Updating the City of Austin Rainfall Period of Record Timeseries and Statistics

SR-18-05, March 2018

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Abstract

The City of Austin Watershed Protection Department maintains historic timeseries of precipitation for a variety of purposes including simulation of SCM performance. This report describes the process used to develop, validate and characterize the latest edition of the precipitation timeseries. Three timeseries have been prepared and their characteristics are presented in this report. The three timeseries are hourly precipitation at Camp Mabry NOAA gauge and 15-minute precipitation at the LCRA Redbud Trail and Onion Creek at US highway 183 gauges. The gauge data are consistent with one another during overlapping time periods and are presumed to all be representative of climatic conditions in the Austin area. The purpose for developing three timeseries data sets is to make available to users data of different time intervals and data covering different historical periods.

Introduction

The City of Austin Watershed Protection Department (WPD) requires a historical time series of local precipitation data for a variety of purposes. Uses of this data include input to continuous simulation hydrologic models in order to evaluate stormwater control measure (SCM) performance and as input to water balance models to evaluate the viability of wet ponds and rainwater harvesting and reuse facilities. In addition, these data are also used to create event statistics for use in lumped parameter water quality models. The minimum requirements for the

data set are at least of five years of reliable, hourly precipitation data over a period that is reflective of current climatic conditions in Austin. As stated, the data is used for a variety of purposes and the applicability of the data set for a particular purpose must be the responsibility of the end user. A time series much longer than five years would be very helpful for obtaining statistically significant conclusions regarding infrequent events and other rare phenomena such as back to back storms. However, long data sets can be less reliable, less stationary and are more difficult to work with.

The objective of this study is to obtain a verified, continuous precipitation record at an hourly, and if practical sub-hourly, time scale. This period of record (POR) rainfall will be used to update rainfall statistics and to recommend a representative five-year and ten-year POR for use in continuous simulations.

Methods and Data

The overall approach to POR development was to search for available historical precipitation records and then evaluate these records for reliability, stationarity and representativeness. Statistical conclusions drawn from long records have lower standard errors than those that rely on shorter records and the criterion for record length varies with the tolerance for error. This tolerance is impossible to predict in advance therefore the definition of what constitutes a long or short record is arbitrary. For simulations and statistical analysis, hydrologists seek the longest meaningful POR available.

A search was conducted of available rainfall gauge records for the Austin area from two primary sources. Databases maintained by the US National Oceanographic and Atmospheric Administration (NOAA), National Center for Environmental Information (NCEI, formerly NCDC), and the Lower Colorado River Authority (LCRA) were explored for long, complete data sets. Such data are difficult to come by as NOAA has only four hourly precipitation stations in the Austin area. Two of these were short-lived gauges located at Lake Georgetown and at the Walnut Creek Wastewater Treatment Plant. Two long-term gauges are maintained by NOAA:

ATT – the Austin City gauge maintained at various locations since 1856 and currently located at the Texas Air National Guard facility at Camp Mabry.
AUS – the current “official” national weather service gauge at Austin Bergstrom International Airport. Incomplete records from Bergstrom Air Force Base are available back to 1940.

The long-time National Weather Service (NWS) site known as ATT is the official climate record for Austin. It began in the mid 1800’s and was housed at various downtown locations and later, at the University of Texas Engineering building. In August 1942, the official site was moved to Mueller airport where it remained until the airport closed in July 1999, at which time the Texas National Guard facility at Camp Mabry became the official site. In this report, the site is called “Camp Mabry” even though much of the data is from Mueller. Hourly data for Camp Mabry

were obtained from August 22, 1942, to December 31, 2013, via the NCEI (https://data.noaa.gov).

In 2013, the NWS compiled official monthly rainfall for the ATT site from 1856 to 2013, which is referred to as "Mabry Monthly" in this report (www.crh.noaa.gov/Image/ewx/aus/attmonrain.pdf provided in Attachment A). The NWS notes that there is missing data in the mid 1890's, 1905, 1960, 1963, and 1995. The Camp Mabry hourly data was aggregated and compared with the Mabry Monthly to ensure data completeness in the Camp Mabry time series.

The AUS dataset has records in the early 1940's followed by a 59-year gap in the record. Records appear to be continuous since January 1, 2002. Given the much greater continuous length of the ATT record, the AUS data was not used in this study.

LCRA, in partnership with the USGS and the City of Austin, operates the Hydromet network of rain gauges. These gauges were included in this study to provide access to subhourly data and to rainfall events that occurred after the end of 2013. Data from two gauge sites archived in the LCRA Hydromet database were obtained from https://hydromet.lcra.org. The selected sites include Redbud Trail where data was collected from March 3, 2008, to September 10, 2016, and Onion Creek at US 183 where data was collected from August 1, 2005, to September 10, 2016. These sites were selected because they are among the longest and most complete records in the Hydromet network and for their proximity to the NWS sites. The Redbud Trail site is about 3.5 km from Camp Mabry and the US 183 site is 2.5 km from ABIA.

Data at these Hydromet gauges is collected using tipping buckets (confirmed by WPD employee Sam Mahmoud) which continuously record data at roughly 15-minute time intervals. However, there are times when the intervals are much larger than 15 minutes. It was decided that there was no rain during the 15-minute intervals where no data existed through comparison to the Camp Mabry hourly data. Thus, the missing 15-minute intervals are assumed to have zero inches of rainfall, except for the final 15 minute period, which contains 100% of the rainfall from the entire time interval. As opposed to assuming the rainfall fell uniformly over the entire time interval, this approach preserves the intensity of the rainfall.

Table 1. *Datasets obtained and used in the study*

Recording Site	Start Date	End Date	Time Interval	Source
ATT (various locations, currently Camp Mabry)	Jan 1, 1856	Dec 31, 2013	Monthly	noaa.gov
ATT (various locations, currently Camp Mabry)	Aug 22, 1942	Dec 31, 2013	hourly	noaa.gov
Redbud Trail	Mar 18, 2008	Sep 10, 2016	15-minute	hydromet.lcra.org
Onion Crk at US 183	Jan 8, 2004	Sep 10, 2016	15-minute	hydromet.lcra.org

Results and Discussion

Camp Mabry Hourly Data Assessment

Aggregated hourly data collected at Camp Mabry should match the Mabry Monthly totals exactly. Differences between the hourly and monthly datasets have been compiled in Table B1 of Attachment B. As indicated in the table, the datasets match exactly between October 1957 and July 1994, and most of the time since July 2003. Outside of these windows, there are various degrees of missing data in the hourly record. There are no overlapping reliable records that could be used to repair the missing data prior to 2004 when Hydromet data became available. After 2004, there is no missing data in need of repair. The AUS site could be used to repair ATT but there is limited overlapping record available to establish a correlation when the gauges were at their current locations. For the time being, users should avoid using data collected during known periods with extensive missing data as indicated in Table B1.

Long term trends and stationarity

The Mabry monthly record was evaluated for stationarity and consistency to obtain a sense of how Austin's climate might be changing. According to the record, the mean annual rainfall for the entire 157-year period is 33.4 inches with a standard deviation of 9.2 inches. The entire record and the corresponding 30-year moving average are plotted in Figure 1. Examination of the 30-year average rainfall within the record indicates that the 30-year mean has varied between a low of 31.1 inches (for the thirty years preceding 1976) to a high of 36.8 inches (1942). During the most recent available 30 years ending in 2012, the mean annual rainfall was 33.7 inches with a standard deviation of 9.7 inches. This represents a greater than 2 inch increase over the preceding 30 years where the average was near the all-time low. The 1951-1980 average rainfall was 31.5 inches with a standard deviation of 8.6 inches.

Despite this recent trend of increasing rainfall and increasing year-to-year variability, there is no long term trend evident in the historical record. The 2.2 inch increase is not statistically significant and visual inspection of the 30-year moving average does not indicate a trend. The shift in 30-year mean would need to be at least 4.7 inches to be significant at the 95 percent confidence level. The recent increases can be attributed to a recovery from unusually dry conditions experienced in the 1950s and 1960s. Since 1990, there has been substantial evidence of regional and global climate change (McCarthy, 2009), but the changing climate has not affected Austin's annual rainfall in a statistically obvious way. There have been some shifts in the monthly distribution of rainfall but additional analysis will be required to determine whether these are driven by the changing climate.

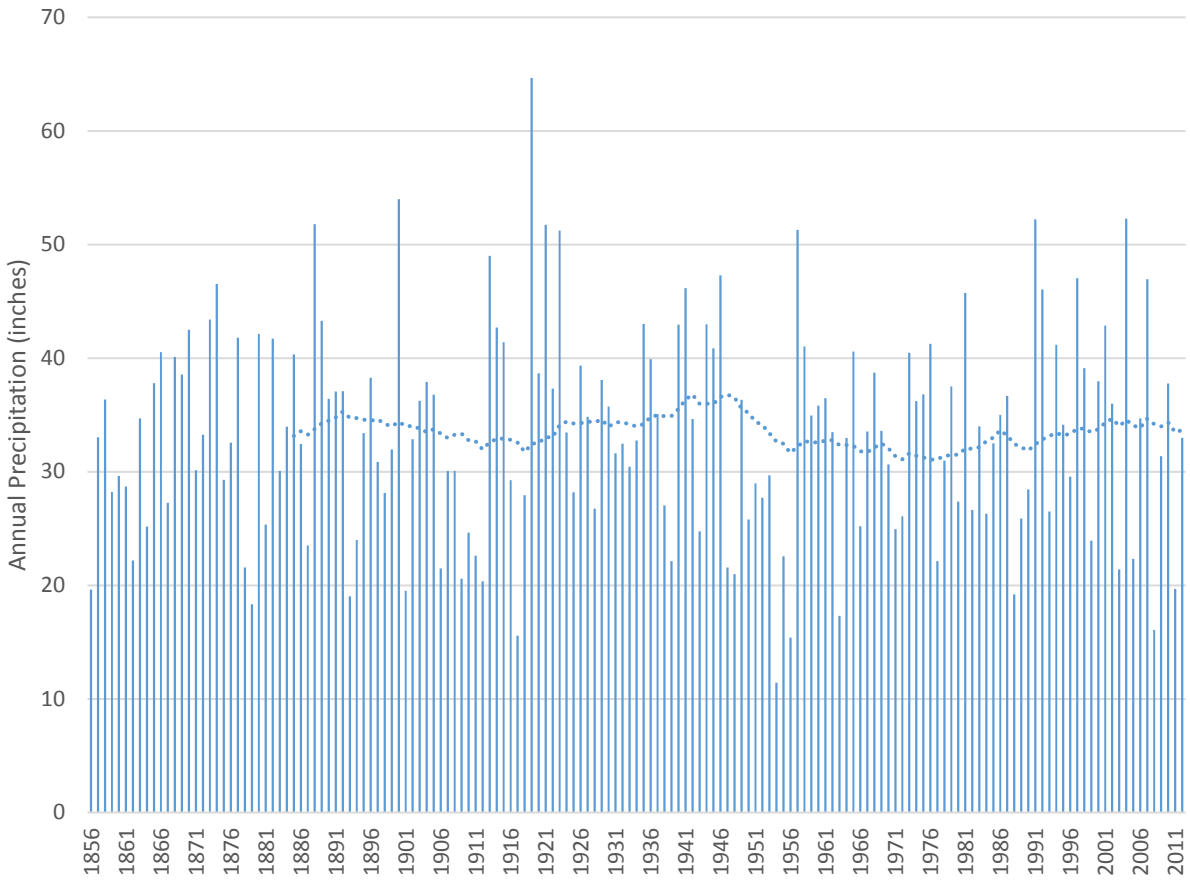

Figure 1. *Austin Annual Precipitation 1856-2012 with 30-year backward looking moving average plotted*

Selection of a Period of Record

One objective of this study is to obtain a historical rainfall period of record (POR) that is indicative of expected current conditions for use in continuous simulations. To be useful, the record should be as long as practical but contain very little missing data. Other expected characteristics of the POR are monthly and annual mean rainfall values that mirror current averages as well as an even distribution of above- and below-average years. The targets for this POR are the 1983 to 2012 average annual rainfall of 33.7 inches with a standard deviation of 9.7 inches.

The missing data analysis indicates that the POR should be selected from data obtained between 1958 and 1994 or from data since June 2002. The 1958 to 1994 period would provide a continuous 37-year record with a mean annual rainfall of 33.6 inches. This mean is close to the target but the year-to-year variability was quite low during this period with a standard deviation of 7.63 inches. No additional assessments were conducted on this part of the record, but studies wishing to use a long continuous record could use this data and expect reliable results.

Recent five-year and ten-year periods that are considered for use in continuous simulation models are listed in Table 2. The earlier records in the 80's and 90's have the advantage of no apparent missing data; however, the 2004-2013 and 2006-2010 periods are more recent and contain a balance of dry and wet years including one extremely dry and one extremely wet year. While 1.05 inches of precipitation was not recorded (that is, missing) between 2003 and the end of 2012, it is the recommendation of this study that the 2004-2013 and 2006-2010 periods be used for future SCM evaluations.

Table 2. *Recommended POR – Wet/Dry year counts do not include years within one inch of the mean*

Period	Length (years)	Mean Annual Precip. (inches)	Wet Years	Dry Years
2004-2013	10	33.4	5	4
1983-1992	10	33.6	4	5
2006-2010	5	33.2	3	2
1983-1987	5	32.9	3	1

Rainfall Statistics for the New Period of Record

A second objective was to develop rainfall statistics needed for certain analyses that rely on the "Adams and Papa" calculation method (Adams and Papa, 2000) rather than the time series itself. The full Camp Mabry time series of August 22, 1942, to December 28, 2013 was used to generate rainfall statistics by first loading data into a SWMM model with a generic basin (U.S. EPA, 2015). The model was run with an hourly time step, which allowed the time series to be processed by SWMM. Then, SWMM's Statistics Report tool was used to group the time series into discrete storms by inputting the following values:

Variable Analyzed: Precipitation
Event Time Period: Event-Dependent
Event Threshold – Precipitation: 0 inches per hour
Event Threshold – Volume: 0 inches
Event Threshold – Separation Time: 6 hours

Essentially, a storm was defined as any rainfall recorded by the gauge (down to 0.01 inches) that occurs greater than 6 hours after the preceding rainfall.

The statistics output by SWMM include a table of storm events including the storm rank, date, event duration (hrs), and event total rainfall (in). SWMM identified 5,630 discrete storm events for the entire POR. The events table was exported to Microsoft Excel for further data analysis. Excel was used to sort the data chronologically, and the following statistics were calculated for each full year on record, 1943 through 2013, using simple math functions:

- Number of events

- Total inches of rainfall (in)
- Rainfall per event (in)
- Time between event midpoints (hrs)
  = Hours per year, accounting for leap years / number of events
- Average event duration (hrs)
- Total rainfall duration (hrs)
- Average intensity (in/hr)
  = Total inches / (Average duration * number of events)
- Average Interevent Time (hrs)
  = Average duration - time between event midpoints

Once statistics for each year were computed, statistics for the whole record (1943 through 2013), the ten-year POR (2004 through 2013), and the 5-year POR (2006 through 2010) were determined using the same methodology. Detailed rainfall statistics are provided in Table 3 for the ten-year POR and all statistics are summarized in Table 4.

Table 3. *Annual and 10-year rainfall statistics for 2004 through 2013*

Year	Hours Per Year	Number of Events	Annual Total Rainfall (in.)	Rain per Event (in.)	Time between Event Midpoints (hrs)	Average Event Duration (hrs)	Hours within events (Duration times # of Events)	Average Event Intensity (in/hr)	Average Inter-event Time (hrs)
2004	8784	103	52.17	0.507	85.3	5.91	609	0.09	79.4
2005	8760	74	22.33	0.302	118.4	5.03	372	0.06	113.4
2006	8760	74	34.67	0.469	118.4	5.14	380	0.09	113.2
2007	8760	108	46.95	0.435	81.1	6.08	657	0.07	75.0
2008	8784	70	16.07	0.230	125.5	4.19	293	0.05	121.3
2009	8760	79	30.74	0.389	110.9	5.87	464	0.07	105.0
2010	8760	70	37.74	0.539	125.1	6.60	462	0.08	118.5
2011	8760	47	19.68	0.419	186.4	5.72	269	0.07	180.7
2012	8784	63	33.04	0.524	139.4	5.94	374	0.09	133.5
2013	8760	80	40.97	0.512	109.5	5.86	469	0.09	103.6
SUM	**87672**	**768**	**334.36**				**4349**		
Annual Mean		**76.8**	**33.4**	**0.435**	**114.2**	**5.66**		**0.08**	**108.5**

Table 4. *Comparison of the updated rainfall statistics and previously derived rainfall statistics*

Parameter	Symbol	Updated Rainfall Statistics (SWMM/Excel)			Previous Rainfall Statistics Derived from SYNOP Model[1]		
		A&P Update (Mabry 1943-2013)	A&P Update[2] (Mabry 2004-2013)	A&P Update (Mabry 2006-2010)	Driscoll et al. 1989	COA SWT Section & ECM Wet Pond Criteria	Adams & Papa[3] (Mueller 1948-1993)
Minimum event rainfall volume (in.)		0.0	0.0	0.0	0.1	0.05	0.0
Interevent Time Definition (hr)	*IETD*	6	6	6	6	6	6
Average event volume (in.)	v	0.41	0.44	0.41	0.7	0.6	0.40
Average event duration (hr)	t_D	5.89	5.66	5.63	8.4	7.8	5.80
Average event intensity (in/hr)		0.069	0.077	0.074	0.119	0.106	0.083
Average time between event midpoints (hr)	Δ	111.2	114.2	109.3	200.0	172.1	109.4
Average interevent time (hr)	b	105.3	108.5	103.7	191.6	164.3	103.6
Average annual number of rainfall events	o	78.8	76.8	80.2	45.0	51.8	80.1
Average annual rainfall volume (in.)	P_p	32.2	33.4	33.2	31.46	31.08	31.73

1. Rainfall statistics from Synop Model. Source: \\coacd.org\dfs\WPDRD\ERM\Common\SCM_Workgroup\POR2016\Statistics\Guidance\FW data here.msg
2. These POR statistics are proposed for updating ECM 1.6.9 (2018)
3. These statistics are currently used in ECM 1.6.9 (2016)

LCRA Hydromet series

Two records were obtained from the LCRA Hydromet Database in order to provide records that extend beyond 2013 and to provide records with sub-hourly time steps. These records are intended for use "as is" with no recommended POR. As these records pick up the wet years of 2013 and 2015, they are generally wetter than the normal values outlined above. These records are as follows:

Redbud – March 3, 2008, to Sept 10, 2016 - 8.5 years with 36.6 inches per year
Onion Creek - Aug 1, 2005, to Sept 10, 2016 - 11.1 years with 35.8 inches per year

These records cannot be tested comprehensively for missing data or spurious data. The data can be compared to the Camp Mabry data for consistency and mass curves are provided in Attachment C. The total annual rainfall recorded during each complete year of available record is provided in Table 5.

Table 5. *Recorded Annual Precipitation at the evaluated rainfall gauge sites*

Year	Mabry	Onion	Redbud
2005	22.33		
2006	34.67	28.60	
2007	46.95	48.50	
2008	16.07	14.46	
2009	30.74	32.22	28.23
2010	37.74	30.43	31.70
2011	19.68	16.38	17.67
2012	32.93	35.76	32.67
2013	41.08	41.47	48.90
2014		33.70	37.81
2015		66.54	66.85

Recommendations

The purpose of this study was to prepare an extended, continuous hourly rainfall record that is indicative of current climate conditions throughout the City of Austin. This analysis examined the stationarity and reliability of historical rainfall datasets and concluded that annual rainfall does not appear to exhibit substantial systematic change. In addition, comparison of the Onion Creek and Redbud records do not show a bias based on location. The study recommends using the 10-year period of record (POR) of Camp Mabry rainfall from January 1, 2004, through December 31, 2013, for evaluating the performance of Stormwater Control Measures and related facilities. The average annual rainfall of this POR is 33.4 inches and is balanced with three dry years and three wet years with the remaining near-normal years ranging from 30.74 to 37.74 inches. The driest year is 2008 with just 16.07 inches; however, the critical dry period in the sequence appears to have occurred in 2011 when only 0.05 inches of rain was recorded between

June 22 and September 16. The wettest year in the record was 2004 with 52.17 inches of annual rainfall. The total rainfall in 2015 was notably greater and 2015 data can be obtained by using the LCRA datasets also developed for this study.

This data should serve its intended purpose for many years to come so no predetermined update schedule has been established. The primary reason the series would need to be extended or revised is due to changing climate. Although this study detected no systematic change in annual rainfall, many recent reports indicate that changes are occurring that affect the frequency, duration and intensity of storms and droughts. One such report is the 2017 Climate Science Special Report: Fourth National Climate Assessment put out by the U.S. Global Change Research Program.

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Attachment A

National Weather Service Monthly Precipitation at Austin Texas

MONTHLY/ ANNUAL/AVERAGE PRECIPITATION
AUSTIN TX (1856 - 2013)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	YEAR
1856	2.15	2.65	1.40	1.21	2.84	0.62	0.41	1.56	2.67	1.88	2.02	0.22	19.63	**1856**
1857	2.15	2.82	0.30	1.59	1.68	3.36	0.46	0.68	4.38	3.35	6.14	6.12	33.03	**1857**
1858	2.95	0.96	7.02	0.49	8.80	1.07	3.80	0.44	5.01	2.90	0.75	2.18	36.37	**1858**
1859	2.13	0.88	1.72	0.49	2.46	2.14	1.31	1.11	9.70	4.49	0.40	1.39	28.22	**1859**
1860	2.53	4.43	0.66	2.05	0.13	0.77	0.15	**10.88**	1.28	0.45	5.85	0.44	29.62	**1860**
1861	2.75	1.23	0.61	1.95	7.89	1.19	0.07	6.12	2.35	3.53	**0.00**	1.00	28.69	**1861**
1862	0.19	1.63	1.24	4.12	4.63	0.02	0.72	3.32	2.08	3.01	0.35	0.87	22.18	**1862**
1863	6.30	6.92	1.70	1.96	2.51	2.92	2.37	1.29	7.02	1.04	0.10	0.57	34.70	**1863**
1864	0.17	3.36	2.43	3.03	0.99	5.16	0.67	0.98	1.34	2.75	2.41	1.87	25.16	**1864**
1865	2.90	6.19	6.77	2.26	0.17	5.73	0.11	**0.00**	8.57	3.37	1.22	0.50	37.79	**1865**
1866	0.32	0.93	3.64	5.30	5.21	1.86	4.34	7.51	4.82	0.42	4.41	1.76	40.52	**1866**
1867	0.01	0.72	1.02	1.86	1.79	3.30	2.02	3.27	6.41	2.08	2.98	1.80	27.26	**1867**
1868	0.36	3.48	4.55	3.63	2.33	0.69	2.55	7.00	1.72	4.65	4.17	4.96	40.09	**1868**
1869	5.06	0.61	3.51	3.09	3.85	2.34	9.20	1.14	4.16	2.72	1.54	1.32	38.54	**1869**
1870	0.69	0.59	2.21	2.72	7.58	2.73	2.55	4.30	1.96	12.54	3.48	1.14	42.49	**1870**
1871	1.73	1.60	2.10	1.23	4.82	0.46	**0.00**	2.08	3.13	7.64	4.89	0.44	30.12	**1871**
1872	2.17	1.06	3.73	3.11	3.45	7.61	2.00	1.34	**0.00**	1.64	2.17	4.97	33.25	**1872**
1873	2.23	0.45	3.34	1.81	4.55	8.41	4.48	2.20	10.54	2.23	2.70	0.45	43.39	**1873**
1874	0.87	1.42	5.60	1.34	1.10	1.88	5.14	0.75	12.78	0.40	7.52	7.72	46.52	**1874**
1875	**0.00**	1.85	1.02	2.22	2.56	0.44	1.30	2.75	4.00	0.92	7.33	4.90	29.29	**1875**
1876	2.04	1.46	5.60	0.58	5.66	4.48	2.33	0.56	2.69	2.46	2.83	1.87	32.56	**1876**
1877	1.26	6.94	3.61	4.69	4.81	5.01	2.44	T	0.55	5.76	2.35	4.36	41.78	**1877**
1878	1.88	1.82	0.66	3.19	3.58	4.09	0.32	2.51	0.18	0.12	2.29	0.92	21.56	**1878**
1879	0.55	1.10	1.25	5.43	0.92	1.28	0.50	0.98	2.15	2.15	0.25	1.78	18.34	**1879**
1880	3.53	3.94	1.82	4.80	5.91	2.64	3.57	4.77	6.71	1.57	2.11	0.75	42.12	**1880**
1881	1.73	1.36	1.35	3.42	4.37	**0.00**	2.19	2.05	1.99	3.14	2.42	1.32	25.34	**1881**
1882	3.46	5.05	3.90	0.53	9.86	**0.00**	2.44	3.98	3.30	4.18	2.42	2.58	41.70	**1882**

1883	2.07	2.39	2.35	1.15	0.53	3.27	6.28	1.99	3.72	2.10	2.16	2.07	30.08	**1883**
1884	2.63	3.87	4.45	7.78	4.26	1.46	**0.00**	0.04	1.76	2.63	3.40	1.68	33.96	**1884**
1885	5.37	T	2.22	4.71	8.40	0.63	1.68	1.66	8.97	2.82	1.17	2.69	40.32	**1885**
1886	0.97	2.18	0.66	5.04	T	0.92	3.24	6.01	12.33	0.25	0.64	0.19	32.43	**1886**
1887	0.28	1.71	1.76	T	6.12	1.60	T	1.67	2.82	3.64	1.78	2.13	23.51	**1887**
1888	1.17	7.22	2.49	6.57	5.87	4.63	0.95	6.38	1.16	4.45	6.61	4.29	51.79	**1888**
1889	8.03	5.02	0.88	2.83	2.95	5.34	3.93	0.47	6.12	0.98	4.62	2.11	43.28	**1889**

MONTHLY/ ANNUAL/AVERAGE PRECIPITATION
AUSTIN TX (1856 - 2013)

YEAR	***JAN***	***FEB***	***MAR***	***APR***	***MAY***	***JUN***	***JUL***	***AUG***	***SEP***	***OCT***	***NOV***	***DEC***	***TOTAL***	***YEAR***
1890	2.44	4.54	0.58	5.49	6.88	4.70	1.75	0.34	4.48	3.12	1.25	0.85	36.42	**1890**
1891	5.65	0.20	2.05	7.50	0.70	3.60	0.10	1.25	5.25	0.25	1.52	9.00	37.07	**1891**
1892	3.17	2.44	1.92	0.10	2.95	4.37	1.60	6.46	0.70	3.40	1.50	8.49	37.10	**1892**
1893*	0.45	T	2.90	0.20	4.35	1.85	0.25	2.10	2.02	**0.00**	4.90	0.02	19.04	**1893***
1894*	1.45	0.60	3.45	6.35	3.85	1.00	T	5.30	0.70	1.30	**0.00**	**0.00**	24.00	**1894***
1895*	1.30	0.80	0.95	2.50	**14.10**	1.80	**0.00**	1.10	2.80	2.90	3.10	2.05	33.40	**1895***
1896*	4.05	7.55	0.40	6.50	1.31	0.42	4.05	T	8.24	3.71	T	2.05	38.28	**1896***
1897*	5.50	0.40	3.08	3.19	1.59	1.29	0.30	1.17	3.74	7.92	**0.00**	2.67	30.85	**1897***
1898	1.51	1.70	2.60	3.80	2.50	5.04	3.20	3.91	0.50	1.10	0.71	1.55	28.12	**1898**
1899	0.80	0.91	**0.00**	2.40	3.70	3.80	4.20	0.40	1.60	5.45	2.90	5.80	31.96	**1899**
1900	4.30	0.51	7.20	9.63	11.05	0.60	5.40	2.90	3.60	5.50	1.70	1.60	53.99	**1900**
1901	0.20	1.80	1.60	1.90	4.13	1.11	2.50	1.80	1.60	1.80	1.00	0.06	19.50	**1901**
1902	0.30	1.41	0.90	3.31	3.30	0.60	6.23	**0.00**	5.61	0.80	6.20	4.20	32.86	**1902**
1903	1.50	**9.41**	1.87	1.27	1.91	2.73	12.65	0.79	0.00	2.75	T	1.35	36.23	**1903**
1904	**0.00**	1.59	0.13	6.08	11.37	3.37	2.57	3.71	3.81	4.01	0.40	0.87	37.91	**1904**
1905*	1.66	2.60	6.68	8.05	1.87	5.18	2.06	0.92	0.75	2.06	2.55	2.40	36.78	**1905**
1906	0.80	1.29	2.47	1.51	1.65	0.78	1.88	2.53	2.37	0.69	1.57	3.95	21.49	**1906**
1907	0.41	0.22	1.68	1.74	6.46	2.20	2.43	0.37	0.97	3.67	7.99	1.93	30.07	**1907**
1908	1.06	3.24	1.64	2.15	6.41	1.30	1.96	2.09	3.84	2.02	1.76	2.60	30.07	**1908**
1909	0.06	0.57	0.50	2.34	4.06	1.92	2.86	1.20	1.20	2.22	1.84	1.80	20.57	**1909**
1910	0.17	2.57	2.96	4.82	2.94	0.73	0.12	0.07	1.18	2.72	1.17	5.20	24.65	**1910**
1911	0.15	2.65	1.70	5.06	2.74	**0.00**	1.86	0.22	0.44	3.39	1.51	2.88	22.60	**1911**
1912	0.27	3.50	2.19	1.76	0.84	2.82	0.22	0.31	0.13	3.00	2.73	2.60	20.37	**1912**

1913	1.26	3.25	0.93	1.41	2.98	1.83	0.01	2.03	5.68	8.92	4.56	**16.14**	49.00	**1913**
1914	0.27	1.40	2.00	8.15	12.59	0.61	0.21	7.75	0.65	3.18	2.98	2.91	42.70	**1914**
1915	2.01	2.18	2.68	**19.82**	1.34	0.70	1.78	5.15	1.95	0.46	0.49	2.83	41.39	**1915**
1916	3.93	**0.00**	0.15	4.57	7.85	0.88	5.29	1.44	1.98	1.68	1.31	0.18	29.26	**1916**
1917	0.55	0.82	0.31	2.62	3.63	2.26	0.10	0.16	2.19	0.31	2.61	0.02	15.58	**1917**
1918	1.02	2.78	0.70	4.36	1.84	1.80	0.11	0.58	1.93	3.93	4.06	4.81	27.92	**1918**
1919	3.71	2.48	4.30	3.50	8.61	7.31	**12.80**	3.20	4.41	10.92	1.94	1.50	**64.68**	**1919**
1920	5.59	0.24	1.93	0.38	6.47	6.47	2.64	5.21	1.61	3.88	2.94	1.32	38.68	**1920**
1921	2.20	0.82	2.84	10.43	2.70	8.22	1.09	T	**20.78**	1.09	0.56	1.00	51.73	**1921**
1922	4.32	2.71	3.77	8.67	8.16	2.78	1.24	0.21	1.14	1.67	2.28	0.37	37.32	**1922**
1923	0.47	6.75	4.18	3.81	1.59	0.30	3.07	1.46	8.41	9.25	4.91	7.04	51.24	**1923**
1924	1.76	4.48	2.69	4.40	6.93	5.27	0.05	0.44	5.85	0.29	0.05	1.25	33.46	**1924**
1925	0.77	0.16	0.04	1.49	2.95	0.48	0.75	0.87	2.73	**12.63**	4.69	0.63	28.19	**1925**
1926	4.25	0.15	**7.23**	6.73	3.10	1.21	3.06	2.04	1.37	3.09	2.94	4.16	39.33	**1926**
1927	1.60	2.69	3.22	4.56	3.37	5.03	1.20	0.69	2.32	6.38	0.02	3.75	34.83	**1927**
1928	0.36	5.43	0.29	2.14	2.70	3.02	1.75	1.02	4.36	0.82	2.18	2.68	26.75	**1928**
1929	1.85	0.82	3.62	2.72	12.75	0.97	2.45	0.01	2.63	1.90	5.87	2.48	38.07	**1929**

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YEAR	***JAN***	***FEB***	***MAR***	***APR***	***MAY***	***JUN***	***JUL***	***AUG***	***SEP***	***OCT***	***NOV***	***DEC***	***TOTAL***	***YEAR***
1930	2.02	1.70	2.09	0.74	8.97	1.60	0.24	1.71	3.01	8.07	1.74	3.85	35.74	**1930**
1931	4.30	5.63	3.35	5.03	0.58	2.63	2.74	1.85	0.02	0.15	1.09	4.24	31.61	**1931**
1932	6.00	3.03	2.15	2.34	1.11	1.88	1.54	4.97	5.36	0.10	1.26	2.72	32.46	**1932**
1933	5.10	2.22	1.64	1.30	3.63	0.41	7.16	0.93	3.08	3.05	0.68	1.24	30.44	**1933**
1934	9.13	2.15	3.82	4.42	1.75	0.20	0.79	0.46	1.07	0.03	5.21	3.72	32.75	**1934**
1935	1.61	3.86	1.02	1.79	9.21	9.71	1.44	0.24	8.79	1.65	0.85	2.84	43.01	**1935**
1936	0.39	1.70	1.52	0.66	8.15	3.30	9.25	2.90	5.22	2.63	2.30	1.88	39.90	**1936**
1937	2.43	0.12	3.64	0.63	3.67	3.92	0.69	4.26	2.21	4.70	3.62	5.21	35.10	**1937**
1938	3.93	2.72	1.57	4.96	3.28	3.17	1.34	0.63	2.85	0.24	0.59	1.75	27.03	**1938**
1939	2.23	1.47	1.04	1.87	3.01	1.00	3.57	1.62	1.64	1.62	2.26	0.80	22.13	**1939**
1940	0.63	3.73	1.36	5.34	2.12	8.83	0.57	1.77	3.39	4.82	5.07	5.32	42.95	**1940**
1941	1.52	3.06	4.66	5.70	3.85	12.60	3.37	0.07	0.72	7.12	1.24	2.25	46.16	**1941**
1942	0.07	1.46	0.66	5.56	2.05	2.23	3.69	2.16	8.11	5.14	1.98	1.53	34.64	**1942**
1943	0.80	0.45	2.54	2.68	5.38	1.27	3.91	0.92	3.31	0.33	1.73	1.42	24.74	**1943**

1944	5.40	3.89	1.83	0.33	9.25	2.01	0.32	4.47	4.66	0.35	4.55	5.91	42.97	**1944**
1945	2.83	3.94	4.98	4.11	1.76	5.69	1.61	5.78	2.76	3.00	1.47	2.94	40.87	**1945**
1946	3.76	2.28	2.77	7.92	6.13	1.34	1.48	3.36	6.00	1.62	7.91	2.71	47.28	**1946**
1947	3.62	0.43	3.28	2.24	3.55	0.11	2.18	2.12	0.07	0.02	2.07	1.89	21.58	**1947**
1948	0.92	2.71	1.35	1.68	4.48	1.25	2.29	0.27	1.24	1.78	1.34	1.67	20.98	**1948**
1949	3.97	2.35	2.24	6.91	0.83	3.52	1.95	2.37	3.77	4.38	0.01	4.04	36.34	**1949**
1950	0.74	3.79	0.80	7.58	4.19	1.98	0.73	0.59	4.77	0.59	0.03	T	25.79	**1950**
1951	0.51	2.96	3.73	1.04	3.51	6.19	0.19	2.07	6.45	0.93	1.06	0.34	28.98	**1951**
1952	0.25	1.73	2.25	5.08	4.06	1.88	0.69	**0.00**	3.26	T	5.36	3.15	27.71	**1952**
1953	0.63	1.32	1.73	4.69	1.88	1.59	0.51	2.10	2.98	6.58	0.38	5.29	29.68	**1953**
1954	1.01	0.28	0.27	1.66	2.86	0.68	0.85	1.14	0.82	0.89	0.35	0.61	**11.42**	**1954**
1955	1.87	4.22	0.83	0.75	4.49	2.61	2.02	1.92	1.33	0.09	1.40	1.01	22.54	**1955**
1956	1.65	1.74	0.26	0.56	3.12	0.94	0.11	1.21	0.09	0.84	2.13	2.76	15.41	**1956**
1957	0.55	3.14	4.58	9.93	7.38	5.25	1.10	T	6.43	8.79	2.95	1.20	51.30	**1957**
1958	3.09	6.39	2.55	4.24	3.67	2.89	3.42	0.68	6.89	5.18	0.87	1.15	41.02	**1958**
1959	0.42	2.30	0.23	4.35	1.66	3.30	3.49	4.80	4.37	5.98	1.95	2.11	34.96	**1959**
1960*	1.03	2.36	1.37	1.01	0.81	4.26	2.41	2.60	1.68	12.31	1.90	4.08	35.82	**1960**
1961	1.27	4.85	0.67	0.10	1.03	11.43	8.40	0.40	3.68	0.91	2.82	0.91	36.47	**1961**
1962	0.56	0.63	1.19	4.04	1.06	8.21	**0.00**	4.58	4.75	4.07	0.92	3.47	33.48	**1962**
1963*	0.59	2.83	0.22	3.51	1.32	2.10	0.58	0.88	1.50	0.78	1.57	1.42	17.30	**1963***
1964	2.57	1.47	1.95	1.47	1.87	7.54	0.65	2.09	6.29	3.74	2.45	0.88	32.97	**1964**
1965	4.09	5.06	1.30	1.91	9.98	0.89	0.37	1.32	5.46	3.26	2.65	4.28	40.57	**1965**
1966	1.58	3.23	0.50	3.74	3.13	1.53	0.47	6.21	3.22	0.60	0.11	0.87	25.19	**1966**
1967	0.25	1.52	1.09	4.44	3.35	T	1.15	3.71	5.71	4.55	4.36	3.41	33.54	**1967**
1968	7.94	1.64	2.09	1.87	8.75	3.10	3.11	0.74	3.42	0.60	4.91	0.55	38.72	**1968**
1969	0.40	4.18	3.26	5.04	3.25	2.66	0.12	5.78	1.17	2.65	0.79	4.29	33.59	**1969**

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YEAR	***JAN***	***FEB***	***MAR***	***APR***	***MAY***	***JUN***	***JUL***	***AUG***	***SEP***	***OCT***	***NOV***	***DEC***	***TOTAL***	***YEAR***
1970	1.83	5.70	2.47	1.36	8.18	0.29	0.66	1.00	3.82	5.22	T	0.11	30.64	**1970**
1971	0.04	0.69	0.79	1.07	1.37	1.68	1.23	5.69	2.13	3.02	3.02	4.22	24.95	**1971**
1972	1.48	0.31	T	1.46	7.88	2.20	2.55	2.53	1.55	2.96	2.62	0.53	26.07	**1972**
1973	3.42	2.05	2.92	3.09	1.38	4.70	2.95	0.06	7.44	11.11	0.58	0.76	40.46	**1973**

1974	2.74	0.36	1.34	1.79	5.88	0.21	0.61	8.90	1.58	3.45	7.35	2.00	36.21	**1974**
1975	1.11	2.30	0.80	3.86	8.16	7.07	2.25	2.54	3.62	2.54	0.52	2.04	36.81	**1975**
1976	1.16	1.11	2.11	8.13	6.05	3.19	4.71	0.80	3.80	5.93	1.78	2.48	41.25	**1976**
1977	2.25	2.58	2.18	6.08	1.24	1.22	0.21	0.06	3.10	1.19	1.69	0.34	22.14	**1977**
1978	0.88	1.95	0.84	1.72	5.78	2.98	1.19	1.49	4.44	1.38	5.48	2.84	30.97	**1978**
1979	2.11	3.54	3.76	2.98	7.29	0.83	10.54	0.61	1.40	0.45	0.59	3.40	37.50	**1979**
1980	0.85	2.33	3.20	2.20	5.43	0.31	0.28	1.18	5.66	1.29	3.41	1.24	27.38	**1980**
1981	1.61	1.18	3.05	0.81	9.02	**14.96**	3.39	0.91	2.65	7.04	0.72	0.39	45.73	**1981**
1982	0.85	0.80	1.39	4.17	5.68	2.99	0.13	0.77	1.88	2.66	3.19	2.12	26.63	**1982**
1983	1.88	2.84	6.03	0.16	5.33	3.84	2.85	2.21	2.83	2.82	2.66	0.53	33.98	**1983**
1984	1.66	1.00	2.49	0.06	1.27	1.69	1.44	0.45	0.79	10.34	1.88	3.23	26.30	**1984**
1985	1.34	2.10	1.84	2.39	1.65	5.64	1.53	0.37	3.98	5.84	4.75	1.06	32.49	**1985**
1986	0.45	1.14	0.41	1.46	7.36	2.20	0.45	1.21	4.77	7.98	1.81	5.77	35.01	**1986**
1987	0.92	2.87	1.36	0.45	6.75	10.85	3.46	0.27	5.03	0.31	3.08	1.31	36.66	**1987**
1988	0.27	0.32	2.66	2.02	3.33	2.60	2.77	1.67	1.43	0.66	0.34	1.14	19.21	**1988**
1989	3.79	0.85	2.12	2.43	6.90	3.10	0.09	2.72	0.27	2.20	1.26	0.14	25.87	**1989**
1990	1.28	3.55	2.08	3.12	3.65	1.55	3.14	0.33	1.76	3.39	3.87	0.72	28.44	**1990**
1991	**9.21**	2.99	0.90	4.91	3.98	4.40	1.16	4.28	2.25	3.06	0.91	14.16	52.21	**1991**
1992	4.83	6.56	5.43	1.90	9.05	4.96	0.96	1.95	1.98	1.38	3.76	3.29	46.05	**1992**
1993	3.39	3.14	2.09	2.94	5.30	3.99	T	0.75	0.34	2.42	1.00	1.14	26.50	**1993**
1994	1.43	2.13	1.70	1.68	3.68	0.74	0.26	8.50	5.69	7.85	1.83	5.67	41.16	**1994**
1995*	0.81	1.44	2.21	3.08	9.49	2.74	0.64	5.71	2.86	1.43	3.22	0.51	34.14	**1995***
1996	0.06	0.62	0.60	1.90	1.82	4.48	0.15	8.81	4.02	0.78	4.13	2.19	29.56	**1996**
1997	1.07	3.94	1.58	5.59	7.10	8.97	2.37	2.34	1.46	5.42	2.91	4.28	47.03	**1997**
1998	2.68	3.26	3.07	0.78	0.73	1.56	0.90	1.39	6.76	12.39	4.04	1.56	39.12	**1998**
1999	0.20	0.03	4.09	0.79	7.07	3.37	4.43	0.70	0.28	1.67	0.15	1.15	23.93	**1999**
2000	2.85	1.75	1.49	2.40	3.59	5.27	1.87	0.13	1.76	6.03	7.95	2.87	37.96	**2000**
2001	2.72	1.41	5.51	0.50	3.27	0.85	0.34	9.48	1.71	2.46	**10.00**	4.62	42.87	**2001**
2002	1.69	0.66	1.24	0.76	1.25	5.64	4.94	2.35	3.23	6.68	3.04	4.52	36.00	**2002**
2003	1.70	3.86	0.54	0.10	1.37	4.55	1.42	2.94	2.08	1.03	1.32	0.50	21.41	**2003**
2004	4.15	3.73	2.31	3.97	3.34	11.41	0.83	1.91	1.57	4.62	14.10	0.33	52.27	**2004**
2005	2.25	2.21	4.30	0.72	3.13	0.89	2.75	2.44	1.44	1.78	0.33	0.09	22.33	**2005**
2006	1.80	0.89	7.54	2.89	5.28	3.18	0.48	0.22	3.00	3.93	1.29	4.20	34.70	**2006**
2007	6.92	0.14	5.95	2.25	7.01	5.41	9.84	2.50	3.97	1.13	1.16	0.67	46.95	**2007**

2008	0.82	0.51	2.86	3.52	1.70	0.74	0.38	2.39	0.02	2.01	0.72	0.40	16.07	**2008**
2009	0.74	1.47	3.04	2.84	1.77	1.35	0.25	0.77	6.86	6.88	2.80	2.61	31.38	**2009**
2010	3.29	3.08	3.32	2.13	1.88	5.93	3.38	T	13.20	0.08	0.68	0.79	37.76	**2010**
2011	2.92	0.48	0.09	0.27	3.65	2.01	0.05	T	0.18	2.19	2.91	4.93	19.68	**2011**
2012	4.70	3.04	5.47	0.22	5.45	0.06	5.82	1.25	5.70	0.96	**0.00**	0.31	32.98	**2012**
2013	2.88	0.38	1.17											**2013**

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ALL-TIME:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	ALL-TIME:
Maximum	**9.21**	**9.41**	**7.54**	**19.82**	**14.10**	**14.96**	**12.80**	**10.88**	**20.78**	**12.63**	**14.10**	**16.14**	**64.68**	**Maximum**
Average	**2.10**	2.32	2.32	3.20	**4.31**	3.06	2.16	2.21	3.50	3.21	2.49	2.47	**33.38**	**Average**
Median	1.66	2.00	2.07	2.50	3.63	2.23	1.54	1.53	2.82	2.65	1.98	1.88	**33.46**	**Median**
Minimum	**0.00**	**0.00**	**0.00**	**TRACE**	**TRACE**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**11.42**	**Minimum**

30-YEAR NORMAL:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	30-YEAR NORMAL:
1981-2010	**2.22**	**2.02**	**2.76**	**2.09**	**4.36**	**4.33**	**1.88**	**2.35**	**2.99**	**3.88**	**2.96**	**2.40**	**34.24**	**1981-2010**

30-YEAR NORMAL:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	30-YEAR NORMAL:
1971-2000	**1.89**	**1.99**	**2.15**	**2.51**	**5.09**	**3.81**	**1.95**	**2.31**	**2.91**	**3.97**	**2.68**	**2.44**	**33.70**	**1971-2000**

30-YEAR NORMAL:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	30-YEAR NORMAL:
1961-1990	**1.71**	**2.17**	**1.87**	**2.56**	**4.78**	**3.72**	**2.04**	**2.05**	**3.30**	**3.43**	**2.37**	**1.88**	**31.88**	**1961-1990**

30-YEAR NORMAL:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	30-YEAR NORMAL:
1951-1980	**1.60**	**2.49**	**1.68**	**3.11**	**4.19**	**3.06**	**1.89**	**2.24**	**3.60**	**3.38**	**2.20**	**2.06**	**31.50**	**1951-1980**

30-YEAR NORMAL:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	30-YEAR NORMAL:
1941-1970	**1.88**	**3.09**	**1.89**	**3.49**	**3.97**	**3.13**	**1.88**	**2.20**	**3.68**	**3.02**	**2.04**	**2.22**	**32.49**	**1941-1970**

30-YEAR NORMAL:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	30-YEAR NORMAL:
1931-1960	2.35	2.58	2.13	3.55	3.71	3.22	2.18	1.94	3.44	2.83	2.12	2.53	32.58	1931-1960

30-YEAR NORMAL:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	30-YEAR NORMAL:
1921-1950	2.63	2.56	2.54	3.96	4.37	3.20	2.18	1.67	4.06	2.95	2.35	2.71	35.18	1921-1950

***NOTE:**
DATA MAY CONTAIN MISSING/ESTIMATED VALUES

MONTHLY/ANNUAL/AVERAGE PRECIPITATION
AUSTIN BERGSTROM AIRPORT TX (1942 - 2013)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	YEAR
1942										1.35	0.68	0.26		**1942**
1943	0.43	0.28	1.86	0.34	3.33	0.96	2.11	0.66	4.93	0.70	1.71	1.33	18.64	**1943**
1944	4.42	1.76	2.77	0.21	6.61	2.13	0.58	3.47	4.45	0.45	5.32	3.78	35.95	**1944**
1945	2.41	2.67	2.82	3.64	1.10	5.49	1.99	2.26	1.31	3.04	0.93	2.09	29.75	**1945**
1946	3.41	0.62								0.68	2.05	0.53		**1946**
1947	1.27	0.28	2.35						1.60	0.01				**1947**
1948	0.15	1.57	0.98	1.20	5.00	1.00	0.61	0.28	0.58	1.24	0.99	0.32	13.92	**1948**
1949	4.29	1.71	1.49	5.31	0.28	3.39	2.41	1.58	3.28	3.76	0.02	3.11	30.63	**1949**
1950	0.40	3.43	0.76	6.28	4.25	2.49	0.76	0.43	5.99	0.44	0.08	0.01	25.32	**1950**
1951	0.65	2.83	5.46	0.62	4.02	5.19	0.02	1.38	4.65	0.42	0.58	0.55	26.37	**1951**
1952	0.82	2.09	2.88	4.09	4.75	1.06	1.51	0.16	4.34	**0.00**	6.61	3.10	31.41	**1952**
1953	2.18	2.28	2.57	3.17	1.61	2.17	0.55	3.95	2.73	5.81	0.57	5.83	33.42	**1953**
1954	0.59	0.15	0.25	2.00	1.85	0.38	0.36	0.63	1.65	1.58	0.20	0.34	**9.98**	**1954**
1955	1.82	4.15	0.46	0.59	3.79	1.83	0.86	0.90	1.83	0.33	1.49	0.86	18.91	**1955**
1956	1.85	2.44	0.53	0.77	4.53	0.16	0.14	1.09	0.11	0.64	1.05	2.34	15.65	**1956**
1957	0.51	2.72	4.28	**12.18**	5.92	4.81	0.80	TRACE	8.82	9.00	5.11	1.59	**55.74**	**1957**
1958	3.72	**7.34**	1.87	2.07	4.15	1.06	1.66	0.38	8.80	5.08	1.19	0.79	38.11	**1958**
1959	0.24	2.98	0.11	4.86	2.10	6.52	2.58	5.56	3.33	6.94	1.35	2.11	38.68	**1959**
1960	1.01	2.40	1.25	1.65	0.98	6.28	2.36	2.88	0.95	**13.08**	1.96	3.74	38.54	**1960**
1961	1.80	3.41	0.65	0.24	1.76	9.60	5.82	0.45	4.40	1.18	2.25	0.97	32.53	**1961**
1962	0.69	0.73	0.73	2.34	1.12	4.13	0.16	2.71	6.31	4.46	1.83	3.52	28.73	**1962**
1963	0.69	2.59	0.62	2.26	0.32	2.24	0.21	1.30	1.66	0.73	1.75	1.62	15.99	**1963**
1964	2.49	1.82	1.98	1.83	1.03	6.99	0.28	1.19	6.41	3.74	2.56	0.85	31.17	**1964**
1965	5.87	5.16	1.30	2.81	**13.69**	0.89	0.45	2.91	6.02	3.43	2.45	5.14	50.12	**1965**
1966	1.29	2.91	1.61	3.43	4.29	1.27	0.73	**8.91**	4.27	0.57	0.11	1.57	30.96	**1966**
1967	0.22	1.09	1.01	2.74	4.84	TRACE	0.52	1.56	6.50	5.26	3.60	3.25	30.59	**1967**
1968	7.62	1.51	2.03	2.57	6.76	4.60	1.18	0.34	3.54	0.37	6.01	1.14	37.67	**1968**
1969	0.71	3.85	3.80	7.88	4.76	3.55	0.19	7.94	1.64	3.30	2.94	4.38	44.94	**1969**
1970	2.05	4.20	3.68	2.46	6.12	0.15	1.18	0.25	3.96	2.84	TRACE	0.66	27.55	**1970**
1971	0.02	0.95	1.05	1.29	1.30	1.23	0.65	7.32	3.89	3.82	2.82	4.07	28.41	**1971**
1972	1.89	0.35	0.05	1.80	5.33	2.25	2.54	2.19	1.95	2.72	3.84	0.52	25.43	**1972**
1973	3.53	2.53	3.26	3.31	0.83	5.93	3.73	2.08	5.48	10.40	0.79	0.62	42.49	**1973**
1974	3.86	0.09	1.35	1.64	10.48	0.30	0.87	7.79	2.02	3.24	**12.49**	2.34	46.47	**1974**
1975	1.12	2.89	0.68	4.35	8.19	4.90	2.15	4.19	1.31	3.46	0.48	2.25	35.97	**1975**

1976	0.76	0.22	5.91	7.97	7.39	0.85	3.76	0.30	3.35	6.99	2.71	2.30	42.51	**1976**
1977	2.18	3.31	2.02	5.07	1.04	1.79	0.07	0.10	1.66	1.62	2.23	0.33	21.42	**1977**
1978	1.30	2.19	1.01	1.61	2.80	2.78	0.55	2.52	4.77	1.22	6.94	3.79	31.48	**1978**
1979	2.48	3.95	3.79	3.36	4.88	1.54	**9.77**	1.21	1.97	0.43	0.80	4.03	38.21	**1979**
1980	1.63	1.66	3.04	2.39	6.53	0.84	0.06	1.54	4.14	0.75	3.01	1.67	27.26	**1980**
1981	1.81	1.39	2.27	1.02	7.05	**15.59**	1.96	1.42	2.48	6.39	0.77	0.31	42.46	**1981**
1982	1.19	0.89	1.53	3.18	7.29	2.88	0.12	1.67	2.24	2.75	4.81	1.94	30.49	**1982**
1983	2.22	3.95	**6.52**	0.23	5.71	3.47	2.52	3.86	4.53	3.31	2.17	0.58	39.07	**1983**
1984	1.76	1.61	2.64	0.03	1.19	3.03	2.86	1.38	0.84	9.30	1.91	3.05	29.60	**1984**
1985	1.79	1.85	2.18	2.81	1.37	8.29	3.37	0.05	3.20	4.72	6.59	0.96	37.18	**1985**
1986	0.61	1.16	0.26	1.18	8.17	3.04	0.02	1.28	**9.36**	9.11	1.72	5.96	41.87	**1986**
1987	1.04	3.51	2.07	0.91	8.29	8.13	2.81	0.25	2.14	0.21	3.11	1.27	33.74	**1987**
1988	0.60	0.71	2.58	2.56	4.81	1.50	4.30	2.79	1.68	2.10	0.42	1.19	25.24	**1988**
1989	3.22	0.83	1.90	3.09	4.23	2.26	0.40	1.60	0.02	1.83	1.48	0.14	21.00	**1989**
1990	1.09	3.33	2.22	3.44	4.13	0.93	4.57	1.64	1.95	3.32	4.18	0.67	31.47	**1990**
1991	**10.53**	2.87	1.05	6.87	3.72	4.67	1.92	6.17	1.84	1.79	0.93	**12.88**	55.24	**1991**
1992	4.83	6.82	4.97	2.18	7.69	4.35	0.94	3.50	3.40	1.14	3.41	3.88	47.11	**1992**
1993	3.92	2.44	2.52	2.82	4.98	3.37	TRACE	TRACE	0.49	4.32	1.13	1.19	27.18	**1993**
1994	1.09	2.14	1.25	1.57	6.51	1.95	0.02	5.52	5.73	7.79	1.82	8.11	43.50	**1994**
1995	1.06	1.48	3.08	4.35	7.91	3.00	0.30	4.96	4.56	2.95	2.84	0.34	36.83	**1995**
1996	0.24	0.75	1.12											**1996**
1997										2.18	2.92	4.14		**1997**
1998	2.86	3.52	2.33	1.49	0.61	0.97	0.55	3.33	4.43	12.73	4.31	1.31	38.44	**1998**
1999	1.70	0.02	4.96	1.23	6.18	2.32	5.34	1.03	0.47	1.57	0.08	0.69	25.59	**1999**
2000	3.69	1.28	0.92	1.82	4.78	3.66	0.57	0.63	0.77	3.46	7.01	2.97	31.56	**2000**
2001	2.75	1.00	3.35	0.39	4.41	3.21	0.33	5.05	5.82	2.39	10.51	3.91	43.12	**2001**
2002	1.54	0.91	1.53	0.86	0.90	4.36	5.32	0.96	2.55	9.11	4.26	4.93	37.23	**2002**
2003	1.69	4.92	0.94	0.06	0.51	4.06	2.98	1.93	4.06	0.89	0.68	0.66	23.38	**2003**
2004	2.55	5.38	1.96	2.89	2.44	14.18	3.20	1.25	1.17	6.76	9.91	0.20	51.89	**2004**
2005	2.44	3.22	3.46	0.91	3.10	0.55	1.78	1.57	0.52	2.71	0.99	0.20	21.45	**2005**
2006	0.62	1.06	3.11	2.50	4.98	2.64	0.97	0.03	1.72	4.72	0.80	4.08	27.23	**2006**
2007	7.66	0.12	6.00	3.71	6.73	7.49	7.62	2.19	0.73	1.80	1.26	0.60	45.91	**2007**
2008	0.82	1.16	3.45	2.86	1.34	0.79	1.37	2.16	0.34	1.20	0.11	0.38	15.98	**2008**
2009	0.40	0.94	3.21	3.74	1.73	1.03	1.27	2.58	6.98	6.90	2.80	2.53	34.11	**2009**
2010	3.29	2.81	2.79	1.44	1.01	4.15	5.37	0.63	5.15	0.06	0.92	0.80	28.42	**2010**
2011	3.67	0.64	0.15	0.19	1.91	1.39	0.05	TRACE	0.01	1.82	2.18	4.89	16.90	**2011**
2012	7.30	3.86	5.11	0.09	5.29	0.21	3.82	3.03	4.75	0.84	TRACE	0.83	35.13	**2012**

2013	2.71	0.64	1.37											**2013**

ALL-TIME:	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**	**ALL-TIME:**
Maximum	**10.53**	**7.34**	**6.52**	**12.18**	**13.69**	**15.59**	**9.77**	**8.91**	**9.36**	**13.08**	12.49	12.88	55.74	Maximum
Average	2.22	2.20	2.25	2.59	4.19	3.31	1.83	2.20	3.26	3.36	2.57	2.22	32.56	Average
Median	1.78	1.97	2.02	2.30	4.27	2.57	1.08	**1.57**	**3.20**	2.72	1.83	1.57	31.48	Median
Minimum	0.02	0.02	0.05	0.03	0.28	TRACE	0.00	TRACE	0.01	0.00	TRACE	0.01	9.98	**Minimum**

30 YEAR NORMAL	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**	**30 YEAR NORMAL**
1981-2010	**2.23**	***2.37***	**2.51**	**2.28**	**2.66**	**4.38**	**2.45**	**1.63**	**2.49**	**3.95**	**2.95**	**2.25**	**32.15**	**1981-2010**

30 YEAR NORMAL	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**	**30 YEAR NORMAL**
1971-2000	**2.21**	***2.02***	**2.36**	**2.63**	**5.12**	**3.42**	**2.03**	**2.51**	**2.88**	**3.99**	**3.02**	**2.53**	**34.72**	**1971-2000**

30-YEAR NORMAL	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**	**30-YEAR NORMAL**
1961-1990	**1.92**	**2.15**	**2.12**	**2.66**	**4.86**	**3.50**	**1.93**	**2.42**	**3.46**	**3.45**	**2.89**	**2.04**	**33.40**	**1961-1990**

30-YEAR NORMAL	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**	**30-YEAR NORMAL**
1951-1980	**1.85**	**2.49**	**1.97**	**3.11**	**4.24**	**2.94**	**1.52**	**2.54**	**3.75**	**3.45**	**2.75**	**2.21**	**32.56**	**1951-1980**

30-YEAR NORMAL	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL**	**30-YEAR NORMAL**
1942-1970	**1.91**	**2.46**	**1.86**	**2.98**	**3.81**	**3.13**	**1.15**	**2.13**	**3.85**	**2.77**	**2.05**	**1.99**	**29.45**	**1942-1970**

DATA FOR YEARS 1942,1946, 1947, 1996, 1997 NOT COMPLETE

AUSTIN CLIMATE SUMMARY

The climate of Austin is humid subtropical with hot summers and relatively mild Winters. Austin, the capital of Texas, is located at the junction of the Colorado River and the Balcones escarpment, separating the Texas Hill Country from the Blackland Prairies to the east. Elevations within the city vary from 400 feet to just above 1000 feet above sea level. Native trees include cedar oak, walnut, mesquite and pecan.

During winter, the area is alternately influenced by a continental regime, with winds from the north and west, and by a modified maritime regime, with south and southeast winds from the Gulf of Mexico. Mild weather prevails during most of the winter. Sub-freezing temperatures occur on average about 25 days each year. North winds with strong cold fronts block any moderating affects from the Gulf of Mexico, and occasionally usher in frigid conditions to central Texas. The coldest low for Austin Mabry was -2 on January 31, 1949 and for Austin Bergstrom -5 on January 31, 1949. Although daytime highs are restrained in cloudy winters, overnight lows can be potentially higher, sometimes preventing the area from the much colder minimums that come under clear skies. In these patterns, the coolest monthly average temperatures may follow, because daytime highs are limited by the cloud cover. On sunny winter days, the temperature warms to pleasant levels, while nights are cooler. Very warm days occur when dry west winds in a mild airmass allow winter temperatures to climb to spring or summerlike levels, such as 90 on December 25, 1955; 90 on January 30, 1971; and 99 on February 21, 1996.

Daytime temperatures in summer are hot, with highs over 90 about 80 percent or more of the time. Cool fronts may affect the area and drop overnight lows to the 50s on some occasions. In these cases, warm winds quickly return, pushing lows to the 70s in a few days. In very hot summers, the continental regime of West and North Texas can have an impact of keeping daytime highs near and above 100, especially with hot west and southwest winds. Most of the time, the moderating affects of the Gulf of Mexico limit daytime highs; however, they also add to the discomfort with higher humidity. Sometimes, when weak fronts that have lost most of their cool air properties and move through the area, warmer than normal daytime highs follow, as the area is blocked from the moderating affects of the Gulf of Mexico. The highest temperature of record at Austin Mabry was 112 on September 5, 2000 and August 28, 2011. The highest temperature of record at Austin Bergstrom was 112 on September 5, 2000.

Precipitation is fairly evenly distributed throughout the year with heaviest amounts occurring in May and September, primarily because of tropical cyclones that migrate out of the Gulf of Mexico, or stalled out cool fronts. Precipitation from April through September usually results from thunderstorms, with large amounts of rain falling within short periods of time. Rainfall amounts have exceeded 5 inches in several hours, causing flash floods. While thunderstorms and heavy rains may occur in all months of the year, most of the winter precipitation consists of light rain. Although snow is not a significant source of moisture, it does visit the area during some winters. Average yearly rainfall is near 33 inches. Extremes at Austin Mabry, since 1856, vary from 11.52 inches in 1954 to

64.68 inches in 1919. At Austin Bergstrom the extremes, since 1943, vary from 9.98 inches in 1954 to 55.74 inches in 1957.

Prevailing winds are southerly; however, in winter, northerly winds are about as frequent as those from the south.

Average sunshine varies from about 50 percent in the winter to near 75 percent in the summer. Stratus clouds frequently develop at night during all seasons with south and southeast winds, as Gulf moisture is lifted from the coastal plains to the higher terrain over the Balcones escarpment. On some days, these clouds do not dissipate, hanging in all day, with few or no late afternoon/early evening breaks. In the winter, these stratus clouds may be accompanied by fog and drizzle, as south and southeast wind brings Gulf moisture over the top of a cool air dome at the surface. In some years, when very cloudy conditions prevail, even if these clouds break up, mostly cloudy skies linger due to a dense high deck of cirrus caused by Pacific moisture over Texas from an active subtropical jet stream.

The average occurrence of the last temperature of 32 degrees in spring is early March and the average first fall occurrence of 32 degrees is late November. The extremes vary from 31 October 26, 1924 to 32 April 9, 1914.

Strong winds come from microbursts, squall lines, strong cold fronts and dissipating tropical storms, that move inland from the Gulf of Mexico. Dissipating tropical storms affect the city with not only strong winds, also heavy rains. Although tornadoes are rare, they have occurred, and they have most often been associated with the dissipating tropical storms.

Explanatory note about Austin Climate sites:

With the opening of Austin Bergstrom International Airport in May 1999, there are two sets of Local Climatological Data (LCD) maintained for Austin, Texas. As a user of National Climate Data Center products, you should be aware of the history of the data sets; in addition, you should know where and how these climatological data records are kept for the two Austin area weather observation sites.

Austin City/Camp Mabry (Texas National Guard) (Identifier ATT)
The Local Climatological Data for this site is based on weather records started back in the 1800s in the downtown Austin area. This National Weather Service first order data set was moved 3 miles northeast of the downtown area with the opening of Austin Robert Mueller Municipal Airport in the 1940s and continued until the closure of the Robert Mueller Airport on May 23, 1999. The National Weather Service ASOS was left without human augmentation effective with the closure of the airport. The National Weather Service held discussions with local users about finding a comparable location (geography and elevation) to maintain this "in city" climate data set. With cooperation of Texas National Guard officials, the National Weather Service moved the ASOS (no human augmentation) to Camp Mabry on July 21, 1999. This location, which is very similar to the former airport site.

Austin Bergstrom International Airport (Identifier AUS)
The Local Climatological Data for this site is based upon U.S. Air Force weather records taken at Bergstrom Air Force Base (formerly occupying this site) for the time period 1942 through 1995. With base conversion to civilian use, Austin Bergstrom International Airport was opened to cargo operations on September 1, 1997, with resumption of manual surface weather observations. On October 2, 1997, an ASOS was commissioned at this airport. Austin Bergstrom International Airport was opened to full civilian operations (with full human augmentation as FAA Service Level "A" weather observations) on May 23, 1999. This weather observation site is located in the Onion Creek watershed. Because the location is in a more outlying and lowlying area, nighttime temperatures (especially during calm wind conditions during the winter time of the year) tend to be considerably cooler than the Austin City/Camp Mabry (Texas National Guard) weather observation site.

As a NCDC Local Climatological data user, you should be aware of these 1999 changes and how it affects the choice of which Local Climatological Data set you use for Austin, Texas.

The history of Austin Climate Locations is listed below.

History of Austin Climate Station Locations

1854 to 1883
Cooperative Weather Observers
Various locations throughout the city of Austin. Specific locations unknown.

1883 to October 1926
Cooperative Weather Station
Engineering Bldg. at The Univ. of Texas at Austin

October 1926 to October 1936
Weather Bureau Office
Littlefield Bldg., Room 901
6th and Congress

October 1936 to February 1942
Weather Bureau Office
Federal Court Bldg.
200 W. 8th Street

February 1942 to August 1942
Weather Bureau Office
Littlefield Bldg., Room 901
6th and Congress

August 1942 to July 1999
National Weather Service
Austin Robert Mueller Airport

July 1999 to Present
National Weather Service
Camp Mabry and Austin/Bergstrom Airport

Attachment B

Comparison of Monthly Precipitation at Austin Texas and Recorded Hourly Precipitation at Camp Mabry

Table B1. *Deviations between the NOAA Mabry Monthly and Camp Mabry hourly data (ATT). Deviations exceeding +/- 0.02 are highlighted. Negative deviations indicate a shortfall in the hourly record.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1942								-1.89	0.3	0	0	0	-17.31
1943	0	0	0	0	0	0	0	0	0	0	0	0	0
1944	-0.06	0	0	0	0	0	0	0	0	0	0	0	-0.06
1945	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
1946	0	0	-0.08	0	-0.06	0	0	0	0.02	0	-0.02	0	-0.14
1947	-3.62	-0.43	-3.28	-2.24	-3.55	-0.11	-2.18	-2.12	-0.07	0	-0.3	0	-17.9
1948	0	-0.05	0	0	0	0	0	0	0	0	0	-0.01	-0.06
1949	-0.09	0	0	-0.09	0	0	-0.07	0	0	0	0	0	-0.25
1950	0	0	0	-0.38	0	0	0	-0.01	0	0	0	0	-0.39
1951	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	-0.36	0	0	0	0	0	0	0	-0.36
1956	0	0	0	0	0	0	0	0	0	0	0	-0.19	-0.19
1957	0	0	0	0	-0.37	0	0	0	-0.07	0	0	0	-0.44
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0

1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	-0.15	-0.1	0	-1.19	0	-1.44
1996	0.01	0	0.01	-0.6	0	-0.53	-0.1	-0.05	-1.1	-0.2	-0.17	-0.06	-2.79
1997	-0.02	0	0	0	0	0	-0.99	0	0	-0.6	0.01	-0.52	-2.12
1998	0.01	-0.12	-0.23	0	0	0.02	-0.05	0	-0.9	-0.45	0	0	-1.72
1999	-0.02	-0.01	0.02	-0.1	-7.07	0	-0.98	0	0	0	0	0	-8.16
2000	0	0	-0.39	0	-0.37	0	0	0	0	0	0	0	-0.76
2001	0	0	0	0	0	0	0	0	0	0	-0.74	-0.01	-0.75
2002	-0.03	0	0.02	0	0	-0.81	0	0.01	0	0.03	0	0	-0.78
2003	0	0	0	0.02	0	-0.3	0	0	0	0.02	0	0	-0.26
2004	-0.01	0	-0.01	0	-0.01	0	-0.07	0	0	0	0	0	-0.1
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	-0.02	-0.01	0	0	0	0	0	0	0	0	0	-0.03
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	-0.13	0	0	-0.51	0	0	-0.64
2010	0	0	0	-0.02	0	0	0	0	0	0	0	0	-0.02
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0

Attachment C

Mass Curves Comparing Hydromet 15-minute Precipitation to Recorded Hourly Precipitation at Camp Mabry

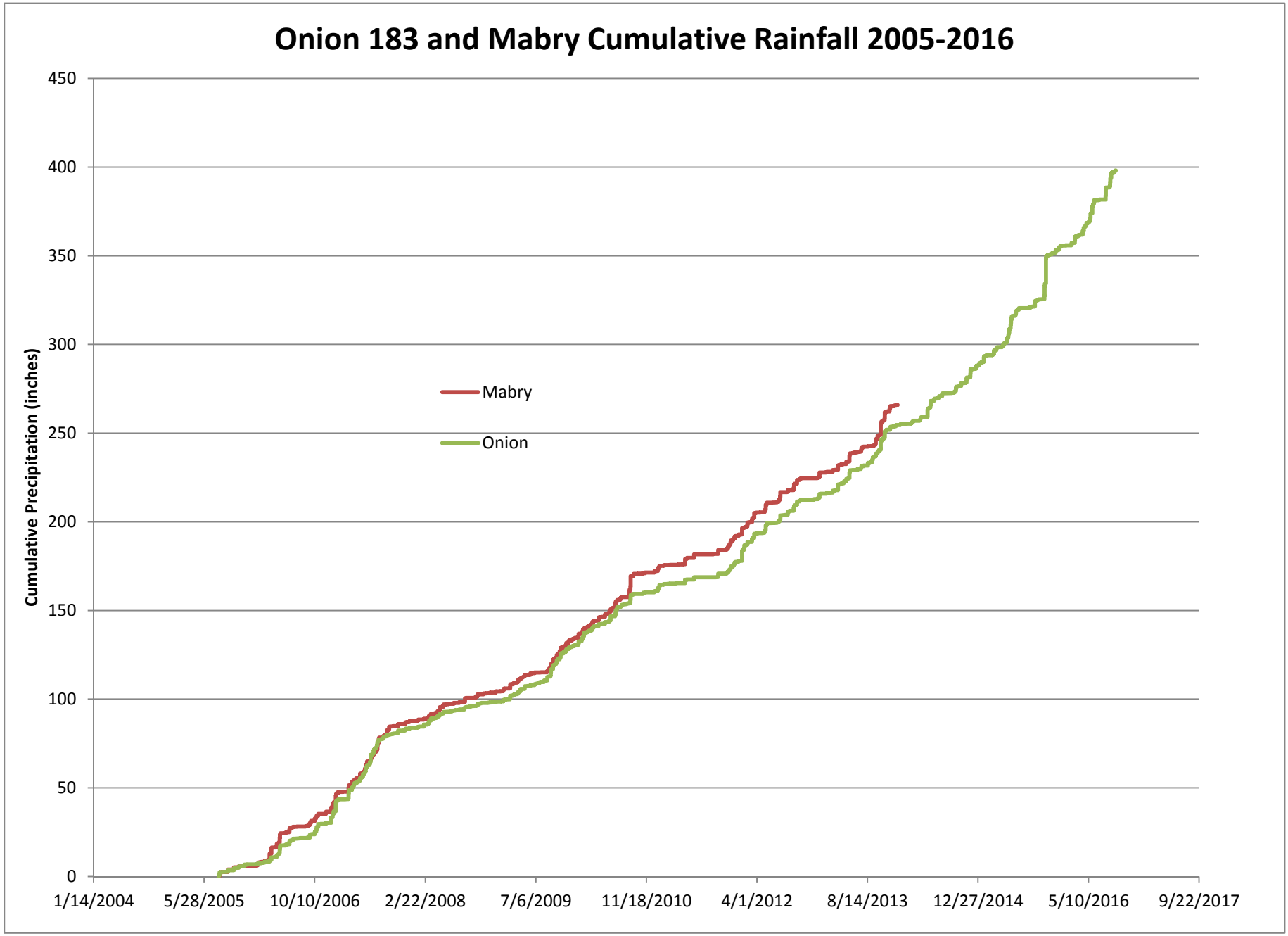
Onion 183 and Mabry Cumulative Rainfall 2005-2016
Cumulative Precipitation (inches)
450
400
350
300
250
200
150
100
50
0
Mabry
Onion
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017

Figure C1.

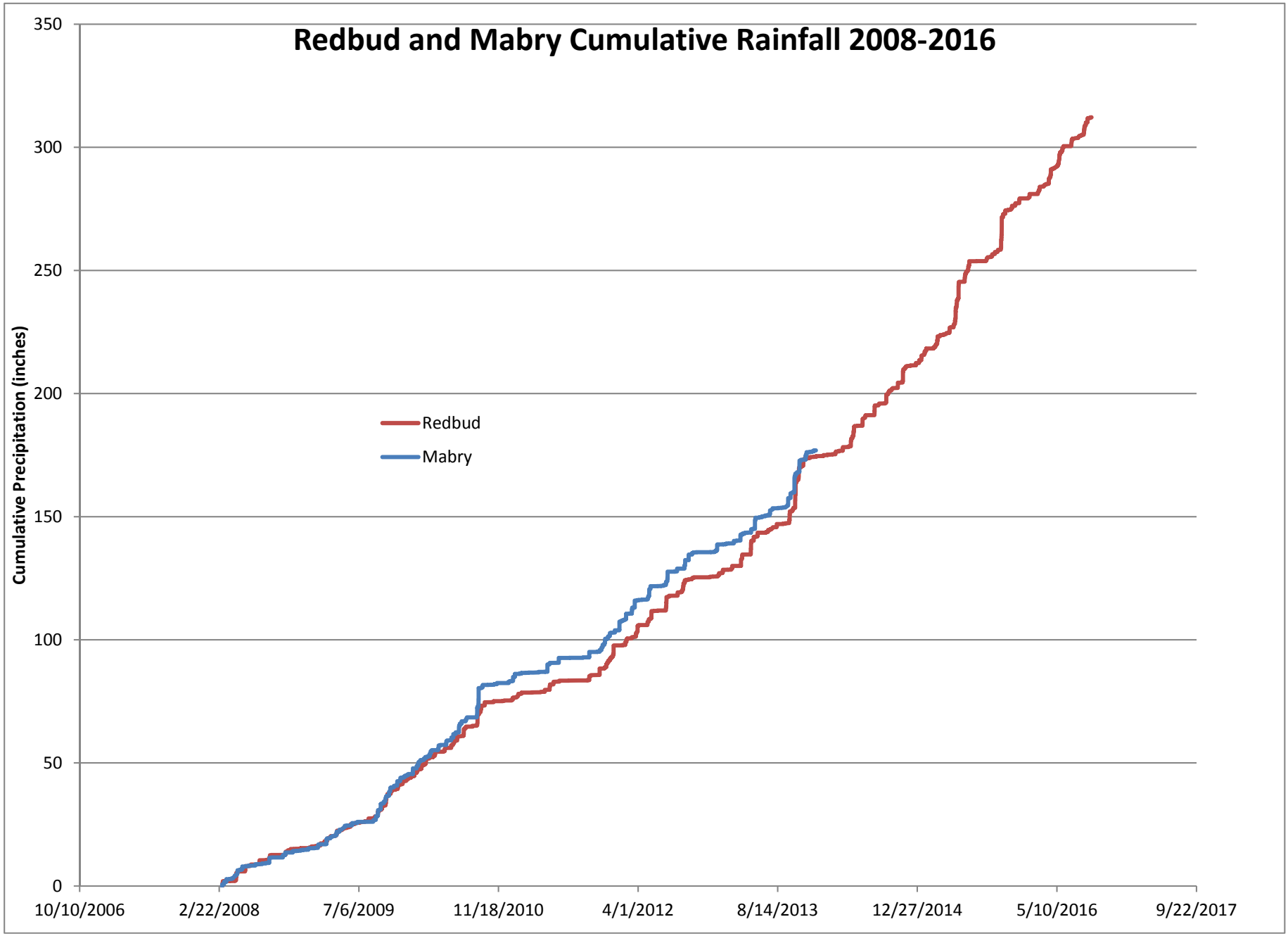
Redbud and Mabry Cumulative Rainfall 2008-2016
Cumulative Precipitation (inches)
350
300
250
200
150
100
50
0
Redbud
Mabry
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
5/10/2016
9/22/2017

Figure C2.