Sandia National Laboratories

# Scientific Analysis/Calculation Administrative Change Notice



*Complete only applicable items.*

| 1. Document Number: | ANL-MGR-MD-000015 | 2. Revision: | 00 | 3. ACN: | 01 |
|---|---|---|---|---|---|
| 4. Title: | Data Analysis for Infiltration Modeling: Extracted Weather Station Data Used to Represent Present-Day and Potential Future Climate Conditions in the Vicinity of Yucca Mountain | | | | |
| 5. No. of Pages Attached: | 13 | | | | |

| 6. Approvals: | | |
|---|---|---|
| Preparer: | Kathleen Economy Print Name and Sign: Kathleen Economy | Date: Feb 7, 2007 |
| Checker: | Alex Sanchez Print name and sign: Alex Sanchez | Date: 2/7/2007 |
| QCS/Lead Lab QA Reviewer: | Bruce Foster Print name and sign: Bruce Foster | Date: 2/7/2007 |
| Responsible Manager: | Kenneth Rehfeldt for Stephanie Kuzio Print name and sign: Kenneth Rehfeldt | Date: 2/7/2007 |

| 7. Affected Pages | 8. Description of Change: |
|---|---|
| vi | Table of Contents – incorporate DOE comment to delete placeholder for Section 6.<br><br>Editorial comment incorporated by deleting yellow highlight from Section 6.4.4. |
| 4-1 | Table 4.1-1, Column 3, Row 12 – Editorial comment incorporated by changing DIRS 176098 to DIRS 178311. |
| 6-4 | 3rd paragraph – incorporate DOE comment to change "five or more" to "six or more." |
| 6-6 | 3rd paragraph – incorporate DOE comment to delete "pressure," and 5th paragraph – incorporate DOE comments to insert ", 1999, 2002," and "one or more other stations" and to delete "YM Site 3." |
| 6-8 | Figure 6.1-2 – incorporate DOE comment to insert "NOTE: Median regression line (dashed), average regression line (solid)." |
| 6-25 | Table 6.1-8, 2nd column – to correct frequency from 54 to 55 for rate >2 to 3 mm/hr in response to CR 9937. |
| 6-50 | 2nd paragraph – incorporate DOE comment to delete the sentence "These lines were added to show similar seasonal variations among the sites, without attempting to distinguish which line was associated with a given site data set." |
| 6-55 | Figure 6.1-53 – incorporate DOE comment to delete the NOTE: "The trend lines shown do not distinguish between sites. The seasonal pattern occurring at all sites is discussed in Section 6.1.5.5. " |
| 6-59 | 3rd paragraph – line 8: incorporate DOE comments to change "that most frequently" to "that the most frequent" and to delete the comma between "total)" and "annual"; line 9: incorporate DOE comment to insert "amount" after "precipitation." |
| 6-72 | Figure 6.2-22 – incorporate DOE comment to insert "NOTE: Median regression line (lower line), average regression line (upper line)." |

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| | |
|---|---|
| 6-112 | 2nd paragraph – line 1: incorporate DOE comments to change "–6.3°C" to "–0°C"; line 7: incorporate DOE comment to insert a new sentence "The average annual temperature range, from the lowest minimum to the highest maximum, is –6.3°C to 30.8°C."<br><br>2nd paragraph, last sentence – editorial comment incorporated to correct lowest minimum temperature from "–6.3°C" to "–6.9°C." |
| 7-3 | Figure 7.1-2 – incorporate DOE comment to add a new sentence to the NOTE: "Median regression line (lower line), average regression line (upper line)." |
| 8-3 | Sec 8.3, 1st entry – editorial comment incorporated by changing DIRS number 176098 to 178311. |
| | |

## CONTENTS (Continued)

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# 4. INPUTS

## 4.1 DIRECT INPUTS

Sections 4.1.1 through 4.1.3 describe inputs used to perform calculations in this analysis.

### 4.1.1 Site-Specific Meteorological Data

Meteorological data collected at YM Sites 1, 2, 3, 6, and 9, during the period 1993 through 2004, are used as inputs to the calculations in this analysis. A subset of precipitation data collected at YM Site 8 in 2004 is also used as input to this analysis. The six sites from which data were collected have been physically checked frequently to prevent data loss, and have been maintained under the Yucca Mountain Project Quality Assurance Program. YM Sites 1, 2, 3, 6, 8, and 9 are located at various elevations within the modeled area (Figure 4.1-1), and are described in *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (BSC 2006 [DIRS 176722], Table A-1). Meteorological data collected from the six sites are appropriate as inputs for assessing spatial variability in climatic conditions within the controlled area that would affect infiltration within the Yucca Mountain region. Source records, with assigned data tracking numbers (DTNs) and corresponding years in which the data were collected, are shown in Table 4.1-1. These data are used as input to the analysis presented in Section 6.1.

Table 4.1-1. Collection Dates and Data Input Files

| Year in Which Data Were Collected | Microsoft® Access® File for Hourly Data | Source DTN |
|---|---|---|
| 1993 | Met1993.mdb | MO0312SEPQ1993.001 [DIRS 176092] |
| 1994 | Met1994.mdb | MO0312SEPQ1994.001 [DIRS 176093] |
| 1995 | Met1995.mdb | MO0312SEPQ1995.001 [DIRS 176094] |
| 1996 | Met1996.mdb | MO0312SEPQ1996.001 [DIRS 176095] |
| 1997 | Met1997.mdb | MO0312SEPQ1997.001 [DIRS 167116] |
| 1998 | Met1998.mdb | MO0206SEPQ1998.001 [DIRS 166731] |
| 1999 | met1999.mdb | MO0302METMON99.001 [DIRS 166165] |
| 2000 | met2000.mdb | MO0209SEPQ2000.001 [DIRS 166730] |
| 2001 | met2001.mdb | MO0305SEP01MET.002 [DIRS 166164] |
| 2002 | met2002.mdb | MO0305SEP02MET.002 [DIRS 166163] |
| 2003 | met2003.mdb | MO0503SEPMMD03.001 [DIRS 176097] |
| 2004 | metdata2004.mdb | MO0607SEPMMD04.001 [DIRS 178311] |

Data in the Access™ files were not always consecutively listed by Julian day. Therefore, a check was performed to ensure that data were listed consecutively, by Julian day. If data were not listed consecutively by Julian day, then the data were corrected by using the Excel® SORT function to sort on Julian day. After sorting was performed, data were plotted to ensure that there were no nonphysical outlier points. If outlier points were found, they were replaced with "n/a" designators.

Using built-in Excel® functions, hourly data were processed over the 24-hour daily cycle, starting with the first hour of the day and ending with the twenty-fourth hour:

- Using the AVERAGE function, daily averages were computed from the extracted 24-hour values.

- Using the MIN and MAX functions, minimum and maximum daily temperature values over the daily 24-hour periods were calculated from extracted hourly data.

- Using the SUM function, cumulative daily precipitation was calculated from hourly data.

Other than precipitation data, if within a single day six or more "n/a" designators were recorded for a measured parameter, then it was deemed that there were insufficient data for that 24-hour period to calculate meaningful averages or minimum and maximum values. Because precipitation is an intermittent and rare occurrence in desert locations, if a day contained more than five "n/a" designators, then professional judgment was used to ascertain whether cumulative precipitation was appropriately calculated. Justification for this approach is presented in Appendix E.

Daily temperature average values and daily minimum and maximum temperature were computed and placed in columns to the left of the source data in calculation worksheets. Cumulative precipitation over the 24-hour day was also computed in columns to the left of the source data. Computed data were located on every twenty-fourth row of the computational columns.

To facilitate viewing of computed data, the Excel® FILTER function was used in the computational columns, with the filter for nonblank rows turned ON, thereby hiding all blank rows and allowing every twenty-fourth row to be easily seen. In addition, daily values were copied without blanks, with the FILTER function invoked, from the calculation worksheets to the summary worksheets listed in Table 6.1-3.

### 6.1.4 Output Site-Specific Data Used for Present-Day Climate Conditions

Output DTN: SN0608WEATHER1.005 consists of six workbooks (Table 6.1-2) that contain values for daily minimum and maximum temperature and total precipitation, in addition to averages for temperature, relative humidity, barometric pressure, and wind speed. The provided data pertain to YM Sites 1, 2, 3, 6, and 9. The sixth workbook is precipitation and temperature data recorded at YM Site 8 for 2004 only. Temperature data are included with precipitation data. Computed daily values derived from hourly measurements are compiled in eight summary worksheets (Table 6.1-3); are listed by Julian day for years 1993 through 2004; and include site names, elevations, and universal transverse mercator (UTM) coordinates.

### 6.1.5 Salient Points of Precipitation, Precipitation Rate, Temperature, and Wind Speed Patterns Observed at Site-Specific Location

Infiltration is inherently tied to precipitation, precipitation rate, temperature, and (to a lesser extent) wind speed. These meteorological parameters are necessary inputs to an infiltration model and are therefore discussed further in Sections 6.1.5.1 and 6.1.5.2.

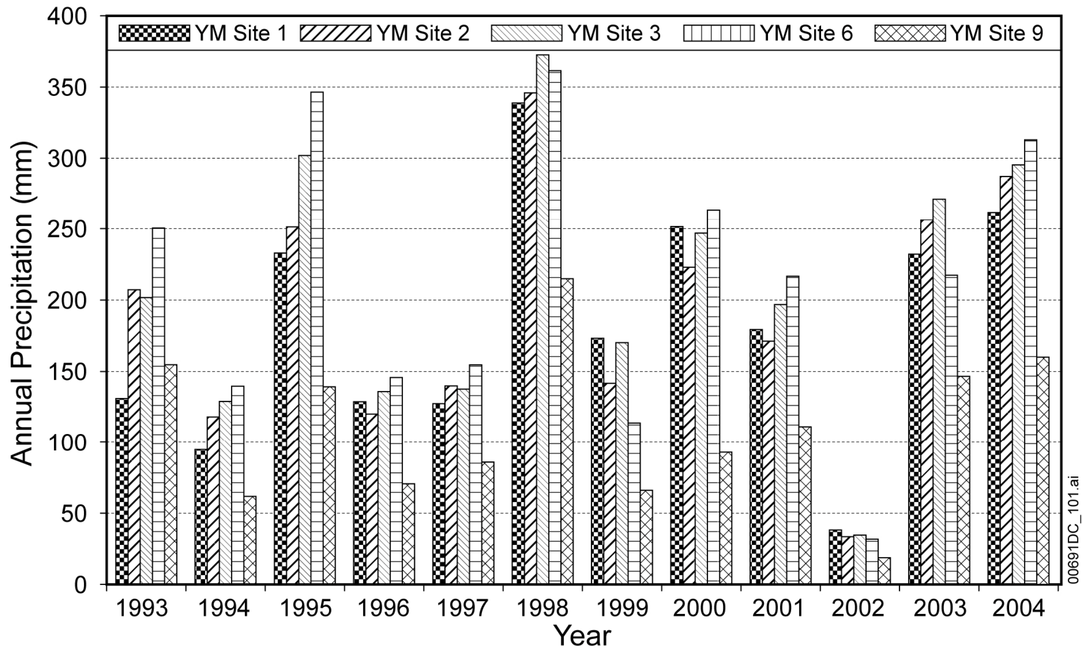
Other parameters, such as barometric pressure, dew point, and relative humidity, provide insights into yearly and daily conditions and cycles, but are not necessary inputs to infiltration modeling, and are not discussed further.

#### 6.1.5.1 Precipitation

Total yearly precipitation at YM Sites 1, 2, 3, 6, and 9, recorded from 1993 through 2004, is plotted in Figure 6.1-1. Due to instrumentation problems, precipitation recorded at YM Site 1 during Julian days 34 through 62, 2004, was underestimated. For those 29 days, therefore, precipitation data recorded at YM Site 8 was used as surrogate data for YM Site 1. The rationale for this use of surrogate data is that YM Site 8 is only 12 m lower in elevation than YM Site 1, and 1.5 km south-southeast.

Total precipitation by year and station are listed in Table 6.1-4. Precipitation in the Yucca Mountain vicinity varies yearly and by location (Figure 6.1-1). Of the five sites, with the exception of 1993, YM Site 9 consistently had the least yearly precipitation throughout the 12-year period, and YM Site 6 generally had the highest yearly precipitation (with the exception of years 1998, 1999, 2002, and 2003, during which one or more other stations recorded more precipitation). At all five sites, cumulative precipitation was highest in 1998.

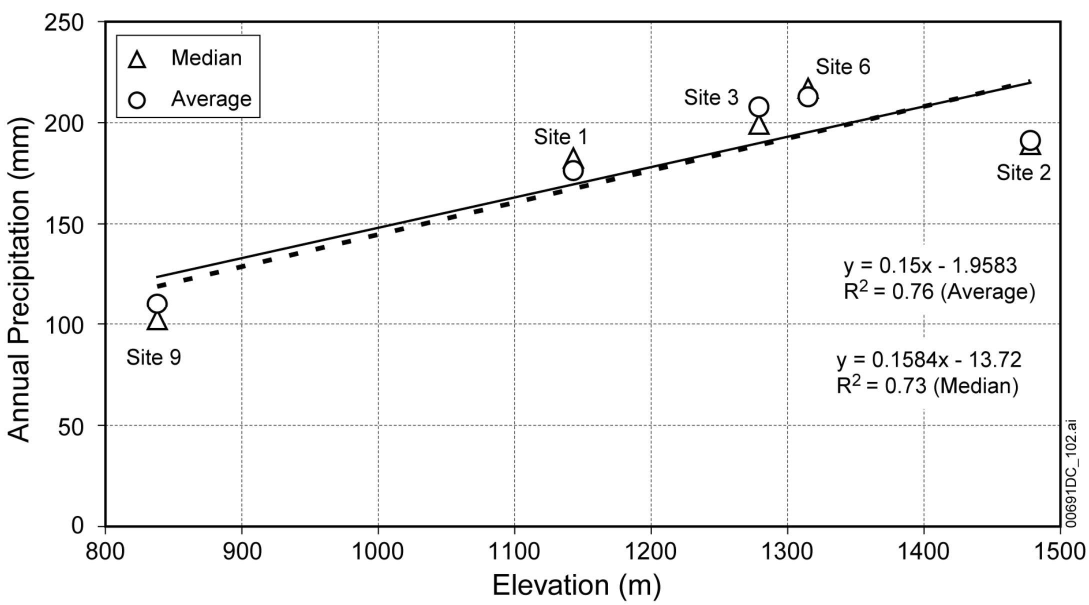
Average and median precipitation was calculated for the five sites over the 12-year time period (1993 through 2004) to determine whether a correlation exists between precipitation and elevation. Calculations confirm that a correlation does exist between average and median yearly precipitation and elevation (Figure 6.1-2).




Source: See Appendix F.

NOTE: YM Site 1 precipitation data for Julian days 34 through 62 (2004) was replaced with surrogate precipitation data from YM Site 8.

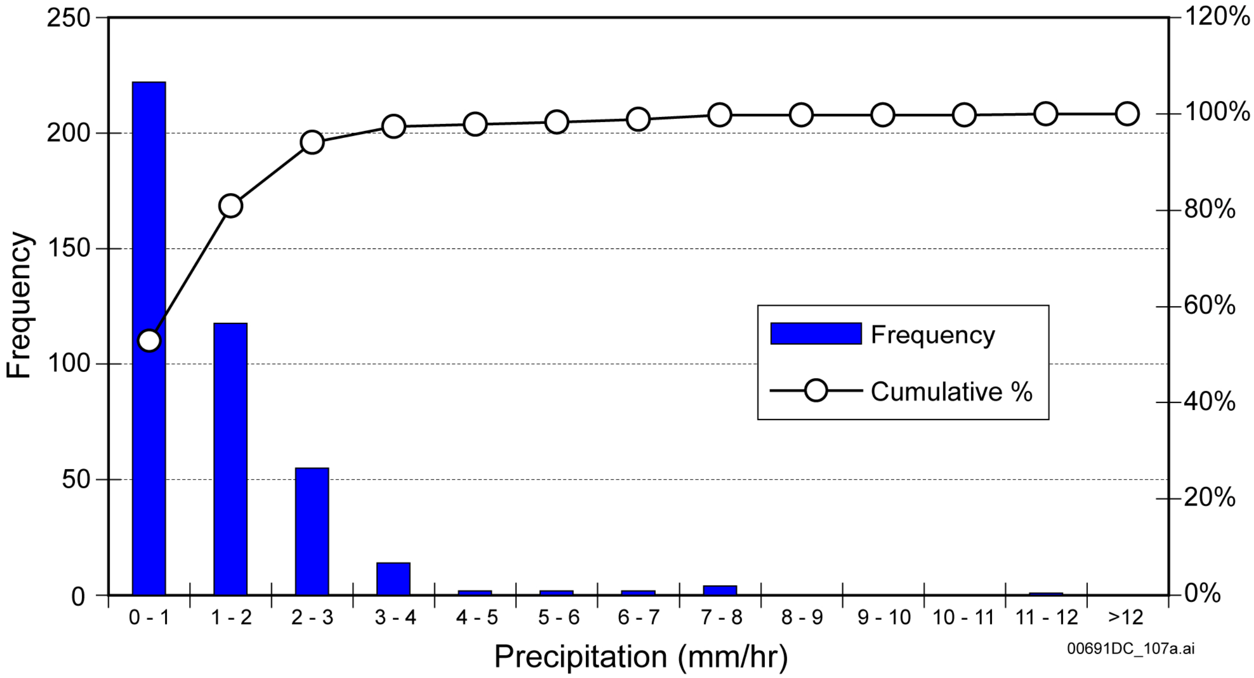
Figure 6.1-1. Yearly Precipitation at YM Sites 1, 2, 3, 6, and 9 (1993 through 2004)




Source: See Appendix F.

NOTE: Median regression line (dashed), average regression line (solid).

Figure 6.1-2. Average and Median Yearly Precipitation with Respect to Elevation for YM Sites 1, 2, 3, 6, and 9




Source: See Appendix F.

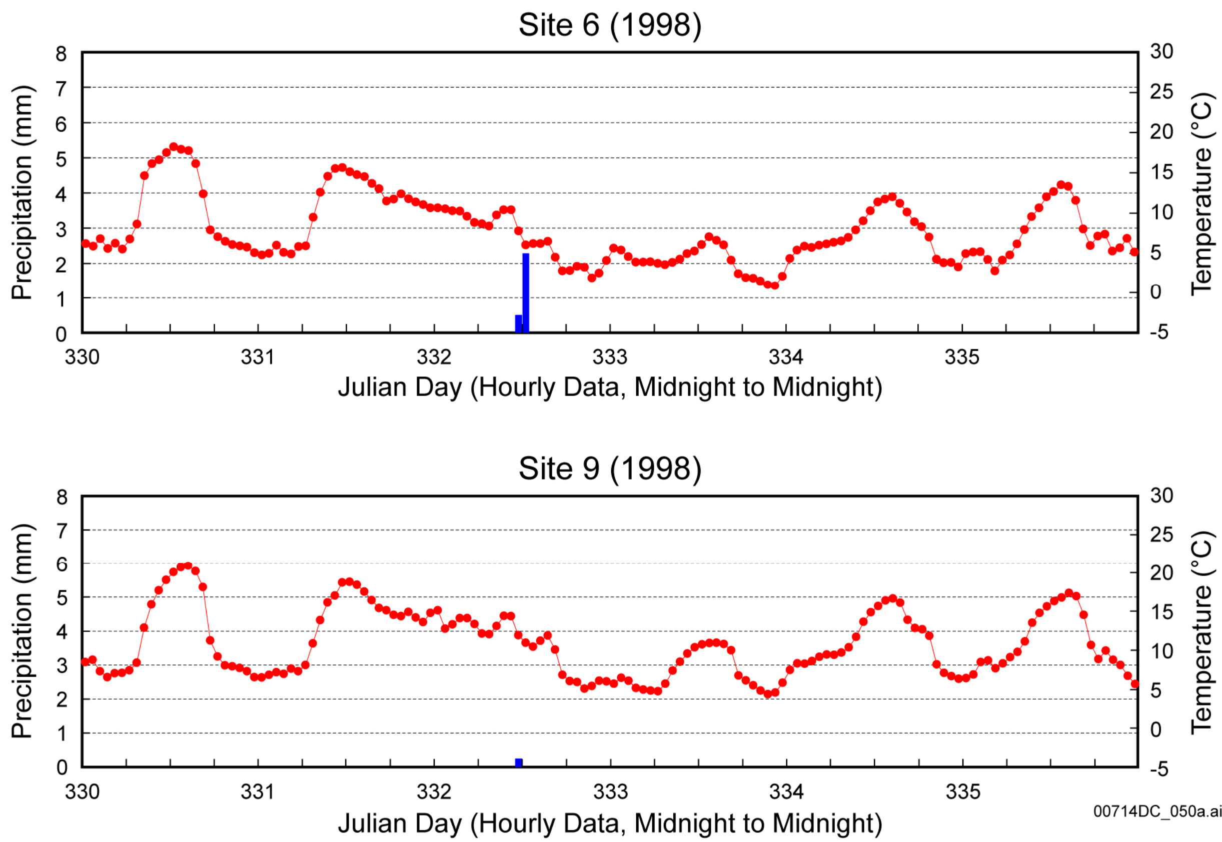
NOTE: Results are binned into groups arranged from lowest rate to highest rate. Frequency is the number of times, within the period of record, that a particular precipitation rate (mm/hr) occurs.

Figure 6.1-23. YM Site 6 Precipitation Rate Histogram for Years 1993 through 2004

Table 6.1-8. YM Site 6 Histogram Table for Precipitation Rates for Years 1993 through 2004

| **Calculated Daily Precipitation Rate and Frequency for All Days (ranked by rate)** | | |
|---|---|---|
| **Rate (mm/hr)** | **Frequency** | **Cumulative %** |
| 0 | 3,963 | 90.42 |
| >0 to 1 | 222 | 95.48 |
| >1 to 2 | 118 | 98.17 |
| >2 to 3 | 55 | 99.43 |
| >3 to 4 | 14 | 99.75 |
| >4 to 5 | 2 | 99.79 |
| >5 to 6 | 2 | 99.84 |
| >6 to 7 | 2 | 99.89 |
| >7 to 8 | 4 | 99.98 |
| >8 to 9 | 0 | 99.98 |
| >9 to 10 | 0 | 99.98 |
| >10 to 11 | 0 | 99.98 |
| >11 to 12 | 1 | 100.00 |
| >12 | 0 | 100.00 |

| **Calculated Daily Precipitation Rate and Frequency for “Wet” Days (ranked by frequency)** | | |
|---|---|---|
| **Rate (mm/hr)** | **Frequency** | **Cumulative %** |
| | | |
| 0 to 1 | 222 | 52.86 |
| 1 to 2 | 118 | 80.95 |
| 2 to 3 | 55 | 94.05 |
| 3 to 4 | 14 | 97.38 |
| 7 to 8 | 4 | 97.86 |
| 4 to 5 | 2 | 98.33 |
| 5 to 6 | 2 | 98.81 |
| 6 to 7 | 2 | 99.76 |
| 11 to 12 | 1 | 100.00 |
| 8 to 9 | 0 | 100.00 |
| 9 to 10 | 0 | 100.00 |
| 10 to 11 | 0 | 100.00 |
| >12 | 0 | 100.00 |




Source: See Appendix F.

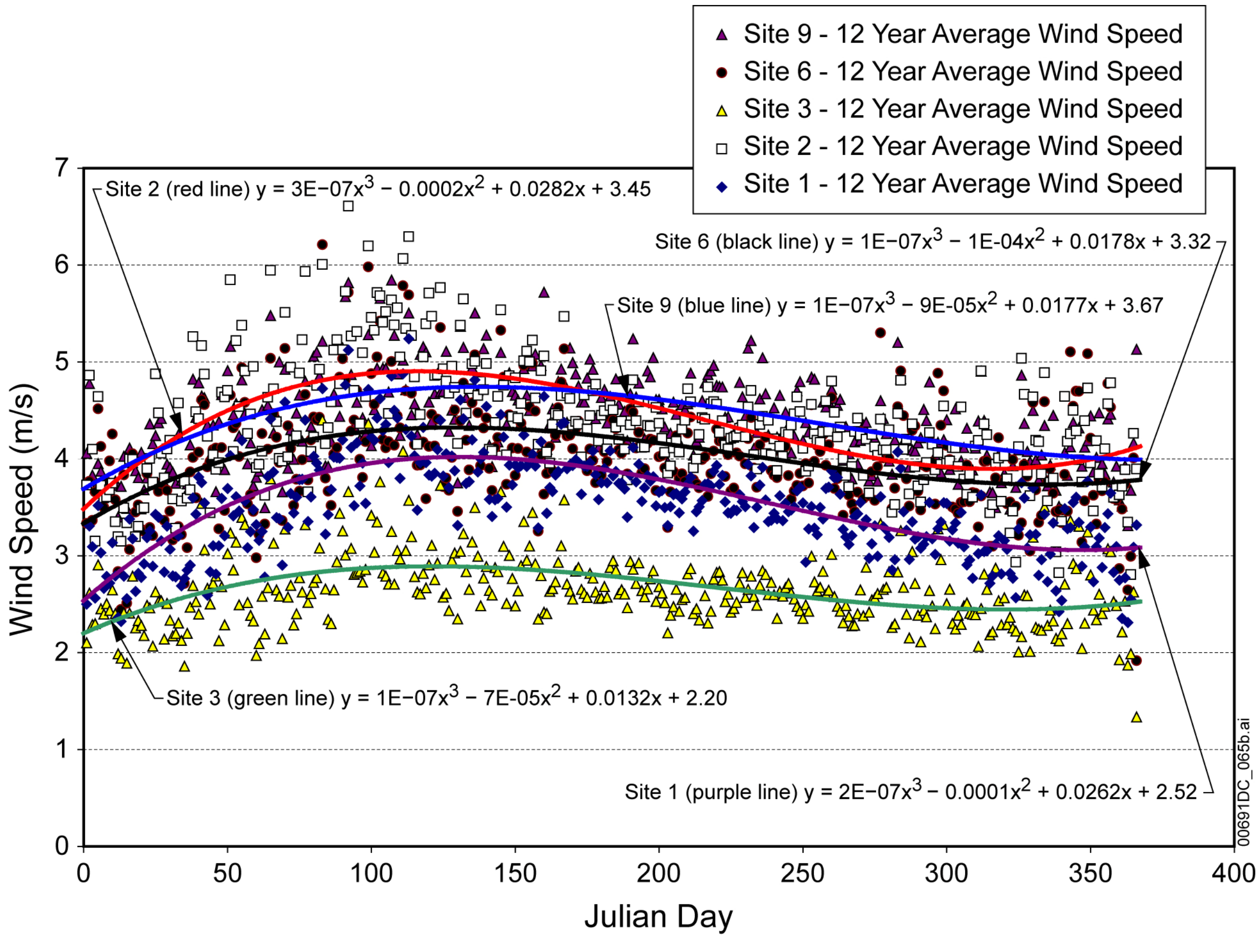
NOTE: Temperature and precipitation are plotted as hourly data.

Figure 6.1-47. Temperature and Precipitation for YM Sites 6 and 9 (1998), Julian Days 330 through 335

### 6.1.5.5 Wind Speed

Figures 6.1-48 through 6.1-52 show scatter plots of all daily wind speed averages for YM Sites 1, 2, 3, 6, and 9 for the period from 1993 through 2004. Data from Sites 1, 2 and 9 cover all 12 years, but the wind data from Site 3 and Site 6 end during 1999. Individual daily average wind speeds during the period were used to calculate average wind speeds for each day of the year, which are shown in Figures 6.1-48 through 6.1-52.

Figure 6.1-53 contains scatter plots of the daily averages calculated for the whole period by site. The figure also shows third-order polynomial trend lines fitted to the individual site daily averages, and the equations used to plot the trend lines. The point of the presentation is to visualize the common seasonal pattern evident at all sites, differing mostly by mean value.




Source: See Appendix F

NOTE: Curves and equations are polynomial fits to data.

Figure 6.1-53. Twelve-Year Average Daily Wind Speed for YM Sites 1, 2, and 9 (1993 through 2004), Six-and-a-Half-Year Average Daily Wind Speed for YM Sites 3 and 6 (1993 through 1998 and the first 195 days in 1999)

Table 6.2-1. Summary Worksheets with Computed Parameters of Daily Values by Julian Day (Continued)

| Excel® Workbook File | Summary Worksheet | Units | Data Description and Timeframe Julian Day (J_day) |
|---|---|---|---|
| *Amargosa Farms_97F.xls* (continued) | Daily MinTemp | degrees Celsius | Minimum temperature intermittently reported for J_day 335 of 1965 through J_day 212 of 1970; Large gaps of daily precipitation reports between J_day 212 of 1970 and J_day 365 of 1978; Minimum temperature reported for J_day 1, 1979, through December 2004 with a few gaps. |
| | Daily_MaxTemp | degrees Celsius | Maximum temperature intermittently reported for J_day 335 of 1965 through J_day 212 of 1970; Large gaps of daily precipitation reports between J_day 212 of 1970 and J_day 365 pf 1978; Maximum temperature reported for J_day 1 of 1979 through December 2004 with a few gaps. |

Source: Output DTN: SN0601PRECPTMP.002.

### 6.2.5 Salient Points for Precipitation and Temperature

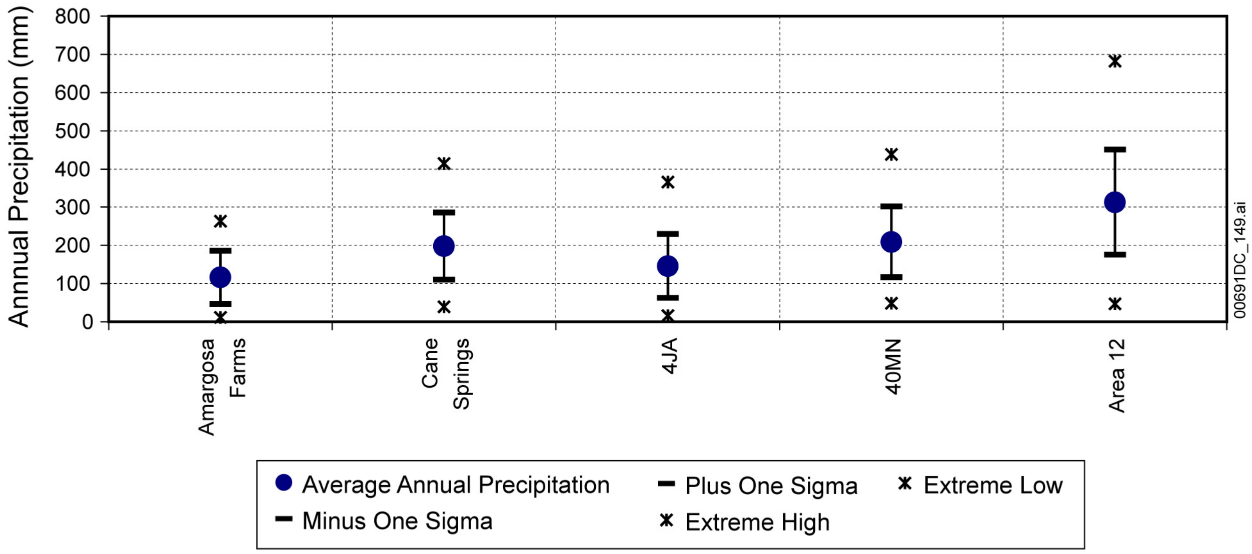
#### 6.2.5.1 Precipitation

Presented in this section are scatter plots and bar plots of precipitation data for the locations Amargosa Farms–Garey, Area 12, Site 4JA, 40MN, and Cane Springs. For each of the five locations, four plots of precipitation data are presented.

The first plot is a bar plot of annual precipitation for each year; this plot also includes an average precipitation over the period of record. The second plot is a scatter plot illustrating daily precipitation; this scatter plot indicates the distribution of precipitation throughout the year. The third plot is a 15-day interval precipitation plot; the precipitation plot presents an average precipitation, calculated for each day of the year. The daily averages are grouped into 15-day intervals, and plotted on a bar graph. These 15-day interval plots show seasonal variability for precipitation. The fourth plot is a histogram of annual precipitation.

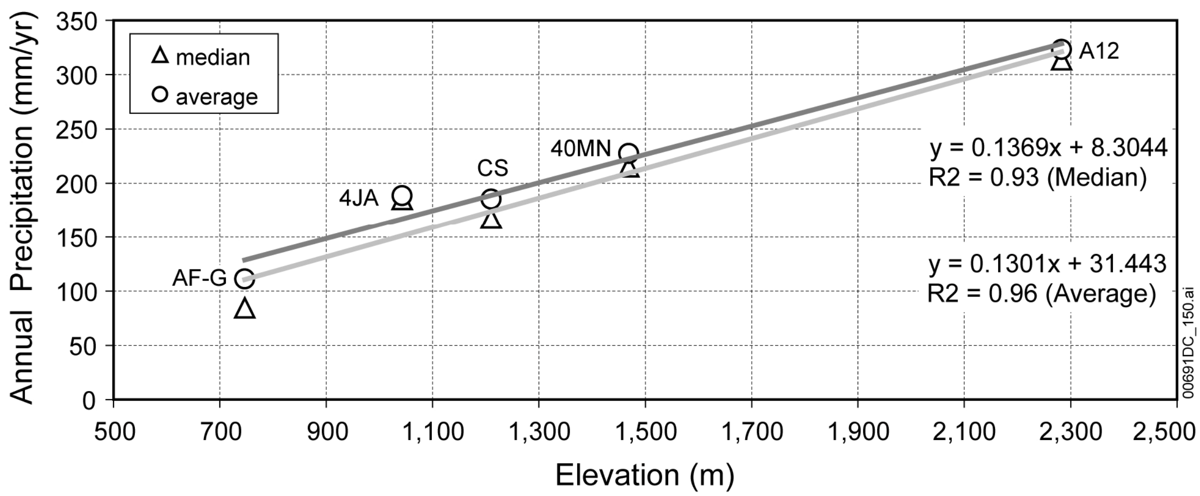
<u>Amargosa Farms–Garey</u>

Annual precipitation for the period 1965 through 2004 is shown in Figure 6.2-1. At Amargosa Farms–Garey, the highest annual precipitation during the period was 263 mm, and occurred in 1983; the lowest annual precipitation was 11 mm, and occurred in 2002. For the 32 years of complete yearly record, the average annual precipitation is approximately 106 mm. From 1971 through 1977, inclusive, and throughout 2001, no precipitation data were available. Figures 6.2-2 and 6.2-3 indicate that two wet periods occurred: one from Julian day 1 through Julian day 75, and the other from Julian day 196 through Julian day 240. The precipitation histogram (Figure 6.2-4) indicates that the most frequent (for 12 years, or 37% of the total) annual precipitation amount is between 50 and 100 mm. For seven of the 32 years (nearly 22% of the total), annual precipitation was 50 mm/yr or less. There were four years (or approximately 12% of the total) during which recorded precipitation exceeded 200 mm.




Source: See Appendix F.

Figure 6.2-21. Average Annual Precipitation Plus and Minus One Standard Deviation (One Sigma) and Extreme High and Low Precipitation Values



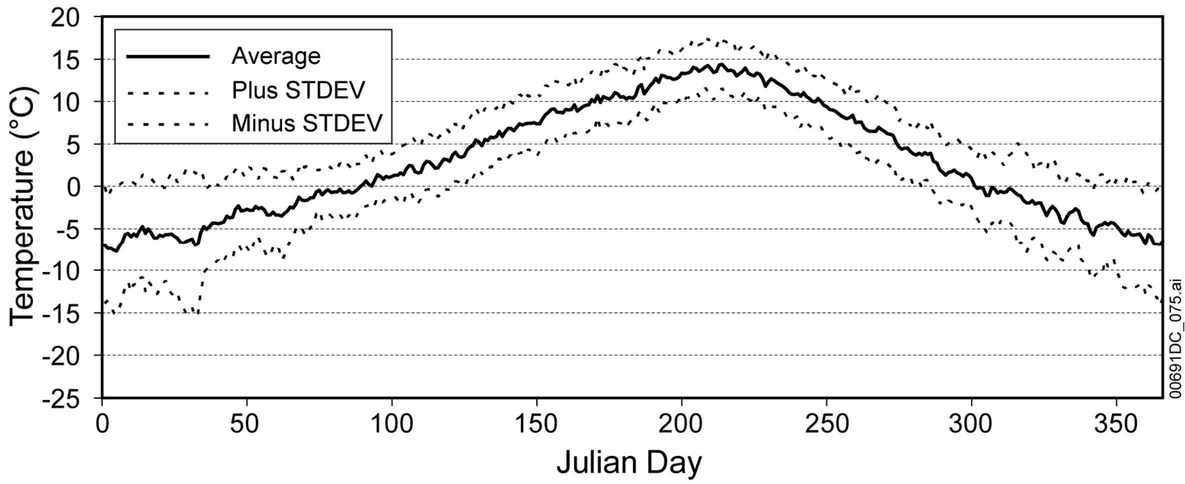

Source: See Appendix F.

NOTE: Median regression line (lower line), average regression line (upper line).

Figure 6.2-22. Average and Median Annual Precipitation with Respect to Elevation for Amargosa Farms–Garey, Area 12, Site 4JA, 40MN, and Cane Springs

### 6.2.5.2. Temperature

Figure 6.2-23 is a scatter plot of maximum temperature, and Figure 6.2-24 is a scatter plot of minimum temperature. Both figures also include daily average values.




Source: See Appendix F.

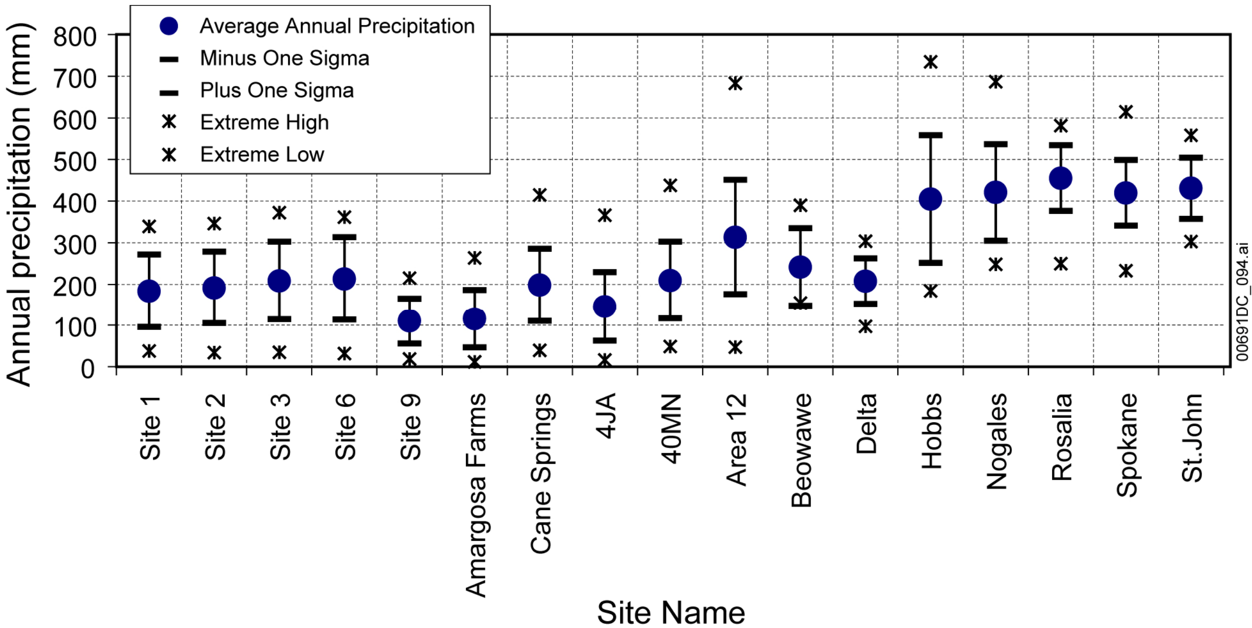
Figure 6.3-49. Average Annual Daily Minimum Temperature Plus and Minus One Standard Deviation Recorded at Spokane, Washington (1948 through 2004)

### 6.3.5.2.6 Rosalia, Washington

Daily maximum and minimum temperatures recorded at Rosalia, Washington, for the period 1949 through 2004, are plotted in Figures 6.3-50 and 6.3-51. Average minimum and maximum temperatures plus or minus one standard deviation are plotted in Figures 6.3-52 and 6.3-53. The overall trend reflects the standard seasonal temperature profile.

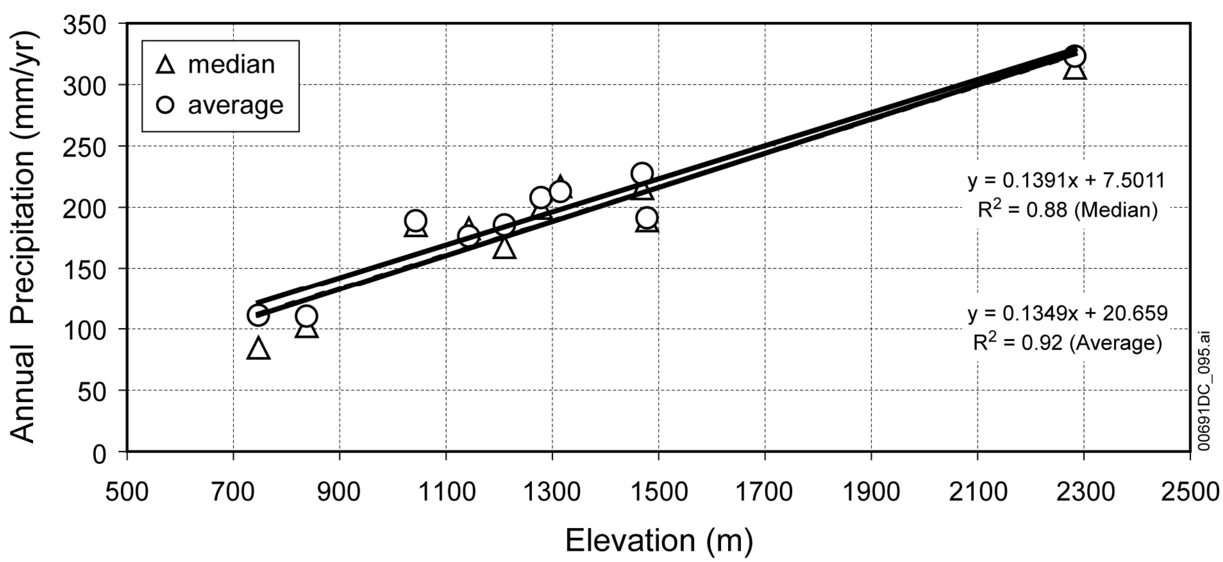
The average annual maximum temperature varies between −0°C and 30.8°C, peaking on or about Julian day 209, after a gradual upward trend that begins around the first of the year (Figure 6.3-52). After the early summer peak, a downward trend begins, but at a steeper rate relative to the first half of the year, dropping to the average annual minimum temperature of −6.9°C on approximately Julian day 2. The average minimum daily temperature profile is similar to the average maximum daily temperature, but with an average annual range of −6.9°C to 11.9°C. The average annual temperature range, from the lowest minimum to the highest maximum, is –6.9°C to 30.8°C.

The standard deviation varies approximately 4°C to 6.5°C in winter and decreases to approximately plus or minus 3.5°C to 5°C from Julian days 70 through 80 (Figures 6.3-52 and 6.3-53). The trend then reverses, with the range increasing to approximately plus or minus 4.5°C to 6°C by Julian days 145 through 155. The range then decreases to approximately plus or minus 4°C to 5°C near Julian day 205. Another reverse in the standard deviation trend takes the range to approximately plus or minus 5°C to 6.5°C near Julian days 265 through 280. The trend then reverses by returning to the range of plus or minus 3°C to 5°C over Julian days 310 through 335, and then increases to a range of plus or minus 4°C to 6°C by Julian day 360. In terms of temperature fluctuations from one day to the next, therefore, early spring, midsummer, and mid-fall seem to be the most stable. This trend is similar to the trend in the Spokane profile (Figures 6.3-48 and 6.3-49).




Source: See Appendix F.

Figure 7.1-1. Average, Standard Deviation, and Extreme Values for Average Annual Precipitation




Source: See Appendix F.

NOTE: Meteorological stations representing the present-day climate conditions are YM Sites 1, 2, 3, 6, and 9, and Area 12, 4JA, Amargosa Farms-Garey, 40MN and Cane Springs. Median regression line (lower line), average regression line (upper line).

Figure 7.1-2. Average Annual Precipitation versus Elevation at Meteorological Stations Representing Present-day Climate Conditions

## 8.3 SOURCE DATA, LISTED BY DATA TRACKING NUMBER

178311 MO0607SEPMMD04.001. Meteorological Monitoring Data for 2004. Submittal date: 07/18/2006.

176092 MO0312SEPQ1993.001. Meteorological Monitoring Data for 1993. Submittal date: 12/24/2003.

176093 MO0312SEPQ1994.001. Meteorological Monitoring Data for 1994. Submittal date: 12/24/2003.

176094 MO0312SEPQ1995.001. Meteorological Monitoring Data for 1995. Submittal date: 12/24/2003.

176095 MO0312SEPQ1996.001. Meteorological Monitoring Data for 1996. Submittal date: 12/24/2003.

167116 MO0312SEPQ1997.001. Meteorological Monitoring Data for 1997. Submittal date: 12/24/2003.

166731 MO0206SEPQ1998.001. Meteorological Monitoring Data for 1998. Submittal date: 06/26/2002.

166165 MO0302METMON99.001. Meteorological Monitoring Data for 1999, Sites 1-9, Hourly and Ten Minute. Submittal date: 02/13/2003.

166730 MO0209SEPQ2000.001. Meteorological Monitoring Data for 2000. Submittal date: 09/09/2002.

166164 MO0305SEP01MET.002. Meteorological Monitoring Data for 2001. Submittal date: 05/21/2003.

166163 MO0305SEP02MET.002. Meteorological Monitoring Data for 2002. Submittal date: 05/21/2003.

176097 MO0503SEPMMD03.001. Meteorological Monitoring Data For 2003. Submittal date: 03/03/2005.

176099 SN0512NOAADATA.002. NOAA/ARL/SORD NTS Precipitation Data (1959-2004) and Amargosa Farms–Garey Precipitation, and Temperature Data (1965-2005).Submittal date: 12/12/2005.