Flood Frequency Determination
El Paso County and Incorporated Communities, Texas

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TABLE OF CONTENTS

1. Background 1
2. Data Collection 1
   2.1 Flow Data 1
   2.2 Dam Storage Data 2
   2.3 Rainfall Data 2
3. Frequency Analyses of Historic Data 2
   3.1 Analysis of El Paso Airport Hourly Rainfall Data 3
   3.2 Analysis of El Paso Airport, La Tuna, and Ysleta Daily Rainfall Data 3
   3.3 Estimation of DDF Relationships by Subregion 4
4. Identify Event Extremes Within Study Area 4
   4.1 Rainfall Extremes 4
   4.2 Flow Extremes 5
5. Estimate Storm Return Probabilities 6
6. Summary 6

LIST OF TABLES

1 Flow Gages in the El Paso Area 8
2 Rain Gages in the El Paso Vicinity 8
3 Depth-Duration-Frequency (DDF) for the El Paso Airport Location, Derived from Hourly Data 9
4 Summary of Extreme Daily Rainfall (inches) by Year 9
5 Summary of Return Probabilities for Daily Rainfall, Based on Daily Data 11
6 Summary of 20 Highest Extreme Rainfall Values for the El Paso Airport 11
7 Depth-Duration-Frequency (DDF) for the La Tuna and Ysleta Locations 12
8 Summary of XMRG Cell Areas by Watershed 13
9 Summary of Extreme Rainfall Values for the Period July-September 2006 by Watershed, Based on Unadjusted XMRG Data 14
10 Summary of Estimated Storm Return Frequency for the Period July-September 2006 Extreme Event, Based on Unadjusted XMRG Data 15
11 Estimated Storm Return Frequency for July-September 2006 Extreme Event for Selected Watersheds, Using Adjusted XMRG Data 16

LIST OF FIGURES

1 Locations of Studied Watersheds
2 Flow Gages in El Paso Area Operational in 2006
3 El Paso Dam Locations
4 August 2006 Rainfall Data Sources in El Paso Area
5 Comparison of Annual Extreme 24-Hour and Daily Rainfall Totals
6 Spatial Rainfall Distribution, August 1-3, 2006 per XMRG Data
7 Rio Grande Flows July 27 - August 6, 2006

1. BACKGROUND

The purpose of this report is to estimate the flood return probability for the July-August 2006 floods within eight watersheds in the El Paso area (see Figure 1). The watersheds are sited to the west, south, and east of the Franklin Mountains. The mountains are significant terrain features that potentially strongly affect the local distribution of rainfall and, hence, flooding.

The basic methodology used in the development of flood return probability for the recent storms within these watersheds is described below:

- Identified and collected historic and 2006 flood event data for the watershed area;
- Performed frequency analyses using historic rain data and historic flows, including data collected for the 2006 event;
- Identified event extremes (flow, rainfall) within the study area; and
- Compared event extremes to results of frequency analyses to estimate storm return probabilities

2. DATA COLLECTION

The sources identified for relevant historic and 2006 event data include the National Oceanographic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the International Boundary and Waters Commission (IBWC), the City of El Paso (CEP), and El Paso County Water Improvement District No. 1 (EPCWID#1). NOAA is a source for daily and hourly point (i.e., gage-based) rainfall and for spatial radar-derived precipitation (XMRG) data. The USGS is typically a source for flow data, and in select circumstances, point rainfall data. The IBWC maintains or collects both flow and rain data at selected locations along the Rio Grande main stem and within the Rio Grande watershed. Selected CEP firehouses maintain daily rainfall records. Several CEP dams have staff gages (manually read elevation/depth staffs). EPCWID#1 maintains a continuous (readings recorded every 15 minutes) flow gage and hourly rainfall gage within the watershed.

2.1 Flow Data

Table 1 provides a summary of available flow data within the study area. The locations of the gages that were active during the 2006 flood are shown on Figure 2.

USGS has no current gages in the immediate vicinity of the project area. These records are not of sufficient length and/or do not provide measurements of flows from urban watersheds that have had substantive changes since the beginning of the period of measurement. Hence, these records are not viable for flood frequency analyses. The current IBWC flow gages within the project area are all on the Rio Grande main stem, and their data records are not usable for estimation of flood return frequency for the watersheds that are the subject of this report.

2.2 Dam Storage Data

During the dam inspections in December 2006, URS identified measured 2006 peak reservoir/ detention basin stage data for six of the 23 dams inspected (see Figure 3). These data include:

- Americas Basin – high water estimated to reach 6 feet below auxiliary spillway crest;
- Pershing Dam – over auxiliary spillway crest estimated to be 0.7 foot;
- Phelps Dodge Dam – maximum stage gage measurement estimated to be 8.5 feet;
- Keystone Dam – maximum stage gage measurement estimated to be 8.5 feet;
- Mulberry Dam – maximum stage gage measurement estimated to be 28 feet; and
- Thorn Dam – maximum stage gage measurement estimated to be 22 feet.

These measurements provide an opportunity to estimate runoff volume into the reservoirs impounded by these structures. When (if) future runoff modeling is performed, this information can be used to estimate the likely return probability of this volume of runoff from the watersheds upstream of these structures. The information would also provide independent data relating to regional variations in rainfall by elevations during the 2006 storms.

2.3 Rainfall Data

Table 2 provides a summary of rain gages located within the study area. The locations of the gages from which data were used in analyses are shown in Figure 4.

Note from Table 2 that there are long data records from daily rain gages on both sides of the Franklin Mountains, all at similar elevations. There is only one current gage measuring hourly rainfall with a long data record (i.e., a record in excess of 15 years): the El Paso Airport. There are three gages that measured hourly rainfall through the 2006 storm: one IBWC gage (at El Paso, ID 364000), one EPCWID#1 gage (at Canutillo, ID 363900), and one NOAA gage (El Paso Airport). In addition to these hourly gages, three additional NOAA gages (La Tuna, Ysleta, El Paso AP2 and El Paso No. 2) and 11 CEP fire stations recorded rainfall through the August-September 2006 storms.

NOAA also records hourly level III precipitation data (XMRG) derived from radar on a 4-km grid. The grid is shown on Figure 4. These data were obtained for the project area for the period July through September 2006.

3. FREQUENCY ANALYSES OF HISTORIC DATA

Per discussion with the City of El Paso, there are no CEP flow gages located on tributaries/ streams within the study area. The flow gages on the Rio Grande cannot be used to estimate return probabilities of flow from the subject watersheds (see "Flow Extremes" below). Sufficient rain data exist to make statistically viable estimates of rainfall depth versus duration versus return probability in the area. The basic approach included:

- Hourly historic data for the NOAA El Paso Airport gage (located east of the Franklin Mountains) were analyzed using an L-Moment frequency distribution, creating a rainfall depth-duration- frequency (DDF)/return probability table for that location;
- Daily historic data for La Tuna (located west of the Franklin Mountains), for the El Paso Airport gage, and for the Ysleta gage were analyzed using an L-Moment frequency distribution for identical, overlapping record periods (1948 to current). Ratios of El Paso Airport to La Tuna and to Ysleta rainfall were then estimated for each return probability.
- A DDF table was then created for each of the two daily rainfall gage locations (LaTuna and Ysleta) by applying these ratios to the El Paso Airport DDF table.
- Note that no rainfall gages were identified at higher elevations within the study area. Estimation of historic variability at higher elevations (e.g., between the east and west slopes of the Franklin Mountains) or historic variability between high and low elevations is not feasible.

3.1 Analysis of El Paso Airport Hourly Rainfall Data

Hourly historic rainfall data for the El Paso Airport gage were analyzed to identify peak extreme values by year of rainfall for durations of 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, and 24 hours. These data were fit to an L-Moment extreme probability distribution, and a DDF table was generated (see Table 3). Details concerning this analysis are provided in Appendix A.

3.2 Analysis of El Paso Airport, La Tuna, and Ysleta Daily Rainfall Data

Daily historic rainfall data for the El Paso Airport, La Tuna, and Ysleta gages were analyzed separately to identify peak extreme daily values by year (see Table 4). The 2006 storm had the highest daily rainfall on record for the El Paso Airport; the storm ranked second and sixth, respectively, for the La Tuna and Ysleta locations. These data were fit to an L-Moment extreme probability distribution, and an annual return probability table was generated for daily rainfall depth (see Table 5). Table 5 also provides a ratio of values for La Tuna and Ysleta to values for El Paso Airport for corresponding probabilities.

When the rainfall depths in Table 5 (based upon daily data) are compared to the depths associated with a storm of 24-hour duration in Table 3 (based upon hourly data), the depths estimated for the 24-hour duration storms are consistently larger than depths associated with daily rain totals. For example, the 100-year (0.01 return probability) daily rainfall depth at the El Paso Airport location is 2.68 inches; the 100-year (0.01 return probability) 24-hour rainfall depth at the El Paso Airport location is 3.34 inches. Part of this difference is the use per USGS methodology of a different L-Moment Distribution for daily data-based annual extremes (GEV distribution per USGS recommendation) and for hourly data-based annual extremes (GLO distribution per USGS recommendation). Using the GLO distribution, the 100-year (0.01 return probability) daily rainfall depth is 2.85 inches.

The remainder of the difference (2.85 inches versus 3.34 inches) is attributable to the daily data being collected at a fixed time, while the 24-hour extremes are based upon analysis of a continuous 1-hour record. Using the 59-year overlapping daily and hourly rainfall records at the

El Paso Airport gage, the annual extreme 24-hour rainfall depth exceeds the annual extreme daily depth in 39 of the 59 years, equals the daily extreme in 16 years, and is less than the daily extreme in 4 years (see Figure 5).

Tables 3 and 5 also show that the 100-year, 12-hour storm depth of 3.06 inches exceeds the 100-year, daily depth of 2.68 inches. To check this result, the annual extreme 12-hour storms were analyzed. Table 6 shows the 20 highest annual daily and 12-hour storm extreme values for the El Paso Airport gage. The reason the daily 100-year (0.01 return probability) rainfall depth, 2.68 inches, is less than the 59-year extreme value measured (2.85 inches in 2006) is due to: 1) the rate of rise between the seventh highest daily rainfall (1.77 inches) and highest value (2.85 inches) and 2) the large drop between the first and second highest rainfalls (2.85 inches to 2.26 inches). In this circumstance, the highest value is clearly an extreme outlier and is assigned a low probability of return. In contrast, the 2006 daily value measured at the El Paso Airport is assigned a return probability of slightly more than 0.004 (return period slightly less than 250 years, see Table 5).

3.3 Estimation of DDF Relationships by Subregion

The ratios for daily rainfall presented in Table 5 were applied to corresponding return probabilities in Table 3 to create estimated DDF relationships for the La Tuna and Ysleta locations (see Table 7). The DDF relationships for La Tuna and for Ysleta agree reasonably well with each other (typically within 10%). The values for either DDF table are significantly higher than values in the DDF table for the El Paso Airport. The results presented in Section 5 provide recommendations as to which DDF table should be applied to which watershed.

4. IDENTIFY EVENT EXTREMES WITHIN STUDY AREA

4.1 Rainfall Extremes

The storm events in July through September 2006 were recorded by the following relevant sources:

- Hourly rainfall at the El Paso Airport, Canutillo, and IBWC El Paso gages (see Table 2, Figure 4);
- Daily rainfall at the El Paso Airport**,** La Tuna, and Ysleta gages (see Table 2, Figure 4);
- Daily rainfall at CEP fire stations (see Figure 4); and
- Hourly rainfall on a 4-km grid per Stage III (XMRG) radar-based precipitation data.

Figure 6 shows the XMRG data grid superimposed on the point rainfall gage locations. The cells of the grid are shaded according to estimated XMRG rainfall depths through the period July 28 through August 3, 2006. There is a clear pattern of increasing rainfall total with elevation, with rainfall totals over the crest of the Franklin Mountains 50% greater than over the Airport location. Given this spatial variation, estimation of storm rainfall depths by watershed clearly requires use of spatial XMRG data. Storm event extremes by watershed were therefore identified as follows:

- XMRG rainfall totals were compared to point rainfall totals at corresponding locations. Adjustments to XMRG data were not required for most of the study area (see Appendix B, "Comparison of XMRG Data to Point Rainfall Data").
- The analysis in Appendix B identified that XMRG rainfall totals for August 1 (the date when most annual extreme values occurred) for cells 27, 28, 37, and 38 were significantly higher than reliable point gage data at Canutillo. Canutillo is located within cell 28, adjacent to cells 27, 37, and 38. This disparity was independently confirmed by the daily rainfall value for August 1 collected at Fire Station 6 (in cell 37). XMRG totals for these four cells for August 1 (7/31/206 9:00 a.m. to 8/1/2006 8:00 a.m.) were reduced approximately 25% (per the discussion in Appendix B) in the final analysis for the affected watersheds (Watersheds 6 and 7).
- Representative watersheds for the streams that are the focus of this study were delineated and aggregated into larger areas when they are adjacent (see Figure 1). A total of eight watersheds were created.
- These eight watersheds were superimposed on the XMRG grid, and areas by XMRG grid cell were estimated for each watershed (see Table 8). The table also includes the percent of total area within each watershed represented by individual XMRG cells. Calculations were performed to estimate extreme duration rainfall totals for 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, and 24 hours for each watershed during the July through September time period. For example, to identify the extreme 2-hour storm for Watershed 4, the following steps were taken for each hour in the study period:
  - The total of rainfall for a given hour and the next hour for XMRG cell 29 was calculated and multiplied by 0.428 (42.8% of the area of Watershed 4 is within XMRG Cell 29 per Table 8);
  - Similarly, the 2-hour total for XMRG cell 39 was calculated and multiplied by 0.572; and
  - These two totals were added to form a composite total and stored in a matrix.

  The maximum 2-hour composite total for the study period was identified from the resulting matrix.
- The results from this analysis are summarized in Table 9 for unadjusted XMRG rainfall data.

4.2 Flow Extremes

Data were procured for flows recorded throughout August-September 2006 at the Canutillo and El Paso Rio Grande locations. These records were reviewed to ascertain the feasibility of estimating the volume of inflow to the river from the intervening watershed (largely western El Paso) during and following the storm event. These recorded flows are plotted on Figure 7. From this plot, it is evident that the period of constant flow on August 1 recorded at Canutillo (11:00 a.m. to 3:45 p.m.) is unlikely to be a valid measurement and occurs at a critical time (in the immediate vicinity of the flow peak) for purposes of this study. This issue, coupled with several other minor periods when the gage did not take readings, makes a reasonable estimate of volume of inflow to the river from the intervening watershed not feasible.

5. ESTIMATE STORM RETURN PROBABILITIES

Tables 3 and 7 provide the estimated DDFs for the El Paso Airport and La Tuna daily rain gage locations. The La Tuna DDF was the basis of comparison for Watersheds 4, 5, and 6; the El Paso Airport DDF was the basis of comparison for Watersheds 1, 2, and 8. Watersheds 3 and 7 are located in an intermediate area between the El Paso Airport and La Tuna, and either DDF provides a reasonable basis for comparison. The Ysleta gage is not located closest to any portion of the studied watersheds, therefore the Ysleta DDF was not used as the basis of comparison for any of the watersheds.

The extreme values in Table 9 were compared to the associated DDF curve for each watershed, and a return period in years (equal to the inverse of the probability) was estimated for each watershed. The results for unadjusted XMRG data are shown in Table 10 with comparisons to both relevant DDFs. The recommended DDF for comparison is highlighted. Table 11 shows results for Watersheds 6 and 7 with adjusted XMRG rainfall totals per earlier discussion. Changes versus Table 10 for these watersheds were minor.

Discussion. The method used aggregate spatial rainfall by watershed irrespective of elevation range within the watershed. This aggregate value was then compared to a DDF table derived from low elevation (i.e., near river level) point gage data. If extreme values of high elevation (i.e., over the Franklin Mountains) rainfall are typically significantly higher than lower elevation extreme values, the method used will overestimate to some extent the return period for the extreme 2006 storm. Given the lack of data collected at higher elevations, this issue cannot be conclusively addressed. It is recommended that CEP or another local agency initiate collection of rainfall data at a higher elevation to allow this issue to be addressed at some time in the future. These new data would also allow confirmation (adjustment of XMRG rainfall estimates over the Franklin Mountains).

6. SUMMARY

Based on the best estimates from the analysis, the return probability for the most intense 2-hour storm in the El Paso area during July-August 2006 is between 0.5 (2-year return frequency) and 0.25 (4-year return frequency). Similarly, the return probability for the most intense 24-hour storm in the El Paso area during August 2006 is between 0.02 (50-year return frequency) and 0.0025 (400-year return frequency).

In addition, the results of the storm frequency study have shown:

- Sufficient flow data do not exist to allow for estimation of the flood return period based upon experienced flows or high water marks.
- There is one longstanding (since 1942) hourly gage at the El Paso Airport whose data record was used to develop a statistically viable DDF curve for that location. There are several other regional longstanding (latest since 1948) daily rainfall gages (La Tuna, Ysleta) whose data records can be used to develop statistically viable estimates of daily rainfall return probability. These daily records provide a basis for comparison of historic low elevation rainfall throughout the area of study. There are

no rainfall gages located at higher elevations in the study area. Estimation of historic variability at higher elevations (e.g., between the east and west slopes of the Franklin Mountains) or historic variability between high and low elevations is not feasible.

- Per radar data, there was significant variation in rainfall by elevation in the 2006 storms. Rainfall totals over the higher elevations of the Franklin Mountains were on average double the rainfall totals at the elevation of the Rio Grande.
- For all watersheds studied, the extreme value of rainfall depth for durations of 3 hours or more occurred on August 1. Extreme values of rainfall depth for 1- or 2-hour durations occurred either on August 1 or August 3.
- For all watersheds studied, the return period for the 2006 storm increased as storm duration increased. For example, from Table 10 for Watershed 1, the largest rainfall to occur in 1 hour during the 2006 storm was 0.84 inch. This hourly rainfall amount had an estimated return period of 2 years (or a probability of recurrence in any one year of 0.5). Similarly, for Watershed 1, the largest rainfall during a 12-hour period during the 2006 storm was 3.88 inches. This 12-hour storm had an estimated return period of 100 years (or a probability of recurrence in any one year of 0.01).
- Typically, peak floods from a watershed are generated by extreme rainfall of a duration matching the time it takes water to drain from the upper limits of the watershed. This drain time (the "time of concentration") typically increases as basin area increases. This duration of most intense rainfall is typically embedded within a storm of duration longer than the time of concentration. Because return probability decreases in the 2006 storm with increased storm duration, the peak flood experienced from the largest watershed (Watershed 8) with a single point of concentration would be expected to have the lowest return probability (i.e., higher return period). The smallest watersheds with a single point of concentration (Watersheds 1, 2, 3, and 4), for example, would be expected to have experienced relatively routine peak floods. The situation for Watersheds 5, 6, and 7, which lack a single point of concentration, requires that the subwatersheds of these watersheds be considered. Since the subwatersheds are relatively small, these watersheds when considered individually would be expected to have experienced relatively routine peak floods.
- Once hydraulic models have been defined for study watersheds, then return probabilities for each watershed peak **flood** can be estimated (if high water mark data exist) as opposed to return probabilities for each watershed peak **storm** (by duration), which are estimated in this technical report.

As noted above, all the analyses and conclusions presented in this report are based upon source data received from agencies cited in the report and are subject to the same uncertainties associated with collection of those data.

Table 1. Flow Gages in the El Paso Area

Agency	Site Number	Site Name	Drainage Area (Mi^2)	Start	End
USGS	8363840	Rio Grande at Vinton Bridge near Anthony, TX	28680	1/21/1970	9/30/1974
USGS	8365600	McKelligon Canyon at El Paso, TX	2	10/1/1957	9/30/1977
USGS	8365800	Government Ditch at El Paso, TX	6	7/1/1958	10/4/1977
USGS	8366400	Riverside Canal near Socorro, TX	NA	10/1/1968	9/30/1972
IBWC	08-3640.00	Rio Grande at El Paso	NA	1889	Current
IBWC	08-3645.00	Diversions from Rio Grande American Canal at El Paso	NA	6/2/1938	Current
IBWC	08-3650.00	Rio Grande below American Dam at El Paso	NA	6/1938	Current
IBWC	08-3655.00	Diversions from Rio Grande Acequia Madre at Juarez	75,812	1938	Current
EPCWID#1	08-3639.00	Rio Grande at Canutillo	Not a long record, data procured for 2006 event only	Not a long record, data procured for 2006 event only	Current

NA = Not applicable.

Table 2. Rain Gages in the El Paso Vicinity

Station Name	Agency	Data Frequency	Begin Date	End Date	Data Available July-September 2006?
Cottonwood Dam #2	NOAA	Hourly	08/16/1943	11/01/1948	No
Cottonwood Dam 1	NOAA	Hourly	10/01/1947	07/31/1949	No
El Paso AP	NOAA	Hourly	08/01/1942	current	Yes
Fabens	NOAA	Hourly	02/01/1953	09/30/1977	No
Fabens 2	NOAA	Hourly	07/18/1949	04/30/1951	No
Island Stn	NOAA	Hourly	01/01/1942	07/25/1942	No
Rio Grande at El Paso	IBWC	Hourly	NAv	current	Yes
Rio Grande at Canutillo	EPCWID#1	Hourly	NAv	current	Yes
Socorro	NOAA	Daily	04/03/1918	10/31/1950	No
Ysleta	NOAA	Daily	02/01/1939	current	Yes
El Paso AP	NOAA	Daily	01/01/1948	current	Yes
El Paso #2	NOAA	Daily	08/01/2001	current	Yes
La Tuna 1 S	NOAA	Daily	03/01/1943	current	Yes

NAv = Not readily available from IBWC; data procured starting on 7/1/06.

Table 3. Depth-Duration-Frequency (DDF) for the El Paso Airport Location, Derived from Hourly Data

Return Frequency (years)	Return Probability	Total Rainfall Depth (inches) by Duration						
		1 hr	2 hrs	3 hrs	4 hrs	6 hrs	12 hrs	24 hrs
1	1	0.41	0.52	0.57	0.61	0.66	0.72	0.80
2	0.5	0.70	0.88	0.95	0.99	1.07	1.18	1.35
5	0.2	0.97	1.22	1.30	1.36	1.46	1.61	1.83
10	0.1	1.15	1.45	1.55	1.62	1.73	1.91	2.16
25	0.04	1.41	1.79	1.89	1.99	2.11	2.33	2.60
50	0.02	1.61	2.06	2.18	2.30	2.43	2.68	2.96
100	0.01	1.84	2.36	2.49	2.64	2.78	3.06	3.34
250	0.004	2.18	2.82	2.96	3.16	3.30	3.63	3.89
500	0.002	2.47	3.21	3.37	3.62	3.74	4.12	4.35

Table 4. Summary of Extreme Daily Rainfall (inches) by Year

Gage					
Year	El Paso Airport	Year	La Tuna	Year	Ysleta
2006	2.84	1958	3.15	1974	3.30
1974	2.26	2006	2.65	1968	3.08
2005	2.26	1987	2.50	1997	2.38
1982	2.20	1955	2.47	1958	2.35
1957	2.00	1999	2.40	1982	2.26
1958	1.96	1953	2.25	2006	2.02
1964	1.77	2005	2.08	2000	1.93
1960	1.75	1996	2.00	2004	1.91
1975	1.69	1969	1.99	1985	1.90
1955	1.68	1972	1.95	1975	1.87
1984	1.68	1964	1.86	1962	1.86
1954	1.66	1979	1.86	1972	1.68
1961	1.66	1957	1.83	1965	1.66
1968	1.65	1981	1.83	1996	1.66
1971	1.65	1984	1.80	1966	1.62
1992	1.64	1978	1.78	1977	1.58
1962	1.62	1954	1.75	1978	1.58
1972	1.55	2004	1.75	1984	1.47
1981	1.54	1974	1.72	1950	1.40
1973	1.53	1968	1.70	1980	1.39
1976	1.51	1993	1.63	1955	1.35
1987	1.46	1965	1.61	1973	1.35
1978	1.37	1991	1.40	1987	1.35
2004	1.37	1995	1.40	1952	1.25

Table 4. (Continued)

Gage					
Year	El Paso Airport	Year	La Tuna	Year	Ysleta
2000	1.36	1950	1.39	1990	1.25
1949	1.29	1976	1.36	1963	1.20
1990	1.28	1959	1.32	1981	1.18
1988	1.27	1971	1.29	1983	1.15
1965	1.21	1966	1.25	1954	1.10
1989	1.19	1970	1.15	1989	1.10
1991	1.18	1975	1.12	2003	1.10
1966	1.17	1986	1.12	1992	1.04
1996	1.15	1997	1.10	1991	1.02
1986	1.13	1948	1.09	1960	1.00
1995	1.13	1982	1.08	1998	0.99
1998	1.13	1994	1.08	1951	0.98
1993	1.08	1992	1.07	1953	0.98
1980	1.06	1951	1.05	1994	0.98
1985	1.06	1998	1.05	1988	0.95
1999	0.99	1949	1.01	1979	0.89
2003	0.99	1973	0.96	1957	0.88
1983	0.98	1962	0.95	1986	0.86
1967	0.96	1980	0.95	1949	0.82
1951	0.94	1990	0.93	1959	0.82
1948	0.93	2002	0.93	1967	0.81
1950	0.91	1961	0.90	1970	0.80
1997	0.90	1977	0.90	2002	0.80
1952	0.82	1983	0.90	1964	0.77
1956	0.81	1956	0.87	1993	0.76
1977	0.80	1989	0.87	1948	0.72
1979	0.76	1952	0.85	1969	0.72
1994	0.76	1985	0.84	1976	0.70
1963	0.71	1988	0.80	1995	0.70
1959	0.70	2000	0.77	1961	0.60
2001	0.60	1967	0.65	1971	0.57
1953	0.59	1963	0.58	2001	0.50
1970	0.59	1960	0.57	1956	0.46
1969	0.56	2001	0.50	1999	0.42
2002	0.54	2003	0*	2005	0.35

*No data for LaTuna, year not included.

Table 5. Summary of Return Probabilities for Daily Rainfall, Based on Daily Data

Return Frequency (years)	Return Probability	El Paso Airport Daily Rainfall (inches)	La Tuna		Ysleta	
			Daily Rainfall (inches)	Ratio to El Paso Airport Rainfall	Daily Rainfall (inches)	Ratio to El Paso Airport Rainfall
1	1	0.76	0.79	1.04	0.65	0.86
2	0.5	1.23	1.28	1.04	1.13	0.92
5	0.2	1.68	1.81	1.08	1.68	1.00
10	0.1	1.95	2.17	1.11	2.07	1.06
25	0.04	2.26	2.64	1.17	2.59	1.15
50	0.02	2.48	2.99	1.21	3.01	1.22
100	0.01	2.68	3.35	1.25	3.45	1.29
250	0.004	2.92	3.83	1.31	4.07	1.39
500	0.002	3.09	4.21	1.36	4.57	1.48

Table 6. Summary of 20 Highest Extreme Rainfall Values for the El Paso Airport

12-hour Storm		Daily Gage Reading	
Year	Rainfall (inches)	Year	Rainfall (inches)
2006	2.78	2006	2.84
1992	2.40	1974	2.26
2005	2.26	2005	2.26
1968	2.20	1982	2.20
1982	2.20	1957	2.00
1975	2.01	1958	1.96
1958	1.96	1964	1.77
2004	1.95	1960	1.75
1957	1.92	1975	1.69
1964	1.77	1955	1.68
1984	1.75	1984	1.68
1973	1.67	1954	1.66
1961	1.66	1961	1.66
1950	1.63	1968	1.65
1972	1.63	1971	1.65
1962	1.62	1992	1.64
1960	1.58	1962	1.62
1974	1.57	1972	1.55
1981	1.55	1981	1.54
1971	1.51	1973	1.53

Table 7. Depth-Duration-Frequency (DDF) for the LaTuna and Ysleta Locations

La Tuna								
Return Frequency (years)	Return Probability	Total Rainfall Depth (inches) by Duration						
		1 hr	2 hrs	3 hrs	4 hrs	6 hrs	12 hrs	24 hrs
1	1	0.43	0.54	0.59	0.63	0.68	0.74	0.83
2	0.5	0.73	0.91	0.98	1.03	1.11	1.22	1.40
5	0.2	1.04	1.31	1.40	1.47	1.58	1.74	1.98
10	0.1	1.28	1.62	1.72	1.81	1.93	2.13	2.41
25	0.04	1.64	2.08	2.20	2.32	2.46	2.72	3.03
50	0.02	1.95	2.49	2.63	2.77	2.93	3.23	3.57
100	0.01	2.31	2.96	3.12	3.31	3.47	3.83	4.18
250	0.004	2.86	3.70	3.89	4.15	4.33	4.76	5.11
500	0.002	3.36	4.36	4.58	4.92	5.09	5.60	5.92
Ysleta								
Return Frequency (years)	Return Probability	Total Rainfall Depth (inches) by Duration						
		1 hr	2 hrs	3 hrs	4 hrs	6 hrs	12 hrs	24 hrs
1	1	0.35	0.45	0.49	0.52	0.56	0.61	0.69
2	0.5	0.64	0.80	0.87	0.91	0.98	1.08	1.23
5	0.2	0.97	1.22	1.30	1.36	1.46	1.61	1.83
10	0.1	1.22	1.54	1.64	1.72	1.84	2.02	2.29
25	0.04	1.61	2.05	2.17	2.28	2.42	2.67	2.98
50	0.02	1.96	2.50	2.64	2.79	2.95	3.25	3.59
100	0.01	2.38	3.05	3.21	3.41	3.58	3.94	4.30
250	0.004	3.04	3.92	4.12	4.40	4.59	5.05	5.42
500	0.002	3.65	4.73	4.97	5.34	5.52	6.08	6.42

Table 8. Summary of XMRG Cell Areas by Watershed

Watershed	XMRG Cell per Figure 4	Area (sq mi)	Fraction of Total Area	Watershed	XMRG Cell per Figure 4	Area (sq mi)	Fraction of Total Area
1	48	0.12	0.059	8	74	1.49	0.015
	68	0.76	0.376		64	2.44	0.024
	58	1.14	0.565		54	0.75	0.007
	Total	2.02			85	0.06	0.001
2	56	0.56	0.438		75	5.48	0.053
	46	0.09	0.071		65	5.86	0.057
	47	0.09	0.074		55	4.67	0.045
	57	0.53	0.417		45	0.51	0.005
	Total	1.27			86	0.10	0.001
3	44	0.25	0.337		86	0.06	0.001
	45	0.50	0.663		86	0.06	0.001
	Total	0.75			76	5.86	0.057
4	39	0.49	0.572		66	5.87	0.057
	29	0.36	0.428		56	5.87	0.057
	Total	0.85			46	1.29	0.013
5	49	1.08	0.127		87	1.22	0.012
	39	0.22	0.026		77	5.87	0.057
	50	1.58	0.186		67	5.87	0.057
	30	1.59	0.187		57	5.87	0.057
	40	4.03	0.474		47	1.42	0.014
	Total	10.20			88	1.05	0.010
6	47	0.70	0.061		78	5.87	0.057
	37	0.43	0.038		68	5.87	0.057
	27	0.76	0.067		58	5.87	0.057
	28	1.85	0.162		48	1.33	0.013
	38	4.04	0.353		89	0.07	0.001
	48	3.65	0.319		79	4.67	0.046
	Total	11.45			69	5.88	0.057
7	45	2.24	0.117		49	1.29	0.013
	35	2.58	0.134		59	5.84	0.057
	46	4.57	0.238		60	0.01	0.000
	26	0.44	0.023		60	1.40	0.014
	36	5.58	0.291		70	1.97	0.019
	37	1.07	0.056		80	0.87	0.008
	47	2.72	0.142		Total	102.61	
	Total	19.20					

Table 9. Summary of Extreme Rainfall Values for Period July-September 2006 by Watershed, Based on Unadjusted XMRG Data

Storm Duration		Watershed							
		1	2	3	4	5	6	7	8
1 hr	Extreme Value (inches)	0.84	0.76	0.87	0.85	0.80	0.71	0.76	0.74
	Date/Time of Extreme Value	8/3/2006 1:00:00 AM	8/3/2006 1:00:00 AM	8/1/2006 12:00:00 PM	8/1/2006 12:00:00 PM	8/1/2006 12:00:00 PM	8/3/2006 1:00:00 AM	7/31/2006 10:00:00 AM	8/3/2006 1:00:00 AM
2 hr	Extreme Value (inches)	1.01	1.09	1.15	1.20	1.19	1.18	1.21	0.89
	Date/Time of Extreme Value	8/3/2006 1:00:00 AM	8/1/2006 12:00:00 PM	8/1/2006 11:00:00 AM	8/1/2006 12:00:00 PM	8/1/2006 12:00:00 PM	8/1/2006 12:00:00 PM	8/1/2006 11:00:00 AM	8/3/2006 1:00:00 AM
3 hr	Extreme Value (inches)	1.42	1.44	1.53	1.38	1.39	1.54	1.75	1.13
	Date/Time of Extreme Value	8/1/2006 6:00:00 AM	8/1/2006 12:00:00 PM	8/1/2006 10:00:00 AM	8/1/2006 11:00:00 AM	8/1/2006 11:00:00 AM	8/1/2006 7:00:00 AM	8/1/2006 10:00:00 AM	8/1/2006 6:00:00 AM
4 hr	Extreme Value (inches)	1.86	1.63	1.79	1.60	1.52	1.91	2.00	1.41
	Date/Time of Extreme Value	8/1/2006 6:00:00 AM	8/1/2006 10:00:00 AM	8/1/2006 9:00:00 AM	8/1/2006 9:00:00 AM	8/1/2006 10:00:00 AM	8/1/2006 7:00:00 AM	8/1/2006 10:00:00 AM	8/1/2006 6:00:00 AM
6 hr	Extreme Value (inches)	2.29	2.33	2.55	2.34	2.24	2.88	2.82	1.76
	Date/Time of Extreme Value	8/1/2006 4:00:00 AM	8/1/2006 8:00:00 AM	8/1/2006 8:00:00 AM	8/1/2006 7:00:00 AM	8/1/2006 7:00:00 AM	8/1/2006 7:00:00 AM	8/1/2006 7:00:00 AM	8/1/2006 8:00:00 AM
12 hr	Extreme Value (inches)	3.88	3.90	3.35	3.18	3.18	4.15	3.78	3.31
	Date/Time of Extreme Value	8/1/2006 4:00:00 AM	8/1/2006 4:00:00 AM	8/1/2006 4:00:00 AM	8/1/2006 4:00:00 AM	8/1/2006 4:00:00 AM	8/1/2006 3:00:00 AM	8/1/2006 4:00:00 AM	8/1/2006 4:00:00 AM
24 hr	Extreme Value (inches)	4.25	4.18	3.63	3.83	3.80	4.72	4.21	3.57
	Date/Time of Extreme Value	7/31/2006 5:00:00 PM	7/31/2006 5:00:00 PM	7/31/2006 7:00:00 PM	7/31/2006 6:00:00 PM	7/31/2006 6:00:00 PM	7/31/2006 5:00:00 PM	7/31/2006 6:00:00 PM	7/31/2006 5:00:00 PM

Table 10. Summary of Estimated Storm Return Frequency for July-September 2006 Extreme Event, Based on Unadjusted XMRG Data

Storm Duration	Watershed											
	1			2			3			4		
	La Tuna DDF Curve											
	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)
1-hr	0.844	8/3/2006 1:00	2	0.764	8/3/2006 1:00	2	0.868	8/1/2006 12:00	2	0.855	8/1/2006 12:00	2
2-hr	1.011	8/3/2006 1:00	2	1.090	8/1/2006 12:00	2	1.146	8/1/2006 11:00	3	1.202	8/1/2006 12:00	3
3-hr	1.416	8/1/2006 6:00	5	1.438	8/1/2006 12:00	5	1.526	8/1/2006 10:00	6	1.377	8/1/2006 11:00	4
4-hr	1.860	8/1/2006 6:00	10	1.627	8/1/2006 10:00	7	1.792	8/1/2006 9:00	9	1.604	8/1/2006 9:00	6
6-hr	2.293	8/1/2006 4:00	15	2.328	8/1/2006 8:00	20	2.554	8/1/2006 8:00	25	2.343	8/1/2006 7:00	20
12-hr	3.876	8/1/2006 4:00	100	3.900	8/1/2006 4:00	100	3.350	8/1/2006 4:00	50	3.185	8/1/2006 4:00	45
24-hr	4.255	7/31/2006 17:00	100	4.179	7/31/2006 17:00	100	3.626	7/31/2006 19:00	50	3.827	7/31/2006 18:00	60
	El Paso Airport DDF Curve											
	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)
1-hr	0.844	8/3/2006 1:00	3	0.764	8/3/2006 1:00	2	0.868	8/1/2006 12:00	3	0.855	8/1/2006 12:00	3
2-hr	1.011	8/3/2006 1:00	2	1.090	8/1/2006 12:00	3	1.146	8/1/2006 11:00	4	1.202	8/1/2006 12:00	4
3-hr	1.416	8/1/2006 6:00	6	1.438	8/1/2006 12:00	7	1.526	8/1/2006 10:00	9	1.377	8/1/2006 11:00	6
4-hr	1.860	8/1/2006 6:00	15	1.627	8/1/2006 10:00	10	1.792	8/1/2006 9:00	15	1.604	8/1/2006 9:00	9
6-hr	2.293	8/1/2006 4:00	30	2.328	8/1/2006 8:00	40	2.554	8/1/2006 8:00	60	2.343	8/1/2006 7:00	40
12-hr	3.876	8/1/2006 4:00	350	3.900	8/1/2006 4:00	350	3.350	8/1/2006 4:00	150	3.185	8/1/2006 4:00	100
24-hr	4.255	7/31/2006 17:00	400	4.179	7/31/2006 17:00	350	3.626	7/31/2006 19:00	150	3.827	7/31/2006 18:00	200
Storm Duration	Watershed											
	5			6			7			8		
	La Tuna DDF Curve											
	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)
1-hr	0.804	8/1/2006 12:00	2	0.709	8/3/2006 1:00	1	0.755	7/31/2006 10:00	2	0.737	8/3/2006 1:00	2
2-hr	1.194	8/1/2006 12:00	3	1.180	8/1/2006 12:00	3	1.209	8/1/2006 11:00	3	0.892	8/3/2006 1:00	1.15
3-hr	1.388	8/1/2006 11:00	4	1.541	8/1/2006 7:00	6	1.747	8/1/2006 10:00	10	1.127	8/1/2006 6:00	2
4-hr	1.515	8/1/2006 10:00	5	1.911	8/1/2006 7:00	10	2.002	8/1/2006 10:00	10	1.406	8/1/2006 6:00	4
6-hr	2.238	8/1/2006 7:00	15	2.883	8/1/2006 7:00	45	2.816	8/1/2006 7:00	40	1.759	8/1/2006 8:00	7
12-hr	3.177	8/1/2006 4:00	45	4.147	8/1/2006 3:00	100	3.785	8/1/2006 4:00	90	3.305	8/1/2006 4:00	50
24-hr	3.802	7/31/2006 18:00	60	4.719	7/31/2006 17:00	150	4.208	7/31/2006 18:00	100	3.568	7/31/2006 17:00	45
	El Paso Airport DDF Curve											
	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)
1-hr	0.804	8/1/2006 12:00	2	0.709	8/3/2006 1:00	2	0.755	7/31/2006 10:00	2	0.737	8/3/2006 1:00	2
2-hr	1.194	8/1/2006 12:00	4	1.180	8/1/2006 12:00	4	1.209	8/1/2006 11:00	4	0.892	8/3/2006 1:00	2
3-hr	1.388	8/1/2006 11:00	6	1.541	8/1/2006 7:00	9	1.747	8/1/2006 10:00	15	1.127	8/1/2006 6:00	3
4-hr	1.515	8/1/2006 10:00	7	1.911	8/1/2006 7:00	20	2.002	8/1/2006 10:00	25	1.406	8/1/2006 6:00	5
6-hr	2.238	8/1/2006 7:00	30	2.883	8/1/2006 7:00	100	2.816	8/1/2006 7:00	100	1.759	8/1/2006 8:00	10
12-hr	3.177	8/1/2006 4:00	100	4.147	8/1/2006 3:00	500	3.785	8/1/2006 4:00	300	3.305	8/1/2006 4:00	150
24-hr	3.802	7/31/2006 18:00	200	4.719	7/31/2006 17:00	500	4.208	7/31/2006 18:00	400	3.568	7/31/2006 17:00	100

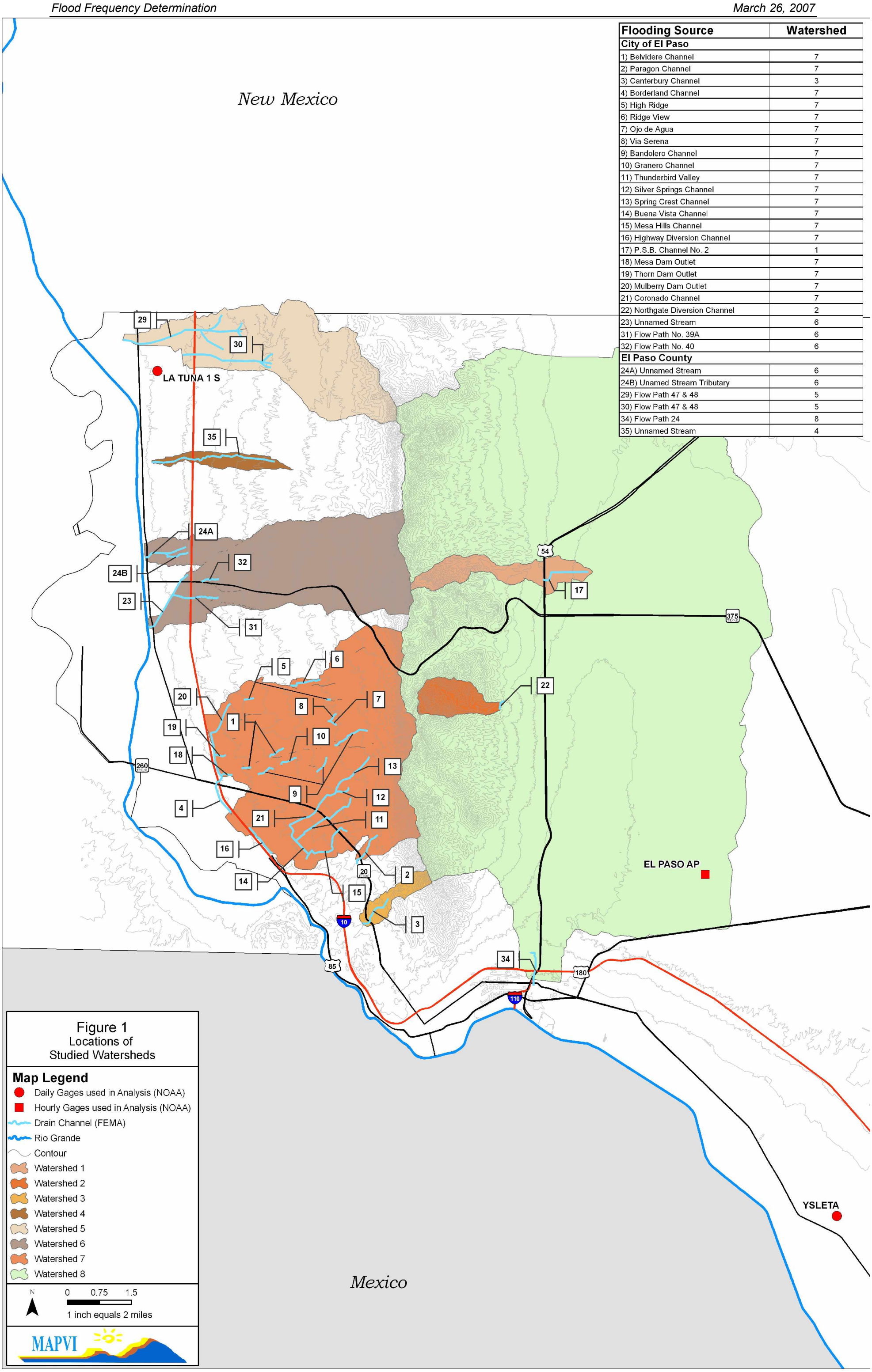
DDF = Depth-duration-frequency
RF = Return frequency of storm, years
EV = Extreme value of rainfall, inches
= Applicable rain gage return frequency for respective watershed

Table 11. Estimated Storm Return Frequency for July-September 2006 Extreme Event for Selected Watersheds, Using Adjusted XMRG Data

Storm Duration	Watershed					
	6			7		
	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)
La Tuna DDF Curve						
1-hr	0.709	8/3/2006 1:00	1	0.747	7/31/2006 10:00	2
2-hr	1.180	8/1/2006 12:00	3	1.209	8/1/2006 11:00	3
3-hr	1.462	8/1/2006 11:00	5	1.747	8/1/2006 10:00	10
4-hr	1.831	8/1/2006 10:00	10	2.002	8/1/2006 10:00	10
6-hr	2.777	8/1/2006 7:00	40	2.807	8/1/2006 7:00	40
12-hr	3.990	8/1/2006 4:00	100	3.770	8/1/2006 4:00	90
24-hr	4.504	7/31/2006 17:00	100	4.190	7/31/2006 18:00	100
	EV (in)	Date	RF (yrs)	EV (in)	Date	RF (yrs)
El Paso Airport DDF Curve						
1-hr	0.709	8/3/2006 1:00	2	0.747	7/31/2006 10:00	2
2-hr	1.180	8/1/2006 12:00	4	1.209	8/1/2006 11:00	4
3-hr	1.462	8/1/2006 11:00	7	1.747	8/1/2006 10:00	15
4-hr	1.831	8/1/2006 10:00	15	2.002	8/1/2006 10:00	25
6-hr	2.777	8/1/2006 7:00	100	2.807	8/1/2006 7:00	100
12-hr	3.990	8/1/2006 4:00	400	3.770	8/1/2006 4:00	300
24-hr	4.504	7/31/2006 17:00	500	4.190	7/31/2006 18:00	350

DDF = Depth duration frequency
EV = Extreme value of rainfall, inches
RF = Return frequency of storm, years
[ ] = Applicable rain gage return frequency for respective watershed

Flooding Source	Watershed
City of El Paso	
1) Belvidere Channel	7
2) Paragon Channel	7
3) Canterbury Channel	3
4) Borderland Channel	7
5) High Ridge	7
6) Ridge View	7
7) Ojo de Agua	7
8) Via Serena	7
9) Bandolero Channel	7
10) Granero Channel	7
11) Thunderbird Valley	7
12) Silver Springs Channel	7
13) Spring Crest Channel	7
14) Buena Vista Channel	7
15) Mesa Hills Channel	7
16) Highway Diversion Channel	7
17) P.S.B. Channel No. 2	1
18) Mesa Dam Outlet	7
19) Thorn Dam Outlet	7
20) Mulberry Dam Outlet	7
21) Coronado Channel	7
22) Northgate Diversion Channel	2
23) Unnamed Stream	6
31) Flow Path No. 39A	6
32) Flow Path No. 40	6
El Paso County	
24A) Unnamed Stream	6
24B) Unamed Stream Tributary	6
29) Flow Path 47 & 48	5
30) Flow Path 47 & 48	5
34) Flow Path 24	8
35) Unnamed Stream	4



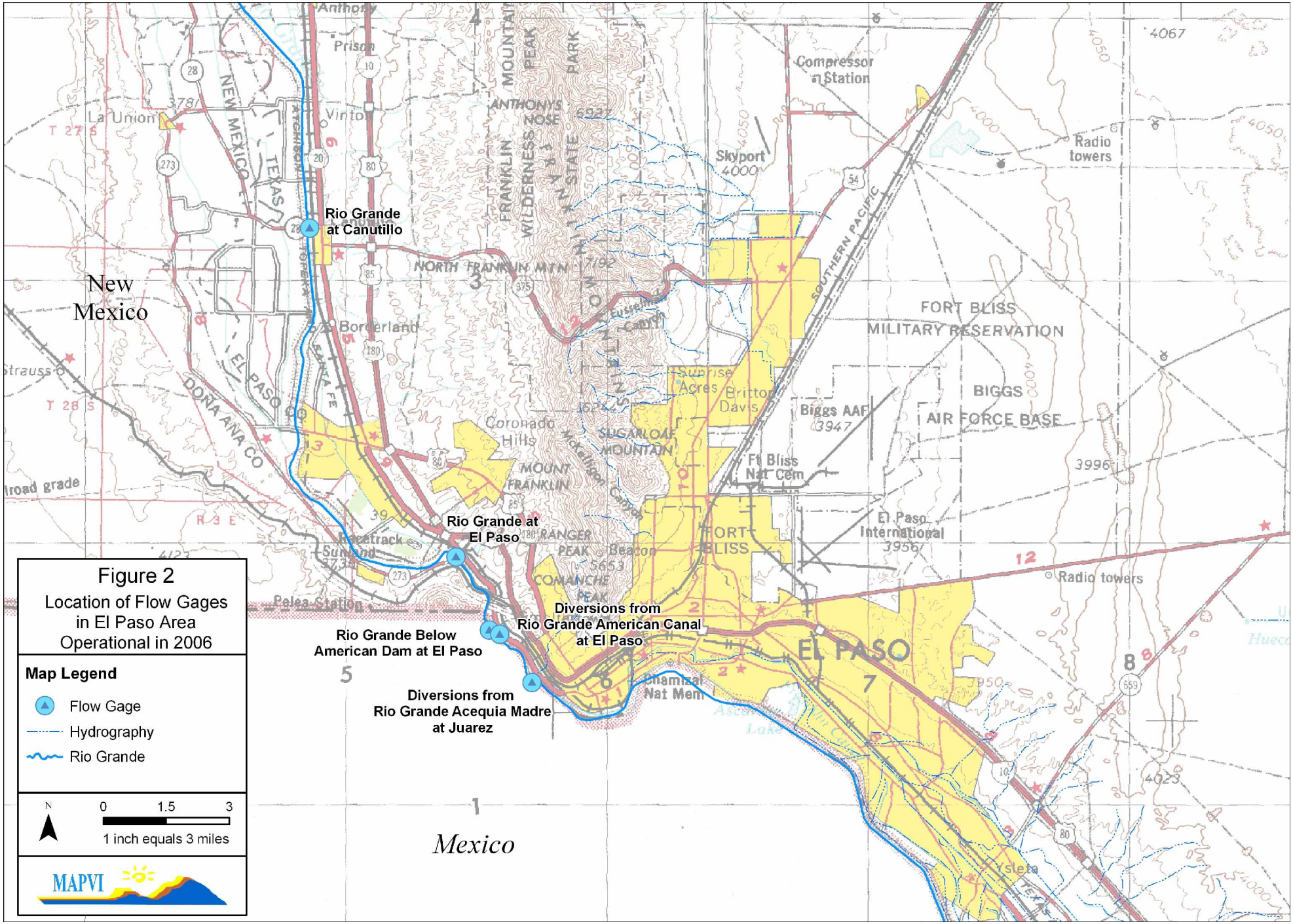
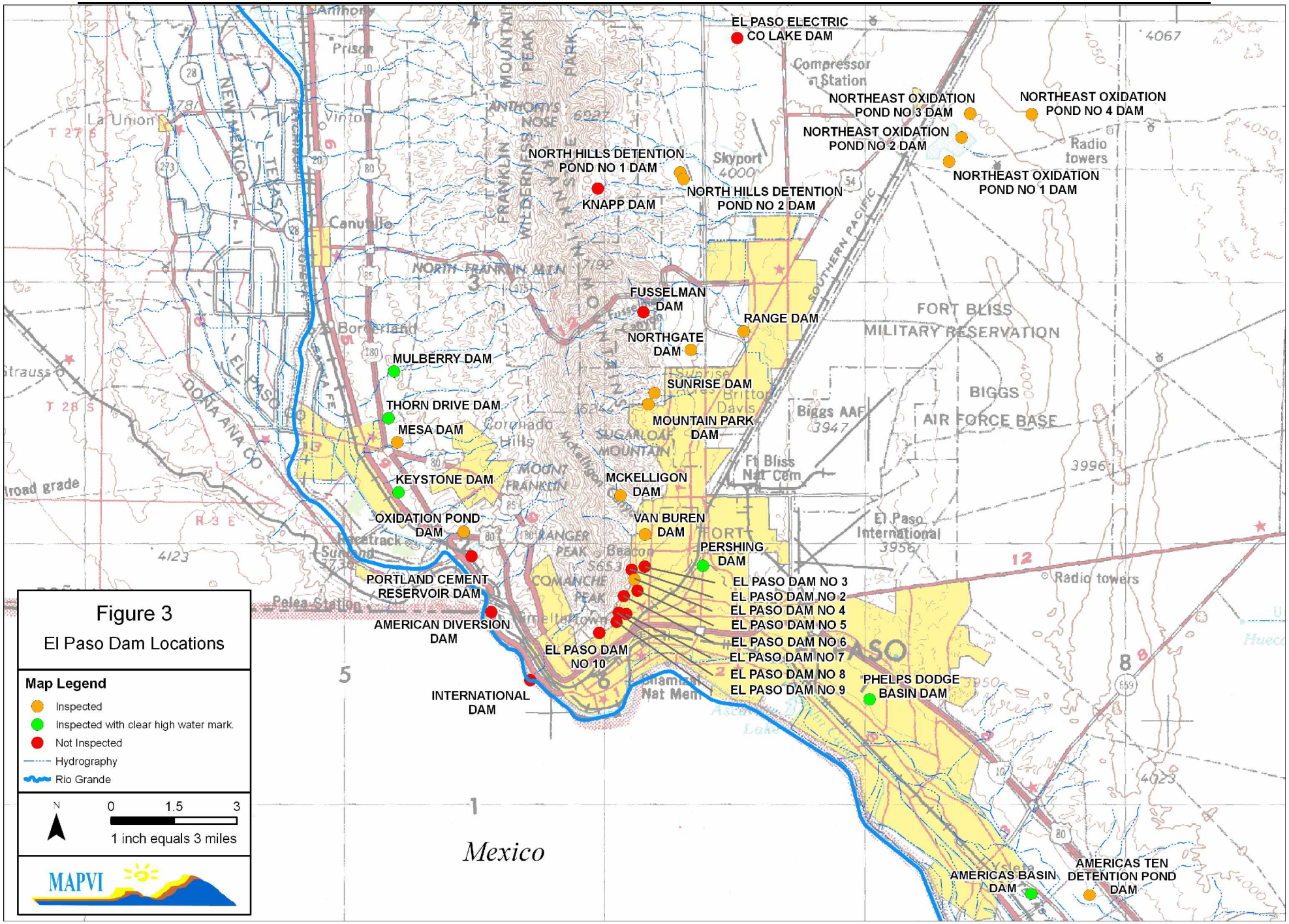


Figure 2
Location of Flow Gages in El Paso Area Operational in 2006


EL PASO ELECTRIC CO LAKE DAM
NORTHEAST OXIDATION POND NO 3 DAM
NORTHEAST OXIDATION POND NO 4 DAM
NORTHEAST OXIDATION POND NO 2 DAM
NORTHEAST OXIDATION POND NO 1 DAM
NORTH HILLS DETENTION POND NO 1 DAM
NORTH HILLS DETENTION POND NO 2 DAM
KNAPP DAM
FUSSELMAN DAM
RANGE DAM
NORTHGATE DAM
MULBERRY DAM
SUNRISE DAM
THORN DRIVE DAM
MESA DAM
MOUNTAIN PARK DAM
KEYSTONE DAM
MCKELLIGON DAM
OXIDATION POND DAM
VAN BUREN DAM
PERSHING DAM
PORTLAND CEMENT RESERVOIR DAM
EL PASO DAM NO 3
EL PASO DAM NO 2
EL PASO DAM NO 4
EL PASO DAM NO 5
EL PASO DAM NO 6
EL PASO DAM NO 7
EL PASO DAM NO 8
EL PASO DAM NO 9
AMERICAN DIVERSION DAM
EL PASO DAM NO 10
INTERNATIONAL DAM
PHELPS DODGE BASIN DAM
AMERICAS BASIN DAM
AMERICAS TEN DETENTION POND DAM
Mexico
Figure 3
El Paso Dam Locations
Map Legend
Inspected
Inspected with clear high water mark.
Not Inspected
Hydrography
Rio Grande
N
0 1.5 3
1 inch equals 3 miles
MAPVI

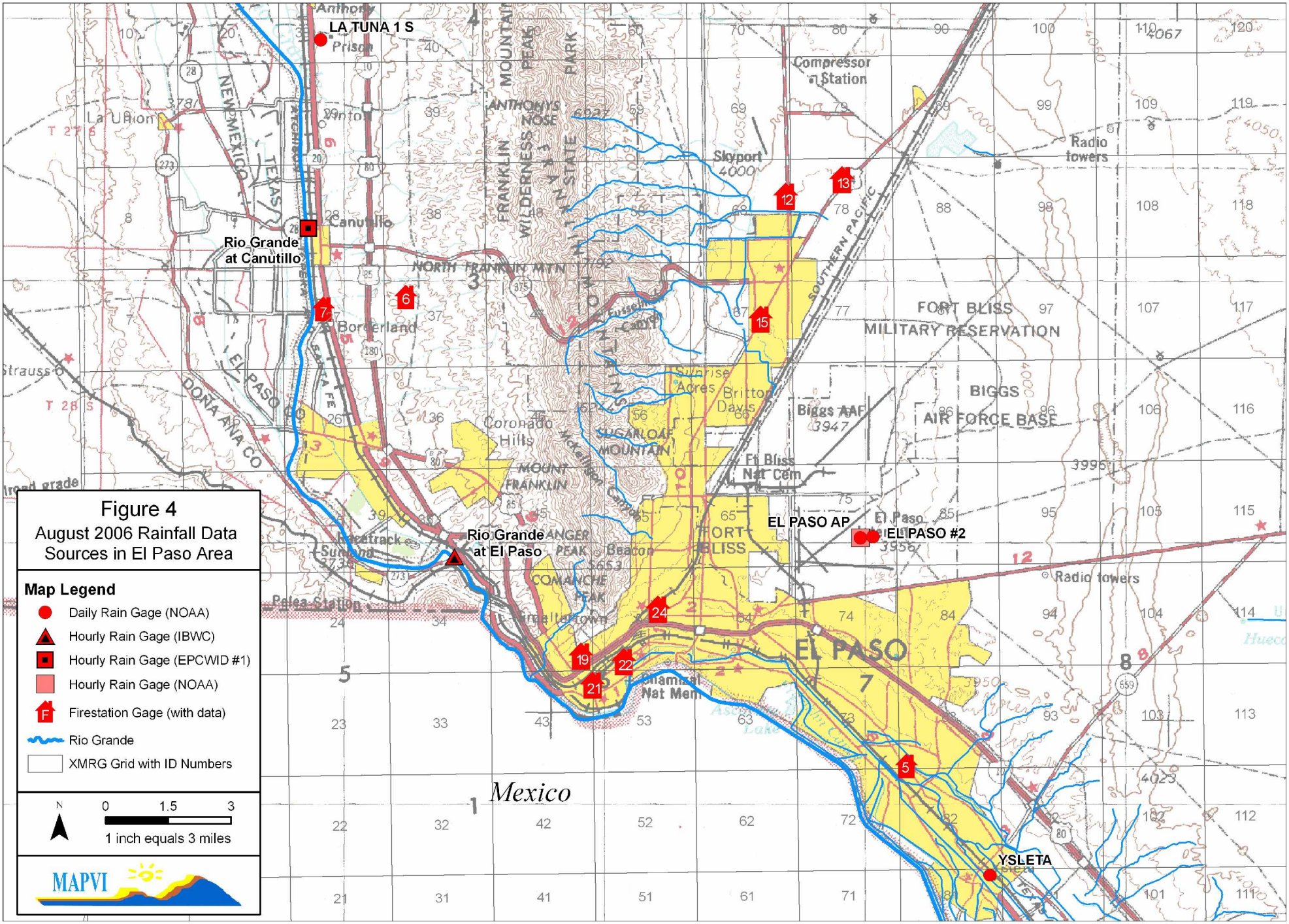
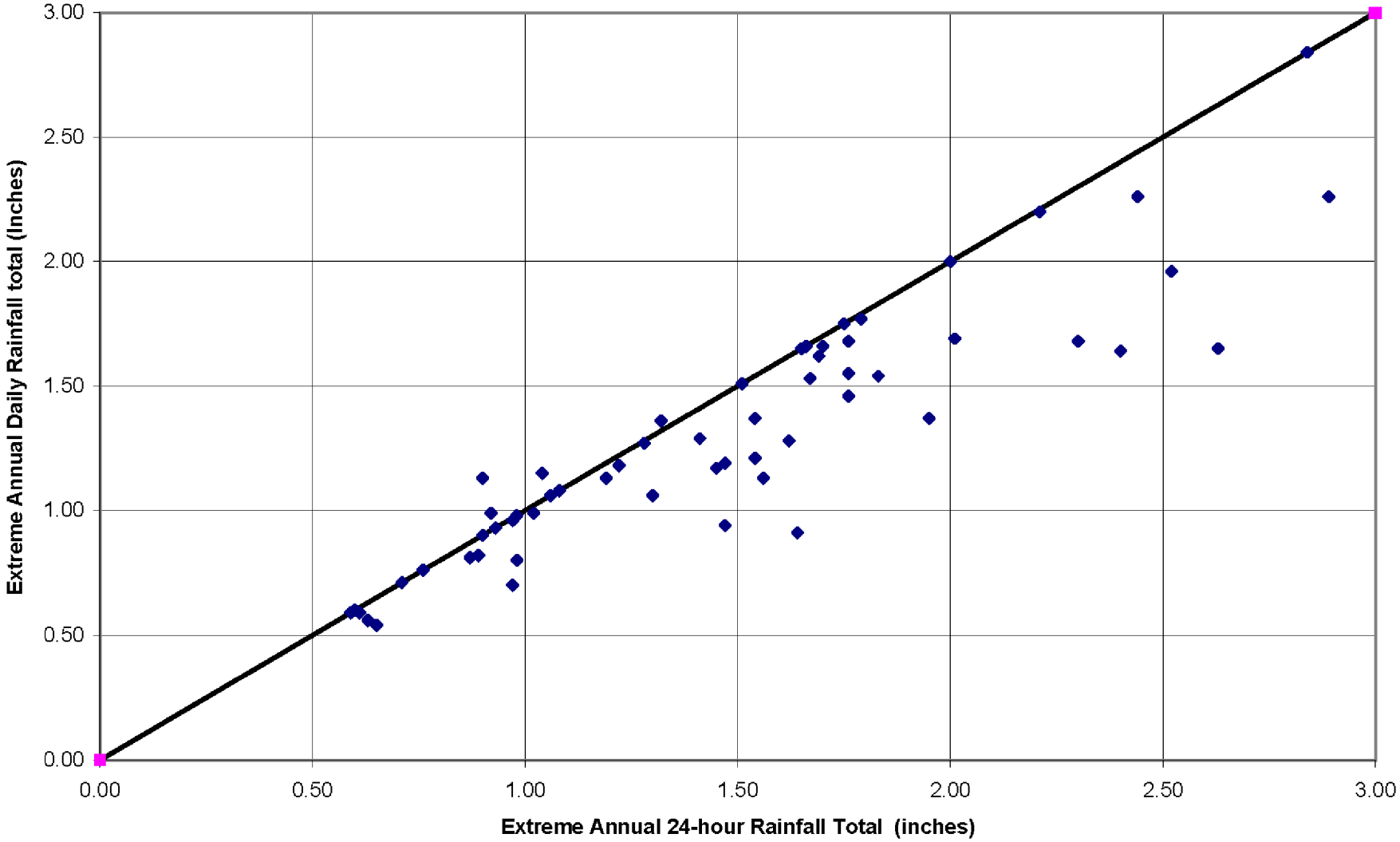

LA TUNA 1 S
Rio Grande at Canutillo
Rio Grande at El Paso
EL PASO AP
EL PASO #2
YSLETA
Figure 4
August 2006 Rainfall Data Sources in El Paso Area
Map Legend
Daily Rain Gage (NOAA)
Hourly Rain Gage (IBWC)
Hourly Rain Gage (EPCWID #1)
Hourly Rain Gage (NOAA)
Firestation Gage (with data)
Rio Grande
XMRG Grid with ID Numbers
N
0 1.5 3
1 inch equals 3 miles
MAPVI
Mexico
EL PASO
FORT BLISS
MILITARY RESERVATION
BIGGS
AIR FORCE BASE
Anthony
Canutillo
Borderland
Sunland
Compressor Station
Radio towers
Skyport
Biggs AAF
Ft Bliss Nat Cem
Coronado Hills
Sunrise Acres
Britton Davis
Beacon
Pelea Station
Hueco

Figure 5. Comparison of Annual Extreme 24-Hour and Daily Rainfall Values



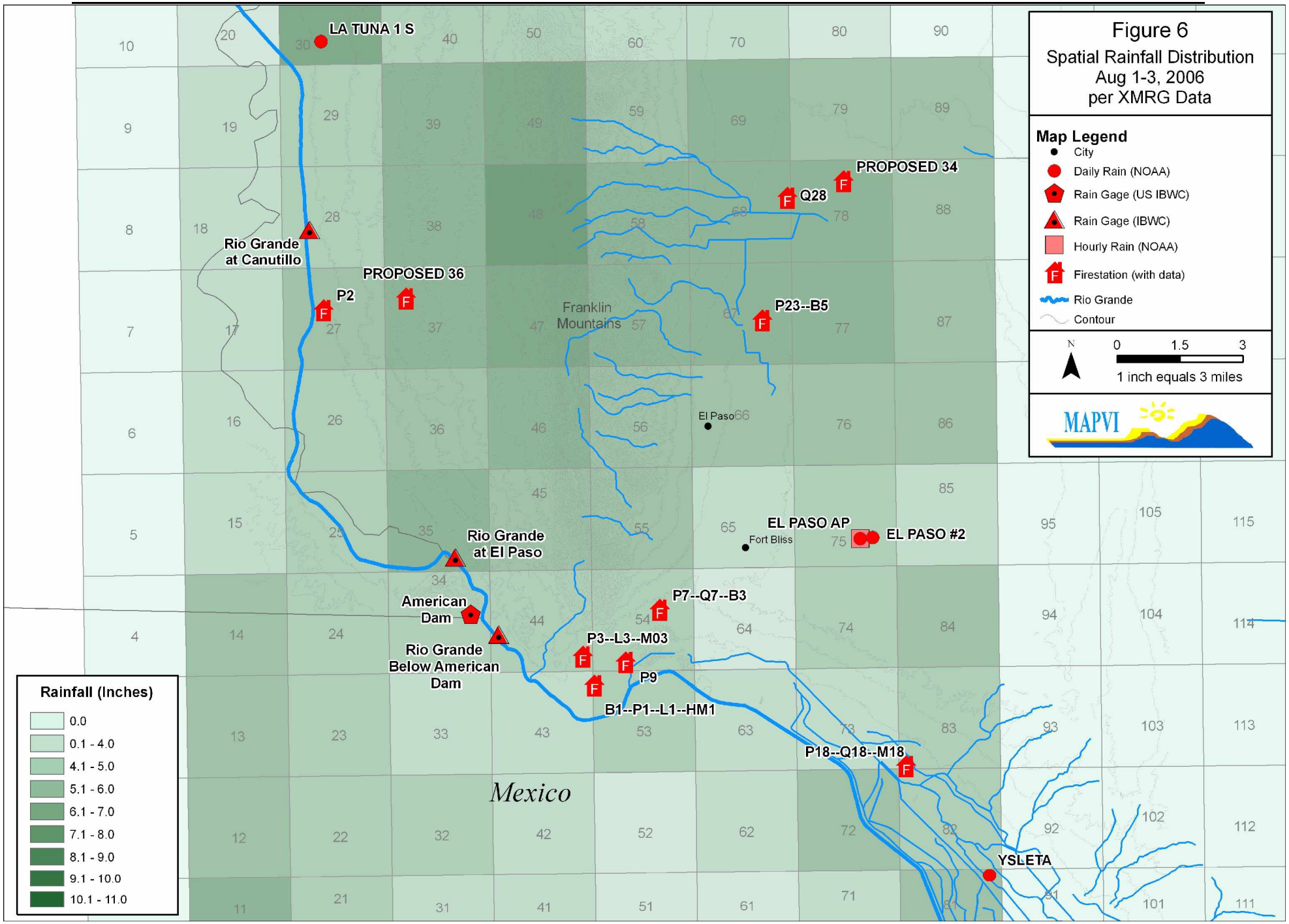


Figure 6
Spatial Rainfall Distribution
Aug 1-3, 2006
per XMRG Data
Map Legend
City
Daily Rain (NOAA)
Rain Gage (US IBWC)
Rain Gage (IBWC)
Hourly Rain (NOAA)
Firestation (with data)
Rio Grande
Contour
N
0 1.5 3
1 inch equals 3 miles
MAPVI
LA TUNA 1 S
Rio Grande at Canutillo
PROPOSED 36
P2
Franklin Mountains
PROPOSED 34
Q28
P23--B5
El Paso
EL PASO AP
Fort Bliss
EL PASO #2
Rio Grande at El Paso
American Dam
Rio Grande Below American Dam
P7--Q7--B3
P3--L3--M03
P9
B1--P1--L1--HM1
P18--Q18--M18
YSLETA
Mexico
Rainfall (Inches)
0.0
0.1 - 4.0
4.1 - 5.0
5.1 - 6.0
6.1 - 7.0
7.1 - 8.0
8.1 - 9.0
9.1 - 10.0
10.1 - 11.0

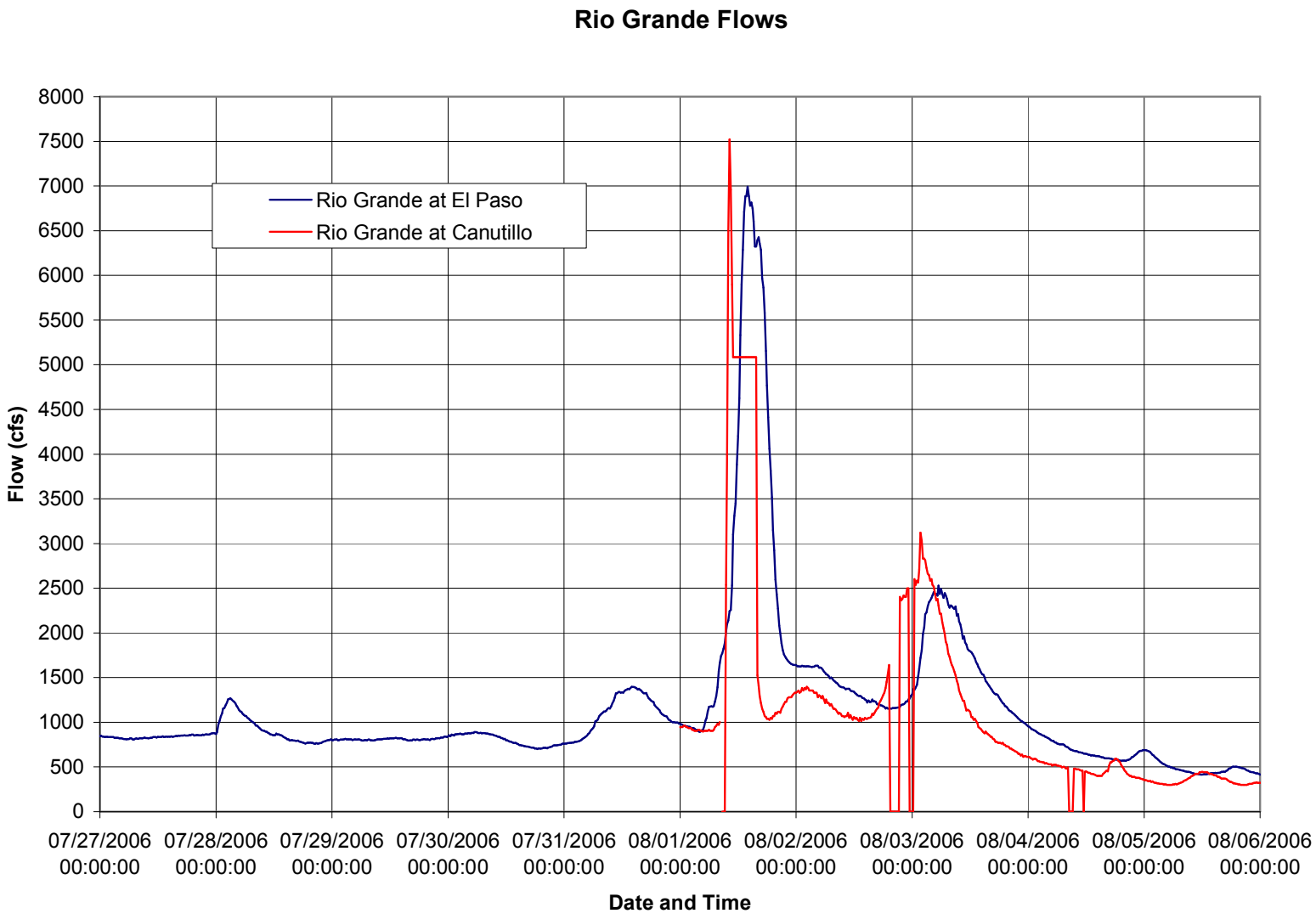


Figure 7
Rio Grande Flows July 27-August 6, 2006

APPENDIX A

The purpose of Appendix A is to provide documentation of the data sources and methods used in the derivation of statistical rainfall depth probabilities for the El Paso Airport location.

DATA COLLECTION

The National Climatic Data Center (NCDC) maintains the data records for numerous climatic gages throughout the United States, to include the data record for the rainfall gage at El Paso Airport. This gage has a 58-year continuous daily (one reading per day) rainfall record, and a slightly longer record (approximately 66 years) of hourly data. The data for the full records through December 2005 were procured indirectly from Earthinfo (a vendor of formatted NCDC data). The data for January 2006 through September 2006 were procured directly from the National Weather Service.

IDENTIFICATION OF ANNUAL EXTREME RAINFALL DEPTHS

The 65-year (including the partial year for 2006) hourly rainfall record was analyzed to identify the extreme rainfall depth in each year for durations of 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, and 24 hours. Table A-1 provides a listing of measured extreme rainfall by year and storm duration.

The hourly data set for the 65 years marked in Table A-1 was used to identify extreme rainfall amounts in each year for storms of durations of 2 hours, 3 hours, 4 hours, 6 hours, 12 hours, and 24 hours. This was performed in spreadsheets by keeping a running total of accumulated hours of the specified duration for each hour of the year. At the end of the year, rainfall depths from the following January 1 were added in to complete the requisite storm durations for December 31. In no case (all years, all storm durations) were any of these transitional storms the largest in a year.

ESTIMATION OF RETURN FREQUENCY FOR EACH STORM DURATION

The annual extreme rainfall depths from Table A-1 were fit to an extreme probability distribution. The Generalized Logistic (GLO) distribution was used, appropriate for storm durations from 15 minutes to 24 hours (Asquith, 2004). The parameters for this distribution can be estimated using L-moment statistics through the method of L-moments (described in Asquith, 2004). The results from the application of this method are presented in Table A-2.

Table A-3 provides a comparison to results presented in the most current source for DDF estimates for the El Paso area, USGS SIR 2004-5041 (Asquith and Roussel, 2004). Values from the USGS reference are somewhat ambiguous because depth estimates are provided as contours, and contours do not extend outside Texas. Therefore, estimates for the El Paso area often involve choosing a value west of the westernmost contour for the state. Values presented in Table A-2 are consistent with USGS values. The greatest differences occur at the 24-hour/1-day duration for the lower probability storms. Table A-4 shows how the storms from 2006 rank for each duration within the 65-year record.

REFERENCES

Asquith, William and Roussel, Meghan, 2004. Atlas of Depth-Duration Frequency of Precipitation Annual Maxima in Texas, U.S. Geological Survey Scientific Investigations Report 2004-5041.

Table A-1. Annual Rainfall Extremes at the El Paso Airport (in inches)

Year	Hourly Gage							Daily Gage
	Hours							
	1	2	3	4	6	12	24	
1942	0.46	0.46	0.53	0.56	0.70	0.83	0.99	
1943	0.26	0.36	0.49	0.53	0.53	0.81	1.19	
1944	0.48	0.49	0.67	0.69	0.73	0.90	1.00	
1945	0.48	0.59	0.68	0.80	1.12	1.65	1.77	
1946	0.72	0.86	0.92	0.93	0.93	1.02	1.05	
1947	0.28	0.28	0.29	0.29	0.32	0.37	0.37	
1948	0.68	0.79	0.86	0.86	0.87	0.92	0.93	0.93
1949	0.56	0.56	0.56	0.63	0.88	1.12	1.41	1.29
1950	0.52	0.68	1.01	1.14	1.41	1.63	1.64	0.91
1951	0.78	0.85	0.87	0.90	0.95	0.95	1.47	0.94
1952	0.39	0.46	0.55	0.60	0.74	0.85	0.89	0.82
1953	0.26	0.33	0.40	0.46	0.58	0.61	0.61	0.59
1954	1.01	1.02	1.02	1.02	1.02	1.20	1.70	1.66
1955	0.44	0.62	0.68	0.78	0.86	0.91	1.76	1.68
1956	0.41	0.77	0.81	0.81	0.81	0.81	0.87	0.81
1957	1.06	1.55	1.66	1.81	1.92	1.92	2.00	2.00
1958	1.21	1.37	1.40	1.51	1.77	1.96	2.52	1.96
1959	0.68	0.68	0.68	0.70	0.70	0.70	0.97	0.70
1960	0.64	1.14	1.33	1.39	1.54	1.58	1.75	1.75
1961	1.45	1.58	1.62	1.64	1.66	1.66	1.66	1.66
1962	0.85	1.29	1.33	1.34	1.36	1.62	1.69	1.62
1963	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
1964	1.23	1.58	1.70	1.76	1.77	1.77	1.79	1.77
1965	0.50	0.69	0.71	0.84	1.14	1.18	1.54	1.21
1966	0.61	0.79	0.82	0.98	1.17	1.41	1.45	1.17
1967	0.70	0.96	0.97	0.97	0.97	0.97	0.97	0.96
1968	1.20	1.29	1.31	1.31	1.32	2.20	2.63	1.65
1969	0.30	0.35	0.40	0.40	0.40	0.40	0.63	0.56
1970	0.54	0.58	0.58	0.59	0.59	0.59	0.59	0.59
1971	1.04	1.34	1.48	1.50	1.51	1.51	1.65	1.65
1972	0.65	0.82	0.92	0.97	1.32	1.63	1.76	1.55
1973	0.44	0.80	1.20	1.35	1.53	1.67	1.67	1.53
1974	0.88	0.88	0.88	0.88	0.97	1.57	2.44	2.26
1975	0.76	1.33	1.51	1.75	2.01	2.01	2.01	1.69
1976	0.88	1.33	1.51	1.51	1.51	1.51	1.51	1.51

Year	Hourly Gage Hours 1	2	3	4	6	12	24	Daily Gage
1977	0.45	0.75	0.78	0.80	0.80	0.80	0.98	0.80
1978	0.91	1.01	1.12	1.29	1.39	1.41	1.54	1.37
1979	0.38	0.76	0.76	0.76	0.76	0.76	0.76	0.76
1980	0.51	0.97	1.02	1.03	1.03	1.06	1.30	1.06
1981	1.10	1.53	1.53	1.54	1.55	1.55	1.83	1.54
1982	1.44	2.20	2.20	2.20	2.20	2.20	2.21	2.20
1983	0.39	0.50	0.50	0.80	0.98	0.98	0.98	0.98
1984	1.24	1.36	1.47	1.59	1.67	1.75	2.30	1.68
1985	0.76	1.01	1.06	1.06	1.06	1.06	1.06	1.06
1986	0.78	0.93	1.07	1.11	1.11	1.12	1.56	1.13
1987	0.69	0.75	0.76	0.76	0.81	1.05	1.76	1.46
1988	0.92	1.06	1.13	1.16	1.27	1.28	1.28	1.27
1989	0.65	0.98	0.99	1.01	1.20	1.42	1.47	1.19
1990	1.04	1.27	1.28	1.28	1.28	1.28	1.62	1.28
1991	1.00	1.03	1.03	1.03	1.06	1.11	1.22	1.18
1992	1.25	1.67	1.84	2.07	2.37	2.40	2.40	1.64
1993	0.83	1.08	1.08	1.08	1.08	1.08	1.08	1.08
1994	0.58	0.62	0.63	0.63	0.67	0.68	0.76	0.76
1995	0.46	0.63	0.70	0.70	0.70	0.70	0.90	1.13
1996	0.76	0.85	1.04	1.04	1.04	1.04	1.04	1.15
1997	0.79	0.90	0.90	0.90	0.90	0.90	0.90	0.90
1998	0.48	0.50	0.52	0.55	0.59	1.03	1.19	1.13
1999	0.74	0.88	0.91	0.92	0.92	0.92	0.92	0.99
2000	1.04	1.26	1.29	1.30	1.32	1.32	1.32	1.36
2001	0.59	0.60	0.60	0.60	0.60	0.60	0.60	0.60
2002	0.51	0.53	0.54	0.54	0.54	0.64	0.65	0.54
2003	0.32	0.56	0.76	0.85	0.90	0.93	1.02	0.99
2004	1.37	1.50	1.70	1.87	1.95	1.95	1.95	1.37
2005	1.52	2.06	2.14	2.18	2.25	2.26	2.89	2.26
2006	0.76	1.02	1.06	1.27	1.56	2.78	2.84	2.84

Table A-2. DDF for El Paso Airport

Return Frequency (years)	Return Probability	Hourly Data (Using GLO) 1 hr	2 hrs	3 hrs	4 hrs	6 hrs	12 hrs	24 hrs
1	1	0.41	0.52	0.57	0.61	0.66	0.72	0.80
2	0.5	0.70	0.88	0.95	0.99	1.07	1.18	1.35
5	0.2	0.97	1.22	1.30	1.36	1.46	1.61	1.83
10	0.1	1.15	1.45	1.55	1.62	1.73	1.91	2.16
25	0.04	1.41	1.79	1.89	1.99	2.11	2.33	2.60
50	0.02	1.61	2.06	2.18	2.30	2.43	2.68	2.96
100	0.01	1.84	2.36	2.49	2.64	2.78	3.06	3.34
250	0.004	2.18	2.82	2.96	3.16	3.30	3.63	3.89
500	0.002	2.47	3.21	3.37	3.62	3.74	4.12	4.35

Table A-3. Comparison Between DDF Curves from Table A-2 and Values in USGS SIR 2004-5041

El Paso Airport Depth-Duration-Frequency (per Table A-2)							
Return Frequency (years)	Return Probability	Duration					
		1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
1	1	0.41	0.52	0.57	0.66	0.72	0.80
2	0.5	0.70	0.88	0.95	1.07	1.18	1.35
5	0.2	0.97	1.22	1.30	1.46	1.61	1.83
10	0.1	1.15	1.45	1.55	1.73	1.91	2.16
25	0.04	1.41	1.79	1.89	2.11	2.33	2.60
50	0.02	1.61	2.06	2.18	2.43	2.68	2.96
100	0.01	1.84	2.36	2.49	2.78	3.06	3.34
250	0.004	2.18	2.82	2.96	3.30	3.63	3.89
500	0.002	2.47	3.21	3.37	3.74	4.12	4.35
El Paso Area Depth-Duration-Frequency (per USGS SIR 2004-5041)							
Return Frequency (years)	Return Probability	Duration (Interpolated from USGS 2004-5041)					
		1 hr	2 hr	3 hr	6 hr	12 hr	1-day*
2	0.5	0.5	0.9	0.9	1.1	1.1	1.3
5	0.2	1.1	1.2	1.3	1.4	1.6	1.8
10	0.1	1.6	1.6	1.7	1.7	1.9	2.3
25	0.04	1.8	1.9	2.1	2.4	2.3	2.7
50	0.02	2.2	2.3	2.4	2.3	2.5	3.7
100	0.01	2.5	2.6	2.7	2.9	3.2	3.8
250	0.004	2.8	3.2	3.3	3.4	3.8	4.2
500	0.002	3.3	3.6	3.8	3.9	4.5	5.0
Comparison							
Return Frequency (years)	Return Probability	Difference from USGS Results (USGS-ELP)					
		1 hr	2 hr	3 hr	6 hr	12 hr	1-day*
2	0.5	-0.2	0.0	0.0	0.0	-0.1	0.0
5	0.2	0.1	0.0	0.0	-0.1	0.0	0.0
10	0.1	0.4	0.1	0.2	0.0	0.0	0.1
25	0.04	0.4	0.1	0.2	0.3	0.0	0.1
50	0.02	0.6	0.2	0.2	-0.1	-0.2	0.7
100	0.01	0.7	0.2	0.2	0.1	0.1	0.5
250	0.004	0.6	0.4	0.3	0.1	0.2	0.3
500	0.002	0.8	0.4	0.4	0.2	0.4	0.6

*USGS 1-day statistics include data from daily precip gages.

Table A-4. Extreme Storms by Duration in El Paso Airport Data Record

1-Hour		2-Hour		3-Hour		4-Hour		6-Hour		12-Hour		24-Hour	
Year	Rain (in)	Year	Rain (in)	Year	Rain (in)	Year	Rain (in)	Year	Rain (in)	Year	Rain (in)	Year	Rain (in)
2005	1.52	1982	2.20	1982	2.20	1982	2.20	1992	2.37	2006	2.78	2005	2.89
1961	1.45	2005	2.06	2005	2.14	2005	2.18	2005	2.25	1992	2.40	2006	2.84
1982	1.44	1992	1.67	1992	1.84	1992	2.07	1982	2.20	2005	2.26	1968	2.63
2004	1.37	1961	1.58	1964	1.70	2004	1.87	1975	2.01	1968	2.20	1958	2.52
1992	1.25	1964	1.58	2004	1.70	1957	1.81	2004	1.95	1982	2.20	1974	2.44
1984	1.24	1957	1.55	1957	1.66	1964	1.76	1957	1.92	1975	2.01	1992	2.40
1964	1.23	1981	1.53	1961	1.62	1975	1.75	1958	1.77	1958	1.96	1984	2.30
1958	1.21	2004	1.50	1981	1.53	1961	1.64	1964	1.77	2004	1.95	1982	2.21
1968	1.20	1958	1.37	1975	1.51	1984	1.59	1984	1.67	1957	1.92	1975	2.01
1981	1.10	1984	1.36	1976	1.51	1981	1.54	1961	1.66	1964	1.77	1957	2.00
1957	1.06	1971	1.34	1971	1.48	1958	1.51	2006	1.56	1984	1.75	2004	1.95
1971	1.04	1975	1.33	1984	1.47	1976	1.51	1981	1.55	1973	1.67	1981	1.83
1990	1.04	1976	1.33	1958	1.40	1971	1.50	1960	1.54	1961	1.66	1964	1.79
2000	1.04	1962	1.29	1960	1.33	1960	1.39	1973	1.53	1945	1.65	1945	1.77
1954	1.01	1968	1.29	1962	1.33	1973	1.35	1971	1.51	1950	1.63	1955	1.76
1991	1.00	1990	1.27	1968	1.31	1962	1.34	1976	1.51	1972	1.63	1972	1.76
1988	0.92	2000	1.26	2000	1.29	1968	1.31	1950	1.41	1962	1.62	1987	1.76
1978	0.91	1960	1.14	1990	1.28	2000	1.30	1978	1.39	1960	1.58	1960	1.75
1974	0.88	1993	1.08	1973	1.20	1978	1.29	1962	1.36	1974	1.57	1954	1.70
1976	0.88	1988	1.06	1988	1.13	1990	1.28	1968	1.32	1981	1.55	1962	1.69
1962	0.85	1991	1.03	1978	1.12	2006	1.27	1972	1.32	1971	1.51	1973	1.67
1993	0.83	1954	1.02	1993	1.08	1988	1.16	2000	1.32	1976	1.51	1961	1.66
1997	0.79	2006	1.02	1986	1.07	1950	1.14	1990	1.28	1989	1.42	1971	1.65
1951	0.78	1978	1.01	1985	1.06	1986	1.11	1988	1.27	1966	1.41	1950	1.64
1986	0.78	1985	1.01	2006	1.06	1993	1.08	1989	1.20	1978	1.41	1990	1.62
1975	0.76	1989	0.98	1996	1.04	1985	1.06	1966	1.17	2000	1.32	1986	1.56
1985	0.76	1980	0.97	1991	1.03	1996	1.04	1965	1.14	1988	1.28	1965	1.54
1996	0.76	1967	0.96	1954	1.02	1980	1.03	1945	1.12	1990	1.28	1978	1.54
2006	0.76	1986	0.93	1980	1.02	1991	1.03	1986	1.11	1954	1.20	1976	1.51

APPENDIX B

COMPARISON OF FIXED GAGE RAINFALL ESTIMATES TO RADAR-BASED SPATIAL RAINFALL ESTIMATES

The purpose of Appendix B is to provide a comparison of point rainfall data (measured at fixed gage locations) to spatial rainfall data (XMRG data derived from radar measurements) for the study area, for the periods of intense rainfall during July through September 2006. This comparison is summarized in Table B-1. Fixed gage locations and the corresponding XMRG cells are presented in Figure 4 of the parent technical report.

The table is organized so that rainfall data from fixed gage locations (e.g., Fire Station 6) can be directly compared to spatial rainfall data for the XMRG cell in which the fixed gage is located (e.g., cell V37 for Fire Station 6) and one to three other XMRG cells closest to the fixed gage. Daily rainfall totals and totals for selected dates and subtotals for periods of most intense rainfall (July 31 to August 4; August 30 to September 5) are presented in the table. Hourly XMRG data and hourly fixed gage data (from "Rio Grande at Canutillo," "Rio Grande at El Paso," and "El Paso Airport") were totaled from 8 a.m. on the previous day to 8 a.m. on the day listed in the table. This corresponded to the usual practice at the fire stations, which was to take a manual reading of rainfall at 8 a.m. Some judgment was applied in the transferring of fire station data to this table, as recording practices varied from station to station. For this reason, the multiple-day total comparisons are more supportable when using the fire station data. The table has been annotated by color shading of cells. The colors indicate level of agreement between point data and spatial data, and in some cases, highlight dates where recorded data are suspect. The right two columns of the table provide notes and conclusions relating to the apparent viability of the XMRG rainfall estimates for use in analysis.

In general, the fixed gage data agree well at the El Paso, Canutillo, and El Paso Airport hourly gage locations. Data from these gages are maintained by the IBWC and the U.S. Weather Service. It is likely that the radar-based rainfall estimates were checked and adjusted to correspond to the gage data at these locations. Agreement is less consistent at the daily U.S. Weather Service gage at La Tuna, and the EPCWID#1 hourly gage at "Rio Grande at Canutillo." In particular, XMRG rainfall estimates in the region of cells V27, V28, V37, and V38 (see Figure 4 of the parent report) for August 1 may be significantly high. The extreme storm in the period July through September for most durations occurred on August 1 (see Table 8 of the parent report). Thus, the potential overestimate affects estimates of rainfall depth and associated storm return period for watersheds that intersect these XMRG cells: primarily Watershed 6, and to a lesser extent, Watershed 7 (see Figure 1 of the parent report for watershed locations, and Table 8 of the parent report for XMRG cell areas by watershed).

To improve agreement between radar rainfall data (cells V27, V28, V37, and V38) and point rainfall data (Fire Station 6 and the gage at "Rio Grande at Canutillo") for August 1 only, the following adjustments were made to the radar rainfall estimates:

- Cell V28 data were scaled down about 22% to match the larger daily total (1.76 inches) between the values measured at Fire Station 6 (1.76 inches) and "Rio Grande at Canutillo" (1.02 inches). The original V28 value for August 1 was 2.25 inches.
- The other cells with estimated high values (V27, V37, and V38) were scaled down in a manner that kept the relative difference in rainfall in inches constant between the cells. For example, cell V27 had an estimated daily rain total for August 1 of 3.03 inches, 0.77 inch larger than the unscaled value for V28 (2.25 inches). The adjusted V27 daily value was 1.76 inches (the adjusted V28 value) plus 0.77 inch, or 2.53 inches.

Table B-1. Summary of Comparison of Spatial Radar-Based (XMRG) Rainfall Data (inches) Versus Point Data (inches)

		Rainfall Totals (Inches)																								
	XMRG Cell	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5	8/6	Subtotal 7/27-8/4	8/16	8/17	8/19	8/26	8/31	9/2	9/3	9/4	9/5	Subtotal 8/30-9/5	Total 7/27-9/5	Note	Conclusion
Fire Station 5		0.00	2.00	0.00	0.00	0.00	0.00	2.08	1.65	0.00	0.00	0.00	5.73	0.00	0.00	0.00	0.00	0.39	0.00	0.00	1.38	0.10	1.87	7.61	8/2 reading probably includes 7/31/ and 8/1	XMRG data likely OK
	V72	0.00	2.12	0.32	0.03	0.07	0.77	1.92	1.35	0.05	0.23	0.04	6.64	0.34	1.28	0.16	0.02	0.52	0.74	0.86	1.20	0.06	3.37	12.11		
	V73	0.00	1.25	0.22	0.00	0.05	0.62	1.02	1.35	0.06	0.58	0.01	4.58	0.09	1.24	0.05	0.02	0.32	0.40	0.74	1.03	0.10	2.59	9.22		
	V82	0.00	1.58	0.29	0.01	0.08	0.80	1.49	1.12	0.03	0.49	0.01	5.41	0.10	1.25	0.14	0.05	0.24	0.44	0.82	1.04	0.11	2.65	10.13		
	V83	0.00	1.47	0.36	0.00	0.05	0.73	1.17	1.38	0.01	0.64	0.00	5.16	0.06	1.39	0.13	0.04	0.17	0.47	0.72	0.97	0.06	2.39	9.82		
Fire Station 6		0.00	2.40	0.04	0.00	0.10	1.76	0.00	0.00	1.00	1.30	0.00	5.30	no data											8/4 reading probably includes 8/2 and 8/3	XMRG OK except for 8/1, which appear high
	V27	0.05	0.64	0.25	0.14	0.33	3.03	1.25	0.81	0.23	0.27	0.51	6.72	0.52	0.64	1.37	0.13	0.31	0.96	0.93	0.82	0.15	3.25	14.17	8/1 values high, confirmed by Canutillo gage	
	V28	0.03	0.37	0.15	0.08	0.50	2.26	1.37	0.67	0.13	0.16	0.73	5.55	1.27	0.84	1.25	0.13	0.20	0.67	0.76	0.67	0.11	2.43	13.28		
	V37	0.00	0.81	0.25	0.01	0.14	3.31	1.70	1.12	0.05	0.16	0.12	7.38	0.15	0.76	1.05	0.01	0.15	0.93	0.83	1.11	0.03	3.04	12.78		
	V38	0.00	0.37	0.10	0.00	0.45	2.68	2.63	0.97	0.07	0.07	0.19	7.27	0.39	0.55	0.87	0.03	0.10	0.72	0.79	0.76	0.02	2.39	11.82		
Fire Station 7		0.00	1.35	0.00	0.00	0.00	0.45	0.00	0.00	0.20	0.10	0.00	2.00	0.00	1.40	0.20	0.00	0.05	1.75	0.00	2.00	0.00	3.80	7.68	Highly unlikely no rain on 8/2 and 8/3	No conclusion
	V27	0.05	0.64	0.25	0.14	0.33	3.03	1.25	0.81	0.23	0.27	0.51	6.72	0.52	0.64	1.37	0.13	0.31	0.96	0.93	0.82	0.15	3.25	14.17		
Fire Station 12		0.00	1.00	0.06	0.00	0.27	2.50	0.00	0.00	0.00	1.00	0.00	3.83	0.00	0.10	0.10	0.00	0.00	1.00	0.45	2.00	0.00	3.45	8.60	Highly unlikely no rain on 8/2 and 8/3, significant difference with nearby STN 13; 8/1 reading confirms high XMRG readings	No conclusion, but reinforces XMRG high rain on 8/1 (which governs)
	V68	0.00	0.20	0.05	0.00	1.55	2.60	2.03	0.91	0.26	0.22	0.10	7.60	0.72	0.21	0.41	0.11	1.64	0.24	1.01	1.28	0.07	4.25	13.92		
	V78	0.00	0.18	0.07	0.00	1.79	2.85	1.43	0.78	0.28	0.18	0.13	7.38	0.26	0.17	0.46	0.05	1.35	0.34	0.89	1.46	0.13	4.17	13.00		
Fire Station 13		0.00	0.00	1.44	0.00	0.34	0.00	2.18	1.95	0.00	0.00	0.00	5.91	0.00	0.00	0.65	0.00	0.75	0.00	1.03	1.51	0.00	4.09	11.19	8/2 reading probably includes 8/1	No conclusion
	V78	0.00	0.18	0.07	0.00	1.79	2.85	1.43	0.78	0.28	0.18	0.13	7.38	0.26	0.17	0.46	0.05	1.35	0.34	0.89	1.46	0.13	4.17	13.00		
	V79	0.00	0.17	0.07	0.01	1.58	2.53	1.12	0.78	0.15	0.28	0.12	6.41	1.12	0.24	0.49	0.13	0.98	0.46	0.90	1.54	0.16	4.03	13.17		
Fire Station 15		0.00	1.63	0.01	0.03	0.00	2.00	0.00	1.38	0.00	0.00	0.02	5.05	0.05	1.26	0.00	0.00	0.00	0.00	1.04	1.25	0.00	3.37	11.75	No readings 7/31 and 8/2	No conclusion, but reinforces XMRG high rain on 8/1 (which governs)
	V66	0.00	0.69	0.04	0.00	0.53	1.98	1.85	1.13	0.10	0.28	0.01	6.31	0.51	0.24	0.63	0.07	0.35	0.82	1.03	1.52	0.07	3.80	11.89		
	V67	0.00	0.44	0.06	0.00	1.46	2.49	1.73	1.22	0.11	0.13	0.05	7.50	0.44	0.32	0.65	0.07	0.36	0.22	1.12	1.77	0.11	3.58	12.87		
	V76	0.00	0.69	0.11	0.00	0.77	1.93	2.27	1.14	0.07	0.38	0.01	6.98	0.24	0.23	0.66	0.02	0.58	0.81	0.99	1.59	0.08	4.06	12.63		
	V77	0.00	0.47	0.07	0.00	1.45	2.24	1.67	1.23	0.10	0.27	0.11	7.25	0.26	0.19	0.59	0.02	0.89	0.28	0.96	1.57	0.09	3.80	12.65		
Fire Station 19		0.00	1.95	0.00	0.00	0.00	1.40	0.98	0.01	0.04	1.18	0.00	4.38	0.00	1.41	0.00	0.40	0.72	1.00	0.93	1.61	0.00	4.26	11.63		Stations 19, 21, 22 located near each other. Station 21 data likely a misrecording; Station 19 is 0.7 inches to 1.3 inches low vs XMRG, Station 22 is 0.5 inch high vs XMRG. July-August XMRG data appear OK.
	V43	0.00	1.18	0.08	0.00	0.07	1.18	1.58	0.84	0.20	0.03	0.24	5.14	0.20	1.01	0.33	0.06	0.27	0.66	0.71	1.43	0.10	3.16	10.37		
	V44	0.00	1.00	0.03	0.00	0.07	1.62	2.25	0.64	0.10	0.00	0.53	5.71	0.14	0.73	0.25	0.04	0.58	0.74	0.83	1.40	0.02	3.57	11.04		
	V53	0.00	1.52	0.17	0.00	0.12	1.10	1.63	0.75	0.11	0.06	0.16	5.41	0.84	1.11	0.48	0.05	0.34	0.98	0.88	1.44	0.04	3.68	11.91		
	V54	0.00	0.97	0.06	0.00	0.14	1.26	1.92	0.93	0.13	0.09	0.15	5.42	0.30	0.83	0.40	0.07	0.46	1.18	0.95	1.48	0.05	4.13	11.68		
Fire Station 21		2.10	0.00	0.00	0.00	2.10	2.10	1.85	1.60	0.02	0.17	0.21	9.77	0.76	0.00	1.62	0.20	1.43	0.29	1.45	1.75	0.00	4.92	17.73	Identical readings 7/31, 8/1 unlikely; inconsistent Aug storm total with nearby STNs 19, 22	
	V43	0.00	1.18	0.08	0.00	0.07	1.18	1.58	0.84	0.20	0.03	0.24	5.14	0.20	1.01	0.33	0.06	0.27	0.66	0.71	1.43	0.10	3.16	10.37		
	V44	0.00	1.00	0.03	0.00	0.07	1.62	2.25	0.64	0.10	0.00	0.53	5.71	0.14	0.73	0.25	0.04	0.58	0.74	0.83	1.40	0.02	3.57	11.04		
	V53	0.00	1.52	0.17	0.00	0.12	1.10	1.63	0.75	0.11	0.06	0.16	5.41	0.84	1.11	0.48	0.05	0.34	0.98	0.88	1.44	0.04	3.68	11.91		
	V54	0.00	0.97	0.06	0.00	0.14	1.26	1.92	0.93	0.13	0.09	0.15	5.42	0.30	0.83	0.40	0.07	0.46	1.18	0.95	1.48	0.05	4.13	11.68		
Fire Station 22		0.00	1.65	0.00	0.09	0.08	2.36	0.36	1.40	0.00	0.65	0.00	5.94	0.05	1.10	0.75	0.08	0.00	no data						STN 22 is high vs XMRG	
	V43	0.00	1.18	0.08	0.00	0.07	1.18	1.58	0.84	0.20	0.03	0.24	5.14	0.20	1.01	0.33	0.06	0.27	0.66	0.71	1.43	0.10	3.16	10.37		
	V44	0.00	1.00	0.03	0.00	0.07	1.62	2.25	0.64	0.10	0.00	0.53	5.71	0.14	0.73	0.25	0.04	0.58	0.74	0.83	1.40	0.02	3.57	11.04		
	V53	0.00	1.52	0.17	0.00	0.12	1.10	1.63	0.75	0.11	0.06	0.16	5.41	0.84	1.11	0.48	0.05	0.34	0.98	0.88	1.44	0.04	3.68	11.91		
	V54	0.00	0.97	0.06	0.00	0.14	1.26	1.92	0.93	0.13	0.09	0.15	5.42	0.30	0.83	0.40	0.07	0.46	1.18	0.95	1.48	0.05	4.13	11.68		
Fire Station 24		0.00	1.60	0.46	0.00	0.11	0.40	0.67	1.03	0.00	1.30	0.00	4.27	0.00	1.89	0.00	0.00	0.00	0.76	0.95	1.29	0.23	3.23	10.69		XMRG data bracket point data: likely OK
	V54	0.00	0.97	0.06	0.00	0.14	1.26	1.92	0.93	0.13	0.09	0.15	5.42	0.30	0.83	0.40	0.07	0.46	1.18	0.95	1.48	0.05	4.13	11.68		
	V64	0.00	0.64	0.02	0.00	0.16	0.63	0.37	0.75	0.06	0.13	0.03	2.62	0.57	0.19	0.36	0.04	0.31	0.79	0.98	1.45	0.06	3.58	7.63		

		Rainfall Totals (Inches)																								
	XMRG Cell	7/27	7/28	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5	8/6	Subtotal 7/27-8/4	8/16	8/17	8/19	8/26	8/31	9/2	9/3	9/4	9/5	Subtotal 8/30-9/5	Total 7/27-9/5	Note	Conclusion
Rio Grande at Canutillo		0.00	0.17	0.16	0.00	0.10	1.02	1.90	0.37	0.28	0.11	0.61	3.99	0.99	1.01	0.74	0.02	0.07	0.65	0.14	1.35	0.98	3.23	11.17		
	V17	0.00	0.51	0.04	0.00	0.11	2.27	0.88	0.62	0.00	0.01	0.37	4.44	0.22	0.50	0.93	0.01	0.12	0.73	0.79	0.66	0.04	2.35	8.88		8/1 XMRG values likely to be significantly too high
	V18	0.00	0.34	0.06	0.00	0.31	1.81	1.32	0.43	0.03	0.09	0.22	4.30	0.76	0.48	0.69	0.06	0.15	0.59	0.67	0.87	0.13	2.41	9.13		
	V27	0.05	0.64	0.25	0.14	0.33	3.03	1.25	0.81	0.23	0.27	0.51	6.72	0.52	0.64	1.37	0.13	0.31	0.96	0.93	0.82	0.15	3.25	14.17	8/1 values high, confirmed by STN 6	
	V28	0.03	0.37	0.15	0.08	0.50	2.26	1.37	0.67	0.13	0.16	0.73	5.55	1.27	0.84	1.25	0.13	0.20	0.67	0.76	0.67	0.11	2.43	13.28		
Rio Grande at El Paso		0.00	1.24	0.02	0.00	0.09	2.54	2.50	0.83	0.04	0.00	0.13	7.25	0.01	0.81	0.20	0.08	0.88	0.87	0.72	1.23	0.00	3.70	12.28		
	V44	0.00	1.00	0.03	0.00	0.07	1.62	2.25	0.64	0.10	0.00	0.53	5.71	0.14	0.73	0.25	0.04	0.58	0.74	0.83	1.40	0.02	3.57	11.04		XMRG data close to point data: OK
	V45	0.00	0.90	0.02	0.00	0.07	2.23	2.41	0.90	0.06	0.01	0.21	6.60	0.01	0.74	0.40	0.11	0.48	0.57	0.86	1.21	0.00	3.11	11.29		
	V34	0.00	1.37	0.05	0.02	0.16	1.68	1.72	0.73	0.14	0.02	0.75	5.86	0.06	0.68	0.23	0.16	0.53	0.58	0.85	1.31	0.12	3.40	11.51		
	V35	0.00	1.31	0.02	0.00	0.07	2.39	2.61	0.84	0.07	0.00	0.15	7.31	0.01	0.83	0.31	0.08	0.89	0.88	0.78	1.24	0.03	3.82	12.70		
El Paso Airport		0.01	0.83	0.07	0.00	0.39	1.90	1.56	1.14	0.00	0.95	0.00	5.90	0.12	0.28	1.06	0.18	0.28	0.95	1.13	1.56	0.10	4.02	12.51		
	V74	0.00	0.93	0.07	0.00	0.41	1.90	1.59	1.15	0.02	0.95	0.00	6.06	0.12	0.29	1.05	0.02	0.28	0.96	1.14	1.60	0.10	4.08	12.57		
	V75	0.00	0.99	0.13	0.00	0.40	1.35	1.60	1.22	0.01	0.63	0.01	5.70	0.21	0.29	0.61	0.01	0.42	1.05	0.89	1.54	0.09	4.00	11.47		XMRG data close to point data: OK
	V84	0.00	1.48	0.18	0.00	0.46	1.16	1.44	1.43	0.01	0.90	0.00	6.16	0.06	0.78	0.38	0.06	0.38	0.76	0.76	1.18	0.08	3.16	11.50		
	V85	0.00	0.90	0.17	0.00	0.27	1.19	1.48	0.90	0.00	0.49	0.01	4.90	0.06	0.32	0.25	0.01	0.75	0.57	0.71	1.05	0.08	3.15	9.23		
La Tuna		0.00	0.23	0.01	0.02	2.00	2.65	0.02	0.70	0.86	0.02	0.00	6.49	0.39	0.73	0.58	0.08	0.40	0.23	2.00	1.00	0.02	3.65	12.92		
	V19	0.00	0.50	0.10	0.00	0.17	1.99	0.96	0.48	0.05	0.40	0.12	4.24	0.66	0.49	0.58	0.10	0.41	0.32	0.79	1.04	0.18	2.76	9.52		
	V20	0.00	0.45	0.07	0.00	0.06	1.59	0.55	0.57	0.08	0.50	0.11	3.37	0.44	0.51	0.55	0.07	0.61	0.28	0.90	1.20	0.16	3.15	8.99		8/2 XMRG values likely to be significantly too high, otherwise XMRG OK
	V29	0.07	0.39	0.19	0.10	0.55	2.22	1.21	0.58	0.13	0.29	0.25	5.44	0.93	0.51	0.68	0.16	0.44	0.31	0.64	0.74	0.16	2.34	11.44		
	V30	0.21	0.58	0.73	0.56	0.99	2.63	2.07	0.86	0.77	1.10	0.64	9.39	1.54	0.89	1.14	0.41	0.99	0.35	1.26	1.43	0.35	4.66	22.45	8/2 reading appears too high	

Days with no or minimal rainfall are not shown

- Point and XMRG data in reasonable agreement
- Point data outside range of closest XMRG cells, difference approx 10-40 per cent
- Potential misreading or lack of reading at Fire Station, and associated totals
- Potentially significantly erroneous XMRG spatial rainfall estimate
- Bolded cells are XMRG cell in which point data source is located; e.g. Fire Station 6 is in XMRG Cell V37. Where multiple cells are bolded, the point gage is on the boundary between two XMRG cells