratio diagrams was reported in Asquith (1998) and later employed in the creation of Asquith and others (2006). The results of the analyzed rainfall data from Asquith (1998) was compiled into the Texas DDF Atlas (Asquith and Roussel, 2004) and is incorporated by reference in the TxDOT Hydraulic Design Manual (Texas Department of Transportation, 2014).

The research project updated the e, b, and d rainfall coefficients for Texas based on the Asquith and Roussel (2004) DDF values . In addition to revising the coefficients, the researchers redesigned the current `EBDLKUP.xls` to include the updated coefficients. The redesigned tool is called `EBDLKUP-2015.xlsx`. The research team also developed a companion tool to parameterize Texas Hyetographs (Williams-Sether and others, 2004) called `TXHYETO-2015.xlsx` that makes use of these design storms in HEC-HMS or SWMM far easier than in the past. Training materials and video tutorials for both spreadsheet tools were also developed.

1.2 Scope of Work

Project 0-6824 had four objectives. The first objective was to make adjustments in the recent Depth-Duration-Frequency (DDF) values to maintain parallelism expected in Intensity-Duration-Frequency (IDF) curves as reflected in current practice. The second objective was to revise the *ebd* rainfall coefficients for each county in Texas based on these adjusted DDF values, that arise from research in Texas; the prior *ebd* values are from circa 1985, based on DDF values from analysis not much beyond the late 1970's. The third objective was to build specific tools to enable designers to rapidly

[3] NOAA Atlas 14 is a collection of regional atlases, similar to Asquith and Roussel (2004), built by researchers at the National Weather Service, that are the basis of the web server tool. Texas is not included in the NOAA Atlas 14 collection as of this writing.

access *ebd* values by county, and estimate rainfall intensity for specific Annual Recurrence Intervals (ARI) and arbitrary duration. The fourth objective was to construct training materials to facilitate rapid deployment of the tools and enable designers to self-train in their use.

Previous research and implementation projects that formed the basis for the project included:

- 0-4193, Regional Characteristics of Unit Hydrographs;
- 0-4194, Regional Characteristics of Storm Hyetographs;
- 0-5521, Develop Statewide Regression Equations for Improved Flood Peak Estimation; and
- 5-1301, Updated Precipitation Atlases for Texas.

The Texas Tech University (TTU) and United States Geological Survey (USGS) research teams worked concurrently to develop new rainfall coefficients for Texas, provide tables of *ebd* values by county, recurrence interval and duration, and to provide equations to generate design storm hyetographs in Texas. The results of the research were then utilized in two spreadsheet tools: `EBDLKUP-2015.xlsx` and `TXHYETO-2015.xlsx`.

`EBDLKUP-2015.xlsx` calculates intensity based on the user's input of units, county, and duration. The current `EBDLKUP.xls` tool was redesigned and updated to: `EBDLKUP-2015.xlsx`. The new spreadsheet includes the revised *ebd* rainfall coefficients, a complete redesign of the interface, as well as a name change to create a clear distinction from the previous tool.

The `TXHYETO-2015.xlsx` spreadsheet was created to implement the distribution-mixture function model to dimensionalize a 50th or 90th percentile Texas hyetograph based on the user's input of storm duration, storm depth and time interval. The tool facilitates construction of design storms for durations ranging from 10 minutes to 24 hours. It is a companion tool to `EBDLKUP-2015.xlsx`.

In addition, training materials were created for both spreadsheets. Both tools are accompanied by a DES-601 training module, written tutorials, video tutorials, and technical reference manuals to facilitate ease of use.

Deliverables include:

- Revised DDF values for the 2-, 5-, 10-, 25-, 50-, and 100-year ARI;
- Revised *ebd* values varying from 15-minute to 24-hour durations at each ARI;
- `EBDLKUP-2015.xlsx` and `TXHYETO-2015.xlsx` spreadsheet tools; and
- Training modules, written tutorials and technical reference manuals for spreadsheet tools.

2 Background

In the 1950s the Weather Bureau, a part of the National Oceanic and Atmospheric Administration (NOAA) currently known as the National Weather Service (NWS), was engaged in researching and developing rainfall frequency data for the United States. In 1955, the Weather Bureau, in corporation with the Soil Conservation Service, began to define a depth-area-duration-frequency regime within the United States.

The results of their studies produced a series of Technical Papers that established concepts such as a methodology for point-to-area rainfall frequency ratios (Myers and Zehr, 1980), rainfall IDF curves (U. S. Weather Bureau, 1955), and the well known rainfall frequency atlas of the United States, known as Technical Paper No. 40 (TP-40) (Hershfield, 1961). TP-40 is composed of maps of the United States with rainfall depths displayed by isohyetal lines for durations ranging from 30 minutes to 24 hours at ARIs of 1, 2, 5, 10, 25, 50, and 100 years (Hershfield, 1961).

Notable publications from the 1970's that referred to or built upon TP-40 included: Texas' first design Hydraulic Manual (Texas Highway Department, 1970), NOAA Atlas 2 (Miller and others, 1973), and HYDRO-35 (Fredrick and others, 1977). NOAA Atlas 2 has since been replaced by the point precipitation frequency data server (NOAA, 2015).

The rational method, Equation 1, and the power-law intensity model, Equation 3, appear in the first edition of the Hydraulic Manual (Texas Highway Department, 1970), published in 1970 by the Bridge Department of the Texas Highway Department, now the Texas Department of Transportation. The Hydraulic Manual was created by the department to provide a set of design guidelines and procedures for hydraulic structures to engineers within the state of Texas.

The Hydraulic Manual provided two methods for calculating intensity. The first method consisted of manually calculating the intensity formula, Equation 3, with *ebd* rainfall coefficients and time of concentration. The second method consisted of using a nomograph with *ebd* rainfall coefficients and time of concentration to determine intensity.[4] Both methods used the intensity equation and required the use of *ebd* rainfall coefficients based on a county in Texas and a specified ARI.

[4]The nomograph provided in the 1970 Hydraulic Manual is shown in Appendix I for historical purposes. Using the equation method, designers could calculate intensity by simply computing a time of concentration and finding the corresponding *ebd* values for a county at an ARI. The HP-35 scientific calculator appeared in 1972 at about $400 and the TI-30 in 1976 at about $25. So a designer at the time would likely be using a slide-rule and thus the manual provided a second method of calculating intensity through the use of a nomograph, a graphical computational tool. The two-dimensional diagram allows for an approximate calculation of a function by connecting scales together with lines to approximate a calculation. The proper connections are numbered in parenthesis across the scales with an example problem as a guide. The graph consists of five scales including: Time of Concentration in minutes, Factor-d, Factor-e, Factor-b, and Intensity in inches per hour. Interestingly, the nomograph would work with the 2015 *ebd* values if a designer wished to use it – it is simply a special purpose graphical calculator.

The *ebd* values for the state of Texas were placed in the 1970 edition of the Hydraulic Manual. The original table was then almost immediately replaced in June of 1975 by new rainfall coefficients that were based on more comprehensive observations and approximately 25 more years of data. The updated *ebd* constants were generated from TP-40 and were created for each county at a 5, 10, 25, and 50 year ARI (Texas Highway Department, 1970). The creators of the 1975 coefficients chose to keep the *d* coefficient constant whereas the *e* and *b* coefficients varied across frequencies.[5]

Although TP-40 only provided maps starting at durations of 30 minutes, it provided a method to determining precipitation for durations less than an hour by using nationwide return-period independent ratios. Further research by NOAA observed that the ratios had a describable geographic pattern and varied with return periods. In 1977, NOAA published Technical Memorandum HYDRO-35 that reanalyzed and derived new precipitation frequencies at durations ranging from 5 to 60 minutes for approximately 37 states. HYDRO-35 consisted of maps of the eastern half of the United States that displayed rainfall depths as isohyetal lines for durations less than an hour at a 2- and 100-year frequency (Fredrick and others, 1977).

In March of 1984, the Federal Highway Administration published the Hydrologic Engineering Circular No. 12 (Johnson and Chang, 1984). The manual was created to provide design charts and procedures for a variety of design conditions mainly dealing with drainage of highway pavements across the United States of America. One of the most prominent parts of the manual can be found in Appendix A of HEC 12. Appendix A of HEC 12 describes an equation fitting process to solve for rainfall coefficients and establishes provenance for the equation structure chosen within the current *ebd* coefficient research. Dependent on a location within the United States, the manual walks through the steps necessary to develop IDF Curves for 2- to 100-year frequencies based on data from: Technical Paper No. 40 (Hershfield, 1961), NOAA Atlas 2 (Miller and others, 1973), and HYDRO-35 (Fredrick and others, 1977).

Using the IDF curve of a certain location, an engineer could retrieve duration and intensity at a certain frequency and use the values to develop an equation for rainfall intensity. Instead of *b*, *d*, and *e* rainfall coefficients, HEC 12 refers to the coefficients as *a*, *b*, and *m*, respectively. To determine the constants *abm* within the intensity equation for a specified location and ARI, duration and rainfall intensity at the specified ARI are plotted on 2-cycle logarithmic paper with a curve drawn through the data points. The constant *b* is guessed at a low value to begin with and changed until the plotted data points resemble approximately a straight line. The value of *a* is read as the point where $T_c = 1$ and the value of *m* is the slope of the line. The constants are then confirmed by checking against the

[5] The table of *ebd* values from 1975 is presented in Appendix II for historical purposes.

original values of intensity with adjustments necessary. These steps were to be repeated for other frequencies.

Shortly after, in 1985 the Bridge Department of the Texas Highway Department produced another Hydraulic Manual (Texas Highway Department, 1985). One of the prominent parts of the manual was the revised and expanded table (Table 6) of *ebd* coefficients for every county in Texas. The table of coefficients displayed in the manual are currently still in use for determining intensity and are incorporated in the current spreadsheet tool, `EBDLKUP.xls`.[6]

The 1985 constants were developed and updated based on rainfall frequency data found in Hershfield (1961) and Fredrick and others (1977). Contrasted with the 1975 manual, the 1985 table includes 2- and 100-year frequencies and the values for *d* no longer remain constant but are varied across each frequency.

Since 1985, newer research and statistical analysis techniques of rainfall data has allowed for the development of revised DDF values. A change in DDF values directly affects and thus requires updating of the *ebd* constants. Although the analysis techniques might differ, the intensity equation used for developing coefficients in the 1980's is structurally identical to the equation used in the current New Rainfall Coefficients research project (0-6824). The methods used in the research are similar to and built upon the pre-existing structures found in Hydraulic Manuals and Technical Memorandums of the past.

[6]The 1985 *ebd* coefficients are shown in Appendix III for historical purposes.

3 Updated DDF Values and Related *ebd* IDF Coefficients

Updated DDF values for Texas were created using certain statistical tools (L-moments) and flexible probability distributions (GLO and GEV) using methods described in Asquith (1998) and later mapped in Asquith and Roussel (2004). These values were further refined and updated in this work to produce values at county centroids that served as the initial values for the *ebd* generation process described in this section of the report. The result of this analysis produced adjusted DDF values caused by preserving certain parallelism expected in DDF or IDF curves for different ARI. These adjusted DDF values further produced *ebd* values that form the basis of the tool `EBDLKUP-2015.xlsx`.

3.1 Texas Rainfall Intensity-Duration Frequency (IDF) Coefficient Estimation Process

The construction of depth-duration frequency of rainfall is an inherently complex problem to smoothly generalize for the problem of reliable IDF coefficients specification. There exist at least six dimensions (domain) of depth, duration, frequency and the estimation of this tuple from observational data and adapt to the location in the three dimensions of latitudinal and longitudinal location and elevation.

3.1.1 Provisional County-Mean IDF Values

Asquith (1998) contoured parameters of selected probability distributions for selected rainfall durations and ARI. These contours are necessary and even sufficient to define depth-duration frequency (DDF) of rainfall in Texas.[7] For example, the “Asquith-98 contours” represent fundamental and subtle interactions of Texas climate and physiography on annual maxima storms.[8] A feature of the contours by their mathematical basis is that they guarantee that the relation between IDF and ARI is smooth and monotonic increasing. However, the contours do not guarantee for a given ARI that the relation between duration and rainfall depth is wholly smooth, and there exist possibilities that in limited parts of Texas and within uncertainty of original contour placement and later end-user

[7] These contours are distribution parameters for a location. The parameters are put into the associated distribution function to allow the designer to estimate a probability for a given location, depth, and duration.

[8] The values estimated herein for DDF and IDF are based on annual maxima. NOAA Atlas 14 and the related web-based tool are based on both annual- and partial-duration series, although, at the user’s discretion, annual maxima adjusted values are available on the web-server interface (NOAA, 2015).

interpretation (interpolation) that the relation for a given location is not monotonically increasing in rainfall depth and duration.

Asquith anticipated that end-users would plot estimates of depth (or equivalently intensity) as a function of duration and re-interpret the estimates for greater reliability. Ultimately, the distribution-parameter contours were too difficult to use in some applied circumstances and a traditional atlas of contours of rainfall depths throughout Texas by duration and ARI was fulfilled with the subsequent publication of Asquith and Roussel (2004), which herein is referred to at the Texas DDF Atlas.

Those authors made some slight revisions or updates to Asquith (1998) and contoured rainfall using "lines of equal depth."[9] In general, the Asquith and Roussel (2004) contours are such that monotonic increase in rainfall depth and duration exists respectively in the depth-duration space as well as the horizontal dimension across Texas. This observation again is made given the inherent uncertainty of original contour placement and later end-user interpretation (interpolation) that the relation for a given location. Unfortunately, the contours of depth in Asquith and Roussel (2004) still do not guarantee that for a given ARI that the relation between duration and rainfall depth is wholly smooth, and such smoothness is a physical expectation.

For some of the maps in Asquith and Roussel (2004), the contour intervals are not constant and V-shaped "valleys" and "troughs" occasionally exist. Further implied flat-bottomed sinks or table-topped mesas of rainfall depth are seen by closed contours within Texas. The contours in Asquith and Roussel (2004) represent level-sets on a "statistical surface," and these level-sets are not wholly analogous to lines of equal elevation as seen on topographic maps familiar to hydrologic designers and many others.

The Asquith and Roussel (2004) contours were later represented by an estimated raster surface and provisional county-mean values estimated by computer (Lucia Barbato, Texas Tech University, written commun., Dec. 2007). Exploratory analyses for Asquith and Roussel (2009) using these mean values as potential predictors of peak-streamflow frequency ("flood frequency") suggested limited prediction potential; however, there remains promise that "rainfall frequency" should have some predictive potential for flood frequency. Lastly, it is important to note that for some locations in Texas and because of the nature of the contour lines (in both Asquith (1998) and Asquith and Roussel (2004)) that a human analyst might estimate a value differently than a computer algorithm (such as that implemented by Lucia Barbato in Dec. 2007).

For this study, these county-mean values of DDF were converted to IDF values by dividing each DDF value by its respective duration. These county-mean values for purposes of this study were

[9] Isohyets.

considered provisional and are not reported here, but for sake of clarify, these are identified as the "2007-IDF values."

The 2007-IDF values remained provisional until county-by-county supervisory scrutiny was made in this study. The scrutiny resulted in some adjustments as context dictates and after each county had been inspected by four analysts working independently, the "adjusted 2007-IDF values" became the formal values for purposes of defining IDF coefficients for Texas.

As the researchers scrutinized the 2007-IDF values, if the computer interpolation algorithm for a given county resulted in an estimated IDF curve for a given ARI that diverged considerably from the pattern of other IDF values, then the analyst could adjust this point with information such as trends in IDF relations and manual lookup/confirmation in Asquith and Roussel (2004). Ultimately, the scrutiny enormously enhanced the reliability and validity of the ensemble of IDF coefficients for a given county developed for this study.

3.2 Database Description

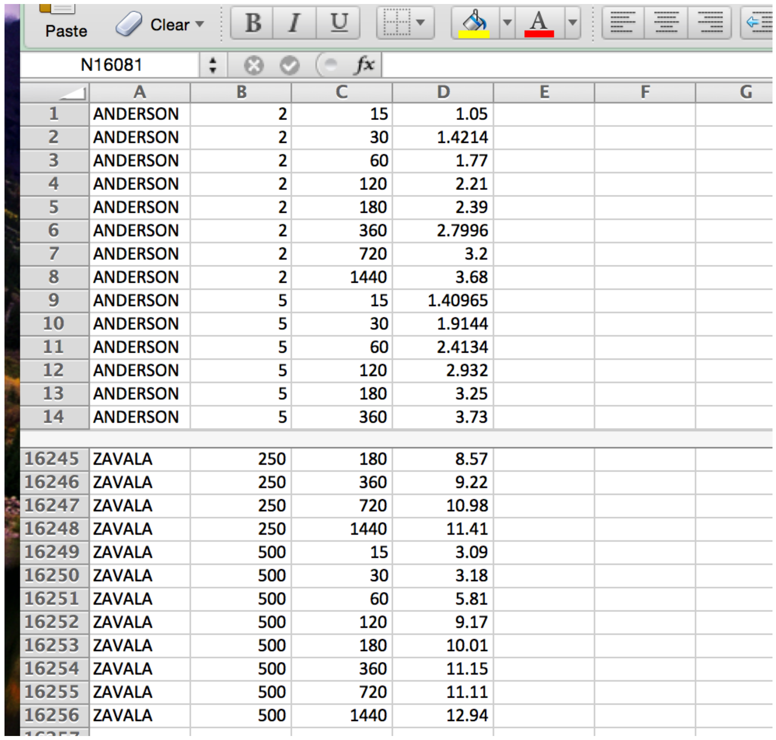
The results from Asquith and Roussel (2004) and the provisional mean values in Asquith and Roussel (2009) for the 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-year ARIs from 15-minute to 24 hour duration were extracted and initially examined. Fifteen counties had missing values which were manually inserted into the database. The values were derived from Asquith (1998) and/or interpolated from border counties as appropriate. Effort was expended to try to match behavior with NOAA Atlas 14 (NOAA, 2015) for counties bordering adjacent states. The resulting database contains 16,256 related values of depth, duration, and frequency for Texas counties, as seen in Figure 1 below.

3.3 Algorithms and Methods

The revised *ebd* values were estimated by a method involving three independent research teams. Three separate teams were chosen to have the ability to compare each result as a measure of quality assurance and quality control.

3.3.1 Mathematical Background

IDF behavior are often expressed as comparatively simple algebraic equations. A benefit of specifying such analytical solutions are avoidances of graphical computations (consider the nomograph in



	A	B	C	D	E	F	G
1	ANDERSON	2	15	1.05			
2	ANDERSON	2	30	1.4214			
3	ANDERSON	2	60	1.77			
4	ANDERSON	2	120	2.21			
5	ANDERSON	2	180	2.39			
6	ANDERSON	2	360	2.7996			
7	ANDERSON	2	720	3.2			
8	ANDERSON	2	1440	3.68			
9	ANDERSON	5	15	1.40965			
10	ANDERSON	5	30	1.9144			
11	ANDERSON	5	60	2.4134			
12	ANDERSON	5	120	2.932			
13	ANDERSON	5	180	3.25			
14	ANDERSON	5	360	3.73			
16245	ZAVALA	250	180	8.57			
16246	ZAVALA	250	360	9.22			
16247	ZAVALA	250	720	10.98			
16248	ZAVALA	250	1440	11.41			
16249	ZAVALA	500	15	3.09			
16250	ZAVALA	500	30	3.18			
16251	ZAVALA	500	60	5.81			
16252	ZAVALA	500	120	9.17			
16253	ZAVALA	500	180	10.01			
16254	ZAVALA	500	360	11.15			
16255	ZAVALA	500	720	11.11			
16256	ZAVALA	500	1440	12.94			

Figure 1: DDF database used to generate *ebd* values by analyst-directed method. The database is structurally identical to the contents of Appendix IV.

Appendix I) or ponderous tabular lookup for common design rainfall intensities. DDF analyses of rainfall are often restricted to only a few discrete durations (Asquith, 1998; Asquith and Roussel, 2004), while equations for IDF curves provide a mechanism by which rainfall intensity can be determined for arbitrary durations between some stated duration limits (10 minutes to 1 day for this study). The simplicity and ability to select arbitrary durations make IDF curves especially attractive to hydrologic design practitioners.

Over many decades various algebraic forms have been used by others to represent IDF curves fit to IDF values and thus produce wholly smooth definitions of rainfall IDF. Some select functional forms and respective references are shown in the following equations:

Chow and others (1988)

$$IDF_{\mathcal{F}}(T_c;\ c, E, f) = K \times \frac{c}{T_c^E + f}, \tag{4}$$

Haan and others (1994)

$$IDF(T_c, \mathcal{F};\ x, n) = K \times \frac{\mathcal{F}^x}{(T_c + b)^n}, \tag{5}$$

McCuen and others (2002)

$$IDF_{\mathcal{F}}(T_c;\ a, b, c, D) = K \times \begin{cases} \frac{a}{T_c+b} & \text{for } T_c \leq 2 \text{ hours} \\ cT_c^D & \text{for } T_c > 2 \text{ hours,} \end{cases} \tag{6}$$

Texas Department of Transportation (2014)

$$IDF_{\mathcal{F}}^{\text{county}}(T_c;\ e, b, d) = K \times \frac{b}{(T_c + d)^e}, \tag{7}$$

where IDF is an intensity, T_c is characteristic watershed time (critical storm duration in the same time units as the coefficient b or D), K is a units conversion constant and is ignored hereinafter ($K \equiv 1$), $\mathcal{F}$ is a frequency that may be either equal to or numerically related to ARI, and a, b, c, d, D, e, E, and f are coefficients. These coefficients are empirical and likely would be generated from some form of regression analyses.

The variables e, b, and d also are coefficients and are separately acknowledged because these are colloquially known as the "*ebd* coefficients" for Texas.[10] The provenance of the *ebd* values for Texas has been discussed in the Background. Lastly, the subscripted $\mathcal{F}$ as in $IDF_{\mathcal{F}}$ implies that the corresponding coefficients are all a function of frequency, and the superscripted "county" implies that the e, b, and d are county-specific values.

The last form of an IDF curve in Equation 7 is the expression in current practice by TxDOT (TxDOT, 2014, p. 10-45) including that used in various forms of a oft-copied spreadsheet amongst Texas hydrologic engineering practitioners and academics. The spreadsheet is known under various names—and is Internet searchable using a variety of keywords.

Some examples of "found" spreadsheets are `TXDOT_IDF_Coeffs.xls` and `EBDLKUP.xls`. The naming convention sourced from TxDOT at `http:onlinemanuals.txdot.gov/txdotmanuals/hyd/ebdlkup.xls` (accessed on Sept. 26, 2014) is `ebdlkup.xls`.

[10]The lower case *ebd* representation is consistent with the 1970 and 1985 Hydraulic Manual and hence is the reason these are retained as lower case for the present study.

The prevalence for the renaming of the spreadsheet is not particularly surprising although such a practice has impact on the innate pedigree or provenance of any given spreadsheet. As suggested simply by Internet searches, TxDOT strives to maintain a persistent URL as part of the agency's mission, and provides guidelines for hydrologic design computations in Texas.

3.3.2 IDF Optimization Algorithm using Sequential Unconstrained Minimization

Because a primal objective of this project is to derive IDF coefficients that are compatible with existing spreadsheet lookup tables that are based on specific counties as well as various software utilities in use by the Texas hydrologic engineering community, the algebraic form seen in Equation 7 was selected as the standard and will be useful for future re-derivations of county ensembles of EDB coefficients.[11]

The authors recognize that other analytical expressions have been used to fit rainfall intensities to corresponding durations and thus define rainfall intensity coefficients. The literature is unclear as to a grand preference of form by practitioners. There are some features of the long-used IDF curve form by TxDOT, however, they are especially attractive from several perspectives, and there is no reasonable justification to abandon the form long in practice in Texas. Additional commentary from these perspectives follows:

- The inherent nature of IDF values is that collectively they are substantially linearized with respect to duration when rainfall intensity and duration are each logarithmically transformed prior to graphical visualization. The use of logarithms mathematically means that the basic functional form of an IDF expression will include multiplication as well as exponentiation parameters. However, the transformation is not guaranteed to result in ideal or sub-ideal linear relations, and in turn an additional parameter will be instated;
- Inspection of many IDF values that include short durations such as less than about 1 to 3 hours often show a departure from linearity in log-log space—the relation seemingly "breaks over towards the left" for the shortest durations meaning that continued increase along the trend line established at longer durations (say >3 hours) as duration decreases is not constant. In other words, there often is curvature on the left-hand side of the conventional log-log plot of IDF values. Inspection of the relations between IDF values that can be derived from Asquith and Roussel (2004) shows that as a general rule most locales in Texas show such curvature. Therefore in order to remove the necessity of having two different

[11] Perhaps as soon as circa 2019, National Oceanic and Atmospheric Administration (NOAA) is anticipated to update their rainfall frequency products ("NOAA Atlas 14") to include Texas NOAA (2015) (Jerry Cotter, U.S. Army Corps of Engineers – Fort Worth, written commun., 2015; Dale Unruh, NOAA, written commun., 2015).

IDF formula that must also intersect at specific durations to maintain physical plausibility, a single form such as the three-parameter IDF equation form in Equation 7 is to be preferred;

- The fact that Texas encompasses a broad range of climatic and physiographic conditions that impact DDF/IDF variation throughout the state (Asquith, 1998; Asquith and Roussel, 2004) makes a flexible form of an IDF curve defensible because there are heuristic expectations that varying curvature across the state for short durations might exist; and

- The form in Equation 5 of the IDF curve shown by Hann and others (1994) has ARI embedded along with T_c. Related to the scope of the current study, that includes all 254 counties in Texas, it might be problematic in reliably mimicking all of the available IDF and duration pairs derived from Asquith and Roussel (2004) for a given county. Although not used for this study, the IDF relation in Equation 5 might otherwise prove convenient or extendable because substantially fewer coefficients by county are needed.

The researchers observe that the form in Equation 7 provides for sufficient flexibility in model fit. For example, logarithms can be used to partially linearize the equation in which the exponent and intercept are the parameters e and b, respectively. Yet the transformed relation is not yet linear and all terms for the coefficient d functions as a “logarithmic offset.” The logarithmic offset controls the curvature of the IDF curve for short durations.

Exploratory analysis for IDF values by county derived from Asquith and Roussel (2004) indicates that there is neither a mathematical nor statistical reason to not remain congruent with Equation 7 for the development of new rainfall coefficients for the state of Texas. For example, if a given suite of IDF values for a given ARI and county are collinear then $d = 0$; so Equation 7 accommodates perfect log-log linearity.

An example IDF relation between provisional county-mean IDF values, IDF curves of existing TxDOT *ebd* values, and IDF curves fit using the algorithm described in this section is shown in Figure 2. This figure is cited several times in subsequent discussion. Several features of the figure though can be identified.

First, the plot is in dual base-10 logarithmic units.[12] Second, the minimum duration is 10 minutes and the maximum is 24 hours—these are the limits of the operational durations for IDF curve application for TxDOT. Third, the vertical ensembles of IDF values represent values for a specific duration and the effect of increasing AEP is for the values to plot at sequentially large IDF magnitude. The figure is said to show provisional county-mean values and provisional fits to these values because

[12] A log-log plot.

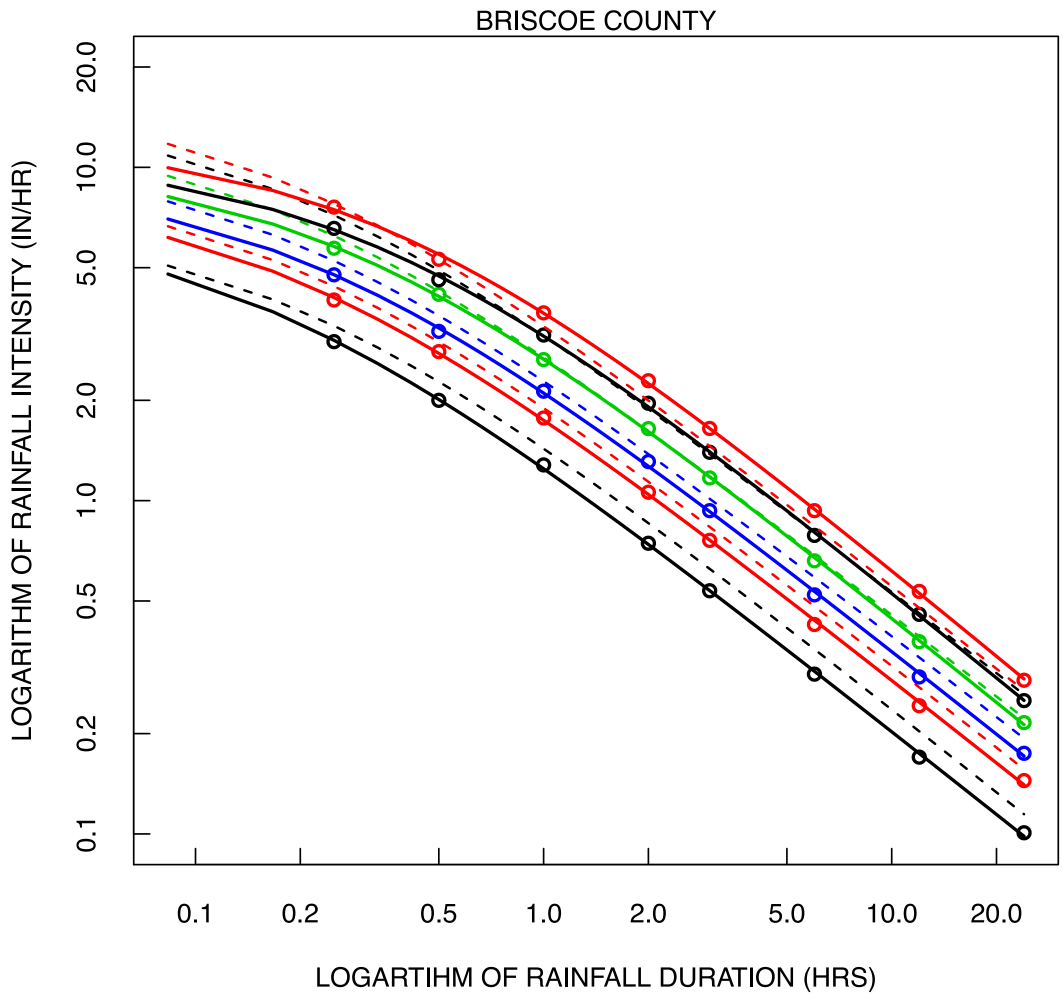


Figure 2: Provisional county-mean values of intensity-duration frequency (IDF) of rainfall for Briscoe County, Texas derived from Asquith (1998) and Asquith and Roussel (2004) for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals and in addition IDF curves (dashed lines) following Equation 7 using existing TxDOT (circa 1985) *ebd* coefficients (TxDOT, 2014, p. 10–45) and provisional IDF fits to the values (solid lines) to county-mean values.

the figure was generated ahead of county-by-county quality control and quality assurance for this project.

Provided that the functional form of the IDF is established as Equation 7, the challenge of parameter (coefficient) estimation remains. Equation 7 is nonlinear. Nonlinear least squares (NLS) in a regression context (Bates and Watts, 2007; Ritz and Streibig, 2008) could be chosen for parameter estimation with the burden on the analyst that starting values for the coefficients would be needed. The existing TxDOT (circa 1985) *ebd* coefficients were considered as starting values for NLS. Exploratory analysis of NLS as a means for parameter estimation using large-scale batch processes encompassing all 254 counties of Texas as well as the six ARI and eight distinct durations (12,192 pairs of rainfall intensity and duration) indicated unsatisfactory performance as measured by general quality of fit. Occasional grossly inadequate mimicry of the underlying data was obtained, and discouragingly in other circumstances, there was a general failure to find a solution at all. The researchers concluded exploratory analysis with a decision that an alternative algorithm should be sought because of the sheer scale of the project (in aggregate 1,524 equations for the 254 counties and six ARI values).

A mathematical and statistically robust algorithm was developed for to complete the computational aspects of this study. The basic tenants of the algorithm were:

- Linear regression using ordinary least squares (OLS) when compared to NLS is robust and guarantees a solution;
- If d is known, then elementary algebra when letting $\eta = T_c + d$ can linearize Equation 7 to $IDF_{\mathcal{F}}(\eta; e, b) \rightarrow \log_{10}(IDF_{\mathcal{F}}) = b + e\log_{10}(\eta)$. Once linearity is formed then the solution to e and b is trivial for a computer script using OLS;
- In implementation, the challenge for parameter estimation is the single coefficient d, which is the logarithmic offset; and
- Single variables in smooth functions are readily solved for using "one dimensional root (zero) finding," which is often just a single function call in statistical programming languages such as R (R Core Team, 2015).

The process above uses OLS results as an intermediate computational step in the one-dimensional line search for d, essentially employing the sequential unconstrained minimization technique SUMT (Fiacco and McCormick, 1964). At each step of the line search, as d is varied, the optimal values of b and e are estimated. The method is far less sensitive to the initial value of d and because the discrete durations T_c are never less than 10 minutes, the probability of the line search returning a negative value for d is reduced.[13]

Listing 1: Pseudo language representing the algorithm for determination of IDF coefficients on a county-by-county basis given a database of county-mean values for IDF.

```
foreach COUNTY in COUNTIES do { # 254 counties in Texas, so 254 loops passes
   foreach ARI in ARIS do {      # six ARI values, so six loops
      Dvalues = [-10 to 1440]    # the units are in minutes, reset each loop
      db  = get IDFpairings(COUNTY, ARI) # the county-mean database
      IDF = log10( grab a IDF(db) )       # vector of IDF values (inch/hour)
      DUR = get a DURATION(db)         # vector of eight durations (minutes)
      Droot = minimize a dim1root foreach D in Dvalues { # def. 1D root func.
          logETA = log10(DUR + D)                # the log with an offset
          LM     = do LinearRegress(IDF~logETA)   # IDF as func. of logETA
          PRESS  = get PRESSfromLinearRegress(LM) # regression diagnostic
          return(PRESS)              # the PRESS statistic for the optimal D
      }
      D = get minimized NumericalRoot(Droot) # from Droot "object"
      logETA = log10(DUR + D)               # the log-offsetting
      LM     = do LinearRegress(IDF~logETA)  # final regression fit
      (E, B) = get RegressCoef(LM)           # extract coefficients
      print these(COUNTY, ARI, E, B, D)      # report solution
   }
}
```

Listing 1 is the SUMT algorithm in pseudo-programming language. The pseudo-language consists of logic blocks {...}, sequencing blocks [...], verbs (do, get, grab, print, return) and other keywords (a, foreach, in, log10, minimize, minimized, to) that are typeset in a green san serif typeface. In the Listing, the function arguments are denoted by opening and closing pairs of parentheses. Comments for further guidance are in *red italics*. A custom function needed for the algorithm is `IDFpairings`, which is responsible for a database interconnect between tables of county-mean IDF values by ARI.

The conceptually most critical detail in the algorithm shown in the listing is the function referred to as `PRESSfromLinearRegress`. This particular function is responsible for computing the PRESS statistic of a regression.[14] The PRESS statistic as shown herein mimics the greater part of the description of the PRESS statistic in Asquith and Thompson (2008). Those authors formally introduce the PRESS statistic of a regression as part of an optimization problem for instantaneous

[13]The non-zero result is important. Line searches fail in three ways; divide by a zero gradient while the function is still non-zero, cycling (cannot find a root) because the gradient changes sign each iteration, overshoot when near the solution but the gradient points to a next estimate that is too far away from the solution. In this work, the line search is on η which has the non-zero T_c embedded within its value.

[14]PRESS is the acronym for predicted residual sum of squares statistic, which is a form of cross-validation used in regression analysis to provide a summary measure of the fit of a model to a sample of observations that were not themselves used to estimate the model.

peak-streamflow frequency estimation in Texas. Asquith and Roussel (2009) subsequently used a similar algorithm for their revisitation of peak-streamflow frequency estimation for Texas.

Conceptually similar justification for use of the PRESS statistic for optimization of regression for purposes of line fitting of the IDF function in Equation 7 is made. The choice of PRESS minimization is not arbitrary. Extensive testing of nonlinear regression resulted in great difficulties in identification of sets of *ebd* coefficients among the AEPs for a county that resulted in consistently subparallel trajectories of the curves.

The PRESS statistic generally is regarded as a measure of regression performance when the model is used to predict new data or information (Montgomery and others, 2012). Regression equations with small PRESS values are desirable and all else being equal a fit with the smallest (minimized) has maximized information content of the regression fit. Thus, PRESS minimization is an appropriate goal. Helsel and Hirsch (2002) (p. 247) state that, "Minimizing PRESS means that the equation produces the least error when making new predictions."

The PRESS statistic is computed from the PRESS residuals, which are defined as

$$e_{(i)} = y_i - y'_i, \tag{8}$$

where $e_{(i)}$ is the PRESS residual, y_i is the observed ith IDF value for a given AEP and county, and y'_i is the predicted value based on the remaining $n-1$ sample values. The ith IDF value is in other words not used to generate the ith regression equation, and therefore PRESS residuals are regarded as validation statistics. The PRESS statistic is

$$\mathrm{PRESS} = \sum_{i=1}^{n} e^2_{(i)}. \tag{9}$$

This form of PRESS is computationally intensive (n regressions are required). A more efficient computation of PRESS is made using regression residuals (e_i) and leverage (h_{ii}) (Montgomery and others, 2012). The double subscript ii refers to the diagonal of the "hat matrix," which is a well-known concept to regression analysts. The h_{ii} values are readily available from modern regression software packages (R Core Team, 2015). The PRESS computation is made by

$$\mathrm{PRESS} = \sum_{i=1}^{n}\left(\frac{e_i}{1-h_{ii}}\right)^2. \tag{10}$$

In summary, the SUMT algorithm that was chosen to compute updated e, b, and d, determines e and b by ordinary-least squares regression on the logarithms of rainfall intensity and a given value of d, the offset duration. The minimization of PRESS is used as the merit function to identify the numerical values of the logarithmic offset d using a line-search technique.[15] The information content in the $IDF_{\mathcal{F}}^{\mathrm{county}}(T_c; e, b, d)$ in effect has been maximized. The coefficients e and b control the general slope and intercept of the IDF curve and the d controls the curvature of the line towards $IDF_{\mathcal{F}}^{\mathrm{county}}(T_c \rightarrow \tau;\ e, b, d)$ where $\tau \equiv 10$ minutes—that is the minimum accepted T_c for IDF curve application in Texas.

3.3.3 Analyst-Directed *ebd* Generation

Analyst directed *ebd* generation used the SUMT algorithm and the DDF results from Asquith (1998) and Asquith and Roussel (2004) for 2-, 5-, 10-, 25-, 50-, and 100-year ARI from 15-minute to 24 hour durations. The results of this program are initally provisional IDF curves for each county, such as Figure 2. Then the analyst can adjust DDF values to preserve quasi-parallel curves as is typically expected with IDF curves.

Figure 3 is an example of an instance where the initial estimates are not consistent with current state-of-practice for IDF curves at the lower durations. The software was written to allow for adjustments of DDF values and re-fitting after adjustment. The DDF values are the dots in the figure.

Figure 4 is the result after analyst adjustments. Each county in Texas was examined in this fashion. The resulting 2015—DDF coefficients and 2015—*ebd* values are saved from such analysis and constitute the revised values from this research.

[15] The line search is essentially Newton's method using finite-differences to approximate the gradient of the PRESS function; the value searched is η. At a line-search solution, the offset, d, is recovered by subtracting the duration T_c.

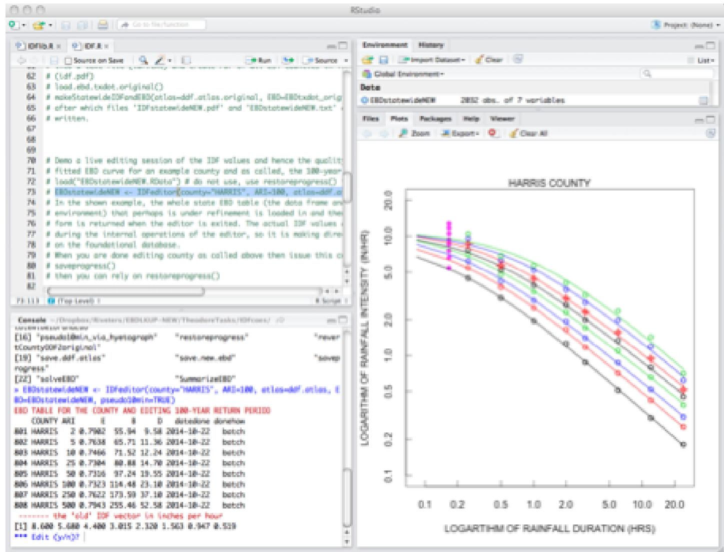


Figure 3: Screen capture of the R Software used for graphically displaying, editing, and estimating IDF curves. IDF curves displayed for Harris County, Texas is derived from Asquith (1998) and Asquith and Roussel (2004) for 2-, 5-, 10-, 25-, 50-, and 100-year ARI.

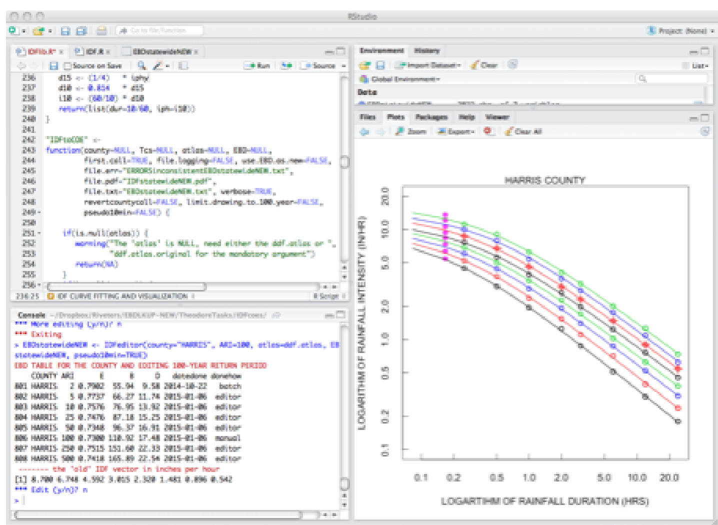


Figure 4: Screen capture of the R Software used for graphically displaying, editing, and estimating IDF curves. IDF curves displayed for Harris County, Texas is the result of adjustments from team member to construct quasi-parallel curves. Original DDF estimates are derived from Asquith (1998) and Asquith and Roussel (2004) for 2-, 5-, 10-, 25-, 50-, and 100-year ARI.

The practical purpose of the adjustments in addition to maintaining quasi-parallelism was to correct inconsistencies in a few counties (some had IDF curves for different ARI crossing) and extrapolate behavior in border (New Mexico, Oklahoma, Louisiana) counties. Upon completion of these adjustments the DDF values are changed and these changed values are reported as the 2015—DDF coefficients. The 2015—DDF coefficients are listed, by county, in Appendix IV.

3.4 Summary

The 2015—DDF values and associated 2015—*ebd* values were generated by the Analyst-Directed SUMT algorithm. The Analyst-Directed method generated *ebd* estimates initially through linear regression using least ordinary squares (OLS) with assumed values for d. Equation 7 was then linearized to solve for e and b coefficients through OLS. The d values were then refined using a one-dimensional line search with OLS re-estimating b and e at each iteration to preserve optimal estimate values. Once the *ebd* values were generated, computer programming software R (R Core Team, 2015) was used to generate provisional IDF curves for each county. The provisional curves were then adjusted by changing (in a graphical user interface) some DDF values to maintain a quasi-parallel curve structure that is typical with IDF curves. The DDF values obtained from the adjustments are referred to as the revised 2015—DDF coefficients. The results of the Analyst-Directed analysis ordered by county are tabulated in Appendix IV, Table 3 as the revised 2015—DDF values for the 2-, 5-, 10-, 25-, 50-, and 100-year ARI from 15-minute to 24 hour durations.

The DDF and *ebd* analysis was implemented by three independent analysts. The DDF values were examined collectively then averaged and declared the final 2015—DDF values that were then used to generate the final updated *ebd* values that are incorporated in the `EBDLKUP-2015.xlsx` spreadsheet. Appendix V, Table 4 and Appendix V, Table 5 are the 2015—*ebd* rainfall coefficients corresponding to the 2015—DDF values.

4 EBDLKUP-2015.xlsx Spreadsheet Tool

`EBDLKUP-2015.xlsx` was created to assist designers in estimating rainfall intensity for use in the rational method and other intensity based methods. For further guidance on utilization of the spreadsheet, a step-by-step Tutorial with an example problem can be found in Appendix VII. Additionally, for in-depth information regarding formulas or editing within the `EBDLKUP-2015.xlsx` spreadsheet, refer to the Technical Reference Manual in Appendix VI.

`EBDLKUP.xls` is a spreadsheet tool that is commonly downloaded and currently used by design engineers in Texas to calculate intensity. The spreadsheet uses a database of *ebd* rainfall coefficients to calculate intensity using Equation 3, based on a given duration and location. In addition to calculating intensity, the spreadsheet also displays the *ebd* coefficients for the selected county at each ARI. The coefficients in the current spreadsheet were last examined in 1985 and have since been revised based on data found DDF Atlas (Asquith and Roussel, 2004) by the TTU and USGS research teams. The in-depth analysis regarding the development of the updated *ebd* constants can be found previously in Section 3: Updated DDF Coefficients.

The revision of the *ebd* rainfall constants prompted for an update of the intensity-duration-frequency spreadsheet. A newly improved tool, `EBDLKUP-2015.xlsx`, was designed by the team to replace the current spreadsheet and is discussed within this section. To reiterate, `EBDLKUP-2015.xlsx` is for the state of Texas only.

4.1 Spreadsheet Description

The `EBDLKUP-2015.xlsx` spreadsheet is composed of two sheets: an interface and hidden database sheet. In addition to the database of revised *ebd* coefficients, the layout of the new tool was reformatted, but retains similar look-and-feel. The new spreadsheet was intentionally designed to be distinguishable from the current spreadsheet, with changes made to colors, format, and filename.

A reference to the DDF Atlas (Asquith and Roussel, 2004) was included below the new spreadsheet title to further distinguish it from the current spreadsheet. Additionally, the last revision date of the spreadsheet was added to the bottom right corner of the spreadsheet to further affirm the most up-to-date spreadsheet is being used.

A brief comparison of the current `EBDLKUP.xls` and the new `EBDLKUP-2015.xlsx` spreadsheet tools can be seen below in Figure 5. Even with a lack of detail the current spreadsheet, displayed on the left, is visibly differentiable from the new spreadsheet, displayed on the right.

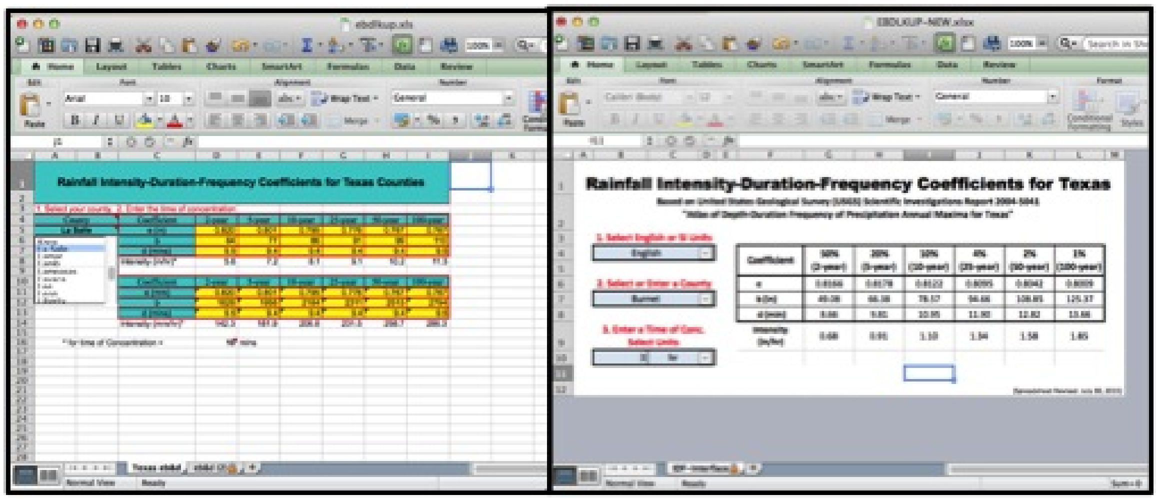


Figure 5: Screenshots of both the current `EBDLKUP.xls`, on the left, and the new `EBDLKUP-2015.xlsx` spreadsheet, on the right. Notice the distinct differences in layout style, colors, and format.

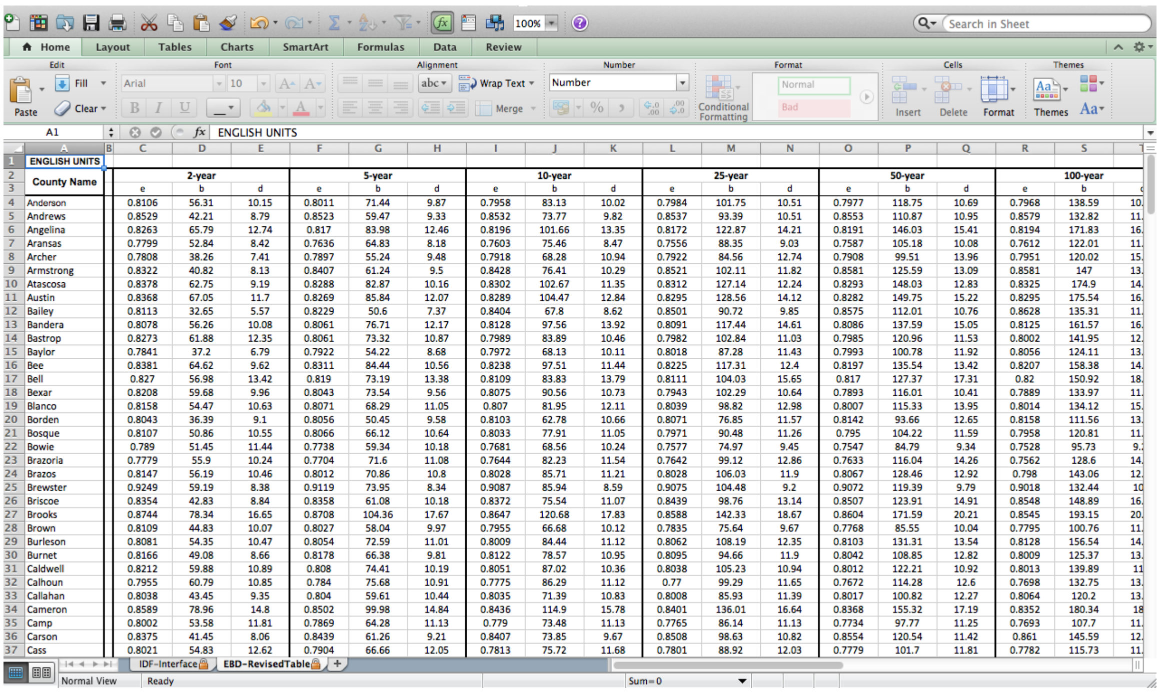
In addition to an update in format and layout, the new spreadsheet additionally resolves confusion from the current spreadsheet regarding units. Confusion from a difference in temporal units between calculated intensity (inches per hour) and user input of time of concentration (minutes) was often expressed by users. Although the `EBDLKUP.xls` spreadsheet accounted for the unit conversion in its calculations, it was not explicitly stated and thus to source of the confusion. The new spreadsheet reduces the confusion by allowing users to enter duration in either units of minutes or hours. The spreadsheet accounts for either unit of duration by a simple unit conversion imbedded within the intensity (in/hr) calculation.

4.1.1 Database

The updated *ebd* rainfall coefficients, developed by the research team, were placed within the new `EBDLKUP-2015.xlsx` spreadsheet. The coefficients are based on precipitation data from the Texas DDF Atlas (Asquith and Roussel, 2004) and are located on a hidden tab sheet, `EBD-RevisedTable`, ordered by county and ARIs of 2-, 5-, 10-, 25-, 50-, and 100-year.

The tab sheet, `EBD-RevisedTable`, is and should remain password protected in order to reduce the chance of unintentional changes within the database. The hidden database sheet is referenced based on county selection and displays corresponding *ebd* coefficients in the interface of

EBDLKUP-2015.xlsx. The referencing effortlessly produces coefficients and eliminates the need of displaying the database for manual searching. Figure 6 below displays a view of this unhidden *ebd* database sheet.



ENGLISH UNITS																			
County Name	2-year			5-year			10-year			25-year			50-year			100-year	
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b
Anderson	0.8106	56.31	10.15	0.8011	71.44	9.87	0.7958	83.13	10.02	0.7984	101.75	10.51	0.7977	118.75	10.69	0.7968	138.59
Andrews	0.8529	42.21	8.79	0.8523	59.47	9.33	0.8532	73.77	9.82	0.8537	93.39	10.51	0.8553	110.87	10.95	0.8579	132.82
Angelina	0.8263	65.79	12.74	0.817	83.98	12.46	0.8196	101.66	13.35	0.8172	122.87	14.21	0.8191	146.03	15.41	0.8194	171.83
Aransas	0.7799	52.84	8.42	0.7636	64.83	8.18	0.7603	75.46	8.47	0.7556	88.35	9.03	0.7587	105.18	10.08	0.7612	122.01
Archer	0.7808	38.26	7.41	0.7897	55.24	9.48	0.7918	68.28	10.94	0.7922	84.56	12.74	0.7908	99.51	13.96	0.7951	120.02
Armstrong	0.8322	40.82	8.13	0.8407	61.24	9.5	0.8428	76.41	10.29	0.8521	102.11	11.82	0.8581	125.59	13.09	0.8581	147
Atascosa	0.8378	62.75	9.19	0.8288	82.87	10.16	0.8302	102.67	11.35	0.8312	127.14	12.24	0.8293	148.03	12.83	0.8325	174.9
Austin	0.8368	67.05	11.7	0.8269	85.84	12.07	0.8289	104.47	12.84	0.8295	128.56	14.12	0.8282	149.75	15.22	0.8295	175.54
Bailey	0.8113	32.65	5.57	0.8229	50.6	7.37	0.8404	67.8	8.62	0.8501	90.72	9.85	0.8575	112.01	10.76	0.8628	135.31
Bandera	0.8078	56.26	10.08	0.8061	76.71	12.17	0.8128	97.56	13.92	0.8091	117.44	14.61	0.8086	137.59	15.05	0.8125	161.57
Bastrop	0.8273	61.88	12.35	0.8061	73.32	10.87	0.7989	83.89	10.46	0.7982	102.84	11.03	0.7985	120.96	11.53	0.8002	141.95
Baylor	0.7841	37.2	6.79	0.7922	54.22	8.68	0.7972	68.13	10.11	0.8018	87.28	11.43	0.7993	100.78	11.92	0.8056	124.11
Bee	0.8381	64.62	9.62	0.8311	84.44	10.56	0.8238	97.51	11.44	0.8225	117.31	12.4	0.8197	135.54	13.42	0.8207	158.38
Bell	0.827	56.98	13.42	0.819	73.19	13.38	0.8109	83.83	13.79	0.8111	104.03	15.65	0.817	127.37	17.31	0.82	150.92
Bexar	0.8208	59.68	9.96	0.8043	73.54	9.56	0.8075	90.56	10.73	0.7943	102.29	10.64	0.7893	116.01	10.41	0.7889	133.97
Blanco	0.8158	54.47	10.63	0.8071	68.29	11.05	0.807	81.95	12.11	0.8039	98.82	12.98	0.8007	115.33	13.95	0.8014	134.12
Borden	0.8043	36.39	9.1	0.8056	50.45	9.58	0.8103	62.78	10.66	0.8071	76.85	11.57	0.8142	93.66	12.65	0.8158	111.56
Bosque	0.8107	50.86	10.55	0.8066	66.12	10.64	0.8033	77.91	11.05	0.7971	90.48	11.26	0.795	104.22	11.59	0.7958	120.81
Bowie	0.789	51.45	11.44	0.7738	59.34	10.18	0.7681	68.56	10.24	0.7577	74.97	9.45	0.7547	84.79	9.34	0.7528	95.73
Brazoria	0.7779	55.9	10.24	0.7704	71.6	11.08	0.7644	82.23	11.54	0.7642	99.12	12.86	0.7633	116.04	14.26	0.7562	128.6
Brazos	0.8147	56.19	10.46	0.8012	70.86	10.8	0.8028	85.71	11.21	0.8028	106.03	11.9	0.8067	128.46	12.92	0.798	143.06
Brewster	0.9249	59.19	8.38	0.9119	73.95	8.34	0.9087	85.94	8.59	0.9075	104.48	9.2	0.9072	119.39	9.79	0.9018	132.44
Briscoe	0.8354	42.83	8.84	0.8358	61.08	10.18	0.8372	75.54	11.07	0.8439	98.76	13.14	0.8507	123.91	14.91	0.8548	148.89
Brooks	0.8744	78.34	16.65	0.8708	104.36	17.67	0.8647	120.68	17.83	0.8588	142.33	18.67	0.8604	171.59	20.21	0.8545	193.15
Brown	0.8109	44.83	10.07	0.8027	58.04	9.97	0.7955	66.68	10.12	0.7835	75.64	9.67	0.7768	85.55	10.04	0.7795	100.76
Burleson	0.8081	54.35	10.47	0.8054	72.59	11.01	0.8009	84.44	11.12	0.8062	108.19	12.35	0.8103	131.31	13.54	0.8128	156.54
Burnet	0.8166	49.08	8.66	0.8178	66.38	9.81	0.8122	78.57	10.95	0.8095	94.66	11.9	0.8042	108.85	12.82	0.8009	125.37
Caldwell	0.8212	59.88	10.89	0.808	74.41	10.19	0.8051	87.02	10.36	0.8038	105.23	10.94	0.8012	122.21	10.92	0.8013	139.89
Calhoun	0.7955	60.79	10.85	0.784	75.68	10.91	0.7775	86.29	11.12	0.77	99.29	11.65	0.7672	114.28	12.6	0.7698	132.75
Callahan	0.8038	43.45	9.35	0.804	59.61	10.44	0.8035	71.39	10.83	0.8008	85.93	11.39	0.8017	100.82	12.27	0.8064	120.2
Cameron	0.8589	78.96	14.8	0.8502	99.98	14.84	0.8436	114.9	15.78	0.8401	136.01	16.64	0.8368	155.32	17.19	0.8352	180.34
Camp	0.8002	53.58	11.81	0.7869	64.28	11.13	0.779	73.48	11.13	0.7765	86.14	11.13	0.7734	97.77	11.25	0.7693	107.7
Carson	0.8375	41.45	8.06	0.8439	61.26	9.21	0.8407	73.85	9.67	0.8508	98.63	10.82	0.8554	120.54	11.42	0.861	145.59
Cass	0.8021	54.83	12.62	0.7904	66.66	12.05	0.7813	75.72	11.68	0.7801	88.92	12.03	0.7779	101.7	11.81	0.7782	115.73

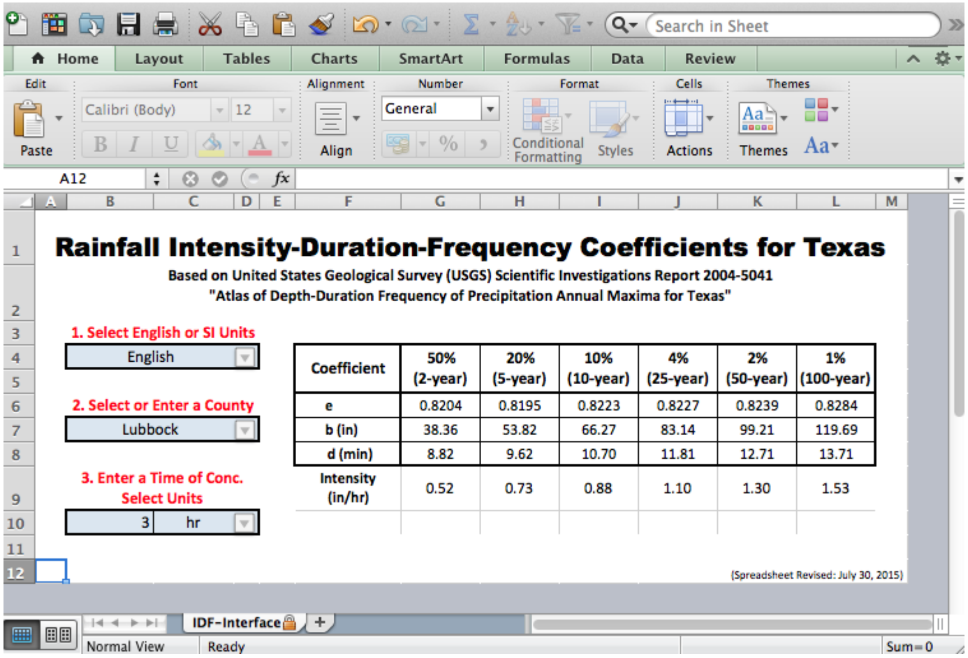
Figure 6: Locked and unhidden display of the EBD-RevisedTable sheet which acts as a storage database for the updated *ebd* rainfall coefficients within the new EBDLKUP-2015.xlsx spreadsheet.

4.1.2 Interface

The interface tab sheet, labeled IDF-Interface, was designed to be the only viewable and user-interactive sheet of the spreadsheet. The tab sheet, IDF-Interface, was also password protected to prevent unintentional user errors. The interface of the updated EBDLKUP-2015.xlsx spreadsheet is displayed in Figure 7 below.

The interface prompts the user to select units, a county, and input a time of concentration and select its units. The three listed commands are numbered in order and displayed in bright red to draw the attention of the user. The cells for user input and selection, placed immediately underneath each prompt, are indicated by a light blue hue.

The entire interface is locked with exception of the blue input cells that are changeable within limits defined by the designers. To change the input cells, a user may manually enter in a desired item or



Coefficient	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)
e	0.8204	0.8195	0.8223	0.8227	0.8239	0.8284
b (in)	38.36	53.82	66.27	83.14	99.21	119.69
d (min)	8.82	9.62	10.70	11.81	12.71	13.71
Intensity (in/hr)	0.52	0.73	0.88	1.10	1.30	1.53

Figure 7: Screen capture of the initial display upon opening the new `EBDLKUP-2015.xlsx` spreadsheet. The sheet is referred to as the IDF-Interface and interacts with the user through prompts.

double-click on the down arrows to select from a list of items. Changing any part of the blue input cells, automatically changes the data table on the right. The data table displays *ebd* coefficients at ARI of 2-, 5-, 10-, 25-, 50-, and 100-year and displays calculated intensity below.

Regarding units, if SI units are selected, the referenced *b* coefficient and intensity are displayed in millimeters (mm) instead of inches (in) through the unit conversion of 25.4 mm/in. To reiterate, time of concentration may be entered in units of minutes (min) or hours (hr) and is accounted for through the unit conversion of 60 min/hr.

After each prompt has been acknowledged, the user may retrieve *ebd* coefficients or intensity for the selected county at any ARI. As stated previously, the spreadsheet automatically provides a county's *e*, *b*, and *d* coefficients at each ARI by indexing the hidden EBD-RevisedTable sheet. Intensity is automatically calculated using Equation 3. It should be noted that intensity is automatically calculated based on the data provided within the blue input cells and users should always verify inputs before retrieving intensity. The desired intensity may then be copied and used elsewhere, if needed.

5 TXHYETO-2015.xlsx Spreadsheet Tool

`TXHYETO-2015.xlsx` was created as a companion tool for `EBDLKUP-2015.xlsx` and assists designers in generating entire hyetographs in situations where they are useful (unit hydrographs). The spreadsheet simplifies the task of using Texas dimensionless hyetographs for design storm modeling programs, such as HEC-HMS. The spreadsheet dimensionalizes Texas hyetographs through the use of a distribution-mixture based model. The model was created by fitting a function to the dimensionless 50th and 90th percentile Texas hyetographs (Williams-Sether and others, 2004). The researchers suggest use of the 50th percentile hyetograph for typical drainage design and the 90th percentile for when there is concern regarding performance during intense portions of a storm. The remainder of this section discusses the background of the Texas hyetographs, explains in detail the methodology used for for creating the distribution mixture-based model, and describes the resulting spreadsheet tool, `TXHYETO-2015.xlsx`.

For additional information regarding use of the spreadsheet, the Tutorial can be found in Appendix IX. Additionally, for in-depth information regarding formulas or editing within the spreadsheet, refer to the Technical Reference Manual in Appendix VIII.

5.1 Hyetograph Background

Research to develop Texas-specific storm hyetographs was sponsored by the Texas Department of Transportation (TxDOT) and the results were reported in Williams-Sether and others (2004). However use of the Texas hyetographs have been limited by difficulty in using the graphical or tabulated hyetographs for arbitrary durations and depths (dimensional mapping), and additional difficulty in producing uniform time step estimates for inclusion into hydrologic software such as HEC-HMS or SWMM.

The Williams-Sether and others (2004) report analyzed data from 1,659 runoff-producing storms near 91 U.S. Geological Survey streamflow-gauging stations in north and south central Texas. These streamflow-gauging stations were used to develop empirical, dimensionless, cumulative-rainfall hyetographs. The report presented statistics for the empirical, dimensionless, cumulative-rainfall hyetographs along with the hyetographs as curves and tabulations, which are applicable for estimating distributions of rainfall with time for drainage areas of less than 160 square miles in urban and small rural watersheds in Texas.

Figure 8 below displays the fundamental result from Williams-Sether and others (2004). The curved lines represent the 10th through 90th percentile hyetographs and are interpreted as showing the temporal pattern of storms in Texas at the indicated percentile. The 90th percentile curve means that 90 percent of the observed hyetographs plot on or below this curve and so on for the other various curves. From Figure 8, the 90th percentile hyetograph and the 50th percentile (median) hyetograph

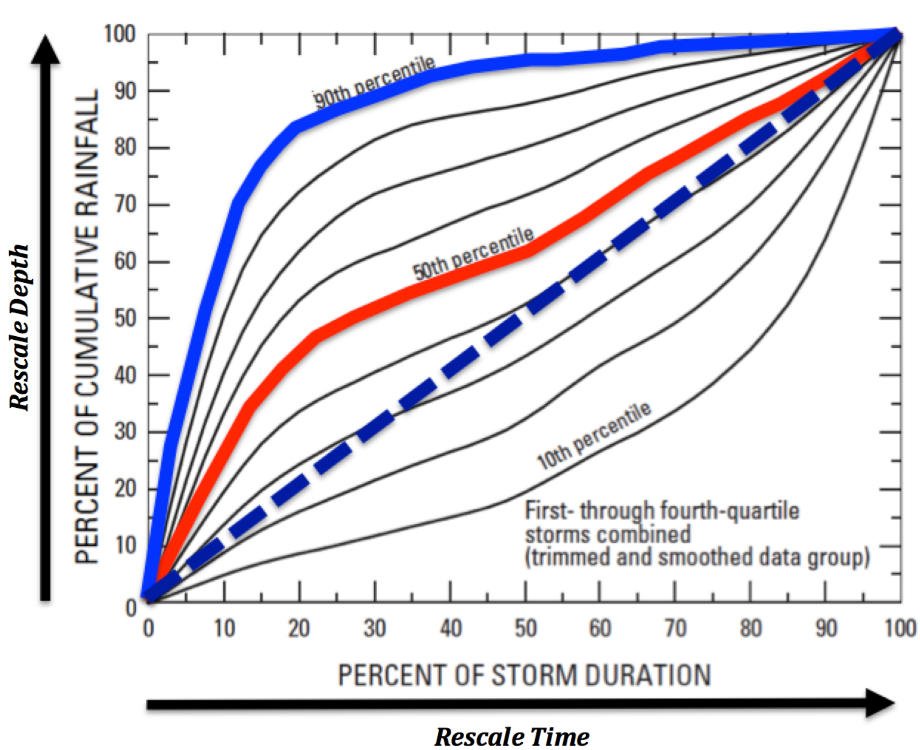


Figure 8: Dimensionless Hyetograph from Williams-Sether (2004) with annotations (rescaling arrows of depth and time).

are highlighted by respective solid blue and red lines. The dashed line represents the cumulative hyetograph from an "average intensity" storm whose intensity is the ratio of total storm depth and total storm duration. The two rescaling arrows indicate dimensional mapping. For practical application an engineer would determine the depth for a particular duration and rescale the plots in dimensional space of depth and time.

Tools to estimate a depth and duration in Texas can be found in these publications: DDF Atlas for Texas (Asquith and Roussel, 2004), DDF Precipitation for Texas (Asquith, 1998), NWS HYDRO-35 (Fredrick and others, 1977), and TP-40 (Hershfield, 1961). The tools authored by Asquith are incorporated by reference in the Hydraulic Design Manual (Texas Department of Transportation, 2014).[16]

5.2 Methodology

The research explored two ways to build a tool to perform the dimensionalization mapping onto prescribed time intervals. Direct interpolation of the tabular values was analyzed and although useful the resulting spreadsheet proved to be too cumbersome and easily prone to user-breakage for routine use. The method is documented briefly in Appendix VIII.

The second method, which proved to be useful and more accessible,was to fit the tabulation to smooth functions and perform the dimensionalization using those functions within the spreadsheet. The second method was chosen as the basis for the `TXHYETO-2015.xlsx` spreadsheet and is discussed in further detail in this section.

Several functional forms were investigated to fit the shape of the tabulated Texas hyetographs (in dimensionless space) into continuous functions (for subsequent dimensional mapping) for arbitrary durations, depths and time steps. Considerable exploratory analysis including graphing functions and tabulations were conducted using many postulated functional forms.

The two most visually satisfying were a function based on an inverse tangent function, and a second function based on a mixture of a cumulative beta function and a normal density function. The authors note herein, that the use of cumulative beta and normal density nomenclature is to identify the functions.

The functional forms are entirely to preserve shape, and for all practical purposes these structures are treated as ordinary continuous functions (like a logarithm) without regard to any statistical meaning of the functions or the parameters.

The trigonometric function-based model is described by Equation 11

$$D^*(t^*) = w_1(\tan^{(-1)}(t^*))^{\alpha} \tag{11}$$

where, $D^*(\,)$ is the dimensionless depth (a function of dimensionless time), t^* is the dimensionless time, w_1 is a weighting parameter, and α is an exponent to adjust curvature.

[16]The dimensionless charts in this document are for Texas only. The methods of Williams-Sether and others (2004) would need to be applied to rainfall records in other states to produce state specific dimensionless hyetographs.

The distribution mixture-based model is described by Equation 12

$$D^*(t^*) = w_1(I_{t*}(\alpha,\beta)) - \frac{w_2}{\sigma\sqrt{2\pi}}\exp\left[\frac{(t^*-\mu)^2}{2\sigma^2}\right] \tag{12}$$

where,

$D^*(\,)$ is the dimensionless depth (a function of dimensionless time),
t^* is the dimensionless time,
w_1 is a weighting parameter,
α is a shape parameter for the Beta distribution,
β is a shape parameter for the Beta distribution,
w_2 is a weighting parameter,
μ is used to locate the mode of the function in this work, and
σ is used to control the width of the function.

The functional forms were fit using a non-linear least-squares approach where the difference between the model value and the tabulated value were minimized by changing the values of the parameters. The Generalized Reduced Gradient (GRG) Algorithm in the Microsoft (MS) Excel Solver Add-In, using Solver defaults, was applied to accomplish the minimization exercise. Initial parameter estimates were determined by trial-and-error using graphical exploratory data analysis. Essentially the functions were plotted on the same axes and the tabulated values and the parameters adjusted until the function plots were close to the tabular values. The MS Excel Solver was then applied to refine these initial estimates to the final values.

5.2.1 Parameter Estimation

The minimization procedure was applied to the inverse tangent function model with the results listed in Table 1

Table 1: Inverse tangent dimensionless hyetograph parameters.

Parameter	50th% MODEL	90th% MODEL
w_1	1.322947116	1.359494588
α	1.258701623	1.304471405

The minimization procedure was applied to the distribution-mixture function model with the results listed in Table 2

Table 2: Distribution-mixture dimensionless hyetograph parameters.

Parameter	50th% MODEL	90th% MODEL
w_1	1.038977414	0.990892603
α	0.795462882	0.989635985
β	3.485892325	10.26915766
w_2	0.248832841	0.032686418
μ	0.471873548	0.325310683
σ	0.283390998	0.189525712

The distribution-mixture model was ultimately selected because it was able to reproduce the shape of the dimensionless distributions better than the inverse-tangent model.

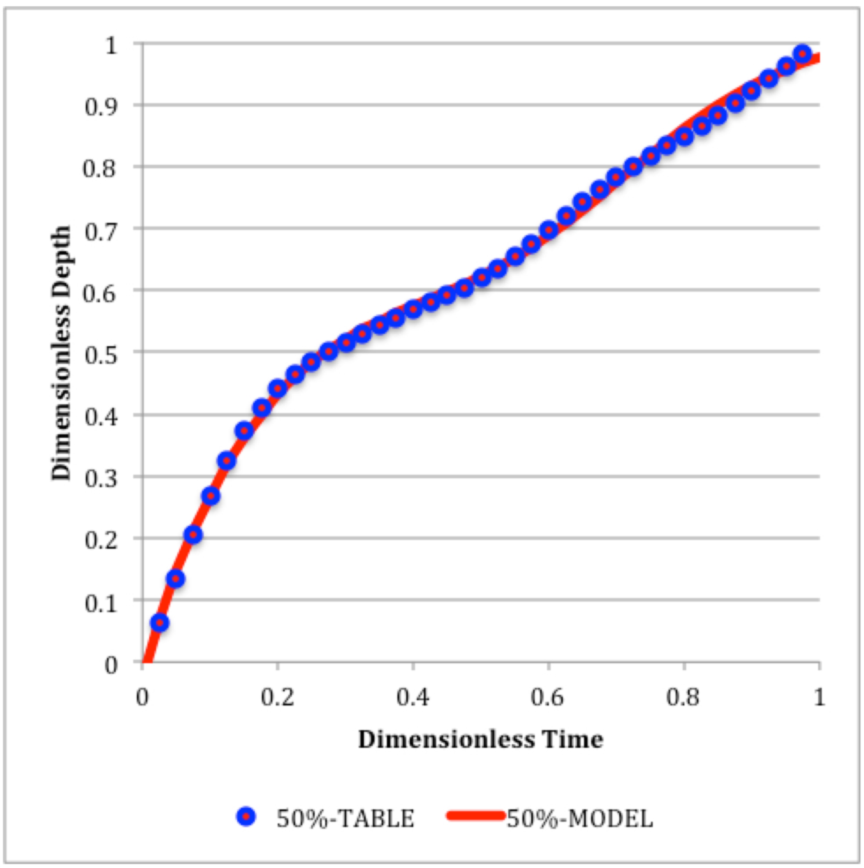


Figure 9: Distribution-mixture model for 50th percentile dimensionless hyetograph. Markers are tabulation values, solid line is the fitted function.

Figure 9 is a plot of the fitted distribution-mixture model and the tabulated values from Williams-Sether (2004) for the 50th-percentile dimensionless hyetograph. The figure is still in dimensionless form, but the tabulation is now replaced with a continuous function. The authors modified the functions at 0 and 1 in dimensionless time and built the functions to force 0 and 1 dimensionless depth at these two particular time values. The remaining values are as computed with the function.

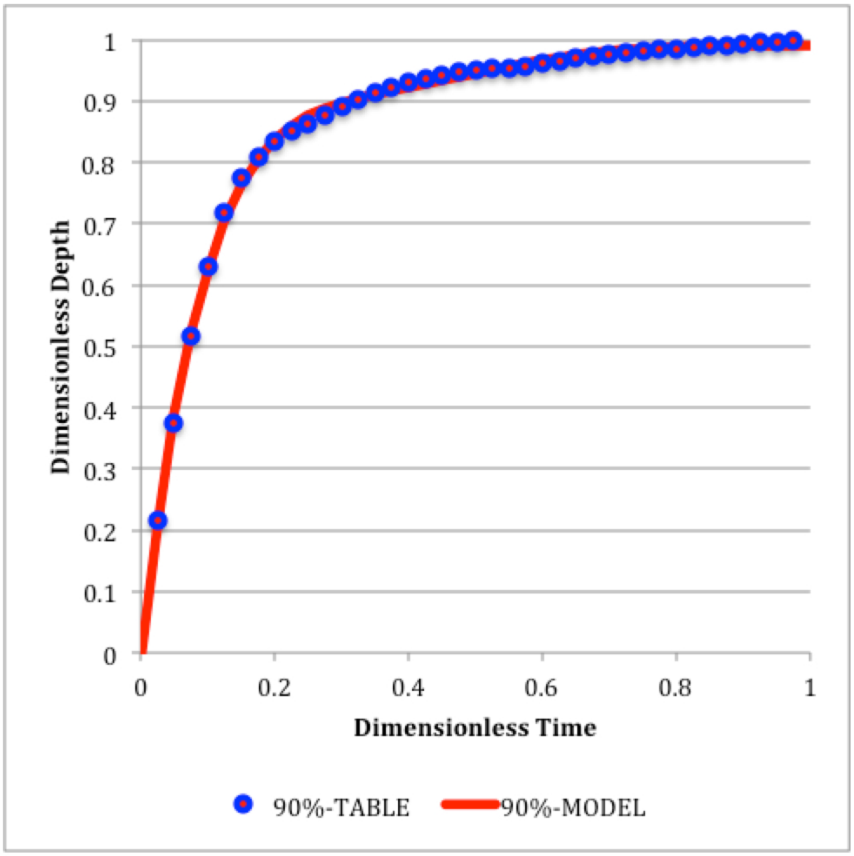


Figure 10: Distribution-mixture model for 90th percentile dimensionless hyetograph. Markers are tabulation values, solid line is the fitted function.

Figure 10 is a plot of the fitted distribution-mixture model and the tabulated values from Williams-Sether (2004) for the 90th-percentile dimensionless hyetograph. As with the previous figure, the relationship is still in dimensionless form, but the tabulation is now replaced with a continuous function. Also as before, the authors modified the functions at 0 and 1 in dimensionless time to force 0 and 1 dimensionless depth at these two particular time values. The remaining values are as computed with the function.

5.2.2 Relative Error

The error associated with using the functional form and the tabulation was estimated by computing the difference between the functional model result and the tabular result and dividing that difference by the tabular result for a relative error assessment. The error for any dimensionless value in the tabulation was less than 5 percent. Thus the designer who uses the functional model instead of interpolation can expect results to be within 5 percent of the tabular values.[17]

Figure 11 is a plot showing the relative error for the example conditions between using direct interpolation and the distribution-mixture function model.

Spreadsheet to dimensionalize Texas hyetographs
50-th Percentile Hyetograph
INPUT: 6 Storm Duration, hours, from DDF Atlas, TP40, or equivalent.
INPUT: 10 Storm Depth , inches, from DDF Atlas, TP40, or equivalent.

TIME (MIN)	TIME (HRS)	DEPTH (IN) - MIXTURE	DEPTH (IN) - INTERPOLATION	PERCENT DIFFERENCE
0	0	0	0	0.00%
15	0.25	1.1409	1.118	2.08%
30	0.5	2.3559	2.26	4.23%
45	0.75	3.2524	3.242	0.32%
60	1	3.928	3.974	-1.15%
75	1.25	4.4387	4.492	-1.19%
90	1.5	4.8261	4.854	-0.57%
105	1.75	5.1255	5.12	0.11%
120	2	5.3678	5.336	0.60%
135	2.25	5.5801	5.549	0.56%
150	2.5	5.785	5.762	0.40%
165	2.75	6.0004	5.97	0.50%
180	3	6.2383	6.197	0.67%
195	3.25	6.5054	6.476	0.45%
210	3.5	6.8025	6.832	-0.44%
225	3.75	7.126	7.211	-1.18%
240	4	7.4684	7.569	-1.33%
255	4.25	7.8199	7.881	-0.77%
270	4.5	8.1696	8.161	0.11%
285	4.75	8.5072	8.431	0.90%
300	5	8.8234	8.713	1.27%
315	5.25	9.1113	9.021	1.00%
330	5.5	9.3665	9.354	0.13%
345	5.75	9.5869	9.688	-1.04%
360	6	10	10	0.00%

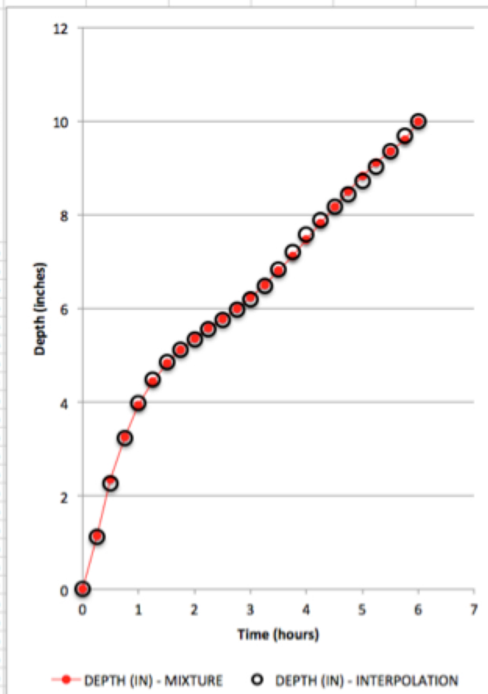


Figure 11: Distribution-mixture model for 50th percentile dimensionless hyetograph compared to direct interpolation for the example problem conditions. Circular markers are direct interpolation tabulation values, red line is the fitted function.

[17]To reiterate, the research associated with the interpolation method can be found in Appendix VIII. The researchers recommend using the functional form, the method discussed within the methodology, which is directly associated with the TXHYETO-2015.xlsx spreadsheet.

5.3 Spreadsheet Description

The `TXHYETO-2015.xlsx` spreadsheet is a tool that implements the developed distribution-mixture function model as a way to dimensionalize the Texas hyetographs. It is intended to be used in conjunction with either the DDF Atlas (Asquith and Roussel, 2004) or the `EBDLKUP-2015.xlsx` tool. The spreadsheet eases the task of dimensionalizing Texas dimensionless hyetographs for modeling programs, such as HEC-HMS or SWMM.

Because the `TXHYETO-2015.xlsx` spreadsheet was designed to be a companion tool to the new `EBDLKUP-2015.xlsx` spreadsheet, the color schemes, layout and format were kept almost identical. Similar to the `EBDLKUP-2015.xlsx` tool, the last revision date of the spreadsheet was added below the title to affirm that the most up-to-date spreadsheet is being used.

5.3.1 Interface

The spreadsheet consists of two sheets: one for the 50th percentile hyetograph and the second for the 90th percentile hyetograph. The layout of the sheets are almost identical and easily differentiable based on tab and title color. Both sheets were password protected to prevent unintentional user errors.

Figure 12 below shows a screen capture of the 50th percentile sheet of the `TXHYETO-2015.xlsx` spreadsheet tool. The `TXHYETO-2015.xlsx` tool consists of prompts that are bright red and numbered in order, and input/interactive cells that are indicated by a blue hue. The format and layout of the prompt and input cells, which are identical to the `EBDLKUP-2015.xlsx` tool, should resonate familiarity with the user. Below the prompts, the mixture model parameters are shown in light grey. The model parameters are used with the distributed function and differ for the 50th and 90th percentile. The parameters exist simply for calculation purposes.

The tool prompts the user to enter a design storm duration in hours, a design storm depth in inches, and a desired time-step interval in minutes. The units for the prompts were predefined to avoid any possible unit confusion and are accounted for within the dimensionalizing. To change the input cells, the user must manually enter in a desired number in numerical form only. Any change in the input cells automatically changes the hyetograph table on the right.

The spreadsheet then uses the input values, the mixed-distribution model Equation 12, and the appropriate parameters from Table 2 to compute the cumulative, dimensional depth values at different times during the design storm.

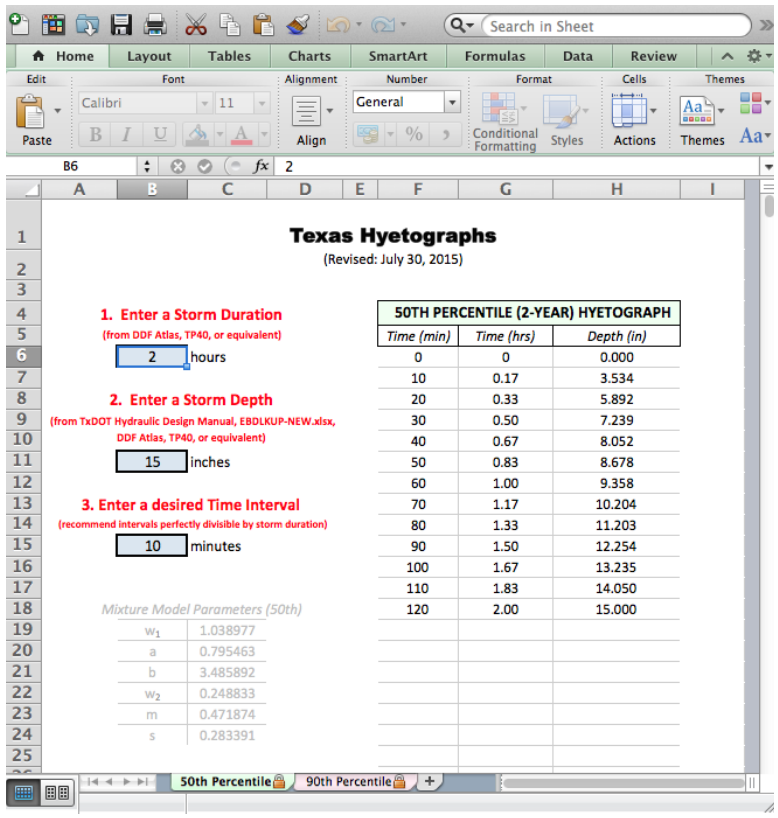


Figure 12: `TXHYETO-2015.xlsx` tool that implements the distribution-mixture model for 50th percentile dimensionless hyetograph.

The model uses fractional hours, which are computed from the designer's choice of time step, and these hours are returned in the second to last column on the right side of the spreadsheet, and the dimensional depth in the right-most column of the spreadsheet.

The dimensionalized hyetograph data table on the right consists of three columns: time in minutes, time in hours, and depth in inches. The first column takes the user inputs and separates the duration into the desired time-step (min). The second column simply converts the time in the first column into hours for ease of use with modeling programs. The third column uses the entered storm depth in inches and parameterizes the depth based on the distribution mixture model. The table was designed to automatically calculate and display cells based on the user's input.

The tool was intended as an intermediate step in preparing input for HEC-HMS and similar hydrologic modeling tools. Once the user has verified all three inputs, the produced hyetograph table on the right may be selected, copied, and pasted into the desired model.

6 Training Materials

`EBDLKUP-2015.xlsx` and `TXHYETO-2015.xlsx` spreadsheets were created to assist designers in estimating rainfall intensity for use in the rational method and other intensity based methods, and to generate entire hyetographs in situations where they are useful (unit hydrographs).

A part of the scope of work for the research project includes providing training tutorials and video tutorials for both the `EBDLKUP-2015.xlsx` and `TXHYETO-2015.xlsx` spreadsheets. The training tutorials and videos are meant to offer an in-depth guidance for each spreadsheet in two separate forms of media. In addition, the `EBDLKUP-2015.xlsx` and `TXHYETO-2015.xlsx` spreadsheets were integrated into an existing "DES-601 Basic Hydrology and Hydraulics" training module. Training modules are frequently used to continually educate TxDOT employees.

The spreadsheets (.xlsx), tutorials (.pdf), training videos (.mp4), and DES-601 Module (.pptx) are to be searchable and available for download off of the TxDOT website in the near future. Closed captioning is provided in all tutorial videos.

6.1 Spreadsheet Training Materials

The training tutorials and video tutorials for both spreadsheets provide users with an overall guidance on spreadsheet use and include a walkthrough of each with an example problem. The example provided in the written tutorials parallel the example shown in the video tutorials.

6.1.1 EBDLKUP-2015.xlsx

The example problem used in both the `EBDLKUP-2015.xlsx` written tutorial and video tutorial asks to find the intensity for a 3-hour, 100-year storm in Harris County. The video tutorial makes an additional effort to walk the user through possible errors that might occur and how to resolve the issues within the spreadsheet. An example of a user error would be mistyping the the name of a county into the input box. The video and written tutorial were created to compliment each other and provide multiple forms of aid for users. The written tutorial for `EBDLKUP-2015.xlsx` can be found in Appendix VII. The video tutorial for the spreadsheet will be available for download off the TxDOT website.

The initial image that appears when the `EBDLKUP-2015.xlsx` video tutorial is opened can be seen in Figure 13 below.

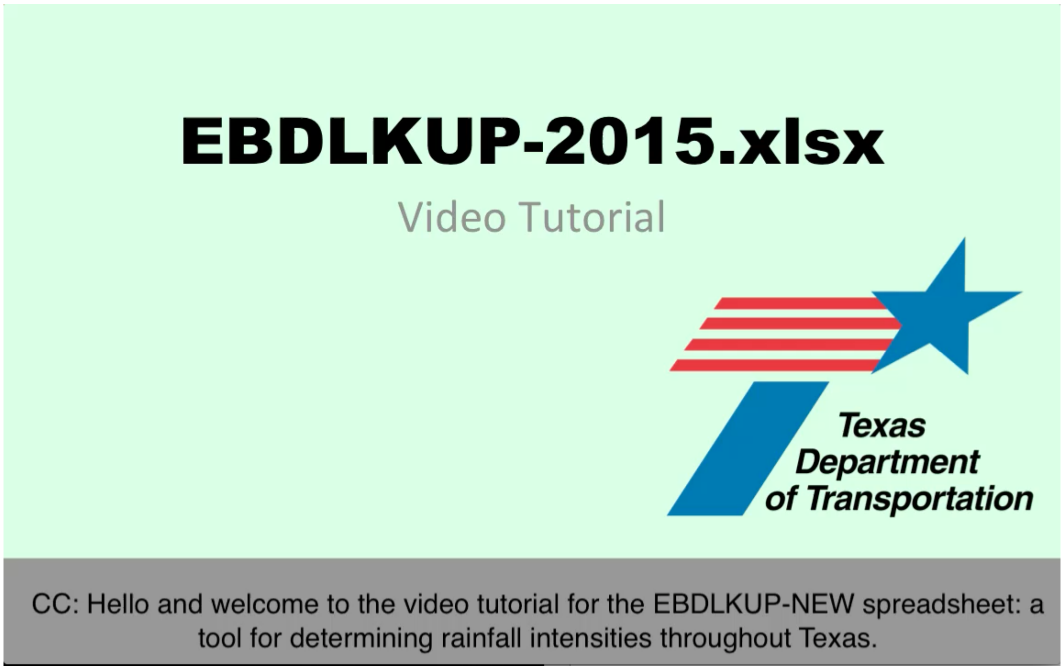


Figure 13: Initial display of the `EBDLKUP-2015.xlsx` Video Tutorial.

6.1.2 TXHYETO-2015.xlsx

The training materials for the `TXHYETO-2015.xlsx` spreadsheet are identical in format to the `EBDLKUP-2015.xlsx` training materials. The example problem used in the `TXHYETO-2015.xlsx` training materials asks to find the 50th percentile hyetograph given a storm duration of 6 hours, a storm depth of 10 inches, and a time interval of 15 minutes. The video and written tutorial are similar in guidance. Additionally, the video explains visibly the importance behind choosing perfectly divisible time intervals and ultimately guides the user to use the generated hyetograph in HEC-HMS.

The `TXHYETO-2015.xlsx` video tutorial is distinguishable from the `EBDLKUP-2015.xlsx` video tutorial by a clear difference in title, color and content. The written tutorial for `TXHYETO-2015.xlsx` can be found in Appendix IX.

The initial display of the `TXHYETO-2015.xlsx` video tutorial is shown in Figure 14 below. The change in title and purple background color distinguish it from the initial green display of the `EBDLKUP-2015.xlsx` video tutorial.

Figure 14: Initial display of the `TXHYETO-2015.xlsx` Video Tutorial.

In addition to the training materials, Technical Reference Manuals were created for each spreadsheet. The manuals are meant to train a user to comprehend the formulas within the spreadsheet in order to make edits without compromising the original work. In addition to spreadsheet editing tutorials, the manuals also include video editing tutorials. The technical manuals provide spreadsheet passwords and editing guidance for both tools but are not intended to be distributed to the general public. The Technical Reference Manuals for `EBDLKUP-2015.xlsx` and `TXHYETO-2015.xlsx` can be found in Appendix VI and Appendix VIII, respectively.

6.2 DES-601 Training Materials

The training module was created to further challenge users with additional example problems. The module, provided in MS PowerPoint, guides the user through the utilization of both spreadsheets. Annotation is also included that is intended to serve as the basis of a script for trainers to use when using the module. A post-presentation is also provided in MS Word for use by trainers to reinforce use of the two spreadsheet tools. In addition, a video intended for brief review runs through the module is offered.

An annotated instructor guide is included in this report as Appendix X.

6.2.1 Module Powerpoint Content

The training module content is provided in a MS Powerpoint file. The 60-slide module begins with an introduction of precipitation, depth-duration and intensity-duration frequencies. The module provides three example problems that are solved through methods that involve utilization of the newly created `EBDLKUP-2015.xlsx` and `TXHYETO-2015.xlsx` spreadsheets. It should be noted that the example problems used within the modules were purposely created to differ from the example problems used within the user manual and video tutorials of the spreadsheet tools.

The first example problem estimates the rainfall intensity for a 2-hour, 2-year storm in Harris County. The module guides the user through in-depth solutions using multiple methods: the DDF Atlas (Asquith and Roussel, 2004), end-user-computation form and lastly the newly created `EBDLKUP-2015.xlsx` spreadsheet.

The second problem integrates the utilization of both spreadsheets and asks to construct a design storm for a 3-hour, 2-year storm in Harris County using the Texas Empirical Hyetograph (Williams-Sether and others, 2004). To obtain the depth, the intensity is found through the `EBDLKUP-2015.xlsx` spreadsheet and is used to calculate storm depth. The module then guides the user through the `TXHYETO-2015.xlsx` spreadsheet to create an empirical hyetograph.

The last example problem takes a step further and not only integrates the two spreadsheets but additionally guides the user on how to further use the generated spreadsheet solutions. The problem asks the user to estimate the response of a 3-hour, 5-year storm given a watershed and its properties. The powerpoint walks through the spreadsheet tools and eventually inputs the generated empirical hyetograph from `TXHYETO-2015.xlsx` into the hydrologic modeling program, HEC-HMS.

6.2.2 Module Training Video

A short video was produced that goes through the MS PowerPoint version of the module. The 20 minute video runs through the 60 slide training course and is intended for a DES-601 trainer to review and refresh their understanding of the module content. The video could also benefit a designer who wished to review the module after the DES-601 course.

7 Summary and Conclusions

This project updated the Texas Depth-Duration-Frequency coefficients by county based on findings reported in Asquith (1998) and Asquith and Roussel (2004). The updated values are herein referred to as the 2015—DDF values and are listed in Appendix IV for six durations and eight ARI values.

The 2015—DDF values were used to estimate revised *ebd* values to parameterize Equation 7 using a sequential unconstrained minimization technique. The resulting *ebd* values are herein referred to as the 2015—*ebd* values and are listed in Appendix V for six ARI values.

A spreadsheet tool named `EBDLKUP-2015.xlsx` was built based upon the earlier spreadsheet tool in common use in Texas. The inclusion of the year in the file name is to identify the tool that contains the 2015—*ebd* values, and is consistent with departmental tradition as new methods become available to distinguish them from older or deprecated tools. The spreadsheet tools differs from the older tool in look and contains a password protection to reduce unintentional changes to the underlying database of *ebd* values. The spreadsheet is delivered protected, with the password included in Appendix VI.[18]

A companion spreadsheet tool named `TXHYETO-2015.xlsx` was built to enable designers to rapidly generate Texas specific hyetographs for importing into HEC-HMS and similar hydrologic modeling tools. The spreadsheet implements an approximation to the tabulations reported in Williams-Sether and others (2004). The spreadsheet is delivered protected, with the password included in Appendix VIII.[19]

7.1 Suggestions for Additional Research

The results of this research are fully implementable as-is and will provide the department a functional tool until a NOAA Atlas 14 product is completed for Texas. At that time, the researchers suggest

[18]The password for `EBDLKUP-2015.xlsx` is **ebdlkup-2015**.
Additionally, if the password is lost, a programmer can replicate the spreadsheet by (1) unhide the *ebd* tab, (2) copy each sheet of the worksheet to a new worksheet. The interface sheet should be copied after the database is copied. Name the sheets in the new worksheet exactly the same as the protected sheet. Close the password protected sheet. Move it to another directory. Then save the new worksheet. The new worksheet will be a fully functional, unprotected copy, of the protected sheet.

[19]The password for `TXHYETO-2015.xlsx` is **txhyeto-2015**.
Additionally, if the password is lost, a programmer can replicate the spreadsheet by (1) copy each sheet of the protected worksheet to a new worksheet. Name the sheets in the new worksheet exactly the same as the protected sheet. Close the password protected sheet. Move it to another directory. Then save the new worksheet. The new worksheet will be a fully functional, unprotected copy, of the protected sheet.

that the department deprecate the existing tools, adopt the federal tool, or adapt that tool into a spreadsheet structure as in this report. Values for *ebd* from NOAA Atlas 14 should be generated for inclusion in `GEOPACK Drainage` when the federal tool becomes available, and if the department wishes to maintain their own tool, the *ebd* values from NOAA Atlas 14 can be constructed as described herein, and then directly input into the spreadsheet (and the spreadsheet renamed to reflect the year that the update was performed).

The researchers suggest that the rainfall DDF values be examined in 20 years (circa 2035) to update *ebd* again to reflect changes in rainfall conditions that are occurring now in response to current (circa 1990–2015) climatic variation.

The researchers suggest that the department consider creating a web-based implementation of both tools to reduce the probability of an accidental change in the database of either spreadsheet and distribution of the changed sheet without knowledge of the unintentional change. The web-based implementation could be readily accomplished using `HTML`, `PERL`, the `CGI-BIN` structure already built into most web servers (e.g. Microsoft Internet Information Services and Apache HTTP Server).

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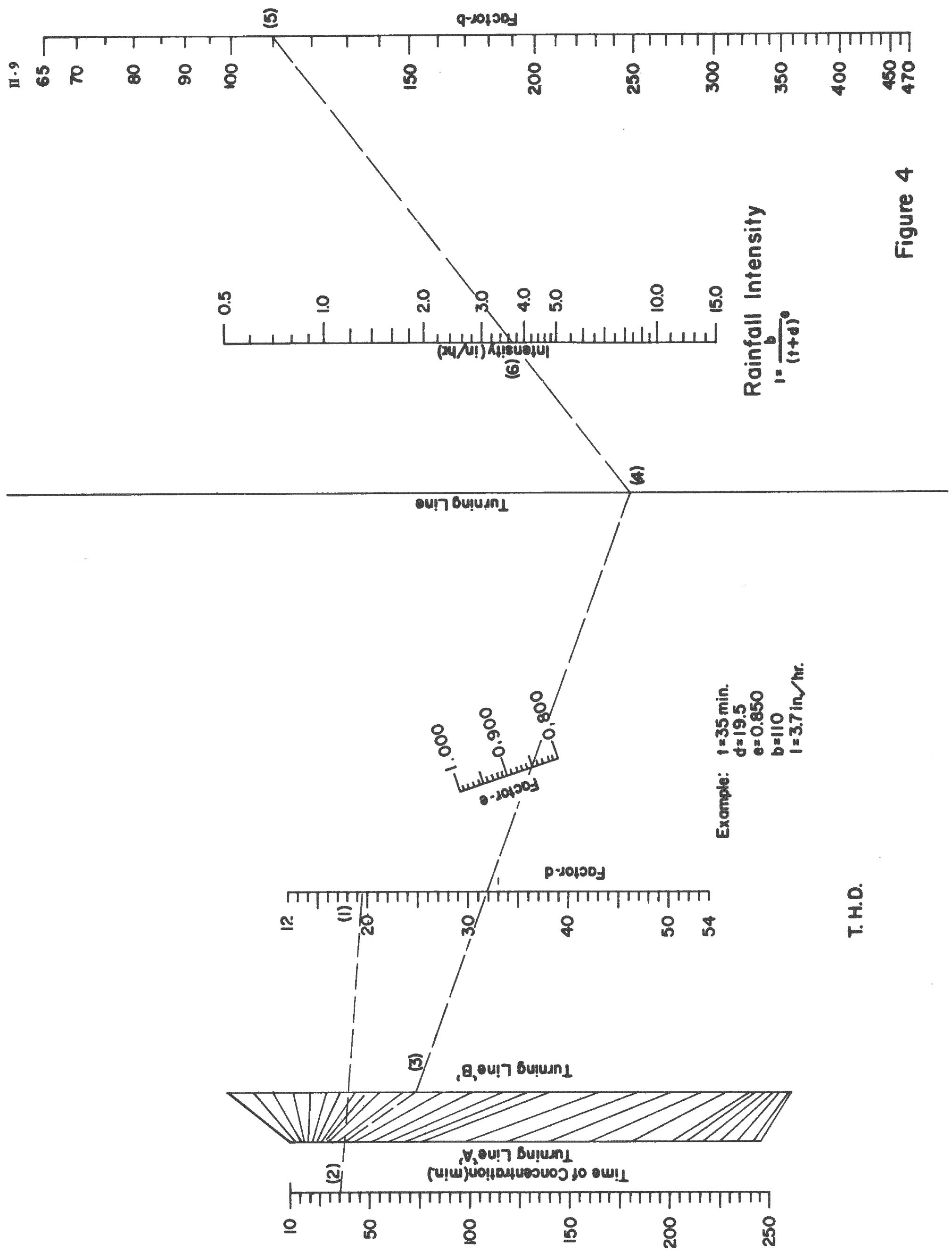
8 Appendix – I: EBD-Intensity nomograph

Nomograph for calculating intensity from *ebd* coefficients from Texas Highway Department (1970).



9 Appendix – II: Historical 1970 EBD Values

Table VI from the 1970 Hydraulic Manual starts on the next page. There are 7 pages of EBD values.

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TABLE VI

CONSTANTS FOR USE IN FORMULA $I = \frac{b}{(t+d)^e}$

Based on Weather Bureau (NWS) Technical Paper No. 40
"Rainfall Frequency Atlas of the United States"

COUNTY	5 year		10 year		25 year		50 year		All Freqs.
	e	b	e	b	e	b	e	b	d
Anderson	0.792	77	0.763	78	0.772	92	0.744	93	8.8
Andrews	0.827	57	0.809	63	0.793	69	0.807	84	10.2
Angelina	0.762	69	0.746	73	0.726	77	0.727	86	7.6
Aransas	0.787	77	0.753	79	0.745	88	0.739	95	8.5
Archer	0.783	61	0.794	74	0.789	86	0.792	100	8.5
Armstrong	0.819	63	0.820	75	0.835	95	0.831	105	10.4
Atascosa	0.791	74	0.780	80	0.770	90	0.757	95	9.0
Austin	0.781	75	0.757	79	0.739	85	0.733	92	8.1
Bailey	0.848	62	0.777	55	0.806	72	0.819	85	9.0
Bandera	0.770	62	0.774	72	0.764	82	0.765	94	8.2
Bastrop	0.781	72	0.765	77	0.762	88	0.748	93	8.4
Baylor	0.780	59	0.797	75	0.791	87	0.801	103	8.8
Bee	0.796	78	0.762	79	0.760	92	0.748	97	8.7
Bell	0.780	69	0.773	77	0.771	90	0.754	93	8.5
Bexar	0.784	70	0.779	79	0.769	88	0.756	94	8.7
Blanco	0.777	65	0.776	75	0.766	85	0.758	93	8.4
Borden	0.808	58	0.802	66	0.805	80	0.795	87	10.2
Bosque	0.779	66	0.772	74	0.776	91	0.765	97	8.6
Bowie	0.769	64	0.753	68	0.743	76	0.742	83	8.0
Brazoria	0.751	70	0.749	80	0.730	85	0.718	90	8.0
Brazos	0.785	76	0.763	80	0.754	89	0.745	98	8.5
Brewster	0.819	60	0.833	70	0.818	78	0.833	91	9.6
Briscoe	0.824	63	0.815	73	0.823	89	0.818	101	10.3
Brooks	0.797	80	0.769	82	0.771	97	0.746	98	9.1
Brown	0.770	57	0.763	66	0.768	80	0.770	91	7.6
Burleson	0.784	74	0.763	79	0.760	90	0.743	97	8.4
Burnet	0.773	64	0.777	75	0.769	86	0.758	94	8.5
Caldwell	0.785	72	0.769	77	0.764	88	0.748	92	8.5
Calhoun	0.772	73	0.760	81	0.745	88	0.737	95	8.4
Callahan	0.767	55	0.776	68	0.770	80	0.783	95	8.1
Cameron	0.786	78	0.781	90	0.760	95	0.727	93	8.8
Camp	0.782	70	0.761	74	0.758	84	0.743	87	8.8
Carson	0.828	65	0.829	77	0.842	97	0.849	113	10.6
Cass	0.768	65	0.750	69	0.746	78	0.738	83	8.3
Castro	0.819	56	0.802	65	0.827	84	0.829	95	9.5
Chambers	0.735	66	0.742	76	0.727	83	0.711	87	7.4
Cherokee	0.783	74	0.754	75	0.751	85	0.742	91	8.5
Childress	0.807	65	0.814	78	0.821	97	0.822	108	10.2
Clay	0.787	64	0.790	74	0.787	88	0.790	99	8.4
Cochran	0.840	60	0.782	57	0.802	70	0.813	83	9.5

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TABLE VI (continued)

COUNTY	5 year		10 year		25 year		50 year		All Freqs.
	e	b	e	b	e	b	e	b	d
Coke	0.766	51	0.777	65	0.778	77	0.787	91	9.3
Coleman	0.763	54	0.770	66	0.763	78	0.781	92	8.0
Collin	0.781	67	0.778	79	0.779	92	0.776	102	8.8
Collings-worth	0.821	68	0.822	81	0.837	102	0.825	110	10.5
Colorado	0.778	74	0.756	79	0.744	87	0.736	94	8.3
Comal	0.781	69	0.775	78	0.766	87	0.753	91	8.6
Comanche	0.770	59	0.765	68	0.773	83	0.769	92	7.8
Concho	0.752	50	0.779	67	0.755	73	0.785	91	8.0
Cooke	0.779	65	0.780	77	0.791	93	0.787	104	8.7
Coryell	0.774	66	0.777	76	0.774	89	0.761	95	8.5
Cottle	0.799	61	0.805	75	0.811	91	0.817	105	9.8
Crane	0.819	55	0.818	66	0.785	69	0.801	82	10.2
Crockett	0.791	56	0.781	63	0.782	74	0.777	82	9.3
Crosby	0.815	61	0.809	69	0.811	83	0.807	92	10.1
Culberson	0.851	53	0.831	58	0.814	62	0.818	72	10.8
Dallam	0.866	68	0.824	68	0.846	90	0.872	111	10.6
Dallas	0.782	68	0.777	78	0.774	90	0.771	101	8.7
Dawson	0.818	59	0.814	68	0.807	77	0.801	86	10.4
Deaf Smith	0.844	60	0.794	61	0.831	82	0.837	94	9.3
Delta	0.783	68	0.775	77	0.770	89	0.759	94	9.1
Denton	0.777	65	0.779	77	0.781	90	0.780	102	8.5
DeWitt	0.785	75	0.758	78	0.758	90	0.747	96	8.7
Dickens	0.807	61	0.803	71	0.808	85	0.808	96	10.0
Dimmit	0.806	74	0.795	82	0.783	94	0.781	105	9.4
Donley	0.832	68	0.825	79	0.836	96	0.823	103	10.6
Duval	0.802	79	0.781	84	0.772	94	0.755	98	9.2
Eastland	0.772	58	0.771	69	0.772	81	0.775	92	7.8
Ector	0.821	56	0.816	65	0.789	68	0.802	82	10.5
Edwards	0.759	54	0.759	63	0.769	76	0.776	88	7.5
Ellis	0.788	71	0.777	79	0.771	91	0.766	98	8.8
El Paso	0.802	34	0.795	42	0.843	60	0.900	90	12.0
Erath	0.772	61	0.770	72	0.785	89	0.772	96	8.1
Falls	0.786	72	0.771	79	0.772	93	0.750	94	8.5
Fannin	0.778	66	0.782	79	0.782	93	0.770	99	9.1
Fayette	0.782	73	0.758	76	0.758	88	0.743	94	8.2
Fisher	0.779	55	0.793	70	0.790	83	0.798	96	9.5
Floyd	0.821	63	0.809	71	0.818	85	0.813	97	10.0
Foard	0.787	60	0.806	77	0.807	91	0.817	109	9.5
Fort Bend	0.760	71	0.751	80	0.729	84	0.726	91	8.1
Franklin	0.782	69	0.765	74	0.759	84	0.751	89	8.8

TABLE VI (continued)

COUNTY	5 year		10 year		25 year		50 year		All Freqs.
	e	b	e	b	e	b	e	b	d
Freestone	0.795	77	0.769	80	0.775	95	0.749	94	9.0
Frio	0.789	71	0.789	82	0.772	89	0.765	96	9.1
Gaines	0.832	58	0.805	63	0.797	70	0.807	84	10.0
Galveston	0.739	66	0.742	78	0.727	85	0.704	88	7.6
Garza	0.811	60	0.800	67	0.810	83	0.799	88	10.2
Gillespie	0.766	60	0.767	71	0.765	82	0.764	94	8.1
Glasscock	0.796	55	0.803	66	0.789	74	0.789	83	10.0
Goliad	0.789	75	0.758	77	0.755	89	0.746	97	8.7
Gonzales	0.788	74	0.763	77	0.760	89	0.747	95	8.6
Gray	0.837	70	0.836	83	0.842	99	0.841	114	10.8
Grayson	0.778	65	0.779	78	0.790	95	0.781	104	8.9
Gregg	0.783	71	0.750	72	0.753	84	0.740	87	8.6
Grimes	0.784	75	0.760	81	0.744	87	0.742	95	8.3
Guadalupe	0.787	72	0.772	78	0.765	89	0.750	93	8.7
Hale	0.827	61	0.815	69	0.823	84	0.812	92	9.9
Hall	0.821	66	0.815	75	0.822	92	0.819	103	10.3
Hamilton	0.770	62	0.761	72	0.778	89	0.766	95	8.3
Hansford	0.846	73	0.842	84	0.862	104	0.867	124	11.3
Hardeman	0.794	61	0.810	78	0.816	95	0.817	110	9.5
Hardin	0.738	65	0.740	74	0.720	80	0.718	87	7.5
Harris	0.749	70	0.753	81	0.724	81	0.728	91	7.7
Harrison	0.773	69	0.750	70	0.747	80	0.730	82	8.4
Hartley	0.855	67	0.814	67	0.840	85	0.863	106	10.2
Haskell	0.779	57	0.799	74	0.787	85	0.805	103	9.2
Hays	0.783	69	0.776	78	0.765	87	0.747	90	8.6
Hemphill	0.851	76	0.842	87	0.843	103	0.840	115	10.7
Henderson	0.796	77	0.770	79	0.773	93	0.752	93	9.0
Hidalgo	0.795	80	0.778	87	0.771	98	0.749	99	9.2
Hill	0.790	72	0.777	78	0.773	91	0.764	98	8.8
Hockley	0.832	60	0.807	64	0.812	78	0.810	87	10.0
Hood	0.773	63	0.773	75	0.782	90	0.773	98	8.3
Hopkins	0.783	70	0.775	77	0.767	88	0.754	93	9.1
Houston	0.780	73	0.757	78	0.748	86	0.740	93	8.3
Howard	0.800	56	0.802	65	0.796	76	0.791	86	10.1
Hudspeth	0.840	44	0.827	50	0.819	60	0.856	78	11.4
Hunt	0.785	69	0.783	80	0.776	93	0.764	99	9.2
Hutchinson	0.844	70	0.837	80	0.851	100	0.863	121	11.0
Irion	0.789	55	0.775	61	0.783	77	0.759	81	9.6
Jack	0.779	63	0.786	75	0.782	88	0.782	98	8.5
Jackson	0.769	73	0.757	80	0.745	89	0.737	95	8.5

TABLE VI (continued)

COUNTY	5 year		10 year		25 year		50 year		All Freqs.
	e	b	e	b	e	b	e	b	d
Jasper	0.743	65	0.736	73	0.719	78	0.715	84	7.4
Jeff Davis	0.865	63	0.853	69	0.802	65	0.818	77	10.8
Jefferson	0.733	65	0.727	74	0.730	86	0.710	87	7.5
Jim Hogg	0.813	82	0.786	87	0.780	98	0.756	99	9.4
Jim Wells	0.797	79	0.765	80	0.768	94	0.748	98	8.9
Johnson	0.779	67	0.773	77	0.776	90	0.771	99	8.6
Jones	0.771	55	0.794	73	0.780	82	0.803	102	9.0
Karnes	0.791	75	0.766	77	0.767	91	0.751	95	8.9
Kaufman	0.790	72	0.776	80	0.777	93	0.763	98	9.0
Kendall	0.771	64	0.773	74	0.764	84	0.762	94	8.3
Kenedy	0.793	79	0.771	84	0.763	94	0.735	96	8.7
Kent	0.801	60	0.796	70	0.806	85	0.799	93	10.0
Kerr	0.765	58	0.764	69	0.763	80	0.766	91	8.0
Kimble	0.758	53	0.763	66	0.757	75	0.772	88	7.6
King	0.794	59	0.804	74	0.802	87	0.811	103	9.6
Kinney	0.780	62	0.773	70	0.777	82	0.790	97	8.0
Kleberg	0.794	79	0.764	81	0.761	93	0.739	96	8.7
Knox	0.788	58	0.801	76	0.798	88	0.809	104	9.3
Lamar	0.777	66	0.770	74	0.769	87	0.759	93	8.9
Lamb	0.828	60	0.800	63	0.821	80	0.818	88	9.6
Lampasas	0.770	63	0.770	73	0.771	86	0.762	94	8.4
LaSalle	0.801	77	0.795	86	0.776	91	0.767	99	9.4
Lavaca	0.782	74	0.757	78	0.750	89	0.741	95	8.5
Lee	0.782	73	0.764	77	0.761	89	0.745	94	8.3
Leon	0.788	76	0.766	80	0.762	92	0.746	95	8.8
Liberty	0.739	65	0.747	78	0.716	78	0.726	90	7.4
Limestone	0.792	74	0.772	79	0.772	92	0.753	93	8.8
Lipscomb	0.858	78	0.846	89	0.849	106	0.851	121	10.7
Live Oak	0.795	76	0.768	79	0.765	92	0.752	96	8.9
Llano	0.768	60	0.768	72	0.769	84	0.763	93	8.2
Loving	0.825	50	0.822	61	0.804	63	0.813	77	10.2
Lubbock	0.821	60	0.813	69	0.816	82	0.808	88	10.1
Lynn	0.821	59	0.813	69	0.815	81	0.802	87	10.3
Madison	0.785	76	0.765	81	0.751	90	0.755	100	8.7
Marion	0.770	67	0.750	71	0.746	79	0.736	83	8.4
Martin	0.813	57	0.820	70	0.796	74	0.797	85	10.4
Mason	0.766	56	0.760	68	0.770	81	0.769	91	7.9
Matagorda	0.757	71	0.759	83	0.737	87	0.727	94	8.5
Maverick	0.801	70	0.788	76	0.782	88	0.796	106	8.7
McCulloch	0.761	53	0.767	67	0.766	79	0.772	91	7.8

TABLE VI (continued)

COUNTY	5 year		10 year		25 year		50 year		All Freqs.
	e	b	e	b	e	b	e	b	d
McLennan	0.787	71	0.777	78	0.774	91	0.757	94	8.7
McMullen	0.797	77	0.782	83	0.770	91	0.758	96	9.2
Medina	0.779	67	0.784	79	0.771	86	0.765	95	8.7
Menard	0.751	51	0.781	69	0.750	72	0.779	91	7.6
Midland	0.812	57	0.823	71	0.788	71	0.795	83	10.5
Milam	0.784	72	0.769	78	0.768	91	0.748	93	8.4
Mills	0.769	59	0.763	69	0.772	84	0.766	93	7.9
Mitchell	0.778	54	0.782	64	0.792	78	0.792	88	9.7
Montague	0.785	65	0.783	75	0.785	89	0.788	100	8.6
Montgomery	0.771	73	0.757	81	0.728	82	0.736	92	7.7
Moore	0.847	65	0.825	72	0.851	96	0.864	118	10.7
Morris	0.777	67	0.760	71	0.757	81	0.741	85	8.5
Motley	0.817	63	0.806	72	0.807	85	0.814	101	10.0
Nacogdoches	0.773	71	0.748	73	0.740	81	0.733	86	8.0
Navarro	0.795	75	0.776	80	0.777	94	0.757	95	8.9
Newton	0.741	65	0.734	71	0.718	76	0.709	82	7.4
Nolan	0.768	52	0.780	68	0.781	79	0.793	96	9.3
Nueces	0.794	79	0.762	79	0.759	91	0.741	96	8.7
Ochiltree	0.847	74	0.848	88	0.858	106	0.866	127	11.2
Oldham	0.844	64	0.804	62	0.833	84	0.850	103	9.6
Orange	0.733	65	0.728	73	0.730	85	0.709	87	7.5
Palo Pinto	0.775	61	0.781	74	0.781	87	0.778	96	8.4
Panola	0.773	70	0.743	70	0.741	79	0.724	81	8.3
Parker	0.777	63	0.781	76	0.781	88	0.777	99	8.4
Parmer	0.845	62	0.783	56	0.821	76	0.827	88	9.1
Pecos	0.819	56	0.811	64	0.786	69	0.806	84	9.7
Polk	0.761	69	0.748	75	0.718	76	0.730	88	7.5
Potter	0.817	58	0.818	70	0.841	93	0.855	112	10.2
Presidio	0.860	62	0.854	72	0.837	75	0.848	90	10.6
Rains	0.786	73	0.781	81	0.771	91	0.759	94	9.2
Randall	0.793	52	0.811	68	0.837	89	0.846	106	9.5
Reagan	0.800	58	0.802	67	0.785	74	0.781	82	9.9
Real	0.769	57	0.771	68	0.770	78	0.769	91	7.6
Red River	0.776	66	0.758	70	0.758	81	0.752	86	8.4
Reeves	0.846	57	0.834	65	0.793	62	0.810	77	10.5
Refugio	0.788	77	0.753	78	0.751	90	0.743	96	8.6
Roberts	0.848	72	0.845	87	0.849	103	0.856	121	11.2
Robertson	0.784	74	0.767	80	0.765	91	0.748	96	8.6
Rockwall	0.787	70	0.780	79	0.778	92	0.768	100	8.9
Runnels	0.756	50	0.778	67	0.767	76	0.792	96	8.5

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TABLE VI (continued)

COUNTY	5 year		10 year		25 year		50 year		All Freqs.
	e	b	e	b	e	b	e	b	d
Rusk	0.781	72	0.749	72	0.751	84	0.738	87	8.5
Sabine	0.758	66	0.740	71	0.721	75	0.715	80	7.6
San Augustine	0.758	67	0.741	72	0.725	76	0.719	82	7.6
San Jacinto	0.761	70	0.751	79	0.723	79	0.731	91	7.5
San Patricio	0.789	78	0.759	78	0.757	91	0.743	96	8.7
San Saba	0.767	59	0.762	69	0.771	83	0.767	92	8.0
Schleicher	0.771	53	0.772	63	0.769	74	0.771	86	8.6
Scurry	0.800	57	0.790	67	0.800	82	0.791	89	10.0
Shackelford	0.777	58	0.786	72	0.777	82	0.788	97	8.5
Shelby	0.768	68	0.742	71	0.737	78	0.717	80	8.0
Sherman	0.857	71	0.836	77	0.859	101	0.870	120	10.9
Smith	0.787	74	0.760	76	0.760	87	0.746	90	8.8
Somervell	0.771	63	0.770	73	0.782	90	0.770	97	8.4
Starr	0.805	82	0.791	89	0.780	99	0.758	100	9.4
Stephens	0.775	59	0.782	72	0.776	83	0.781	94	8.1
Sterling	0.779	53	0.780	62	0.788	76	0.783	85	9.6
Stonewall	0.790	59	0.801	74	0.797	85	0.806	100	9.5
Sutton	0.760	51	0.764	61	0.765	73	0.772	85	8.1
Swisher	0.808	58	0.807	69	0.826	87	0.822	98	10.0
Tarrant	0.778	66	0.777	77	0.774	88	0.775	101	8.5
Taylor	0.760	52	0.781	69	0.776	80	0.796	100	8.7
Terrell	0.793	54	0.800	67	0.793	76	0.806	91	9.0
Terry	0.828	59	0.806	65	0.809	77	0.806	86	10.0
Throckmorton	0.779	59	0.792	74	0.783	84	0.795	98	8.6
Titus	0.780	69	0.759	72	0.758	82	0.744	87	8.6
Tom Green	0.769	51	0.777	64	0.771	75	0.782	88	9.0
Travis	0.780	69	0.775	77	0.766	87	0.751	91	8.6
Trinity	0.764	71	0.750	76	0.729	80	0.734	90	7.7
Tyler	0.750	66	0.740	74	0.716	77	0.721	86	7.4
Upshur	0.782	71	0.760	74	0.757	84	0.742	87	8.7
Upton	0.808	56	0.824	71	0.788	72	0.793	82	10.0
Uvalde	0.779	64	0.779	73	0.772	83	0.773	95	8.2
Val Verde	0.767	52	0.767	61	0.780	76	0.794	92	8.0
Van Zandt	0.792	74	0.775	79	0.772	91	0.755	93	9.1
Victoria	0.782	75	0.755	78	0.752	90	0.745	97	8.6
Walker	0.778	73	0.759	80	0.739	84	0.740	94	8.0
Waller	0.785	77	0.757	80	0.736	84	0.729	91	8.1
Ward	0.833	56	0.810	61	0.789	65	0.808	81	10.5
Washington	0.784	75	0.759	79	0.747	87	0.740	94	8.2
Webb	0.812	81	0.801	90	0.781	95	0.774	103	9.6

TABLE VI (continued)

COUNTY	5 year		10 year		25 year		50 year		All Freqs.
	e	b	e	b	e	b	e	b	d
Wharton	0.767	72	0.758	81	0.738	86	0.733	93	8.3
Wheeler	0.832	71	0.832	85	0.836	103	0.833	114	10.6
Wichita	0.784	62	0.795	76	0.792	88	0.797	104	8.7
Wilbarger	0.782	60	0.797	77	0.799	90	0.807	107	9.0
Willacy	0.790	78	0.777	87	0.762	95	0.732	95	8.8
Williamson	0.779	68	0.777	77	0.769	88	0.751	92	8.5
Wilson	0.792	74	0.769	78	0.768	90	0.752	95	8.9
Winkler	0.829	56	0.811	61	0.790	66	0.817	83	10.4
Wise	0.778	65	0.782	77	0.782	89	0.781	100	8.6
Wood	0.787	73	0.770	78	0.761	87	0.753	92	8.9
Yoakum	0.841	59	0.798	59	0.797	69	0.812	82	9.6
Young	0.779	61	0.786	74	0.781	85	0.787	97	8.4
Zapata	0.815	84	0.795	91	0.785	99	0.763	100	9.6
Zavala	0.794	69	0.785	77	0.779	89	0.778	98	8.9

10 Appendix – III: Historical 1985 EBD Values

Table 6 from the 1985 Hydraulic Manual starts on the next page. There are 8 pages of EBD values.

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TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$

Based on Weather Bureau (NWS) Technical Paper No. 40
"Rainfall Frequency Atlas of the United States"

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
Anderson	0.799	62	8.6	0.792	77	8.8	0.763	78	8.8	0.772	92	8.8	0.744	93	8.8	0.740	99	8.6
Andrews	0.812	40	9.8	0.827	57	10.2	0.809	63	10.2	0.793	69	10.2	0.807	84	10.2	0.804	92	9.8
Angelina	0.785	62	8.8	0.762	69	7.6	0.746	73	7.6	0.726	77	7.6	0.727	86	7.6	0.716	90	8.8
Aransas	0.821	73	9.2	0.787	77	8.5	0.753	79	8.5	0.745	88	8.5	0.739	95	8.5	0.725	98	9.2
Archer	0.798	49	9.2	0.783	61	8.5	0.794	74	8.5	0.789	86	8.5	0.792	100	8.5	0.784	111	9.2
Armstrong	0.846	52	10.8	0.819	63	10.4	0.820	75	10.4	0.835	95	10.4	0.831	105	10.4	0.840	113	10.8
Atascosa	0.808	60	9.2	0.791	74	9.0	0.780	80	9.0	0.770	90	9.0	0.757	95	9.0	0.761	108	9.2
Austin	0.811	69	8.0	0.781	75	8.1	0.757	79	8.1	0.739	85	8.1	0.733	92	8.1	0.719	95	8.0
Bailey	0.833	44	9.8	0.848	62	9.0	0.777	55	9.0	0.806	72	9.0	0.819	85	9.0	0.825	101	9.8
Bandera	0.795	52	8.6	0.770	62	8.2	0.774	72	8.2	0.764	82	8.2	0.765	94	8.2	0.769	105	8.6
Bastrop	0.802	62	8.2	0.781	72	8.4	0.765	77	8.4	0.762	88	8.4	0.748	93	8.4	0.747	103	8.2
Baylor	0.800	48	9.4	0.780	59	8.8	0.797	75	8.8	0.791	87	8.8	0.801	103	8.8	0.790	112	9.4
Bee	0.815	65	9.8	0.796	78	8.7	0.762	79	8.7	0.760	92	8.7	0.748	97	8.7	0.740	103	9.8
Bell	0.798	56	8.0	0.780	69	8.5	0.773	77	8.5	0.771	90	8.5	0.754	93	8.5	0.751	102	8.0
Bexar	0.798	56	8.7	0.784	70	8.7	0.779	79	8.7	0.769	88	8.7	0.756	94	8.7	0.762	107	8.7
Blanco	0.792	53	8.3	0.777	65	8.4	0.776	75	8.4	0.766	85	8.4	0.758	93	8.4	0.758	104	8.3
Borden	0.810	43	9.4	0.808	58	10.2	0.802	66	10.2	0.805	80	10.2	0.795	87	10.2	0.794	96	9.4
Bosque	0.784	51	7.9	0.779	66	8.6	0.772	74	8.6	0.776	91	8.6	0.765	97	8.6	0.761	104	7.9
Bowie	0.768	50	7.7	0.769	64	8.0	0.753	68	8.0	0.743	76	8.0	0.742	83	8.0	0.740	92	7.7
Brazoria	0.796	69	7.8	0.751	70	8.0	0.749	80	8.0	0.730	85	8.0	0.718	90	8.0	0.696	89	7.8
Brazos	0.806	65	8.0	0.785	76	8.5	0.763	80	8.5	0.754	89	8.5	0.745	98	8.5	0.730	96	8.0
Brewster	0.860	50	10.4	0.819	60	9.6	0.833	70	9.6	0.818	78	9.6	0.833	91	9.6	0.832	110	10.4
Briscoe	0.835	50	10.5	0.824	63	10.3	0.815	73	10.3	0.823	89	10.3	0.818	101	10.3	0.832	115	10.5
Brooks	0.828	73	9.3	0.797	80	9.1	0.769	82	9.1	0.771	97	9.1	0.746	98	9.1	0.738	99	9.3
Brown	0.775	43	7.7	0.770	57	7.6	0.763	66	7.6	0.768	80	7.6	0.770	91	7.6	0.763	98	7.7
Burleson	0.805	64	8.0	0.784	74	8.4	0.763	79	8.4	0.760	90	8.4	0.743	97	8.4	0.739	98	8.0
Burnet	0.791	51	8.1	0.773	64	8.5	0.777	75	8.5	0.769	86	8.5	0.758	94	8.5	0.758	103	8.1
Caldwell	0.800	60	8.2	0.785	72	8.5	0.769	77	8.5	0.764	88	8.5	0.748	92	8.5	0.749	104	8.2
Calhoun	0.810	70	8.9	0.772	73	8.4	0.760	81	8.4	0.745	88	8.4	0.737	95	8.4	0.720	96	8.9
Callahan	0.774	42	8.2	0.767	55	8.1	0.776	68	8.1	0.770	80	8.1	0.783	95	8.1	0.774	100	8.2
Cameron	0.826	74	9.2	0.786	78	8.8	0.781	90	8.8	0.760	95	8.8	0.727	93	8.8	0.730	102	9.2
Camp	0.779	53	8.0	0.782	70	8.8	0.761	74	8.8	0.758	84	8.8	0.743	87	8.8	0.740	94	8.0
Carson	0.852	55	10.6	0.828	65	10.6	0.829	77	10.6	0.842	97	10.6	0.849	113	10.6	0.840	114	10.6
Cass	0.769	50	7.7	0.768	65	8.3	0.750	69	8.3	0.746	78	8.3	0.738	83	8.3	0.737	91	7.7
Castro	0.842	49	10.4	0.819	56	9.5	0.802	65	9.5	0.827	84	9.5	0.829	95	9.5	0.823	105	10.4

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TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
Chambers	0.789	69	8.2	0.753	66	7.4	0.742	76	7.4	0.727	83	7.4	0.711	87	7.4	0.690	85	8.2
Cherokee	0.793	61	8.4	0.783	74	8.5	0.754	75	8.5	0.751	85	8.5	0.742	91	8.5	0.733	96	8.4
Childress	0.825	51	10.3	0.807	65	10.2	0.814	78	10.2	0.821	97	10.2	0.822	108	10.2	0.824	126	10.3
Clay	0.797	50	8.8	0.787	64	8.4	0.790	74	8.4	0.787	88	8.4	0.790	99	8.4	0.780	110	8.8
Cochran	0.829	42	9.8	0.840	60	9.5	0.782	57	9.5	0.802	70	9.5	0.813	83	9.5	0.824	100	9.8
Coke	0.773	37	8.4	0.766	51	9.3	0.777	65	9.3	0.778	77	9.3	0.787	91	9.3	0.779	98	8.4
Coleman	0.767	40	7.6	0.763	54	8.0	0.770	66	8.0	0.763	78	8.0	0.781	92	8.0	0.769	98	7.6
Collin	0.790	54	8.2	0.781	67	8.8	0.778	79	8.8	0.779	92	8.8	0.776	102	8.8	0.764	106	8.2
Collingsworth	0.833	53	10.8	0.821	68	10.5	0.822	81	10.5	0.837	102	10.5	0.825	110	10.5	0.839	135	10.8
Colorado	0.810	68	8.3	0.778	74	8.3	0.756	79	8.3	0.744	87	8.3	0.736	94	8.3	0.723	96	8.3
Comal	0.796	56	8.4	0.781	69	8.6	0.775	78	8.6	0.766	87	8.6	0.753	91	8.6	0.758	105	8.4
Comanche	0.776	45	7.5	0.770	59	7.8	0.765	68	7.8	0.773	83	7.8	0.769	92	7.8	0.763	101	7.5
Concho	0.760	38	7.8	0.752	50	8.0	0.779	67	8.0	0.755	73	8.0	0.785	91	8.0	0.767	95	7.8
Cooke	0.793	51	8.4	0.779	65	8.7	0.780	77	8.7	0.791	93	8.7	0.787	104	8.7	0.774	109	8.4
Coryell	0.790	52	7.7	0.774	66	8.5	0.777	76	8.5	0.774	89	8.5	0.761	95	8.5	0.758	103	7.7
Cottle	0.816	48	9.8	0.799	61	9.8	0.805	75	9.8	0.811	91	9.8	0.817	105	9.8	0.813	118	9.8
Crane	0.815	38	9.4	0.819	55	10.2	0.818	66	10.2	0.785	69	10.2	0.801	82	10.2	0.798	88	9.4
Crockett	0.790	40	9.0	0.791	56	9.3	0.781	63	9.3	0.782	74	9.3	0.777	82	9.3	0.775	90	9.0
Crosby	0.819	46	9.6	0.815	61	10.1	0.809	69	10.1	0.811	83	10.1	0.807	92	10.1	0.810	106	9.6
Culberson	0.810	31	8.9	0.851	53	10.8	0.831	58	10.8	0.814	62	10.8	0.818	72	10.8	0.828	84	8.9
Dallam	0.860	51	10.8	0.866	68	10.6	0.824	68	10.6	0.846	90	10.6	0.872	111	10.6	0.840	108	10.8
Dallas	0.791	54	8.3	0.782	68	8.7	0.777	78	8.7	0.774	90	8.7	0.771	101	8.7	0.762	106	8.3
Dawson	0.820	44	10.0	0.818	59	10.4	0.814	68	10.4	0.807	77	10.4	0.801	86	10.4	0.798	93	10.0
Deaf Smith	0.847	48	10.7	0.844	60	9.3	0.794	61	9.3	0.831	82	9.3	0.837	94	9.3	0.830	107	10.7
Delta	0.788	54	8.2	0.783	68	9.1	0.775	77	9.1	0.770	89	9.1	0.759	94	9.1	0.753	100	8.2
Denton	0.789	51	8.0	0.777	65	8.5	0.779	77	8.5	0.781	90	8.5	0.780	102	8.5	0.769	107	8.0
DeWitt	0.810	65	8.9	0.785	75	8.7	0.758	78	8.7	0.758	90	8.7	0.747	96	8.7	0.739	102	8.9
Dickens	0.810	45	9.4	0.807	61	10.0	0.803	71	10.0	0.808	85	10.0	0.808	96	10.0	0.809	109	9.4
Dimmit	0.830	60	9.6	0.806	74	9.4	0.795	82	9.4	0.783	94	9.4	0.781	105	9.4	0.779	113	9.6
Donley	0.839	52	11.0	0.832	68	10.6	0.825	79	10.6	0.836	96	10.6	0.823	103	10.6	0.845	129	11.0
Duval	0.826	70	8.8	0.802	79	9.2	0.781	84	9.2	0.772	94	9.2	0.755	98	9.2	0.750	104	8.8
Eastland	0.780	45	8.0	0.772	58	7.8	0.771	69	7.8	0.772	81	7.8	0.775	92	7.8	0.770	101	8.0
Ector	0.812	39	9.5	0.821	56	10.5	0.816	65	10.5	0.789	68	10.5	0.802	82	10.5	0.800	89	9.5
Edwards	0.790	44	8.2	0.759	54	7.5	0.759	63	7.5	0.769	76	7.5	0.776	88	7.5	0.772	100	8.2
Ellis	0.798	56	8.4	0.788	71	8.8	0.777	79	8.8	0.771	91	8.8	0.766	98	8.8	0.760	105	8.4

TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$ (Continued)

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
El Paso	0.797	24	9.5	0.802	34	12.0	0.795	42	12.0	0.843	60	12.0	0.900	90	12.0	0.825	65	9.5
Erath	0.780	47	7.7	0.772	61	8.1	0.770	72	8.1	0.785	89	8.1	0.772	96	8.1	0.765	103	7.7
Falls	0.801	60	8.0	0.786	72	8.5	0.771	79	8.5	0.772	93	8.5	0.750	94	8.5	0.748	102	8.0
Fannin	0.790	54	8.3	0.778	66	9.1	0.782	79	9.1	0.782	93	9.1	0.779	99	9.1	0.762	103	8.3
Fayette	0.805	65	8.3	0.782	73	8.2	0.758	76	8.2	0.758	88	8.2	0.743	94	8.2	0.740	100	8.3
Fisher	0.786	41	8.6	0.779	55	9.5	0.793	70	9.5	0.790	83	9.5	0.798	96	9.5	0.788	102	8.6
Floyd	0.829	48	10.1	0.821	63	10.0	0.890	71	10.0	0.818	85	10.0	0.813	97	10.0	0.822	110	10.1
Foard	0.810	48	9.8	0.787	60	9.5	0.806	77	9.5	0.807	91	9.5	0.817	109	9.5	0.806	116	9.8
Fort Bend	0.804	70	7.9	0.760	71	8.1	0.751	80	8.1	0.729	84	8.1	0.726	91	8.1	0.710	92	7.9
Franklin	0.780	53	8.1	0.782	69	8.8	0.765	74	8.8	0.759	84	8.8	0.751	89	8.8	0.745	95	8.1
Freestone	0.803	62	8.5	0.795	77	9.0	0.769	80	9.0	0.775	95	9.0	0.749	94	9.0	0.745	100	8.5
Frio	0.814	61	9.3	0.789	71	9.1	0.789	82	9.1	0.772	89	9.1	0.765	96	9.1	0.769	110	9.3
Gaines	0.820	42	10.0	0.832	58	10.0	0.805	63	10.0	0.797	70	10.0	0.807	84	10.0	0.813	95	10.0
Galveston	0.787	67	7.8	0.739	66	7.6	0.742	78	7.6	0.727	85	7.6	0.704	88	7.6	0.690	85	7.8
Garza	0.812	44	9.4	0.811	60	10.2	0.800	67	10.2	0.810	83	10.2	0.799	88	10.2	0.800	100	9.4
Gillespie	0.787	49	8.5	0.766	60	8.1	0.767	71	8.1	0.765	82	8.1	0.764	94	8.1	0.765	104	8.5
Glasscock	0.801	40	9.1	0.796	55	10.0	0.803	66	10.0	0.789	74	10.0	0.789	83	10.0	0.784	92	9.1
Goliad	0.812	65	9.1	0.789	75	8.7	0.758	77	8.7	0.755	89	8.7	0.746	97	8.7	0.738	101	9.1
Gonzales	0.801	61	8.4	0.788	74	8.6	0.763	77	8.6	0.760	89	8.6	0.747	95	8.6	0.745	104	8.4
Gray	0.845	54	10.8	0.837	70	10.8	0.836	83	10.8	0.842	99	10.8	0.841	114	10.8	0.846	125	10.8
Grayson	0.790	52	8.3	0.778	65	8.9	0.779	78	8.9	0.790	95	8.9	0.781	104	8.9	0.769	108	8.3
Gregg	0.783	56	8.1	0.783	71	8.6	0.750	72	8.6	0.753	84	8.6	0.740	87	8.6	0.737	94	8.1
Grimes	0.808	68	8.0	0.784	75	8.3	0.760	81	8.3	0.744	87	8.3	0.742	95	8.3	0.721	94	8.0
Guadalupe	0.796	58	8.4	0.787	72	8.7	0.772	78	8.7	0.765	89	8.7	0.750	93	8.7	0.754	105	8.4
Hale	0.834	48	10.3	0.827	61	9.9	0.815	69	9.9	0.823	84	9.9	0.812	92	9.9	0.817	104	10.3
Hall	0.829	50	10.4	0.821	66	10.3	0.815	75	10.3	0.822	92	10.3	0.819	103	10.3	0.830	126	10.4
Hamilton	0.779	48	7.3	0.770	62	8.3	0.761	72	8.3	0.778	89	8.3	0.766	95	8.3	0.761	103	7.3
Hansford	0.865	57	10.4	0.846	73	11.3	0.842	84	11.3	0.862	104	11.3	0.867	124	11.3	0.839	116	10.4
Hardeman	0.815	49	10.0	0.794	61	9.5	0.810	78	9.5	0.816	95	9.5	0.817	110	9.5	0.810	120	10.0
Hardin	0.788	68	8.4	0.738	65	7.5	0.740	74	7.5	0.720	80	7.5	0.718	87	7.5	0.700	87	8.4
Harris	0.800	68	7.9	0.749	70	7.7	0.753	81	7.7	0.724	81	7.7	0.728	91	7.7	0.706	91	7.9
Harrison	0.771	53	8.0	0.773	69	8.4	0.750	70	8.4	0.747	80	8.4	0.730	82	8.4	0.732	90	8.0
Hartley	0.858	51	10.8	0.855	67	10.2	0.814	67	10.2	0.840	85	10.2	0.863	106	10.2	0.832	107	10.8
Haskett	0.790	45	8.9	0.779	57	9.2	0.799	74	9.2	0.787	85	9.2	0.805	103	9.2	0.788	106	8.9
Hays	0.796	56	8.2	0.783	69	8.6	0.776	78	8.6	0.765	87	8.6	0.747	90	8.6	0.755	104	8.2

TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$ (Continued)

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
Hemphill	0.845	56	10.6	0.851	76	10.7	0.842	87	10.7	0.843	103	10.7	0.840	115	10.7	0.847	132	10.6
Henderson	0.800	60	8.7	0.796	77	9.0	0.770	79	9.0	0.773	93	9.0	0.752	93	9.0	0.749	102	8.7
Hidalgo	0.831	74	9.6	0.795	80	9.2	0.778	87	9.2	0.771	98	9.2	0.749	99	9.2	0.740	103	9.6
Hill	0.799	57	8.2	0.790	72	8.8	0.777	78	8.8	0.773	91	8.8	0.764	98	8.8	0.759	105	8.2
Hockley	0.832	46	9.9	0.832	60	10.0	0.807	64	10.0	0.812	78	10.0	0.810	87	10.0	0.817	101	9.9
Hood	0.782	48	7.7	0.773	63	8.3	0.773	75	8.3	0.782	90	8.3	0.773	98	8.3	0.766	105	7.7
Hopkins	0.788	54	8.3	0.783	70	9.1	0.775	77	9.1	0.767	88	9.1	0.754	93	9.1	0.750	100	8.3
Houston	0.797	63	8.2	0.780	73	8.3	0.757	78	8.3	0.748	86	8.3	0.740	93	8.3	0.727	94	8.2
Howard	0.805	42	9.2	0.800	56	10.1	0.802	65	10.0	0.796	76	10.1	0.791	86	10.1	0.788	95	9.2
Hudspeth	0.800	27	9.4	0.840	44	11.4	0.827	50	11.4	0.819	60	11.4	0.856	78	11.4	0.833	77	7.4
Hunt	0.793	55	8.4	0.785	69	9.2	0.783	80	9.2	0.776	93	9.2	0.764	99	9.2	0.758	104	8.4
Hutchinson	0.860	56	10.4	0.844	70	11.0	0.837	80	11.0	0.851	100	11.0	0.863	121	11.0	0.837	115	10.4
Irion	0.780	37	8.1	0.789	55	9.6	0.775	61	9.6	0.783	77	9.6	0.759	81	9.6	0.770	90	8.1
Jack	0.789	48	8.5	0.779	63	8.5	0.786	75	8.5	0.782	88	8.5	0.782	98	8.5	0.775	109	8.5
Jackson	0.809	68	8.8	0.769	73	8.5	0.757	80	8.5	0.745	89	8.5	0.737	95	8.5	0.720	97	8.8
Jasper	0.782	66	8.1	0.743	65	7.4	0.736	73	7.4	0.719	78	7.4	0.715	84	7.4	0.700	87	8.1
Jeff Davis	0.821	35	9.6	0.865	63	10.8	0.853	69	10.8	0.802	65	10.8	0.818	77	10.8	0.832	93	9.6
Jefferson	0.799	74	9.2	0.733	65	7.5	0.727	74	7.5	0.730	86	7.5	0.710	87	7.5	0.687	84	9.2
Jim Hogg	0.831	73	9.4	0.813	82	9.4	0.786	87	9.4	0.780	98	9.4	0.756	99	9.4	0.750	104	9.4
Jim Wells	0.825	71	9.4	0.797	79	8.9	0.765	80	8.9	0.768	94	8.9	0.748	98	8.9	0.740	102	9.4
Johnson	0.789	52	8.1	0.779	67	8.6	0.773	77	8.6	0.776	90	8.6	0.771	99	8.6	0.763	106	8.1
Jones	0.780	41	8.5	0.771	55	9.0	0.794	73	9.0	0.780	82	9.0	0.803	102	9.0	0.784	104	8.5
Karnes	0.800	60	8.8	0.791	75	8.9	0.766	77	8.9	0.767	91	8.9	0.751	95	8.9	0.749	106	8.8
Kaufman	0.797	57	8.6	0.790	72	9.0	0.776	80	9.0	0.777	93	9.0	0.763	98	9.0	0.757	104	8.6
Kendall	0.791	53	8.6	0.771	64	8.3	0.773	74	8.3	0.764	84	8.3	0.762	94	8.3	0.763	104	8.6
Kenedy	0.826	73	9.2	0.793	79	8.7	0.771	84	8.7	0.763	94	8.7	0.735	96	8.7	0.731	100	9.2
Kent	0.801	43	9.0	0.801	60	10.0	0.796	70	10.0	0.806	85	10.0	0.799	93	10.0	0.798	104	9.0
Kerr	0.789	49	8.4	0.765	58	8.0	0.764	69	8.0	0.763	80	8.0	0.766	91	8.0	0.768	104	8.4
Kimble	0.775	42	8.2	0.758	53	7.6	0.763	66	7.6	0.757	75	7.6	0.772	88	7.6	0.768	100	8.2
King	0.804	45	9.4	0.794	59	9.6	0.804	74	9.6	0.802	87	9.6	0.811	103	9.6	0.802	111	9.4
Kinney	0.812	53	8.8	0.780	62	8.0	0.773	70	8.0	0.777	82	8.0	0.790	97	8.0	0.781	108	8.8
Kleberg	0.826	72	9.4	0.794	79	8.7	0.764	81	8.7	0.761	93	8.7	0.739	96	8.7	0.731	99	9.4
Knox	0.800	46	9.4	0.788	58	9.3	0.801	76	9.3	0.798	88	9.3	0.809	104	9.3	0.798	111	9.4
Lamar	0.783	53	8.2	0.777	66	8.9	0.770	74	8.9	0.769	87	8.9	0.759	93	8.9	0.752	98	8.2
Lamb	0.837	47	10.1	0.828	60	9.6	0.800	63	9.6	0.821	80	9.6	0.818	88	9.6	0.820	103	10.1

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TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$ (Continued)

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
Lampasas	0.787	49	7.8	0.770	63	8.4	0.770	73	8.4	0.771	86	8.4	0.762	94	8.4	0.759	103	7.8
LaSalle	0.820	64	9.5	0.801	77	9.4	0.795	86	9.4	0.776	91	9.4	0.767	99	9.4	0.767	110	9.5
Lavaca	0.810	66	8.7	0.782	74	8.5	0.757	78	8.5	0.750	89	8.5	0.741	95	8.5	0.732	100	8.7
Lee	0.803	63	8.2	0.782	73	8.3	0.764	77	8.3	0.761	89	8.3	0.745	94	8.3	0.743	101	8.2
Leon	0.804	64	8.2	0.788	76	8.8	0.766	80	8.8	0.762	92	8.8	0.746	95	8.8	0.735	97	8.2
Liberty	0.790	67	8.0	0.739	65	7.4	0.747	78	7.4	0.716	78	7.4	0.726	90	7.4	0.704	89	8.0
Limestone	0.802	61	8.2	0.792	74	8.8	0.772	79	8.8	0.772	92	8.8	0.753	93	8.8	0.748	102	8.2
Lipscomb	0.854	57	10.4	0.858	78	10.7	0.846	89	10.7	0.849	106	10.7	0.851	121	10.7	0.848	131	10.4
Live Oak	0.815	65	9.3	0.795	76	8.9	0.768	79	8.9	0.765	92	8.9	0.752	96	8.9	0.748	104	9.3
Llano	0.783	48	9.1	0.768	60	8.2	0.768	72	8.2	0.769	84	8.2	0.763	93	8.2	0.761	102	9.1
Loving	0.813	35	9.4	0.825	50	10.2	0.822	61	10.2	0.804	63	10.2	0.813	77	10.2	0.810	86	9.4
Lubbock	0.830	47	10.0	0.821	60	10.1	0.813	69	10.1	0.816	82	10.1	0.808	88	10.1	0.810	101	10.0
Lynn	0.825	46	9.8	0.821	59	10.3	0.813	69	10.3	0.815	81	10.3	0.802	87	10.3	0.802	96	9.8
Madison	0.804	65	8.0	0.785	76	8.7	0.765	81	8.7	0.751	90	8.7	0.755	100	8.7	0.729	96	8.0
Marion	0.769	51	8.8	0.770	67	8.4	0.750	71	8.4	0.746	79	8.4	0.736	83	8.4	0.734	90	8.8
Martin	0.818	44	9.9	0.813	57	10.4	0.820	70	10.4	0.796	74	10.4	0.797	85	10.4	0.791	92	9.9
Mason	0.778	44	8.2	0.766	56	7.9	0.760	68	7.9	0.770	81	7.9	0.769	91	7.9	0.763	101	8.2
Matagorda	0.804	70	8.4	0.757	71	8.5	0.759	83	8.5	0.737	87	8.5	0.727	94	8.5	0.710	92	8.4
Maverick	0.831	58	9.4	0.801	70	8.7	0.788	76	8.7	0.782	88	8.7	0.796	106	8.7	0.787	111	9.4
McCulloch	0.770	42	7.6	0.761	53	7.8	0.767	67	7.8	0.766	79	7.8	0.772	91	7.8	0.763	98	7.6
McLennan	0.799	57	8.0	0.787	71	8.7	0.777	78	8.7	0.774	91	8.7	0.757	94	8.7	0.753	103	8.0
McMullen	0.818	65	9.3	0.797	77	9.2	0.782	83	9.2	0.770	91	9.2	0.758	96	9.2	0.759	106	9.3
Medina	0.805	56	9.0	0.779	67	8.7	0.784	79	8.7	0.771	86	8.7	0.765	95	8.7	0.768	108	9.0
Menard	0.765	40	8.2	0.751	51	7.6	0.781	69	7.6	0.750	72	7.5	0.779	91	7.6	0.761	95	8.2
Midland	0.817	42	9.8	0.812	57	10.5	0.823	71	10.5	0.788	71	10.5	0.795	83	10.5	0.789	90	9.8
Milam	0.803	61	8.0	0.784	72	8.4	0.769	78	8.4	0.768	91	8.4	0.748	93	8.4	0.745	102	8.0
Mills	0.777	45	7.3	0.769	59	7.9	0.763	69	7.9	0.772	84	7.9	0.766	93	7.9	0.762	101	7.3
Mitchell	0.793	40	9.0	0.778	54	9.7	0.782	64	9.7	0.792	78	9.7	0.792	88	9.7	0.785	98	9.0
Montague	0.793	50	8.6	0.785	65	8.6	0.783	75	8.6	0.785	89	8.6	0.788	100	8.6	0.777	109	8.6
Montgomery	0.800	68	7.9	0.771	73	7.7	0.757	81	7.7	0.728	82	7.7	0.736	92	7.7	0.712	92	7.9
Moore	0.865	56	10.5	0.847	65	10.7	0.825	72	10.7	0.851	96	10.7	0.864	118	10.7	0.825	105	10.5
Morris	0.773	52	7.8	0.777	67	8.5	0.760	71	8.5	0.757	81	8.5	0.741	85	8.5	0.739	93	7.8
Motley	0.820	47	10.0	0.817	63	10.0	0.806	72	10.0	0.807	85	10.0	0.814	101	10.0	0.823	118	10.0
Nacogdoches	0.786	60	8.3	0.773	71	8.0	0.748	73	8.0	0.740	81	8.0	0.733	86	8.0	0.725	92	8.3
Navarro	0.801	59	8.5	0.795	75	8.9	0.776	80	8.9	0.777	94	8.9	0.757	95	8.9	0.753	104	8.5

TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$ (Continued)

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
Newton	0.780	66	8.0	0.741	65	7.4	0.734	71	7.4	0.718	76	7.4	0.709	82	7.4	0.700	85	8.0
Nolan	0.774	39	8.4	0.768	52	9.3	0.780	68	9.3	0.781	79	9.3	0.793	96	9.3	0.782	99	8.4
Nueces	0.824	71	9.4	0.794	79	8.7	0.762	79	8.7	0.759	91	8.7	0.741	96	8.7	0.730	99	9.4
Ochiltree	0.859	57	10.2	0.847	74	11.2	0.848	88	11.2	0.858	106	11.2	0.866	127	11.2	0.841	123	10.2
Oldham	0.851	50	10.8	0.844	64	9.6	0.804	62	9.6	0.833	84	9.6	0.850	103	9.6	0.830	107	10.8
Orange	0.799	74	9.1	0.733	65	7.5	0.728	73	7.5	0.730	85	7.5	0.709	87	7.5	0.688	84	9.1
Palo Pinto	0.784	47	8.2	0.775	61	8.4	0.781	74	8.4	0.781	87	8.4	0.778	96	8.4	0.770	105	8.2
Panola	0.778	55	8.4	0.773	70	8.3	0.743	70	8.3	0.741	79	8.3	0.724	81	8.3	0.729	90	8.4
Parker	0.785	48	8.0	0.777	63	8.4	0.781	76	8.4	0.781	88	8.4	0.777	99	8.4	0.769	107	8.0
Parmer	0.840	45	10.4	0.845	62	9.1	0.783	56	9.1	0.821	76	9.1	0.827	88	9.1	0.829	105	10.4
Pecos	0.822	41	9.5	0.819	56	9.7	0.811	64	9.7	0.786	69	9.7	0.806	84	9.7	0.809	93	9.5
Polk	0.789	64	7.8	0.761	69	7.5	0.748	75	7.5	0.718	76	7.5	0.730	88	7.5	0.711	91	7.8
Potter	0.857	54	10.6	0.817	58	10.2	0.818	70	10.2	0.841	93	10.2	0.855	112	10.2	0.826	109	10.6
Presidio	0.864	48	10.8	0.860	62	10.6	0.854	72	10.6	0.837	75	10.6	0.848	90	10.6	0.850	107	10.8
Rains	0.793	56	8.5	0.786	73	9.2	0.781	81	9.2	0.771	91	9.2	0.759	94	9.2	0.751	102	8.5
Randall	0.851	52	10.8	0.793	52	9.5	0.811	68	9.5	0.837	89	9.5	0.846	106	9.5	0.826	107	10.8
Reagan	0.795	38	8.6	0.800	58	9.9	0.802	67	9.9	0.785	74	9.9	0.781	82	9.9	0.779	89	8.6
Real	0.791	46	8.4	0.769	57	7.6	0.771	68	7.6	0.770	78	7.6	0.769	91	7.6	0.775	105	8.4
Red River	0.778	52	8.0	0.776	66	8.4	0.758	70	8.4	0.758	81	8.4	0.752	86	8.4	0.745	93	8.0
Reeves	0.815	35	9.0	0.846	57	10.5	0.834	65	10.5	0.793	62	10.5	0.810	77	10.5	0.816	87	9.0
Refugio	0.820	70	9.2	0.788	77	8.6	0.753	78	8.6	0.751	90	8.6	0.743	96	8.6	0.730	98	9.2
Roberts	0.853	56	10.4	0.848	72	11.2	0.845	87	11.2	0.849	103	11.2	0.856	121	11.2	0.842	124	10.4
Robertson	0.803	63	8.0	0.784	74	8.6	0.767	80	8.6	0.765	91	8.6	0.748	96	8.6	0.740	99	8.0
Rockwall	0.795	55	8.4	0.787	70	8.9	0.780	79	8.9	0.778	92	8.9	0.768	100	8.9	0.760	105	8.4
Runnels	0.756	36	7.8	0.756	50	8.5	0.778	67	8.5	0.767	76	8.5	0.792	96	8.5	0.774	98	7.8
Rusk	0.788	57	8.4	0.781	72	8.5	0.749	72	8.5	0.751	84	8.5	0.738	87	8.5	0.734	94	8.4
Sabine	0.775	59	7.9	0.758	66	7.6	0.740	71	7.6	0.721	75	7.6	0.715	80	7.6	0.712	87	7.9
San Augustine	0.778	60	7.9	0.758	67	7.6	0.741	72	7.6	0.725	76	7.6	0.719	82	7.6	0.715	88	7.9
San Jacinto	0.793	65	7.4	0.761	70	7.5	0.751	79	7.5	0.723	79	7.5	0.731	91	7.5	0.711	91	7.4
San Patricio	0.822	71	9.4	0.789	78	8.7	0.759	78	8.7	0.757	91	8.7	0.743	96	8.7	0.733	100	9.4
San Saba	0.775	45	7.7	0.767	59	8.0	0.762	69	8.0	0.771	83	8.0	0.767	92	8.0	0.762	101	7.7
Schleicher	0.770	38	7.8	0.771	53	8.6	0.772	63	8.6	0.769	74	8.6	0.771	86	8.6	0.764	90	7.8
Scurry	0.798	41	9.0	0.800	57	10.0	0.790	67	10.0	0.800	82	10.0	0.791	89	10.0	0.790	99	9.0
Shackelford	0.782	45	8.6	0.777	58	8.5	0.786	72	8.5	0.777	82	8.5	0.788	97	8.5	0.780	104	8.6
Shelby	0.778	57	8.2	0.768	68	8.0	0.742	71	8.0	0.737	78	8.0	0.717	80	8.0	0.721	89	8.2

TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$ (Continued)

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
Sherman	0.868	56	10.6	0.857	71	10.9	0.836	77	10.9	0.859	101	10.9	0.870	120	10.9	0.830	109	10.6
Smith	0.792	58	8.4	0.787	74	8.8	0.760	76	8.8	0.760	87	8.8	0.746	90	8.8	0.740	98	8.4
Somervell	0.781	49	7.6	0.771	63	8.4	0.770	73	8.4	0.782	90	8.4	0.770	97	8.4	0.762	104	7.6
Starr	0.831	73	9.6	0.805	82	9.4	0.791	89	9.4	0.780	99	9.4	0.758	100	9.4	0.750	105	9.6
Stephens	0.786	47	8.4	0.775	59	8.1	0.782	72	8.1	0.776	83	8.1	0.781	94	8.1	0.774	105	8.4
Sterling	0.790	39	8.7	0.779	53	9.6	0.780	62	9.6	0.788	76	9.6	0.783	85	9.6	0.783	95	8.7
Stonewall	0.794	43	9.0	0.790	59	9.5	0.801	74	9.5	0.797	85	9.5	0.806	100	9.5	0.792	106	9.0
Sutton	0.775	40	7.7	0.760	51	8.1	0.764	61	8.1	0.765	73	8.1	0.772	85	8.1	0.764	90	7.7
Swisher	0.841	50	10.6	0.808	58	10.0	0.807	69	10.0	0.826	87	10.0	0.822	98	10.0	0.826	106	10.6
Tarrant	0.788	51	8.0	0.778	66	8.5	0.777	77	8.5	0.774	88	8.5	0.775	101	8.5	0.767	106	8.0
Taylor	0.761	39	8.2	0.760	52	8.7	0.781	69	8.7	0.776	80	8.7	0.796	100	8.7	0.778	100	8.2
Terrel	0.808	43	8.8	0.793	54	9.0	0.800	67	9.0	0.793	76	9.0	0.806	91	9.0	0.805	104	8.8
Terry	0.828	45	10.0	0.828	59	10.0	0.806	65	10.0	0.809	77	10.0	0.806	86	10.0	0.812	97	10.0
Throckmorton	0.791	47	9.1	0.779	59	8.6	0.792	74	8.6	0.783	84	8.6	0.795	98	8.6	0.783	107	9.1
Titus	0.779	52	8.0	0.780	69	8.6	0.759	72	8.6	0.758	82	8.6	0.744	87	8.6	0.741	94	8.4
Tom Green	0.768	37	7.9	0.769	51	9.0	0.777	64	9.0	0.771	75	9.0	0.782	88	9.0	0.770	95	7.9
Travis	0.796	56	8.1	0.780	69	8.6	0.775	77	8.6	0.766	87	8.6	0.751	91	8.6	0.752	103	8.1
Trinity	0.791	63	7.8	0.764	71	7.7	0.750	76	7.7	0.729	80	7.7	0.734	90	7.7	0.716	91	7.8
Tyler	0.782	65	8.0	0.750	66	7.4	0.740	74	7.4	0.716	77	7.4	0.721	86	7.4	0.709	89	8.0
Upshur	0.781	54	8.1	0.782	71	8.7	0.760	74	8.7	0.757	84	8.7	0.742	87	8.7	0.738	94	8.1
Upton	0.810	39	9.1	0.808	56	10.0	0.824	71	10.0	0.788	72	10.0	0.793	82	10.0	0.787	89	9.1
Uvalde	0.810	54	9.0	0.779	64	8.2	0.779	73	8.2	0.772	83	8.2	0.773	95	8.2	0.778	107	9.0
Val Verde	0.794	45	8.0	0.767	52	8.0	0.767	61	8.0	0.780	76	8.0	0.794	92	8.0	0.780	99	8.0
Van Zandt	0.795	58	8.6	0.792	74	9.1	0.775	79	9.1	0.772	91	9.1	0.755	93	9.1	0.750	102	8.6
Victoria	0.815	68	9.0	0.782	75	8.6	0.755	78	8.6	0.752	90	8.6	0.745	97	8.6	0.730	99	9.0
Walker	0.800	66	8.0	0.778	73	8.0	0.759	80	8.0	0.739	84	8.0	0.740	94	8.0	0.720	93	8.0
Waller	0.809	70	8.0	0.785	77	8.1	0.757	80	8.1	0.736	84	8.1	0.729	91	8.1	0.714	92	8.0
Ward	0.815	37	9.5	0.833	56	10.5	0.810	61	10.5	0.789	65	10.5	0.808	81	10.5	0.807	90	9.5
Washington	0.809	67	8.0	0.784	75	8.2	0.759	79	8.2	0.747	87	8.2	0.740	94	8.2	0.728	95	8.0
Webb	0.830	66	9.6	0.812	81	9.6	0.801	90	9.6	0.781	95	9.6	0.781	103	9.6	0.770	110	9.6
Wharton	0.808	69	8.2	0.767	72	8.3	0.758	81	8.3	0.738	86	8.3	0.733	93	8.3	0.715	94	8.2
Wheeler	0.838	54	10.8	0.832	71	10.6	0.832	85	10.6	0.836	103	10.6	0.833	114	10.6	0.843	135	10.8
Wichita	0.803	51	9.4	0.784	62	8.7	0.795	76	8.7	0.792	88	8.7	0.797	104	8.7	0.792	114	9.4
Wilbarger	0.804	50	9.8	0.782	60	9.0	0.797	77	9.0	0.799	90	9.0	0.807	107	9.0	0.800	116	9.8
Willacy	0.826	73	9.3	0.790	78	8.8	0.777	87	8.8	0.762	95	8.8	0.732	95	8.8	0.732	102	9.3

TABLE 6. CONSTANTS FOR USE IN FORMULA $I = b/(t_c+d)^e$ (Continued)

COUNTY	2 year			5 year			10 year			25 year			50 year			100 year		
	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d
Williamson	0.798	56	8.0	0.779	68	8.5	0.777	77	8.5	0.769	88	8.5	0.751	92	8.5	0.751	103	8.0
Wilson	0.794	57	8.7	0.792	74	8.9	0.769	78	8.9	0.768	90	8.9	0.752	95	8.9	0.755	108	8.7
Winkler	0.809	37	9.4	0.829	56	10.4	0.811	61	10.4	0.790	66	10.4	0.817	83	10.4	0.808	90	9.4
Wise	0.789	49	8.2	0.778	65	8.6	0.782	77	8.6	0.782	89	8.6	0.781	100	8.6	0.773	108	8.2
Wood	0.789	55	8.3	0.787	73	8.9	0.770	78	8.9	0.761	87	8.9	0.753	92	8.9	0.745	98	8.3
Yoakum	0.821	41	9.8	0.841	59	9.6	0.798	59	9.6	0.797	69	9.6	0.812	82	9.6	0.823	100	9.8
Young	0.790	47	8.8	0.779	61	8.4	0.786	74	8.4	0.781	85	8.4	0.787	97	8.4	0.779	107	8.8
Zapata	0.832	71	9.0	0.815	84	9.6	0.795	91	9.6	0.785	99	9.6	0.763	100	9.6	0.760	108	9.0
Zavala	0.820	58	9.4	0.794	69	8.9	0.785	77	8.9	0.779	89	8.9	0.778	98	8.9	0.778	110	9.4

11 Appendix – IV: Revised 2015 DDF Values

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI)

[COUNTY, Texas county; T_c, Design storm duration for given ARI in minutes; D_{t-yr}, Design storm depth for given ARI in inches. 60 min. = 1 hrs.; 120 min. = 2 hrs.; 180 min. = 3 hrs.; 360 min. = 6 hrs.; 720 min. = 12 hrs.; 1440 min. = 24 hrs.]

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
ANDERSON	15	1.01	1.3	1.53	1.87	2.18	2.5
ANDERSON	30	1.4	1.82	2.14	2.62	3.05	3.49
ANDERSON	60	1.79	2.35	2.78	3.4	3.96	4.55
ANDERSON	120	2.18	2.89	3.44	4.2	4.9	5.66
ANDERSON	180	2.4	3.21	3.83	4.68	5.46	6.33
ANDERSON	360	2.8	3.77	4.54	5.54	6.47	7.57
ANDERSON	720	3.23	4.38	5.32	6.48	7.59	8.95
ANDERSON	1440	3.7	5.05	6.2	7.55	8.85	10.52
ANDREWS	15	.71	0.98	1.18	1.43	1.7	1.98
ANDREWS	30	0.93	1.3	1.58	1.94	2.3	2.68
ANDREWS	60	1.14	1.61	1.96	2.44	2.9	3.38
ANDREWS	120	1.34	1.89	2.32	2.91	3.47	4.05
ANDREWS	180	1.45	2.05	2.53	3.18	3.8	4.44
ANDREWS	360	1.64	2.32	2.89	3.64	4.37	5.11
ANDREWS	720	1.84	2.61	3.28	4.13	4.98	5.83
ANDREWS	1440	2.06	2.92	3.69	4.65	5.63	6.61
ANGELINA	15	1.03	1.35	1.55	1.81	2.06	2.3
ANGELINA	30	1.45	1.89	2.21	2.61	3.01	3.41
ANGELINA	60	1.87	2.45	2.91	3.48	4.05	4.66
ANGELINA	120	2.3	3.03	3.62	4.37	5.13	5.98
ANGELINA	180	2.54	3.38	4.04	4.91	5.78	6.78
ANGELINA	360	2.97	4.	4.81	5.89	6.96	8.25
ANGELINA	720	3.43	4.69	5.64	6.97	8.24	9.87
ANGELINA	1440	3.93	5.45	6.58	8.19	9.7	11.73
ARANSAS	15	1.12	1.42	1.64	1.87	2.1	2.33
ARANSAS	30	1.52	1.95	2.28	2.64	3.01	3.39
ARANSAS	60	1.95	2.52	2.99	3.51	4.05	4.61
ARANSAS	120	2.38	3.13	3.76	4.48	5.22	5.98
ARANSAS	180	2.65	3.52	4.25	5.1	5.98	6.87
ARANSAS	360	3.14	4.26	5.18	6.3	7.45	8.59
ARANSAS	720	3.7	5.1	6.26	7.72	9.18	10.61

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
ARANSAS	1440	4.33	6.09	7.54	9.42	11.26	13.04
ARCHER	15	0.84	1.1	1.27	1.47	1.67	1.88
ARCHER	30	1.13	1.51	1.79	2.12	2.45	2.8
ARCHER	60	1.43	1.94	2.34	2.82	3.3	3.81
ARCHER	120	1.74	2.38	2.89	3.52	4.16	4.84
ARCHER	180	1.93	2.64	3.21	3.94	4.65	5.44
ARCHER	360	2.28	3.11	3.78	4.67	5.52	6.47
ARCHER	720	2.66	3.62	4.39	5.46	6.44	7.56
ARCHER	1440	3.11	4.2	5.06	6.32	7.44	8.74
ARMSTRONG	15	0.75	1.02	1.21	1.5	1.72	1.99
ARMSTRONG	30	1.	1.38	1.65	2.08	2.41	2.81
ARMSTRONG	60	1.23	1.73	2.08	2.65	3.1	3.64
ARMSTRONG	120	1.45	2.06	2.5	3.18	3.75	4.41
ARMSTRONG	180	1.58	2.24	2.74	3.47	4.11	4.84
ARMSTRONG	360	1.79	2.56	3.16	3.96	4.72	5.55
ARMSTRONG	720	2.01	2.88	3.6	4.45	5.34	6.26
ARMSTRONG	1440	2.24	3.23	4.08	4.97	6.01	7.01
ATASCOSA	15	1.09	1.41	1.66	1.98	2.27	2.55
ATASCOSA	30	1.45	1.92	2.29	2.76	3.17	3.6
ATASCOSA	60	1.81	2.42	2.92	3.55	4.11	4.72
ATASCOSA	120	2.14	2.91	3.55	4.34	5.06	5.83
ATASCOSA	180	2.33	3.2	3.92	4.81	5.62	6.49
ATASCOSA	360	2.65	3.71	4.57	5.65	6.63	7.66
ATASCOSA	720	2.99	4.26	5.27	6.55	7.72	8.93
ATASCOSA	1440	3.36	4.87	6.05	7.56	8.96	10.36
AUSTIN	15	1.06	1.35	1.59	1.82	2.03	2.28
AUSTIN	30	1.46	1.86	2.2	2.58	2.92	3.32
AUSTIN	60	1.85	2.4	2.86	3.4	3.91	4.51
AUSTIN	120	2.24	2.95	3.54	4.28	4.98	5.79
AUSTIN	180	2.46	3.28	3.96	4.82	5.65	6.6
AUSTIN	360	2.85	3.89	4.73	5.82	6.89	8.11
AUSTIN	720	3.27	4.56	5.61	6.95	8.31	9.86
AUSTIN	1440	3.72	5.32	6.61	8.26	9.98	11.92
BAILEY	15	0.7	0.97	1.17	1.46	1.7	1.97
BAILEY	30	0.92	1.29	1.57	1.98	2.32	2.71
BAILEY	60	1.12	1.6	1.94	2.47	2.91	3.42
BAILEY	120	1.3	1.88	2.28	2.91	3.44	4.05

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
BAILEY	180	1.41	2.04	2.47	3.14	3.72	4.38
BAILEY	360	1.58	2.3	2.78	3.52	4.18	4.93
BAILEY	720	1.76	2.57	3.08	3.89	4.63	5.45
BAILEY	1440	1.96	2.85	3.4	4.26	5.09	5.99
BANDERA	15	1.04	1.32	1.55	1.84	2.13	2.39
BANDERA	30	1.42	1.85	2.21	2.64	3.06	3.46
BANDERA	60	1.82	2.42	2.92	3.5	4.07	4.63
BANDERA	120	2.2	2.98	3.63	4.4	5.13	5.86
BANDERA	180	2.43	3.32	4.05	4.93	5.78	6.6
BANDERA	360	2.84	3.93	4.8	5.9	6.95	7.94
BANDERA	720	3.28	4.58	5.61	6.97	8.26	9.43
BANDERA	1440	3.77	5.32	6.52	8.19	9.77	11.14
BASTROP	15	1.	1.33	1.57	1.89	2.19	2.5
BASTROP	30	1.4	1.85	2.18	2.63	3.05	3.51
BASTROP	60	1.8	2.37	2.8	3.4	3.97	4.58
BASTROP	120	2.17	2.89	3.42	4.18	4.89	5.68
BASTROP	180	2.39	3.2	3.79	4.64	5.45	6.34
BASTROP	360	2.75	3.73	4.45	5.49	6.45	7.52
BASTROP	720	3.13	4.31	5.17	6.42	7.55	8.84
BASTROP	1440	3.54	4.94	5.96	7.46	8.8	10.33
BAYLOR	15	0.83	1.06	1.21	1.41	1.61	1.83
BAYLOR	30	1.1	1.46	1.71	2.03	2.35	2.73
BAYLOR	60	1.38	1.87	2.24	2.7	3.16	3.74
BAYLOR	120	1.67	2.3	2.79	3.39	3.99	4.78
BAYLOR	180	1.85	2.56	3.12	3.8	4.49	5.4
BAYLOR	360	2.18	3.03	3.72	4.53	5.37	6.48
BAYLOR	720	2.55	3.56	4.38	5.32	6.32	7.64
BAYLOR	1440	2.98	4.15	5.12	6.2	7.38	8.91
BEE	15	1.1	1.41	1.61	1.88	2.1	2.32
BEE	30	1.47	1.93	2.23	2.64	2.98	3.33
BEE	60	1.84	2.44	2.87	3.43	3.92	4.42
BEE	120	2.19	2.94	3.5	4.21	4.86	5.52
BEE	180	2.38	3.22	3.87	4.67	5.43	6.18
BEE	360	2.72	3.71	4.51	5.48	6.42	7.35
BEE	720	3.08	4.23	5.2	6.35	7.5	8.63
BEE	1440	3.46	4.79	5.96	7.31	8.72	10.06
BELL	15	0.89	1.17	1.35	1.6	1.81	2.08

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
BELL	30	1.26	1.66	1.94	2.32	2.64	3.05
BELL	60	1.64	2.16	2.55	3.1	3.54	4.13
BELL	120	2.	2.66	3.16	3.88	4.47	5.25
BELL	180	2.2	2.95	3.53	4.34	5.02	5.91
BELL	360	2.54	3.46	4.16	5.15	5.99	7.08
BELL	720	2.9	3.99	4.85	6.01	7.05	8.36
BELL	1440	3.27	4.58	5.6	6.97	8.24	9.8
BEXAR	15	1.07	1.41	1.65	1.95	2.25	2.54
BEXAR	30	1.46	1.92	2.27	2.7	3.12	3.54
BEXAR	60	1.84	2.44	2.9	3.47	4.04	4.61
BEXAR	120	2.2	2.96	3.54	4.27	4.98	5.7
BEXAR	180	2.41	3.27	3.92	4.75	5.54	6.37
BEXAR	360	2.78	3.82	4.59	5.62	6.57	7.58
BEXAR	720	3.16	4.42	5.32	6.6	7.71	8.94
BEXAR	1440	3.58	5.1	6.14	7.71	9.02	10.5
BLANCO	15	0.96	1.22	1.41	1.66	1.9	2.11
BLANCO	30	1.31	1.68	1.97	2.35	2.71	3.06
BLANCO	60	1.68	2.16	2.56	3.09	3.6	4.1
BLANCO	120	2.04	2.65	3.17	3.84	4.52	5.19
BLANCO	180	2.25	2.95	3.53	4.3	5.09	5.85
BLANCO	360	2.64	3.49	4.19	5.11	6.11	7.04
BLANCO	720	3.06	4.09	4.92	6.01	7.25	8.36
BLANCO	1440	3.53	4.78	5.74	7.03	8.56	9.86
BORDEN	15	0.7	0.95	1.12	1.36	1.56	1.78
BORDEN	30	0.96	1.3	1.55	1.89	2.2	2.54
BORDEN	60	1.21	1.66	1.99	2.44	2.86	3.33
BORDEN	120	1.46	2.01	2.42	3.	3.51	4.11
BORDEN	180	1.6	2.22	2.68	3.33	3.89	4.57
BORDEN	360	1.85	2.6	3.13	3.92	4.56	5.35
BORDEN	720	2.12	3.	3.61	4.56	5.27	6.18
BORDEN	1440	2.42	3.46	4.15	5.27	6.05	7.08
BOSQUE	15	0.91	1.21	1.42	1.66	1.9	2.17
BOSQUE	30	1.25	1.66	1.96	2.3	2.65	3.05
BOSQUE	60	1.6	2.13	2.53	2.98	3.45	3.97
BOSQUE	120	1.94	2.59	3.1	3.67	4.26	4.92
BOSQUE	180	2.14	2.88	3.44	4.09	4.76	5.5
BOSQUE	360	2.5	3.38	4.04	4.86	5.66	6.54

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
BOSQUE	720	2.88	3.93	4.71	5.7	6.65	7.7
BOSQUE	1440	3.31	4.54	5.44	6.66	7.78	9.01
BOWIE	15	0.96	1.22	1.44	1.67	1.92	2.18
BOWIE	30	1.33	1.7	2.	2.3	2.64	3.01
BOWIE	60	1.73	2.2	2.6	2.99	3.43	3.92
BOWIE	120	2.15	2.74	3.25	3.75	4.31	4.91
BOWIE	180	2.4	3.07	3.66	4.24	4.87	5.55
BOWIE	360	2.86	3.69	4.42	5.17	5.95	6.77
BOWIE	720	3.37	4.4	5.29	6.26	7.22	8.19
BOWIE	1440	3.95	5.21	6.31	7.55	8.73	9.87
BRAZORIA	15	1.14	1.47	1.7	1.97	2.2	2.47
BRAZORIA	30	1.58	2.06	2.39	2.81	3.18	3.61
BRAZORIA	60	2.05	2.69	3.14	3.73	4.28	4.9
BRAZORIA	120	2.53	3.35	3.93	4.71	5.46	6.3
BRAZORIA	180	2.82	3.76	4.42	5.32	6.2	7.18
BRAZORIA	360	3.34	4.51	5.34	6.44	7.56	8.81
BRAZORIA	720	3.92	5.34	6.38	7.71	9.09	10.66
BRAZORIA	1440	4.57	6.3	7.58	9.18	10.87	12.83
BRAZOS	15	1.	1.32	1.55	1.87	2.17	2.49
BRAZOS	30	1.38	1.83	2.16	2.61	3.07	3.54
BRAZOS	60	1.76	2.35	2.79	3.39	4.	4.65
BRAZOS	120	2.13	2.87	3.42	4.18	4.95	5.77
BRAZOS	180	2.34	3.17	3.79	4.65	5.5	6.44
BRAZOS	360	2.72	3.7	4.45	5.48	6.49	7.63
BRAZOS	720	3.11	4.28	5.17	6.39	7.55	8.91
BRAZOS	1440	3.54	4.91	5.97	7.41	8.73	10.35
BREWSTER	15	0.82	1.06	1.17	1.42	1.58	1.73
BREWSTER	30	1.03	1.36	1.51	1.87	2.1	2.31
BREWSTER	60	1.19	1.6	1.81	2.25	2.56	2.84
BREWSTER	120	1.31	1.78	2.08	2.56	2.94	3.28
BREWSTER	180	1.36	1.86	2.23	2.71	3.12	3.5
BREWSTER	360	1.42	1.98	2.48	2.93	3.4	3.84
BREWSTER	720	1.47	2.08	2.74	3.14	3.65	4.16
BREWSTER	1440	1.52	2.18	3.01	3.33	3.89	4.47
BRISCOE	15	0.76	1.02	1.22	1.45	1.67	1.92
BRISCOE	30	1.01	1.39	1.67	2.04	2.39	2.76
BRISCOE	60	1.25	1.75	2.12	2.63	3.12	3.63

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
BRISCOE	120	1.48	2.09	2.55	3.19	3.82	4.46
BRISCOE	180	1.61	2.28	2.8	3.49	4.2	4.91
BRISCOE	360	1.85	2.61	3.23	3.99	4.84	5.67
BRISCOE	720	2.09	2.94	3.67	4.5	5.48	6.42
BRISCOE	1440	2.35	3.3	4.16	5.02	6.15	7.21
BROOKS	15	0.95	1.27	1.48	1.75	2.02	2.29
BROOKS	30	1.35	1.82	2.13	2.53	2.96	3.38
BROOKS	60	1.75	2.37	2.79	3.34	3.94	4.52
BROOKS	120	2.09	2.87	3.4	4.1	4.87	5.61
BROOKS	180	2.27	3.13	3.72	4.51	5.38	6.21
BROOKS	360	2.55	3.56	4.25	5.19	6.21	7.19
BROOKS	720	2.8	3.97	4.77	5.84	7.01	8.14
BROOKS	1440	3.05	4.38	5.29	6.52	7.84	9.12
BROWN	15	0.82	1.09	1.27	1.52	1.71	1.95
BROWN	30	1.13	1.51	1.77	2.1	2.38	2.75
BROWN	60	1.44	1.93	2.28	2.71	3.09	3.6
BROWN	120	1.74	2.34	2.79	3.34	3.84	4.5
BROWN	180	1.9	2.58	3.09	3.73	4.29	5.05
BROWN	360	2.19	3.	3.62	4.42	5.12	6.05
BROWN	720	2.48	3.44	4.19	5.2	6.05	7.18
BROWN	1440	2.8	3.93	4.82	6.08	7.12	8.47
BURLESON	15	0.98	1.29	1.52	1.8	2.11	2.4
BURLESON	30	1.36	1.79	2.12	2.53	2.98	3.42
BURLESON	60	1.75	2.31	2.74	3.31	3.92	4.52
BURLESON	120	2.12	2.84	3.38	4.13	4.9	5.68
BURLESON	180	2.34	3.15	3.77	4.62	5.5	6.38
BURLESON	360	2.71	3.71	4.46	5.53	6.59	7.67
BURLESON	720	3.1	4.32	5.23	6.55	7.8	9.1
BURLESON	1440	3.52	4.99	6.1	7.73	9.2	10.75
BURNET	15	0.93	1.19	1.37	1.6	1.83	2.04
BURNET	30	1.24	1.62	1.9	2.25	2.57	2.92
BURNET	60	1.55	2.06	2.44	2.92	3.38	3.88
BURNET	120	1.86	2.48	2.99	3.61	4.22	4.9
BURNET	180	2.04	2.73	3.31	4.02	4.73	5.52
BURNET	360	2.37	3.18	3.89	4.76	5.67	6.66
BURNET	720	2.71	3.66	4.52	5.58	6.72	7.95
BURNET	1440	3.09	4.18	5.21	6.5	7.94	9.44

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
CALDWELL	15	1.04	1.37	1.6	1.93	2.24	2.58
CALDWELL	30	1.42	1.87	2.21	2.68	3.1	3.58
CALDWELL	60	1.81	2.39	2.82	3.44	3.99	4.61
CALDWELL	120	2.19	2.9	3.44	4.19	4.88	5.65
CALDWELL	180	2.41	3.2	3.8	4.64	5.41	6.26
CALDWELL	360	2.79	3.74	4.45	5.44	6.35	7.35
CALDWELL	720	3.19	4.33	5.15	6.31	7.37	8.54
CALDWELL	1440	3.63	4.99	5.93	7.28	8.51	9.86
CALHOUN	15	1.15	1.47	1.69	1.98	2.22	2.47
CALHOUN	30	1.6	2.06	2.39	2.81	3.2	3.58
CALHOUN	60	2.07	2.68	3.13	3.71	4.27	4.8
CALHOUN	120	2.53	3.32	3.9	4.66	5.39	6.1
CALHOUN	180	2.81	3.7	4.36	5.24	6.07	6.89
CALHOUN	360	3.29	4.39	5.22	6.3	7.31	8.36
CALHOUN	720	3.82	5.15	6.17	7.5	8.7	10.02
CALHOUN	1440	4.4	6.02	7.26	8.88	10.29	11.94
CALLAHAN	15	0.83	1.09	1.29	1.53	1.72	1.96
CALLAHAN	30	1.14	1.51	1.79	2.13	2.43	2.77
CALLAHAN	60	1.45	1.94	2.31	2.76	3.18	3.65
CALLAHAN	120	1.75	2.36	2.84	3.41	3.96	4.55
CALLAHAN	180	1.92	2.61	3.15	3.81	4.44	5.11
CALLAHAN	360	2.23	3.04	3.7	4.53	5.31	6.11
CALLAHAN	720	2.55	3.51	4.29	5.34	6.28	7.23
CALLAHAN	1440	2.91	4.02	4.96	6.25	7.39	8.51
CAMERON	15	1.07	1.4	1.61	1.88	2.13	2.37
CAMERON	30	1.51	1.98	2.3	2.71	3.09	3.49
CAMERON	60	1.94	2.55	3.	3.57	4.08	4.7
CAMERON	120	2.33	3.09	3.65	4.39	5.05	5.87
CAMERON	180	2.55	3.38	4.01	4.84	5.59	6.54
CAMERON	360	2.9	3.87	4.6	5.59	6.52	7.67
CAMERON	720	3.24	4.37	5.2	6.35	7.48	8.82
CAMERON	1440	3.6	4.88	5.82	7.14	8.5	10.05
CAMP	15	0.95	1.23	1.44	1.72	1.97	2.22
CAMP	30	1.34	1.71	2.01	2.38	2.72	3.05
CAMP	60	1.74	2.22	2.61	3.1	3.54	3.97
CAMP	120	2.15	2.76	3.26	3.88	4.43	4.97
CAMP	180	2.39	3.09	3.66	4.36	4.99	5.62

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
CAMP	360	2.83	3.69	4.42	5.28	6.06	6.84
CAMP	720	3.31	4.36	5.28	6.34	7.31	8.27
CAMP	1440	3.85	5.13	6.28	7.58	8.77	9.97
CARSON	15	0.75	1.04	1.25	1.56	1.83	2.15
CARSON	30	0.99	1.39	1.67	2.11	2.47	2.93
CARSON	60	1.21	1.72	2.08	2.63	3.1	3.67
CARSON	120	1.43	2.03	2.47	3.12	3.69	4.35
CARSON	180	1.55	2.2	2.69	3.39	4.03	4.72
CARSON	360	1.76	2.49	3.08	3.84	4.61	5.34
CARSON	720	1.98	2.79	3.5	4.3	5.22	5.97
CARSON	1440	2.21	3.11	3.95	4.79	5.88	6.63
CASS	15	0.93	1.19	1.38	1.63	1.89	2.16
CASS	30	1.32	1.69	1.95	2.31	2.66	3.03
CASS	60	1.73	2.22	2.58	3.05	3.52	4.01
CASS	120	2.15	2.78	3.26	3.87	4.46	5.1
CASS	180	2.4	3.11	3.68	4.38	5.06	5.79
CASS	360	2.84	3.72	4.47	5.34	6.19	7.12
CASS	720	3.31	4.4	5.38	6.45	7.51	8.68
CASS	1440	3.84	5.17	6.44	7.76	9.07	10.54
CASTRO	15	0.71	0.99	1.18	1.46	1.7	1.98
CASTRO	30	0.94	1.33	1.59	2.	2.35	2.76
CASTRO	60	1.16	1.65	1.98	2.52	2.98	3.53
CASTRO	120	1.37	1.95	2.35	2.99	3.56	4.21
CASTRO	180	1.48	2.12	2.56	3.26	3.88	4.58
CASTRO	360	1.68	2.41	2.91	3.7	4.4	5.17
CASTRO	720	1.89	2.71	3.27	4.15	4.91	5.75
CASTRO	1440	2.11	3.02	3.65	4.62	5.45	6.35
CHAMBERS	15	1.11	1.36	1.53	1.74	1.95	2.22
CHAMBERS	30	1.57	1.96	2.24	2.6	2.94	3.37
CHAMBERS	60	2.06	2.64	3.07	3.62	4.14	4.8
CHAMBERS	120	2.57	3.39	4.	4.79	5.54	6.49
CHAMBERS	180	2.89	3.87	4.6	5.54	6.45	7.6
CHAMBERS	360	3.48	4.77	5.74	7.01	8.23	9.79
CHAMBERS	720	4.15	5.81	7.09	8.75	10.36	12.45
CHAMBERS	1440	4.92	7.05	8.7	10.86	12.97	15.74
CHEROKEE	15	1.00	1.31	1.54	1.85	2.15	2.44
CHEROKEE	30	1.39	1.82	2.15	2.6	3.03	3.45

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
CHEROKEE	60	1.78	2.35	2.79	3.4	3.96	4.55
CHEROKEE	120	2.18	2.89	3.46	4.21	4.93	5.68
CHEROKEE	180	2.41	3.22	3.86	4.71	5.51	6.38
CHEROKEE	360	2.81	3.8	4.59	5.6	6.57	7.64
CHEROKEE	720	3.25	4.45	5.39	6.58	7.75	9.06
CHEROKEE	1440	3.73	5.17	6.3	7.69	9.08	10.68
CHILDRESS	15	0.79	1.07	1.27	1.56	1.77	1.99
CHILDRESS	30	1.04	1.44	1.72	2.17	2.52	2.89
CHILDRESS	60	1.29	1.81	2.19	2.79	3.29	3.84
CHILDRESS	120	1.55	2.17	2.66	3.4	4.05	4.75
CHILDRESS	180	1.71	2.39	2.94	3.75	4.48	5.27
CHILDRESS	360	1.99	2.78	3.44	4.35	5.22	6.12
CHILDRESS	720	2.31	3.21	4.00	4.99	5.99	6.98
CHILDRESS	1440	2.67	3.68	4.61	5.68	6.83	7.88
CLAY	15	0.86	1.13	1.33	1.56	1.79	2.04
CLAY	30	1.15	1.54	1.83	2.19	2.53	2.91
CLAY	60	1.46	1.97	2.36	2.85	3.33	3.86
CLAY	120	1.78	2.41	2.91	3.55	4.16	4.83
CLAY	180	1.98	2.69	3.24	3.97	4.65	5.42
CLAY	360	2.34	3.18	3.84	4.73	5.55	6.49
CLAY	720	2.74	3.74	4.52	5.58	6.53	7.67
CLAY	1440	3.2	4.37	5.28	6.55	7.64	8.99
COCHRAN	15	0.69	0.97	1.17	1.48	1.71	2.01
COCHRAN	30	0.91	1.3	1.57	1.98	2.32	2.72
COCHRAN	60	1.12	1.6	1.95	2.47	2.89	3.4
COCHRAN	120	1.31	1.88	2.3	2.91	3.43	4.03
COCHRAN	180	1.41	2.04	2.48	3.15	3.72	4.39
COCHRAN	360	1.59	2.31	2.8	3.56	4.22	5.00
COCHRAN	720	1.77	2.59	3.11	3.98	4.74	5.64
COCHRAN	1440	1.96	2.88	3.44	4.42	5.28	6.31
COKE	15	0.76	1.00	1.16	1.34	1.5	1.67
COKE	30	1.03	1.37	1.61	1.91	2.17	2.44
COKE	60	1.29	1.75	2.08	2.5	2.88	3.27
COKE	120	1.55	2.12	2.55	3.09	3.59	4.13
COKE	180	1.7	2.33	2.82	3.43	4.01	4.63
COKE	360	1.97	2.71	3.32	4.03	4.75	5.52
COKE	720	2.26	3.11	3.85	4.66	5.54	6.48

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
COKE	1440	2.57	3.55	4.45	5.36	6.41	7.54
COLEMAN	15	0.82	1.09	1.3	1.55	1.78	2.01
COLEMAN	30	1.11	1.5	1.77	2.13	2.48	2.82
COLEMAN	60	1.41	1.9	2.25	2.73	3.21	3.66
COLEMAN	120	1.69	2.3	2.74	3.34	3.93	4.5
COLEMAN	180	1.85	2.53	3.02	3.7	4.35	5.00
COLEMAN	360	2.13	2.94	3.54	4.35	5.11	5.88
COLEMAN	720	2.43	3.38	4.1	5.06	5.92	6.84
COLEMAN	1440	2.74	3.87	4.73	5.85	6.82	7.91
COLLIN	15	0.95	1.22	1.46	1.7	1.95	2.2
COLLIN	30	1.31	1.68	1.98	2.32	2.62	2.98
COLLIN	60	1.68	2.15	2.54	2.97	3.37	3.84
COLLIN	120	2.06	2.64	3.13	3.68	4.19	4.78
COLLIN	180	2.29	2.95	3.49	4.12	4.72	5.38
COLLIN	360	2.71	3.51	4.18	4.95	5.72	6.52
COLLIN	720	3.17	4.14	4.96	5.9	6.89	7.85
COLLIN	1440	3.69	4.86	5.86	7.00	8.28	9.43
COLLINGSWORTH	15	0.79	1.08	1.3	1.59	1.84	2.11
COLLINGSWORTH	30	1.04	1.44	1.74	2.18	2.55	2.98
COLLINGSWORTH	60	1.29	1.8	2.19	2.78	3.27	3.87
COLLINGSWORTH	120	1.55	2.17	2.64	3.38	4.00	4.72
COLLINGSWORTH	180	1.7	2.39	2.92	3.73	4.43	5.21
COLLINGSWORTH	360	1.98	2.78	3.42	4.35	5.19	6.05
COLLINGSWORTH	720	2.29	3.21	3.96	5.02	6.02	6.92
COLLINGSWORTH	1440	2.63	3.7	4.58	5.76	6.96	7.86
COLORADO	15	1.09	1.43	1.67	1.94	2.22	2.52
COLORADO	30	1.5	1.97	2.3	2.71	3.14	3.59
COLORADO	60	1.91	2.5	2.95	3.52	4.1	4.73
COLORADO	120	2.31	3.04	3.59	4.34	5.09	5.91
COLORADO	180	2.53	3.35	3.98	4.83	5.67	6.61
COLORADO	360	2.92	3.9	4.67	5.72	6.72	7.89
COLORADO	720	3.33	4.49	5.42	6.7	7.87	9.3
COLORADO	1440	3.78	5.14	6.25	7.8	9.15	10.89
COMAL	15	1.02	1.31	1.52	1.8	2.08	2.33
COMAL	30	1.4	1.82	2.13	2.54	2.94	3.33
COMAL	60	1.79	2.35	2.77	3.31	3.85	4.42
COMAL	120	2.18	2.88	3.41	4.11	4.81	5.54

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
COMAL	180	2.4	3.2	3.8	4.6	5.39	6.22
COMAL	360	2.79	3.77	4.49	5.47	6.45	7.45
COMAL	720	3.2	4.39	5.24	6.43	7.63	8.81
COMAL	1440	3.65	5.08	6.08	7.53	8.99	10.37
COMANCHE	15	0.83	1.09	1.28	1.55	1.79	2.05
COMANCHE	30	1.16	1.53	1.81	2.16	2.5	2.88
COMANCHE	60	1.49	1.98	2.36	2.8	3.26	3.78
COMANCHE	120	1.82	2.42	2.91	3.48	4.05	4.73
COMANCHE	180	2.00	2.68	3.23	3.89	4.54	5.31
COMANCHE	360	2.32	3.11	3.81	4.65	5.44	6.37
COMANCHE	720	2.65	3.57	4.43	5.49	6.46	7.57
COMANCHE	1440	3.01	4.07	5.12	6.46	7.63	8.95
CONCHO	15	0.84	1.09	1.25	1.47	1.65	1.85
CONCHO	30	1.12	1.49	1.73	2.06	2.36	2.67
CONCHO	60	1.38	1.88	2.21	2.66	3.09	3.55
CONCHO	120	1.63	2.25	2.68	3.25	3.82	4.43
CONCHO	180	1.76	2.46	2.95	3.59	4.23	4.94
CONCHO	360	1.99	2.82	3.41	4.18	4.95	5.83
CONCHO	720	2.23	3.18	3.9	4.8	5.7	6.77
CONCHO	1440	2.48	3.58	4.43	5.48	6.52	7.81
COOKE	15	0.98	1.25	1.46	1.7	1.96	2.23
COOKE	30	1.29	1.66	1.95	2.28	2.62	2.99
COOKE	60	1.61	2.09	2.47	2.91	3.34	3.82
COOKE	120	1.93	2.55	3.02	3.58	4.14	4.75
COOKE	180	2.13	2.84	3.38	4.01	4.65	5.35
COOKE	360	2.49	3.37	4.04	4.81	5.64	6.5
COOKE	720	2.89	3.98	4.8	5.75	6.79	7.86
COOKE	1440	3.35	4.69	5.69	6.84	8.16	9.47
CORYELL	15	0.85	1.11	1.29	1.54	1.77	1.99
CORYELL	30	1.2	1.58	1.84	2.19	2.54	2.89
CORYELL	60	1.56	2.07	2.43	2.9	3.39	3.9
CORYELL	120	1.91	2.56	3.03	3.64	4.29	4.97
CORYELL	180	2.11	2.84	3.38	4.09	4.84	5.63
CORYELL	360	2.44	3.34	4.02	4.92	5.86	6.85
CORYELL	720	2.79	3.86	4.7	5.84	7.00	8.23
CORYELL	1440	3.16	4.43	5.47	6.9	8.31	9.83
COTTLE	15	0.79	1.06	1.25	1.53	1.75	2.02

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
COTTLE	30	1.04	1.43	1.7	2.12	2.46	2.87
COTTLE	60	1.29	1.8	2.16	2.72	3.21	3.76
COTTLE	120	1.54	2.17	2.62	3.33	3.95	4.65
COTTLE	180	1.69	2.39	2.9	3.68	4.38	5.16
COTTLE	360	1.97	2.78	3.38	4.31	5.13	6.04
COTTLE	720	2.27	3.2	3.91	4.98	5.93	6.96
COTTLE	1440	2.62	3.67	4.49	5.71	6.8	7.95
CRANE	15	0.75	1.04	1.22	1.45	1.67	1.88
CRANE	30	0.96	1.35	1.61	1.95	2.28	2.57
CRANE	60	1.14	1.63	1.97	2.41	2.84	3.22
CRANE	120	1.3	1.88	2.29	2.82	3.34	3.81
CRANE	180	1.39	2.02	2.46	3.03	3.6	4.13
CRANE	360	1.54	2.24	2.75	3.38	4.03	4.64
CRANE	720	1.69	2.47	3.04	3.72	4.44	5.16
CRANE	1440	1.85	2.71	3.34	4.06	4.86	5.69
CROCKETT	15	0.86	1.14	1.34	1.56	1.8	2.04
CROCKETT	30	1.15	1.55	1.84	2.18	2.53	2.88
CROCKETT	60	1.42	1.94	2.32	2.78	3.24	3.71
CROCKETT	120	1.65	2.29	2.75	3.32	3.88	4.48
CROCKETT	180	1.78	2.48	2.98	3.61	4.22	4.89
CROCKETT	360	1.99	2.77	3.34	4.08	4.75	5.55
CROCKETT	720	2.2	3.06	3.69	4.54	5.26	6.19
CROCKETT	1440	2.42	3.36	4.05	5.01	5.77	6.85
CROSBY	15	0.74	0.99	1.17	1.38	1.57	1.78
CROSBY	30	0.99	1.36	1.62	1.94	2.26	2.6
CROSBY	60	1.23	1.72	2.07	2.51	2.98	3.45
CROSBY	120	1.47	2.06	2.49	3.06	3.67	4.29
CROSBY	180	1.6	2.26	2.74	3.38	4.06	4.76
CROSBY	360	1.85	2.6	3.16	3.93	4.73	5.56
CROSBY	720	2.11	2.96	3.59	4.51	5.41	6.37
CROSBY	1440	2.4	3.35	4.06	5.13	6.13	7.24
CULBERSON	15	0.81	0.93	1.14	1.36	1.58	1.78
CULBERSON	30	1.03	1.2	1.47	1.79	2.09	2.37
CULBERSON	60	1.22	1.44	1.77	2.16	2.56	2.92
CULBERSON	120	1.38	1.65	2.03	2.49	2.98	3.43
CULBERSON	180	1.47	1.75	2.17	2.67	3.21	3.7
CULBERSON	360	1.62	1.92	2.39	2.96	3.58	4.17

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
CULBERSON	720	1.76	2.09	2.61	3.24	3.95	4.64
CULBERSON	1440	1.91	2.26	2.84	3.53	4.35	5.15
DALLAM	15	0.72	0.98	1.24	1.51	1.79	2.14
DALLAM	30	0.91	1.25	1.6	1.97	2.35	2.81
DALLAM	60	1.08	1.49	1.93	2.38	2.86	3.43
DALLAM	120	1.25	1.73	2.24	2.76	3.32	3.98
DALLAM	180	1.35	1.86	2.41	2.96	3.57	4.28
DALLAM	360	1.52	2.1	2.7	3.31	3.99	4.77
DALLAM	720	1.71	2.35	3.00	3.65	4.41	5.27
DALLAM	1440	1.91	2.62	3.31	4.02	4.86	5.78
DALLAS	15	0.99	1.27	1.51	1.78	2.05	2.31
DALLAS	30	1.36	1.75	2.06	2.42	2.77	3.13
DALLAS	60	1.72	2.24	2.62	3.09	3.54	4.02
DALLAS	120	2.08	2.72	3.21	3.8	4.38	4.99
DALLAS	180	2.29	3.01	3.56	4.24	4.9	5.6
DALLAS	360	2.65	3.53	4.21	5.06	5.88	6.76
DALLAS	720	3.03	4.1	4.93	5.98	7.01	8.1
DALLAS	1440	3.45	4.73	5.75	7.05	8.33	9.67
DAWSON	15	0.7	0.95	1.13	1.39	1.59	1.81
DAWSON	30	0.94	1.29	1.54	1.9	2.19	2.53
DAWSON	60	1.17	1.62	1.95	2.41	2.8	3.28
DAWSON	120	1.4	1.94	2.35	2.93	3.42	4.02
DAWSON	180	1.53	2.14	2.59	3.24	3.78	4.46
DAWSON	360	1.76	2.48	3.02	3.78	4.43	5.25
DAWSON	720	2.02	2.85	3.48	4.37	5.14	6.1
DAWSON	1440	2.3	3.25	4.00	5.03	5.93	7.05
DEAFSMITH	15	0.72	0.99	1.19	1.48	1.71	1.99
DEAFSMITH	30	0.93	1.3	1.58	1.99	2.32	2.73
DEAFSMITH	60	1.13	1.59	1.94	2.48	2.91	3.45
DEAFSMITH	120	1.31	1.87	2.28	2.91	3.45	4.09
DEAFSMITH	180	1.41	2.02	2.48	3.14	3.74	4.44
DEAFSMITH	360	1.59	2.3	2.82	3.53	4.24	5.00
DEAFSMITH	720	1.78	2.58	3.18	3.91	4.73	5.55
DEAFSMITH	1440	1.98	2.89	3.57	4.3	5.25	6.12
DELTA	15	1.01	1.27	1.46	1.69	1.91	2.13
DELTA	30	1.39	1.72	1.98	2.28	2.57	2.88
DELTA	60	1.77	2.2	2.53	2.92	3.29	3.7

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
DELTA	120	2.15	2.7	3.12	3.62	4.09	4.61
DELTA	180	2.39	3.01	3.5	4.06	4.6	5.21
DELTA	360	2.81	3.58	4.19	4.9	5.59	6.35
DELTA	720	3.27	4.23	4.99	5.88	6.76	7.7
DELTA	1440	3.8	4.98	5.92	7.04	8.15	9.32
DENTON	15	0.98	1.25	1.47	1.72	2.00	2.27
DENTON	30	1.32	1.67	1.97	2.3	2.65	3.00
DENTON	60	1.66	2.1	2.48	2.91	3.35	3.78
DENTON	120	1.99	2.54	3.01	3.55	4.09	4.62
DENTON	180	2.19	2.82	3.33	3.95	4.56	5.16
DENTON	360	2.55	3.32	3.93	4.68	5.44	6.16
DENTON	720	2.94	3.88	4.6	5.51	6.45	7.33
DENTON	1440	3.37	4.52	5.37	6.46	7.63	8.69
DEWITT	15	1.12	1.48	1.73	2.04	2.34	2.67
DEWITT	30	1.5	2.01	2.35	2.79	3.23	3.7
DEWITT	60	1.88	2.53	2.97	3.55	4.13	4.75
DEWITT	120	2.24	3.03	3.58	4.31	5.02	5.78
DEWITT	180	2.46	3.33	3.95	4.76	5.55	6.39
DEWITT	360	2.83	3.83	4.59	5.55	6.48	7.47
DEWITT	720	3.23	4.37	5.28	6.41	7.49	8.64
DEWITT	1440	3.66	4.95	6.04	7.37	8.6	9.93
DICKENS	15	0.76	1.00	1.16	1.39	1.58	1.8
DICKENS	30	1.01	1.36	1.62	1.97	2.28	2.63
DICKENS	60	1.25	1.72	2.08	2.58	3.01	3.52
DICKENS	120	1.5	2.08	2.54	3.18	3.75	4.42
DICKENS	180	1.64	2.29	2.8	3.53	4.18	4.93
DICKENS	360	1.91	2.66	3.26	4.15	4.93	5.82
DICKENS	720	2.2	3.05	3.76	4.8	5.73	6.74
DICKENS	1440	2.52	3.49	4.29	5.52	6.62	7.74
DIMMIT	15	1.07	1.36	1.63	1.92	2.18	2.49
DIMMIT	30	1.43	1.88	2.27	2.73	3.14	3.65
DIMMIT	60	1.76	2.39	2.93	3.58	4.15	4.91
DIMMIT	120	2.05	2.86	3.56	4.41	5.15	6.14
DIMMIT	180	2.21	3.12	3.92	4.88	5.73	6.84
DIMMIT	360	2.47	3.55	4.52	5.7	6.72	8.01
DIMMIT	720	2.73	3.99	5.16	6.57	7.76	9.21
DIMMIT	1440	3.00	4.45	5.84	7.52	8.92	10.52

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
DONLEY	15	0.76	1.05	1.25	1.54	1.76	2.07
DONLEY	30	1.01	1.42	1.69	2.11	2.45	2.91
DONLEY	60	1.26	1.78	2.13	2.69	3.15	3.76
DONLEY	120	1.5	2.13	2.57	3.25	3.84	4.58
DONLEY	180	1.64	2.33	2.83	3.57	4.25	5.05
DONLEY	360	1.89	2.69	3.3	4.14	4.97	5.84
DONLEY	720	2.16	3.08	3.81	4.73	5.76	6.67
DONLEY	1440	2.45	3.5	4.38	5.38	6.63	7.56
DUVAL	15	0.89	1.19	1.36	1.64	1.87	2.12
DUVAL	30	1.3	1.75	2.02	2.46	2.85	3.24
DUVAL	60	1.7	2.34	2.71	3.34	3.92	4.49
DUVAL	120	2.06	2.87	3.35	4.17	4.95	5.7
DUVAL	180	2.25	3.14	3.69	4.62	5.51	6.37
DUVAL	360	2.52	3.57	4.21	5.32	6.39	7.42
DUVAL	720	2.77	3.95	4.68	5.99	7.22	8.41
DUVAL	1440	3.00	4.32	5.15	6.66	8.05	9.4
EASTLAND	15	0.85	1.12	1.32	1.56	1.8	2.03
EASTLAND	30	1.18	1.56	1.85	2.17	2.5	2.84
EASTLAND	60	1.52	2.01	2.4	2.82	3.23	3.71
EASTLAND	120	1.83	2.45	2.94	3.48	4.00	4.61
EASTLAND	180	2.02	2.7	3.25	3.88	4.47	5.16
EASTLAND	360	2.33	3.12	3.8	4.6	5.34	6.18
EASTLAND	720	2.65	3.57	4.38	5.4	6.3	7.32
EASTLAND	1440	3.00	4.05	5.02	6.31	7.4	8.63
ECTOR	15	0.72	1.00	1.19	1.44	1.66	1.92
ECTOR	30	0.95	1.33	1.59	1.96	2.26	2.63
ECTOR	60	1.17	1.64	1.98	2.45	2.85	3.32
ECTOR	120	1.36	1.92	2.33	2.91	3.39	3.97
ECTOR	180	1.46	2.07	2.53	3.16	3.7	4.34
ECTOR	360	1.64	2.33	2.87	3.59	4.22	4.96
ECTOR	720	1.82	2.59	3.22	4.02	4.75	5.59
ECTOR	1440	2.00	2.87	3.59	4.48	5.32	6.28
EDWARDS	15	0.9	1.17	1.38	1.63	1.87	2.18
EDWARDS	30	1.27	1.68	2.01	2.39	2.76	3.23
EDWARDS	60	1.64	2.22	2.67	3.22	3.73	4.39
EDWARDS	120	1.98	2.74	3.33	4.06	4.73	5.6
EDWARDS	180	2.17	3.03	3.7	4.55	5.32	6.31

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
EDWARDS	360	2.48	3.52	4.34	5.4	6.35	7.56
EDWARDS	720	2.79	4.03	5.01	6.3	7.47	8.91
EDWARDS	1440	3.11	4.58	5.73	7.3	8.73	10.44
ELLIS	15	0.77	1.01	1.25	1.45	1.64	1.85
ELLIS	30	0.99	1.33	1.62	1.87	2.14	2.43
ELLIS	60	1.19	1.62	1.96	2.28	2.64	3.02
ELLIS	120	1.37	1.88	2.29	2.69	3.13	3.63
ELLIS	180	1.47	2.02	2.49	2.93	3.42	3.99
ELLIS	360	1.64	2.26	2.82	3.37	3.95	4.67
ELLIS	720	1.81	2.52	3.19	3.87	4.55	5.43
ELLIS	1440	1.99	2.8	3.6	4.43	5.22	6.32
ELPASO	15	0.85	1.1	1.3	1.5	1.68	1.91
ELPASO	30	1.12	1.47	1.75	2.04	2.29	2.62
ELPASO	60	1.38	1.83	2.19	2.58	2.92	3.35
ELPASO	120	1.64	2.19	2.62	3.12	3.56	4.1
ELPASO	180	1.79	2.4	2.88	3.44	3.94	4.55
ELPASO	360	2.05	2.76	3.33	4.02	4.63	5.35
ELPASO	720	2.32	3.14	3.82	4.65	5.4	6.25
ELPASO	1440	2.62	3.56	4.36	5.35	6.26	7.26
ERATH	15	0.89	1.16	1.38	1.62	1.88	2.16
ERATH	30	1.22	1.6	1.9	2.23	2.58	2.95
ERATH	60	1.55	2.06	2.45	2.88	3.32	3.8
ERATH	120	1.88	2.5	3.00	3.54	4.09	4.69
ERATH	180	2.07	2.77	3.33	3.95	4.57	5.24
ERATH	360	2.41	3.24	3.93	4.7	5.46	6.26
ERATH	720	2.77	3.74	4.58	5.53	6.46	7.41
ERATH	1440	3.17	4.3	5.32	6.49	7.62	8.75
FALLS	15	0.93	1.23	1.45	1.74	2.03	2.35
FALLS	30	1.3	1.72	2.02	2.44	2.87	3.33
FALLS	60	1.67	2.22	2.62	3.18	3.75	4.36
FALLS	120	2.03	2.73	3.23	3.94	4.64	5.4
FALLS	180	2.25	3.03	3.59	4.4	5.16	6.03
FALLS	360	2.62	3.55	4.25	5.23	6.1	7.15
FALLS	720	3.02	4.13	4.96	6.14	7.12	8.37
FALLS	1440	3.46	4.76	5.77	7.18	8.26	9.74
FANNIN	15	1.02	1.29	1.48	1.72	1.94	2.17
FANNIN	30	1.38	1.74	1.99	2.32	2.62	2.95

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
FANNIN	60	1.75	2.2	2.54	2.96	3.35	3.79
FANNIN	120	2.11	2.69	3.11	3.64	4.15	4.71
FANNIN	180	2.33	2.99	3.48	4.07	4.66	5.29
FANNIN	360	2.73	3.55	4.16	4.88	5.63	6.39
FANNIN	720	3.16	4.19	4.93	5.82	6.75	7.67
FANNIN	1440	3.65	4.92	5.83	6.91	8.08	9.18
FAYETTE	15	1.03	1.35	1.6	1.91	2.22	2.51
FAYETTE	30	1.43	1.87	2.22	2.66	3.11	3.54
FAYETTE	60	1.83	2.4	2.86	3.46	4.06	4.63
FAYETTE	120	2.22	2.93	3.51	4.28	5.03	5.78
FAYETTE	180	2.44	3.24	3.91	4.78	5.62	6.47
FAYETTE	360	2.82	3.8	4.61	5.68	6.69	7.74
FAYETTE	720	3.21	4.39	5.39	6.69	7.86	9.16
FAYETTE	1440	3.63	5.06	6.27	7.83	9.2	10.79
FISHER	15	0.75	1.00	1.16	1.36	1.54	1.73
FISHER	30	1.02	1.38	1.62	1.94	2.25	2.55
FISHER	60	1.3	1.77	2.1	2.55	3.00	3.46
FISHER	120	1.58	2.17	2.58	3.16	3.77	4.38
FISHER	180	1.74	2.4	2.87	3.53	4.22	4.91
FISHER	360	2.04	2.82	3.38	4.18	5.00	5.82
FISHER	720	2.36	3.28	3.93	4.88	5.84	6.78
FISHER	1440	2.73	3.79	4.55	5.66	6.77	7.81
FLOYD	15	0.75	1.01	1.2	1.46	1.68	1.93
FLOYD	30	1.	1.38	1.65	2.03	2.38	2.76
FLOYD	60	1.25	1.74	2.09	2.6	3.08	3.6
FLOYD	120	1.48	2.07	2.52	3.14	3.75	4.39
FLOYD	180	1.61	2.27	2.76	3.45	4.12	4.84
FLOYD	360	1.85	2.6	3.17	3.97	4.75	5.57
FLOYD	720	2.1	2.94	3.6	4.5	5.38	6.3
FLOYD	1440	2.37	3.32	4.07	5.07	6.05	7.07
FOARD	15	0.81	1.08	1.27	1.55	1.78	2.05
FOARD	30	1.06	1.45	1.72	2.14	2.49	2.9
FOARD	60	1.32	1.82	2.19	2.75	3.23	3.81
FOARD	120	1.58	2.21	2.67	3.38	3.99	4.73
FOARD	180	1.75	2.44	2.97	3.76	4.43	5.26
FOARD	360	2.06	2.87	3.5	4.44	5.22	6.17
FOARD	720	2.4	3.35	4.09	5.18	6.06	7.13

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
FOARD	1440	2.79	3.9	4.75	6.01	6.98	8.15
FORTBEND	15	1.11	1.39	1.58	1.8	1.98	2.17
FORTBEND	30	1.54	1.94	2.23	2.6	2.92	3.25
FORTBEND	60	1.97	2.53	2.95	3.49	3.99	4.52
FORTBEND	120	2.4	3.14	3.71	4.47	5.18	5.96
FORTBEND	180	2.66	3.52	4.19	5.08	5.93	6.88
FORTBEND	360	3.11	4.21	5.08	6.23	7.35	8.63
FORTBEND	720	3.59	4.97	6.09	7.56	8.99	10.68
FORTBEND	1440	4.13	5.85	7.28	9.12	10.94	13.13
FRANKLIN	15	0.98	1.26	1.47	1.73	1.97	2.23
FRANKLIN	30	1.36	1.74	2.01	2.35	2.68	3.02
FRANKLIN	60	1.74	2.23	2.6	3.03	3.45	3.9
FRANKLIN	120	2.15	2.76	3.22	3.76	4.29	4.85
FRANKLIN	180	2.39	3.08	3.61	4.23	4.82	5.45
FRANKLIN	360	2.84	3.68	4.34	5.11	5.83	6.6
FRANKLIN	720	3.34	4.36	5.18	6.13	7.01	7.94
FRANKLIN	1440	3.9	5.14	6.16	7.33	8.39	9.53
FREESTONE	15	1.02	1.33	1.56	1.86	2.16	2.43
FREESTONE	30	1.4	1.83	2.15	2.54	2.95	3.34
FREESTONE	60	1.78	2.34	2.75	3.25	3.77	4.3
FREESTONE	120	2.16	2.84	3.36	3.98	4.63	5.3
FREESTONE	180	2.37	3.14	3.73	4.43	5.16	5.93
FREESTONE	360	2.76	3.67	4.39	5.26	6.13	7.07
FREESTONE	720	3.17	4.24	5.12	6.18	7.23	8.37
FREESTONE	1440	3.62	4.87	5.93	7.24	8.48	9.87
FRIO	15	1.08	1.45	1.73	2.06	2.36	2.69
FRIO	30	1.44	1.97	2.38	2.88	3.35	3.82
FRIO	60	1.79	2.48	3.02	3.7	4.34	4.99
FRIO	120	2.13	2.96	3.64	4.47	5.27	6.1
FRIO	180	2.32	3.24	3.99	4.9	5.79	6.72
FRIO	360	2.64	3.71	4.58	5.62	6.65	7.77
FRIO	720	2.99	4.19	5.2	6.35	7.52	8.83
FRIO	1440	3.36	4.72	5.85	7.11	8.43	9.94
GAINES	15	0.7	0.98	1.17	1.44	1.72	1.98
GAINES	30	0.92	1.29	1.56	1.95	2.32	2.68
GAINES	60	1.13	1.58	1.94	2.44	2.91	3.37
GAINES	120	1.33	1.87	2.3	2.91	3.47	4.04

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
GAINES	180	1.44	2.03	2.51	3.18	3.79	4.42
GAINES	360	1.65	2.32	2.87	3.65	4.36	5.08
GAINES	720	1.86	2.62	3.25	4.13	4.95	5.78
GAINES	1440	2.1	2.94	3.66	4.66	5.59	6.54
GALVESTON	15	1.14	1.45	1.67	1.95	2.2	2.5
GALVESTON	30	1.59	2.05	2.39	2.83	3.22	3.68
GALVESTON	60	2.07	2.71	3.17	3.81	4.35	5.01
GALVESTON	120	2.56	3.39	4.01	4.84	5.56	6.44
GALVESTON	180	2.86	3.81	4.53	5.47	6.3	7.33
GALVESTON	360	3.4	4.59	5.49	6.63	7.69	8.96
GALVESTON	720	4.	5.45	6.58	7.94	9.25	10.79
GALVESTON	1440	4.67	6.44	7.85	9.43	11.05	12.92
GARZA	15	0.72	0.97	1.15	1.39	1.59	1.8
GARZA	30	0.98	1.33	1.6	1.95	2.25	2.59
GARZA	60	1.23	1.69	2.04	2.51	2.92	3.41
GARZA	120	1.47	2.04	2.47	3.06	3.58	4.21
GARZA	180	1.61	2.24	2.71	3.38	3.95	4.66
GARZA	360	1.86	2.6	3.14	3.93	4.59	5.43
GARZA	720	2.11	2.98	3.59	4.51	5.26	6.23
GARZA	1440	2.39	3.4	4.08	5.14	5.97	7.09
GILLESPIE	15	0.95	1.21	1.39	1.63	1.86	2.09
GILLESPIE	30	1.3	1.68	1.95	2.33	2.67	3.04
GILLESPIE	60	1.66	2.17	2.55	3.09	3.55	4.09
GILLESPIE	120	2.01	2.68	3.18	3.89	4.5	5.22
GILLESPIE	180	2.21	2.98	3.56	4.38	5.08	5.92
GILLESPIE	360	2.58	3.53	4.26	5.29	6.16	7.21
GILLESPIE	720	2.97	4.13	5.04	6.3	7.39	8.67
GILLESPIE	1440	3.4	4.81	5.93	7.47	8.8	10.36
GLASSCOCK	15	0.71	0.96	1.11	1.3	1.47	1.64
GLASSCOCK	30	0.98	1.33	1.56	1.86	2.12	2.41
GLASSCOCK	60	1.24	1.7	2.01	2.43	2.8	3.23
GLASSCOCK	120	1.47	2.04	2.44	2.98	3.46	4.02
GLASSCOCK	180	1.6	2.23	2.68	3.29	3.84	4.46
GLASSCOCK	360	1.81	2.55	3.08	3.82	4.47	5.2
GLASSCOCK	720	2.02	2.88	3.49	4.36	5.13	5.93
GLASSCOCK	1440	2.24	3.23	3.92	4.95	5.83	6.71
GOLIAD	15	1.14	1.45	1.65	1.93	2.17	2.45

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
GOLIAD	30	1.52	1.97	2.28	2.67	3.05	3.47
GOLIAD	60	1.89	2.49	2.93	3.46	3.99	4.6
GOLIAD	120	2.24	3.01	3.58	4.28	4.99	5.8
GOLIAD	180	2.45	3.32	3.97	4.78	5.6	6.55
GOLIAD	360	2.81	3.86	4.66	5.7	6.74	7.94
GOLIAD	720	3.19	4.44	5.41	6.73	8.02	9.52
GOLIAD	1440	3.6	5.09	6.25	7.91	9.5	11.35
GONZALES	15	1.08	1.43	1.65	2.	2.32	2.64
GONZALES	30	1.48	1.94	2.27	2.73	3.17	3.63
GONZALES	60	1.86	2.46	2.9	3.49	4.05	4.68
GONZALES	120	2.23	2.96	3.52	4.26	4.95	5.76
GONZALES	180	2.44	3.26	3.89	4.72	5.5	6.42
GONZALES	360	2.79	3.78	4.53	5.57	6.5	7.64
GONZALES	720	3.15	4.33	5.22	6.51	7.62	9.
GONZALES	1440	3.54	4.93	5.99	7.57	8.88	10.56
GRAY	15	0.76	1.07	1.28	1.59	1.86	2.17
GRAY	30	1.01	1.42	1.72	2.14	2.53	2.98
GRAY	60	1.25	1.76	2.14	2.68	3.19	3.77
GRAY	120	1.48	2.09	2.55	3.2	3.81	4.5
GRAY	180	1.61	2.28	2.79	3.5	4.17	4.91
GRAY	360	1.85	2.62	3.2	4.02	4.77	5.6
GRAY	720	2.1	2.98	3.64	4.57	5.4	6.3
GRAY	1440	2.38	3.37	4.11	5.17	6.08	7.04
GRAYSON	15	1.01	1.26	1.49	1.72	1.98	2.22
GRAYSON	30	1.35	1.67	1.99	2.3	2.65	2.98
GRAYSON	60	1.69	2.11	2.52	2.93	3.38	3.81
GRAYSON	120	2.03	2.57	3.08	3.61	4.17	4.73
GRAYSON	180	2.23	2.86	3.43	4.04	4.67	5.32
GRAYSON	360	2.6	3.4	4.08	4.85	5.64	6.45
GRAYSON	720	3.	4.02	4.83	5.78	6.76	7.78
GRAYSON	1440	3.46	4.73	5.69	6.87	8.08	9.35
GREGG	15	0.96	1.24	1.46	1.7	1.98	2.26
GREGG	30	1.34	1.74	2.05	2.38	2.79	3.19
GREGG	60	1.74	2.26	2.69	3.13	3.67	4.2
GREGG	120	2.14	2.81	3.35	3.93	4.61	5.29
GREGG	180	2.38	3.14	3.76	4.43	5.19	5.97
GREGG	360	2.81	3.74	4.5	5.36	6.28	7.25

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
GREGG	720	3.27	4.41	5.33	6.43	7.52	8.71
GREGG	1440	3.78	5.16	6.29	7.68	8.96	10.42
GRIMES	15	1.04	1.36	1.59	1.86	2.13	2.47
GRIMES	30	1.42	1.87	2.22	2.62	3.04	3.54
GRIMES	60	1.8	2.4	2.88	3.43	4.02	4.7
GRIMES	120	2.17	2.94	3.55	4.26	5.03	5.9
GRIMES	180	2.39	3.26	3.95	4.77	5.64	6.62
GRIMES	360	2.78	3.83	4.67	5.68	6.75	7.92
GRIMES	720	3.19	4.46	5.45	6.68	7.98	9.35
GRIMES	1440	3.65	5.17	6.34	7.83	9.39	11.
GUADALUPE	15	1.06	1.4	1.63	1.92	2.2	2.52
GUADALUPE	30	1.44	1.9	2.22	2.61	3.01	3.46
GUADALUPE	60	1.82	2.41	2.82	3.33	3.85	4.44
GUADALUPE	120	2.19	2.91	3.42	4.07	4.71	5.45
GUADALUPE	180	2.4	3.21	3.77	4.51	5.23	6.07
GUADALUPE	360	2.77	3.73	4.4	5.32	6.18	7.21
GUADALUPE	720	3.15	4.3	5.09	6.21	7.24	8.49
GUADALUPE	1440	3.56	4.93	5.86	7.23	8.45	9.96
HALE	15	0.73	0.98	1.15	1.4	1.61	1.84
HALE	30	0.97	1.33	1.59	1.97	2.28	2.62
HALE	60	1.21	1.68	2.03	2.53	2.97	3.42
HALE	120	1.44	2.01	2.44	3.06	3.62	4.18
HALE	180	1.57	2.2	2.67	3.35	3.98	4.61
HALE	360	1.79	2.52	3.07	3.84	4.6	5.32
HALE	720	2.02	2.86	3.48	4.33	5.22	6.06
HALE	1440	2.28	3.22	3.92	4.85	5.87	6.84
HALL	15	0.77	1.05	1.25	1.51	1.74	2.01
HALL	30	1.02	1.42	1.71	2.11	2.46	2.88
HALL	60	1.27	1.79	2.16	2.71	3.2	3.77
HALL	120	1.52	2.15	2.61	3.29	3.91	4.63
HALL	180	1.67	2.36	2.88	3.62	4.32	5.11
HALL	360	1.93	2.72	3.34	4.19	5.01	5.91
HALL	720	2.22	3.11	3.85	4.78	5.72	6.7
HALL	1440	2.54	3.53	4.4	5.42	6.49	7.54
HAMILTON	15	0.86	1.11	1.32	1.57	1.84	2.04
HAMILTON	30	1.19	1.56	1.85	2.19	2.57	2.88
HAMILTON	60	1.52	2.02	2.4	2.85	3.36	3.8

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
HAMILTON	120	1.85	2.47	2.95	3.54	4.2	4.78
HAMILTON	180	2.03	2.74	3.29	3.96	4.71	5.39
HAMILTON	360	2.36	3.2	3.89	4.73	5.65	6.52
HAMILTON	720	2.7	3.7	4.55	5.59	6.72	7.8
HAMILTON	1440	3.07	4.24	5.29	6.57	7.95	9.3
HANSFORD	15	0.75	1.05	1.27	1.58	1.87	2.18
HANSFORD	30	0.98	1.38	1.68	2.08	2.47	2.89
HANSFORD	60	1.19	1.68	2.05	2.54	3.02	3.56
HANSFORD	120	1.38	1.94	2.38	2.96	3.52	4.15
HANSFORD	180	1.49	2.09	2.56	3.2	3.79	4.47
HANSFORD	360	1.67	2.32	2.85	3.59	4.24	5.
HANSFORD	720	1.85	2.56	3.14	3.98	4.68	5.53
HANSFORD	1440	2.04	2.81	3.44	4.4	5.15	6.08
HARDEMAN	15	0.8	1.04	1.22	1.48	1.68	1.95
HARDEMAN	30	1.06	1.41	1.67	2.09	2.41	2.84
HARDEMAN	60	1.32	1.79	2.14	2.72	3.2	3.8
HARDEMAN	120	1.59	2.17	2.62	3.34	3.97	4.75
HARDEMAN	180	1.76	2.4	2.91	3.7	4.41	5.3
HARDEMAN	360	2.06	2.81	3.42	4.32	5.17	6.23
HARDEMAN	720	2.41	3.27	3.98	4.96	5.95	7.18
HARDEMAN	1440	2.8	3.78	4.61	5.66	6.78	8.19
HARDIN	15	1.09	1.35	1.53	1.8	2.01	2.27
HARDIN	30	1.55	1.94	2.24	2.66	3.01	3.44
HARDIN	60	2.04	2.59	3.04	3.66	4.21	4.85
HARDIN	120	2.55	3.31	3.94	4.8	5.58	6.49
HARDIN	180	2.87	3.76	4.52	5.54	6.47	7.57
HARDIN	360	3.46	4.62	5.62	6.96	8.2	9.66
HARDIN	720	4.12	5.6	6.91	8.65	10.26	12.18
HARDIN	1440	4.89	6.76	8.44	10.7	12.78	15.26
HARRIS	15	1.12	1.44	1.65	1.91	2.16	2.43
HARRIS	30	1.53	2.	2.32	2.74	3.12	3.56
HARRIS	60	1.96	2.59	3.04	3.63	4.19	4.83
HARRIS	120	2.4	3.21	3.79	4.57	5.33	6.18
HARRIS	180	2.66	3.58	4.24	5.15	6.02	7.
HARRIS	360	3.15	4.27	5.08	6.2	7.31	8.51
HARRIS	720	3.69	5.04	6.	7.38	8.75	10.2
HARRIS	1440	4.3	5.91	7.06	8.73	10.4	12.13

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
HARRISON	15	0.95	1.22	1.42	1.68	1.93	2.16
HARRISON	30	1.32	1.73	2.02	2.4	2.77	3.13
HARRISON	60	1.72	2.26	2.65	3.18	3.68	4.19
HARRISON	120	2.13	2.81	3.31	3.99	4.63	5.27
HARRISON	180	2.37	3.14	3.71	4.48	5.21	5.93
HARRISON	360	2.81	3.74	4.43	5.37	6.25	7.1
HARRISON	720	3.3	4.4	5.23	6.34	7.41	8.39
HARRISON	1440	3.84	5.15	6.14	7.45	8.72	9.85
HARTLEY	15	0.74	1.04	1.24	1.55	1.8	2.11
HARTLEY	30	0.94	1.33	1.62	2.03	2.37	2.8
HARTLEY	60	1.12	1.6	1.96	2.47	2.9	3.44
HARTLEY	120	1.28	1.84	2.27	2.85	3.39	4.02
HARTLEY	180	1.37	1.98	2.45	3.06	3.67	4.34
HARTLEY	360	1.52	2.21	2.74	3.4	4.14	4.88
HARTLEY	720	1.67	2.44	3.05	3.74	4.63	5.42
HARTLEY	1440	1.83	2.7	3.37	4.1	5.15	5.99
HASKELL	15	0.82	1.06	1.21	1.4	1.59	1.77
HASKELL	30	1.09	1.45	1.7	2.02	2.32	2.63
HASKELL	60	1.37	1.85	2.2	2.67	3.12	3.59
HASKELL	120	1.64	2.25	2.71	3.35	3.93	4.57
HASKELL	180	1.8	2.49	3.02	3.75	4.41	5.15
HASKELL	360	2.09	2.92	3.58	4.46	5.27	6.17
HASKELL	720	2.41	3.39	4.19	5.24	6.19	7.26
HASKELL	1440	2.77	3.92	4.87	6.1	7.22	8.46
HAYS	15	0.97	1.28	1.48	1.75	2.04	2.31
HAYS	30	1.36	1.78	2.07	2.46	2.89	3.3
HAYS	60	1.75	2.29	2.69	3.21	3.79	4.36
HAYS	120	2.13	2.81	3.32	3.97	4.72	5.45
HAYS	180	2.36	3.12	3.69	4.43	5.28	6.11
HAYS	360	2.75	3.68	4.36	5.26	6.29	7.3
HAYS	720	3.16	4.29	5.1	6.17	7.41	8.62
HAYS	1440	3.62	4.97	5.92	7.2	8.69	10.11
HEMPHILL	15	0.78	1.1	1.32	1.64	1.96	2.31
HEMPHILL	30	1.03	1.45	1.74	2.18	2.6	3.08
HEMPHILL	60	1.27	1.78	2.15	2.7	3.21	3.83
HEMPHILL	120	1.5	2.11	2.56	3.21	3.8	4.55
HEMPHILL	180	1.64	2.31	2.8	3.5	4.14	4.96

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
HEMPHILL	360	1.88	2.65	3.23	4.02	4.73	5.68
HEMPHILL	720	2.14	3.02	3.7	4.57	5.36	6.44
HEMPHILL	1440	2.43	3.43	4.22	5.19	6.05	7.27
HENDERSON	15	1.01	1.31	1.53	1.83	2.09	2.41
HENDERSON	30	1.39	1.81	2.13	2.53	2.89	3.34
HENDERSON	60	1.78	2.33	2.74	3.26	3.73	4.31
HENDERSON	120	2.17	2.84	3.35	4.	4.59	5.33
HENDERSON	180	2.39	3.14	3.72	4.45	5.11	5.95
HENDERSON	360	2.79	3.68	4.38	5.26	6.07	7.1
HENDERSON	720	3.21	4.27	5.1	6.15	7.14	8.38
HENDERSON	1440	3.67	4.91	5.91	7.15	8.36	9.86
HIDALGO	15	1.02	1.36	1.57	1.86	2.12	2.34
HIDALGO	30	1.41	1.91	2.22	2.66	3.06	3.47
HIDALGO	60	1.79	2.44	2.86	3.46	4.03	4.64
HIDALGO	120	2.12	2.92	3.44	4.19	4.91	5.71
HIDALGO	180	2.3	3.17	3.76	4.58	5.39	6.27
HIDALGO	360	2.58	3.57	4.26	5.21	6.14	7.14
HIDALGO	720	2.84	3.95	4.74	5.81	6.86	7.94
HIDALGO	1440	3.11	4.33	5.23	6.42	7.59	8.73
HILL	15	0.96	1.26	1.48	1.73	1.97	2.26
HILL	30	1.32	1.74	2.04	2.4	2.76	3.17
HILL	60	1.68	2.23	2.62	3.1	3.59	4.13
HILL	120	2.04	2.72	3.21	3.82	4.43	5.12
HILL	180	2.25	3.01	3.56	4.25	4.95	5.71
HILL	360	2.63	3.54	4.19	5.03	5.87	6.79
HILL	720	3.03	4.11	4.89	5.89	6.9	7.97
HILL	1440	3.48	4.75	5.66	6.85	8.06	9.32
HOCKLEY	15	0.7	0.97	1.16	1.44	1.66	1.92
HOCKLEY	30	0.93	1.3	1.58	1.96	2.29	2.66
HOCKLEY	60	1.15	1.62	1.98	2.47	2.9	3.39
HOCKLEY	120	1.36	1.93	2.36	2.95	3.48	4.08
HOCKLEY	180	1.48	2.1	2.57	3.22	3.8	4.46
HOCKLEY	360	1.69	2.4	2.93	3.68	4.35	5.12
HOCKLEY	720	1.92	2.72	3.3	4.15	4.92	5.79
HOCKLEY	1440	2.16	3.06	3.7	4.65	5.52	6.5
HOOD	15	0.93	1.23	1.44	1.67	1.93	2.22
HOOD	30	1.27	1.67	1.96	2.29	2.64	3.02

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
HOOD	60	1.6	2.12	2.49	2.94	3.38	3.86
HOOD	120	1.93	2.57	3.04	3.61	4.15	4.75
HOOD	180	2.13	2.84	3.38	4.02	4.63	5.3
HOOD	360	2.49	3.33	3.99	4.77	5.52	6.33
HOOD	720	2.87	3.87	4.68	5.6	6.53	7.5
HOOD	1440	3.29	4.48	5.46	6.56	7.69	8.86
HOPKINS	15	1.	1.26	1.49	1.73	1.95	2.18
HOPKINS	30	1.37	1.72	2.02	2.34	2.62	2.94
HOPKINS	60	1.76	2.21	2.59	3.01	3.38	3.81
HOPKINS	120	2.16	2.73	3.22	3.76	4.24	4.82
HOPKINS	180	2.41	3.06	3.63	4.25	4.81	5.49
HOPKINS	360	2.86	3.69	4.4	5.2	5.93	6.8
HOPKINS	720	3.37	4.4	5.3	6.32	7.28	8.4
HOPKINS	1440	3.95	5.23	6.36	7.67	8.91	10.34
HOUSTON	15	1.04	1.33	1.59	1.88	2.16	2.46
HOUSTON	30	1.44	1.85	2.22	2.63	3.04	3.48
HOUSTON	60	1.84	2.38	2.86	3.41	3.97	4.58
HOUSTON	120	2.24	2.92	3.52	4.21	4.92	5.7
HOUSTON	180	2.47	3.24	3.91	4.7	5.5	6.38
HOUSTON	360	2.87	3.81	4.61	5.56	6.54	7.61
HOUSTON	720	3.3	4.44	5.38	6.52	7.7	8.98
HOUSTON	1440	3.77	5.14	6.24	7.6	9.02	10.53
HOWARD	15	0.7	0.94	1.12	1.35	1.53	1.73
HOWARD	30	0.96	1.31	1.56	1.91	2.18	2.5
HOWARD	60	1.22	1.68	2.	2.48	2.85	3.29
HOWARD	120	1.46	2.02	2.41	3.02	3.48	4.05
HOWARD	180	1.6	2.22	2.65	3.32	3.84	4.47
HOWARD	360	1.83	2.55	3.05	3.83	4.44	5.17
HOWARD	720	2.07	2.9	3.46	4.35	5.06	5.87
HOWARD	1440	2.33	3.26	3.91	4.9	5.71	6.61
HUDSPETH	15	0.64	0.88	1.09	1.29	1.47	1.69
HUDSPETH	30	0.75	1.08	1.33	1.6	1.85	2.13
HUDSPETH	60	0.86	1.24	1.55	1.87	2.18	2.53
HUDSPETH	120	0.96	1.39	1.74	2.12	2.49	2.9
HUDSPETH	180	1.01	1.47	1.85	2.27	2.66	3.11
HUDSPETH	360	1.12	1.6	2.03	2.51	2.95	3.48
HUDSPETH	720	1.22	1.73	2.22	2.77	3.26	3.86

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
HUDSPETH	1440	1.34	1.87	2.43	3.05	3.58	4.27
HUNT	15	1.01	1.25	1.49	1.75	2.01	2.28
HUNT	30	1.39	1.7	2.01	2.34	2.69	3.06
HUNT	60	1.77	2.16	2.56	2.96	3.42	3.9
HUNT	120	2.15	2.64	3.12	3.64	4.22	4.81
HUNT	180	2.37	2.93	3.47	4.07	4.72	5.39
HUNT	360	2.76	3.46	4.12	4.88	5.68	6.49
HUNT	720	3.18	4.05	4.85	5.82	6.8	7.78
HUNT	1440	3.65	4.73	5.69	6.92	8.13	9.3
HUTCHINSON	15	0.75	1.05	1.27	1.57	1.86	2.17
HUTCHINSON	30	0.98	1.39	1.67	2.09	2.49	2.92
HUTCHINSON	60	1.2	1.7	2.06	2.58	3.08	3.63
HUTCHINSON	120	1.41	1.99	2.41	3.02	3.61	4.26
HUTCHINSON	180	1.52	2.15	2.61	3.27	3.9	4.6
HUTCHINSON	360	1.72	2.43	2.95	3.7	4.38	5.15
HUTCHINSON	720	1.92	2.71	3.31	4.13	4.86	5.71
HUTCHINSON	1440	2.13	3.02	3.69	4.59	5.37	6.28
IRION	15	0.79	1.05	1.22	1.43	1.63	1.82
IRION	30	1.07	1.44	1.7	2.03	2.34	2.66
IRION	60	1.33	1.82	2.16	2.62	3.06	3.53
IRION	120	1.57	2.16	2.59	3.17	3.72	4.33
IRION	180	1.7	2.35	2.82	3.46	4.08	4.76
IRION	360	1.91	2.65	3.2	3.93	4.65	5.43
IRION	720	2.13	2.96	3.57	4.38	5.19	6.05
IRION	1440	2.35	3.27	3.95	4.83	5.73	6.66
JACK	15	0.93	1.2	1.41	1.67	1.91	2.16
JACK	30	1.24	1.62	1.91	2.28	2.62	2.97
JACK	60	1.55	2.05	2.42	2.9	3.35	3.82
JACK	120	1.86	2.47	2.94	3.54	4.1	4.7
JACK	180	2.05	2.73	3.26	3.93	4.55	5.23
JACK	360	2.37	3.19	3.82	4.63	5.38	6.19
JACK	720	2.73	3.69	4.44	5.41	6.3	7.27
JACK	1440	3.12	4.26	5.14	6.29	7.35	8.49
JACKSON	15	1.14	1.47	1.72	2.02	2.29	2.57
JACKSON	30	1.57	2.05	2.41	2.83	3.23	3.66
JACKSON	60	2.02	2.64	3.12	3.68	4.23	4.83
JACKSON	120	2.46	3.25	3.86	4.57	5.26	6.05

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
JACKSON	180	2.72	3.61	4.3	5.11	5.9	6.79
JACKSON	360	3.18	4.25	5.09	6.1	7.05	8.14
JACKSON	720	3.68	4.96	5.97	7.2	8.35	9.66
JACKSON	1440	4.24	5.76	6.96	8.47	9.83	11.39
JASPER	15	1.07	1.35	1.55	1.82	2.07	2.33
JASPER	30	1.51	1.92	2.23	2.65	3.05	3.48
JASPER	60	1.97	2.54	2.98	3.58	4.17	4.81
JASPER	120	2.44	3.19	3.79	4.59	5.39	6.29
JASPER	180	2.73	3.6	4.3	5.23	6.16	7.22
JASPER	360	3.25	4.34	5.24	6.43	7.6	8.96
JASPER	720	3.82	5.19	6.32	7.82	9.26	10.98
JASPER	1440	4.47	6.16	7.57	9.46	11.2	13.37
JEFFDAVIS	15	0.72	0.96	1.12	1.28	1.45	1.61
JEFFDAVIS	30	0.94	1.27	1.49	1.73	1.97	2.19
JEFFDAVIS	60	1.13	1.54	1.82	2.13	2.44	2.74
JEFFDAVIS	120	1.26	1.75	2.08	2.45	2.83	3.21
JEFFDAVIS	180	1.32	1.85	2.2	2.61	3.03	3.45
JEFFDAVIS	360	1.41	1.98	2.38	2.85	3.33	3.83
JEFFDAVIS	720	1.47	2.1	2.54	3.06	3.59	4.19
JEFFDAVIS	1440	1.54	2.2	2.69	3.26	3.85	4.55
JEFFERSON	15	1.13	1.43	1.64	1.9	2.17	2.44
JEFFERSON	30	1.6	2.07	2.4	2.82	3.24	3.68
JEFFERSON	60	2.11	2.78	3.25	3.85	4.46	5.11
JEFFERSON	120	2.65	3.52	4.16	4.96	5.77	6.66
JEFFERSON	180	2.98	3.98	4.72	5.65	6.59	7.62
JEFFERSON	360	3.59	4.81	5.74	6.93	8.09	9.38
JEFFERSON	720	4.27	5.74	6.89	8.36	9.78	11.35
JEFFERSON	1440	5.05	6.8	8.2	10.02	11.73	13.62
JIMHOGG	15	0.92	1.23	1.43	1.7	1.92	2.2
JIMHOGG	30	1.3	1.77	2.07	2.48	2.85	3.28
JIMHOGG	60	1.67	2.31	2.72	3.3	3.85	4.46
JIMHOGG	120	2.	2.81	3.32	4.09	4.81	5.6
JIMHOGG	180	2.16	3.07	3.65	4.52	5.35	6.24
JIMHOGG	360	2.42	3.49	4.17	5.22	6.22	7.3
JIMHOGG	720	2.65	3.89	4.68	5.92	7.09	8.36
JIMHOGG	1440	2.89	4.29	5.2	6.65	7.98	9.46
JIMWELLS	15	1.	1.31	1.52	1.78	2.05	2.29

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
JIMWELLS	30	1.39	1.85	2.15	2.55	2.99	3.38
JIMWELLS	60	1.78	2.39	2.8	3.34	3.96	4.52
JIMWELLS	120	2.14	2.9	3.42	4.08	4.9	5.6
JIMWELLS	180	2.33	3.18	3.77	4.5	5.41	6.2
JIMWELLS	360	2.66	3.67	4.37	5.21	6.27	7.16
JIMWELLS	720	3.	4.17	4.99	5.92	7.13	8.1
JIMWELLS	1440	3.34	4.7	5.66	6.68	8.03	9.07
JOHNSON	15	0.96	1.28	1.51	1.77	2.03	2.32
JOHNSON	30	1.3	1.74	2.04	2.41	2.75	3.14
JOHNSON	60	1.65	2.2	2.58	3.08	3.51	4.01
JOHNSON	120	1.99	2.68	3.14	3.77	4.3	4.91
JOHNSON	180	2.2	2.96	3.49	4.18	4.78	5.46
JOHNSON	360	2.56	3.47	4.11	4.95	5.67	6.49
JOHNSON	720	2.95	4.03	4.8	5.8	6.68	7.65
JOHNSON	1440	3.39	4.66	5.59	6.76	7.84	8.99
JONES	15	0.79	1.05	1.21	1.38	1.57	1.75
JONES	30	1.08	1.45	1.69	1.99	2.29	2.59
JONES	60	1.37	1.86	2.2	2.64	3.07	3.52
JONES	120	1.66	2.26	2.72	3.3	3.88	4.48
JONES	180	1.83	2.5	3.02	3.7	4.36	5.06
JONES	360	2.12	2.93	3.57	4.41	5.21	6.09
JONES	720	2.44	3.38	4.16	5.18	6.15	7.22
JONES	1440	2.79	3.89	4.82	6.05	7.19	8.48
KARNES	15	1.07	1.39	1.63	1.9	2.2	2.45
KARNES	30	1.46	1.92	2.27	2.67	3.11	3.49
KARNES	60	1.84	2.44	2.91	3.45	4.05	4.56
KARNES	120	2.18	2.93	3.52	4.18	4.94	5.58
KARNES	180	2.37	3.21	3.86	4.6	5.44	6.15
KARNES	360	2.69	3.68	4.43	5.31	6.29	7.12
KARNES	720	3.	4.16	5.02	6.05	7.17	8.11
KARNES	1440	3.33	4.67	5.64	6.84	8.1	9.17
KAUFMAN	15	1.03	1.31	1.52	1.77	2.	2.25
KAUFMAN	30	1.41	1.8	2.09	2.43	2.74	3.08
KAUFMAN	60	1.79	2.29	2.67	3.12	3.52	3.98
KAUFMAN	120	2.17	2.79	3.26	3.82	4.34	4.92
KAUFMAN	180	2.39	3.08	3.61	4.25	4.84	5.5
KAUFMAN	360	2.77	3.61	4.24	5.03	5.76	6.57

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
KAUFMAN	720	3.18	4.18	4.93	5.9	6.8	7.79
KAUFMAN	1440	3.64	4.82	5.71	6.88	7.99	9.21
KENDALL	15	1.	1.28	1.47	1.73	1.97	2.24
KENDALL	30	1.4	1.79	2.08	2.49	2.85	3.27
KENDALL	60	1.8	2.34	2.75	3.32	3.82	4.4
KENDALL	120	2.19	2.9	3.43	4.18	4.84	5.59
KENDALL	180	2.42	3.23	3.84	4.7	5.46	6.32
KENDALL	360	2.82	3.83	4.59	5.64	6.61	7.65
KENDALL	720	3.25	4.5	5.41	6.69	7.89	9.13
KENDALL	1440	3.72	5.25	6.34	7.88	9.38	10.82
KENEDY	15	1.02	1.34	1.56	1.82	2.07	2.34
KENEDY	30	1.43	1.9	2.22	2.62	3.01	3.44
KENEDY	60	1.84	2.45	2.88	3.43	3.99	4.59
KENEDY	120	2.22	2.97	3.51	4.2	4.91	5.69
KENEDY	180	2.42	3.26	3.86	4.62	5.42	6.3
KENEDY	360	2.75	3.74	4.45	5.33	6.27	7.29
KENEDY	720	3.09	4.23	5.04	6.03	7.12	8.26
KENEDY	1440	3.43	4.73	5.66	6.77	8.	9.27
KENT	15	0.74	0.97	1.14	1.31	1.49	1.65
KENT	30	1.	1.32	1.58	1.85	2.12	2.42
KENT	60	1.25	1.69	2.04	2.41	2.8	3.24
KENT	120	1.51	2.05	2.48	2.97	3.48	4.06
KENT	180	1.66	2.27	2.74	3.31	3.88	4.53
KENT	360	1.93	2.67	3.2	3.9	4.6	5.33
KENT	720	2.22	3.1	3.69	4.54	5.37	6.17
KENT	1440	2.54	3.58	4.22	5.25	6.23	7.07
KERR	15	0.98	1.27	1.48	1.78	2.06	2.34
KERR	30	1.37	1.82	2.14	2.59	3.01	3.46
KERR	60	1.77	2.38	2.82	3.45	4.02	4.66
KERR	120	2.15	2.92	3.47	4.26	4.99	5.81
KERR	180	2.36	3.21	3.84	4.72	5.54	6.45
KERR	360	2.73	3.71	4.46	5.47	6.45	7.5
KERR	720	3.1	4.22	5.1	6.23	7.38	8.55
KERR	1440	3.5	4.75	5.78	7.03	8.35	9.63
KIMBLE	15	0.88	1.15	1.34	1.58	1.81	2.09
KIMBLE	30	1.23	1.64	1.94	2.34	2.71	3.13
KIMBLE	60	1.57	2.14	2.56	3.12	3.67	4.25

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
KIMBLE	120	1.89	2.59	3.13	3.86	4.56	5.3
KIMBLE	180	2.06	2.84	3.43	4.25	5.03	5.87
KIMBLE	360	2.34	3.23	3.92	4.86	5.77	6.77
KIMBLE	720	2.61	3.61	4.4	5.43	6.44	7.61
KIMBLE	1440	2.89	4.	4.88	6.	7.1	8.45
KING	15	0.79	1.01	1.17	1.33	1.51	1.69
KING	30	1.04	1.37	1.62	1.89	2.16	2.47
KING	60	1.29	1.73	2.07	2.48	2.87	3.32
KING	120	1.54	2.09	2.52	3.07	3.59	4.18
KING	180	1.69	2.31	2.79	3.42	4.01	4.68
KING	360	1.98	2.69	3.26	4.03	4.75	5.54
KING	720	2.29	3.1	3.77	4.68	5.54	6.45
KING	1440	2.64	3.56	4.34	5.39	6.4	7.43
KINNEY	15	0.99	1.32	1.57	1.88	2.18	2.48
KINNEY	30	1.35	1.85	2.23	2.72	3.18	3.65
KINNEY	60	1.69	2.38	2.89	3.57	4.22	4.88
KINNEY	120	2.01	2.86	3.5	4.37	5.18	6.02
KINNEY	180	2.19	3.12	3.82	4.8	5.69	6.63
KINNEY	360	2.48	3.55	4.35	5.5	6.51	7.58
KINNEY	720	2.79	3.98	4.86	6.19	7.28	8.48
KINNEY	1440	3.11	4.42	5.39	6.89	8.05	9.37
KLEBERG	15	1.01	1.3	1.51	1.74	1.97	2.19
KLEBERG	30	1.42	1.85	2.16	2.52	2.88	3.25
KLEBERG	60	1.84	2.41	2.84	3.34	3.84	4.39
KLEBERG	120	2.23	2.94	3.48	4.15	4.8	5.53
KLEBERG	180	2.44	3.24	3.85	4.61	5.35	6.19
KLEBERG	360	2.81	3.74	4.47	5.39	6.28	7.3
KLEBERG	720	3.18	4.25	5.11	6.19	7.25	8.45
KLEBERG	1440	3.57	4.79	5.8	7.06	8.3	9.69
KNOX	15	0.81	1.04	1.2	1.37	1.56	1.76
KNOX	30	1.07	1.42	1.67	1.97	2.29	2.63
KNOX	60	1.33	1.81	2.17	2.63	3.09	3.62
KNOX	120	1.6	2.21	2.68	3.29	3.92	4.66
KNOX	180	1.76	2.45	2.99	3.69	4.42	5.28
KNOX	360	2.07	2.88	3.55	4.4	5.31	6.37
KNOX	720	2.4	3.37	4.18	5.17	6.28	7.55
KNOX	1440	2.78	3.91	4.89	6.03	7.37	8.87

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
LAMAR	15	1.02	1.29	1.5	1.75	1.97	2.2
LAMAR	30	1.38	1.75	2.04	2.38	2.68	3.02
LAMAR	60	1.75	2.23	2.62	3.06	3.47	3.91
LAMAR	120	2.12	2.73	3.23	3.8	4.34	4.91
LAMAR	180	2.34	3.04	3.62	4.27	4.9	5.56
LAMAR	360	2.73	3.6	4.34	5.17	5.99	6.8
LAMAR	720	3.16	4.22	5.17	6.21	7.26	8.28
LAMAR	1440	3.64	4.93	6.14	7.44	8.79	10.05
LAMB	15	0.78	1.03	1.23	1.51	1.72	1.98
LAMB	30	1.02	1.38	1.66	2.05	2.33	2.72
LAMB	60	1.26	1.73	2.09	2.6	2.96	3.47
LAMB	120	1.51	2.08	2.53	3.14	3.59	4.23
LAMB	180	1.65	2.29	2.79	3.46	3.96	4.68
LAMB	360	1.92	2.67	3.25	4.04	4.63	5.48
LAMB	720	2.21	3.09	3.76	4.67	5.36	6.36
LAMB	1440	2.54	3.56	4.34	5.39	6.18	7.36
LAMPASAS	15	0.83	1.11	1.3	1.56	1.8	2.06
LAMPASAS	30	1.14	1.53	1.8	2.19	2.54	2.94
LAMPASAS	60	1.44	1.94	2.32	2.82	3.29	3.84
LAMPASAS	120	1.71	2.34	2.8	3.43	4.03	4.73
LAMPASAS	180	1.87	2.56	3.08	3.78	4.46	5.24
LAMPASAS	360	2.13	2.94	3.56	4.37	5.2	6.13
LAMPASAS	720	2.4	3.34	4.06	5.	5.97	7.07
LAMPASAS	1440	2.7	3.76	4.59	5.68	6.82	8.09
LASALLE	15	1.	1.3	1.51	1.73	1.98	2.21
LASALLE	30	1.35	1.8	2.12	2.46	2.83	3.2
LASALLE	60	1.69	2.29	2.74	3.21	3.73	4.27
LASALLE	120	2.01	2.75	3.33	3.96	4.61	5.34
LASALLE	180	2.19	3.02	3.66	4.39	5.12	5.94
LASALLE	360	2.49	3.46	4.22	5.13	5.99	6.98
LASALLE	720	2.79	3.92	4.8	5.91	6.91	8.06
LASALLE	1440	3.12	4.4	5.42	6.76	7.91	9.25
LAVACA	15	1.1	1.44	1.67	1.99	2.26	2.57
LAVACA	30	1.51	1.98	2.32	2.74	3.12	3.56
LAVACA	60	1.92	2.52	2.98	3.53	4.04	4.61
LAVACA	120	2.31	3.05	3.63	4.35	5.	5.72
LAVACA	180	2.53	3.36	4.02	4.84	5.58	6.39

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
LAVACA	360	2.92	3.92	4.72	5.73	6.66	7.64
LAVACA	720	3.32	4.51	5.47	6.73	7.88	9.05
LAVACA	1440	3.76	5.17	6.31	7.86	9.28	10.68
LEE	15	0.98	1.29	1.53	1.82	2.14	2.44
LEE	30	1.37	1.8	2.14	2.56	3.02	3.46
LEE	60	1.76	2.33	2.78	3.35	3.96	4.56
LEE	120	2.14	2.86	3.43	4.17	4.93	5.68
LEE	180	2.35	3.17	3.82	4.66	5.51	6.35
LEE	360	2.72	3.71	4.5	5.55	6.55	7.56
LEE	720	3.09	4.29	5.25	6.55	7.7	8.9
LEE	1440	3.49	4.93	6.09	7.68	9.01	10.43
LEON	15	1.03	1.34	1.56	1.91	2.23	2.54
LEON	30	1.4	1.85	2.16	2.64	3.08	3.53
LEON	60	1.78	2.37	2.78	3.4	3.98	4.58
LEON	120	2.15	2.88	3.41	4.2	4.91	5.67
LEON	180	2.37	3.19	3.79	4.68	5.47	6.34
LEON	360	2.76	3.75	4.48	5.57	6.5	7.57
LEON	720	3.18	4.34	5.24	6.56	7.65	8.95
LEON	1440	3.64	5.01	6.1	7.69	8.97	10.54
LIBERTY	15	1.12	1.35	1.54	1.78	1.97	2.19
LIBERTY	30	1.57	1.93	2.22	2.59	2.91	3.26
LIBERTY	60	2.06	2.57	2.98	3.51	3.99	4.53
LIBERTY	120	2.56	3.24	3.79	4.51	5.2	5.96
LIBERTY	180	2.87	3.65	4.31	5.15	5.97	6.88
LIBERTY	360	3.42	4.42	5.27	6.36	7.45	8.66
LIBERTY	720	4.04	5.29	6.38	7.78	9.2	10.77
LIBERTY	1440	4.74	6.29	7.69	9.46	11.31	13.35
LIMESTONE	15	0.99	1.28	1.51	1.8	2.13	2.4
LIMESTONE	30	1.36	1.78	2.08	2.49	2.96	3.34
LIMESTONE	60	1.73	2.29	2.68	3.22	3.84	4.37
LIMESTONE	120	2.1	2.8	3.3	3.99	4.77	5.45
LIMESTONE	180	2.31	3.1	3.68	4.47	5.34	6.13
LIMESTONE	360	2.69	3.64	4.37	5.34	6.4	7.38
LIMESTONE	720	3.09	4.22	5.14	6.31	7.59	8.8
LIMESTONE	1440	3.53	4.86	6.02	7.44	8.96	10.45
LIPSCOMB	15	0.78	1.08	1.29	1.62	1.92	2.29
LIPSCOMB	30	1.02	1.42	1.69	2.12	2.53	3.02

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
LIPSCOMB	60	1.25	1.74	2.09	2.6	3.12	3.72
LIPSCOMB	120	1.47	2.05	2.48	3.08	3.68	4.38
LIPSCOMB	180	1.6	2.23	2.71	3.36	4.01	4.76
LIPSCOMB	360	1.82	2.55	3.12	3.86	4.57	5.42
LIPSCOMB	720	2.06	2.89	3.56	4.4	5.17	6.11
LIPSCOMB	1440	2.31	3.26	4.05	5.	5.83	6.87
LIVEOAK	15	1.07	1.38	1.59	1.86	2.09	2.36
LIVEOAK	30	1.43	1.88	2.18	2.57	2.93	3.34
LIVEOAK	60	1.79	2.37	2.78	3.32	3.81	4.39
LIVEOAK	120	2.12	2.86	3.39	4.07	4.72	5.46
LIVEOAK	180	2.32	3.15	3.74	4.52	5.27	6.11
LIVEOAK	360	2.65	3.65	4.37	5.33	6.26	7.28
LIVEOAK	720	3.	4.2	5.05	6.22	7.36	8.57
LIVEOAK	1440	3.37	4.8	5.81	7.21	8.6	10.02
LLANO	15	0.93	1.19	1.38	1.62	1.85	2.08
LLANO	30	1.21	1.59	1.87	2.21	2.55	2.92
LLANO	60	1.49	1.98	2.37	2.83	3.3	3.82
LLANO	120	1.77	2.38	2.87	3.46	4.08	4.79
LLANO	180	1.94	2.61	3.18	3.85	4.56	5.39
LLANO	360	2.23	3.04	3.74	4.57	5.45	6.5
LLANO	720	2.55	3.5	4.35	5.37	6.47	7.77
LLANO	1440	2.91	4.01	5.04	6.28	7.63	9.25
LOVING	15	0.71	0.99	1.19	1.47	1.72	1.97
LOVING	30	0.9	1.3	1.56	1.96	2.32	2.67
LOVING	60	1.08	1.58	1.91	2.43	2.89	3.34
LOVING	120	1.24	1.82	2.22	2.84	3.39	3.94
LOVING	180	1.32	1.96	2.39	3.07	3.66	4.27
LOVING	360	1.47	2.17	2.67	3.44	4.11	4.8
LOVING	720	1.62	2.38	2.96	3.82	4.55	5.33
LOVING	1440	1.78	2.6	3.25	4.21	5.01	5.89
LUBBOCK	15	0.71	0.97	1.14	1.37	1.58	1.82
LUBBOCK	30	0.96	1.32	1.57	1.91	2.22	2.58
LUBBOCK	60	1.2	1.67	2.	2.45	2.88	3.36
LUBBOCK	120	1.43	2.	2.41	2.98	3.52	4.11
LUBBOCK	180	1.56	2.19	2.65	3.28	3.89	4.55
LUBBOCK	360	1.79	2.52	3.05	3.81	4.53	5.3
LUBBOCK	720	2.02	2.87	3.46	4.37	5.21	6.08

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
LUBBOCK	1440	2.27	3.25	3.91	4.97	5.95	6.93
LYNN	15	0.71	0.97	1.14	1.37	1.55	1.78
LYNN	30	0.96	1.3	1.56	1.9	2.18	2.54
LYNN	60	1.19	1.64	1.98	2.44	2.82	3.33
LYNN	120	1.42	1.98	2.4	2.97	3.45	4.1
LYNN	180	1.55	2.17	2.64	3.28	3.82	4.55
LYNN	360	1.78	2.52	3.05	3.83	4.47	5.32
LYNN	720	2.03	2.89	3.5	4.41	5.16	6.13
LYNN	1440	2.3	3.31	3.99	5.06	5.92	7.01
MADISON	15	1.03	1.34	1.56	1.89	2.18	2.45
MADISON	30	1.4	1.84	2.15	2.62	3.05	3.47
MADISON	60	1.78	2.35	2.78	3.41	3.99	4.59
MADISON	120	2.16	2.88	3.43	4.24	4.99	5.78
MADISON	180	2.38	3.2	3.83	4.76	5.6	6.51
MADISON	360	2.77	3.79	4.56	5.72	6.75	7.88
MADISON	720	3.2	4.43	5.38	6.82	8.05	9.44
MADISON	1440	3.67	5.16	6.32	8.08	9.55	11.24
MARION	15	0.94	1.21	1.42	1.65	1.9	2.18
MARION	30	1.33	1.7	2.	2.33	2.7	3.1
MARION	60	1.73	2.23	2.63	3.07	3.58	4.11
MARION	120	2.14	2.78	3.31	3.88	4.54	5.21
MARION	180	2.38	3.12	3.72	4.38	5.14	5.91
MARION	360	2.82	3.74	4.5	5.34	6.27	7.22
MARION	720	3.29	4.43	5.39	6.43	7.58	8.74
MARION	1440	3.81	5.22	6.42	7.72	9.13	10.53
MARTIN	15	0.7	0.96	1.14	1.38	1.58	1.81
MARTIN	30	0.95	1.31	1.56	1.91	2.2	2.55
MARTIN	60	1.2	1.66	1.98	2.44	2.82	3.29
MARTIN	120	1.42	1.98	2.38	2.94	3.4	3.99
MARTIN	180	1.55	2.17	2.61	3.23	3.73	4.4
MARTIN	360	1.76	2.48	3.	3.72	4.3	5.08
MARTIN	720	1.98	2.8	3.41	4.24	4.88	5.79
MARTIN	1440	2.21	3.15	3.85	4.8	5.51	6.55
MASON	15	0.89	1.14	1.33	1.54	1.78	1.99
MASON	30	1.19	1.56	1.84	2.15	2.49	2.83
MASON	60	1.48	1.98	2.35	2.78	3.24	3.74
MASON	120	1.75	2.38	2.86	3.42	4.02	4.67

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
MASON	180	1.91	2.62	3.16	3.8	4.49	5.24
MASON	360	2.19	3.03	3.69	4.48	5.33	6.26
MASON	720	2.48	3.46	4.26	5.22	6.27	7.39
MASON	1440	2.79	3.93	4.88	6.05	7.33	8.67
MATAGORDA	15	1.14	1.45	1.67	1.92	2.18	2.41
MATAGORDA	30	1.6	2.05	2.37	2.74	3.13	3.5
MATAGORDA	60	2.08	2.69	3.13	3.66	4.2	4.74
MATAGORDA	120	2.57	3.36	3.94	4.65	5.38	6.13
MATAGORDA	180	2.86	3.77	4.44	5.28	6.13	7.03
MATAGORDA	360	3.37	4.52	5.38	6.47	7.56	8.76
MATAGORDA	720	3.93	5.35	6.46	7.85	9.24	10.82
MATAGORDA	1440	4.55	6.3	7.71	9.49	11.24	13.31
MAVERICK	15	1.05	1.38	1.63	1.95	2.24	2.53
MAVERICK	30	1.39	1.9	2.27	2.75	3.18	3.63
MAVERICK	60	1.72	2.4	2.91	3.58	4.18	4.79
MAVERICK	120	2.01	2.87	3.53	4.4	5.17	5.95
MAVERICK	180	2.17	3.14	3.88	4.87	5.75	6.62
MAVERICK	360	2.43	3.59	4.47	5.7	6.76	7.77
MAVERICK	720	2.7	4.06	5.08	6.57	7.85	9.
MAVERICK	1440	2.97	4.57	5.74	7.54	9.07	10.36
MCCULLOCH	15	0.86	1.13	1.31	1.57	1.78	2.
MCCULLOCH	30	1.14	1.52	1.78	2.15	2.48	2.83
MCCULLOCH	60	1.4	1.9	2.24	2.74	3.2	3.7
MCCULLOCH	120	1.66	2.28	2.7	3.34	3.92	4.58
MCCULLOCH	180	1.8	2.49	2.98	3.69	4.35	5.1
MCCULLOCH	360	2.04	2.87	3.46	4.32	5.11	6.02
MCCULLOCH	720	2.3	3.27	3.98	5.	5.94	7.02
MCCULLOCH	1440	2.57	3.71	4.56	5.77	6.87	8.15
MCLENNAN	15	0.89	1.19	1.4	1.64	1.92	2.22
MCLENNAN	30	1.26	1.67	1.97	2.33	2.72	3.15
MCLENNAN	60	1.65	2.18	2.58	3.06	3.58	4.16
MCLENNAN	120	2.01	2.68	3.19	3.82	4.47	5.2
MCLENNAN	180	2.22	2.98	3.56	4.27	5.01	5.83
MCLENNAN	360	2.58	3.52	4.23	5.1	5.99	6.97
MCLENNAN	720	2.94	4.1	4.96	6.01	7.08	8.24
MCLENNAN	1440	3.33	4.75	5.78	7.05	8.34	9.69
MCMULLEN	15	1.04	1.38	1.6	1.84	2.08	2.33

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
MCMULLEN	30	1.41	1.9	2.22	2.6	2.95	3.34
MCMULLEN	60	1.77	2.41	2.84	3.37	3.85	4.41
MCMULLEN	120	2.09	2.89	3.44	4.12	4.75	5.46
MCMULLEN	180	2.27	3.17	3.78	4.55	5.27	6.07
MCMULLEN	360	2.57	3.64	4.37	5.29	6.19	7.13
MCMULLEN	720	2.88	4.12	4.98	6.08	7.17	8.24
MCMULLEN	1440	3.2	4.64	5.65	6.94	8.26	9.46
MEDINA	15	1.07	1.41	1.65	1.94	2.24	2.54
MEDINA	30	1.45	1.94	2.28	2.73	3.16	3.62
MEDINA	60	1.83	2.47	2.94	3.55	4.14	4.77
MEDINA	120	2.19	3.	3.6	4.38	5.14	5.94
MEDINA	180	2.4	3.31	4.	4.87	5.74	6.64
MEDINA	360	2.76	3.86	4.7	5.76	6.81	7.89
MEDINA	720	3.15	4.45	5.47	6.73	7.99	9.26
MEDINA	1440	3.57	5.11	6.33	7.83	9.34	10.82
MENARD	15	0.84	1.08	1.26	1.46	1.64	1.83
MENARD	30	1.15	1.52	1.79	2.12	2.42	2.74
MENARD	60	1.44	1.96	2.33	2.81	3.27	3.76
MENARD	120	1.7	2.37	2.85	3.49	4.11	4.78
MENARD	180	1.84	2.59	3.14	3.87	4.58	5.37
MENARD	360	2.07	2.96	3.63	4.53	5.39	6.38
MENARD	720	2.29	3.32	4.13	5.2	6.23	7.42
MENARD	1440	2.52	3.7	4.67	5.92	7.12	8.56
MIDLAND	15	0.72	0.98	1.17	1.39	1.59	1.8
MIDLAND	30	0.98	1.34	1.6	1.93	2.23	2.54
MIDLAND	60	1.22	1.69	2.03	2.46	2.85	3.29
MIDLAND	120	1.44	2.	2.41	2.95	3.43	3.98
MIDLAND	180	1.56	2.17	2.63	3.22	3.74	4.35
MIDLAND	360	1.75	2.45	2.98	3.66	4.27	4.97
MIDLAND	720	1.94	2.73	3.34	4.11	4.8	5.59
MIDLAND	1440	2.14	3.01	3.71	4.57	5.35	6.22
MILAM	15	0.95	1.24	1.48	1.76	2.06	2.38
MILAM	30	1.33	1.74	2.07	2.46	2.91	3.37
MILAM	60	1.71	2.25	2.69	3.21	3.81	4.43
MILAM	120	2.08	2.76	3.32	3.98	4.73	5.51
MILAM	180	2.28	3.06	3.69	4.45	5.28	6.16
MILAM	360	2.64	3.59	4.37	5.29	6.28	7.32

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
MILAM	720	3.02	4.16	5.12	6.23	7.38	8.59
MILAM	1440	3.42	4.79	5.97	7.3	8.64	10.05
MILLS	15	0.84	1.1	1.29	1.55	1.78	2.02
MILLS	30	1.15	1.52	1.79	2.15	2.48	2.86
MILLS	60	1.46	1.95	2.3	2.77	3.21	3.75
MILLS	120	1.75	2.36	2.81	3.41	3.97	4.67
MILLS	180	1.92	2.59	3.11	3.78	4.43	5.22
MILLS	360	2.19	3.	3.63	4.47	5.27	6.21
MILLS	720	2.46	3.42	4.18	5.22	6.2	7.31
MILLS	1440	2.75	3.88	4.8	6.08	7.26	8.57
MITCHELL	15	0.7	0.94	1.11	1.3	1.46	1.65
MITCHELL	30	0.97	1.32	1.56	1.86	2.11	2.43
MITCHELL	60	1.24	1.7	2.03	2.44	2.81	3.27
MITCHELL	120	1.5	2.07	2.48	3.01	3.5	4.1
MITCHELL	180	1.65	2.29	2.75	3.34	3.9	4.57
MITCHELL	360	1.91	2.66	3.22	3.92	4.59	5.38
MITCHELL	720	2.18	3.05	3.72	4.53	5.31	6.2
MITCHELL	1440	2.47	3.47	4.26	5.2	6.09	7.09
MONTAGUE	15	0.91	1.19	1.4	1.63	1.91	2.18
MONTAGUE	30	1.21	1.61	1.9	2.24	2.62	3.
MONTAGUE	60	1.53	2.05	2.42	2.88	3.36	3.86
MONTAGUE	120	1.85	2.49	2.96	3.55	4.15	4.76
MONTAGUE	180	2.05	2.77	3.29	3.97	4.64	5.32
MONTAGUE	360	2.4	3.26	3.9	4.73	5.55	6.36
MONTAGUE	720	2.8	3.81	4.57	5.58	6.58	7.52
MONTAGUE	1440	3.25	4.43	5.34	6.57	7.76	8.87
MONTGOMERY	15	1.09	1.36	1.57	1.81	2.07	2.31
MONTGOMERY	30	1.5	1.89	2.21	2.57	2.97	3.35
MONTGOMERY	60	1.91	2.46	2.9	3.42	4.	4.54
MONTGOMERY	120	2.33	3.05	3.64	4.33	5.11	5.86
MONTGOMERY	180	2.58	3.4	4.09	4.9	5.81	6.7
MONTGOMERY	360	3.03	4.06	4.93	5.98	7.13	8.29
MONTGOMERY	720	3.52	4.8	5.88	7.22	8.66	10.16
MONTGOMERY	1440	4.07	5.63	6.98	8.69	10.49	12.39
MOORE	15	0.74	1.05	1.26	1.56	1.85	2.15
MOORE	30	0.97	1.37	1.64	2.05	2.42	2.86
MOORE	60	1.17	1.66	2.	2.5	2.97	3.51

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
MOORE	120	1.36	1.93	2.34	2.92	3.47	4.12
MOORE	180	1.46	2.08	2.53	3.14	3.76	4.45
MOORE	360	1.64	2.33	2.85	3.53	4.26	5.02
MOORE	720	1.82	2.59	3.18	3.92	4.78	5.59
MOORE	1440	2.01	2.86	3.54	4.33	5.34	6.2
MORRIS	15	0.96	1.22	1.43	1.69	1.93	2.18
MORRIS	30	1.34	1.7	1.99	2.34	2.67	3.
MORRIS	60	1.74	2.21	2.6	3.05	3.48	3.91
MORRIS	120	2.15	2.74	3.25	3.82	4.37	4.91
MORRIS	180	2.4	3.07	3.66	4.31	4.93	5.56
MORRIS	360	2.85	3.68	4.43	5.23	6.01	6.8
MORRIS	720	3.34	4.37	5.31	6.3	7.26	8.26
MORRIS	1440	3.9	5.17	6.35	7.56	8.75	10.
MOTLEY	15	0.78	1.01	1.16	1.38	1.56	1.75
MOTLEY	30	1.03	1.38	1.61	1.95	2.26	2.57
MOTLEY	60	1.27	1.75	2.06	2.54	2.99	3.45
MOTLEY	120	1.52	2.1	2.51	3.1	3.7	4.3
MOTLEY	180	1.66	2.31	2.76	3.43	4.1	4.78
MOTLEY	360	1.92	2.67	3.21	3.97	4.77	5.56
MOTLEY	720	2.21	3.04	3.69	4.54	5.46	6.34
MOTLEY	1440	2.53	3.45	4.21	5.15	6.19	7.16
NACOGDOCHES	15	1.01	1.28	1.51	1.75	2.	2.24
NACOGDOCHES	30	1.41	1.81	2.15	2.51	2.9	3.28
NACOGDOCHES	60	1.82	2.35	2.82	3.33	3.87	4.41
NACOGDOCHES	120	2.22	2.9	3.49	4.16	4.85	5.58
NACOGDOCHES	180	2.46	3.22	3.89	4.65	5.44	6.28
NACOGDOCHES	360	2.87	3.78	4.59	5.53	6.47	7.52
NACOGDOCHES	720	3.3	4.4	5.34	6.48	7.59	8.87
NACOGDOCHES	1440	3.77	5.07	6.17	7.54	8.83	10.38
NAVARRO	15	1.01	1.29	1.51	1.79	2.07	2.35
NAVARRO	30	1.4	1.8	2.09	2.45	2.81	3.2
NAVARRO	60	1.79	2.31	2.68	3.13	3.59	4.1
NAVARRO	120	2.16	2.81	3.28	3.84	4.41	5.06
NAVARRO	180	2.38	3.1	3.63	4.27	4.91	5.66
NAVARRO	360	2.75	3.61	4.27	5.06	5.85	6.77
NAVARRO	720	3.14	4.16	4.97	5.95	6.9	8.04
NAVARRO	1440	3.56	4.76	5.75	6.96	8.11	9.52

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
NEWTON	15	1.09	1.38	1.57	1.84	2.05	2.29
NEWTON	30	1.52	1.94	2.25	2.65	3.01	3.4
NEWTON	60	1.97	2.56	3.	3.57	4.11	4.69
NEWTON	120	2.44	3.21	3.8	4.58	5.32	6.15
NEWTON	180	2.74	3.62	4.3	5.23	6.09	7.08
NEWTON	360	3.28	4.39	5.24	6.45	7.55	8.87
NEWTON	720	3.89	5.26	6.31	7.88	9.25	10.97
NEWTON	1440	4.59	6.28	7.56	9.57	11.26	13.5
NOLAN	15	0.75	0.99	1.15	1.34	1.52	1.7
NOLAN	30	1.03	1.38	1.61	1.91	2.2	2.5
NOLAN	60	1.31	1.78	2.1	2.51	2.92	3.37
NOLAN	120	1.59	2.17	2.58	3.11	3.65	4.24
NOLAN	180	1.75	2.4	2.86	3.46	4.08	4.74
NOLAN	360	2.05	2.81	3.34	4.07	4.83	5.62
NOLAN	720	2.37	3.24	3.86	4.73	5.62	6.53
NOLAN	1440	2.73	3.72	4.43	5.44	6.49	7.53
NUECES	15	1.05	1.34	1.53	1.77	1.99	2.2
NUECES	30	1.44	1.88	2.16	2.55	2.9	3.25
NUECES	60	1.84	2.43	2.84	3.39	3.9	4.42
NUECES	120	2.24	2.99	3.54	4.27	4.96	5.67
NUECES	180	2.47	3.33	3.96	4.8	5.6	6.44
NUECES	360	2.89	3.93	4.73	5.76	6.78	7.83
NUECES	720	3.34	4.59	5.59	6.81	8.08	9.38
NUECES	1440	3.83	5.33	6.56	8.01	9.57	11.15
OCHILTREE	15	0.76	1.07	1.28	1.59	1.9	2.25
OCHILTREE	30	0.99	1.39	1.67	2.07	2.47	2.94
OCHILTREE	60	1.22	1.7	2.04	2.53	3.03	3.6
OCHILTREE	120	1.43	1.99	2.41	2.99	3.56	4.23
OCHILTREE	180	1.55	2.16	2.62	3.26	3.87	4.59
OCHILTREE	360	1.76	2.45	3.	3.73	4.41	5.22
OCHILTREE	720	1.98	2.76	3.41	4.25	4.99	5.89
OCHILTREE	1440	2.22	3.1	3.86	4.81	5.63	6.62
OLDHAM	15	0.72	1.	1.22	1.51	1.73	2.03
OLDHAM	30	0.93	1.3	1.59	1.99	2.3	2.73
OLDHAM	60	1.12	1.57	1.94	2.44	2.85	3.38
OLDHAM	120	1.3	1.84	2.27	2.84	3.35	3.96
OLDHAM	180	1.4	1.99	2.46	3.06	3.63	4.28

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
OLDHAM	360	1.57	2.24	2.79	3.42	4.11	4.79
OLDHAM	720	1.74	2.51	3.14	3.79	4.6	5.3
OLDHAM	1440	1.93	2.8	3.52	4.18	5.13	5.82
ORANGE	15	1.11	1.38	1.57	1.79	2.01	2.24
ORANGE	30	1.57	1.98	2.26	2.61	2.97	3.35
ORANGE	60	2.07	2.65	3.06	3.57	4.11	4.71
ORANGE	120	2.61	3.39	3.96	4.68	5.45	6.29
ORANGE	180	2.96	3.87	4.55	5.4	6.33	7.34
ORANGE	360	3.61	4.78	5.68	6.81	8.06	9.4
ORANGE	720	4.36	5.84	7.04	8.52	10.16	11.91
ORANGE	1440	5.25	7.11	8.68	10.61	12.76	15.02
PALOPINTO	15	0.92	1.2	1.42	1.64	1.91	2.17
PALOPINTO	30	1.24	1.63	1.93	2.25	2.61	2.97
PALOPINTO	60	1.55	2.07	2.46	2.89	3.35	3.82
PALOPINTO	120	1.87	2.5	2.99	3.54	4.12	4.72
PALOPINTO	180	2.06	2.75	3.3	3.95	4.59	5.29
PALOPINTO	360	2.39	3.21	3.87	4.69	5.47	6.33
PALOPINTO	720	2.76	3.7	4.5	5.52	6.46	7.52
PALOPINTO	1440	3.16	4.25	5.2	6.46	7.6	8.9
PANOLA	15	0.95	1.2	1.4	1.61	1.84	2.08
PANOLA	30	1.33	1.7	1.99	2.32	2.7	3.07
PANOLA	60	1.73	2.23	2.63	3.09	3.63	4.16
PANOLA	120	2.13	2.78	3.29	3.89	4.6	5.3
PANOLA	180	2.37	3.11	3.69	4.38	5.18	5.99
PANOLA	360	2.8	3.71	4.42	5.27	6.23	7.22
PANOLA	720	3.26	4.38	5.23	6.25	7.38	8.58
PANOLA	1440	3.77	5.13	6.15	7.36	8.68	10.1
PARKER	15	0.95	1.25	1.48	1.71	1.99	2.26
PARKER	30	1.28	1.68	1.98	2.3	2.66	3.02
PARKER	60	1.61	2.11	2.5	2.92	3.37	3.82
PARKER	120	1.93	2.55	3.03	3.56	4.12	4.68
PARKER	180	2.13	2.82	3.36	3.96	4.59	5.21
PARKER	360	2.47	3.29	3.96	4.68	5.45	6.22
PARKER	720	2.84	3.81	4.64	5.5	6.44	7.36
PARKER	1440	3.25	4.4	5.4	6.43	7.58	8.7
PARMER	15	0.71	0.98	1.18	1.47	1.69	1.98
PARMER	30	0.92	1.3	1.57	1.99	2.3	2.71

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
PARMER	60	1.11	1.59	1.94	2.47	2.88	3.39
PARMER	120	1.29	1.87	2.28	2.9	3.41	4.01
PARMER	180	1.39	2.03	2.47	3.13	3.69	4.34
PARMER	360	1.57	2.3	2.8	3.51	4.16	4.87
PARMER	720	1.75	2.59	3.15	3.88	4.62	5.39
PARMER	1440	1.94	2.89	3.52	4.27	5.09	5.93
PECOS	15	0.82	1.07	1.26	1.46	1.66	1.88
PECOS	30	1.01	1.36	1.62	1.91	2.2	2.48
PECOS	60	1.18	1.61	1.94	2.32	2.69	3.06
PECOS	120	1.33	1.82	2.23	2.68	3.13	3.59
PECOS	180	1.41	1.94	2.38	2.88	3.37	3.88
PECOS	360	1.54	2.12	2.64	3.19	3.77	4.38
PECOS	720	1.68	2.31	2.89	3.51	4.16	4.89
PECOS	1440	1.82	2.51	3.16	3.84	4.58	5.43
POLK	15	1.07	1.37	1.57	1.86	2.09	2.36
POLK	30	1.52	1.95	2.26	2.69	3.07	3.5
POLK	60	1.98	2.56	3.01	3.62	4.18	4.82
POLK	120	2.44	3.2	3.8	4.61	5.38	6.27
POLK	180	2.7	3.59	4.29	5.23	6.14	7.19
POLK	360	3.17	4.3	5.18	6.39	7.55	8.89
POLK	720	3.67	5.09	6.19	7.7	9.16	10.86
POLK	1440	4.21	5.98	7.35	9.23	11.06	13.19
POTTER	15	0.74	1.02	1.23	1.53	1.77	2.07
POTTER	30	0.97	1.36	1.63	2.06	2.4	2.84
POTTER	60	1.19	1.68	2.01	2.56	3.01	3.55
POTTER	120	1.38	1.96	2.37	3.01	3.56	4.19
POTTER	180	1.49	2.12	2.56	3.25	3.87	4.53
POTTER	360	1.67	2.38	2.9	3.65	4.38	5.08
POTTER	720	1.85	2.63	3.24	4.05	4.89	5.62
POTTER	1440	2.05	2.91	3.6	4.47	5.43	6.17
PRESIDIO	15	0.77	1.	1.16	1.32	1.48	1.64
PRESIDIO	30	0.97	1.28	1.48	1.72	1.94	2.17
PRESIDIO	60	1.12	1.49	1.74	2.05	2.33	2.62
PRESIDIO	120	1.21	1.63	1.93	2.3	2.63	2.97
PRESIDIO	180	1.25	1.69	2.	2.41	2.77	3.14
PRESIDIO	360	1.29	1.75	2.11	2.57	2.97	3.38
PRESIDIO	720	1.31	1.79	2.19	2.7	3.14	3.59

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
PRESIDIO	1440	1.34	1.83	2.26	2.82	3.31	3.79
RAINS	15	0.99	1.27	1.47	1.76	2.02	2.28
RAINS	30	1.38	1.76	2.03	2.41	2.75	3.12
RAINS	60	1.78	2.27	2.63	3.12	3.56	4.06
RAINS	120	2.17	2.79	3.25	3.89	4.46	5.1
RAINS	180	2.4	3.1	3.64	4.38	5.04	5.77
RAINS	360	2.81	3.65	4.35	5.3	6.14	7.05
RAINS	720	3.24	4.26	5.15	6.37	7.43	8.56
RAINS	1440	3.71	4.93	6.07	7.62	8.95	10.36
RANDALL	15	0.73	1.01	1.19	1.47	1.68	1.98
RANDALL	30	0.96	1.35	1.61	2.03	2.33	2.76
RANDALL	60	1.19	1.68	2.01	2.56	2.98	3.53
RANDALL	120	1.39	1.98	2.39	3.05	3.57	4.24
RANDALL	180	1.51	2.15	2.61	3.31	3.91	4.62
RANDALL	360	1.71	2.44	2.99	3.75	4.46	5.26
RANDALL	720	1.92	2.74	3.39	4.18	5.02	5.9
RANDALL	1440	2.14	3.07	3.82	4.62	5.6	6.56
REAGAN	15	0.76	1.	1.17	1.35	1.51	1.68
REAGAN	30	1.04	1.39	1.64	1.93	2.2	2.49
REAGAN	60	1.3	1.77	2.1	2.52	2.91	3.34
REAGAN	120	1.54	2.11	2.52	3.06	3.56	4.14
REAGAN	180	1.66	2.29	2.74	3.36	3.91	4.56
REAGAN	360	1.86	2.57	3.1	3.83	4.48	5.23
REAGAN	720	2.05	2.85	3.45	4.3	5.02	5.86
REAGAN	1440	2.24	3.13	3.81	4.77	5.57	6.48
REAL	15	0.96	1.25	1.5	1.75	2.	2.28
REAL	30	1.35	1.78	2.16	2.53	2.91	3.33
REAL	60	1.74	2.32	2.85	3.36	3.89	4.48
REAL	120	2.11	2.85	3.53	4.2	4.89	5.66
REAL	180	2.32	3.16	3.93	4.69	5.48	6.35
REAL	360	2.67	3.68	4.62	5.56	6.53	7.58
REAL	720	3.03	4.22	5.35	6.49	7.67	8.92
REAL	1440	3.42	4.8	6.16	7.53	8.95	10.44
REDRIVER	15	1.	1.24	1.43	1.68	1.92	2.15
REDRIVER	30	1.36	1.69	1.97	2.3	2.61	2.92
REDRIVER	60	1.74	2.18	2.57	2.98	3.39	3.8
REDRIVER	120	2.13	2.7	3.22	3.73	4.27	4.8

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
REDRIVER	180	2.37	3.03	3.63	4.23	4.84	5.45
REDRIVER	360	2.81	3.65	4.42	5.17	5.94	6.72
REDRIVER	720	3.3	4.35	5.35	6.28	7.26	8.24
REDRIVER	1440	3.85	5.18	6.44	7.61	8.83	10.08
REEVES	15	0.74	0.99	1.19	1.45	1.67	1.91
REEVES	30	0.93	1.28	1.55	1.91	2.22	2.56
REEVES	60	1.09	1.53	1.87	2.31	2.73	3.16
REEVES	120	1.23	1.74	2.14	2.66	3.17	3.69
REEVES	180	1.3	1.85	2.29	2.84	3.4	3.97
REEVES	360	1.41	2.02	2.51	3.12	3.78	4.43
REEVES	720	1.53	2.18	2.73	3.39	4.15	4.89
REEVES	1440	1.65	2.35	2.95	3.66	4.53	5.37
REFUGIO	15	1.13	1.45	1.67	1.94	2.17	2.41
REFUGIO	30	1.53	2.	2.32	2.72	3.07	3.45
REFUGIO	60	1.95	2.57	3.	3.55	4.05	4.61
REFUGIO	120	2.35	3.14	3.71	4.44	5.1	5.84
REFUGIO	180	2.6	3.48	4.14	4.99	5.75	6.62
REFUGIO	360	3.02	4.1	4.92	6.01	6.97	8.07
REFUGIO	720	3.49	4.78	5.8	7.17	8.37	9.74
REFUGIO	1440	4.	5.54	6.8	8.52	10.	11.68
ROBERTS	15	0.76	1.09	1.31	1.66	1.96	2.3
ROBERTS	30	1.	1.42	1.71	2.16	2.55	3.01
ROBERTS	60	1.23	1.74	2.09	2.65	3.12	3.69
ROBERTS	120	1.45	2.05	2.48	3.12	3.67	4.33
ROBERTS	180	1.58	2.23	2.7	3.4	3.99	4.71
ROBERTS	360	1.81	2.55	3.11	3.89	4.56	5.36
ROBERTS	720	2.05	2.89	3.55	4.42	5.17	6.06
ROBERTS	1440	2.31	3.26	4.04	5.	5.84	6.82
ROBERTSON	15	0.98	1.29	1.53	1.81	2.09	2.42
ROBERTSON	30	1.35	1.78	2.11	2.5	2.9	3.39
ROBERTSON	60	1.72	2.29	2.71	3.23	3.76	4.42
ROBERTSON	120	2.08	2.8	3.33	3.99	4.67	5.5
ROBERTSON	180	2.29	3.11	3.71	4.46	5.23	6.16
ROBERTSON	360	2.67	3.65	4.38	5.31	6.26	7.37
ROBERTSON	720	3.07	4.24	5.12	6.28	7.42	8.73
ROBERTSON	1440	3.51	4.9	5.97	7.39	8.75	10.29
ROCKWALL	15	1.02	1.31	1.52	1.77	2.01	2.25

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
ROCKWALL	30	1.39	1.78	2.05	2.38	2.7	3.02
ROCKWALL	60	1.76	2.26	2.61	3.03	3.44	3.86
ROCKWALL	120	2.13	2.75	3.19	3.72	4.24	4.77
ROCKWALL	180	2.34	3.05	3.54	4.16	4.76	5.35
ROCKWALL	360	2.72	3.58	4.2	4.97	5.73	6.46
ROCKWALL	720	3.13	4.16	4.94	5.91	6.85	7.75
ROCKWALL	1440	3.58	4.82	5.79	7.	8.18	9.28
RUNNELS	15	0.81	1.08	1.25	1.48	1.66	1.83
RUNNELS	30	1.08	1.46	1.71	2.05	2.32	2.57
RUNNELS	60	1.36	1.84	2.18	2.64	3.01	3.37
RUNNELS	120	1.63	2.23	2.65	3.24	3.73	4.21
RUNNELS	180	1.8	2.45	2.93	3.6	4.16	4.73
RUNNELS	360	2.08	2.85	3.44	4.25	4.94	5.67
RUNNELS	720	2.4	3.29	4.	4.96	5.81	6.73
RUNNELS	1440	2.74	3.77	4.62	5.76	6.78	7.95
RUSK	15	0.96	1.26	1.48	1.76	2.01	2.28
RUSK	30	1.36	1.78	2.1	2.51	2.89	3.3
RUSK	60	1.76	2.32	2.75	3.3	3.84	4.41
RUSK	120	2.16	2.87	3.42	4.13	4.81	5.55
RUSK	180	2.4	3.19	3.82	4.62	5.4	6.25
RUSK	360	2.81	3.78	4.54	5.51	6.45	7.49
RUSK	720	3.25	4.42	5.32	6.49	7.6	8.87
RUSK	1440	3.74	5.13	6.2	7.6	8.9	10.43
SABINE	15	1.05	1.36	1.57	1.83	2.08	2.36
SABINE	30	1.45	1.89	2.22	2.62	3.02	3.47
SABINE	60	1.86	2.45	2.9	3.46	4.04	4.68
SABINE	120	2.28	3.02	3.6	4.34	5.1	5.95
SABINE	180	2.53	3.37	4.02	4.87	5.73	6.71
SABINE	360	2.98	4.01	4.79	5.82	6.86	8.08
SABINE	720	3.48	4.71	5.65	6.88	8.1	9.59
SABINE	1440	4.03	5.51	6.62	8.08	9.5	11.29
SANAUGUSTINE	15	1.04	1.33	1.5	1.76	1.98	2.21
SANAUGUSTINE	30	1.45	1.87	2.14	2.53	2.9	3.28
SANAUGUSTINE	60	1.86	2.44	2.81	3.36	3.9	4.45
SANAUGUSTINE	120	2.27	3.01	3.5	4.2	4.91	5.66
SANAUGUSTINE	180	2.52	3.35	3.91	4.7	5.51	6.38
SANAUGUSTINE	360	2.94	3.96	4.64	5.6	6.55	7.65

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
SANAUGUSTINE	720	3.4	4.62	5.43	6.58	7.67	9.02
SANAUGUSTINE	1440	3.91	5.36	6.32	7.68	8.9	10.54
SANJACINTO	15	1.09	1.4	1.61	1.87	2.16	2.44
SANJACINTO	30	1.53	1.97	2.29	2.68	3.13	3.56
SANJACINTO	60	1.99	2.59	3.03	3.58	4.22	4.85
SANJACINTO	120	2.45	3.23	3.82	4.55	5.41	6.26
SANJACINTO	180	2.72	3.62	4.31	5.16	6.16	7.17
SANJACINTO	360	3.19	4.32	5.22	6.31	7.56	8.87
SANJACINTO	720	3.69	5.11	6.25	7.63	9.19	10.88
SANJACINTO	1440	4.25	6.01	7.45	9.19	11.12	13.28
SANPATRICIO	15	1.09	1.4	1.59	1.82	2.04	2.24
SANPATRICIO	30	1.47	1.91	2.21	2.57	2.92	3.25
SANPATRICIO	60	1.85	2.45	2.87	3.39	3.89	4.39
SANPATRICIO	120	2.23	3.01	3.57	4.27	4.95	5.64
SANPATRICIO	180	2.47	3.35	4.	4.83	5.62	6.44
SANPATRICIO	360	2.9	3.98	4.82	5.87	6.89	7.94
SANPATRICIO	720	3.37	4.69	5.75	7.06	8.34	9.67
SANPATRICIO	1440	3.91	5.51	6.83	8.46	10.05	11.71
SANSABA	15	0.88	1.14	1.34	1.58	1.82	2.07
SANSABA	30	1.16	1.54	1.82	2.15	2.49	2.89
SANSABA	60	1.44	1.93	2.3	2.74	3.19	3.75
SANSABA	120	1.7	2.31	2.78	3.34	3.92	4.64
SANSABA	180	1.85	2.53	3.06	3.7	4.36	5.18
SANSABA	360	2.12	2.91	3.55	4.35	5.17	6.17
SANSABA	720	2.4	3.31	4.08	5.07	6.08	7.27
SANSABA	1440	2.7	3.75	4.66	5.88	7.12	8.54
SCHLEICHER	15	0.84	1.08	1.24	1.44	1.63	1.8
SCHLEICHER	30	1.15	1.52	1.79	2.11	2.42	2.71
SCHLEICHER	60	1.44	1.96	2.35	2.82	3.26	3.73
SCHLEICHER	120	1.7	2.35	2.86	3.49	4.07	4.72
SCHLEICHER	180	1.84	2.56	3.13	3.85	4.52	5.28
SCHLEICHER	360	2.05	2.9	3.57	4.44	5.26	6.18
SCHLEICHER	720	2.26	3.23	4.	5.02	5.98	7.05
SCHLEICHER	1440	2.48	3.56	4.43	5.61	6.74	7.96
SCURRY	15	0.71	0.95	1.12	1.3	1.47	1.63
SCURRY	30	0.98	1.31	1.56	1.84	2.11	2.38
SCURRY	60	1.24	1.68	2.02	2.41	2.78	3.19

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
SCURRY	120	1.51	2.05	2.48	2.98	3.47	4.01
SCURRY	180	1.66	2.28	2.75	3.31	3.87	4.49
SCURRY	360	1.94	2.67	3.22	3.91	4.59	5.31
SCURRY	720	2.23	3.11	3.72	4.56	5.37	6.19
SCURRY	1440	2.56	3.59	4.28	5.28	6.24	7.14
SHACKELFORD	15	0.84	1.11	1.32	1.54	1.77	2.
SHACKELFORD	30	1.16	1.54	1.83	2.16	2.51	2.88
SHACKELFORD	60	1.47	1.97	2.36	2.82	3.28	3.81
SHACKELFORD	120	1.76	2.38	2.87	3.47	4.06	4.75
SHACKELFORD	180	1.93	2.61	3.17	3.86	4.52	5.31
SHACKELFORD	360	2.22	3.02	3.69	4.54	5.34	6.29
SHACKELFORD	720	2.53	3.45	4.24	5.28	6.22	7.35
SHACKELFORD	1440	2.85	3.91	4.84	6.1	7.2	8.52
SHELBY	15	0.97	1.24	1.43	1.65	1.86	2.08
SHELBY	30	1.35	1.75	2.06	2.42	2.76	3.13
SHELBY	60	1.75	2.3	2.73	3.26	3.77	4.33
SHELBY	120	2.15	2.87	3.43	4.14	4.82	5.6
SHELBY	180	2.39	3.21	3.86	4.68	5.45	6.37
SHELBY	360	2.83	3.84	4.63	5.64	6.59	7.76
SHELBY	720	3.31	4.54	5.48	6.7	7.82	9.29
SHELBY	1440	3.84	5.34	6.45	7.9	9.21	11.02
SHERMAN	15	0.74	1.03	1.25	1.55	1.82	2.13
SHERMAN	30	0.95	1.32	1.6	1.99	2.33	2.75
SHERMAN	60	1.14	1.59	1.93	2.4	2.82	3.33
SHERMAN	120	1.32	1.84	2.24	2.78	3.29	3.89
SHERMAN	180	1.42	1.98	2.42	3.	3.56	4.22
SHERMAN	360	1.6	2.23	2.73	3.38	4.05	4.79
SHERMAN	720	1.79	2.49	3.05	3.77	4.57	5.4
SHERMAN	1440	2.	2.77	3.4	4.2	5.15	6.06
SMITH	15	0.97	1.26	1.51	1.81	2.11	2.42
SMITH	30	1.36	1.76	2.09	2.49	2.91	3.36
SMITH	60	1.76	2.28	2.71	3.24	3.78	4.37
SMITH	120	2.16	2.83	3.37	4.03	4.71	5.45
SMITH	180	2.39	3.16	3.77	4.53	5.29	6.12
SMITH	360	2.81	3.76	4.52	5.47	6.38	7.37
SMITH	720	3.26	4.43	5.37	6.53	7.62	8.78
SMITH	1440	3.75	5.18	6.34	7.78	9.07	10.43

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
SOMERVELL	15	0.93	1.21	1.42	1.63	1.9	2.18
SOMERVELL	30	1.26	1.65	1.94	2.25	2.61	3.01
SOMERVELL	60	1.6	2.1	2.49	2.9	3.38	3.92
SOMERVELL	120	1.93	2.57	3.06	3.6	4.2	4.89
SOMERVELL	180	2.13	2.85	3.41	4.03	4.72	5.5
SOMERVELL	360	2.49	3.36	4.05	4.82	5.69	6.64
SOMERVELL	720	2.87	3.93	4.78	5.73	6.81	7.95
SOMERVELL	1440	3.3	4.58	5.62	6.77	8.11	9.48
STARR	15	0.95	1.26	1.5	1.75	2.01	2.29
STARR	30	1.34	1.81	2.15	2.55	2.97	3.41
STARR	60	1.71	2.35	2.8	3.37	3.97	4.58
STARR	120	2.02	2.83	3.38	4.12	4.9	5.7
STARR	180	2.18	3.08	3.69	4.51	5.4	6.3
STARR	360	2.42	3.45	4.17	5.13	6.19	7.26
STARR	720	2.63	3.79	4.62	5.72	6.92	8.18
STARR	1440	2.83	4.12	5.07	6.3	7.65	9.11
STEPHENS	15	0.88	1.15	1.35	1.58	1.79	2.05
STEPHENS	30	1.2	1.59	1.88	2.21	2.52	2.9
STEPHENS	60	1.52	2.02	2.42	2.87	3.28	3.81
STEPHENS	120	1.83	2.45	2.95	3.54	4.08	4.76
STEPHENS	180	2.01	2.69	3.26	3.96	4.56	5.33
STEPHENS	360	2.32	3.12	3.82	4.71	5.44	6.37
STEPHENS	720	2.65	3.57	4.41	5.54	6.41	7.52
STEPHENS	1440	3.01	4.06	5.07	6.48	7.52	8.83
STERLING	15	0.72	0.96	1.12	1.32	1.48	1.67
STERLING	30	0.99	1.34	1.58	1.88	2.15	2.45
STERLING	60	1.25	1.72	2.04	2.46	2.84	3.26
STERLING	120	1.49	2.07	2.48	3.01	3.51	4.04
STERLING	180	1.63	2.27	2.73	3.32	3.87	4.47
STERLING	360	1.85	2.6	3.14	3.83	4.48	5.18
STERLING	720	2.07	2.93	3.55	4.35	5.08	5.89
STERLING	1440	2.31	3.29	3.99	4.89	5.7	6.63
STONEWALL	15	0.77	1.02	1.18	1.39	1.6	1.78
STONEWALL	30	1.03	1.4	1.65	1.98	2.29	2.62
STONEWALL	60	1.3	1.79	2.12	2.6	3.04	3.53
STONEWALL	120	1.56	2.17	2.6	3.22	3.79	4.45
STONEWALL	180	1.72	2.4	2.88	3.59	4.24	4.98

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
STONEWALL	360	2.	2.8	3.37	4.24	5.02	5.9
STONEWALL	720	2.31	3.24	3.91	4.93	5.87	6.86
STONEWALL	1440	2.65	3.73	4.5	5.7	6.8	7.9
SUTTON	15	0.85	1.1	1.28	1.48	1.66	1.84
SUTTON	30	1.2	1.6	1.88	2.22	2.52	2.85
SUTTON	60	1.55	2.1	2.51	3.02	3.49	4.01
SUTTON	120	1.86	2.58	3.1	3.8	4.45	5.17
SUTTON	180	2.03	2.83	3.43	4.24	4.98	5.82
SUTTON	360	2.3	3.24	3.96	4.95	5.86	6.87
SUTTON	720	2.55	3.65	4.48	5.67	6.72	7.89
SUTTON	1440	2.82	4.06	5.02	6.41	7.63	8.94
SWISHER	15	0.74	0.99	1.17	1.44	1.64	1.9
SWISHER	30	0.98	1.35	1.61	2.02	2.33	2.7
SWISHER	60	1.22	1.7	2.05	2.59	3.03	3.52
SWISHER	120	1.44	2.02	2.46	3.11	3.67	4.27
SWISHER	180	1.56	2.21	2.7	3.4	4.03	4.69
SWISHER	360	1.78	2.52	3.1	3.87	4.61	5.38
SWISHER	720	2.	2.84	3.51	4.34	5.2	6.07
SWISHER	1440	2.24	3.19	3.95	4.84	5.81	6.78
TARRANT	15	0.98	1.28	1.5	1.74	2.	2.27
TARRANT	30	1.32	1.72	2.01	2.35	2.68	3.03
TARRANT	60	1.65	2.17	2.53	2.98	3.39	3.84
TARRANT	120	1.99	2.63	3.08	3.63	4.16	4.71
TARRANT	180	2.2	2.91	3.41	4.04	4.63	5.26
TARRANT	360	2.56	3.42	4.03	4.78	5.53	6.29
TARRANT	720	2.96	3.98	4.72	5.6	6.56	7.48
TARRANT	1440	3.4	4.61	5.5	6.55	7.75	8.87
TAYLOR	15	0.79	1.05	1.23	1.44	1.63	1.82
TAYLOR	30	1.08	1.45	1.71	2.02	2.3	2.59
TAYLOR	60	1.38	1.86	2.2	2.62	3.01	3.43
TAYLOR	120	1.67	2.27	2.7	3.24	3.75	4.29
TAYLOR	180	1.85	2.51	3.	3.61	4.2	4.82
TAYLOR	360	2.15	2.94	3.54	4.28	5.01	5.78
TAYLOR	720	2.49	3.41	4.13	5.01	5.91	6.84
TAYLOR	1440	2.86	3.93	4.79	5.82	6.93	8.06
TERRELL	15	0.87	1.13	1.32	1.52	1.7	1.92
TERRELL	30	1.11	1.5	1.77	2.07	2.35	2.67

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
TERRELL	60	1.33	1.83	2.2	2.61	3.	3.43
TERRELL	120	1.52	2.14	2.59	3.12	3.63	4.16
TERRELL	180	1.63	2.3	2.8	3.41	3.98	4.58
TERRELL	360	1.8	2.58	3.16	3.9	4.57	5.31
TERRELL	720	1.98	2.85	3.52	4.41	5.18	6.06
TERRELL	1440	2.17	3.14	3.89	4.95	5.83	6.88
TERRY	15	0.7	0.97	1.16	1.43	1.65	1.93
TERRY	30	0.93	1.3	1.57	1.95	2.25	2.66
TERRY	60	1.16	1.62	1.97	2.46	2.85	3.39
TERRY	120	1.37	1.92	2.35	2.95	3.42	4.08
TERRY	180	1.49	2.1	2.56	3.23	3.75	4.47
TERRY	360	1.69	2.4	2.93	3.71	4.33	5.15
TERRY	720	1.91	2.72	3.31	4.21	4.93	5.86
TERRY	1440	2.14	3.07	3.71	4.75	5.58	6.62
THROCKMORTON	15	0.86	1.12	1.31	1.53	1.73	1.93
THROCKMORTON	30	1.15	1.54	1.83	2.18	2.5	2.83
THROCKMORTON	60	1.44	1.95	2.35	2.85	3.31	3.81
THROCKMORTON	120	1.73	2.35	2.86	3.5	4.11	4.77
THROCKMORTON	180	1.9	2.59	3.16	3.89	4.56	5.32
THROCKMORTON	360	2.2	3.01	3.68	4.55	5.34	6.25
THROCKMORTON	720	2.53	3.45	4.22	5.24	6.14	7.19
THROCKMORTON	1440	2.89	3.94	4.82	6.	7.	8.19
TITUS	15	0.97	1.23	1.44	1.69	1.94	2.2
TITUS	30	1.36	1.71	2.01	2.35	2.68	3.02
TITUS	60	1.77	2.22	2.62	3.06	3.49	3.92
TITUS	120	2.18	2.74	3.26	3.81	4.36	4.91
TITUS	180	2.42	3.05	3.66	4.28	4.9	5.54
TITUS	360	2.84	3.63	4.39	5.16	5.93	6.73
TITUS	720	3.31	4.27	5.21	6.16	7.11	8.12
TITUS	1440	3.82	5.	6.17	7.34	8.51	9.77
TOMGREEN	15	0.81	1.08	1.25	1.46	1.65	1.87
TOMGREEN	30	1.09	1.47	1.72	2.04	2.35	2.68
TOMGREEN	60	1.35	1.84	2.19	2.63	3.06	3.52
TOMGREEN	120	1.58	2.19	2.62	3.19	3.74	4.33
TOMGREEN	180	1.71	2.38	2.87	3.51	4.12	4.78
TOMGREEN	360	1.93	2.7	3.27	4.03	4.75	5.55
TOMGREEN	720	2.15	3.03	3.69	4.57	5.39	6.32

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
TOMGREEN	1440	2.38	3.37	4.12	5.14	6.07	7.15
TRAVIS	15	0.95	1.24	1.45	1.73	1.99	2.2
TRAVIS	30	1.33	1.74	2.05	2.45	2.83	3.18
TRAVIS	60	1.72	2.26	2.67	3.22	3.74	4.25
TRAVIS	120	2.09	2.77	3.29	4.	4.66	5.35
TRAVIS	180	2.31	3.08	3.66	4.46	5.22	6.01
TRAVIS	360	2.69	3.61	4.32	5.28	6.23	7.19
TRAVIS	720	3.09	4.18	5.03	6.16	7.34	8.49
TRAVIS	1440	3.52	4.82	5.82	7.16	8.6	9.97
TRINITY	15	1.06	1.39	1.6	1.89	2.12	2.37
TRINITY	30	1.49	1.95	2.28	2.71	3.05	3.43
TRINITY	60	1.92	2.53	2.99	3.59	4.07	4.62
TRINITY	120	2.34	3.12	3.72	4.49	5.14	5.88
TRINITY	180	2.59	3.47	4.16	5.03	5.79	6.65
TRINITY	360	3.01	4.1	4.94	6.02	6.97	8.09
TRINITY	720	3.45	4.79	5.8	7.1	8.28	9.71
TRINITY	1440	3.94	5.56	6.77	8.32	9.78	11.59
TYLER	15	1.1	1.37	1.6	1.82	2.06	2.29
TYLER	30	1.54	1.94	2.3	2.64	3.01	3.39
TYLER	60	2.01	2.55	3.06	3.54	4.08	4.63
TYLER	120	2.47	3.17	3.83	4.49	5.21	5.97
TYLER	180	2.75	3.54	4.3	5.07	5.91	6.79
TYLER	360	3.23	4.2	5.14	6.13	7.18	8.31
TYLER	720	3.75	4.92	6.07	7.32	8.61	10.03
TYLER	1440	4.32	5.73	7.12	8.69	10.27	12.03
UPSHUR	15	0.94	1.22	1.43	1.69	1.92	2.17
UPSHUR	30	1.33	1.71	2.01	2.36	2.69	3.04
UPSHUR	60	1.74	2.24	2.63	3.11	3.55	4.03
UPSHUR	120	2.15	2.79	3.29	3.92	4.48	5.12
UPSHUR	180	2.39	3.12	3.71	4.42	5.08	5.81
UPSHUR	360	2.83	3.74	4.48	5.38	6.2	7.12
UPSHUR	720	3.29	4.43	5.35	6.47	7.5	8.66
UPSHUR	1440	3.8	5.22	6.36	7.76	9.04	10.47
UPTON	15	0.77	1.04	1.22	1.44	1.64	1.83
UPTON	30	1.02	1.39	1.65	1.99	2.27	2.58
UPTON	60	1.26	1.72	2.06	2.51	2.89	3.31
UPTON	120	1.46	2.01	2.42	2.98	3.45	3.98

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
UPTON	180	1.57	2.16	2.62	3.23	3.76	4.34
UPTON	360	1.74	2.41	2.93	3.63	4.25	4.93
UPTON	720	1.91	2.66	3.24	4.03	4.73	5.52
UPTON	1440	2.08	2.91	3.55	4.43	5.23	6.12
UVALDE	15	1.04	1.36	1.6	1.88	2.17	2.45
UVALDE	30	1.41	1.88	2.26	2.68	3.14	3.59
UVALDE	60	1.78	2.42	2.94	3.54	4.18	4.84
UVALDE	120	2.12	2.94	3.62	4.4	5.22	6.09
UVALDE	180	2.32	3.25	4.02	4.91	5.84	6.82
UVALDE	360	2.66	3.78	4.73	5.81	6.91	8.09
UVALDE	720	3.02	4.34	5.49	6.78	8.07	9.44
UVALDE	1440	3.4	4.96	6.34	7.87	9.37	10.95
VALVERDE	15	0.9	1.19	1.39	1.63	1.88	2.12
VALVERDE	30	1.22	1.66	1.96	2.34	2.7	3.08
VALVERDE	60	1.52	2.12	2.54	3.07	3.58	4.12
VALVERDE	120	1.79	2.55	3.1	3.78	4.44	5.15
VALVERDE	180	1.95	2.78	3.41	4.19	4.94	5.75
VALVERDE	360	2.2	3.18	3.94	4.88	5.82	6.8
VALVERDE	720	2.45	3.59	4.48	5.59	6.75	7.9
VALVERDE	1440	2.72	4.02	5.06	6.36	7.78	9.12
VANZANDT	15	1.	1.29	1.52	1.81	2.07	2.33
VANZANDT	30	1.39	1.79	2.1	2.47	2.78	3.15
VANZANDT	60	1.79	2.31	2.69	3.16	3.56	4.03
VANZANDT	120	2.18	2.82	3.31	3.89	4.39	5.
VANZANDT	180	2.4	3.13	3.68	4.34	4.91	5.61
VANZANDT	360	2.79	3.66	4.36	5.18	5.89	6.76
VANZANDT	720	3.21	4.24	5.11	6.14	7.02	8.09
VANZANDT	1440	3.66	4.88	5.97	7.24	8.35	9.66
VICTORIA	15	1.12	1.46	1.71	1.98	2.23	2.55
VICTORIA	30	1.55	2.01	2.37	2.75	3.12	3.57
VICTORIA	60	1.97	2.59	3.08	3.59	4.09	4.7
VICTORIA	120	2.39	3.18	3.82	4.49	5.14	5.92
VICTORIA	180	2.63	3.53	4.27	5.05	5.8	6.7
VICTORIA	360	3.06	4.18	5.11	6.12	7.05	8.18
VICTORIA	720	3.52	4.89	6.05	7.34	8.49	9.9
VICTORIA	1440	4.02	5.7	7.13	8.77	10.18	11.92
WALKER	15	1.07	1.4	1.62	1.91	2.17	2.46

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
WALKER	30	1.47	1.93	2.27	2.69	3.09	3.53
WALKER	60	1.88	2.49	2.95	3.53	4.09	4.73
WALKER	120	2.28	3.06	3.65	4.42	5.16	6.
WALKER	180	2.51	3.41	4.08	4.97	5.82	6.79
WALKER	360	2.93	4.04	4.86	5.98	7.04	8.26
WALKER	720	3.38	4.74	5.73	7.12	8.43	9.94
WALKER	1440	3.88	5.53	6.72	8.44	10.06	11.91
WALLER	15	1.08	1.39	1.59	1.81	2.03	2.29
WALLER	30	1.47	1.91	2.2	2.54	2.88	3.26
WALLER	60	1.86	2.44	2.84	3.32	3.81	4.36
WALLER	120	2.24	2.99	3.51	4.15	4.82	5.56
WALLER	180	2.47	3.32	3.93	4.67	5.46	6.32
WALLER	360	2.87	3.93	4.7	5.65	6.66	7.76
WALLER	720	3.3	4.59	5.57	6.77	8.05	9.44
WALLER	1440	3.78	5.35	6.57	8.08	9.7	11.46
WARD	15	0.73	1.02	1.22	1.46	1.72	1.96
WARD	30	0.92	1.3	1.57	1.92	2.27	2.61
WARD	60	1.08	1.55	1.89	2.35	2.8	3.24
WARD	120	1.22	1.78	2.17	2.73	3.28	3.82
WARD	180	1.29	1.9	2.33	2.95	3.55	4.14
WARD	360	1.42	2.11	2.6	3.3	4.01	4.68
WARD	720	1.55	2.32	2.87	3.66	4.48	5.24
WARD	1440	1.68	2.54	3.16	4.04	4.98	5.84
WASHINGTON	15	1.01	1.34	1.59	1.83	2.1	2.37
WASHINGTON	30	1.4	1.85	2.21	2.59	2.96	3.38
WASHINGTON	60	1.79	2.37	2.86	3.39	3.9	4.47
WASHINGTON	120	2.17	2.9	3.52	4.21	4.88	5.61
WASHINGTON	180	2.39	3.22	3.91	4.71	5.48	6.3
WASHINGTON	360	2.76	3.79	4.63	5.61	6.59	7.56
WASHINGTON	720	3.16	4.41	5.42	6.62	7.84	8.98
WASHINGTON	1440	3.59	5.11	6.31	7.76	9.29	10.61
WEBB	15	0.97	1.29	1.53	1.83	2.08	2.37
WEBB	30	1.33	1.82	2.2	2.67	3.07	3.52
WEBB	60	1.68	2.35	2.88	3.54	4.11	4.75
WEBB	120	1.98	2.83	3.5	4.36	5.1	5.93
WEBB	180	2.14	3.09	3.84	4.81	5.64	6.58
WEBB	360	2.4	3.52	4.37	5.54	6.53	7.62

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
WEBB	720	2.64	3.94	4.89	6.25	7.4	8.63
WEBB	1440	2.89	4.38	5.42	6.97	8.29	9.68
WHARTON	15	1.13	1.45	1.67	1.95	2.21	2.47
WHARTON	30	1.58	2.02	2.35	2.75	3.14	3.57
WHARTON	60	2.03	2.62	3.06	3.62	4.16	4.78
WHARTON	120	2.46	3.22	3.78	4.52	5.23	6.07
WHARTON	180	2.7	3.57	4.22	5.08	5.89	6.87
WHARTON	360	3.13	4.2	5.01	6.1	7.12	8.36
WHARTON	720	3.57	4.87	5.89	7.25	8.51	10.07
WHARTON	1440	4.05	5.63	6.88	8.59	10.14	12.08
WHEELER	15	0.78	1.1	1.31	1.63	1.93	2.25
WHEELER	30	1.03	1.45	1.75	2.19	2.59	3.05
WHEELER	60	1.28	1.81	2.19	2.75	3.26	3.85
WHEELER	120	1.53	2.16	2.62	3.3	3.92	4.64
WHEELER	180	1.68	2.36	2.88	3.63	4.3	5.09
WHEELER	360	1.94	2.73	3.33	4.2	4.98	5.89
WHEELER	720	2.23	3.13	3.83	4.82	5.71	6.75
WHEELER	1440	2.55	3.57	4.39	5.5	6.52	7.69
WICHITA	15	0.83	1.07	1.24	1.48	1.71	1.96
WICHITA	30	1.11	1.48	1.76	2.13	2.48	2.87
WICHITA	60	1.4	1.91	2.31	2.82	3.3	3.86
WICHITA	120	1.7	2.35	2.86	3.52	4.14	4.87
WICHITA	180	1.9	2.61	3.19	3.93	4.63	5.45
WICHITA	360	2.26	3.1	3.78	4.66	5.49	6.46
WICHITA	720	2.66	3.63	4.42	5.43	6.4	7.51
WICHITA	1440	3.13	4.24	5.13	6.28	7.4	8.65
WILBARGER	15	0.82	1.07	1.26	1.48	1.7	1.94
WILBARGER	30	1.08	1.47	1.76	2.11	2.45	2.84
WILBARGER	60	1.36	1.88	2.29	2.78	3.27	3.84
WILBARGER	120	1.65	2.3	2.82	3.45	4.09	4.85
WILBARGER	180	1.83	2.55	3.14	3.85	4.57	5.44
WILBARGER	360	2.16	3.01	3.7	4.55	5.41	6.45
WILBARGER	720	2.54	3.52	4.31	5.29	6.29	7.5
WILBARGER	1440	2.97	4.09	4.99	6.12	7.25	8.64
WILLACY	15	1.04	1.36	1.55	1.81	2.05	2.25
WILLACY	30	1.46	1.91	2.22	2.62	2.98	3.33
WILLACY	60	1.88	2.47	2.91	3.46	3.98	4.5

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Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
WILLACY	120	2.26	3.	3.56	4.29	4.98	5.67
WILLACY	180	2.45	3.29	3.93	4.76	5.56	6.35
WILLACY	360	2.77	3.77	4.55	5.57	6.58	7.52
WILLACY	720	3.07	4.26	5.19	6.41	7.65	8.74
WILLACY	1440	3.37	4.77	5.86	7.31	8.81	10.06
WILLIAMSON	15	0.93	1.23	1.44	1.68	1.96	2.2
WILLIAMSON	30	1.31	1.72	2.03	2.42	2.81	3.19
WILLIAMSON	60	1.69	2.23	2.65	3.19	3.73	4.27
WILLIAMSON	120	2.06	2.73	3.27	3.96	4.66	5.37
WILLIAMSON	180	2.26	3.02	3.63	4.42	5.2	6.03
WILLIAMSON	360	2.61	3.53	4.28	5.21	6.17	7.19
WILLIAMSON	720	2.97	4.07	4.98	6.05	7.22	8.46
WILLIAMSON	1440	3.35	4.67	5.76	6.99	8.39	9.89
WILSON	15	1.1	1.45	1.7	2.01	2.33	2.65
WILSON	30	1.47	1.95	2.3	2.72	3.17	3.61
WILSON	60	1.83	2.45	2.91	3.44	4.02	4.6
WILSON	120	2.18	2.94	3.51	4.17	4.88	5.6
WILSON	180	2.37	3.23	3.86	4.61	5.4	6.21
WILSON	360	2.7	3.74	4.48	5.41	6.33	7.32
WILSON	720	3.05	4.28	5.14	6.29	7.36	8.54
WILSON	1440	3.42	4.89	5.88	7.28	8.51	9.94
WINKLER	15	0.71	1.	1.2	1.45	1.72	2.01
WINKLER	30	0.92	1.31	1.58	1.95	2.31	2.71
WINKLER	60	1.11	1.6	1.93	2.41	2.87	3.36
WINKLER	120	1.28	1.85	2.25	2.82	3.37	3.95
WINKLER	180	1.37	1.98	2.42	3.03	3.64	4.26
WINKLER	360	1.51	2.2	2.69	3.39	4.09	4.77
WINKLER	720	1.65	2.41	2.97	3.73	4.54	5.28
WINKLER	1440	1.8	2.62	3.26	4.09	5.01	5.82
WISE	15	0.96	1.26	1.47	1.71	1.98	2.27
WISE	30	1.27	1.68	1.96	2.31	2.65	3.04
WISE	60	1.58	2.1	2.47	2.93	3.36	3.86
WISE	120	1.9	2.54	3.	3.58	4.12	4.75
WISE	180	2.09	2.81	3.32	3.98	4.59	5.3
WISE	360	2.45	3.3	3.92	4.72	5.49	6.35
WISE	720	2.83	3.84	4.59	5.55	6.52	7.55
WISE	1440	3.27	4.46	5.36	6.5	7.72	8.95

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
WOOD	15	0.96	1.24	1.46	1.72	1.95	2.21
WOOD	30	1.35	1.73	2.03	2.37	2.68	3.04
WOOD	60	1.75	2.24	2.63	3.08	3.5	3.97
WOOD	120	2.16	2.78	3.28	3.85	4.39	5.01
WOOD	180	2.4	3.1	3.68	4.34	4.96	5.67
WOOD	360	2.82	3.7	4.43	5.26	6.03	6.93
WOOD	720	3.27	4.36	5.27	6.32	7.29	8.41
WOOD	1440	3.77	5.11	6.26	7.57	8.76	10.16
YOAKUM	15	0.7	0.97	1.17	1.44	1.7	1.99
YOAKUM	30	0.91	1.28	1.57	1.94	2.29	2.69
YOAKUM	60	1.12	1.58	1.94	2.43	2.85	3.37
YOAKUM	120	1.31	1.86	2.29	2.88	3.37	4.01
YOAKUM	180	1.42	2.02	2.48	3.13	3.66	4.36
YOAKUM	360	1.62	2.29	2.81	3.54	4.15	4.98
YOAKUM	720	1.82	2.56	3.14	3.96	4.65	5.61
YOAKUM	1440	2.04	2.86	3.49	4.4	5.18	6.28
YOUNG	15	0.88	1.16	1.37	1.62	1.87	2.15
YOUNG	30	1.18	1.58	1.89	2.25	2.62	3.03
YOUNG	60	1.49	2.	2.42	2.91	3.41	3.96
YOUNG	120	1.8	2.42	2.94	3.58	4.19	4.91
YOUNG	180	1.98	2.66	3.25	3.98	4.66	5.48
YOUNG	360	2.3	3.1	3.79	4.69	5.49	6.48
YOUNG	720	2.66	3.57	4.38	5.47	6.39	7.58
YOUNG	1440	3.05	4.09	5.02	6.33	7.39	8.8
ZAPATA	15	0.94	1.26	1.47	1.72	1.98	2.26
ZAPATA	30	1.3	1.8	2.13	2.53	2.94	3.38
ZAPATA	60	1.65	2.33	2.78	3.36	3.95	4.57
ZAPATA	120	1.94	2.8	3.36	4.11	4.89	5.7
ZAPATA	180	2.09	3.04	3.66	4.51	5.39	6.31
ZAPATA	360	2.31	3.41	4.12	5.13	6.17	7.27
ZAPATA	720	2.51	3.76	4.53	5.7	6.89	8.17
ZAPATA	1440	2.7	4.1	4.93	6.25	7.59	9.08
ZAVALA	15	1.07	1.42	1.73	2.03	2.34	2.67
ZAVALA	30	1.43	1.95	2.39	2.86	3.34	3.83
ZAVALA	60	1.77	2.47	3.06	3.72	4.39	5.05
ZAVALA	120	2.08	2.96	3.71	4.56	5.41	6.26
ZAVALA	180	2.26	3.23	4.08	5.03	5.99	6.95

Continued on next page

Table 3: Depth-Duration-Frequency Values for 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	$T_c(min.)$	$D_2(in.)$	$D_5(in.)$	$D_{10}(in.)$	$D_{25}(in.)$	$D_{50}(in.)$	$D_{100}(in.)$
ZAVALA	360	2.57	3.71	4.72	5.86	6.99	8.14
ZAVALA	720	2.89	4.2	5.4	6.72	8.04	9.39
ZAVALA	1440	3.23	4.72	6.13	7.68	9.2	10.77

12 Appendix – V: Revised 2015 EBD Values

Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI)

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
ANDERSON	0.816	58	11.4	0.803	73	11.7	0.787	80	11.1
ANDREWS	0.844	40	8.1	0.849	59	9.2	0.841	69	9.4
ANGELINA	0.815	62	12.7	0.789	71	11.2	0.791	87	13.1
ARANSAS	0.777	52	8.3	0.752	60	8.1	0.737	67	8.6
ARCHER	0.784	39	7.8	0.789	55	9.6	0.800	72	12.5
ARMSTRONG	0.851	46	9.4	0.843	63	10.5	0.829	71	10.5
ATASCOSA	0.836	62	9.0	0.821	79	10.0	0.813	93	10.8
AUSTIN	0.825	63	11.1	0.783	66	9.7	0.768	74	9.5
BAILEY	0.865	44	8.9	0.852	59	9.5	0.865	77	10.5
BANDERA	0.805	55	9.9	0.791	71	11.6	0.793	88	13.3
BASTROP	0.841	67	13.3	0.814	77	11.5	0.805	87	11.1
BAYLOR	0.782	37	6.7	0.785	52	9.6	0.781	63	11.8
BEE	0.832	62	9.2	0.830	84	10.8	0.809	91	11.2
BELL	0.836	60	14.4	0.814	71	13.5	0.808	83	14.5
BEXAR	0.835	64	10.7	0.803	73	9.5	0.802	88	10.2
BLANCO	0.799	50	9.6	0.785	61	9.7	0.784	72	10.9
BORDEN	0.829	41	10.8	0.806	51	10.0	0.810	63	11.1
BOSQUE	0.809	50	10.5	0.796	62	9.8	0.793	74	10.3
BOWIE	0.770	45	9.7	0.766	57	9.7	0.753	63	9.0
BRAZORIA	0.781	57	10.2	0.769	71	10.5	0.759	79	10.4
BRAZOS	0.823	59	11.3	0.809	74	11.2	0.803	86	11.4
BREWSTER	0.962	70	9.1	0.950	91	10.1	0.877	74	8.1
BRISCOE	0.836	43	8.7	0.843	64	11.0	0.828	72	10.9
BROOKS	0.891	84	17.3	0.874	106	17.3	0.864	120	17.4
BROWN	0.833	51	11.7	0.821	64	11.5	0.808	72	11.5
BURLESON	0.822	59	11.9	0.794	68	10.7	0.789	79	10.8
BURNET	0.811	47	8.1	0.814	65	9.9	0.801	74	10.8
CALDWELL	0.814	58	10.2	0.803	72	9.7	0.808	88	10.7
CALHOUN	0.803	64	11.3	0.786	77	11.2	0.779	87	11.7
CALLAHAN	0.824	48	10.9	0.812	62	11.3	0.796	69	10.8

Continued on next page

Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
CAMERON	0.866	82	15.2	0.855	102	14.9	0.853	120	16.0
CAMP	0.798	53	12.1	0.769	58	9.8	0.761	66	9.7
CARSON	0.845	43	8.5	0.853	64	9.8	0.834	71	9.1
CASS	0.793	52	12.7	0.777	62	12.0	0.746	62	10.4
CASTRO	0.845	41	8.9	0.851	61	10.1	0.847	72	10.2
CHAMBERS	0.769	55	11.2	0.727	59	11.4	0.710	64	12.3
CHEROKEE	0.810	57	11.3	0.790	68	10.6	0.781	78	10.6
CHILDRESS	0.797	37	6.7	0.812	56	8.8	0.794	63	8.8
CLAY	0.774	38	7.1	0.779	53	8.6	0.778	64	9.4
COCHRAN	0.858	42	9.1	0.861	62	10.2	0.861	76	10.5
COKE	0.824	43	9.7	0.814	56	10.5	0.799	63	11.0
COLEMAN	0.822	46	9.9	0.822	63	10.9	0.799	67	9.3
COLLIN	0.790	48	9.9	0.781	59	9.3	0.762	63	7.7
COLLINGSWORTH	0.800	37	6.8	0.802	53	7.8	0.796	63	7.9
COLORADO	0.827	65	11.3	0.816	81	10.7	0.801	89	10.3
COMAL	0.810	56	10.4	0.797	70	10.9	0.794	82	11.6
COMANCHE	0.825	51	12.5	0.819	66	12.8	0.804	74	12.8
CONCHO	0.855	52	9.6	0.840	68	11.2	0.824	75	11.6
COOKE	0.793	45	6.7	0.768	52	6.3	0.761	60	6.4
CORYELL	0.826	54	13.7	0.809	67	13.7	0.790	72	13.2
COTTLE	0.806	38	7.0	0.809	55	8.9	0.802	65	9.3
CRANE	0.886	48	7.8	0.875	66	8.5	0.873	80	9.6
CROCKETT	0.878	60	10.8	0.871	81	12.0	0.873	98	12.9
CROSBY	0.827	41	8.9	0.838	61	11.4	0.834	73	12.1
CULBERSON	0.894	53	7.7	0.892	63	8.7	0.882	73	8.3
DALLAM	0.848	38	5.8	0.853	54	6.5	0.859	72	7.5
DALLAS	0.824	58	10.8	0.806	69	10.5	0.787	73	8.9
DAWSON	0.827	39	9.1	0.823	53	9.8	0.814	62	9.9
DEAFSMITH	0.853	41	7.5	0.846	57	8.2	0.850	71	9.1
DELTA	0.802	54	10.1	0.769	56	7.8	0.759	62	7.4
DENTON	0.813	52	8.9	0.787	58	7.4	0.787	68	7.6
DEWITT	0.823	61	8.9	0.828	86	10.1	0.813	93	9.6
DICKENS	0.813	39	7.8	0.813	54	9.7	0.819	69	12.2

Continued on next page

Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
DIMMIT	0.877	74	10.7	0.853	92	12.7	0.825	100	12.4
DONLEY	0.821	40	8.3	0.828	60	9.8	0.808	65	9.0
DUVAL	0.904	90	20.7	0.884	114	21.4	0.880	131	22.3
EASTLAND	0.830	53	12.3	0.822	68	12.2	0.812	78	12.4
ECTOR	0.867	46	9.5	0.864	64	9.9	0.849	73	9.8
EDWARDS	0.855	65	14.8	0.827	79	15.7	0.821	94	16.7
ELLIS	0.869	46	7.6	0.873	66	9.4	0.843	68	7.2
ELPASO	0.826	45	7.8	0.822	59	8.7	0.821	71	9.1
ERATH	0.814	49	10.3	0.806	64	10.8	0.790	70	9.9
FALLS	0.820	56	12.2	0.803	69	11.7	0.789	76	10.9
FANNIN	0.802	52	9.0	0.777	58	7.6	0.762	62	7.0
FAYETTE	0.828	63	12.1	0.806	75	11.0	0.793	83	10.5
FISHER	0.799	38	9.3	0.798	53	10.3	0.797	63	11.4
FLOYD	0.832	42	9.0	0.843	63	11.2	0.834	74	11.4
FOARD	0.786	35	6.0	0.792	52	7.9	0.784	60	8.3
FORTBEND	0.811	63	11.2	0.771	67	10.3	0.751	72	10.5
FRANKLIN	0.787	50	10.1	0.775	60	9.3	0.755	63	8.0
FREESTONE	0.817	58	10.6	0.809	73	10.5	0.797	81	10.1
FRIO	0.834	61	9.0	0.837	88	10.6	0.834	106	11.5
GAINES	0.839	39	8.1	0.837	54	8.0	0.834	66	9.0
GALVESTON	0.780	57	10.6	0.765	71	11.3	0.757	81	11.9
GARZA	0.835	43	10.5	0.822	56	10.7	0.833	72	12.3
GILLESPIE	0.811	52	10.3	0.786	61	10.4	0.771	68	10.7
GLASSCOCK	0.868	51	13.1	0.846	64	12.7	0.841	75	13.8
GOLIAD	0.832	64	8.9	0.810	77	9.5	0.800	88	10.6
GONZALES	0.843	68	11.3	0.814	78	9.7	0.811	92	10.6
GRAY	0.835	43	8.7	0.828	58	8.4	0.833	73	9.4
GRAYSON	0.807	51	8.1	0.766	52	6.2	0.767	63	6.7
GREGG	0.794	51	11.3	0.780	63	11.0	0.769	71	10.8
GRIMES	0.817	58	10.2	0.793	70	9.9	0.792	84	11.1
GUADALUPE	0.823	60	10.1	0.809	74	9.4	0.805	86	9.6
HALE	0.828	40	8.7	0.832	58	10.4	0.839	74	12.2
HALL	0.809	38	7.6	0.821	58	9.6	0.817	70	10.2

Continued on next page

Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
HAMILTON	0.821	51	11.5	0.815	66	12.6	0.795	72	11.5
HANSFORD	0.865	46	8.6	0.878	70	9.5	0.879	86	9.9
HARDEMAN	0.792	37	6.9	0.798	52	8.9	0.789	61	9.4
HARDIN	0.770	55	11.8	0.737	60	11.4	0.721	67	12.5
HARRIS	0.784	54	9.0	0.776	70	10.0	0.773	82	11.0
HARRISON	0.779	47	10.4	0.788	66	12.2	0.781	75	12.3
HARTLEY	0.874	44	7.0	0.862	60	7.1	0.869	77	8.6
HASKELL	0.806	41	7.9	0.800	55	9.7	0.796	66	11.7
HAYS	0.822	59	12.6	0.798	69	10.9	0.792	79	11.3
HEMPHILL	0.830	42	8.1	0.827	58	7.8	0.818	67	7.5
HENDERSON	0.808	55	10.6	0.804	71	10.8	0.803	84	11.2
HIDALGO	0.877	78	13.8	0.879	109	15.2	0.869	123	15.6
HILL	0.811	53	10.5	0.803	68	10.5	0.793	76	10.1
HOCKLEY	0.838	40	8.8	0.836	56	9.4	0.849	74	11.1
HOOD	0.816	51	9.9	0.799	62	9.0	0.787	70	8.7
HOPKINS	0.778	47	9.0	0.758	54	7.9	0.741	58	6.7
HOUSTON	0.817	60	11.3	0.800	72	11.0	0.798	86	11.2
HOWARD	0.839	44	11.5	0.842	62	13.0	0.839	73	12.8
HUDSPETH	0.865	31	2.6	0.900	54	5.7	0.877	60	4.9
HUNT	0.814	57	10.7	0.786	60	8.6	0.777	68	7.8
HUTCHINSON	0.846	43	8.0	0.861	65	9.3	0.848	74	8.6
IRION	0.867	54	11.4	0.862	73	12.4	0.863	89	13.7
JACK	0.808	47	8.0	0.803	61	8.8	0.794	70	8.7
JACKSON	0.803	62	10.5	0.797	79	11.1	0.790	91	11.2
JASPER	0.787	57	11.8	0.762	66	11.6	0.748	73	12.1
JEFFDAVIS	0.950	65	11.6	0.933	83	12.0	0.925	95	12.2
JEFFERSON	0.763	55	11.2	0.764	74	13.6	0.756	84	14.4
JIMHOGG	0.890	79	16.5	0.872	103	17.7	0.865	118	18.0
JIMWELLS	0.851	69	13.2	0.844	91	14.3	0.829	99	14.0
JOHNSON	0.805	50	9.2	0.798	65	9.0	0.787	72	8.2
JONES	0.814	44	10.2	0.808	58	10.8	0.790	64	11.2
KARNES	0.858	72	11.8	0.843	90	12.2	0.839	106	12.8
KAUFMAN	0.815	57	10.3	0.806	71	10.2	0.799	80	10.0

Continued on next page

Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
KENDALL	0.822	61	12.5	0.782	66	11.0	0.775	75	11.9
KENEDY	0.856	73	14.3	0.853	97	15.0	0.846	111	15.2
KENT	0.814	39	9.1	0.794	49	9.2	0.811	65	11.4
KERR	0.831	63	13.0	0.842	91	15.9	0.838	107	16.6
KIMBLE	0.860	64	14.0	0.863	90	16.4	0.864	111	18.2
KING	0.803	38	6.9	0.808	53	9.3	0.811	66	11.0
KINNEY	0.855	65	11.4	0.859	96	14.4	0.864	122	15.9
KLEBERG	0.842	69	14.0	0.840	91	15.0	0.831	103	15.3
KNOX	0.795	38	6.9	0.792	52	9.2	0.781	60	10.5
LAMAR	0.801	52	8.9	0.779	60	8.2	0.759	64	7.7
LAMB	0.803	37	6.5	0.806	52	8.3	0.803	63	8.7
LAMPASAS	0.854	55	12.1	0.837	69	11.7	0.827	79	12.0
LASALLE	0.844	61	10.3	0.842	84	12.3	0.835	99	13.5
LAVACA	0.831	66	11.2	0.816	81	10.7	0.809	94	11.3
LEE	0.832	62	12.8	0.804	72	11.6	0.793	82	11.4
LEON	0.808	55	9.6	0.806	73	10.6	0.792	81	10.3
LIBERTY	0.773	55	10.9	0.760	66	12.1	0.744	72	12.1
LIMESTONE	0.815	56	10.6	0.806	71	11.3	0.779	73	9.4
LIPSCOMB	0.836	42	7.6	0.837	60	8.0	0.817	65	7.2
LIVEOAK	0.832	61	9.2	0.818	77	9.9	0.804	85	10.0
LLANO	0.811	45	6.5	0.811	61	8.2	0.796	69	8.8
LOVING	0.865	41	6.7	0.883	67	9.6	0.864	74	8.9
LUBBOCK	0.839	43	10.2	0.830	57	10.5	0.830	69	11.5
LYNN	0.840	42	10.0	0.806	49	8.5	0.817	64	10.4
MADISON	0.804	54	9.4	0.788	67	9.4	0.773	74	9.3
MARION	0.799	53	12.5	0.769	59	10.8	0.755	65	10.4
MARTIN	0.848	44	11.0	0.839	59	11.1	0.830	68	10.9
MASON	0.838	52	9.3	0.824	66	10.7	0.813	75	11.0
MATAGORDA	0.795	62	11.7	0.773	73	11.4	0.756	79	11.1
MAVERICK	0.860	66	9.5	0.848	90	12.0	0.832	103	12.5
MCCULLOCH	0.844	50	8.8	0.825	63	9.2	0.815	71	9.6
MCLENNAN	0.829	58	14.3	0.797	66	11.9	0.787	74	11.7
MCMULLEN	0.857	68	11.2	0.839	87	11.7	0.829	98	12.0

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Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
MEDINA	0.827	61	10.0	0.812	78	10.6	0.794	86	10.4
MENARD	0.876	61	12.6	0.853	78	14.5	0.835	85	14.6
MIDLAND	0.873	51	12.0	0.864	68	12.2	0.852	77	11.9
MILAM	0.832	61	13.0	0.809	72	12.2	0.790	78	11.2
MILLS	0.838	52	11.4	0.825	66	11.6	0.809	73	11.2
MITCHELL	0.828	43	11.9	0.825	59	12.9	0.813	66	12.7
MONTAGUE	0.784	41	7.1	0.787	57	8.4	0.780	65	8.3
MONTGOMERY	0.802	58	10.1	0.773	66	10.1	0.760	74	10.5
MOORE	0.873	47	8.9	0.864	64	8.4	0.848	71	7.8
MORRIS	0.784	49	10.8	0.770	58	10.0	0.751	63	9.2
MOTLEY	0.815	39	7.5	0.826	59	10.6	0.819	68	11.6
NACOGDOCHES	0.814	59	12.0	0.807	75	12.8	0.803	89	13.4
NAVARRO	0.830	62	12.0	0.822	78	12.2	0.801	81	10.6
NEWTON	0.772	53	10.1	0.751	62	10.2	0.750	74	11.8
NOLAN	0.811	41	10.4	0.812	57	11.8	0.804	65	12.1
NUECES	0.805	56	10.1	0.799	74	11.7	0.776	78	11.6
OCHILTREE	0.836	41	7.5	0.838	58	7.3	0.829	67	7.2
OLDHAM	0.860	42	7.6	0.851	57	7.6	0.844	68	7.7
ORANGE	0.745	49	10.2	0.727	59	10.8	0.704	61	10.3
PALOPINTO	0.812	48	8.8	0.809	64	9.5	0.796	72	9.1
PANOLA	0.795	51	11.6	0.781	63	12.0	0.774	72	12.2
PARKER	0.813	50	9.0	0.800	62	8.3	0.784	68	7.4
PARMER	0.858	41	7.7	0.853	59	9.1	0.852	72	9.4
PECOS	0.883	47	5.6	0.896	70	7.8	0.879	79	7.9
POLK	0.815	66	13.6	0.778	72	12.2	0.765	80	12.9
POTTER	0.862	46	8.8	0.868	67	10.2	0.850	74	9.1
PRESIDIO	0.992	76	10.3	0.987	101	11.2	0.957	101	10.1
RAINS	0.812	57	11.8	0.792	66	10.5	0.769	68	9.3
RANDALL	0.844	42	8.5	0.848	61	9.7	0.842	72	10.3
REAGAN	0.878	56	12.7	0.873	76	14.1	0.868	89	14.7
REAL	0.840	65	13.8	0.824	81	14.3	0.814	96	15.1
REDRIVER	0.778	47	8.5	0.753	52	7.6	0.737	57	7.9
REEVES	0.902	49	7.2	0.904	71	9.2	0.894	83	9.4

Continued on next page

Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
REFUGIO	0.804	58	9.2	0.796	76	10.3	0.780	83	10.1
ROBERTS	0.834	41	8.0	0.829	57	7.2	0.822	66	7.0
ROBERTSON	0.819	56	11.0	0.796	68	10.3	0.787	77	9.8
ROCKWALL	0.814	56	9.9	0.794	65	8.9	0.776	69	7.8
RUNNELS	0.804	40	8.0	0.807	56	9.0	0.800	65	9.7
RUSK	0.817	59	13.3	0.797	70	12.3	0.789	81	12.4
SABINE	0.794	55	10.2	0.782	68	10.3	0.786	84	11.9
SANAUGUSTINE	0.812	60	11.6	0.795	73	11.9	0.793	85	13.1
SANJACINTO	0.803	62	12.1	0.772	70	11.2	0.756	76	11.3
SANPATRICIO	0.800	55	8.5	0.775	65	8.6	0.763	73	9.5
SANSABA	0.830	48	8.1	0.829	65	9.7	0.813	72	9.6
SCHLEICHER	0.879	63	12.8	0.869	84	15.2	0.870	104	18.0
SCURRY	0.818	41	10.9	0.799	50	10.3	0.802	62	11.4
SHACKELFORD	0.843	54	12.0	0.832	69	12.2	0.813	76	11.5
SHELBY	0.791	51	10.9	0.774	63	11.5	0.779	78	13.4
SHERMAN	0.857	42	7.1	0.854	58	6.9	0.847	68	6.6
SMITH	0.808	56	12.1	0.780	63	10.6	0.764	69	9.3
SOMERVELL	0.805	48	9.2	0.788	59	8.9	0.775	66	8.6
STARR	0.911	90	17.1	0.895	116	18.5	0.880	129	17.6
STEPHENS	0.823	50	10.3	0.826	69	11.5	0.812	78	11.7
STERLING	0.854	48	12.2	0.847	65	13.4	0.841	76	14.1
STONEWALL	0.803	38	8.2	0.808	55	10.3	0.810	68	11.8
SUTTON	0.870	67	15.6	0.865	92	18.4	0.854	105	19.4
SWISHER	0.838	42	8.8	0.847	63	11.2	0.836	73	11.7
TARRANT	0.808	50	8.6	0.792	61	8.0	0.783	69	7.4
TAYLOR	0.806	42	10.0	0.804	57	10.6	0.797	66	10.8
TERRELL	0.874	53	7.4	0.873	75	9.9	0.860	85	10.4
TERRY	0.838	40	9.0	0.837	56	9.4	0.839	70	10.3
THROCKMORTON	0.811	44	8.3	0.824	65	10.9	0.822	79	12.3
TITUS	0.800	54	11.9	0.782	62	10.4	0.766	68	10.0
TOMGREEN	0.870	55	10.9	0.854	70	11.3	0.844	81	12.0
TRAVIS	0.822	58	12.6	0.806	71	12.2	0.803	84	12.7
TRINITY	0.825	66	12.9	0.796	76	11.6	0.791	89	12.9

Continued on next page

Table 4: EBD Values for 2-year, 5-year, and 10-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{2yr}	B_{2yr}	D_{2yr}	E_{5yr}	B_{5yr}	D_{5yr}	E_{10yr}	B_{10yr}	D_{10yr}
TYLER	0.797	61	11.8	0.787	74	12.3	0.782	88	13.6
UPSHUR	0.799	53	12.7	0.770	59	10.7	0.759	66	10.3
UPTON	0.877	52	10.2	0.874	71	10.7	0.871	85	11.5
UVALDE	0.835	62	10.4	0.812	77	11.2	0.806	93	12.7
VALVERDE	0.864	61	11.3	0.853	83	13.5	0.833	91	13.8
VANZANDT	0.818	59	11.9	0.804	71	11.1	0.788	76	9.9
VICTORIA	0.823	66	11.4	0.786	73	9.7	0.768	80	9.6
WALKER	0.811	59	10.5	0.782	69	9.7	0.783	83	11.0
WALLER	0.815	59	9.8	0.790	70	9.5	0.771	75	9.4
WARD	0.897	47	7.2	0.874	61	7.2	0.871	74	7.8
WASHINGTON	0.826	61	11.8	0.797	70	10.3	0.790	82	10.7
WEBB	0.878	72	13.1	0.861	97	15.1	0.866	125	17.4
WHARTON	0.834	72	12.9	0.798	79	11.3	0.790	89	11.7
WHEELER	0.809	39	7.4	0.810	55	7.4	0.814	68	8.4
WICHITA	0.774	36	6.9	0.785	54	10.1	0.795	70	12.8
WILBARGER	0.771	34	6.0	0.792	54	9.7	0.793	67	11.3
WILLACY	0.870	80	15.1	0.841	92	13.9	0.839	110	15.7
WILLIAMSON	0.837	62	13.8	0.810	71	12.1	0.800	82	12.4
WILSON	0.836	63	9.2	0.815	77	8.9	0.811	90	9.3
WINKLER	0.879	46	8.5	0.877	66	9.3	0.870	77	9.3
WISE	0.798	45	7.1	0.792	59	7.3	0.781	66	7.1
WOOD	0.802	54	12.1	0.778	62	10.4	0.762	67	9.4
YOAKUM	0.835	38	7.4	0.843	56	8.6	0.858	75	10.2
YOUNG	0.801	44	8.3	0.812	63	9.8	0.811	76	10.8
ZAPATA	0.898	79	14.8	0.892	113	17.7	0.897	141	19.5
ZAVALA	0.852	66	9.7	0.841	90	11.6	0.822	102	11.5

Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI)

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
ANDERSON	0.791	99	11.3	0.787	114	11.1	0.771	121	10.3
ANDREWS	0.838	86	10.5	0.827	97	9.9	0.825	112	9.8
ANGELINA	0.779	99	13.8	0.778	117	15.2	0.765	128	16.4
ARANSAS	0.719	74	9.1	0.711	83	10.1	0.710	96	11.5
ARCHER	0.797	87	14.6	0.802	108	16.9	0.804	128	18.9
ARMSTRONG	0.852	102	12.9	0.843	116	13.6	0.848	141	14.6
ATASCOSA	0.807	112	11.5	0.795	122	11.3	0.797	143	12.5
AUSTIN	0.760	87	11.1	0.745	95	12.0	0.736	106	13.0
BAILEY	0.874	103	11.8	0.871	121	12.3	0.874	146	13.1
BANDERA	0.779	99	13.2	0.770	110	12.9	0.771	128	13.8
BASTROP	0.793	100	10.8	0.786	113	10.8	0.784	130	11.3
BAYLOR	0.785	79	13.9	0.786	94	15.5	0.788	116	18.4
BEE	0.806	108	12.3	0.793	117	12.8	0.789	132	13.8
BELL	0.798	98	15.4	0.788	107	15.5	0.780	121	15.9
BEXAR	0.788	99	10.1	0.784	113	10.3	0.778	126	10.5
BLANCO	0.784	88	12.1	0.768	96	12.3	0.772	114	14.1
BORDEN	0.795	72	10.9	0.812	93	12.9	0.814	111	14.2
BOSQUE	0.782	82	10.1	0.781	96	10.6	0.784	113	11.3
BOWIE	0.735	66	7.7	0.732	75	7.4	0.737	88	8.0
BRAZORIA	0.756	94	11.6	0.747	105	12.6	0.741	118	13.5
BRAZOS	0.792	99	11.2	0.801	124	12.7	0.795	141	13.0
BREWSTER	0.926	117	11.2	0.914	127	11.7	0.902	133	11.6
BRISCOE	0.849	102	14.3	0.845	121	15.8	0.842	140	16.4
BROOKS	0.852	136	17.5	0.853	164	19.1	0.853	190	20.0
BROWN	0.780	74	9.7	0.773	82	10.1	0.770	96	11.1
BURLESON	0.772	89	10.9	0.770	105	11.3	0.769	122	12.1
BURNET	0.793	87	11.7	0.767	88	10.8	0.762	101	12.3
CALDWELL	0.809	109	11.2	0.800	120	10.7	0.800	140	10.9
CALHOUN	0.765	97	11.6	0.770	116	13.3	0.760	126	13.4
CALLAHAN	0.781	76	10.4	0.777	88	11.5	0.773	99	11.6
CAMERON	0.842	138	16.6	0.833	152	16.7	0.827	173	18.6

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Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
CAMP	0.748	73	8.6	0.743	81	8.2	0.735	88	7.6
CARSON	0.854	100	10.8	0.836	108	10.0	0.861	145	11.7
CASS	0.742	72	10.3	0.733	79	9.5	0.724	86	8.8
CASTRO	0.858	99	12.0	0.859	119	12.9	0.869	149	14.3
CHAMBERS	0.697	73	14.0	0.683	79	14.4	0.667	85	14.6
CHEROKEE	0.783	96	11.4	0.780	111	11.4	0.771	122	11.5
CHILDRESS	0.819	93	11.9	0.823	114	14.3	0.834	144	17.2
CLAY	0.777	78	10.9	0.777	92	11.8	0.776	107	12.6
COCHRAN	0.853	92	10.1	0.857	112	11.1	0.849	126	10.6
COKE	0.811	82	13.9	0.804	93	15.2	0.792	101	15.8
COLEMAN	0.795	80	9.9	0.804	99	11.5	0.802	113	11.9
COLLIN	0.759	73	7.8	0.734	73	6.0	0.739	85	6.7
COLLINGSWORTH	0.807	86	10.2	0.804	101	10.9	0.828	136	13.8
COLORADO	0.790	102	11.1	0.792	122	12.3	0.783	135	12.6
COMAL	0.785	95	11.7	0.775	105	11.5	0.776	123	12.8
COMANCHE	0.773	75	10.1	0.769	86	10.2	0.764	98	10.6
CONCHO	0.819	89	12.6	0.819	106	14.6	0.804	114	15.1
COOKE	0.753	68	6.5	0.738	73	5.7	0.734	82	5.7
CORYELL	0.767	77	11.9	0.759	87	12.4	0.754	99	13.5
COTTLE	0.806	84	11.0	0.805	101	12.5	0.810	123	13.7
CRANE	0.881	103	11.3	0.884	126	12.7	0.870	134	12.3
CROCKETT	0.872	119	14.5	0.876	143	15.3	0.863	155	15.2
CROSBY	0.824	86	13.1	0.831	109	16.0	0.832	129	17.5
CULBERSON	0.891	95	9.9	0.872	104	9.7	0.861	113	9.8
DALLAM	0.872	95	8.7	0.871	115	9.1	0.871	137	9.2
DALLAS	0.770	80	8.0	0.754	84	7.0	0.747	93	7.0
DAWSON	0.805	74	9.7	0.802	85	10.3	0.802	101	11.7
DEAFSMITH	0.867	100	11.0	0.856	112	11.2	0.866	141	12.6
DELTA	0.746	67	6.6	0.736	72	6.0	0.732	80	6.2
DENTON	0.773	75	7.0	0.761	81	6.0	0.758	90	5.6
DEWITT	0.807	109	9.9	0.811	131	10.8	0.811	151	11.2
DICKENS	0.808	83	13.3	0.808	98	15.0	0.810	118	16.7
DIMMIT	0.817	120	14.0	0.814	140	15.2	0.822	176	17.9

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Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
DONLEY	0.819	88	10.7	0.811	101	11.6	0.830	133	13.3
DUVAL	0.867	154	23.2	0.866	185	25.6	0.857	204	25.8
EASTLAND	0.783	79	10.5	0.775	87	9.9	0.771	99	10.5
ECTOR	0.857	95	11.3	0.845	105	11.1	0.844	122	11.5
EDWARDS	0.800	104	16.7	0.793	117	17.1	0.787	134	17.4
ELLIS	0.818	70	6.1	0.813	80	6.7	0.793	84	6.5
ELPASO	0.808	79	9.4	0.793	84	9.2	0.792	96	9.6
ERATH	0.777	78	9.4	0.771	87	8.8	0.765	96	8.3
FALLS	0.783	90	11.2	0.797	114	12.5	0.793	130	12.5
FANNIN	0.759	72	7.1	0.747	77	6.7	0.747	88	7.2
FAYETTE	0.779	95	10.4	0.781	113	11.0	0.775	126	11.3
FISHER	0.798	79	13.4	0.803	98	16.2	0.801	113	17.7
FLOYD	0.836	94	12.6	0.843	117	14.6	0.847	141	15.8
FOARD	0.789	79	10.0	0.796	97	11.5	0.799	117	12.9
FORTBEND	0.738	82	12.1	0.728	92	13.8	0.711	97	14.9
FRANKLIN	0.745	70	7.1	0.745	79	7.2	0.740	87	6.7
FREESTONE	0.780	88	8.8	0.777	101	8.6	0.771	113	8.9
FRIO	0.844	139	13.4	0.849	170	15.1	0.835	183	14.7
GAINES	0.838	86	10.2	0.832	99	9.8	0.828	114	9.9
GALVESTON	0.761	100	13.7	0.756	113	14.3	0.750	128	14.8
GARZA	0.824	86	12.7	0.826	102	13.8	0.827	122	15.7
GILLESPIE	0.765	82	12.2	0.757	91	12.2	0.754	104	13.5
GLASSCOCK	0.835	90	15.3	0.827	100	16.0	0.837	125	18.8
GOLIAD	0.773	92	9.6	0.765	104	10.6	0.751	113	10.8
GONZALES	0.790	99	9.2	0.786	113	9.1	0.776	126	9.2
GRAY	0.829	90	9.5	0.837	113	10.7	0.849	142	11.9
GRAYSON	0.751	68	6.2	0.747	77	6.1	0.738	84	5.9
GREGG	0.749	75	9.7	0.756	91	10.5	0.751	102	10.3
GRIMES	0.780	96	11.5	0.778	113	12.7	0.778	132	13.1
GUADALUPE	0.786	92	8.7	0.787	108	9.2	0.781	121	9.2
HALE	0.851	99	14.2	0.837	110	14.5	0.837	127	15.0
HALL	0.831	95	12.7	0.827	112	13.8	0.838	142	15.7
HAMILTON	0.773	76	10.3	0.762	86	10.0	0.754	94	10.6

Continued on next page

Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
HANSFORD	0.863	98	9.0	0.870	121	9.5	0.869	142	9.9
HARDEMAN	0.816	90	13.2	0.811	106	15.0	0.813	129	16.6
HARDIN	0.704	75	12.9	0.694	83	14.1	0.685	93	15.0
HARRIS	0.769	98	12.7	0.756	107	13.0	0.758	127	14.7
HARRISON	0.775	88	12.6	0.773	101	13.0	0.782	122	14.5
HARTLEY	0.878	102	9.3	0.856	108	8.8	0.865	135	9.7
HASKELL	0.792	81	14.2	0.790	95	15.7	0.791	113	18.0
HAYS	0.788	93	11.6	0.783	108	12.1	0.782	125	12.9
HEMPHILL	0.829	90	8.5	0.836	110	8.6	0.832	130	8.9
HENDERSON	0.789	93	10.2	0.782	103	9.9	0.776	116	9.8
HIDALGO	0.870	151	16.9	0.866	175	18.0	0.886	231	22.3
HILL	0.787	88	10.4	0.787	103	11.2	0.784	117	11.2
HOCKLEY	0.841	89	10.9	0.846	108	12.1	0.843	125	12.5
HOOD	0.780	80	9.1	0.775	90	8.6	0.768	99	8.0
HOPKINS	0.728	64	6.0	0.712	66	5.1	0.701	71	4.9
HOUSTON	0.789	98	11.1	0.784	113	11.5	0.780	128	11.9
HOWARD	0.839	92	14.4	0.837	106	15.1	0.843	128	16.8
HUDSPETH	0.873	72	5.5	0.874	85	6.4	0.861	94	6.1
HUNT	0.757	71	6.3	0.750	79	6.2	0.750	91	6.4
HUTCHINSON	0.859	99	9.7	0.867	123	10.5	0.870	148	11.1
IRION	0.867	112	15.9	0.865	131	17.2	0.871	160	19.7
JACK	0.791	83	9.1	0.789	95	9.4	0.782	105	9.4
JACKSON	0.778	101	10.8	0.777	116	11.4	0.774	132	12.2
JASPER	0.739	85	12.9	0.736	99	14.2	0.728	112	15.4
JEFFDAVIS	0.923	112	13.3	0.911	122	13.3	0.888	123	12.7
JEFFERSON	0.753	100	15.7	0.751	116	16.5	0.750	134	17.8
JIMHOGG	0.844	131	18.2	0.843	155	20.4	0.836	175	20.8
JIMWELLS	0.842	128	15.9	0.845	157	18.0	0.856	193	20.1
JOHNSON	0.783	84	8.7	0.775	92	8.0	0.774	105	7.9
JONES	0.791	80	14.2	0.785	92	15.3	0.782	105	16.9
KARNES	0.837	126	13.6	0.833	146	14.1	0.835	168	15.0
KAUFMAN	0.786	87	9.4	0.773	93	8.8	0.764	100	8.5
KENDALL	0.774	92	13.4	0.764	102	13.4	0.768	120	14.5

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Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
KENEDY	0.850	137	16.6	0.848	160	17.9	0.850	189	19.3
KENT	0.801	75	12.5	0.792	84	13.1	0.816	113	17.4
KERR	0.839	133	17.7	0.834	152	17.9	0.843	187	19.9
KIMBLE	0.874	146	21.4	0.878	178	23.5	0.866	194	22.9
KING	0.802	77	13.3	0.789	85	13.6	0.801	107	16.5
KINNEY	0.861	151	17.7	0.866	186	19.2	0.869	221	20.6
KLEBERG	0.822	118	16.2	0.819	135	17.1	0.819	157	19.0
KNOX	0.785	77	13.9	0.782	91	15.9	0.776	107	18.2
LAMAR	0.746	71	7.1	0.729	74	6.6	0.730	84	7.1
LAMB	0.807	79	9.4	0.799	87	9.0	0.802	105	10.1
LAMPASAS	0.831	100	13.2	0.820	112	13.2	0.821	132	14.4
LASALLE	0.816	108	13.9	0.814	124	14.5	0.809	142	15.8
LAVACA	0.781	97	9.5	0.770	106	9.4	0.769	121	9.5
LEE	0.778	93	11.3	0.782	112	11.8	0.782	130	12.3
LEON	0.779	93	9.7	0.778	108	9.7	0.774	122	10.0
LIBERTY	0.731	80	12.5	0.718	87	13.5	0.704	94	13.9
LIMESTONE	0.769	84	9.4	0.768	100	9.7	0.757	108	9.5
LIPSCOMB	0.824	83	7.2	0.835	106	8.1	0.840	129	8.4
LIVEOAK	0.791	96	10.3	0.784	108	11.1	0.782	124	12.0
LLANO	0.781	77	8.8	0.768	85	9.1	0.758	96	10.2
LOVING	0.865	96	10.2	0.871	119	11.3	0.865	134	11.5
LUBBOCK	0.825	84	12.2	0.819	96	12.9	0.825	117	13.9
LYNN	0.813	78	11.4	0.816	93	12.7	0.818	113	14.4
MADISON	0.760	85	9.3	0.760	101	10.0	0.755	115	11.0
MARION	0.745	73	10.1	0.742	84	10.6	0.741	96	10.6
MARTIN	0.833	86	12.0	0.839	103	12.8	0.838	121	13.8
MASON	0.797	83	11.3	0.781	90	10.8	0.778	104	12.4
MATAGORDA	0.737	85	10.9	0.728	93	11.0	0.715	100	11.5
MAVERICK	0.812	117	12.9	0.803	131	13.3	0.809	157	14.6
MCCULLOCH	0.802	82	9.8	0.802	98	11.3	0.797	113	12.6
MCLENNAN	0.782	87	12.3	0.776	99	11.8	0.775	114	12.0
MCMULLEN	0.825	117	13.6	0.809	124	13.3	0.812	146	14.7
MEDINA	0.797	107	12.0	0.786	119	11.9	0.789	141	13.0

Continued on next page

Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
MENARD	0.826	101	16.6	0.819	117	18.5	0.809	130	20.1
MIDLAND	0.855	97	13.2	0.859	116	14.2	0.854	131	14.9
MILAM	0.778	88	10.7	0.786	110	12.0	0.785	127	12.2
MILLS	0.792	81	10.5	0.781	89	10.4	0.784	107	12.1
MITCHELL	0.817	83	14.5	0.809	93	15.5	0.821	117	18.2
MONTAGUE	0.773	76	9.0	0.769	87	8.6	0.772	102	9.0
MONTGOMERY	0.742	81	10.7	0.733	91	11.4	0.722	99	11.8
MOORE	0.863	97	8.9	0.846	105	8.1	0.862	136	9.7
MORRIS	0.743	71	8.5	0.738	79	8.2	0.730	84	7.4
MOTLEY	0.827	89	13.8	0.832	110	16.6	0.835	132	18.7
NACOGDOCHES	0.790	99	13.8	0.793	119	15.0	0.786	132	15.7
NAVARRO	0.783	86	9.0	0.772	93	8.0	0.763	103	7.9
NEWTON	0.726	79	11.3	0.726	93	13.3	0.712	100	13.9
NOLAN	0.805	80	13.7	0.802	93	15.1	0.808	113	17.5
NUECES	0.777	96	13.5	0.766	106	14.3	0.762	119	15.6
OCHILTREE	0.825	81	6.9	0.831	100	7.2	0.838	123	7.7
OLDHAM	0.867	96	9.3	0.851	105	9.4	0.873	140	11.1
ORANGE	0.692	68	11.0	0.679	75	11.7	0.673	84	13.0
PALOPINTO	0.780	79	9.2	0.773	88	8.6	0.763	96	8.3
PANOLA	0.774	86	13.4	0.783	107	15.7	0.777	121	16.3
PARKER	0.777	77	7.6	0.768	85	6.8	0.765	95	6.6
PARMER	0.877	105	11.7	0.865	116	11.8	0.875	144	12.5
PECOS	0.878	95	9.1	0.875	110	9.9	0.851	112	8.9
POLK	0.748	89	12.7	0.741	101	14.0	0.730	112	14.7
POTTER	0.868	103	11.0	0.856	116	11.2	0.881	155	12.9
PRESIDIO	0.948	117	11.3	0.938	127	11.4	0.936	143	12.0
RAINS	0.744	72	7.6	0.730	76	6.7	0.727	86	7.0
RANDALL	0.867	106	13.0	0.849	113	12.9	0.857	140	13.7
REAGAN	0.859	105	16.5	0.868	129	19.1	0.870	154	21.5
REAL	0.800	106	15.0	0.793	120	15.4	0.789	136	15.7
REDRIVER	0.730	64	7.0	0.717	68	6.1	0.710	74	5.8
REEVES	0.898	106	10.3	0.882	116	10.5	0.879	134	11.0
REFUGIO	0.762	90	10.2	0.753	100	10.7	0.747	112	11.6

Continued on next page

Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
ROBERTS	0.826	85	7.0	0.831	103	7.1	0.838	126	7.8
ROBERTSON	0.773	86	9.4	0.768	98	9.6	0.772	118	10.6
ROCKWALL	0.761	74	6.9	0.751	80	6.4	0.745	88	6.2
RUNNELS	0.793	77	10.4	0.783	85	10.8	0.765	88	10.6
RUSK	0.783	95	12.7	0.783	111	13.6	0.779	126	14.2
SABINE	0.780	98	12.9	0.782	118	14.6	0.779	137	15.8
SANAUGUSTINE	0.789	100	13.9	0.798	124	16.5	0.791	139	17.6
SANJACINTO	0.743	85	11.5	0.737	99	12.4	0.724	108	12.6
SANPATRICIO	0.748	82	10.3	0.740	91	11.2	0.732	101	12.2
SANSABA	0.791	78	9.0	0.779	86	8.9	0.781	104	10.6
SCHLEICHER	0.852	117	19.2	0.846	133	20.5	0.836	149	22.5
SCURRY	0.799	74	12.8	0.797	86	13.9	0.802	103	16.3
SHACKELFORD	0.798	85	11.9	0.800	101	12.9	0.799	119	14.4
SHELBY	0.775	93	15.4	0.776	110	17.1	0.767	123	18.5
SHERMAN	0.853	86	7.0	0.835	94	6.3	0.841	114	6.9
SMITH	0.751	77	8.4	0.753	91	8.6	0.758	109	9.3
SOMERVELL	0.766	75	9.0	0.753	81	8.2	0.750	93	8.6
STARR	0.877	156	19.5	0.871	182	21.0	0.864	206	21.7
STEPHENS	0.784	81	10.9	0.781	92	11.3	0.775	105	11.7
STERLING	0.837	91	15.1	0.845	112	17.5	0.847	132	18.8
STONEWALL	0.801	81	13.4	0.792	91	13.8	0.807	118	17.5
SUTTON	0.841	123	21.7	0.834	140	23.6	0.841	172	27.4
SWISHER	0.860	106	14.4	0.853	121	15.5	0.850	139	15.4
TARRANT	0.782	81	8.0	0.765	85	6.8	0.759	93	6.3
TAYLOR	0.791	77	11.4	0.778	83	11.5	0.773	94	12.2
TERRELL	0.839	93	10.8	0.833	106	11.9	0.825	117	12.2
TERRY	0.834	86	10.7	0.827	96	10.5	0.834	119	11.7
THROCKMORTON	0.819	97	14.2	0.821	116	15.9	0.819	134	17.8
TITUS	0.759	76	9.4	0.748	82	8.5	0.738	88	7.6
TOMGREEN	0.834	94	13.1	0.840	115	15.1	0.833	129	15.5
TRAVIS	0.791	95	12.5	0.781	106	12.5	0.781	122	14.2
TRINITY	0.784	104	13.3	0.768	110	13.1	0.754	117	13.1
TYLER	0.766	95	13.8	0.757	106	14.3	0.752	120	15.5

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Table 5: EBD Values for 25-year, 50-year, and 100-year Annual Recurrence Intervals (ARI) — Continued

COUNTY	E_{25yr}	B_{25yr}	D_{25yr}	E_{50yr}	B_{50yr}	D_{50yr}	E_{100yr}	B_{100yr}	D_{100yr}
UPSHUR	0.740	71	9.2	0.735	80	9.2	0.725	87	8.8
UPTON	0.876	108	13.5	0.861	116	13.2	0.867	140	15.1
UVALDE	0.795	107	13.4	0.801	133	15.2	0.801	157	16.8
VALVERDE	0.828	110	15.4	0.808	117	14.8	0.805	135	15.9
VANZANDT	0.771	82	8.3	0.752	83	6.6	0.748	94	6.8
VICTORIA	0.750	86	9.0	0.746	97	9.4	0.738	107	9.2
WALKER	0.763	91	10.7	0.757	104	11.5	0.749	117	12.1
WALLER	0.758	83	10.1	0.744	90	10.5	0.730	97	10.4
WARD	0.865	92	9.1	0.851	103	8.9	0.849	118	9.5
WASHINGTON	0.785	97	12.0	0.764	101	10.9	0.772	122	12.3
WEBB	0.855	148	18.6	0.853	173	20.0	0.850	199	20.9
WHARTON	0.767	95	11.1	0.760	106	11.4	0.755	122	12.8
WHEELER	0.814	86	8.8	0.812	101	8.7	0.818	124	9.6
WICHITA	0.798	88	14.4	0.799	104	15.3	0.801	125	16.7
WILBARGER	0.798	86	13.5	0.796	101	14.7	0.797	122	16.7
WILLACY	0.825	123	16.1	0.805	130	15.9	0.812	155	18.4
WILLIAMSON	0.809	105	14.8	0.792	113	13.9	0.787	127	14.8
WILSON	0.797	100	8.7	0.799	119	9.2	0.792	131	9.0
WINKLER	0.880	103	11.3	0.866	115	10.8	0.873	139	11.2
WISE	0.779	78	7.9	0.763	83	6.6	0.758	93	6.5
WOOD	0.744	71	8.1	0.734	77	7.6	0.726	84	7.3
YOAKUM	0.849	90	10.4	0.853	108	10.4	0.843	122	10.4
YOUNG	0.792	85	10.7	0.798	103	11.8	0.789	116	11.9
ZAPATA	0.885	164	21.0	0.874	186	22.0	0.866	209	22.6
ZAVALA	0.819	125	13.2	0.820	150	14.6	0.814	169	14.8

13 Appendix – VI: `EBDLKUP-2015` Technical Reference Manual

The technical reference manual is provided as a guidance to help any personnel understand and edit the spreadsheet if necessary.

13.1 Enable/Disable Editing

The `EBDLKUP-2015.xlsx` spreadsheet is entirely password protected to prevent any changes in the interface logic and the underlying *ebd* coefficient database. The use of simple password protection was deemed sufficient to protect the worksheet and the underlying database from accidental changes. To make any changes to the database component, the appointed editor needs to unhide the EBD-RevisedTable sheet. To enable editing of either sheet, the password `ebdlkup-2015`, all lowercase, is needed. Upon completion of any necessary changes the editor should change the revision date on the spreadsheet, re-lock all sheets with the password and hide the database.

13.1.1 Spreadsheet Password

Figure 15 is a screen capture of `EBDLKUP-2015.xlsx`. The interface is locked – a padlock symbol appears at the bottom next to the tab sheet name to indicate that the worksheet is protected.

The locked configuration is intended as the default, preferred configuration, and users should not have to unlock the interface to use the tool. The worksheet should only be unlocked for maintenance, changes to the underlying database, or for addition of special features. Upon completion of such maintenance activities, the worksheet should be locked again.

If a user desires to edit components of the spreadsheet, the password is `ebdlkup-2015`. The password is applied individually to tab sheets within the spreadsheet, so the user will need to re-enter the password repeatedly if different tab sheets are edited. To unlock the spreadsheet, the user right-clicks the tab sheet and selects **Unprotect Sheet** from the resulting pull-down menu.

Figure 16 shows a screen capture of the spreadsheet, where the user has just right-clicked the sheet tab and selected **Unprotect Sheet**. Upon selection of **Unprotect Sheet**, the program issues a password prompt. The user responds to the prompt by typing in the password in the dialog box. The password characters are not displayed (just dots), so the user needs to be careful to enter the password correctly.

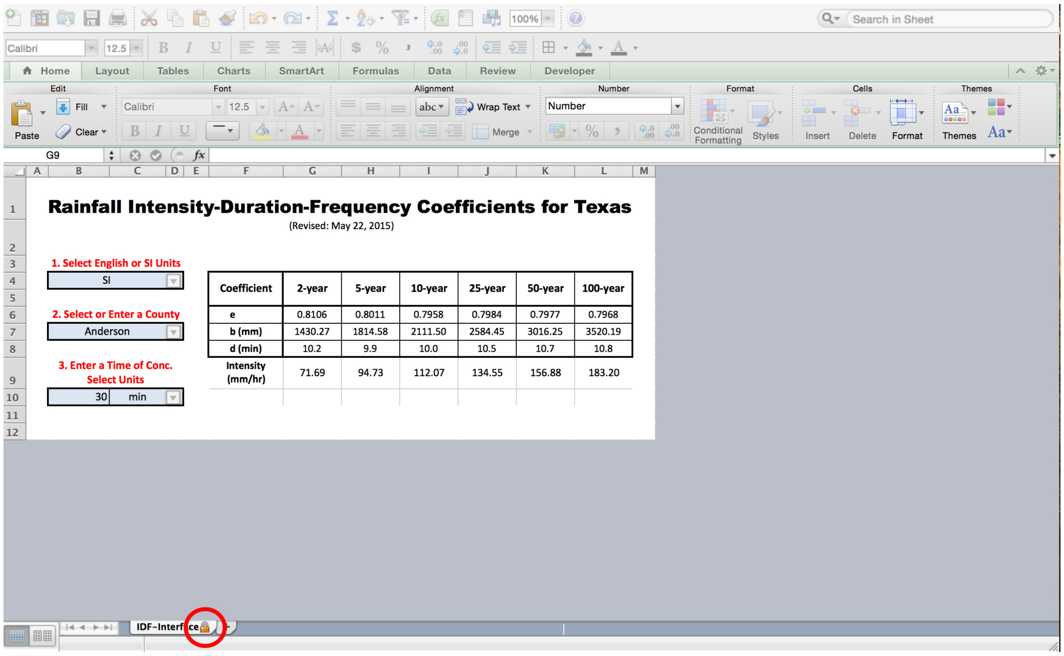


Figure 15: Interface of EBDLKUP-2015.xlsx Spreadsheet. The interface is locked. The padlock symbol appears at the bottom next to the tab sheet name to indicate that the worksheet is protected.

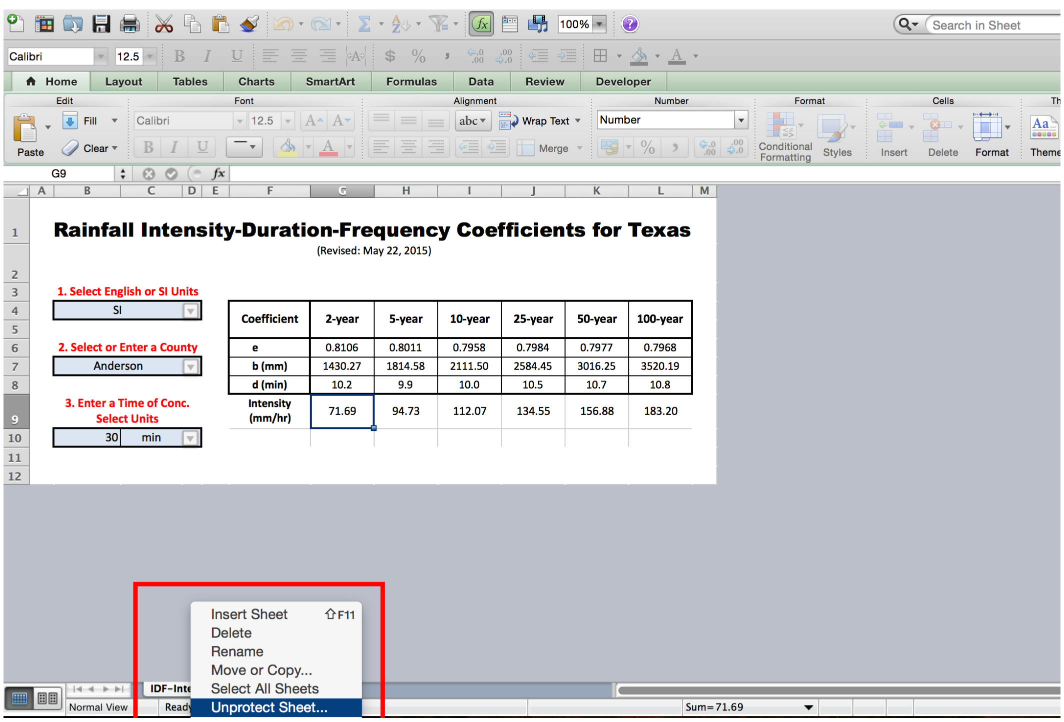
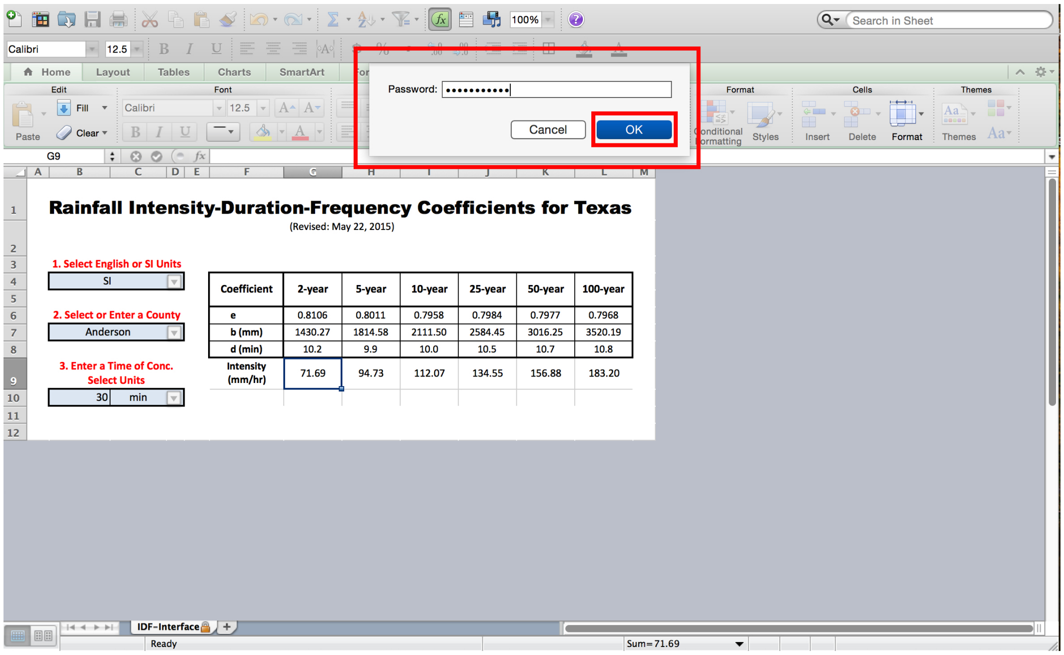


Figure 16: Interface of EBDLKUP-NEW.XLS Spreadsheet. The user has just right-clicked the sheet tab and selected **Unprotect Sheet**.



Coefficient	2-year	5-year	10-year	25-year	50-year	100-year
e	0.8106	0.8011	0.7958	0.7984	0.7977	0.7968
b (mm)	1430.27	1814.58	2111.50	2584.45	3016.25	3520.19
d (min)	10.2	9.9	10.0	10.5	10.7	10.8
Intensity (mm/hr)	71.69	94.73	112.07	134.55	156.88	183.20

Figure 17: Interface of EBDLKUP-NEW.XLS Spreadsheet. The user has just entered the password and is about to click **OK**.

Figure 17 shows the user responding to the challenge. In the figure the user has just entered the password `ebdlkup-new` and is about to select **OK**.

Upon sucessful completion of entering the password the worksheet is unlocked. Figure 18 shows the unlocked worksheet. The padlock symbol is absent indicating the worksheet is enabled for editing.

When **OK** is selected the spreadsheet either unlocks as depicted, or states that an incorrect password was entered. The most likely password failure would be to forget the hyphen in the password, or accidentally enter the password in upper case.

During development and testing, the authors used copy-and-paste to enter the password, which is an additional option – simply copy the password from this document and paste into the dialog box. This feature (copy-and-paste) is a good method to reset passwords after substantial editing, and will help avoid any accidental character change that could render the worksheet useless.

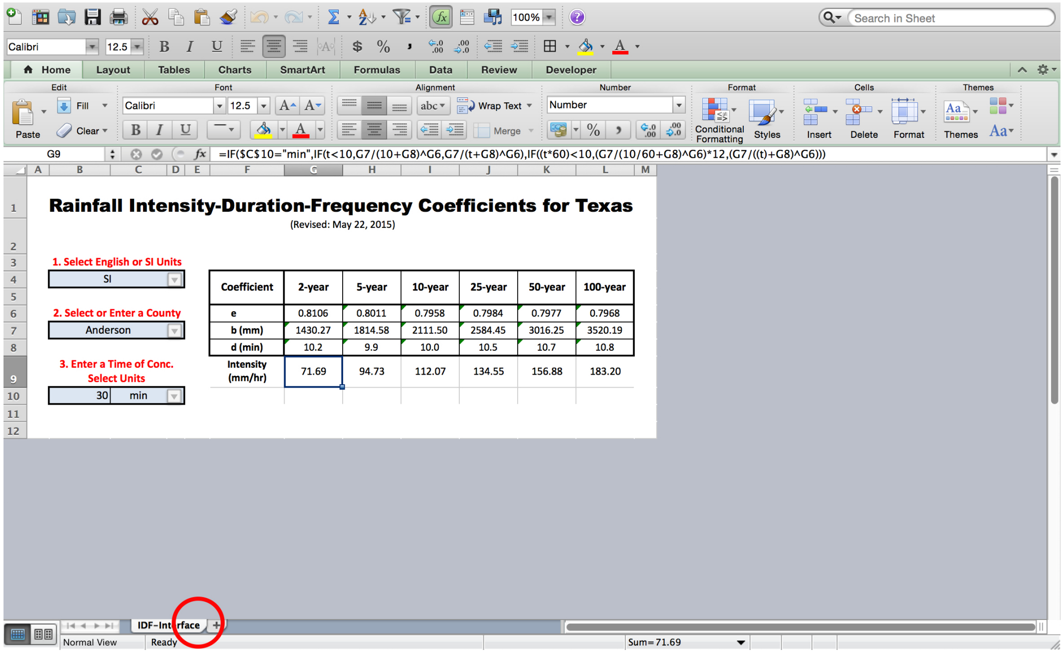


Figure 18: Interface of EBDLKUP-NEW.XLS Spreadsheet. The padlock symbol is absent indicating that he spreadsheet is unlocked and can be edited as deemed necessary.

13.1.2 Hidden Tabs

The *ebd* database is the most important component of the spreadsheet and is kept hidden to reduce possible user errors or unintentional changes. The database is constantly indexed and referred to through the interface, therefore unhiding, unlocking, and editing the database is unnecessary for routine use of the tool.

If the user needs to unhide tabs, **right click** any exposed (unhidden) tab[20] at the bottom of the screen, select unhide in the pull-down-menu, then select a sheet name from the list presented, and press **OK**.

Figure 19 is a screen capture of the unlocked spreadsheet. The user has right clicked the sheet name and selected **Unhide** from the pull-down-menu, and is about to click to select the unhide option. When the unhide option is selected the user is presented with a list of hidden sheet names and can select the particular sheet to unhide.

[20]There will always be at least one tab sheet.

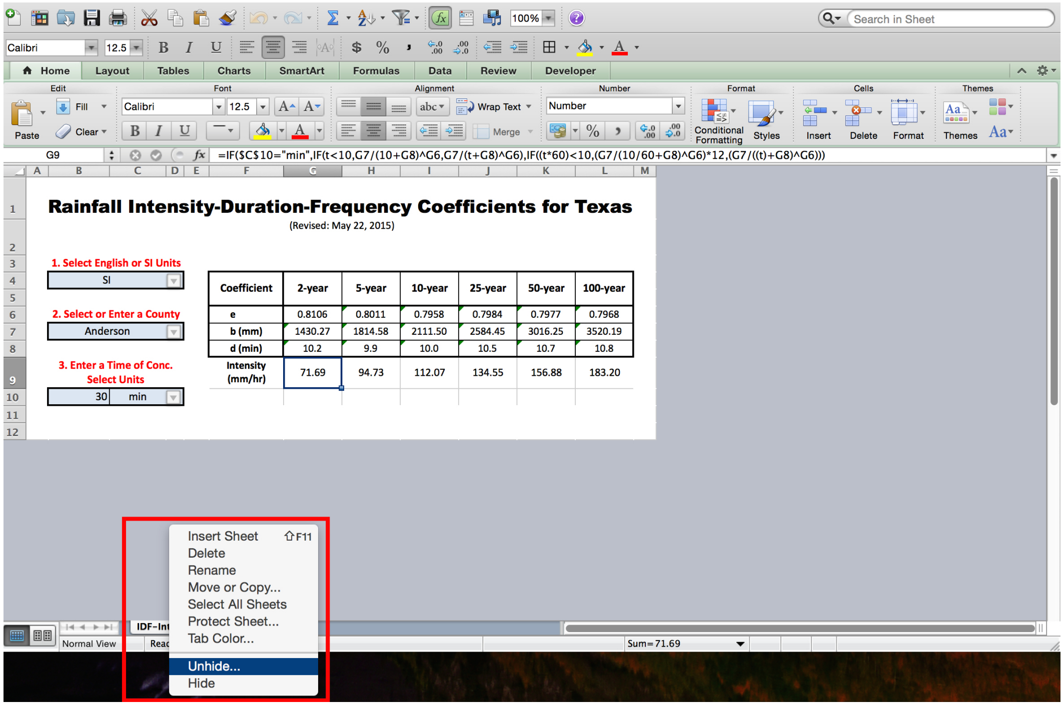


Figure 19: Interface of EBDLKUP-NEW.XLS Spreadsheet. On the unlocked spreadsheet, the user has right clicked the sheet name and selected **Unhide** from the pull-down-menu, and is about to click to select the unhide option.

Figure 20 is a screen capture of the *ebd* database sheet ready to be unhidden. Additionally each sheet must be unprotected by right clicking the tab at the bottom of the screen (with an image of a lock), select unprotect sheet, and enter in the password: `ebdlkup-new`.

Figure 21 is a screen capture of the *ebd* database unhidden (but still locked). Elements of the database are described in detail below. One distinguishing feature of the revised tool is that the database is in US Customary units only. Unit conversion is accomplished directly through the calculations within the interface rather than maintaining a separate database as was done in the older tool. This feature along with the slightly different look-and-feel will help users transition to the newer tool, and distinguish from the current tool (which has a teal and yellow color scheme).

The spreadsheet was designed to protect the interface and the database from accidental tampering. The use of hidden tab sheets and protected sheets is the method employed to help protect the tool without being overly complicated. The only caveat is to not change the password after editing – if the password is changed and forgotten, the worksheet will still function, but cannot be repaired beyond that moment in time.

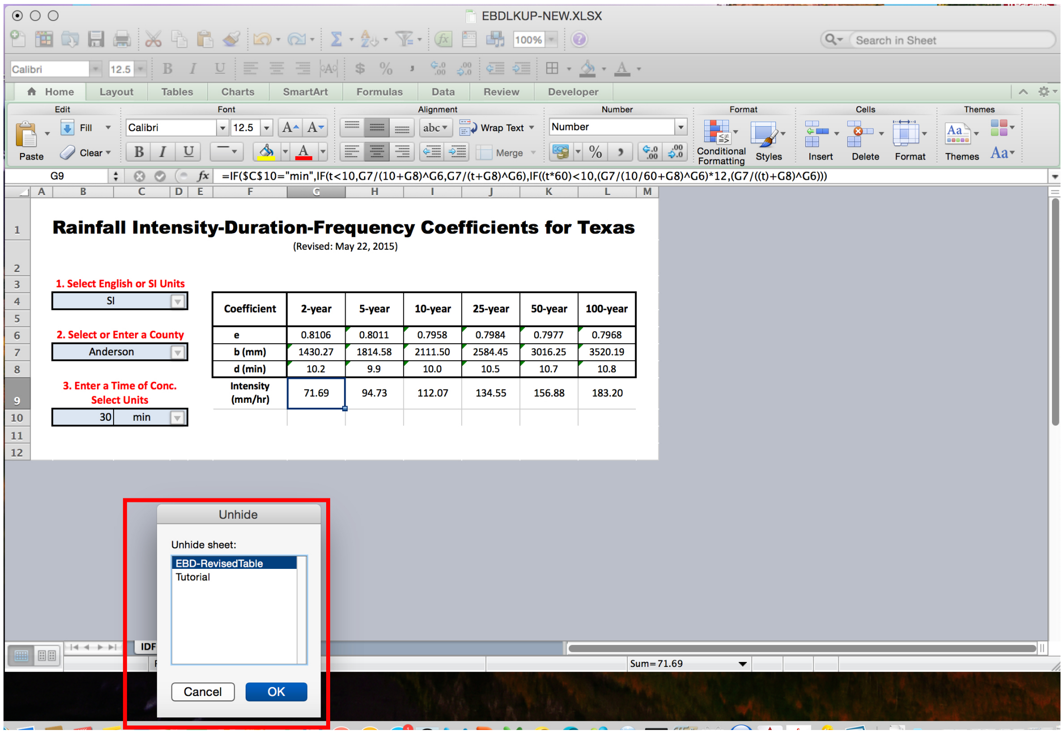


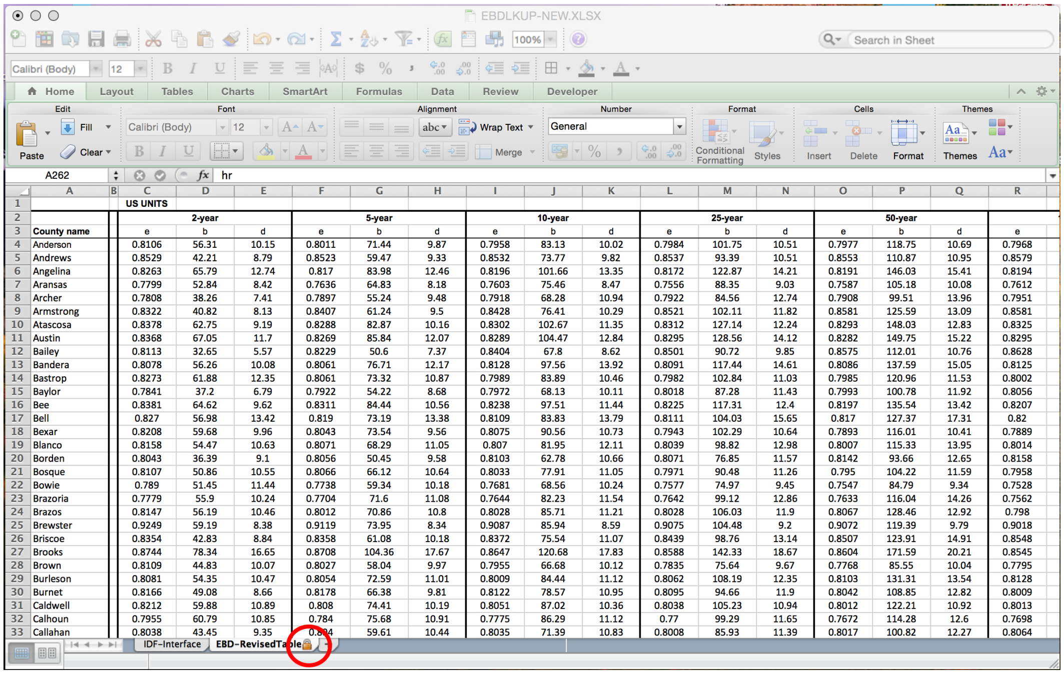
Figure 20: Interface of EBDLKUP-NEW.XLS Spreadsheet. Select a sheet name to unhide – in this example the choices are the EBD-RevisedTable database and the Tutorial sheet. In the final product, the tutorial sheet will be default unhidden – the user should not have to enter a password to follow the tutorial.

13.1.3 `EBD-RevisedTable`

Figure 21 is a screen capture of the *ebd* database unhidden (but still locked). If changes are deemed necessary to the underlying table, the user must first unlock the tab sheet. The same password is used throughout the spreadsheet.[21]

If any changes to *ebd* coefficients need to be made, they should be changed in the `EBD-RevisedTable` tab. The changed coefficients should be pasted directly into the cells without changing any formatting. The user needs to ensure the placement of coefficients match the county and respective ARI headings. Additionally, the decimal placements for each coefficient should be formatted similarly.

[21] The version distributed starts with the same password for all sheets. It is possible to change names on a per-sheet basis, but such changes are not recommended because of the likelihood of forgetting the individual sheet passwords. The password is included on the interface sheet in cell **B12**. It is rendered invisible, but can be copied and pasted into the password challenge.



	US UNITS															
	2-year			5-year			10-year			25-year			50-year			
County name	e	b	d	e	b	d	e	b	d	e	b	d	e	b	d	e
Anderson	0.8106	56.31	10.15	0.8011	71.44	9.87	0.7958	83.13	10.02	0.7984	101.75	10.51	0.7977	118.75	10.69	0.7968
Andrews	0.8529	42.21	8.79	0.8523	59.47	9.33	0.8532	73.77	9.82	0.8537	93.39	10.51	0.8553	110.87	10.95	0.8579
Angelina	0.8263	65.79	12.74	0.817	83.98	12.46	0.8196	101.66	13.35	0.8172	122.87	14.21	0.8191	146.03	15.41	0.8194
Aransas	0.7799	52.84	8.42	0.7636	64.83	8.18	0.7603	75.46	8.47	0.7556	88.35	9.03	0.7587	105.18	10.08	0.7612
Archer	0.7808	38.26	7.41	0.7897	55.24	9.48	0.7918	68.28	10.94	0.7922	84.56	12.74	0.7908	99.51	13.96	0.7951
Armstrong	0.8322	40.82	8.13	0.8407	61.24	9.5	0.8428	76.41	10.29	0.8521	102.11	11.82	0.8581	125.59	13.09	0.8581
Atascosa	0.8378	62.75	9.19	0.8288	82.87	10.16	0.8302	102.67	11.35	0.8312	127.14	12.24	0.8293	148.03	12.83	0.8325
Austin	0.8368	67.05	11.7	0.8269	85.84	12.07	0.8289	104.47	12.84	0.8295	128.56	14.12	0.8282	149.75	15.22	0.8295
Bailey	0.8113	32.65	5.57	0.8229	50.6	7.37	0.8404	67.8	8.62	0.8501	90.72	9.85	0.8575	112.01	10.76	0.8628
Bandera	0.8078	56.26	10.08	0.8061	76.71	12.17	0.8128	97.56	13.92	0.8091	117.44	14.61	0.8086	137.59	15.05	0.8125
Bastrop	0.8273	61.88	12.35	0.8061	73.32	10.87	0.7989	83.89	10.46	0.7982	102.84	11.03	0.7985	120.96	11.53	0.8002
Baylor	0.7841	37.2	6.79	0.7922	54.22	8.68	0.7972	68.13	10.11	0.8018	87.28	11.43	0.7993	100.78	11.92	0.8056
Bee	0.8381	64.62	9.62	0.8311	84.44	10.56	0.8238	97.51	11.44	0.8225	117.31	12.4	0.8197	135.54	13.42	0.8207
Bell	0.827	56.98	13.42	0.819	73.19	13.38	0.8109	83.83	13.79	0.8111	104.03	15.65	0.817	127.37	17.31	0.82
Bexar	0.8208	59.68	9.96	0.8043	73.54	9.56	0.8075	90.56	10.73	0.7943	102.29	10.64	0.7893	116.01	10.41	0.7889
Blanco	0.8158	54.47	10.63	0.8071	68.29	11.05	0.807	81.95	12.11	0.8039	98.82	12.98	0.8007	115.33	13.95	0.8014
Borden	0.8043	36.39	9.1	0.8056	50.45	9.58	0.8103	62.78	10.66	0.8071	76.85	11.57	0.8142	93.66	12.65	0.8158
Bosque	0.8107	50.86	10.55	0.8066	66.12	10.64	0.8033	77.91	11.05	0.7971	90.48	11.26	0.795	104.22	11.59	0.7958
Bowie	0.789	51.45	11.44	0.7738	59.34	10.18	0.7681	68.56	10.24	0.7577	74.97	9.45	0.7547	84.79	9.34	0.7528
Brazoria	0.7779	55.9	10.24	0.7704	71.6	11.08	0.7644	82.23	11.54	0.7642	99.12	12.86	0.7633	116.04	14.26	0.7562
Brazos	0.8147	56.19	10.46	0.8012	70.86	10.8	0.8028	85.71	11.21	0.8028	106.03	11.9	0.8067	128.46	12.92	0.798
Brewster	0.9249	59.19	8.38	0.9119	73.95	8.34	0.9087	85.94	8.59	0.9075	104.48	9.2	0.9072	119.39	9.79	0.9018
Briscoe	0.8354	42.83	8.84	0.8358	61.08	10.18	0.8372	75.54	11.07	0.8439	98.76	13.14	0.8507	123.91	14.91	0.8548
Brooks	0.8744	78.34	16.65	0.8708	104.36	17.67	0.8647	120.68	17.83	0.8588	142.33	18.67	0.8604	171.59	20.21	0.8545
Brown	0.8109	44.83	10.07	0.8027	58.04	9.97	0.7955	66.68	10.12	0.7835	75.64	9.67	0.7768	85.55	10.04	0.7795
Burleson	0.8081	54.35	10.47	0.8054	72.59	11.01	0.8009	84.44	11.12	0.8062	108.19	12.35	0.8103	131.31	13.54	0.8128
Burnet	0.8166	49.08	8.66	0.8178	66.38	9.81	0.8122	78.57	10.95	0.8095	94.66	11.9	0.8042	108.85	12.82	0.8009
Caldwell	0.8212	59.88	10.89	0.808	74.41	10.19	0.8051	87.02	10.36	0.8038	105.23	10.94	0.8012	122.21	10.92	0.8013
Calhoun	0.7955	60.79	10.85	0.784	75.68	10.91	0.7775	86.29	11.12	0.77	99.29	11.65	0.7672	114.28	12.6	0.7698
Callahan	0.8038	43.45	9.35	[illegible]	59.61	10.44	0.8035	71.39	10.83	0.8008	85.93	11.39	0.8017	100.82	12.27	0.8064

Figure 21: Unhidden *ebd* database contained in tab sheet `EBD-RevisedTable`. Notice the database is still locked and if there is a desire to edit the database, it would be unlocked following the process for unlocking the interface, using the same password.

Cells must not be shifted nor inserted, otherwise the index values called within the `IDF-Interface` tab sheet will no longer correspond to the correct county and/or ARI values. Such a shift is extremely difficult to detect, and the user is warned to go slowly when manually editing the database.

Counties in column A are placed into a list object entitled "List" and this object is used to create the drop down menu in the interface. Changing the counties would directly change the drop down list on the interface. Additionally, the cells A263 to A266 are used for the list objects of "Units" and "time" that are also used to generate drop down menus in the `IDF-Interface`.[22]

The use of these list objects are explained in greater detail in the `IDF-Interface` section. Once any necessary changes have been made, the `EBD-RevisedTable` tab should be protected with the same password and the tab should be hidden from view.

[22] Lists objects are created by selecting cells and typing in a name in the cell range box in the upper left corner of Excel. The objects function much like list objects in web browsers.

13.2 `IDF-Interface`

The tab sheet, `IDF-Interface`, is composed of a user prompt section on the left and a data table display with automated calculations on the right.

13.2.1 Prompt Cells

The interface is created and protected for the user to only be able to select or change cells from the drop down menus (noted by the arrows pointing down). The first drop down menu was created by selecting the merged cell (B4) and using the `Data_Validation` tool. The source is typed in based on its respective list name which was titled “Units.” The other two drop down menus were also created using the `Data_Validation` tool in MS Excel with a source of “List” corresponding to the counties and “time” for time of concentration units.

Because the arrows for the drop down lists do not appear unless the cell is selected, an object of a box with a downwards arrow was created to guide the user to select the arrow. The object was placed where the drop down arrows show when the cell is selected, and an internal (to the spreadsheet) document hyperlink was then added to each object to link to the cell with the drop down list. The ScreenTip was entered in as ‘Click’ to prompt the user to click.

When the object is clicked, the hyperlink selects the cell and shows the drop down arrow for the user to click. Once the actual drop down arrow is clicked, a list appears for the user to select items from. In all the lists, if the user types in a listed value (e.g. a correct county) the spreadsheet also functions as intended. The typed entry is case independent, but spelling must be exact. To edit the hyperlinked objects, right click on the object.

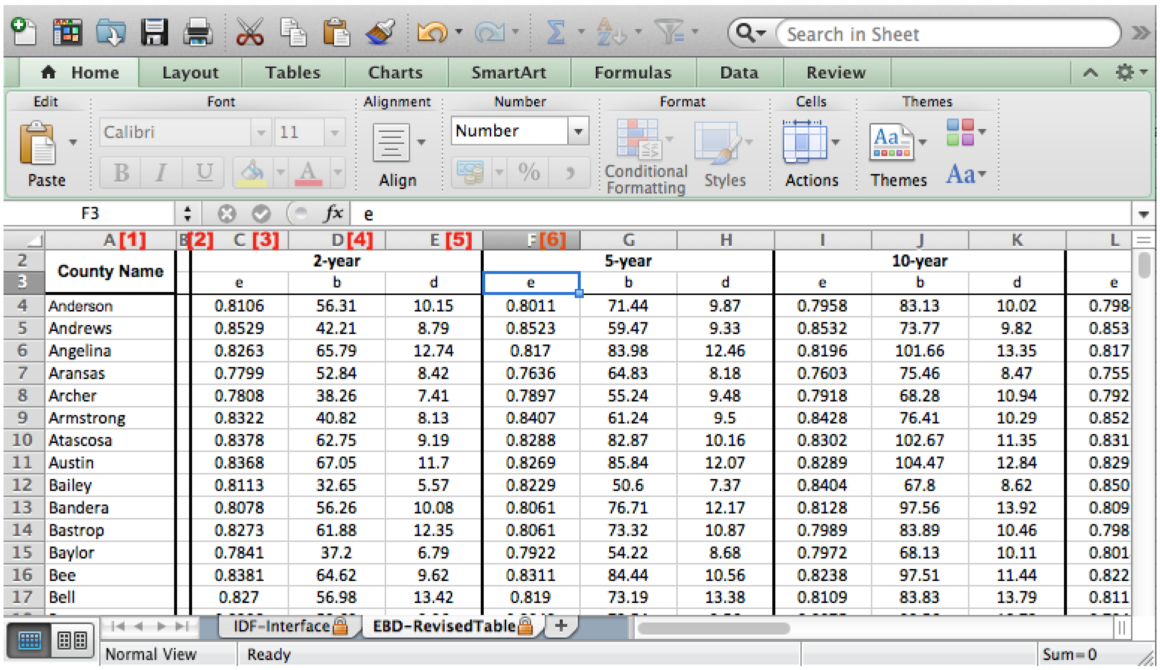
13.2.2 Data Table

The data table displays the *EBD* coefficients indexed from the database and uses the values to calculate intensities at different ARIs.

The values for the *e* coefficient at each ARI are retrieved from the database based on the selected county from the drop down menu. The MS Excel formula (for the 2-year ARI) is:

```
=INDEX('EBD-RevisedTable'!$A$4:$T$257,MATCH($B$7,List,0),3)
```

The values are indexed from the entire `EBD-RevisedTable` sheet and matched to the county chosen in the drop down menu and its list name. The formula selects the row in the `EBD-RevisedTable` based on the county selected in the interface. The 3 at the end of the index correlates with the column number in the `EBD-RevisedTable` sheet which corresponds to a certain ARI for the *e* coefficient. So the 5-year *e* coefficient for example would be in column 6 according to the database. Figure 24 shows the column count within the database. The *e* coefficient is the same regardless of the units system selected.



County Name	2-year e	2-year b	2-year d	5-year e	5-year b	5-year d	10-year e	10-year b	10-year d	e
Anderson	0.8106	56.31	10.15	0.8011	71.44	9.87	0.7958	83.13	10.02	0.798
Andrews	0.8529	42.21	8.79	0.8523	59.47	9.33	0.8532	73.77	9.82	0.853
Angelina	0.8263	65.79	12.74	0.817	83.98	12.46	0.8196	101.66	13.35	0.817
Aransas	0.7799	52.84	8.42	0.7636	64.83	8.18	0.7603	75.46	8.47	0.755
Archer	0.7808	38.26	7.41	0.7897	55.24	9.48	0.7918	68.28	10.94	0.792
Armstrong	0.8322	40.82	8.13	0.8407	61.24	9.5	0.8428	76.41	10.29	0.852
Atascosa	0.8378	62.75	9.19	0.8288	82.87	10.16	0.8302	102.67	11.35	0.831
Austin	0.8368	67.05	11.7	0.8269	85.84	12.07	0.8289	104.47	12.84	0.829
Bailey	0.8113	32.65	5.57	0.8229	50.6	7.37	0.8404	67.8	8.62	0.850
Bandera	0.8078	56.26	10.08	0.8061	76.71	12.17	0.8128	97.56	13.92	0.809
Bastrop	0.8273	61.88	12.35	0.8061	73.32	10.87	0.7989	83.89	10.46	0.798
Baylor	0.7841	37.2	6.79	0.7922	54.22	8.68	0.7972	68.13	10.11	0.801
Bee	0.8381	64.62	9.62	0.8311	84.44	10.56	0.8238	97.51	11.44	0.822
Bell	0.827	56.98	13.42	0.819	73.19	13.38	0.8109	83.83	13.79	0.811

Figure 22: Locating the corresponding column number for the 5-year *E* coefficient. Numbers in red are display as an example of column count and are not on the actual spreadsheet.

The *b* coefficient is found similarly to the *e* coefficient. The MS Excel formula (for the 2-year ARI) is:[23]

```
=IF($B$4="English",
   INDEX('EBD-RevisedTable'!$A$4:$T$257,MATCH($B$7,List,0),4),
   (INDEX('EBD-RevisedTable'!$A$4:$T$257,MATCH($B$7,List,0),4))*25.4)
```

The formula implements an `IF` statement which changes the values from the database based upon the user's selection of units. If SI units are selected, the statement is FALSE and the formula converts the values (in) matched from the database into millimeters (mm) by multiplying by 25.4. If `English` units are selected, the formula directly supplies the corresponding values from the database.

[23] In MS Excel the formula is on a single line, long formulas are broken across several lines in this document to fit the printed format.

An `IF` statement is also implemented into the label for *b* that changes the units within the parenthesis based on the user's selection of units. The Excel formula for the label in the interface is

```
=IF($B$4="SI","b (mm)", "b (in)    ")
```

The *d* coefficients are are retrieved from the database in the same fashion as the *e* coefficients except with appropriate changes made to the column call outs at the end of the formula and requisite time conversions for changing between input durations in either minutes or hours. The MS Excel formula for the 2-year ARI is:

```
=IF($C$10="min",
   INDEX('EBD-RevisedTable'!$A$4:$T$257,MATCH($B$7,List,0),5),
   INDEX('EBD-RevisedTable'!$A$4:$T$257,MATCH($B$7,List,0),5)/60)
```

Intensity is then calculated using Equation 3 and is displayed in mm/hr or in/hr, again based on user-defined units. The MS Excel formula is:

```
=IF($C$10="min",
   IF(t<10,G7/(10+G8)^G6,G7/(t+G8)^G6),
   IF((t*60)<10,G7/(10+G8)^G6,G7/((t*60)+G8)^G6))
```

The two nested `IF` statements are implemented to calculate intensity to account for user choice of time unit (minutes or hours). The first (and outer) `IF` statement is to account for units of minutes of hours that the user defines in the time of concentration box. If the first `IF` statement evaluates as TRUE and time is equivalent to minutes, then the spreadsheet determines if the duration is smaller than 10 minutes. If that condition evaluates as TRUE, then the spreadsheet calculates intensity using 10 minutes as the lowest allowable duration, otherwise it calculates intensity using the user supplied duration value. If the first (outer) `IF` statement evaluates FALSE, the program assumes the time is in hours, and converts time into minutes for the calculation, and proceeds in essentially the same fashion as above.

The label for intensity changes based on evaluation of an `IF` statement parameterized by the user's selection of English or SI units. The Excel formula for the label in the interface is

```
=IF($B$4="SI","Intensity (mm/hr)", "Intensity (in/hr)")
```

The IDF-Interface should always be protected after editing with the same password.

13.3 Training Videos

The training video was created from screen casting software. The editing instructions are a substantial component because editing instructions will be necessary for maintenance and development of future videos. The software will likely change, but the target – a video that is accessible by a variety of platforms will be the same.

13.3.1 Editing Instructions

Before editing, the editor should watch the `GettingStarted.cmproj` video provided by Camtasia. The video walks through the editing tools which are widely utilized in the spreadsheet video tutorials. To begin editing, open up the wanted `.cmproj` file in Camtasia by selecting File, Open Project and selecting the file. When the file is opened, the screen should look similar to Figure 23.

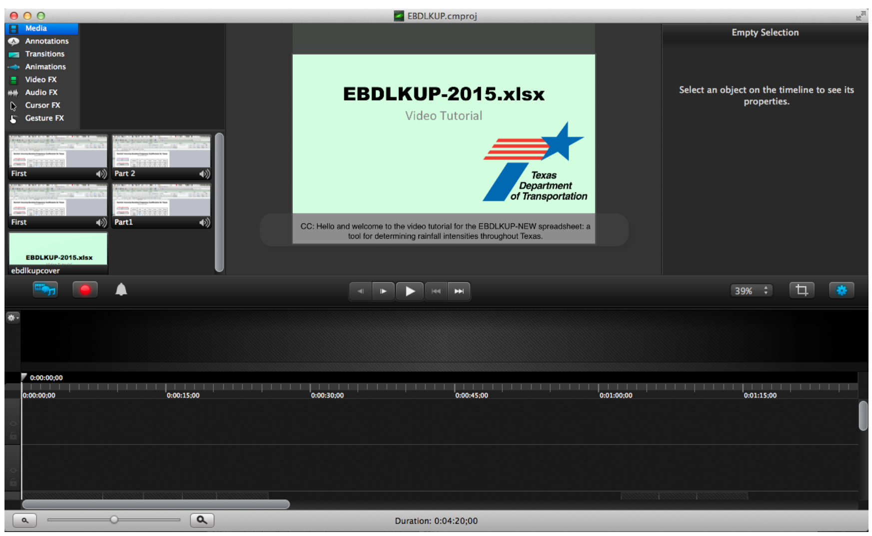


Figure 23: Window displaying the startup of the EBDLKUP.cmproj file in Camtasia 2.

Additional screen and voice recordings may be done and added into the existing file by clicking the red record button. Once the video has been recorded you may select, drag, and drop the clip in the desired place within the video timeline below. Closed captioning was created by adding in an annotation box, positioning it at the bottom of the screen and manually typing in sentences as they corresponded to the audio. For ease, copy an existing annotation box and paste it within the timeline. It should be noted that the audio and screen recording were recorded together on a single clip. Once the video is done being edited, simply click Share and Export to a specified location.

For more specific questions, please refer to the help guide provided by Camtasia.

14 Appendix – VII: EBDLKUP-2015 Tutorial

14.1 Tutorial

The tutorial provides information on how to use the EBDLKUP-2015.xlsx spreadsheet tool. A step-by-step example is included.

After downloading, move EBDLKUP-2015.xlsx into a preferred folder. To start the tool, find the file within your preferred folder, or use the search function to find the file.

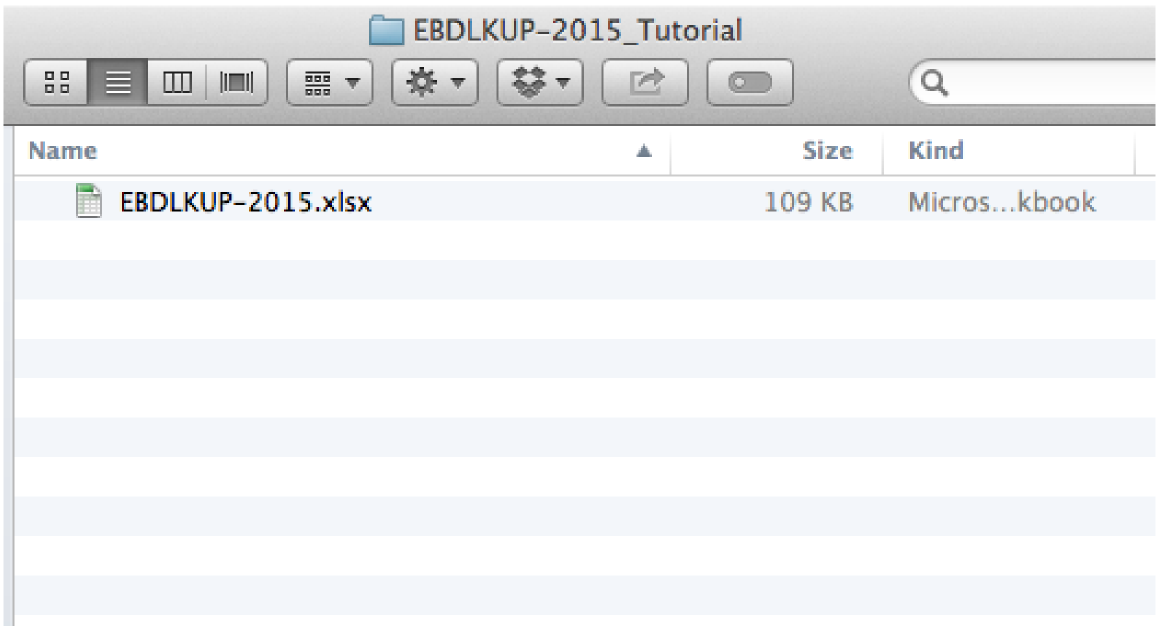


Figure 24: Locating the file EBDLKUP-2015.xlsx in the operating system. The user can move the file about to suit their preference, however the moves should be with the compressed folder so that the video and tutorial document are carried along. Failure to do so will cause the internal hyperlinks to point to nonexistent files.

Figure 24 is a screen capture showing the selection of a file location after download for running the spreadsheet.

14.2 The Interface

Figure 25 is a screen capture of the user interface. The interface consists of three prompts in red, three drop down lists in light blue cells and provided information in the large outlined table. The user should read each prompt and select from the drop down lists to retrieve desired data.

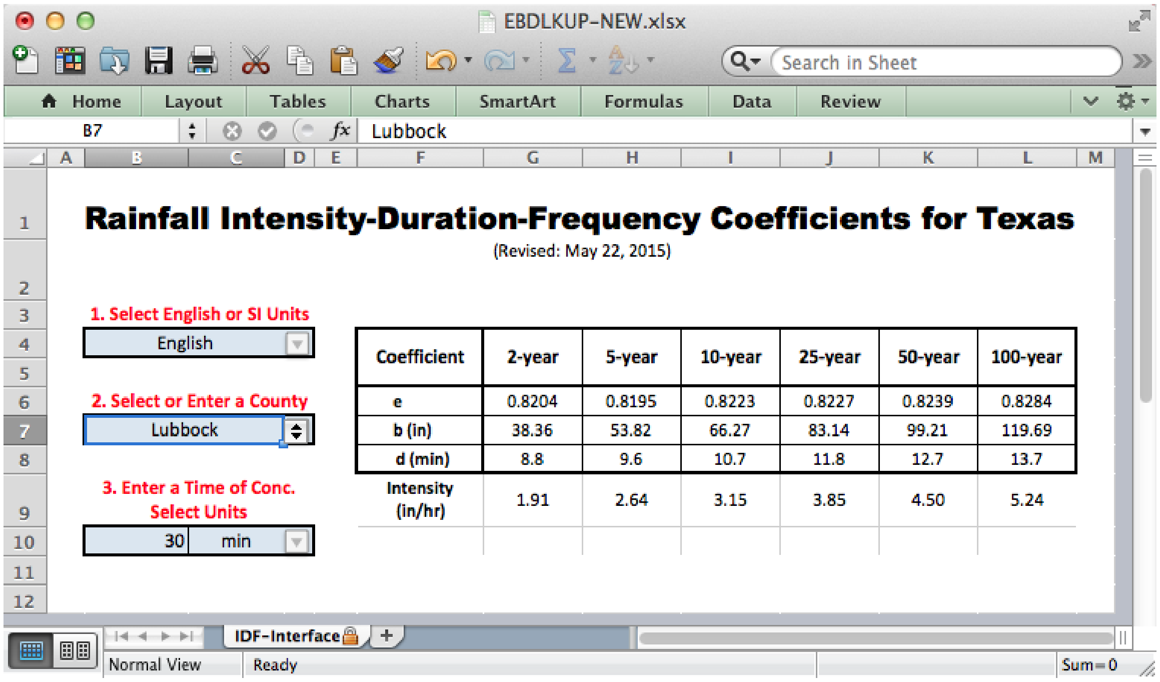


Figure 25: Interface of the `EBDLKUP-2015.xlsx` spreadsheet. This is the only tab the user needs to interact with to determine intensity.

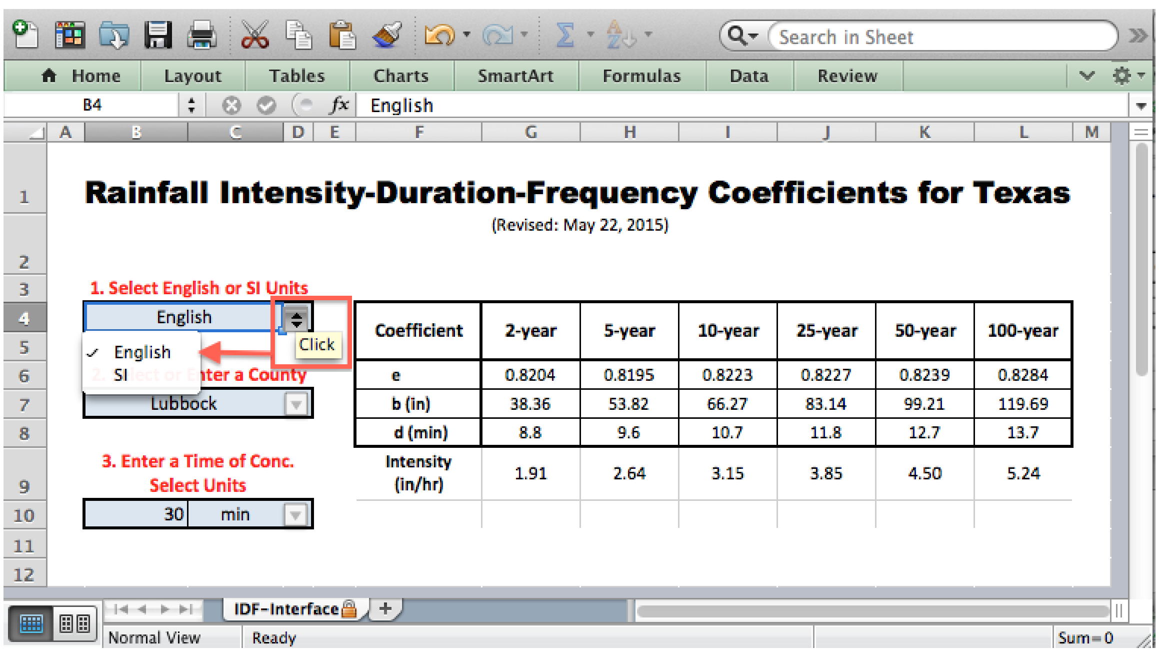


Figure 26: Opening the drop down list. Click the arrow in the red box twice until the grey drop down list appears. Selected item will have a check mark next to it.

The drop down lists can be seen by clicking on the arrow object twice until a list appears. The arrows also prompt the user with a yellow comment box to click when the mouse hovers over.

Figure 26 is a screen capture of the interface with a drop-down-list selected. Once the list appears, user can select the desired item.

The user can also manually type inputs instead of selecting from the drop down list. If the entered input does not correlate with the provided list items, an error message will appear as shown in the figure below.

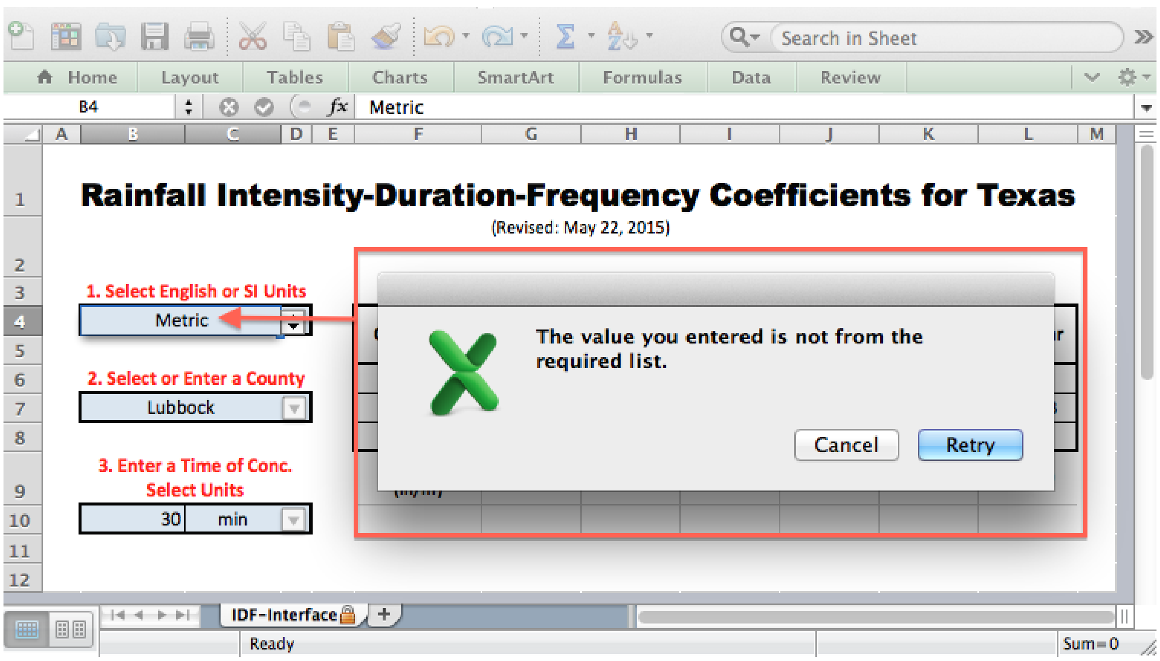
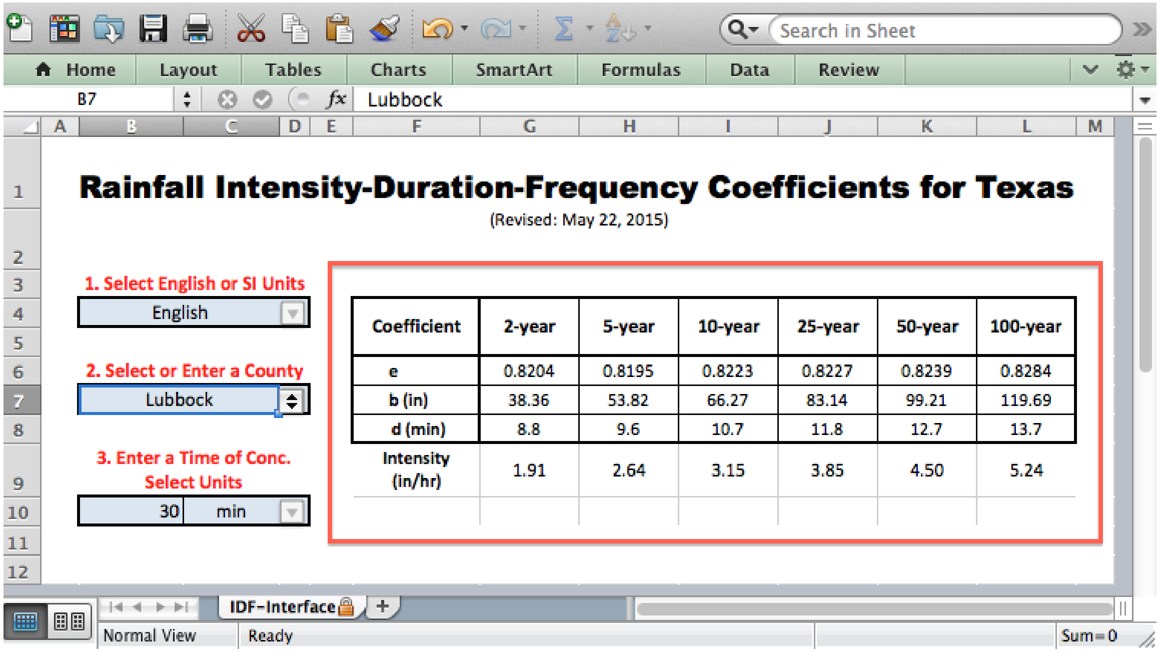


Figure 27: Error message that prompts user to change manually entered item. Retry allows for re-entry and cancel shows the previously selected item.

Figure 27 is a screen capture of such an error message. If the message appears, the user must check for spelling or grammatical errors in input or can choose to use the drop down lists instead. The input cells are not case sensitive, but spelling must be exact for a match to occur. The cells do not have an autocorrect feature.



Coefficient	2-year	5-year	10-year	25-year	50-year	100-year
e	0.8204	0.8195	0.8223	0.8227	0.8239	0.8284
b (in)	38.36	53.82	66.27	83.14	99.21	119.69
d (min)	8.8	9.6	10.7	11.8	12.7	13.7
Intensity (in/hr)	1.91	2.64	3.15	3.85	4.50	5.24

Figure 28: Data table is shown within the red box. Annual recurrence intervals range from 2 to 100-years. EBD coefficients are retrieved from a hidden database based on selected county. Intensity is displayed below.

Changing each drop down list directly affects the data table of *EBD* coefficients and calculated intensities. Figure 28 is a screen capture of the *EBD* coefficients extracted from the database. These tables update automatically.

14.3 Example Problem

The example assumes that the designer has determined a rainfall averaging time suitable for their project. The time may be a time of concentration computed by the methods in the Hydraulic Design Manual (Texas Department of Transportation, 2014) or some other authoritative reference. Once this time is determined, then the designer can proceed with using the tool.

Suppose that the designer needs to calculate the intensity for a 3-hour, 100-year storm in Harris County.

Set-Up

1. Select between English or SI Units. Double click the downwards arrow from the first drop down list and select **English** as the unit of choice. SI units would be selected in cases where the metrification requirements demand use of SI units.[24] Figure 29 shows a screen capture with the user selecting the “English” units for the tool.

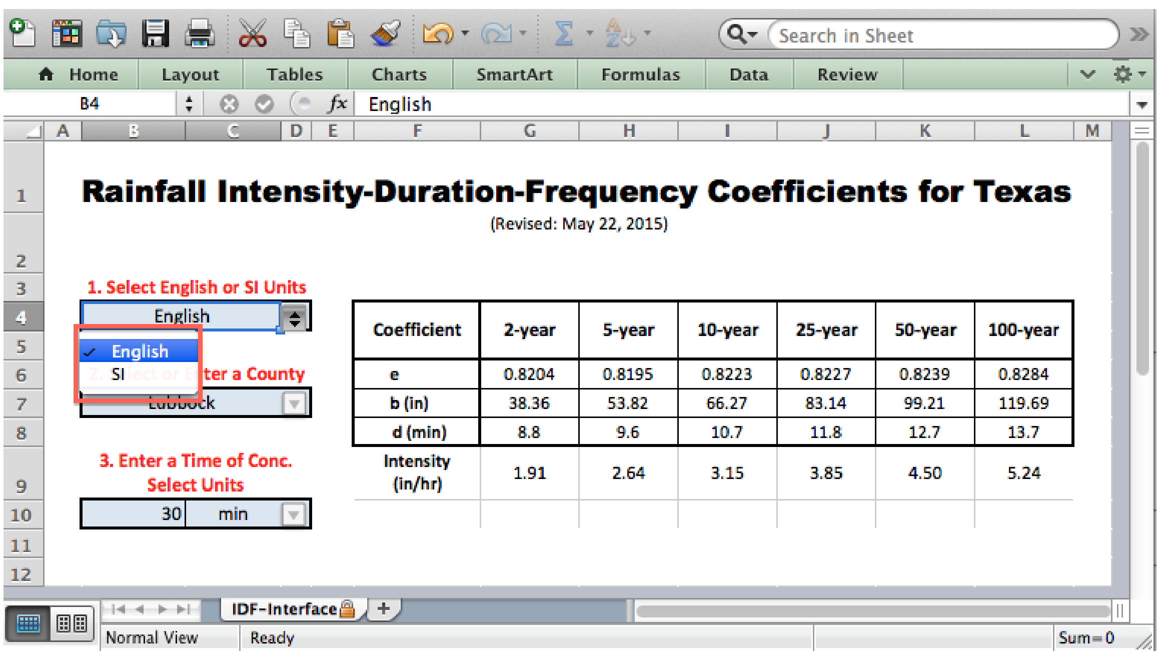


Figure 29: Selection of the first drop down list. Choice between English and SI. English is selected based on example problem.

[24]English or US Customary units are still used in the United States. Although the United Kingdom is largely metric; road signs, milk, and beer are still measured and reported in imperial units.

2. Select or manually enter in Harris as the desired County in the second drop down cell. Figure 30 is a screen capture showing the designer selecting "HARRIS" county.

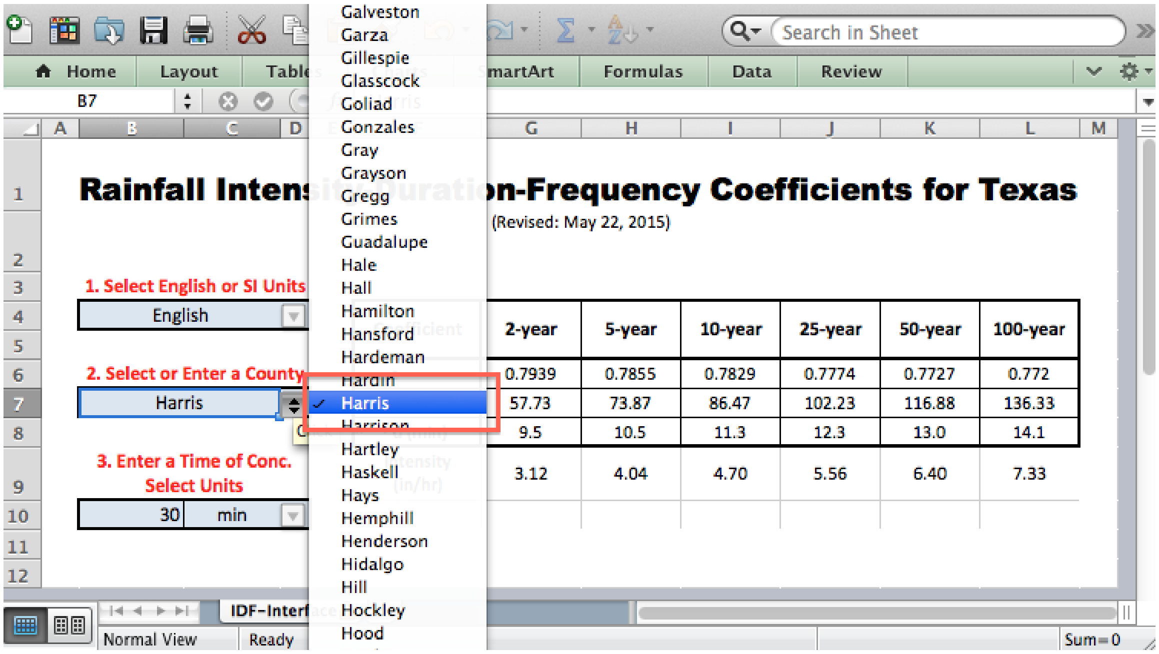


Figure 30: Selection of the second drop down list. All counties are listed in alphabetical order. Harris County is chosen based on example problem.

3. Enter in the time of concentration of 3 hours by entering in the value of 3 and changing the units to the desired hours. Figure 31 is a screen capture showing the designer selecting the duration in hours and entering the value of 3 for the time value.

4. To find the intensity for the 3 hour, 100 year storm, in the data table, find the 100-year column and follow it down to the intensity row. The intensity for a 3 hour, 100 year storm in Harris County is approximately 2.33 inches per hour. Figure 32 is a screen capture showing the result for "HARRIS" county at the 1-percent chance storm, 3 hour duration.

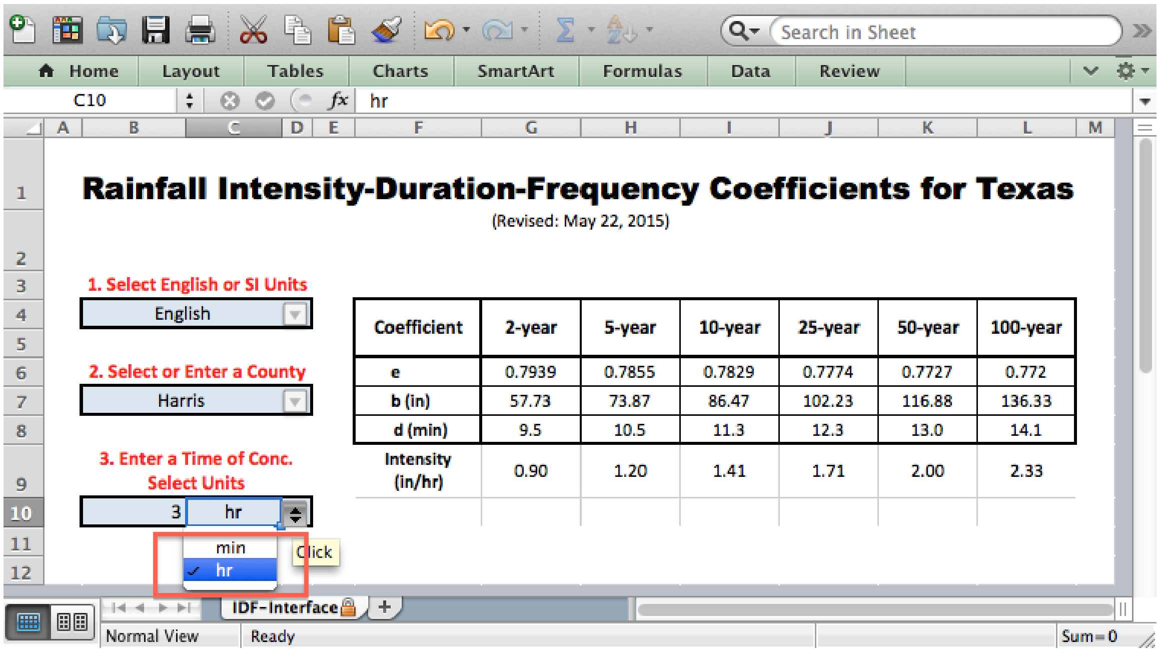


Figure 31: Selection and entry of the third prompt. Numerical value is entered before the cell containing units. A value of 3 is used based on example problem. The third drop down list consists of units of minutes (min) and hours (hr). Hours was selected based on problem statement.

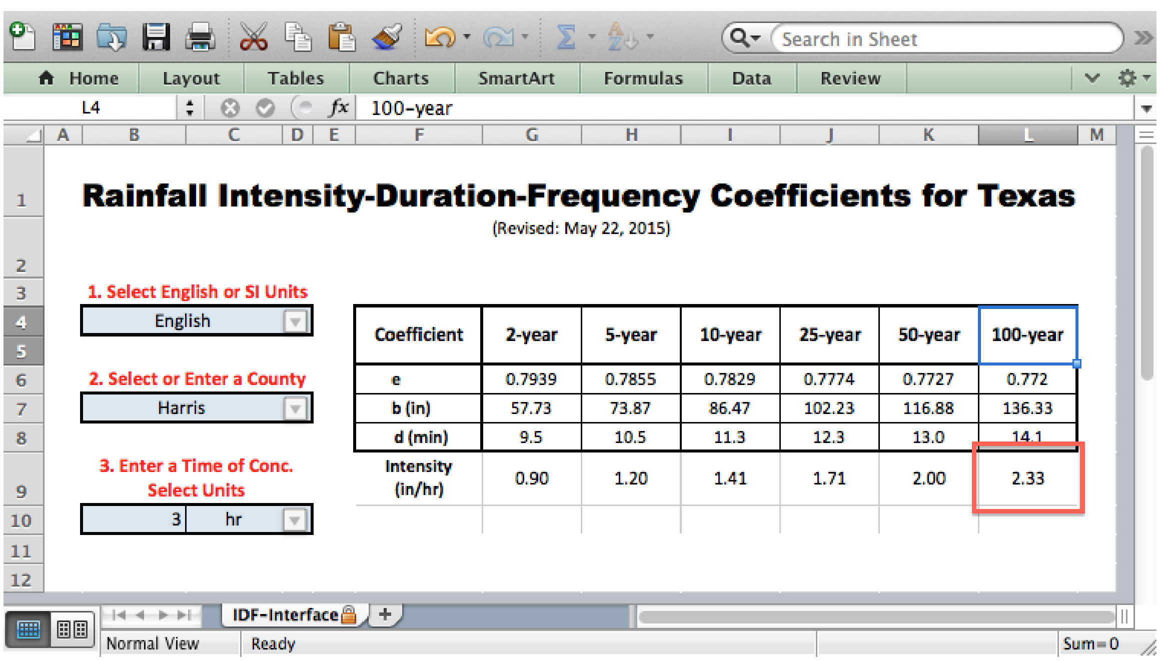


Figure 32: After prompts are selected, intensity at desired ARI can be found. For this example, 100-year ARI was chosen.

14.4 Links to Online Resources

TxDOT Hydraulic Design Manual (Texas Department of Transportation, 2014)
`http://onlinemanuals.txdot.gov/txdotmanuals/hyd/hyd.pdf`.

DDF Atlas ((Asquith and Roussel, 2004))
`http://pubs.usgs.gov/sir/2004/5041/pdf/sir2004-5041.pdf`

15 Appendix – VIII: `TXHYETO-2015.xlsx` Technical Reference Manual

The technical reference manual is provided as a guidance to help any personnel understand and edit the spreadsheet if necessary.

15.1 Enable/Disable Editing

The `TXHYETO-2015.xlsx` spreadsheet is password protected to prevent any changes in the interface logic and the underlying function coefficient database. The use of simple password protection was deemed sufficient to protect the worksheet and the underlying database from accidental changes. To make any changes to the database component, the appointed editor needs to unprotect the worksheet. To enable editing of either sheet, the password, `txhyeto-2015` all lowercase, is needed. Upon completion of any necessary changes the editor should change the revision date on the spreadsheet, and re-lock all sheets with the password.

15.1.1 Spreadsheet Password

Figure 33 is a screen capture of `TXHYETO-2015.xlsx`. The interface is locked – a padlock symbol appears at the bottom next to the tab sheet names to indicate that the worksheet is protected.

The locked configuration is intended as the default, preferred configuration, and users should not have to unlock the interface to use the tool. The worksheet should only be unlocked for maintenance, changes to the underlying database, or for addition of special features. Upon completion of such maintenance activities, the worksheet should be locked again.

If a user desires to edit components of the spreadsheet, the password is `txhyeto-2015`. The password is applied to all tab sheets within the spreadsheet, so the user will need to re-enter the password repeatedly if different tab sheets are edited. To unlock the spreadsheet, the user right-clicks the tab sheet and selects **Unprotect Sheet** from the resulting pull-down menu.

Figure 34 shows a screen capture of the spreadsheet, where the user has just right-clicked the sheet tab and selected **Unprotect Sheet**. Upon selection of **Unprotect Sheet**, the program issues a password prompt. The user responds to the prompt by typing in the password in the dialog box. The password is suppressed, so the user needs to be careful to enter the password correctly.

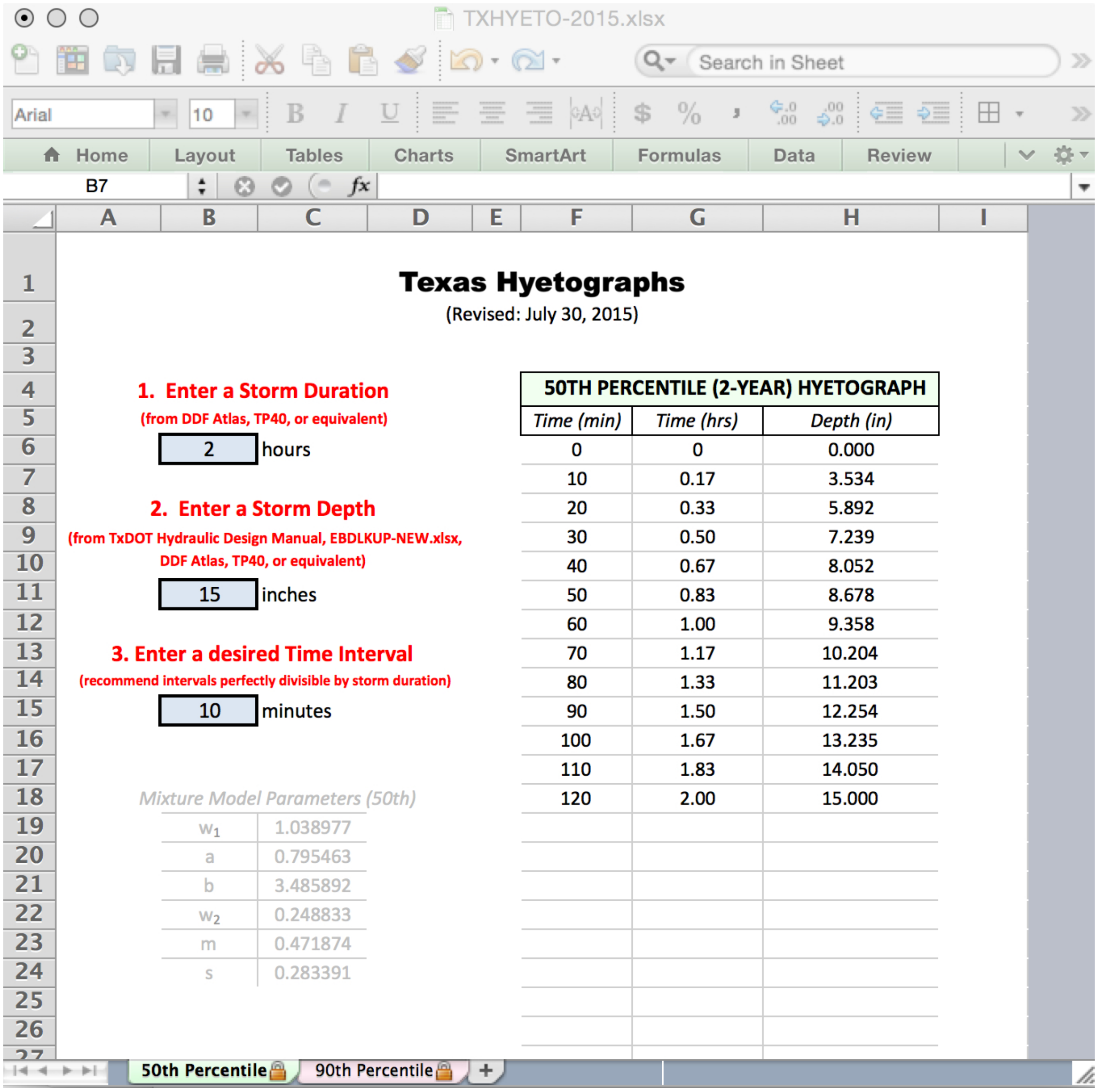


Figure 33: Interface of `TXHYETO-2015.xlsx` Spreadsheet. The interface is locked. The padlock symbols appear at the bottom next to the tab sheet names to indicate that the worksheet is protected.

Figure 35 shows the user responding to the challenge. In the figure the user has just entered the password `ebdlkup-new` and is about to select **OK**.

Upon sucessful completion of entering the password the worksheet is unlocked. Figure 36 shows the unlocked worksheet. The padlock symbol is absent indicating the worksheet is enabled for editing.

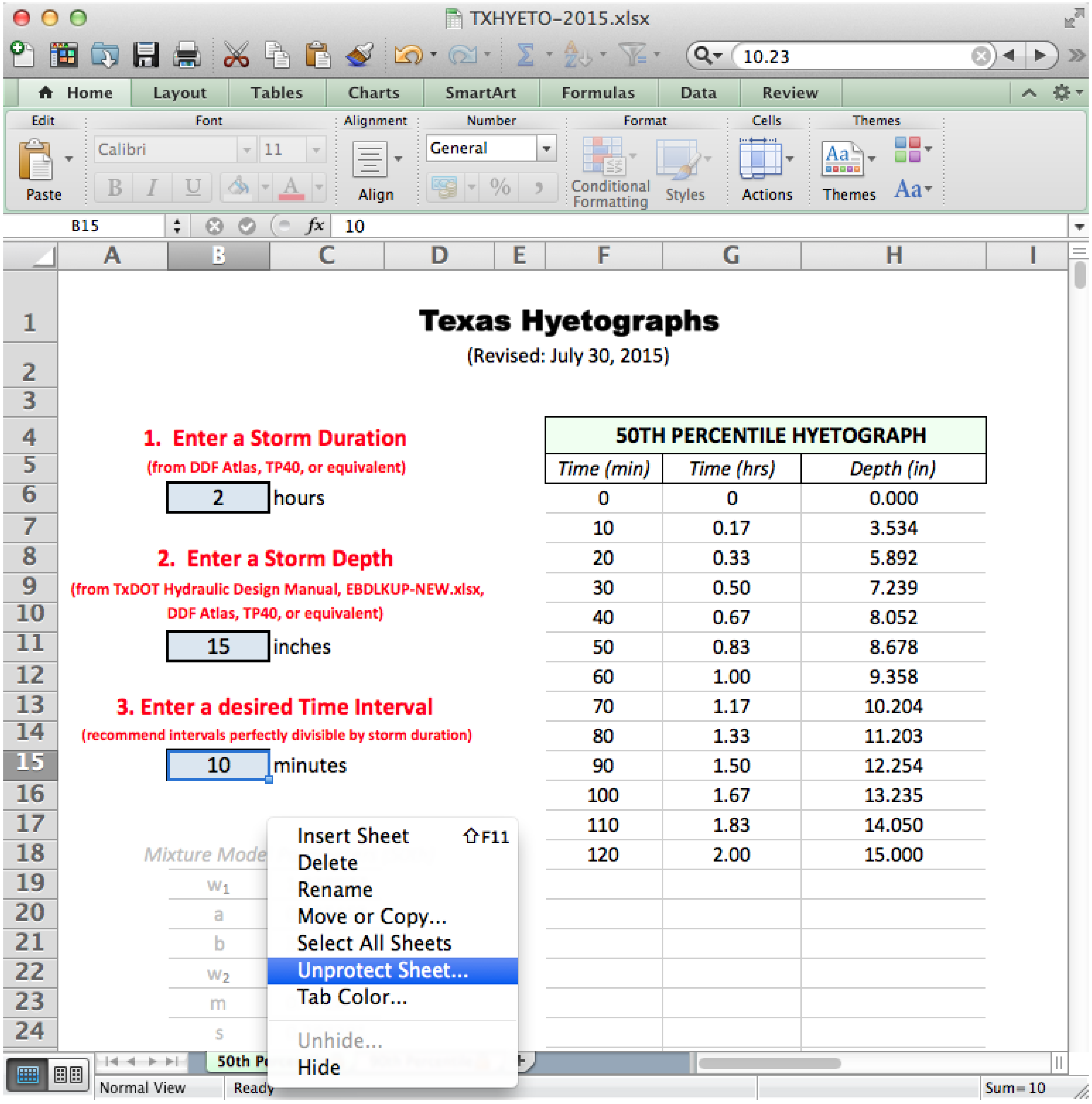


Figure 34: Interface of `TXHYETO-2015.xlsx` Spreadsheet. The user has just right-clicked the sheet tab and selected **Unprotect Sheet**.

When **OK** is selected the spreadsheet either unlocks as depicted, or states that an incorrect password was entered. The most likely password failure would be to forget the hyphen in the password, or accidentally enter the password in upper case.

During development and testing, the authors used copy-and-paste to enter the password, which is an additional option – simply copy the password from this document and paste into the dialog box.

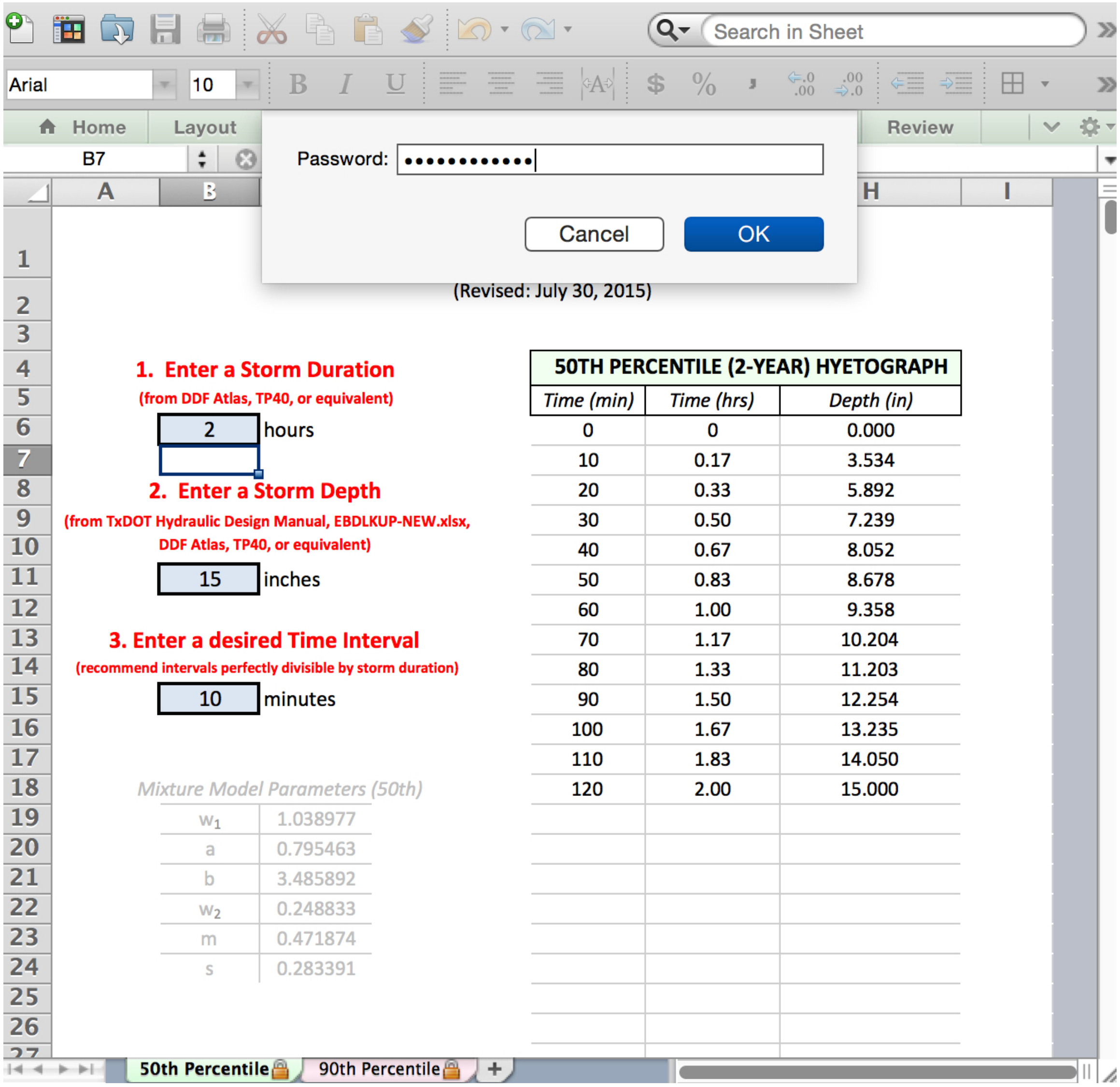


Figure 35: Interface of `TXHYETO-2015.xlsx` Spreadsheet. The user has just entered the password and is about to click **OK**.

This feature (copy-and-paste) is a good method to reset passwords after substantial editing, and will help avoid any accidental character change that could render the worksheet useless.

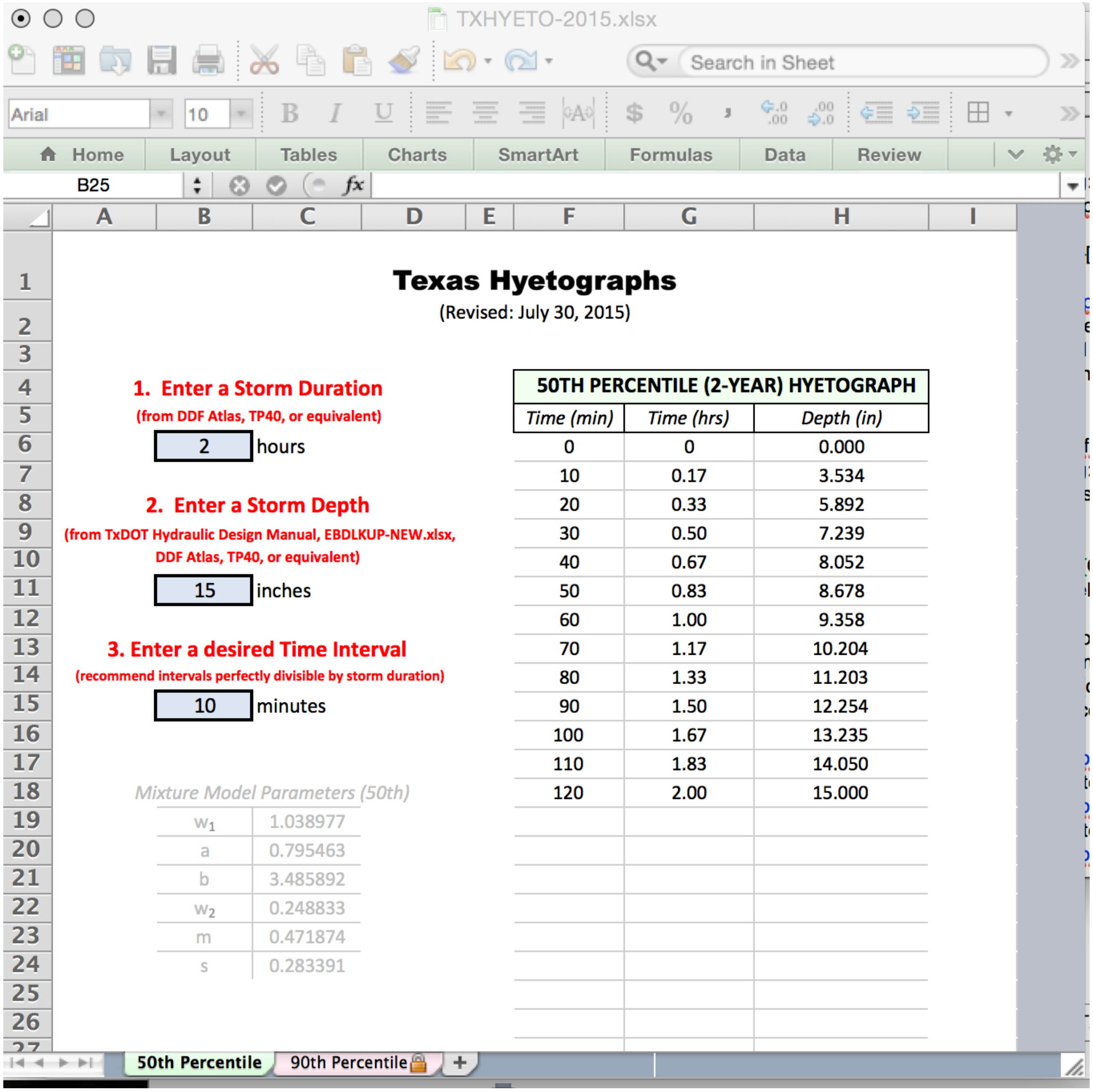


Figure 36: Interface of `TXHYETO-2015.xlsx` Spreadsheet. The padlock symbol is absent indicating that he spreadsheet is unlocked and can be edited as deemed necessary.

15.2 TXHYETO-2015 Interface

The TXHYETO-2015 interface is comprised of a user prompt section on the left and a results table display with automated calculations on the right. Figures 37 and 38 are pictures of the interface with important sections identified on the figure.

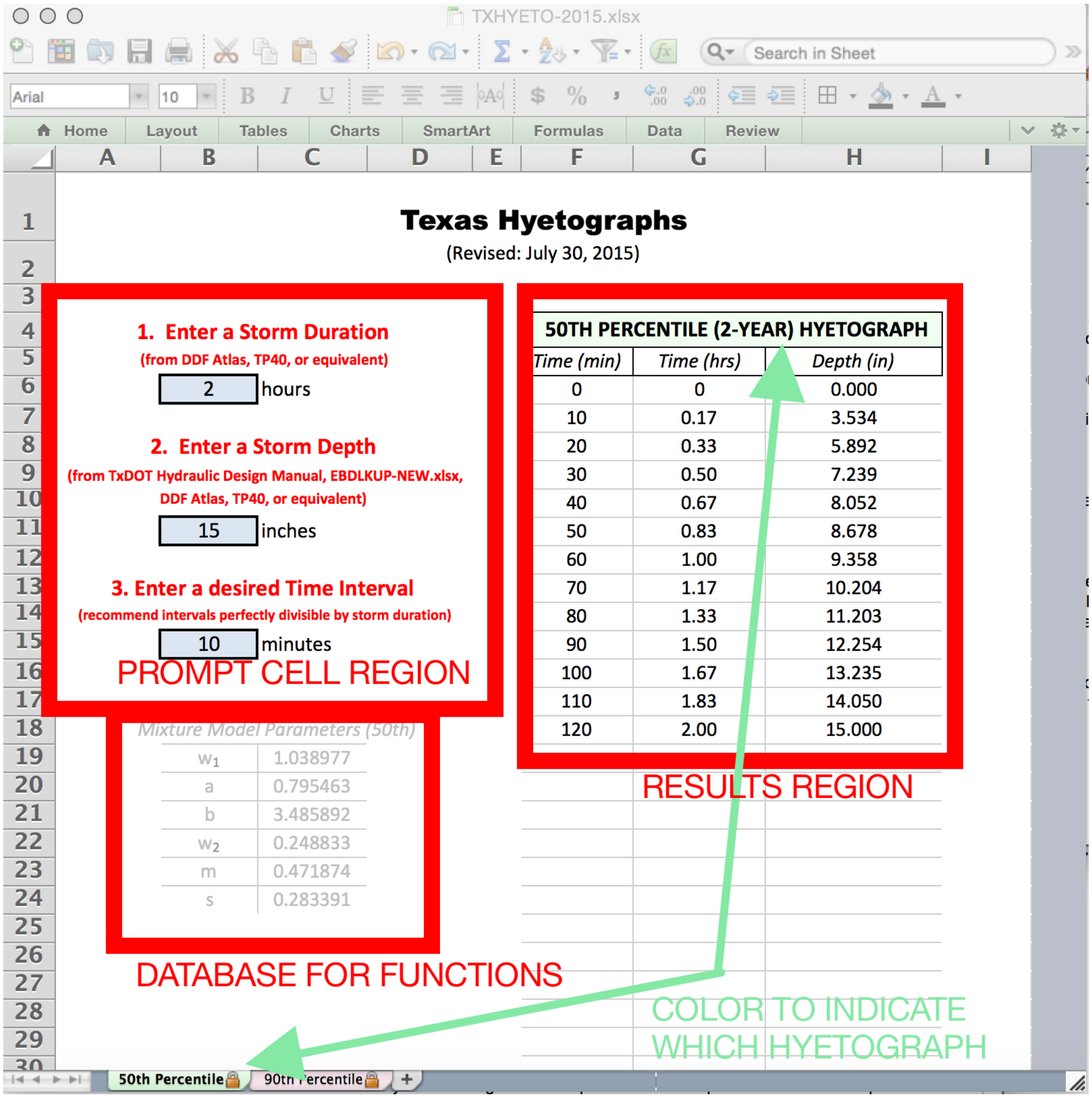


Figure 37: Interface of `TXHYETO-2015.xlsx` 50th Percentile Storm Spreadsheet, with interface sections identified.

15.2.1 Prompt Cells

The interface is created and protected for the user to only be able to select or change cells from the three prompt fields. The three fields accept numeric input – they do not error check the input, so a user could input values that cause the spreadsheet to fail. In that situation, the user should exit the spreadsheet (do not save changes) and restart.

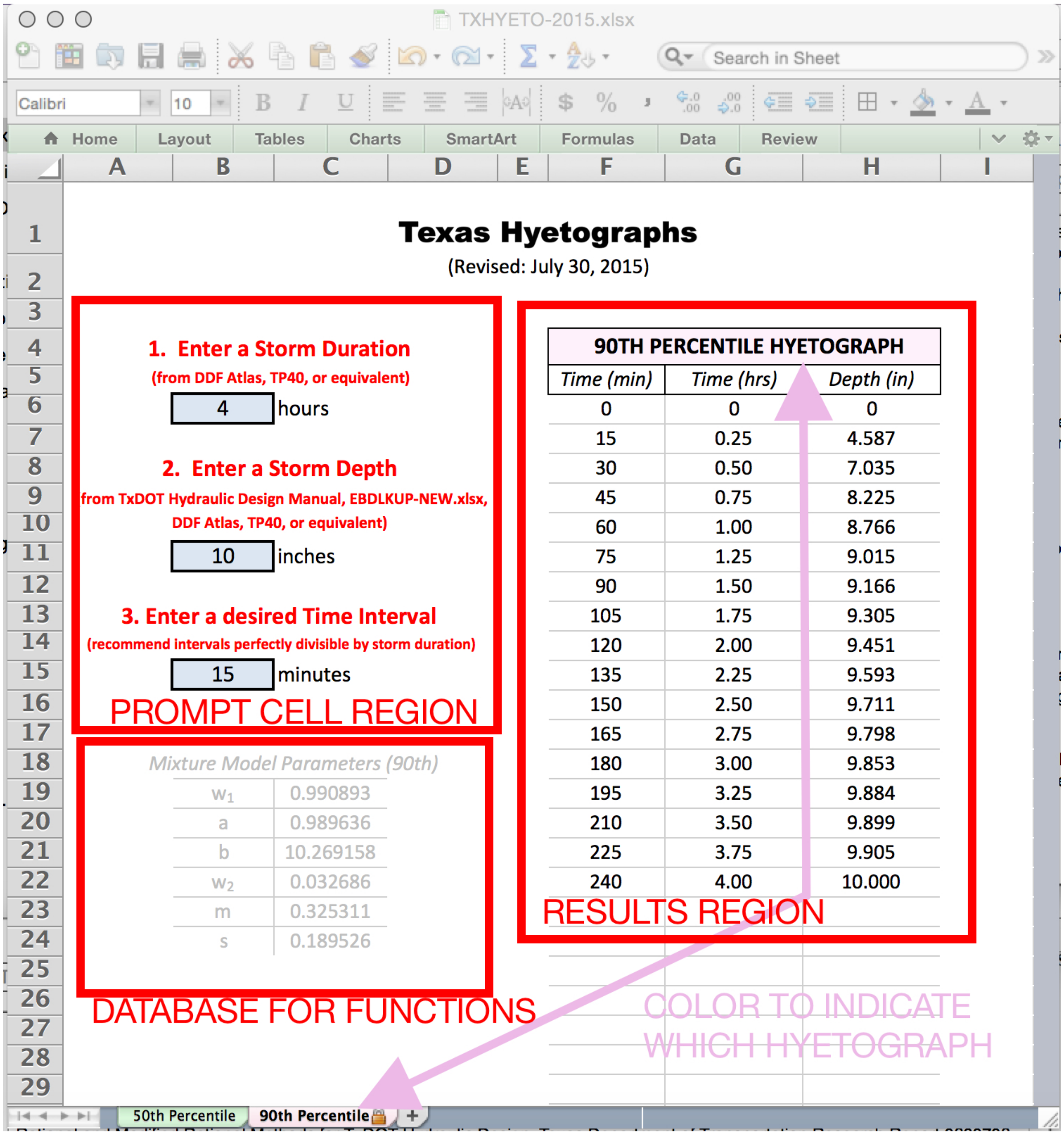


Figure 38: Interface of `TXHYETO-2015.xlsx` 90th Percentile Storm Spreadsheet, with interface sections identified.

15.2.2 Data Table

The data tables for two tab sheets are shown in the subdued grey for below the user prompt region. The functions in the results section refer to these values. The values themselves are the parameters for the approximation functions of the tabulations in Williams-Sether and others (2004).

15.3 Programmer Notes

The results region automatically resizes based on user input. The region uses the programming construct of over-dimensioning to accomplish the resizing. The formulas extend for 600 rows (at 5-minute intervals it provides about 2 days of simulation time — more than enough for any realistic use of the Texas Hyetographs). If the user needs to simulate more, then they will need to unlock and extend the formulas by copy-and-paste starting from the last row.

Figure 39 is a screen capture of the relevant portion of the spreadsheet that produces the results columns, showing formulas instead of the computed (numeric) values.

	F	G	H
1		Texas Hyetographs	
2		(Revised: July 30, 2015)	
3			
4			50TH PERCENTILE HYETOGRAPH
5	*Time (min)*	*Time (hrs)*	*Depth (in)*
6	0	=F6/60	=IF(H5=$B$11,"",IF(H5="","",IF(G6<=0,0,IF(ROUND(G6,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G6/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G6/$B$6,$C$23,$C$24,FALSE))*$B$11))))
7	=IF(H7="","",F6+$B$15)	=IF(G6>=$B$6,"",IF(G6="","",(G6+($B$15/60))))	=IF(H6=$B$11,"",IF(H6="","",IF(G7<=0,0,IF(ROUND(G7,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G7/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G7/$B$6,$C$23,$C$24,FALSE))*$B$11))))
8	=IF(H8="","",F7+$B$15)	=IF(G7>=$B$6,"",IF(G7="","",(G7+($B$15/60))))	=IF(H7=$B$11,"",IF(H7="","",IF(G8<=0,0,IF(ROUND(G8,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G8/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G8/$B$6,$C$23,$C$24,FALSE))*$B$11))))
9	=IF(H9="","",F8+$B$15)	=IF(G8>=$B$6,"",IF(G8="","",(G8+($B$15/60))))	=IF(H8=$B$11,"",IF(H8="","",IF(G9<=0,0,IF(ROUND(G9,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G9/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G9/$B$6,$C$23,$C$24,FALSE))*$B$11))))
10	=IF(H10="","",F9+$B$15)	=IF(G9>=$B$6,"",IF(G9="","",(G9+($B$15/60))))	=IF(H9=$B$11,"",IF(H9="","",IF(G10<=0,0,IF(ROUND(G10,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G10/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G10/$B$6,$C$23,$C$24,FALSE))*$B$11))))
11	=IF(H11="","",F10+$B$15)	=IF(G10>=$B$6,"",IF(G10="","",(G10+($B$15/60))))	=IF(H10=$B$11,"",IF(H10="","",IF(G11<=0,0,IF(ROUND(G11,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G11/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G11/$B$6,$C$23,$C$24,FALSE))*$B$11))))
12	=IF(H12="","",F11+$B$15)	=IF(G11>=$B$6,"",IF(G11="","",(G11+($B$15/60))))	=IF(H11=$B$11,"",IF(H11="","",IF(G12<=0,0,IF(ROUND(G12,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G12/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G12/$B$6,$C$23,$C$24,FALSE))*$B$11))))
13	=IF(H13="","",F12+$B$15)	=IF(G12>=$B$6,"",IF(G12="","",(G12+($B$15/60))))	=IF(H12=$B$11,"",IF(H12="","",IF(G13<=0,0,IF(ROUND(G13,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G13/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G13/$B$6,$C$23,$C$24,FALSE))*$B$11))))
14	=IF(H14="","",F13+$B$15)	=IF(G13>=$B$6,"",IF(G13="","",(G13+($B$15/60))))	=IF(H13=$B$11,"",IF(H13="","",IF(G14<=0,0,IF(ROUND(G14,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G14/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G14/$B$6,$C$23,$C$24,FALSE))*$B$11))))
15	=IF(H15="","",F14+$B$15)	=IF(G14>=$B$6,"",IF(G14="","",(G14+($B$15/60))))	=IF(H14=$B$11,"",IF(H14="","",IF(G15<=0,0,IF(ROUND(G15,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G15/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G15/$B$6,$C$23,$C$24,FALSE))*$B$11))))
16	=IF(H16="","",F15+$B$15)	=IF(G15>=$B$6,"",IF(G15="","",(G15+($B$15/60))))	=IF(H15=$B$11,"",IF(H15="","",IF(G16<=0,0,IF(ROUND(G16,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G16/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G16/$B$6,$C$23,$C$24,FALSE))*$B$11))))
17	=IF(H17="","",F16+$B$15)	=IF(G16>=$B$6,"",IF(G16="","",(G16+($B$15/60))))	=IF(H16=$B$11,"",IF(H16="","",IF(G17<=0,0,IF(ROUND(G17,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G17/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G17/$B$6,$C$23,$C$24,FALSE))*$B$11))))
18	=IF(H18="","",F17+$B$15)	=IF(G17>=$B$6,"",IF(G17="","",(G17+($B$15/60))))	=IF(H17=$B$11,"",IF(H17="","",IF(G18<=0,0,IF(ROUND(G18,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G18/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G18/$B$6,$C$23,$C$24,FALSE))*$B$11))))
19	=IF(H19="","",F18+$B$15)	=IF(G18>=$B$6,"",IF(G18="","",(G18+($B$15/60))))	=IF(H18=$B$11,"",IF(H18="","",IF(G19<=0,0,IF(ROUND(G19,2)>=$B$6,$B$11,($C$19*(BETA.DIST(G19/$B$6,$C$20,$C$21,TRUE,0,1))-$C$22*NORM.DIST(G19/$B$6,$C$23,$C$24,FALSE))*$B$11))))

Figure 39: Results section of Spreadsheet showing actual formulas.

To suppress un-necessary output the formula in the right most column H tests for total accumulated depth. If that value is reached, then further output is suppressed by placing null results into that cell. The first column F tests if the right most column is blank, if true, they it too places a blank result in that space, otherwise it increments time. The middle column G is simply a temporal rescaling between hours and minutes.

15.4 Training Videos

The training video was created from screen casting software. Editing will be necessary for maintenance and development of future videos. The software will likely change, but the target – a video that is accessible by a variety of platforms will be the same.

15.4.1 Editing Instructions

The editor needs to watch the `GettingStarted.cmproj` video provided by Camtasia before editing. The video walks through the editing tools which are widely utilized in the spreadsheet video tutorials.

To begin editing, open up the wanted `.cmproj` file in Camtasia by selecting File, Open Project and selecting the file. When the file is opened, the screen should look similar to Figure 40.

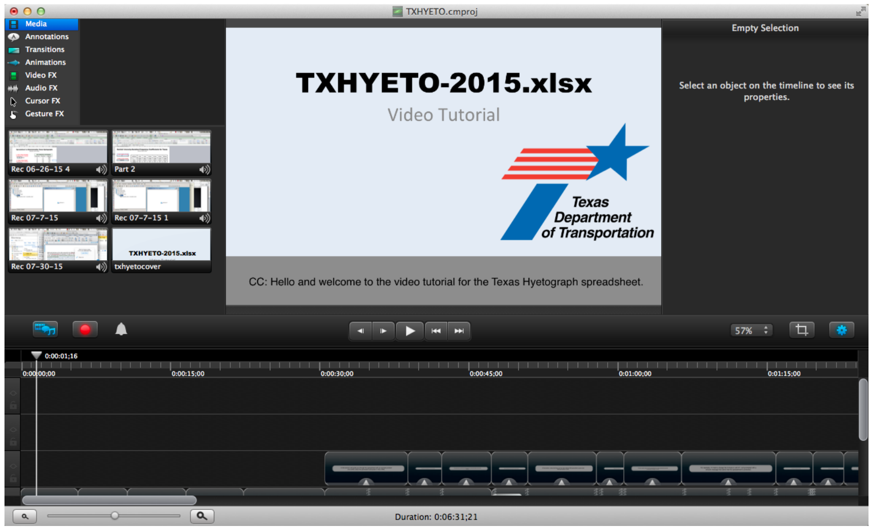


Figure 40: Window displaying the startup of the TXHYETO.cmproj file in Camtasia 2.

Additional screen and voice recordings may be done and added into the existing file by clicking the red record button. Once the video has been recorded you may select, drag, and drop the clip in the desired place within the video timeline below. Closed captioning was created by adding in an annotation box, positioning it at the bottom of the screen and manually typing in sentences as they corresponded to the audio. For ease, copy an existing annotation box and paste it within the timeline. It should be noted that the audio and screen recording were recorded together on a single clip. Once the video is done being edited, simply click Share and Export to a specified location.

For more specific questions, please refer to the help guide provided by Camtasia.

15.5 Additional Documentation

15.5.1 Interpolation of the Original Tables

The Texas Department of Transportation sponsored research to develop Texas-specific storm hyetographs. The results were reported in Williams-Sether and others (2004), but use of the hyetographs has been limited by difficulty in using either the graphical or tabulated hyetographs for arbitrary durations and depths (dimensional mapping), and in producing uniform time step estimates for inclusion into hydrologic software such as HEC-HMS or SWMM.

15.6 Tabular Representation

Supplement 5. Trimmed and smoothed percentiles for empirical hyetograph analysis, 1959–86.—Continued

[The interval is the center of the percent-of-storm-duration interval; --, no data]

Interval	Percentile										
	10th	20th	25th	30th	40th	50th	60th	70th	75th	80th	90th
First- through fourth-quartile storms combined; storm duration 0 to 72 hours											
2.5	1.08	2.04	2.58	3.34	4.69	6.37	7.81	10.30	12.16	14.66	21.60
5.0	2.35	4.32	5.47	6.84	9.74	13.58	16.97	21.38	24.48	28.12	37.57
7.5	3.59	6.56	8.32	10.27	14.68	20.49	25.56	31.57	35.63	40.20	51.55
10.0	4.82	8.78	11.16	13.68	19.47	26.83	33.19	40.38	45.16	50.47	63.04
12.5	5.92	10.85	13.80	16.85	23.94	32.42	39.68	47.57	52.72	58.62	71.66
15.0	6.92	12.77	16.23	19.72	27.91	37.21	45.23	53.41	58.54	64.61	77.38
17.5	7.80	14.43	18.29	22.14	31.01	41.00	49.56	57.96	62.97	68.83	80.89
20.0	8.60	15.99	20.23	24.32	33.59	44.11	53.16	61.80	66.74	72.25	83.32
22.5	9.31	17.38	21.89	26.21	35.63	46.55	55.92	65.02	69.84	74.94	85.01
25.0	10.06	18.75	23.51	28.07	37.35	48.54	58.09	67.80	72.62	77.28	86.35
27.5	10.87	20.11	25.00	29.79	38.88	50.23	59.80	70.07	75.06	79.47	87.66
30.0	11.70	21.51	26.51	31.41	40.52	51.68	61.22	71.87	76.92	81.38	88.96
32.5	12.51	22.77	27.81	32.85	42.01	52.90	62.34	73.12	78.10	82.81	90.18
35.0	13.35	24.09	29.22	34.30	43.56	54.27	63.76	74.21	79.02	84.02	91.29
37.5	14.16	25.27	30.47	35.54	44.99	55.49	65.16	75.15	79.64	84.83	92.25
40.0	14.96	26.51	31.85	36.89	46.42	56.80	66.62	76.11	80.22	85.47	93.05
42.5	15.78	27.58	33.21	38.24	47.68	58.03	67.98	77.06	80.86	86.03	93.72
45.0	16.71	28.90	34.80	39.80	49.13	59.31	69.33	78.12	81.72	86.61	94.24
47.5	17.89	30.35	36.44	41.44	50.66	60.49	70.35	79.07	82.56	87.09	94.64
50.0	19.41	32.28	38.33	43.33	52.45	61.97	71.60	80.06	83.51	87.72	94.92
52.5	21.16	34.45	40.32	45.28	54.39	63.51	72.89	81.15	84.53	88.42	95.18
55.0	22.94	36.99	42.49	47.39	56.57	65.39	74.37	82.30	85.61	89.20	95.40
57.5	24.82	39.38	44.67	49.56	58.80	67.56	76.05	83.52	86.75	90.06	95.70
60.0	26.62	41.64	46.83	51.75	61.09	69.85	77.89	84.82	88.01	91.04	96.06
62.5	28.29	43.62	49.00	53.94	63.38	72.11	79.55	86.10	89.22	91.97	96.47
65.0	29.86	45.38	50.95	56.07	65.59	74.32	81.14	87.25	90.31	92.83	96.90
67.5	31.76	47.16	52.88	58.23	67.77	76.38	82.65	88.36	91.31	93.60	97.32
70.0	33.75	49.16	54.81	60.32	69.87	78.21	84.02	89.37	92.17	94.27	97.68
72.5	36.00	51.52	56.94	62.47	71.97	80.00	85.35	90.35	92.90	94.84	97.97
75.0	38.51	54.15	59.24	64.72	73.98	81.61	86.69	91.30	93.55	95.38	98.19
77.5	41.45	57.17	62.09	67.30	76.10	83.25	88.02	92.25	94.20	95.89	98.38
80.0	44.54	60.42	65.22	70.08	78.24	84.84	89.34	93.15	94.86	96.39	98.56
82.5	48.24	64.13	68.85	73.31	80.60	86.54	90.72	94.08	95.54	96.87	98.72
85.0	52.41	68.26	72.78	76.77	83.07	88.30	92.09	94.98	96.22	97.34	98.90
87.5	57.68	72.90	77.10	80.53	85.81	90.21	93.49	95.87	96.93	97.81	99.09
90.0	64.02	77.90	81.55	84.43	88.65	92.18	94.92	96.75	97.61	98.28	99.29
92.5	71.71	83.28	86.22	88.48	91.66	94.22	96.37	97.65	98.29	98.75	99.49
95.0	80.43	88.80	90.85	92.47	94.62	96.21	97.81	98.54	98.96	99.22	99.70
97.5	90.01	94.42	95.53	96.53	97.64	98.21	99.26	99.44	99.65	99.70	99.92

Figure 41: Tabulation used to generate dimensionless hyetographs (from Williams-Sether (2004)).

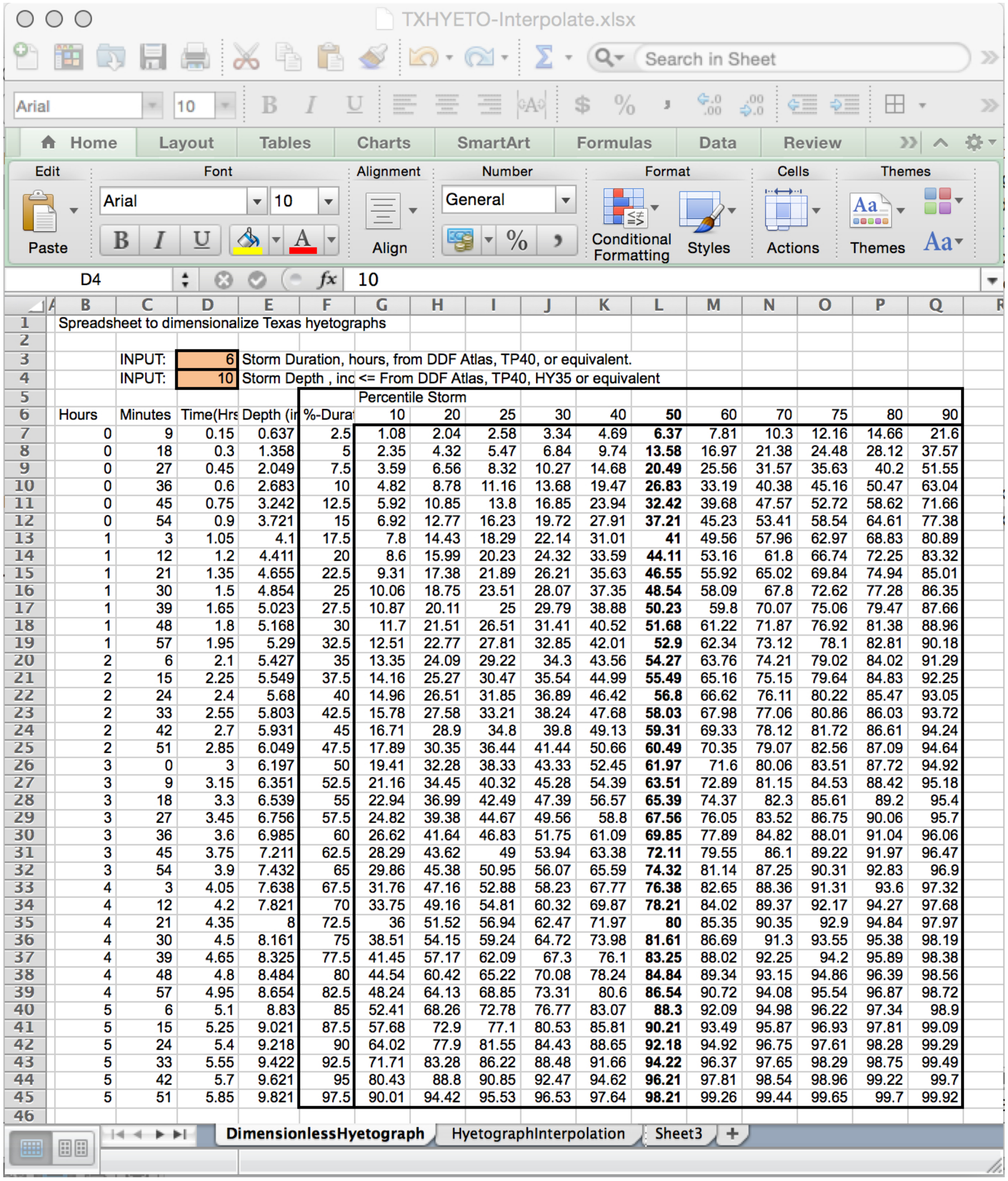
The dimensionless hyetographs in Figures 8 was created from the tabulated values as displayed in Figure 41. These values would be the logical choice for dimensional mapping for small uniform time intervals (say every 15 minutes).

The impediment to using the tabulation is a need to be able to map time and depth (which is relatively straightforward – multiply by the total storm duration and total storm depth) and a subsequent need to interpolate between the dimensional pairs of time and depth which may not fall exactly onto the time intervals needed.

An alternative to interpolation is to "fit" smooth functions to the tabulation in dimensionless space and then directly estimate time-depth pairs from this smooth function. After the smooth function is created, dimensional mapping is relatively straightforward and is the mechanism in `TXHYETO-Function.xlsx`.

15.6.1 Direct Interpolation

An initial attempt at a general tool was explored using the tabulation in Figure 41 and the straight-forward rescaling as illustrated in Figure 42.



Spreadsheet to dimensionalize Texas hyetographs

INPUT: 6 Storm Duration, hours, from DDF Atlas, TP40, or equivalent.

INPUT: 10 Storm Depth , inc <= From DDF Atlas, TP40, HY35 or equivalent

					Percentile Storm										
Hours	Minutes	Time(Hrs	Depth (ir	%-Durat	10	20	25	30	40	**50**	60	70	75	80	90
0	9	0.15	0.637	2.5	1.08	2.04	2.58	3.34	4.69	**6.37**	7.81	10.3	12.16	14.66	21.6
0	18	0.3	1.358	5	2.35	4.32	5.47	6.84	9.74	**13.58**	16.97	21.38	24.48	28.12	37.57
0	27	0.45	2.049	7.5	3.59	6.56	8.32	10.27	14.68	**20.49**	25.56	31.57	35.63	40.2	51.55
0	36	0.6	2.683	10	4.82	8.78	11.16	13.68	19.47	**26.83**	33.19	40.38	45.16	50.47	63.04
0	45	0.75	3.242	12.5	5.92	10.85	13.8	16.85	23.94	**32.42**	39.68	47.57	52.72	58.62	71.66
0	54	0.9	3.721	15	6.92	12.77	16.23	19.72	27.91	**37.21**	45.23	53.41	58.54	64.61	77.38
1	3	1.05	4.1	17.5	7.8	14.43	18.29	22.14	31.01	**41**	49.56	57.96	62.97	68.83	80.89
1	12	1.2	4.411	20	8.6	15.99	20.23	24.32	33.59	**44.11**	53.16	61.8	66.74	72.25	83.32
1	21	1.35	4.655	22.5	9.31	17.38	21.89	26.21	35.63	**46.55**	55.92	65.02	69.84	74.94	85.01
1	30	1.5	4.854	25	10.06	18.75	23.51	28.07	37.35	**48.54**	58.09	67.8	72.62	77.28	86.35
1	39	1.65	5.023	27.5	10.87	20.11	25	29.79	38.88	**50.23**	59.8	70.07	75.06	79.47	87.66
1	48	1.8	5.168	30	11.7	21.51	26.51	31.41	40.52	**51.68**	61.22	71.87	76.92	81.38	88.96
1	57	1.95	5.29	32.5	12.51	22.77	27.81	32.85	42.01	**52.9**	62.34	73.12	78.1	82.81	90.18
2	6	2.1	5.427	35	13.35	24.09	29.22	34.3	43.56	**54.27**	63.76	74.21	79.02	84.02	91.29
2	15	2.25	5.549	37.5	14.16	25.27	30.47	35.54	44.99	**55.49**	65.16	75.15	79.64	84.83	92.25
2	24	2.4	5.68	40	14.96	26.51	31.85	36.89	46.42	**56.8**	66.62	76.11	80.22	85.47	93.05
2	33	2.55	5.803	42.5	15.78	27.58	33.21	38.24	47.68	**58.03**	67.98	77.06	80.86	86.03	93.72
2	42	2.7	5.931	45	16.71	28.9	34.8	39.8	49.13	**59.31**	69.33	78.12	81.72	86.61	94.24
2	51	2.85	6.049	47.5	17.89	30.35	36.44	41.44	50.66	**60.49**	70.35	79.07	82.56	87.09	94.64
3	0	3	6.197	50	19.41	32.28	38.33	43.33	52.45	**61.97**	71.6	80.06	83.51	87.72	94.92
3	9	3.15	6.351	52.5	21.16	34.45	40.32	45.28	54.39	**63.51**	72.89	81.15	84.53	88.42	95.18
3	18	3.3	6.539	55	22.94	36.99	42.49	47.39	56.57	**65.39**	74.37	82.3	85.61	89.2	95.4
3	27	3.45	6.756	57.5	24.82	39.38	44.67	49.56	58.8	**67.56**	76.05	83.52	86.75	90.06	95.7
3	36	3.6	6.985	60	26.62	41.64	46.83	51.75	61.09	**69.85**	77.89	84.82	88.01	91.04	96.06
3	45	3.75	7.211	62.5	28.29	43.62	49	53.94	63.38	**72.11**	79.55	86.1	89.22	91.97	96.47
3	54	3.9	7.432	65	29.86	45.38	50.95	56.07	65.59	**74.32**	81.14	87.25	90.31	92.83	96.9
4	3	4.05	7.638	67.5	31.76	47.16	52.88	58.23	67.77	**76.38**	82.65	88.36	91.31	93.6	97.32
4	12	4.2	7.821	70	33.75	49.16	54.81	60.32	69.87	**78.21**	84.02	89.37	92.17	94.27	97.68
4	21	4.35	8	72.5	36	51.52	56.94	62.47	71.97	**80**	85.35	90.35	92.9	94.84	97.97
4	30	4.5	8.161	75	38.51	54.15	59.24	64.72	73.98	**81.61**	86.69	91.3	93.55	95.38	98.19
4	39	4.65	8.325	77.5	41.45	57.17	62.09	67.3	76.1	**83.25**	88.02	92.25	94.2	95.89	98.38
4	48	4.8	8.484	80	44.54	60.42	65.22	70.08	78.24	**84.84**	89.34	93.15	94.86	96.39	98.56
4	57	4.95	8.654	82.5	48.24	64.13	68.85	73.31	80.6	**86.54**	90.72	94.08	95.54	96.87	98.72
5	6	5.1	8.83	85	52.41	68.26	72.78	76.77	83.07	**88.3**	92.09	94.98	96.22	97.34	98.9
5	15	5.25	9.021	87.5	57.68	72.9	77.1	80.53	85.81	**90.21**	93.49	95.87	96.93	97.81	99.09
5	24	5.4	9.218	90	64.02	77.9	81.55	84.43	88.65	**92.18**	94.92	96.75	97.61	98.28	99.29
5	33	5.55	9.422	92.5	71.71	83.28	86.22	88.48	91.66	**94.22**	96.37	97.65	98.29	98.75	99.49
5	42	5.7	9.621	95	80.43	88.8	90.85	92.47	94.62	**96.21**	97.81	98.54	98.96	99.22	99.7
5	51	5.85	9.821	97.5	90.01	94.42	95.53	96.53	97.64	**98.21**	99.26	99.44	99.65	99.7	99.92

Figure 42: Rescaling spreadsheet using tabulation from Williams-Sether (2004).

The values of duration and depth are the same as the example in the introduction. The rescaling displayed in Figure 42 illustrates the main challenge in rescaling to prescribed time intervals. The three left-most columns in the figure are the rescaled time in hours and minutes, as well as fractional hours.[25] Using the values of depth and duration in the ongoing example, the tabulation estimates fractional depths every 9 minutes – yet suppose we wish to estimate depth at some arbitrary time interval, say every 15 minutes. Hence, once the tabulation is rescaled, the challenge is to obtain estimates at arbitrary time increments.

The interpolation process is as follows:

1. Locate the rescaled time values that bracket the arbitrary time of interest (e.g. 15 minutes, 30 minutes, 45 minutes, ...). One value will lie above the arbitrary time and one below.

   Designate these values as $T_{arbitrary}$, T_{low}, and T_{high}.

   These three values represent the arbitrary time value, the rescaled value immediately smaller than the arbitrary value, and the rescaled value immediately larger than the arbitrary time value.

2. Locate the corresponding depth values that are associated with the rescaled time values. One value will correspond to the time above the arbitrary time, and one below.

   Designate these values as $D_{arbitrary}$, D_{low}, and D_{high}.

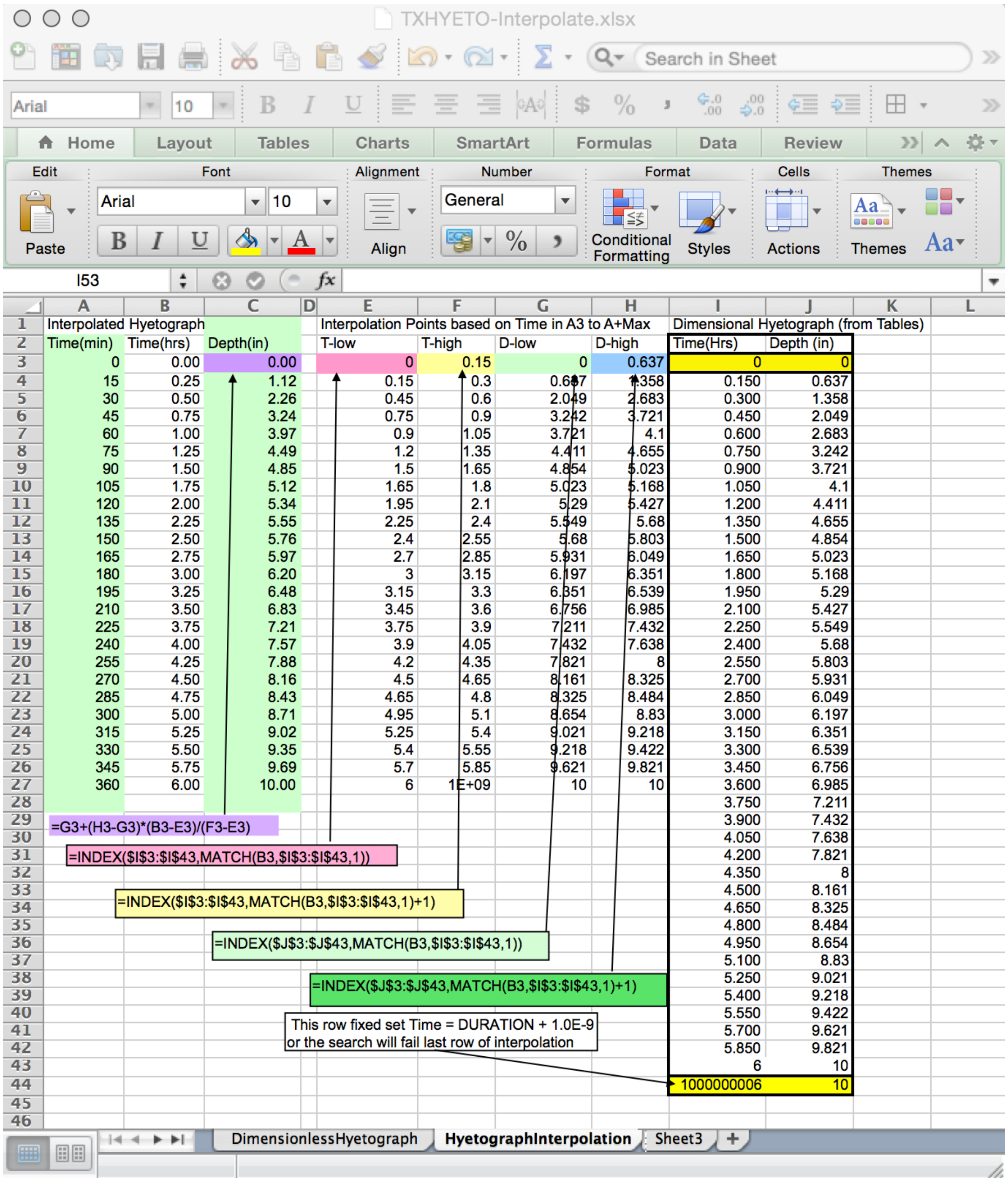
   These three values represent the arbitrary depth value (unknown), the rescaled value associated with the time value immediately smaller than the arbitrary time value, and the rescaled value associated with the time value immediately larger than the arbitrary time value.

3. Estimate the unknown $D_{arbitrary}$ from the simple interpolation formula

$$D_{arbitrary} = D_{low} + (D_{high} - D_{low}) \times \frac{T_{arbitrary} - T_{low}}{T_{high} - T_{low}} \tag{13}$$

Figure 43 is an interpolation spreadsheet using built-in functions in Excel to locate the various values in Equation 13 for the different arbitrary values. The spreadsheet operates on the fractional hours column (Column B in the figure) which is computed from the first column (Column A) in the figure which is the desired time in minutes.

[25] Fractional hours are the actual times used in the tool, the hours and minutes extraction is useful for human interpretation.



	A	B	C	D	E	F	G	H	I	J
1	Interpolated Hyetograph				Interpolation Points based on Time in A3 to A+Max				Dimensional Hyetograph (from Tables)	
2	Time(min)	Time(hrs)	Depth(in)		T-low	T-high	D-low	D-high	Time(Hrs)	Depth (in)
3	0	0.00	0.00		0	0.15	0	0.637	0	0
4	15	0.25	1.12		0.15	0.3	0.637	1.358	0.150	0.637
5	30	0.50	2.26		0.45	0.6	2.049	2.683	0.300	1.358
6	45	0.75	3.24		0.75	0.9	3.242	3.721	0.450	2.049
7	60	1.00	3.97		0.9	1.05	3.721	4.1	0.600	2.683
8	75	1.25	4.49		1.2	1.35	4.411	4.655	0.750	3.242
9	90	1.50	4.85		1.5	1.65	4.854	5.023	0.900	3.721
10	105	1.75	5.12		1.65	1.8	5.023	5.168	1.050	4.1
11	120	2.00	5.34		1.95	2.1	5.29	5.427	1.200	4.411
12	135	2.25	5.55		2.25	2.4	5.549	5.68	1.350	4.655
13	150	2.50	5.76		2.4	2.55	5.68	5.803	1.500	4.854
14	165	2.75	5.97		2.7	2.85	5.931	6.049	1.650	5.023
15	180	3.00	6.20		3	3.15	6.197	6.351	1.800	5.168
16	195	3.25	6.48		3.15	3.3	6.351	6.539	1.950	5.29
17	210	3.50	6.83		3.45	3.6	6.756	6.985	2.100	5.427
18	225	3.75	7.21		3.75	3.9	7.211	7.432	2.250	5.549
19	240	4.00	7.57		3.9	4.05	7.432	7.638	2.400	5.68
20	255	4.25	7.88		4.2	4.35	7.821	8	2.550	5.803
21	270	4.50	8.16		4.5	4.65	8.161	8.325	2.700	5.931
22	285	4.75	8.43		4.65	4.8	8.325	8.484	2.850	6.049
23	300	5.00	8.71		4.95	5.1	8.654	8.83	3.000	6.197
24	315	5.25	9.02		5.25	5.4	9.021	9.218	3.150	6.351
25	330	5.50	9.35		5.4	5.55	9.218	9.422	3.300	6.539
26	345	5.75	9.69		5.7	5.85	9.621	9.821	3.450	6.756
27	360	6.00	10.00		6	1E+09	10	10	3.600	6.985
28									3.750	7.211
29									3.900	7.432
30									4.050	7.638
31									4.200	7.821
32									4.350	8
33									4.500	8.161
34									4.650	8.325
35									4.800	8.484
36									4.950	8.654
37									5.100	8.83
38									5.250	9.021
39									5.400	9.218
40									5.550	9.422
41									5.700	9.621
42									5.850	9.821
43									6	10
44									1000000006	10

Figure 43: Interpolation spreadsheet using Equation 13 and rescaled tabulation from Figure 42

The designer would enter the desired time increments in minutes in Column A. The sheet draws the now dimensional values from columns D and E of Figure 42 and places them into Columns I and J of Figure 43. Then linear interpolation for each time value is implemented by the formulas in Columns E through H of Figure 43 that search the arrays for the various values required in Equation 13 and make the requisite computations in Column C.

This interpolation process is straight forward, but it does require the designer to be able to "reprogram" the interpolation for different storms. For instance, if one minute time steps were desired, the engineer would have to know to enter the values 0,1,..., 360 in column A and then remember to copy the interpolation formulas to the corresponding rows.

This last step is a principal impediment and prone to breakage (of the spreadsheet) and hence there was desire for a slightly more automated way to accomplish the hyetograph construction.

Rather than attempt to program the spreadsheet to automatically build the interpolation formulas (in part to allow for non-uniform time steps) we instead fit a functional form to the dimensionless hyetographs — these functional are described in Section 5 of the report and are not repeated.

15.6.2 Relative Error

The error associated with using the functional form and the tabulation is estimated by computing the difference between the functional model result and the tabular result and that difference is then divided by the tabular result for a relative error assessment. The error for any dimensionless value in the tabulation is less than 5 percent. Thus the designer who uses the functional model instead of interpolation can expect the results to be within 5 percent of the tabular values.

Figure 11 (in Section 5) is a plot showing the relative error for the example conditions between using direct interpolation and the distribution-mixture function model for the 50th percentile hyetograph. Figure 10 (in Section 5) is a similar plot for the 90th percentile hyetograph.

16 Appendix – IX: `TXHYETO-2015.xlsx` Tutorial

16.1 Example Problem

This tutorial illustrates the use of `TXHYETO-2015.xlsx` combined with `EBDLKUP-2015.xlsx` to generate a design storm for use in HEC-HMS.Ash Creek at Highland Road in Dallas, Texas is used as an example watershed for this tutorial.

Figure 44 is a topographic map of the study area with the watershed boundary drawn in brown.[26] The watershed outlet is in the lower left-hand corner and is indicated by the small red square at Highland Road.

Figure 45 is a shaded relief rendering of the watershed built from a 10-meter digital terrain model (DTM) of the study area. Notice the watershed shape is about the same as on the topographic map. The topographic map was hand-drawn, the actual boundary was determined using the DTM. Additionally several watershed metrics were collected, the drainage area, main channel length, slope along the main channel, and a designer's estimation of the composite curve number appropriate for the watershed.

The metrics on Figure 45 would be important in synthesis of a unit hydrograph for the watershed. In addition to synthesis of a unit hydrograph, the designer would need to specify a loss model (e.g curve number), and a design storm. The whole purpose of `TXHYETO-2015.xlsx` is to simplify the generation of a design storm from the Texas Empirical Hyetograph.

Now suppose a 5-year, 3-hour design storm is desired for inclusion in the HEC-HMS model. The designer could use the `EBDLKUP-2015.xlsx` to estimate the storm depth for Dallas County.

Figure 46 shows the result of the designer selecting the units (U.S. Customary), then selecting Dallas County, and finally deleting the duration, 3 hours. The corresponding intensity is reported as 1.01 inches per hour. The product of this intensity and the duration produces a storm depth,

$$1.01 \text{ in/hr } \times 3.0 \text{ hr } = 3.03 \text{ inches} \tag{14}$$

which is the requisite entry for using `TXHYETO-2015.xlsx`.

The designer then opens the `TXHYETO-2015.xlsx` tool and enters the depth just determined, 3.03 inches, the design storm duration, 3 hours, and the desired HEC-HMS time step length. For this tutorial, assume that the designer wishes to estimate hydrologic response every 10 minutes.

[26] The boundary in this figure is hand-drawn — it is an approximate boundary.

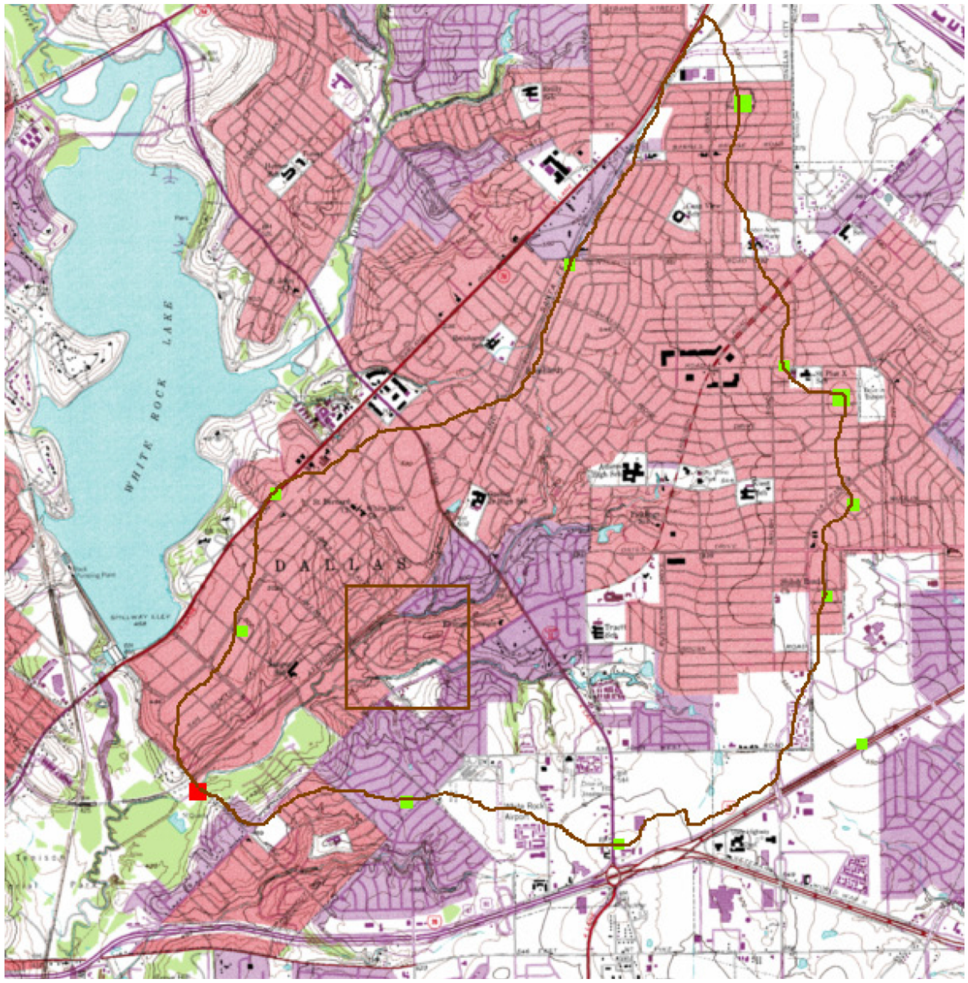


Figure 44: Ash Creek digital raster graphic topographic map. Watershed boundary shown in brown. The brown square in the center of the watershed is a 1-square mile rectangle used for scale and measuring the watershed area, boundary, main channel length, and slope.

Figure 47 is an image of `TXHYETO-2015.xlsx` with these input data supplied. The three columns returned are the design storm for the prescribed conditions and these are the values that can be copied directly into HEC-HMS to simulate hydrologic response.

Figure 48 is a screen capture showing the HEC-HMS model being built for the Ash Creek watershed. The relevant portion of the model for this tutorial is the user-specified hyetograph. In the figure the HEC-HMS entry values are shown.[27] Once these conditions are set up, then the designer can

[27] Manual entry = Cumulative inches 10 minute time step.

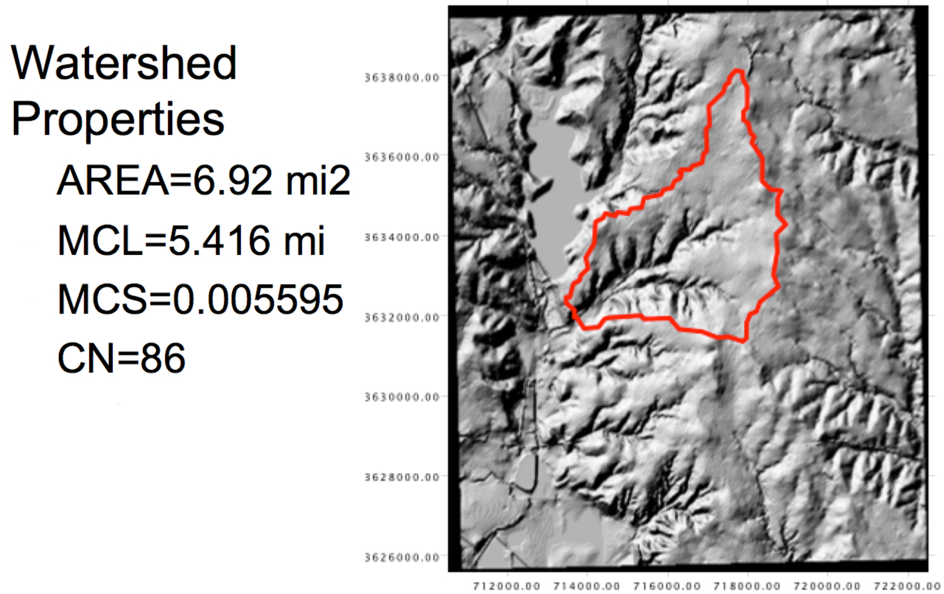
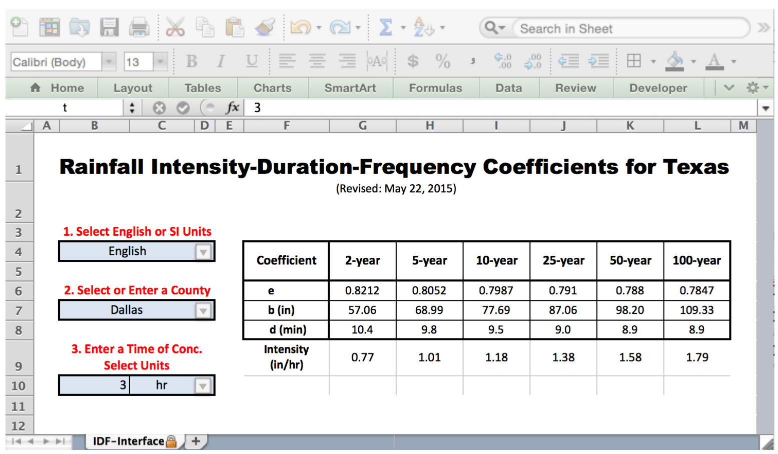


Figure 45: Ash Creek watershed 10-meter digital terrain model rendered in shaded relief. Watershed properties displayed on figure determined using digitizer in mapping software.



Rainfall Intensity-Duration-Frequency Coefficients for Texas

(Revised: May 22, 2015)

1. Select English or SI Units: English

2. Select or Enter a County: Dallas

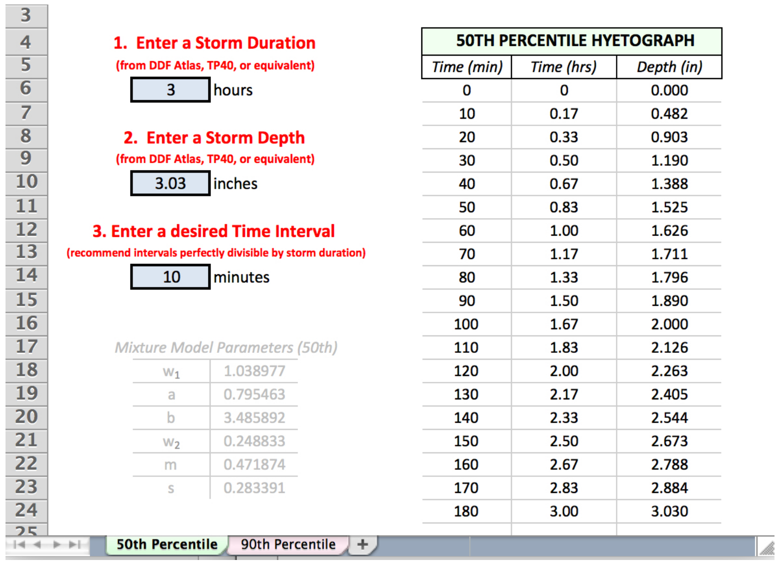
3. Enter a Time of Conc. Select Units: 3 hr

Coefficient	2-year	5-year	10-year	25-year	50-year	100-year
e	0.8212	0.8052	0.7987	0.791	0.788	0.7847
b (in)	57.06	68.99	77.69	87.06	98.20	109.33
d (min)	10.4	9.8	9.5	9.0	8.9	8.9
Intensity (in/hr)	0.77	1.01	1.18	1.38	1.58	1.79

Figure 46: `EBDLKUP-2015.xlsx` tool to estimate 5-year, 3-hour average intensity for Dallas County, Texas.

directly copy the design storm into the home model. In this example we will have the storm start at 11:10 am.[28]

[28]This choice is intended to center the storm at 12:00 — useful when the designer wishes to compare results to a balanced storm such as NRCS/SCS Type storm.



50TH PERCENTILE HYETOGRAPH		
Time (min)	Time (hrs)	Depth (in)
0	0	0.000
10	0.17	0.482
20	0.33	0.903
30	0.50	1.190
40	0.67	1.388
50	0.83	1.525
60	1.00	1.626
70	1.17	1.711
80	1.33	1.796
90	1.50	1.890
100	1.67	2.000
110	1.83	2.126
120	2.00	2.263
130	2.17	2.405
140	2.33	2.544
150	2.50	2.673
160	2.67	2.788
170	2.83	2.884
180	3.00	3.030

Figure 47: Use of `TXHYETO-2015.xlsx` tool to estimate 5-year, 3-hour, 50th percentile design storm hyetograph for Dallas County, Texas.

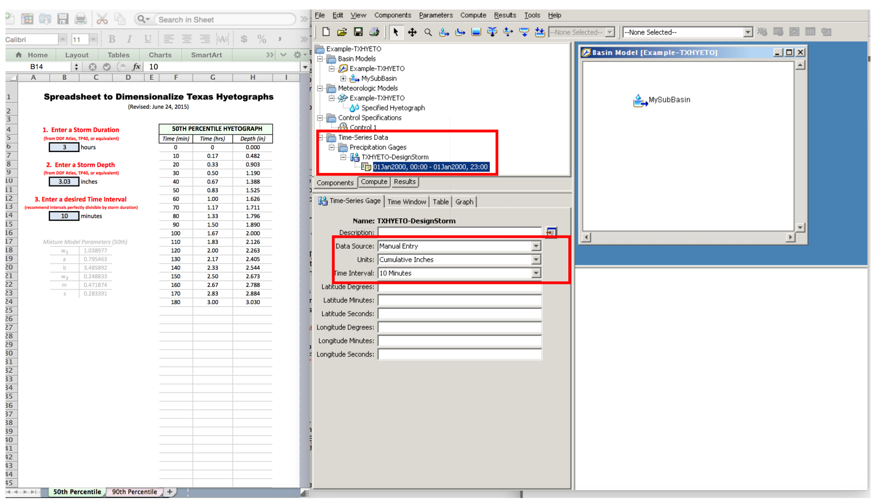


Figure 48: Preparing HEC-HMS to receive design storm from `TXHYETO-2015.xlsx` tool.

Figure 49 is a screen capture showing the selection of the storm from `TXHYETO-2015.xlsx` in preparation to paste into HEC-HMS. The selection is shown, the designer has copied the selection to the clipboard (right-click/copy).

Figure 50 is a screen capture showing the selection of the starting location for the design storm — in this case at 11:10 am in the HEC-HMS table. The designer has selected the target cell and is about to make the copy (right-click/paste).

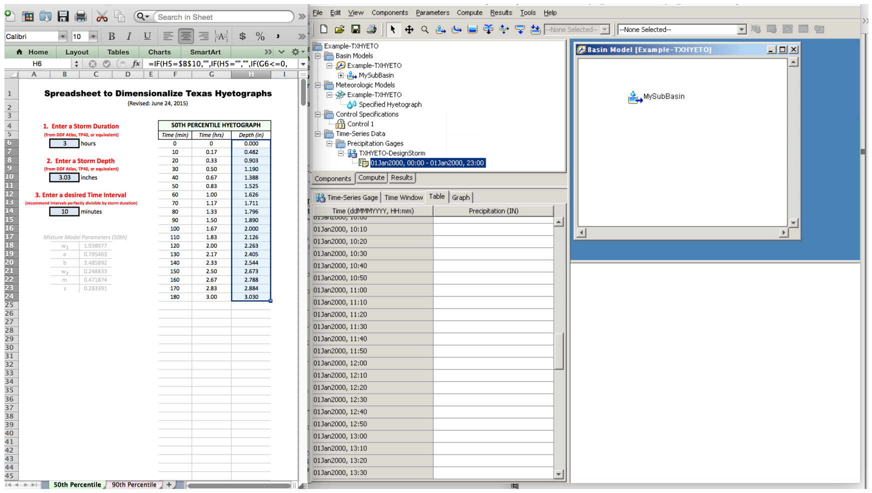


Figure 49: Selecting design storm from `TXHYETO-2015.xlsx` tool.

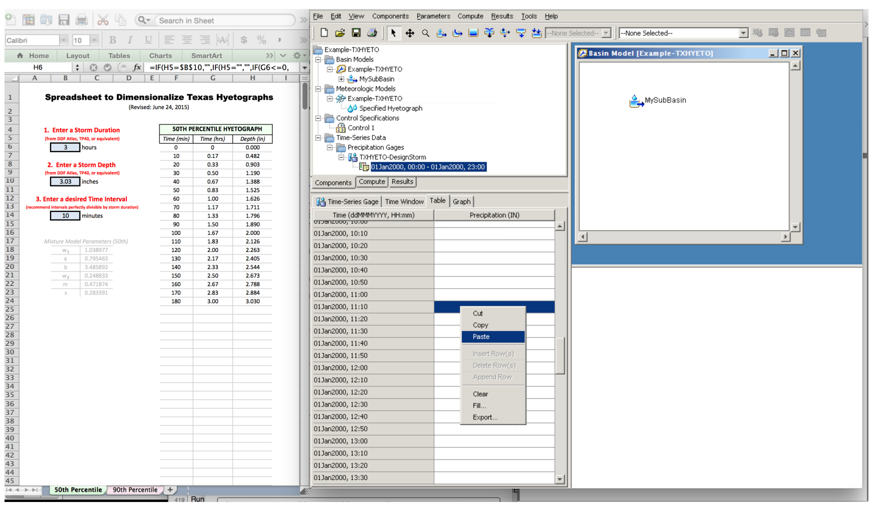


Figure 50: Selecting destination (in HMS) to receive design storm.

Figure 51 is a screen capture showing the result of the prior action. The storm is now copied into the desired location in HEC-HMS.

The designer now need to use the HEC-HMS fill tool to complete the storm creation (in HMS). For the time between 00:00 am and 11:00 am the designer would select that portion of the table, right-click, and choose Fill. Then the designer would fill these cells with 0.00 (there is no rainfall prior to 11:10 am).

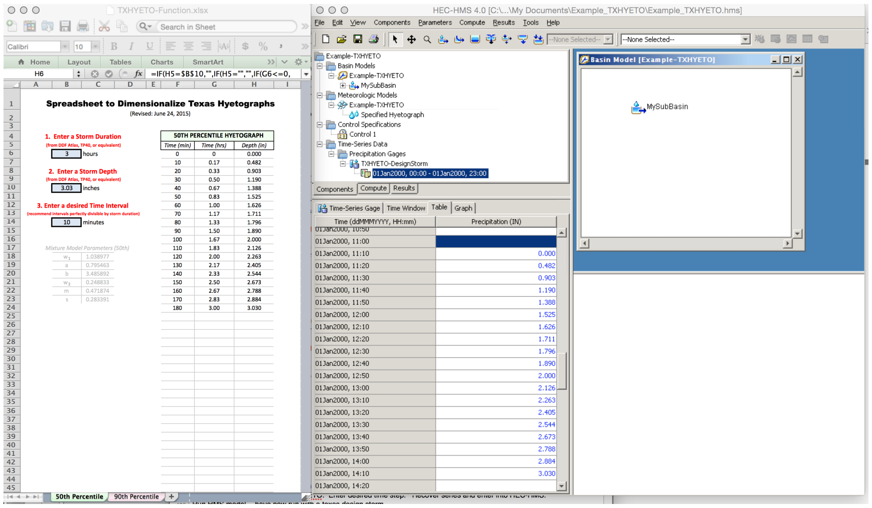


Figure 51: Paste the design storm from `TXHYETO-2015.xlsx` tool.

Next the designer would go to the end of the just entered storm range (3.03 inches) and from than point downward in the chart select those cells. Again the designer would right-click, and choose Fill, and then fill by repeating the first value.[29]

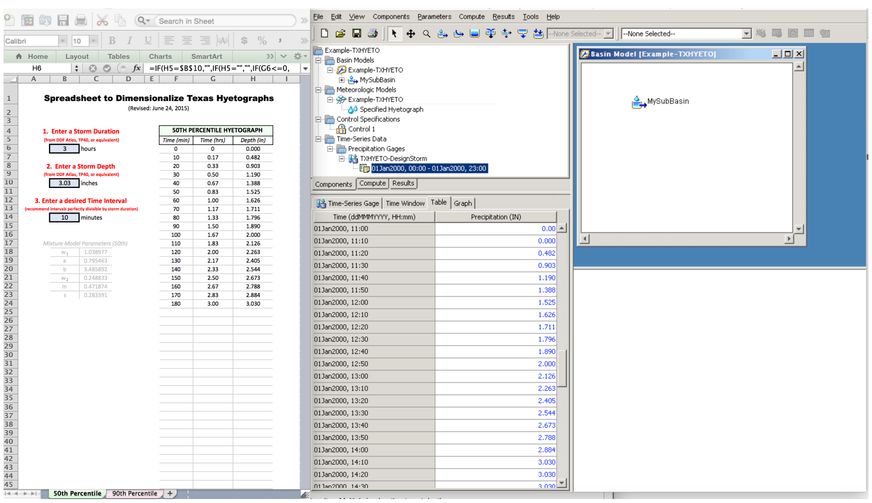


Figure 52: Fill missing values — zeroes before the storm, cumulative storm depth after the storm.

Figure 52 is a screen capture after the two fill actions are completed. At this point the HMS model is ready to run. Figure 53 is the HMS model ready to run with the hyetograph shown as a plot (in lieu of the tabular form in the prior figures).

[29]The repeat first value is one of the several fill options provided by the software.

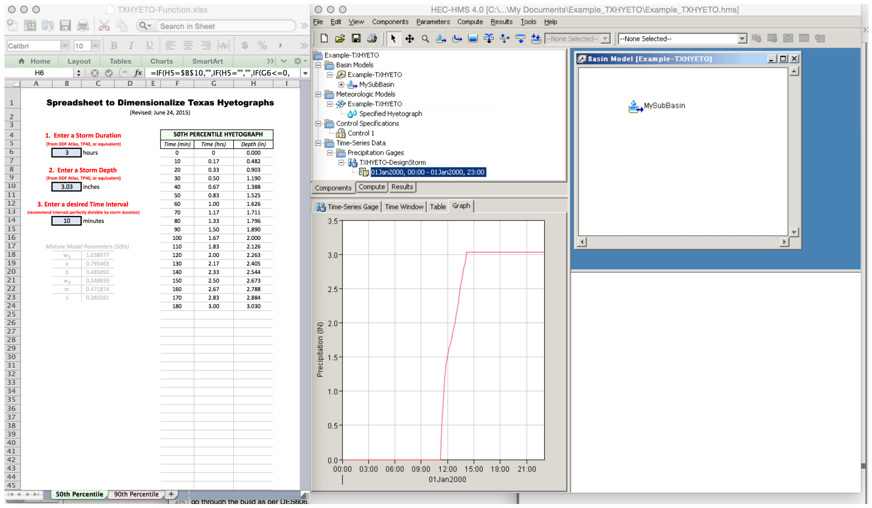


Figure 53: The design storm shown as a plot. Approximately centered at 12:00 pm.

To complete the example, the simulation is run. The designer would set-up a simulation run and choose the various components desired. Upon completion of those actions the simulation can be run.

Figure 54 is a screen capture showing the result of a simulation in HEC-HMS. In Figure 54, the loss model is SCS Curve Number (CN=86), the transform model is SCS Dimensionless Unit Hydrography with T_{lag}=75 minutes, and the input hyetograph is the Texas Empirical Hyetograph as entered in the tutorial.

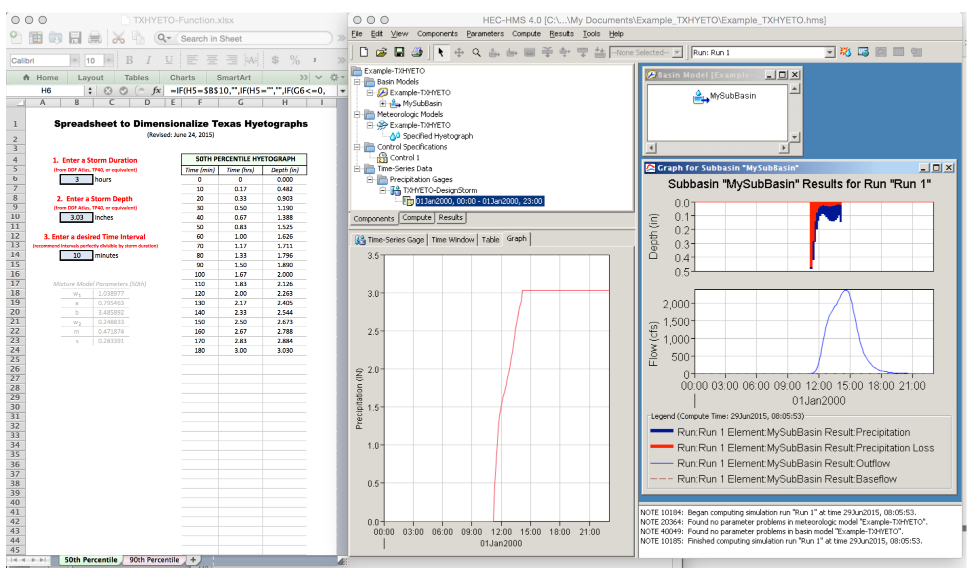


Figure 54: The storm from the tool is now used to run the model. Model run results plotted.

The entire process is summarized in the list below:

1. Determine the watershed of interest and measure values required for hydrologic analysis as per the design manual or other appropriate technique;
2. Determine the risk level of interest;
3. Determine the county where the design storm is desired;
4. Determine the duration of interest;
5. Use `EBDLKUP-2015.xlsx`, or the DDF Atlas, or TP-40/HY-35 to estimate the storm depth for the duration of interest and the desired risk level.
   If `EBDLKUP-2015.xlsx` is used, remember to multiply the computed intensity by the duration to recover a depth;
6. Determine the desired simulation time step for the hydrologic model (HEC-HMS);
7. Use `TXHYETO-2015.xlsx` to construct a design storm from the Texas Empirical Hyetograph;
8. Copy the design storm from `TXHYETO-2015.xlsx` into the HEC-HMS model (the model must already exist – it can be minimally detailed for this copy-paste activity);
9. Fill any missing values using the HEC-HMS fill tool; and
10. Run the HEC-HMS model to generate the hydrograph.

16.2 Links to On-Line Resources

TxDOT Hydraulic Design Manual (Texas Department of Transportation, 2014)
`http://onlinemanuals.txdot.gov/txdotmanuals/hyd/hyd.pdf`.

DDF Atlas ((Asquith and Roussel, 2004))
`http://pubs.usgs.gov/sir/2004/5041/pdf/sir2004-5041.pdf`

17 Appendix – X: Training Module Contents

This appendix is a copy of the training module, with annotations where useful. The annotations are intended to serve as a script for a trainer to use when presenting the materials in a face-to-face setting. A 27 minute video that closely follows the script is also provided as part of the deliverables for this technical memorandum.

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Figure 1: Cover slide for DES601 - Precipitation and Design Storms.

Figure 1 is the introductory slide. The trainer would change the designation from XX to the module sequence number appropriate for DES601.

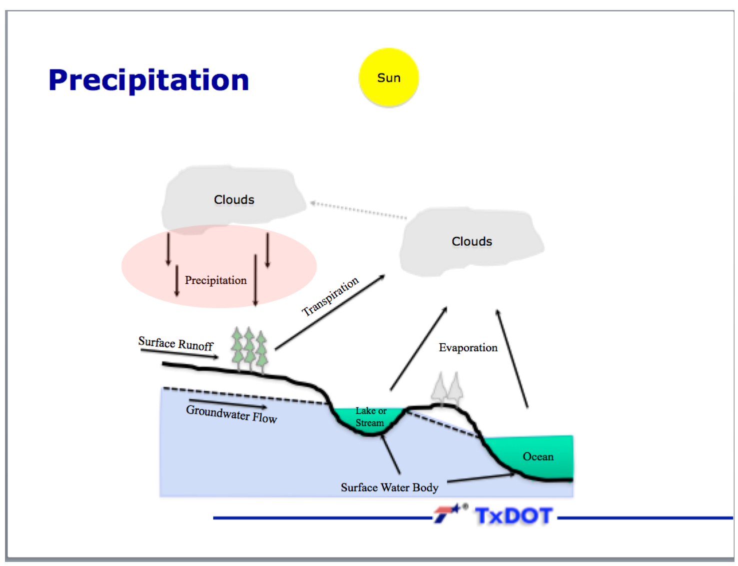

Figure 2: Hydrologic cycle schematic, with emphasis on the precipitation component.

Figure 2 is a schematic of the hydrologic cycle. The precipitation portion of the cycle is shown in the rose oval to the left of the figure. The trainer would focus on this while explaining that the rainfall causes the runoff that is to be managed, with various losses from the signal to evaporation, transpiration, and infiltration.

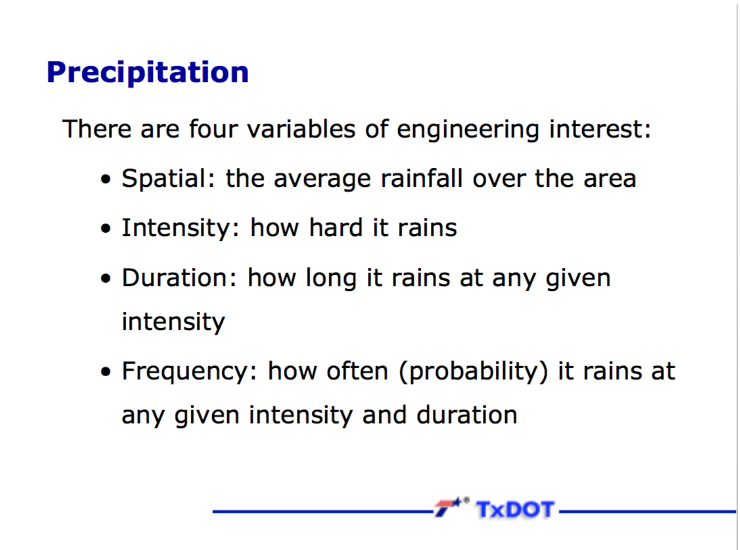

Figure 3: Precipitation components of engineering interest.

Figure 3 lists the components of precipitation of engineering interest. The spatial component is left for a later module (areal reduction factors), whereas the other three components are retained in the training module.

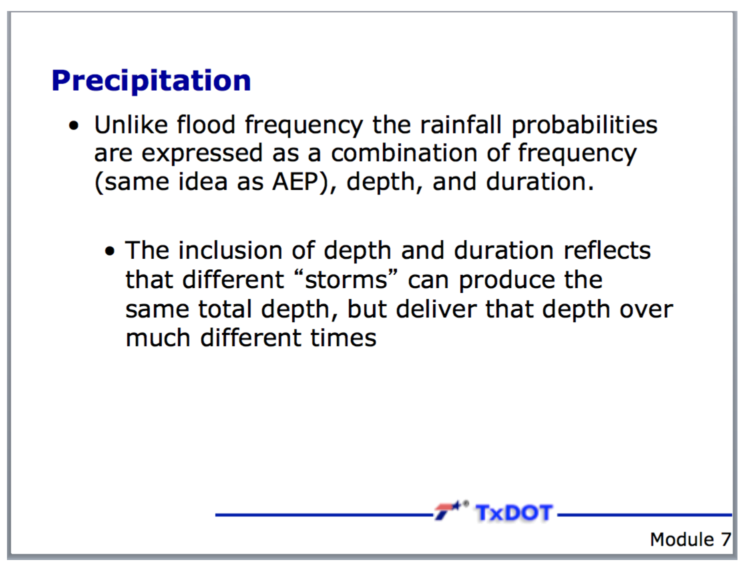

Figure 4: The relationship of the three related variables, depth, duration, and frequency.

Figure 4 explains that the precipitation relationship is more complex than flood frequency in that the three variables must be considered collectively. The spatial component is left for a later module (areal reduction factors), while the other three components are retained in the training module.

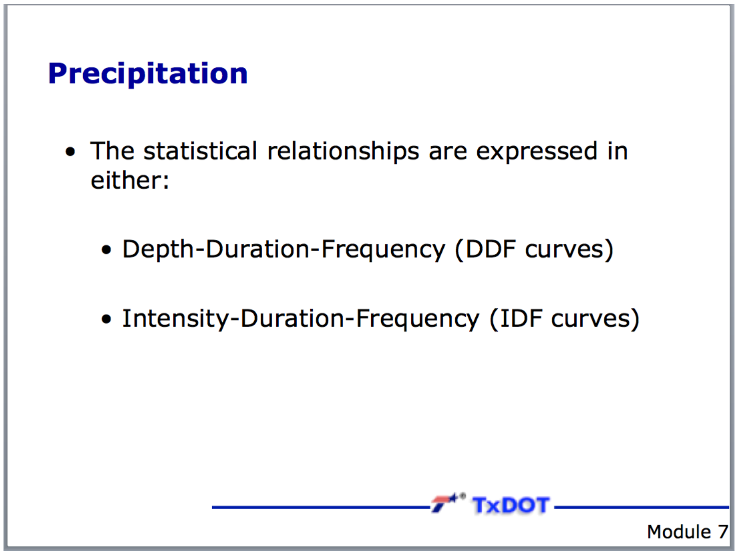

Figure 5: Depth-duration-frequency (DDF) and Intensity-duration-frequency (IDF) representations.

Figure 5 explains that the relationship is conveyed in either the depth-duration-frequency context, or the intensity-duration-frequency context. Figure 6 further defines the meanings of depth, duration,

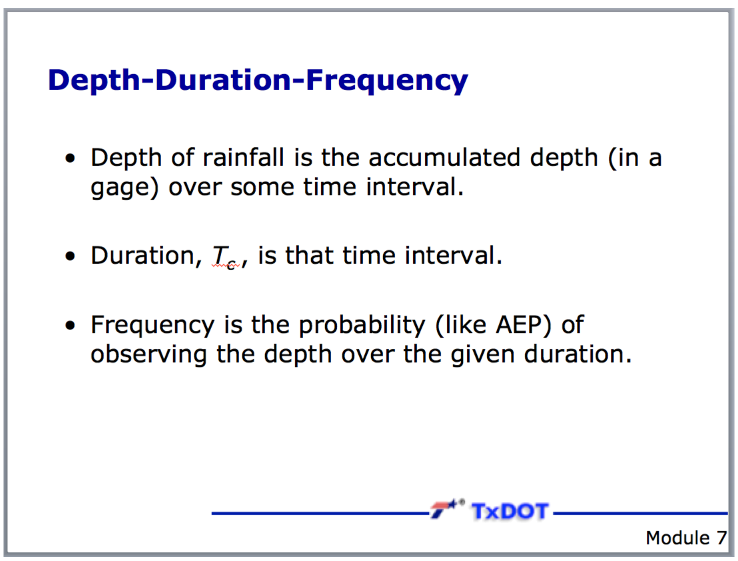

Figure 6: Definitions of depth, duration, and frequency.

and frequency.

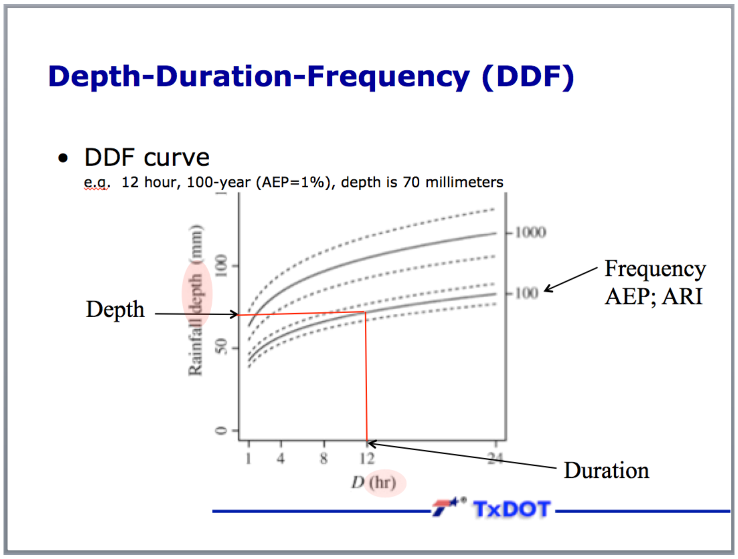

Figure 7: A DDF diagram showing how to estimate a depth for a given duration and ARI.

Figure 7 is a depth-duration-frequency diagram that illustrates how to estimate a depth for a given duration and annual recurrence interval (ARI). Figure 8 lists data sources that the engineer would

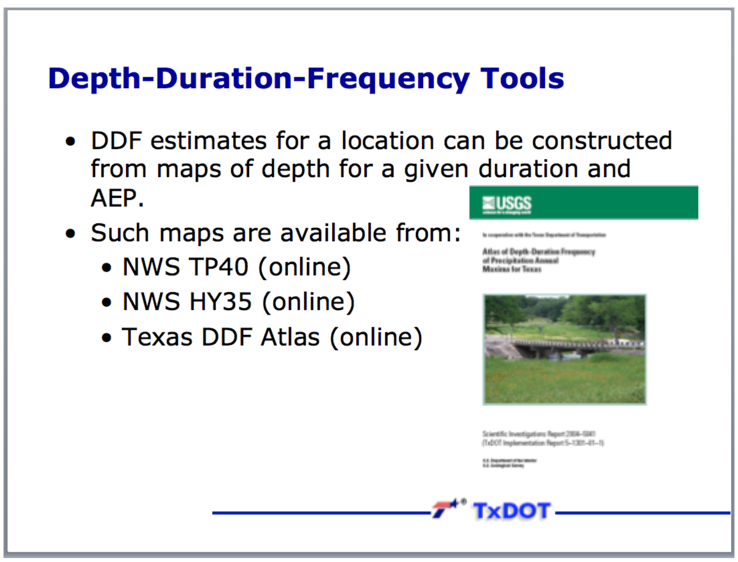

Figure 8: Tools to estimate DDF values in Texas.

consult to estimate a depth.

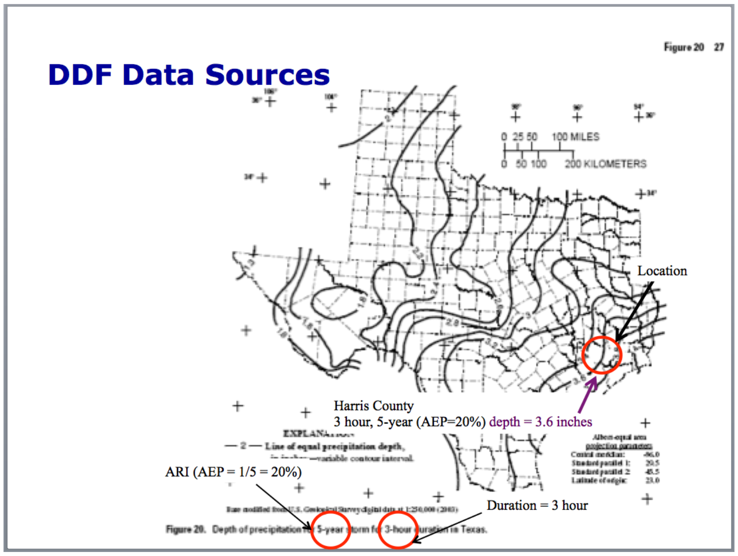

Figure 9: A except from the Texas DDF Atlas indicating the three pieces of information required to use the map. The result (a depth) is inferred from the contour lines at the location of interest.

Figure 9 is a depth-duration-frequency diagram that illustrates how to estimate a depth for a given duration and annual recurrence interval (ARI). Figure 10 is the formula that is used to convert a

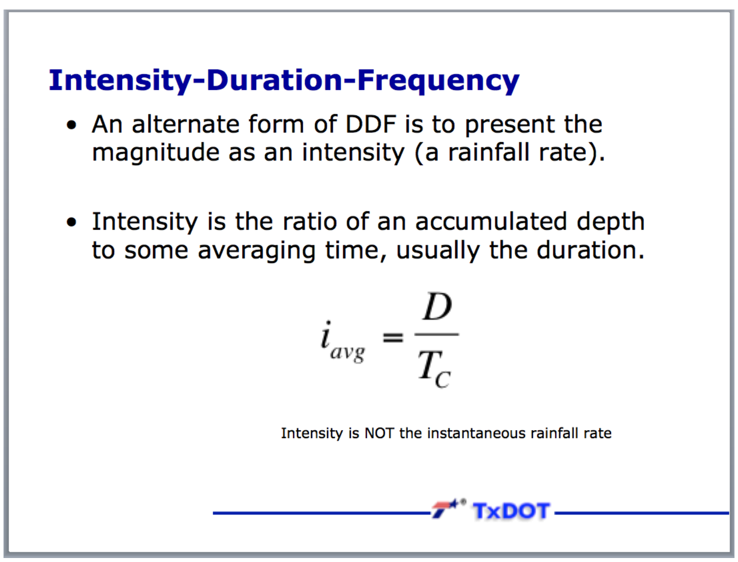

Figure 10: Computing intensity from estimated depth and specified storm duration.

depth into an average intensity. The averaging time is the duration, but the symbol for time of concentration is used to be consistent with usual usage and the hydraulic design manual.

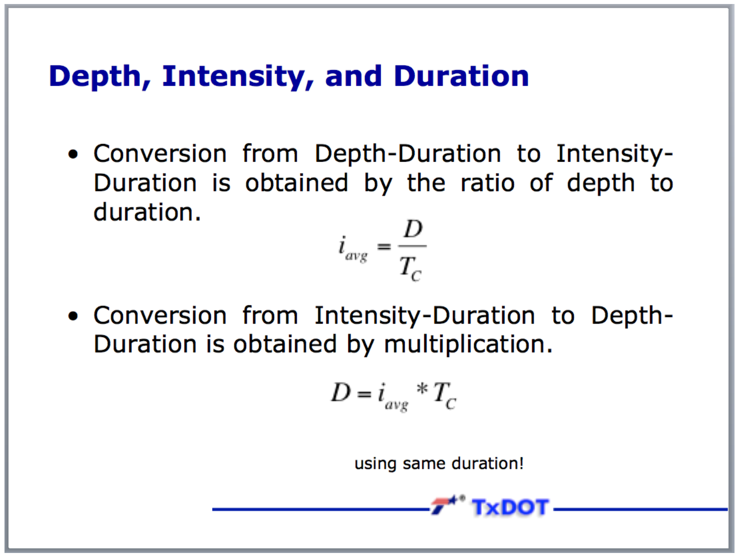

Figure 11: Converting depth and duration into an intensity, and converting an intensity back into a depth.

Figure 11 lists formulas to compute intensity from depth and duration and to convert an intensity back into a depth. These conversions are important when using the EBDLKUP-2105 and TXHYETO-2015 tools to generate a design storm. Figure 12 illustrates the use of a depth to compute an intensity.

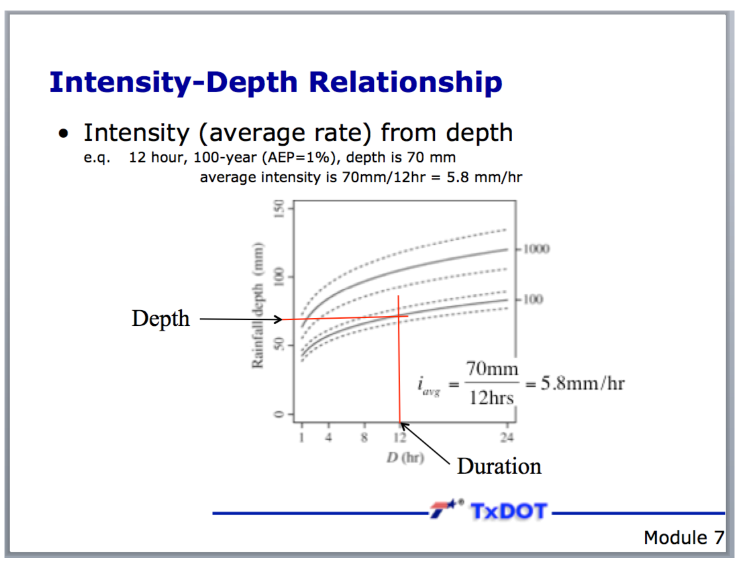

Figure 12: DDF curve interpreted as an intensity.

The intensity is the ratio of depth to a particular duration. For example, if the duration is 12 hours and the accumulated depth is 70 mm (about 3 inches), then the average rate is 70mm/12hours = 5.8 mm/hour. This average rate, if applied over 12 hours will produce the depth of 70mm.

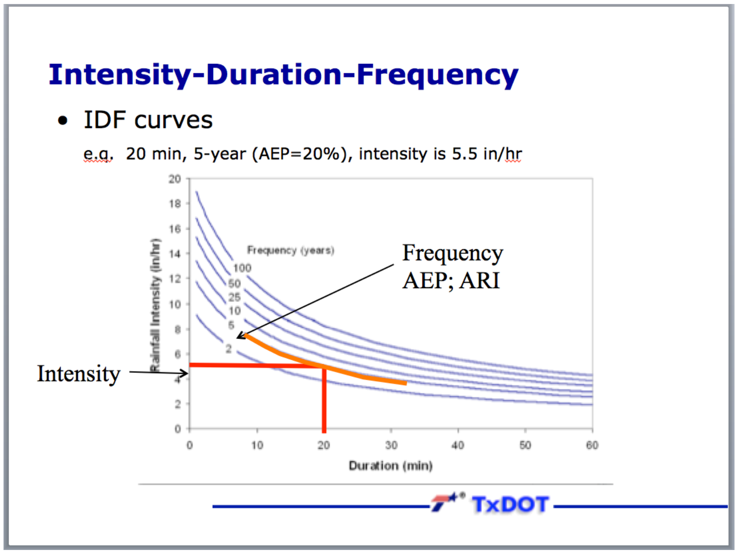

Figure 13: Typical family of Intensity-duration-frequency (IDF) curves.

Figure 13 is a plot of a family of intensity-duration-frequency (IDF) curves. The curve shows an example to estimate the intensity for a 20-minute, 20-percent chance storm (for some undisclosed location). Figure 14 lists the steps to estimate intensity using the DDF Atlas. The example is for

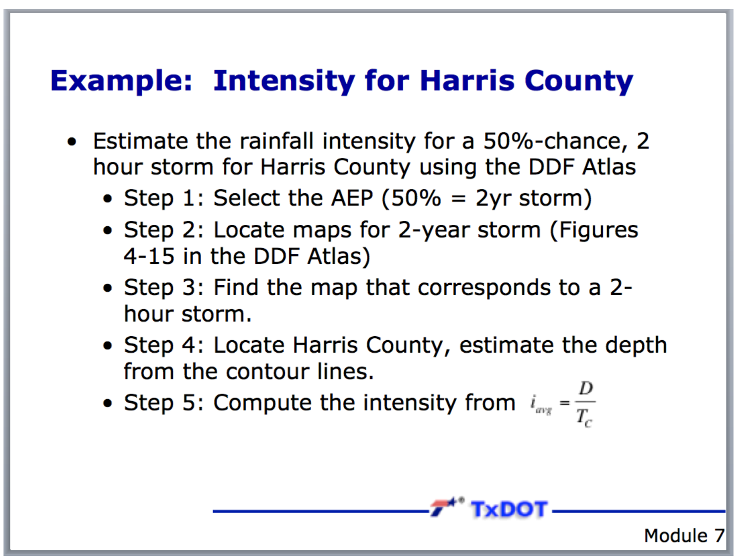

Figure 14: Intensity estimation process for Harris County using DDF Atlas and requisite equations.

Harris County, Texas. Several subsequent slides follow to illustrate each step. Step 1 is presumed in the subsequent slides.

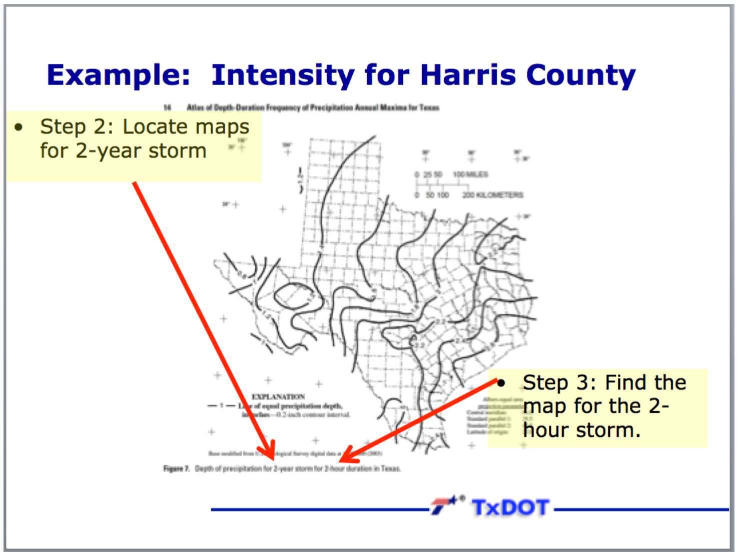

Figure 15: Step 2 and Step 3 of the estimation process. Step 2 is identification of a map of correct annual recurrence interval, Step 3 is the identification of the correct duration.

Figure 15 illustrates step 2 and step 3 of the estimation process.

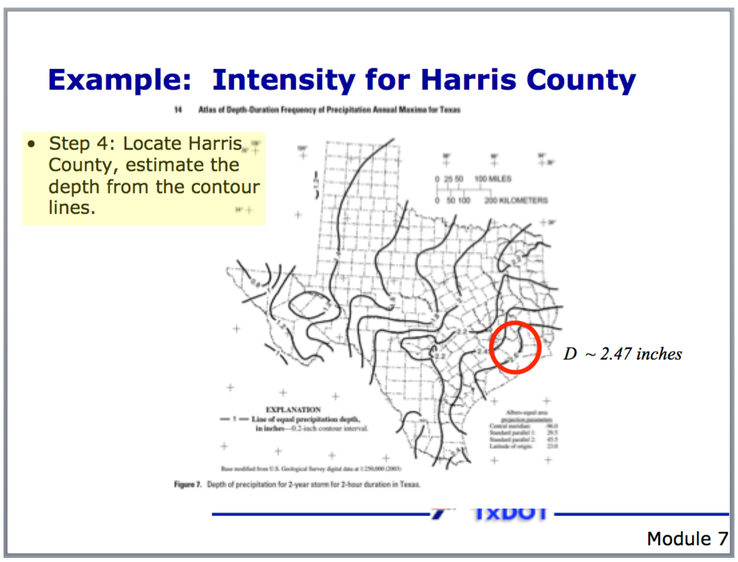

Figure 16: Step 4 of the estimation process – depth estimation for location using contour lines.

Figure 16 illustrates step 4 of the estimation process where the engineer uses the contour lines to estimate the depth at a location. In this example that depth is 2.47 inches of depth.

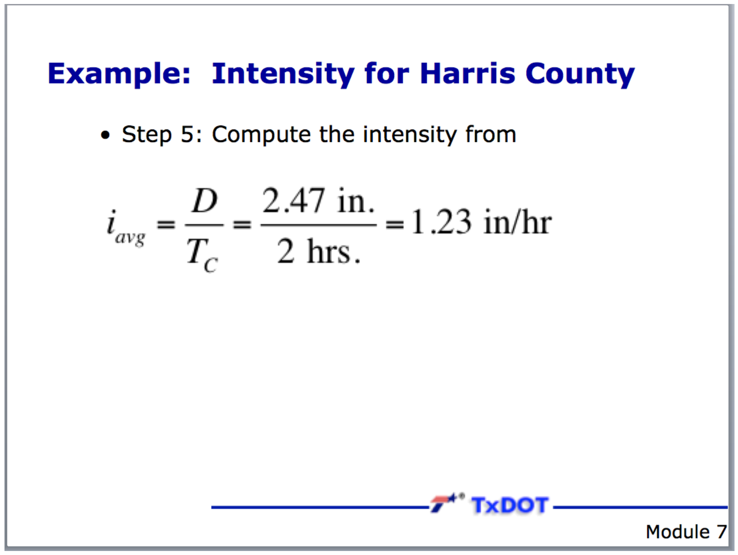

Figure 17: Step 5 of the estimation process — computing the intensity from the depth and duration.

Figure 17 illustrates step 5, computing the intensity, of the estimation process.

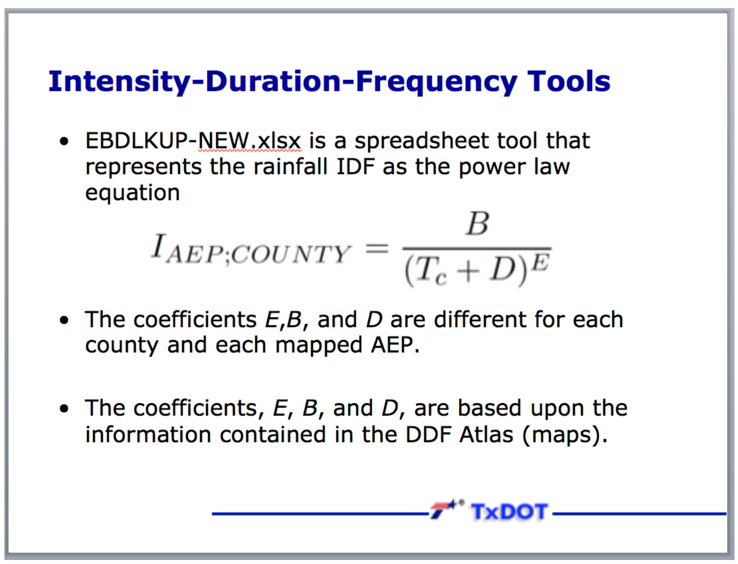

Figure 18: Introduction of the EBD power law model.

Figure 18 introduces the power-law model that is the basis of the EBDLKUP-NEW tool. The model allows for estimation of intensity at time values that are not mapped in the DDF Atlas, thereby simplifying the otherwise bothersome interpolation procedure described in the DDF Atlas.

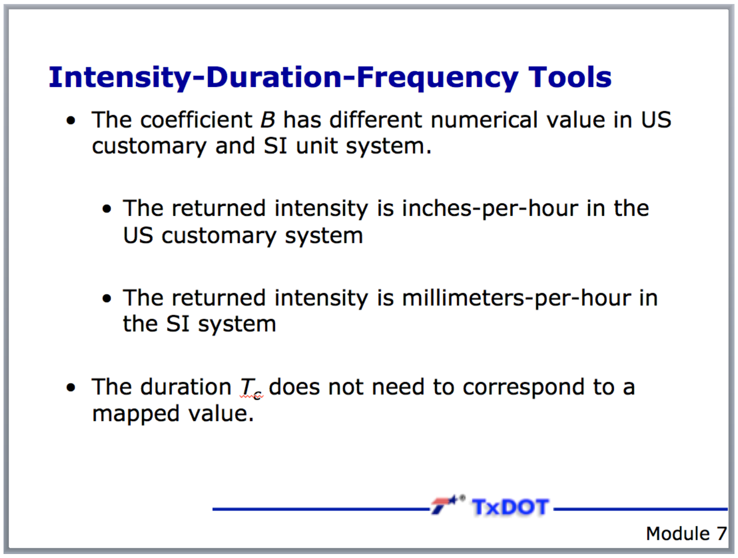

Figure 19: Additional description of the units system and the relationship of the power-law model to the DDF Atlas.

Figure 19 explains the results returned for the two different unit systems employed in the EBDLKUP-NEW model. Figure 20 describes the distribution method and the contents of the distribution. The

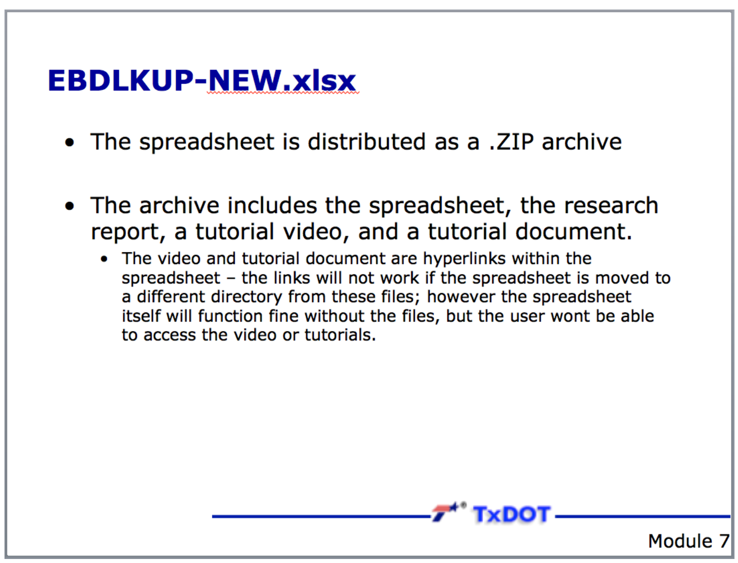

Figure 20: Distribution method and contents.

slide contains the warning that the videos that distribute with the spreadsheet are not accessible from the spreadsheet links if the spreadsheet is moved, but the spreadsheet still functions.

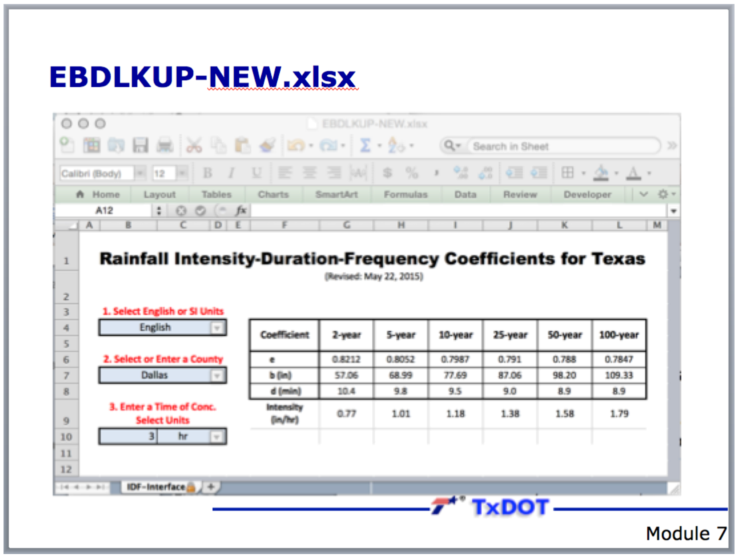

Figure 21: EBDLKUP-NEW interface showing the three input prompts and the results table.

Figure 21 shows the interface of the EBDLKUP-NEW model. The prompts for units, county name, and duration (time of concentration) are on the left of the interface with the output table to the right. The layout is similar to the older EBDLKUP spreadsheet, but the data table is hidden, and the worksheet is protected so the user can only enter data in the prompt cells.

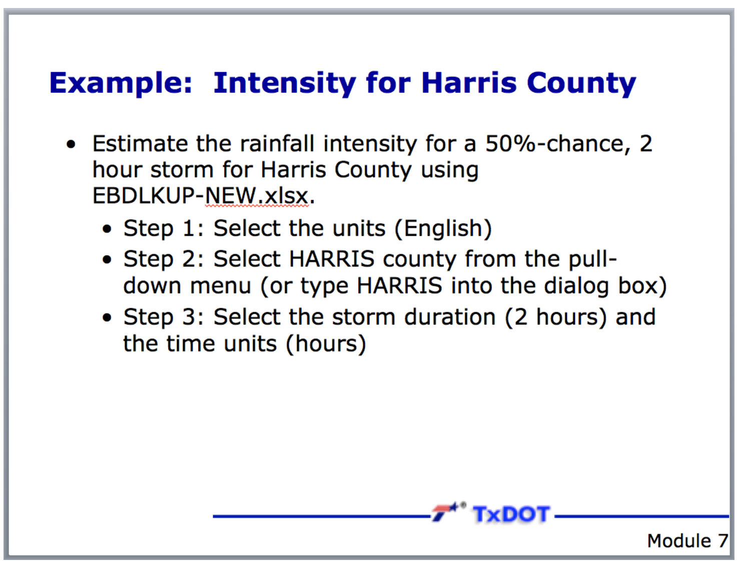

Figure 22: Distribution method and contents.

Figure 22 describes how to use the tool to complete the same example as presented in Figure 14.

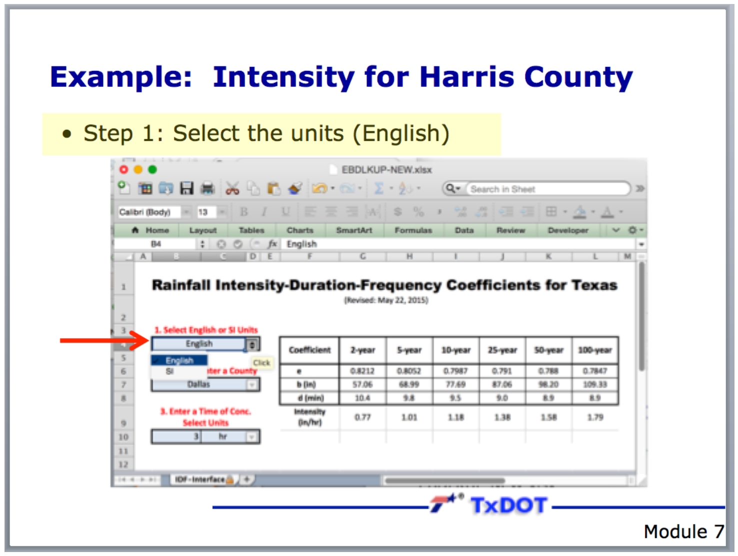

Figure 23: Step 1 of using EBDLKUP-NEW tool.

Figure 23 shows Step 1 of intensity estimation, selecting the units system, of the EBDLKUP-NEW model.

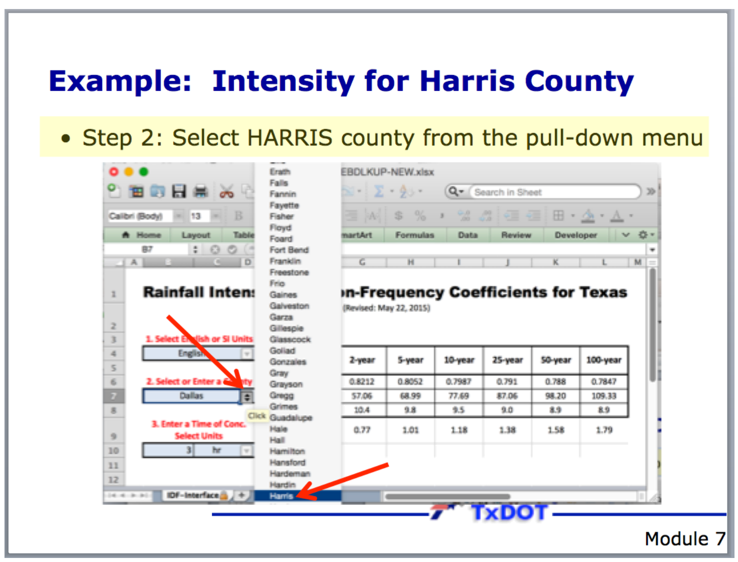

Figure 24: Step 2 of using EBDLKUP-NEW tool.

Figure 24 shows the second step (Step 2), selecting the county, of the EBDLKUP-NEW model.

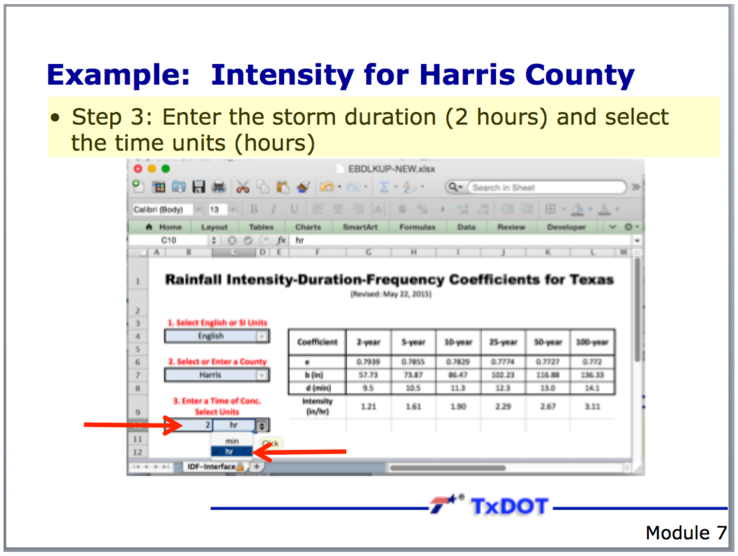

Figure 25: Step 3 of using EBDLKUP-NEW tool.

Figure 25 shows Step 3 of intensity estimation, selecting the duration and preferred time units (minutes or hours), of the EBDLKUP-NEW model.

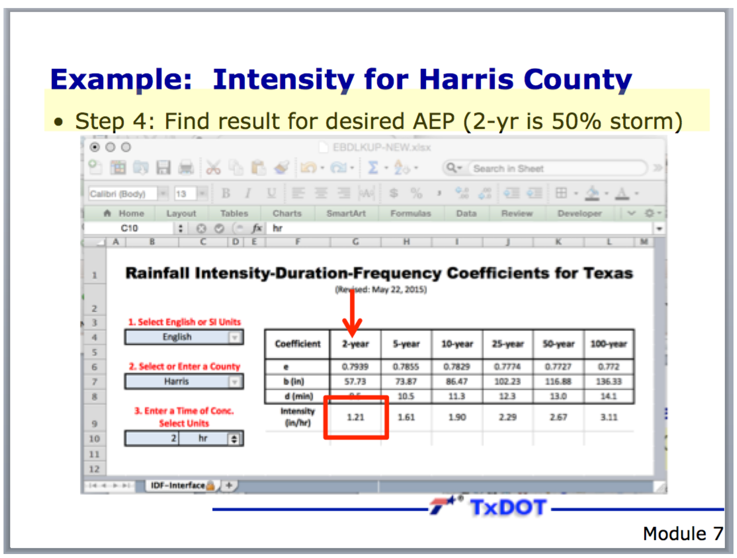

Figure 26: Step 4 of using EBDLKUP-NEW tool.

Figure 26 shows the last step (Step 4), interpreting the results table, of the EBDLKUP-NEW model.

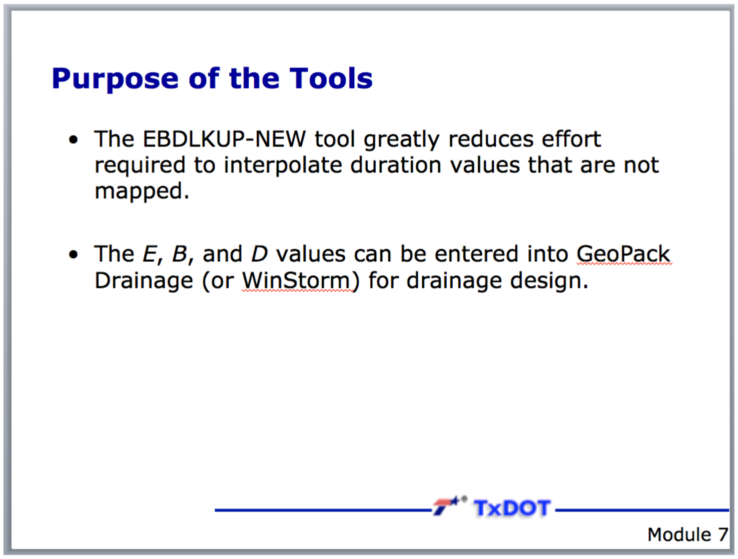

Figure 27: Purpose of EBDLKUP-NEW tool and basis of the E, B, and D values.

Figure 27 describes the purpose of EBDLKUP-NEW as well as the underlying data that were used to generate the E, B, and D values. The tool uses values obtained from the DDF Atlas and facilitates interpolating for durations that are not mapped in the atlas.

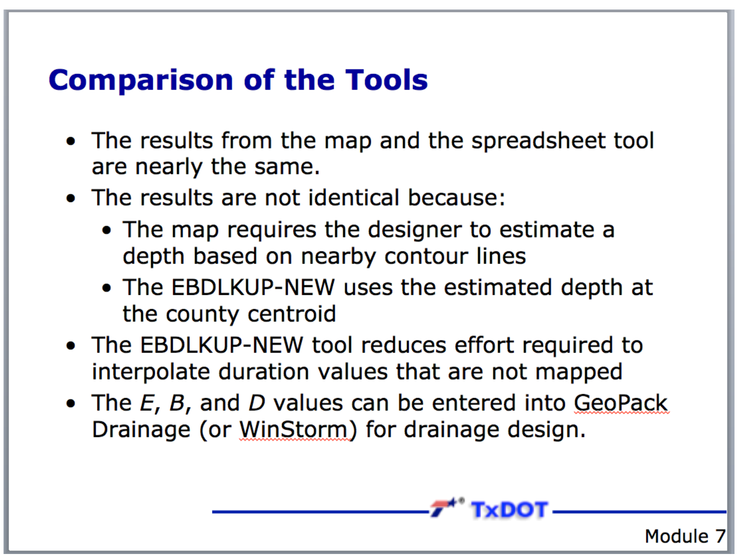

Figure 28: Descriptive comparisons of using EBDLKUP-NEW and the DDF Atlas.

Figure 28 provides a narrative comparison of the two tools (EBDLKUP-NEW, and DDFAtlas). While they are interchangeable, the EBDLKUP-NEW tool does allow for estimation at durations that are not mapped in the DDF Atlas.

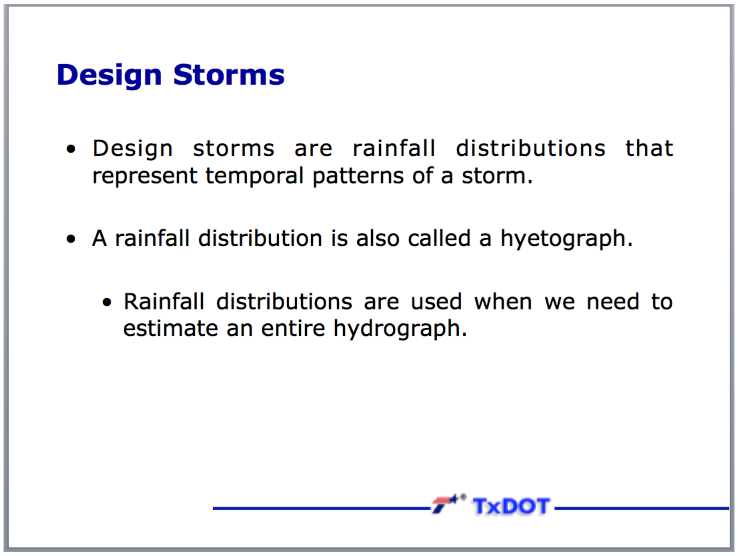

Figure 29: Concept of design storm.

Figure 29 introduces the concept of a design storm and the definition of a hyetograph.

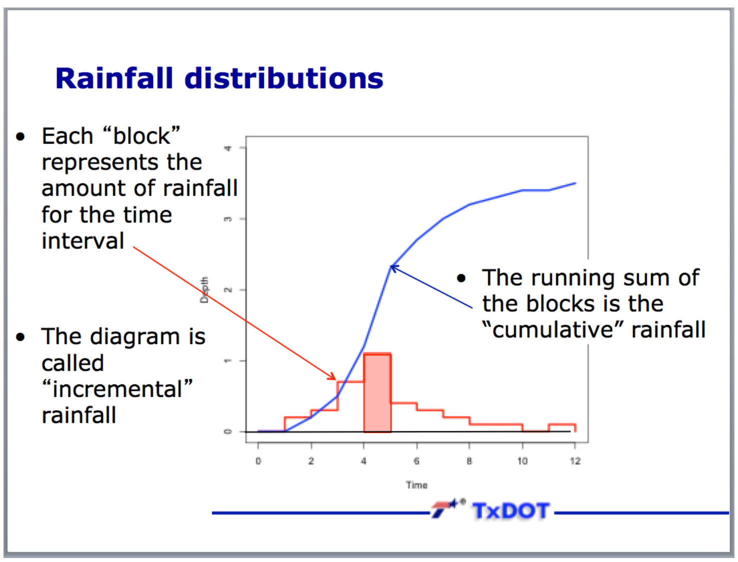

Figure 30: Graphical representation of incremental and cumulative rainfall hyetographs.

Figure 30 presents the relationship between a cumulative and incremental hyetograph. While the two hyetographs are the derivative and integral of each other, most learners seem better served if the concept is presented as running sum, and differencing.

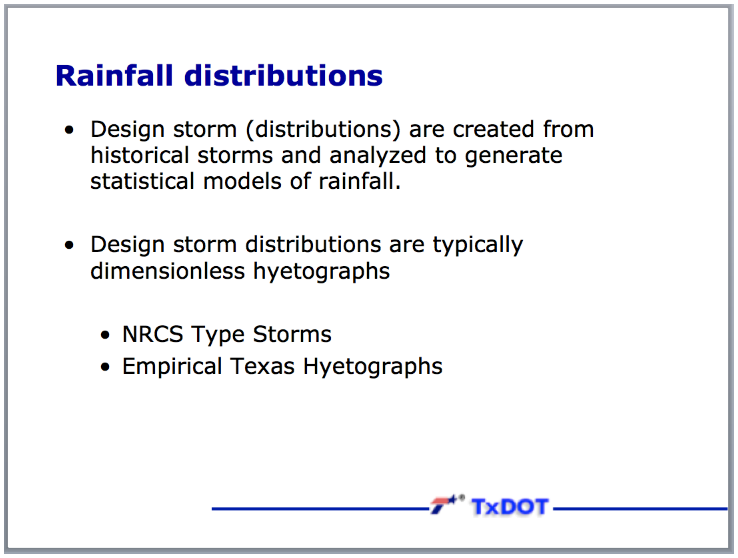

Figure 31: Rainfall distributions in common use.

Figure 31 continues the design storm concept, introducing the NRCS-type storm and the Texas hyetograph. The remainder of the module examines the Texas hyetograph.

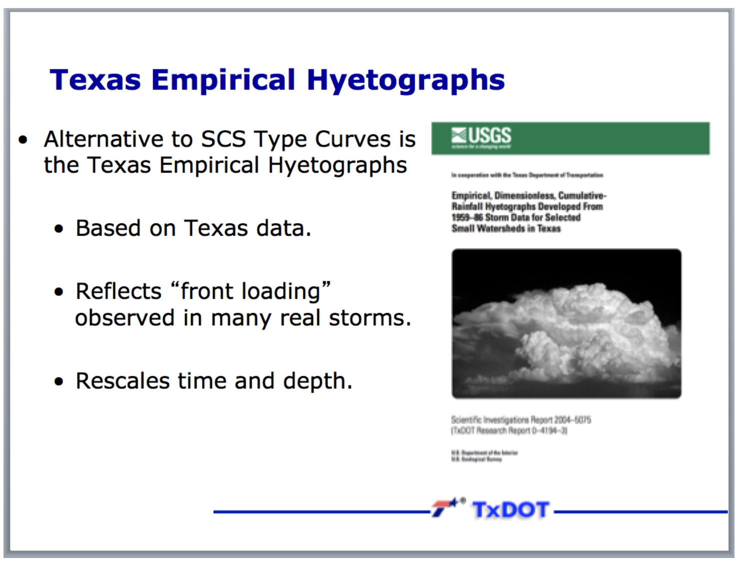

Figure 32: Texas empirical hyetograph.

Figure 32 introduces in further detail the Texas hyetograph. The figure emphasis that the Texas hyetograph reflects actual Texas storms, captures “front loading” and is fully dimensionless (unlike the NRCS storm which retains dimensional time).

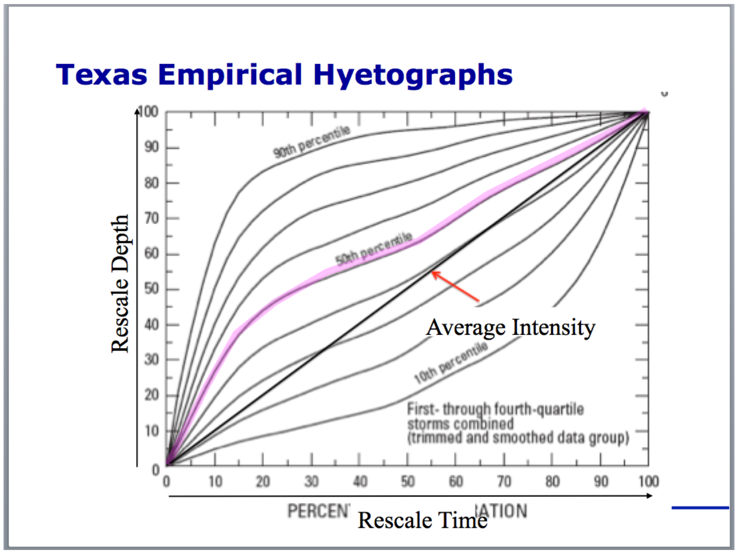

Figure 33: Graphical representation of the Texas dimensionless hyetograph curve family.

Figure 33 presents the Texas hyetograph(s). The curves in the family represent the various "observed" relative frequency of the curve. The 90th percentile curve means that the observed hyetographs lie on or below this curve. The 50th percentile hyetograph means that one-half the observed curves lie above this curve and one-half lie below the curve.

The researchers suggest that the 50th percentile is a reasonable hyetograph to use for drainage design. The 90th percentile curve is an optional choice where the designer is especially concerned about performance during intense portions of a storm. Very few observed storms in the database used to generate the hyetographs had computed intensities exceeding that of the 90th percentile model.

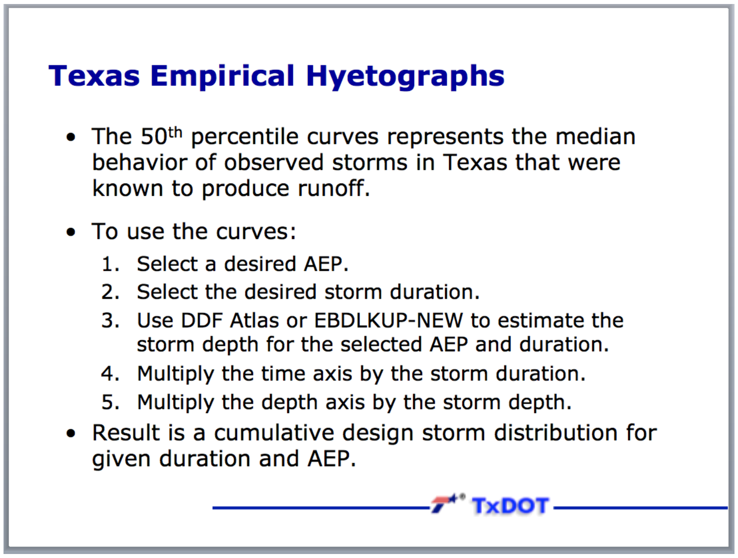

Figure 34: Method to use the empirical hyetographs.

Figure 34 lists the method to use the hyetographs (graphical or tabular form).

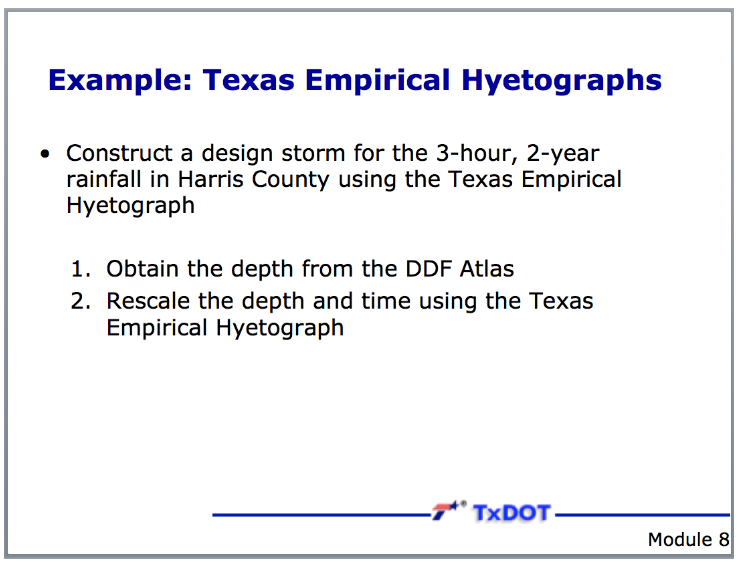

Figure 35: Example to illustrate the use of the Texas Hyetograph.

Figure 35 presents an example problem to illustrate the use of the DDF Atlas and the Texas Hyetograph (graphical tool)

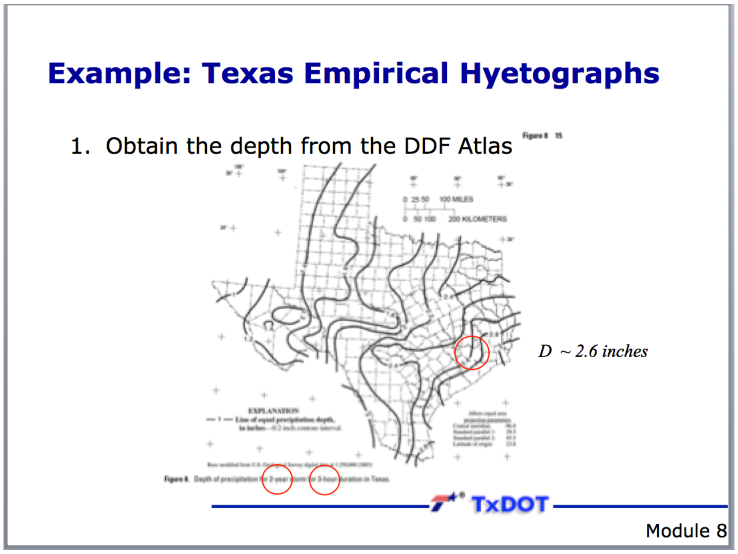

Figure 36: Estimating the depth at a location for a duration and annual recurrence interval using the Texas DDF Atlas.

Figure 36 shows the first step of locating the depth from the DDF Atlas for a given location, annual excellence probability and desired duration.

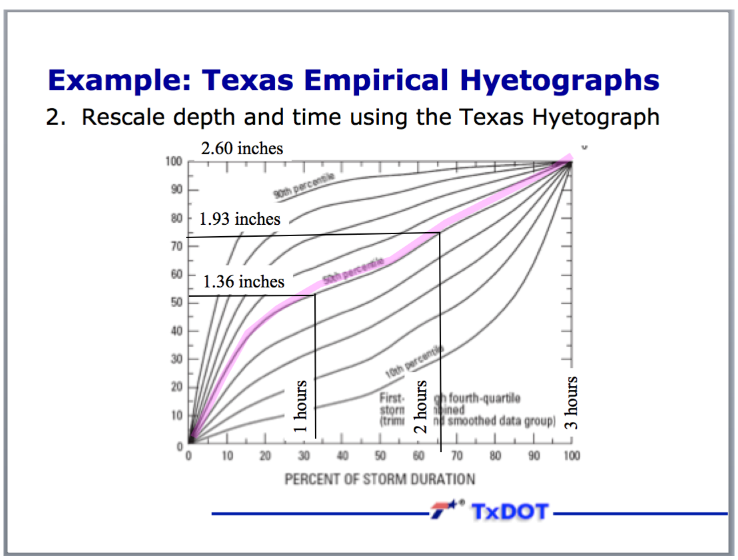

Figure 37: Re-scaling the dimensionless hyetograph using the values just obtained.

Figure 37 shows in a graphical context the rescaling of the hyetograph using the dimensional depth and duration. In this example, hours 1, 2, and 3 are plotted.

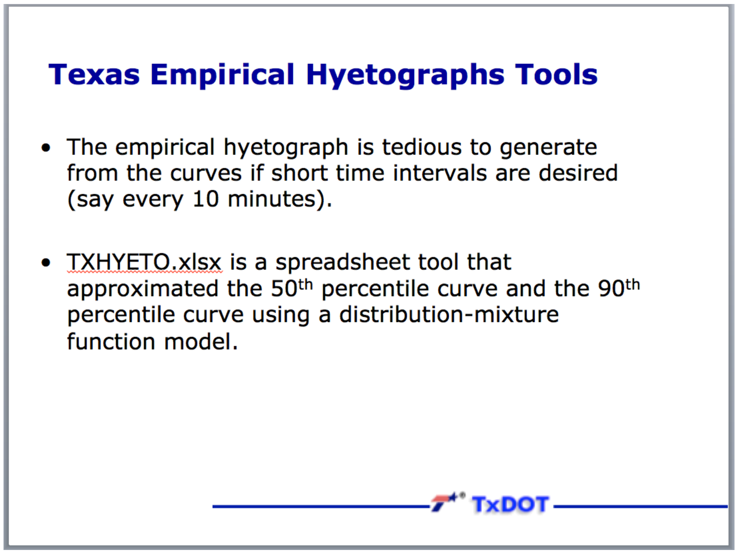

Figure 38: Introduction of the TXHYETO spreadsheet tool.

Figure 38 summarizes the challenges of using a strictly graphical approach to the task of generating hyetgographs.

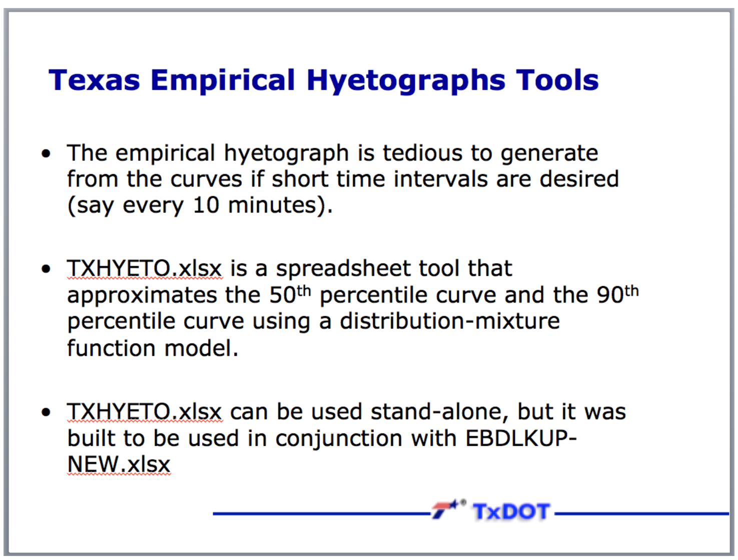

Figure 39: Integrated TXHYETO and EBDLKUP-NEW.

Figure 39 explaination of TXHYETO and integration with EBDLKUP-NEW.

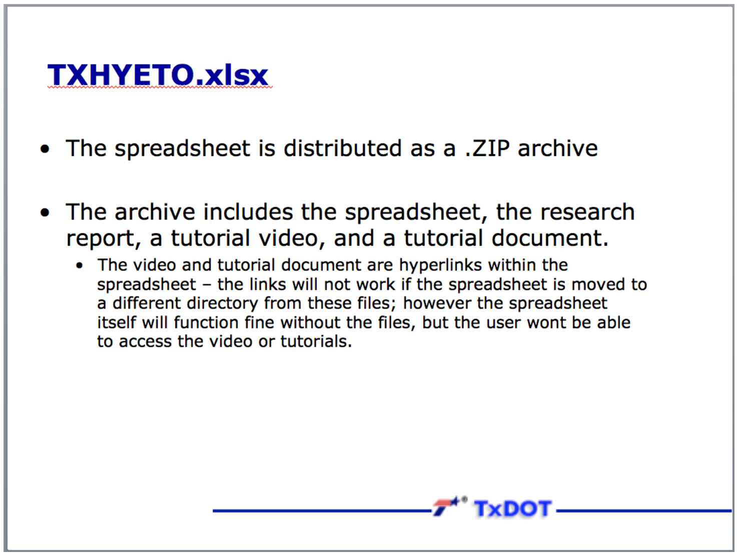

Figure 40: TXHYETO distribution method.

Figure 40 presents the distribution method for TXHYETO.

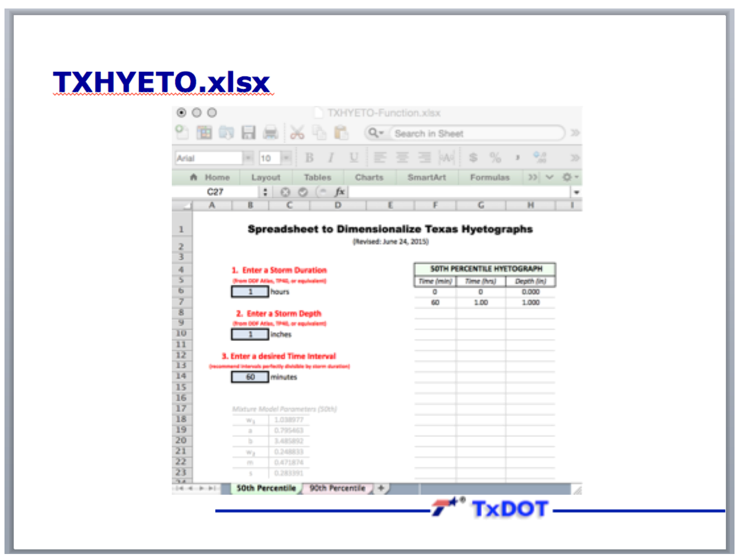

Figure 41: TXHYETO interface.

Figure 41 presents the interface for TXHYETO, the three input prompts are to the left of the interface. The program automatically prepares the output column based on the input values.

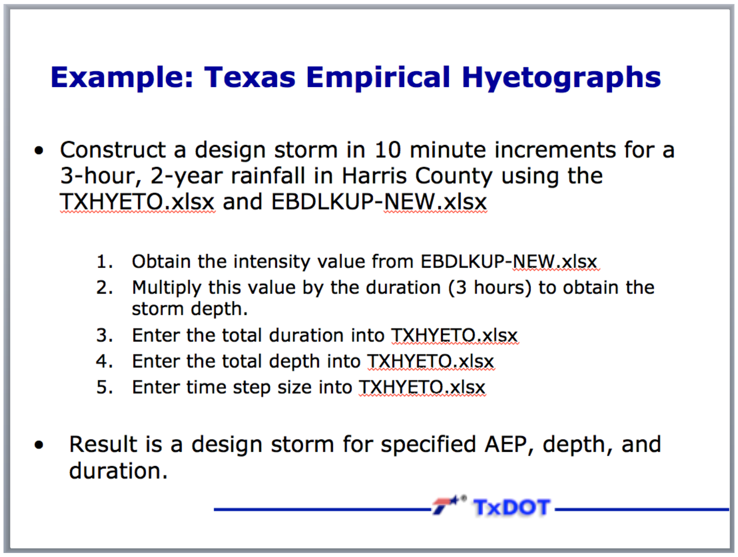

Figure 42: Example to illustratete the use of EBDLKUP-NEW and TXHYETO.

Figure 42 is an example to illustrate the use of EBDLKUP-NEW and TXHYETO. The example is an extension of the earlier example that was used to explain EBDLKUP-NEW.

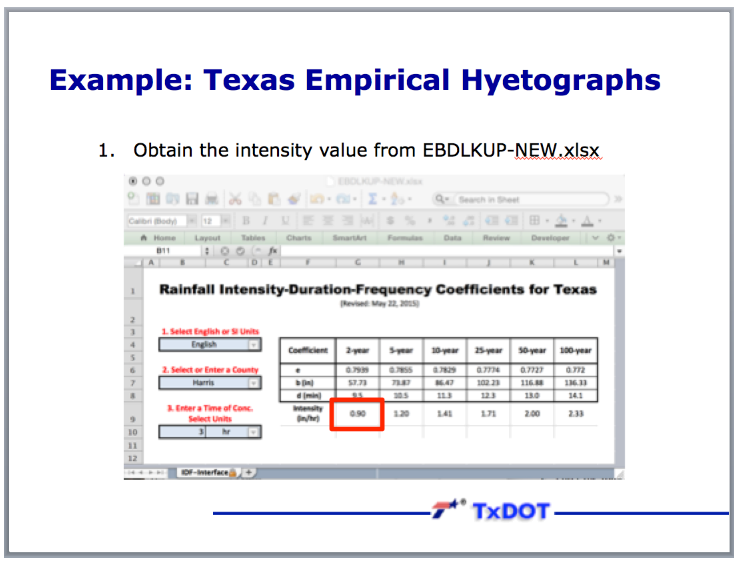

Figure 43: Using EBDLKUP-NEW for the example.

Figure 43 shows the use of EBDLKUP-NEW to estimate an intensity for a given ARI and county in Texas.

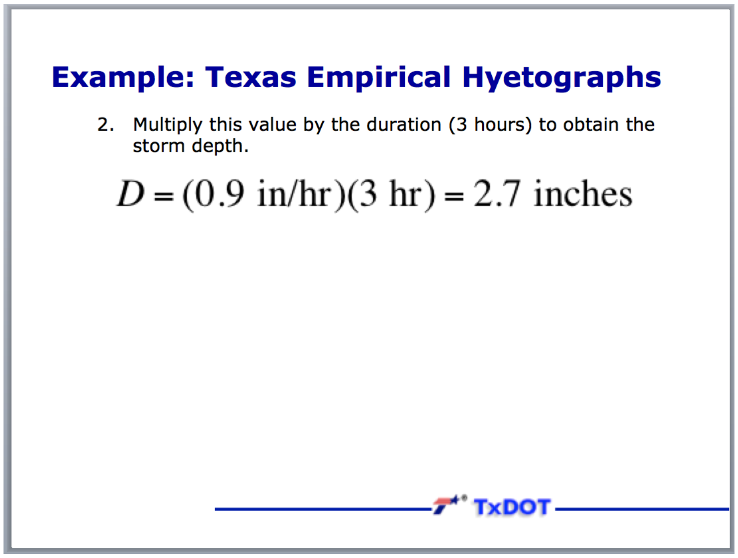

Figure 44: Conversion of intensity into a depth.

Figure 44 shows the conversion of the intensity into a depth by multiplication of that intensity by the associated storm duration.

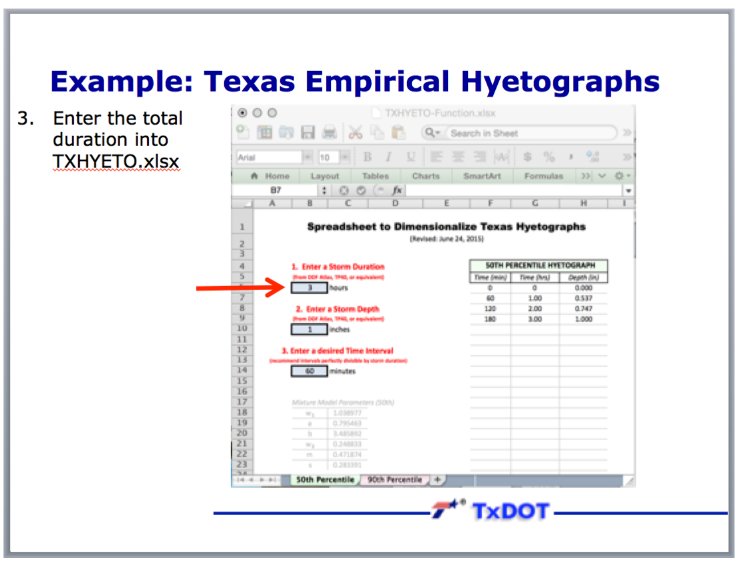

Figure 45: Inserting the duration into the user interface.

Figure 45 shows the insertion of the storm duration into the TXHYETO user interface.

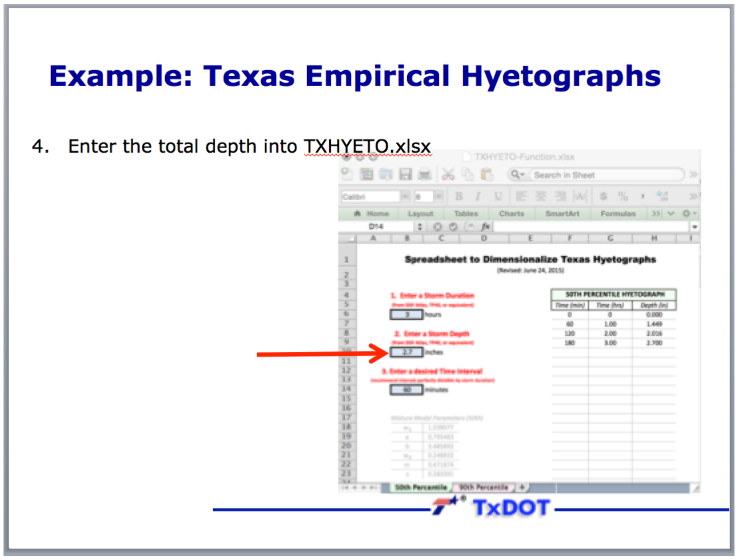

Figure 46: Inserting the storm depth into the interface.

Figure 46 shows the insertion of the just computed storm depth into the TXHYETO user interface.

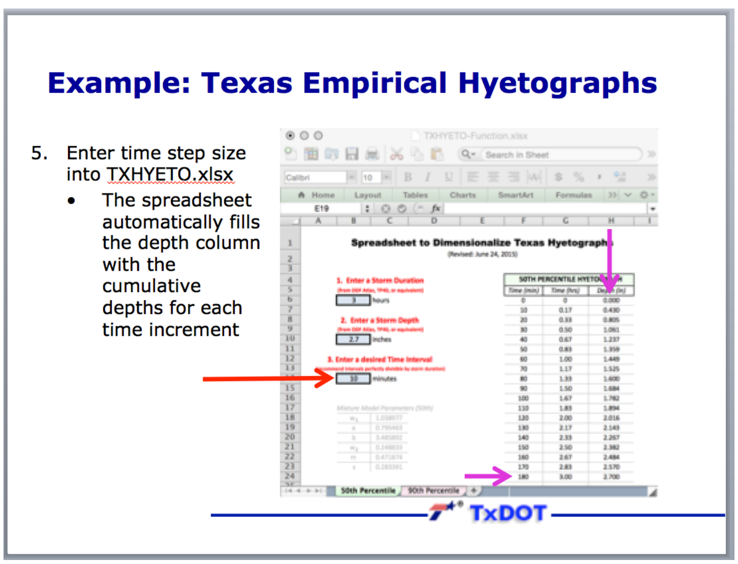

Figure 47: Inserting the time increment.

Figure 47 shows the user inserting the desired time increment for the hyetograph. The increment should be an integer divisor of the total time for best results, however if this situation is not honored, the program will still produce a meaningful result.

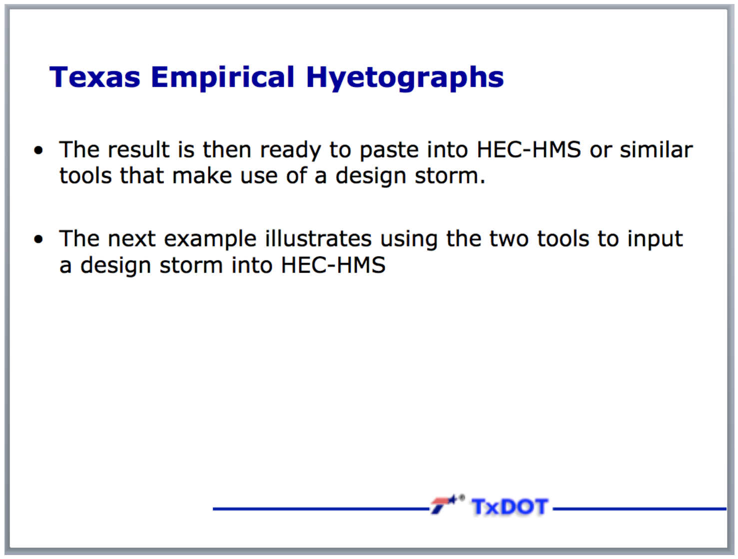

Figure 48: Summary of TXHYETO example result.

Figure 48 explains that the result is ready for insertion into other programs.

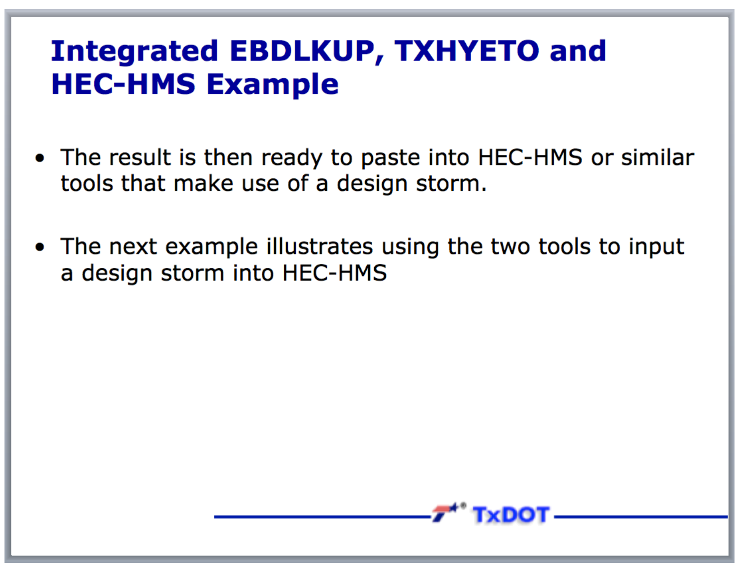

Figure 49: Integrated example of EBDLKUP-NEW, TXHYETO, and HEC-HMS.

Figure 49 introduces an example that is to illustrate the integrated use of the tools with a hydrologic software tool (HEC-HMS).

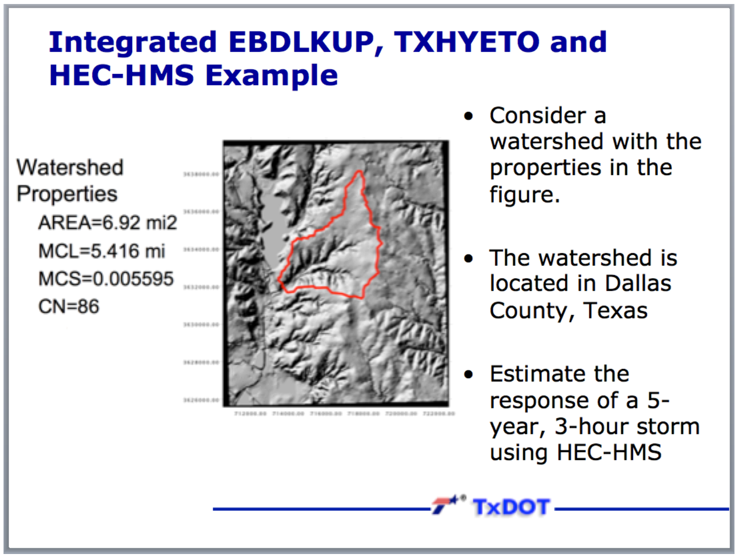

Figure 50: Example problem watershed properties.

Figure 50 shows the example watershed properties, location, and other features that would be important in a watershed simulation.

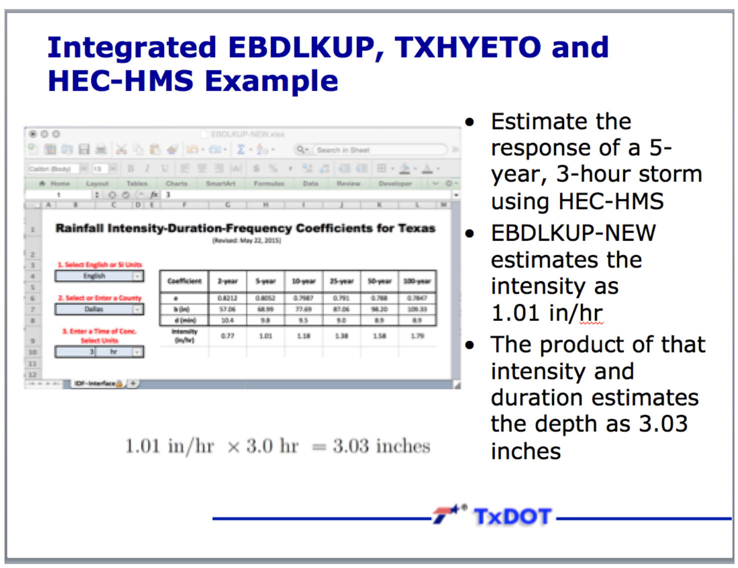

Figure 51: Example watershed rainfall intensity and depth estimation.

Figure 51 is the rainfall intensity and depth estimation process for the integrated example problem. BDLKUP-NEW is used as the estimation tool for intensity, then the value is multiplied by the storm duration to recover the depth.

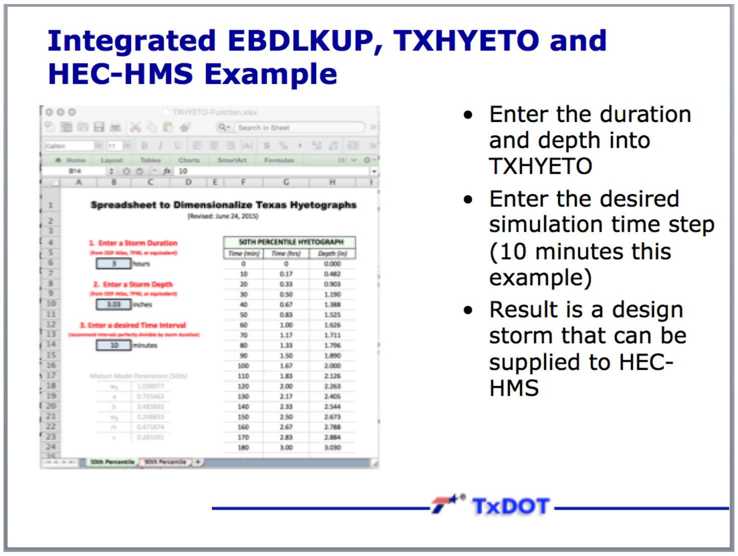

Figure 52: Example hyetograph construction.

Figure 52 then takes the just computed depth and uses TXHYETO to generate a hyetograph. The example uses a 10 minute time step, but other increments could be used.

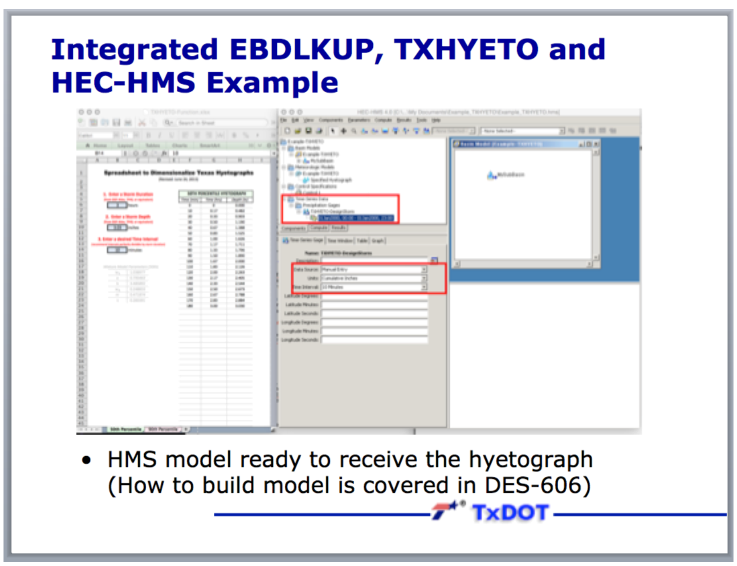

Figure 53: HEC-HMS model and TXHYETO side-by-side.

Figure 53 displays the TXHYETO result and the HEC-HMS model side-by-side. The relevant parts of HEC-HMS are highlighted by red rectangles. The HEC-HMS model should have the raingage object ready to receive the hyetograph by inserting the same time step increment, and instructing the HMS model to use cumulative depth.

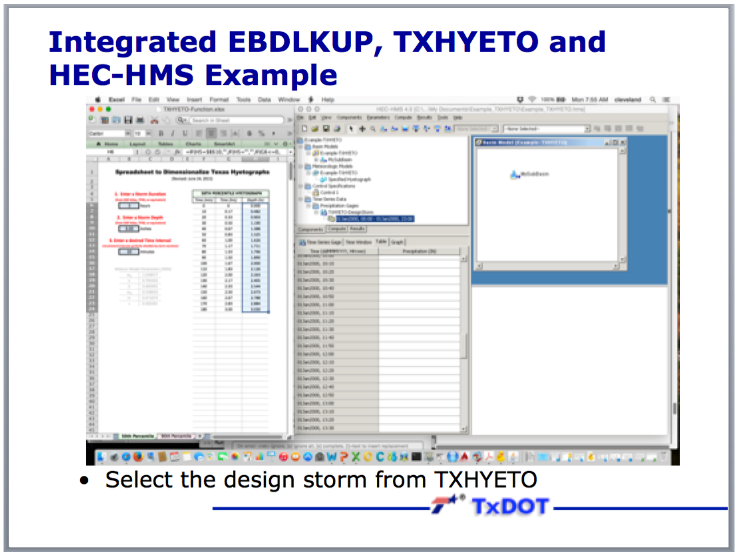

Figure 54: Copy TXHYETO result to clipboard.

Figure 54 is showing the copy of the hyetograph in TXHYETO to the clipboard.

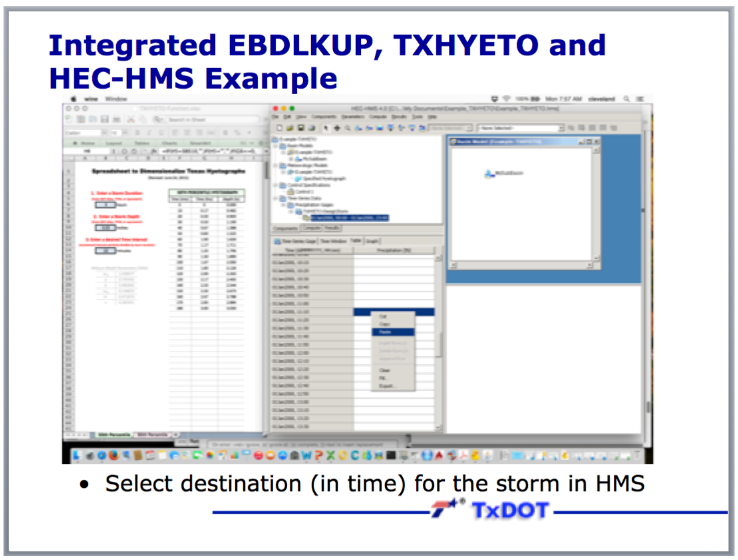

Figure 55: Preparing to paste result into HMS.

Figure 55 illustrates selecting the location in HMS (in time) to insert the hyetograph. In the example the 3 hour block is being inserted at about 11:00 hours in the simulation. Then the time before the beginning time will be filled with zeros (padding the per-storm interval with zero rainfall). The time after the storm is over will be filled with the storm depth (padding the post-storm interval with the total storm depth).

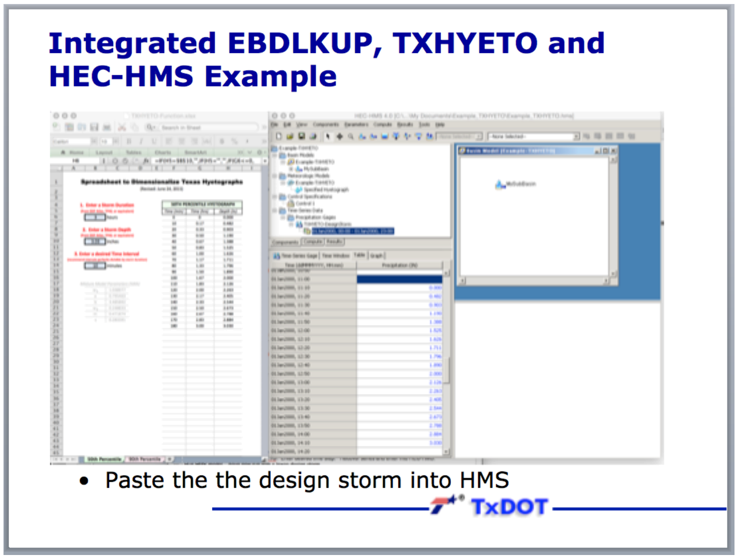

Figure 56: Result pasted into HEC-HMS.

Figure 56 is the result of the paste. When completed the HMS interface contains the hyetograph, but the analyst still has to pad the time before the storm starts with zeroes, and the time after the storm is complete with the total depth.

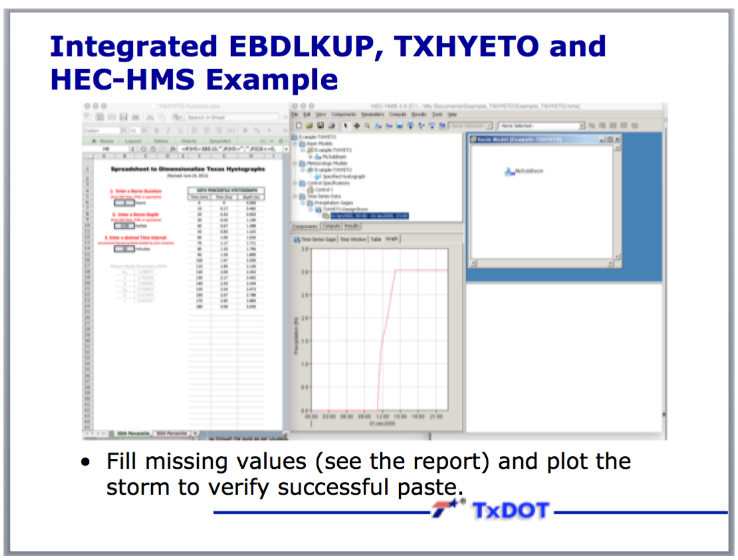

Figure 57: HMS interface showing the design storm with the pre-storm and post-storm data padding.

Figure 57 is the result of the padding operation. In HMS the operation is accomplished using the FILL tool in the raingage data entry interface.

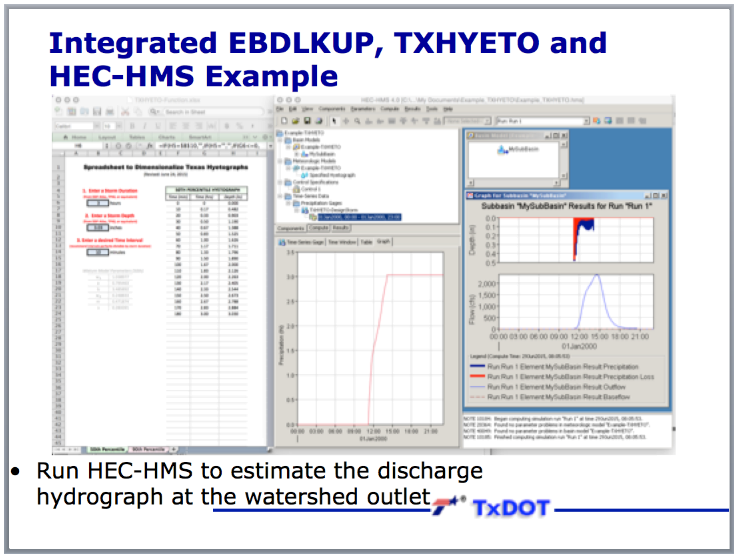

Figure 58: HEC-HMS runoff hydrography using the design storm.

Figure 58 is the completed HMS model after the simulation is run. The hyetograph is used in the HMS model to generate the runoff hydrography shown to the right side of the figure.

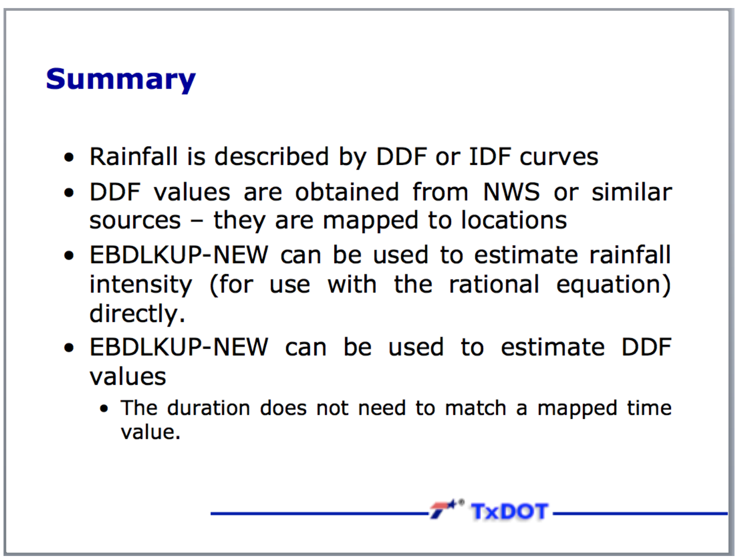

Figure 59: Training module summary (1 of 2).

Figure 59 is the first of two summary slides that reinforce the concepts presented in the module.

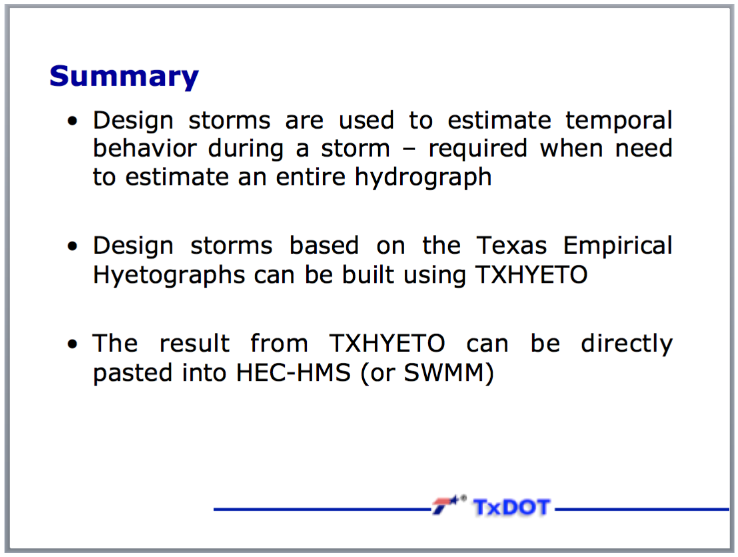

Figure 60: Training module summary (2 of 2).

Figure 60 is the second of two summary slides that reinforce the concepts presented in the module.