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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

METEOROLOGICAL DATA SYNTHESIS STATUS REPORT

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NOTICE

EXECUTIVE SUMMARY

This report summarizes the status of meteorological data synthesis activities by the Radiological/Environmental Field Programs Department (R/EFPD) of the Civilian Radioactive Waste Management System Management and Operating Contractor (CRWMS M&O), Yucca Mountain Site Characterization Office (YMSCO). Meteorological data are collected in selected locations within the Yucca Mountain Site Characterization Project (YMP) study site by two YMP participants: M&O/Environmental Field Programs Division (EFPD) and Environmental Sciences Division (ESD), and the U.S. Geological Survey. Each of these participants operates one or more networks of meteorological instruments to support their specific YMP studies. Meteorological data are also taken within the region surrounding Yucca Mountain by a number of other governmental and private agencies.

The regional analyses of all available data are being accomplished according to the Scientific Investigation Implementation Plan (SIIP) for Regional Meteorology. The SIIP specifies four tasks: 1) acquiring site and regional meteorological data from diverse sources, 2) analyzing site and regional-scale atmospheric dispersion, 3) developing site climatological statistics for surface facility design, and 4) describing general regional meteorological conditions.

This report accomplishes two goals: 1) to summarize the progress toward the completion of SIIPTask 1 by identifying data sources, periods of record, data status, and reports on previous studies conducted near Yucca Mountain and 2) to summarize data availability for YMP participants who may need may require meteorological data to support their studies. To date, M&O/EFPD has acquired a large amount of meteorological data both from the site and from regional sources and continues to research additional sources. The analysis of the acquired data has not yet been completed to determine their adequacy for accomplishing SIIP Tasks 2 through 4. This determination will be made as scheduled in the SIIP.

The preliminary assessment of the available data and on-going monitoring activities indicates that adequate meteorological data will be available for planned analyses. Current monitoring plans include a study of airflow through Crater Flat using portable equipment. This study is intended to provide information relevant to atmospheric dispersion in an area lacking routine meteorological monitoring stations.

A future report will summarize the data collection activities, identify all data needed for site and regional analyses, including unqualified data that must be qualified, and confirm any gaps in the site or regional databases.

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1.0 INTRODUCTION

Meteorological data have been collected in the Yucca Mountain region for decades. A number of governmental and private agencies designed meteorological data collection networks and used various techniques to support a variety of studies. Some of these earlier efforts have ended while others continue. The U.S. Department of Energy (DOE) Yucca Mountain Site Characterization Project (YMP) includes three participant organizations that collect meteorological data in the YMP study area and who acquire data from non-project sources. The variety of data being collected and acquired reflect the differences between program purposes and plans for utilizing data. In order to ensure that the meteorological data users are aware of the various data sources available to them, an early step in performing the Regional Meteorology Study was to synthesize the diverse sources of meteorological data. This status report on the data synthesis effort is intended to provide descriptions of the meteorological data most likely to be used by Project participants. With this information, the participants will be better able to optimize data collection, acquisition, and analysis efforts. It is also intended to demonstrate progress toward a synthesized database of data collected by both YMP participants and non-participants. It is beyond the immediate scope of this status report to explicitly assess the adequacy of collected and acquired data to meet the needs of the Regional Meteorology investigations as outlined in the SIIP. M&O/EFPD will complete this analysis according to the schedule presented in the SIIP and determine if gaps in the data set exist.

A preliminary assessment of data acquired thus far indicates adequate meteorological data are being collected at Yucca Mountain to address near field atmospheric dispersion modeling requirements. In addition, regional data from the NTS are adequate to study regional air flow immediately east of Yucca Mountain. However, there is a lack of adequate surface data outside the NTS boundaries and into the southern Nevada region. A November 1993 intensive data collection effort provided some basic understanding of airflow both immediately east and west of the mountain (DOE, 1995d). Additional studies are planned to address the airflow west of the crest toward Beatty. Adequate upper air data are available from the Desert Rock weather station.

The Yucca Mountain Site Characterization Project requires that the quality assurance program described in DOE/RW-0333P, *Quality Assurance Requirements and Description* (QARD) apply to data used in certain types of site characterization analyses. Data used in these analyses may be either collected or acquired and qualified following procedures subject to the QARD. The data descriptions in this report include statements regarding QARD applicability to the data collection procedures, if known at this time. The remainder of the report will address specific data collection efforts at Yucca Mountain and the surrounding region.

2.0 BACKGROUND

This section provides background information on how and why each monitoring program collects meteorological data to meet program objectives. The data sources considered in this report are covered by two basic categories: data collected as part of the Yucca Mountain studies and data collected by groups outside the Project.

2.1 Yucca Mountain Project Meteorological Studies

The Project is currently collecting meteorological data in programs that have evolved during their operating periods. Collectively, the three programs are studying local and regional meteorology. However, the diverse program purposes dictate the differences in measurement locations and techniques. For example, stations established to determine airflow patterns may not provide the site-specific information needed for vegetation and hydrologic infiltration studies. A brief synopsis of the three Project studies follows.

- The Management and Operating (M&O) Environmental Field Programs Division (EFPD) has the primary task of characterizing atmospheric dispersion conditions in the Project study and surrounding regional areas. This information will be used in the atmospheric dispersion modeling portion of impact assessments due to airborne radiological and non-radiological air quality emissions. The M&O/EFPD operates a nine-station meteorological network that measures a full complement of meteorological parameters. These data will also be used to determine typical and extreme meteorological values for engineering design and general current climate studies. The M&O/EFPD program was preceded by preliminary studies conducted by Sandia National Laboratories.

- The M&O Environmental Sciences Division (ESD) is studying site characterization effects on the terrestrial ecosystem as part of the Project environmental program. The primary interest in collecting meteorological data is in support of vegetation production studies. Precipitation and temperature data are collected at up to 48 environmental study plots (ESP).

- The U.S. Geological Survey (USGS) is conducting investigations of the surface and subsurface hydrology of the Site and surrounding region. To support these studies, the USGS has collected a large amount of Site meteorological data from a network of five meteorological stations and two networks of precipitation gauges. The USGS has also acquired a large amount of historical precipitation data from cooperative stations throughout southern Nevada and southern California.

2.2 Non-Yucca Mountain Project Meteorological Data Sources

The sparsely populated south-central Nevada region has very few routine National Weather Service (NWS) stations taking a full range of meteorological data. The proximity of the Nevada Test Site (NTS) provides a nearby extensive network of routine monitoring stations and many specialized meteorological studies primarily related to atmospheric nuclear testing. The NTS network has been operated by special groups within the National Oceanic and Atmospheric Administration (NOAA) and predecessor organizations. Other federal and private groups have taken a variety of meteorological data for specialized purposes.

- The NOAA Air Resources Laboratory, Special Operations and Research Division (ARL/SORD) is operating the NTS Meteorological Data Acquisition (MEDA) Network. The MEDA network, installed in 1983 as an upgrade of an earlier network, was designed to provide real-time meteorological information during NTS operations. ARL/SORD also operates a network of precipitation gauges throughout the NTS.

- ARL/SORD operates a surface and upper air observation station at Desert Rock. This site originated in the 1950s at Yucca Flat and moved to its present location in 1979.

- The NWS provides a full range of hourly surface meteorological observations as part of the national meteorological observing network at Tonopah, Ely, Elko, Reno, Las Vegas, Winnemucca, and Lovelock. In addition, the NWS takes twice-daily upper air soundings at Reno (formerly at Winnemucca)and Elko (formerly at Ely)

- NOAA supervises a nationwide network of cooperative or volunteer weather observers. Some of these are located within the Yucca Mountain region. Observations are limited to daily measurements of precipitation and maximum and minimum temperature.

- The Bureau of Land Management (BLM) operates remote automated weather stations (RAWS) throughout the western U.S. The data are used primarily to assess fire danger. Several of these stations are within the Yucca Mountain region.

- The USGS operates a meteorological station adjacent to the low-level radioactive waste burial facility along U.S. Highway 95, 10.5 miles southeast of Beatty, Nevada and approximately 12 miles due west of Yucca Mountain. Data were collected as part of a study to estimate the potential for downward movement of radioactive nuclides into the unsaturated sediments below the waste burial trenches.

- Nevada Power Company operates a network of meteorological and air quality stations, including a 100-meter meteorological tower near Moapa, Nevada, since 1978. Although this site is approximately 110 miles east of Yucca Mountain, the data may be useful in regional airflow studies.

- The U.S. Air Force and Sandia National Laboratories collected meteorological data from Tonopah Test Range, Nevada. These operations have concluded.

3.0 OBJECTIVE

The primary objective of this report is to describe the meteorological data being collected at Yucca Mountain and the surrounding region so Project participants are aware of the best data available for their purposes. Meteorological data are the primary subject in some Project studies, such as the atmospheric dispersion study. In other studies, the data are collected to support other scientific investigations, such as surface hydrology, precipitation infiltration, and vegetation distribution.

This data synthesis study is being performed in accordance with the Scientific Investigation Implementation Package (SIIP) for Regional Meteorology (DOE, 1995b). The SIIP specifies that the Project site and regional meteorological data be used to meet the following needs: 1) investigation of site and regional-scale atmospheric dispersion, 2) prepare climatological summaries for surface facility design, and 3) describe general regional meteorological conditions of the present-day climate. The work in the Regional Meteorology SIIP includes three Investigations from Section 8.3.1.12 of the Site Characterization Plan (SCP) (DOE, 1988)

4.0 METEOROLOGICAL MONITORING AND DATA ACQUISITION

4.1 Yucca Mountain Studies

This section discusses both past and current Project activities involved with meteorological data collection at the Yucca Mountain Site.

4.1.1 Early Studies at Yucca Mountain

In July 1982, Sandia National Laboratories brought one of two meteorological stations on-line to gather preliminary meteorological data. This 10-meter tower was installed on the Yucca alluvium (YA) east of Yucca Ridge. In November 1982, a second 10-meter tower was brought into operation on the Yucca Ridge (YR) top just east of and below the crest. Table 4-1 shows the geographical coordinates, elevations, and the meteorological variables measured at each site. Tower YA was

located at the present location of M&O/EFPD Site 1, and Tower YR was near the present site of M&O/EFPD Site 2 (see Figure 4-1). Both sites were operated until October 1984. Data summaries were prepared under four separate reports (Church et al, 1984a, 1984b, 1986, and 1987). These reports provide preliminary insight into seasonal and diurnal temperature and wind profiles. M&O/EFPD is in the process of acquiring these data sets for comparison with later data acquired under quality assurance program controls.

Table 4-1. Meteorological Towers Used for a Preliminary Evaluation of the Yucca Mountain Site.

Map ID	Wnd Dir (3)	Wnd Spd (3)	Tmp (3)	DP/ RH	Solar Rad	Gnd IR Rad	Pcp (2)	BP	Lat (1)	Long (1)	Elev (feet)	POR
YR (4)	X	X	X	X	X	X	TB	X	365051	1162751	4818	1982-1984
YA (5)	X	X	X	X	X	X	TB	X	365034	1162550	3751	1982-1984

Map ID = Map Identification, Wnd Dir = Wind Direction, Wnd Spd = Wind Speed, Tmp = Temperature, DP = Dew Point, RH = Relative Humidity, Solar Rad = Solar Radiation, Gnd IR Rad = Ground Infrared Radiation, Pcp = Precipitation, BP = Barometric Pressure, Lat = Latitude, Long = Longitude, Elev = Elevation, POR = Period of Record

NOTES: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).
(2) TB = Tipping-bucket precipitation gauge.
(3) Variables taken at both 3 and 10 meter-levels. Other variables taken at 3 meters except precipitation taken at 1-meter.
(4) YR = Yucca Ridge
(5) YA = Yucca Alluvial

Eglinton and Driecer (1984) produced a detailed collection of climate information and data for the engineering design of surface and subsurface facilities for a potential repository. Information was presented on precipitation, lightning, temperature, relative humidity, solar radiation, cloud coverage, wind, air pressure, and severe weather potential. These summaries will be updated using more recent site and regional data for the purpose of supporting surface facilities and repository engineering design.

4.1.2 M&O Environmental Field Programs Division

In December 1985, the DOE Yucca Mountain Site Characterization Project began a program to routinely collect meteorological data at Yucca Mountain designed to measure variables for input to atmospheric dispersion modeling. The initial network consisted of one 60-meter tower (Site 1) and four 10-meter towers (Sites 2 through 5). New 10-meter towers were added at Sites 6 through 8 in July 1992 and at Site 9 in January 1993. The numerical site designation was adopted in 1991 as the official site identifiers. Previously, Site 1 through 5 were identified by their named locations at the Site. Table 4-2 presents both the site location name and the number for completeness. The table also lists the geographic coordinates and elevation of each site. Figure 4-1 is a map showing the relative site locations at the Yucca Mountain Site. The equipment and methods used throughout the monitoring program are based on Nuclear Regulatory Commission (NRC) regulatory guidelines (NRC, 1972 and 1977) and Environmental Protection Agency (EPA) Prevention of Significant Deterioration (PSD) (EPA, 1987a) guidelines.

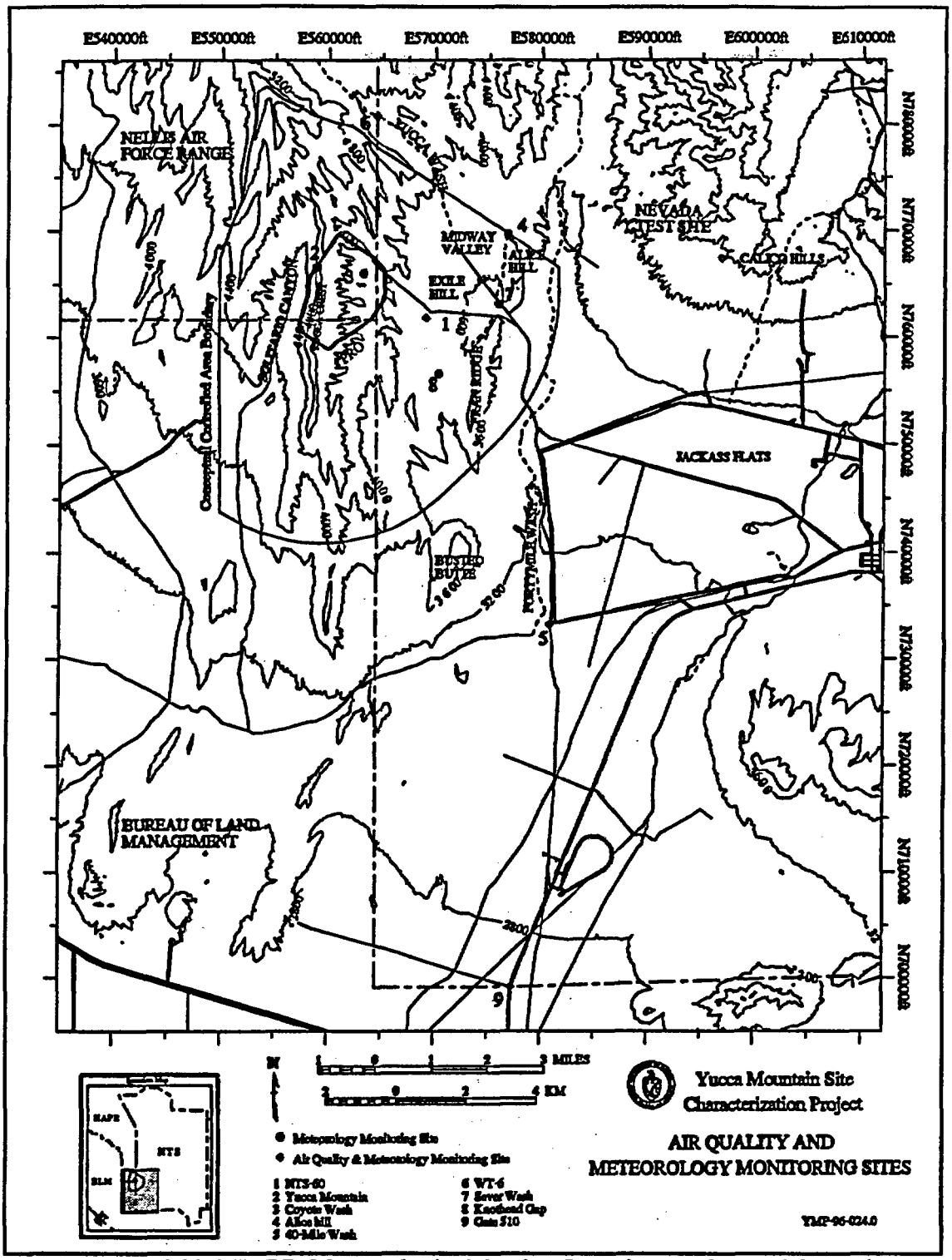

Figure 4-1. M&O/EFPD Meteorological Station Locations at Yucca Mountain.

Table 4-2. Geographical Locations of the Meteorological Monitoring Sites.

Site	Nevada System (feet)		Lat (1)	Long (1)	Elev (feet)	POR
	Easting	Northing				
Site 1 (NTS-60)	569126	761795	365034	1162550	3750	1985-1995
Site 2 (Yucca Mountain)	558844	766356	365119	1162756	4850	1985-1995
Site 3 (Coyote Wash)	562874	766171	365117	1162706	4195	1985-1995
Site 4 (Alice Hill)	576810	769661	365151	1162415	4050	1985-1995
Site 5 (40-Mile Wash)	580843	733378	364552	1162326	3125	1985-1995
Site 6 (WT-6)	564612	780592	365340	1162645	4315	1992-1995
Site 7 (Sever Wash)	575747	763324	365049	1162428	3545	1992-1995
Site 8 (Knothead Gap)	570344	756538	364942	1162535	3710	1992-1995
Site 9 (G-510)	577554	699491	364017	1162408	2750	1993-1995

Lat = Latitude, Long = Longitude, Elev = Elevation
NOTES: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss), POR = Period of Record

Site locations range from Gate-510 on the southern boundary of the Nevada Test Site (NTS) near Amargosa Valley to well pad WT-6, which is 15.5 miles northwest of Gate-510 along the western NTS boundary in Yucca Wash. Site elevations range from 2,750 feet above mean sea level (MSL) at Gate-510 to 4,850 feet above MSL on top of the Yucca Mountain ridge. The site locations and instruments were chosen primarily to characterize airflow and atmospheric dispersion near potential emission sources in Midway Valley and the east side of Yucca Mountain, and along potential airflow pathways toward populated areas. Since topographic features, such as hills and valleys, have significant influence on local airflow and related dispersion characteristics, the sites were located in a variety of topography and over a wide area. Airflow studies (Blumen, 1990) in areas with similar topography to that of Yucca Mountain have demonstrated complicated airflow and dispersion patterns. The data summary report for 1994 (DOE, 1995a) provides a detailed description of each site. The following summarizes: 1) site instrumentation, 2) meteorological variable sampling and averaging, and 3) quality assurance status of data.

Campbell Scientific, Inc. (CSI) dataloggers, powered by 12-volt batteries and recharged by solar panels at Sites 2 through 9 (AC power at Site 1), record data at each site. In particular, they record the following variables: horizontal wind speed and direction (10-meter level at all sites, and 60-meter level at Site 1), temperature (2 and 10-meter levels at all sites, and 60-meter level at Site 1), barometric pressure (2-meter level), relative humidity (2-meter level) at Sites 2 through 9, solar radiation (2-meter level), dew point (2-meter level at Site 1 only), and vertical wind speed (10-meter level), and precipitation using a tipping-bucket gauge. Each site also uses nonrecording storage gauge as a backup to the recording gauge. In addition to these measured values, the parameters of standard deviation of horizontal wind direction

(sigma-theta), standard deviation of vertical wind speed (sigma-w), standard deviation of horizontal wind speed (sigma-u), and vertical temperature difference (delta-T) are reported. These are indicators of atmospheric stability.

The sampling frequency and averaging period has evolved over the life of the network. The current sampling frequency is one second for each variable, and the data are averaged and recorded in three ways: 1) hourly averages, 2) 10-minute averages, and 3) daily extremes of certain measurements. The 10-minute averaging and reporting format and the daily summary of extreme winds, maximum and minimum temperature, and total precipitation were adopted in October 1993 for Sites 2 through 9 and January 1996 for Site 1. Tables 4-3, 4-4, and 4-5 list the reported data under each of these recording schemes, respectively.

Table 4-3. Reported Data - Hourly.

VARIABLE	CALCULATION METHOD	UNITS
Wind speed	scalar average	meters per second
Wind speed	maximum of 1-second averages	meters per second
Wind speed	maximum of 3-second averages	meters per second
Wind direction	average (unit vector)	degrees
Sigma-theta	root-mean-square of 15-minute standard deviations of wind direction	degrees
Sigma-w	standard deviation of vertical wind speed	meters per second
Temperature	average	degrees Celsius
Delta-temperature	average of differences: 10-meter - 2-meter, Sites 1 through 9; 60-meter - 10-meter, Site 1	Celsius degrees
Barometric pressure	average	millibars
Relative humidity	average: measured, Sites 2 through 9; calculated, Site 1	percent
Precipitation	total tips of the tipping-bucket mechanism	millimeters
Solar Radiation	average	Watts per square meter
Dew Point	average: measured, Site 1; calculated, Sites 2 through 9	degrees Celsius

M&O/EFPD operates and maintains the network according to QARD requirements. Frequent site visits, coupled with periodic independent field audits, ensure obtaining the highest-quality data. All sensors are carefully maintained and are recalibrated at approved intervals according to approved Nevada Work Instructions.

Validated data are submitted to the Project Technical Data Base (TDB). Data segments are discretely identified in the Project TDB by unique data tracking numbers (DTN) (see appendix A). These data may be obtained directly from the Project TDB using the DTN. Specific questions on the data should be directed to M&O/EFPD. M&O/EFPD prepares annual data summary reports which summarize data collection

activities and presents useful climatological information (DOE, 1993, 1994, 1995a). A future report is planned to present complete climatological summaries for each site. Address requests or data questions to M&O/EFPD (see Appendix D).

Table 4-4. Reported Data - Ten-Minute.

VARIABLE	CALCULATION METHOD	UNITS
Wind speed	scalar average	meters per second
Wind speed	maximum of 3-second running averages	meters per second
Wind speed	maximum 1-minute average	meters per second
Sigma-u	standard deviation of wind speed	meters per second
Wind direction	average (unit vector)	degrees
Wind direction	1-minute average direction during 1-minute maximum wind speed	degrees
Sigma-theta	standard deviation of wind direction	degrees
Vertical wind speed	average	meters per second
Sigma-w	standard deviation of vertical wind speed	meters per second
Temperature	average	degrees Celsius
Precipitation	total tips	millimeters
Delta-temperature	average of difference: 10-meter - 2-meter temperatures (also 60-meter - 10-meter for Site 1)	degrees Celsius
Solar radiation	average	Watts per square meter

Table 4-5. Reported Data - Daily.

VARIABLE	CALCULATION METHOD	UNITS
Wind speed	maximum 3-second running average	meters per second
Wind speed	maximum 1-minute average	meters per second
Precipitation	daily total (after 1994)	millimeters
Temperature	maximum 1-minute average	degrees Celsius
Temperature	minimum 1-minute average	degrees Celsius

4.1.3 M&O Environmental Sciences Department

The M&O/ESD (formerly EG&G) implemented a program to monitor and mitigate potential impacts to the environment and ensure activities comply with applicable environmental regulations during Site Characterization. To assess any effects on the terrestrial ecosystem, several ecological components were selected for monitoring. The program includes studies of vegetation, small mammals, reptiles, disturbance levels, and abiotic conditions.

In 1989 and 1990, forty-eight 200 by 200-meter ecological study plots (ESP) were selected to conduct these studies (See Figure 4-2). Vegetation was considered a key component of the Yucca Mountain ecosystem and a good indicator of the effects of site characterization activities. Arid ecosystems normally experience tremendous variability from year to year, mostly due to fluctuating precipitation amounts. Site-specific precipitation measurements were made using four-inch diameter plastic fence post rain gauges. Mineral oil was added to the collection tube to minimize evaporation between readings. At the beginning of 1995, the total number of ESPs was reduced to 19. This included the six far-field sites added north of Little Skull Mountain (See Figure 4-3).

Plots were visited on a weekly basis generally during the wetter seasons (winter and spring) and monthly during the drier seasons (summer and fall) although the frequency was determined by precipitation. During each visit, total precipitation was recorded, as well as maximum and minimum air temperature since the last visit. Soil moisture and temperature was recorded at the time of the visit only.

Meteorological data were analyzed in the context of the vegetation production results and reported in annual summary reports (EG&G, 1991, 1992, 1993, 1994, and 1995). M&O/ESD is preparing the meteorological data collected under this program for submission to the TDB. This program is not subject to the QARD requirements. To obtain more information on this activity, contact M&O/ESD (see Appendix D).

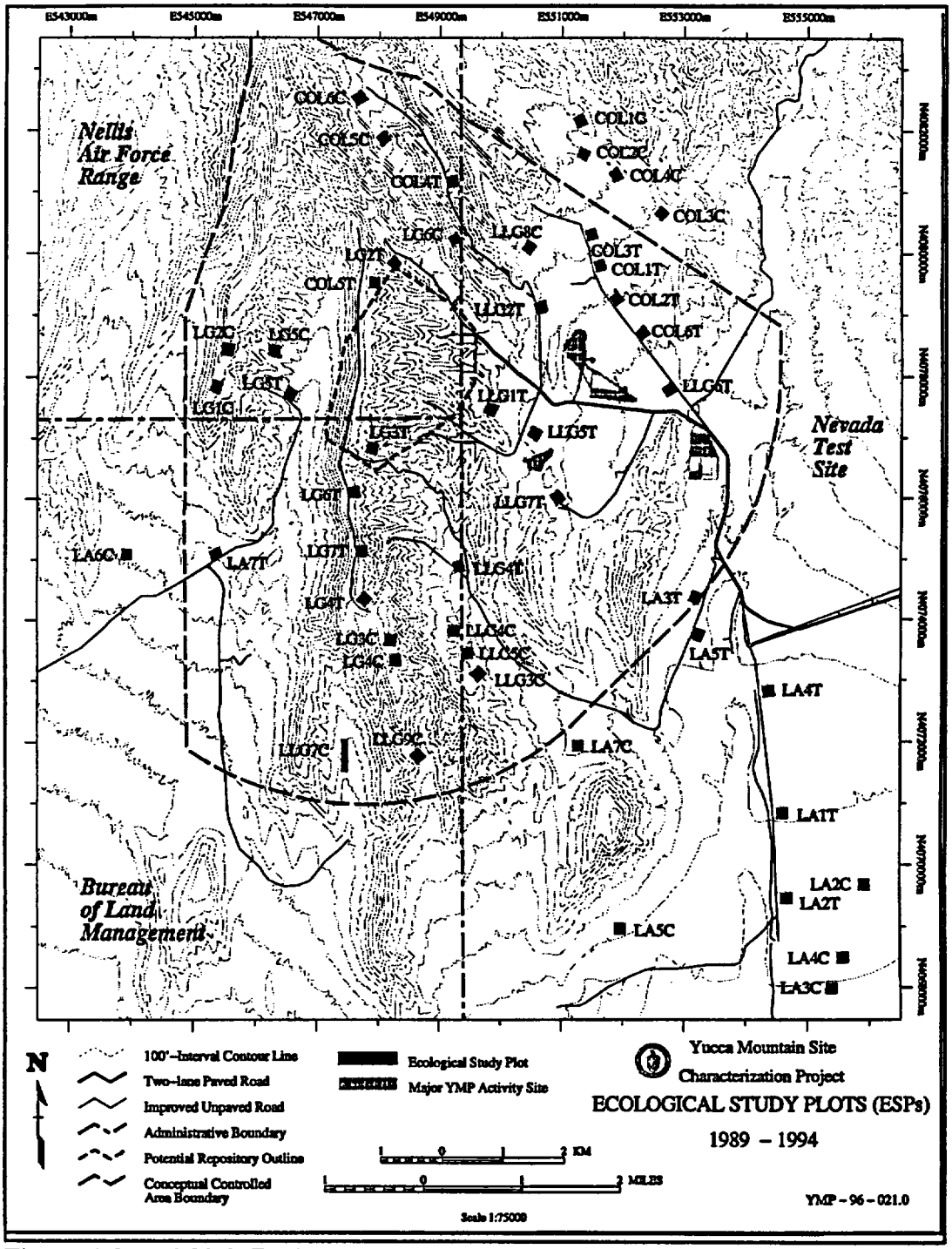

Figure 4-2. M&O Environmental Sciences Department Ecological Study Plots at Yucca Mountain.

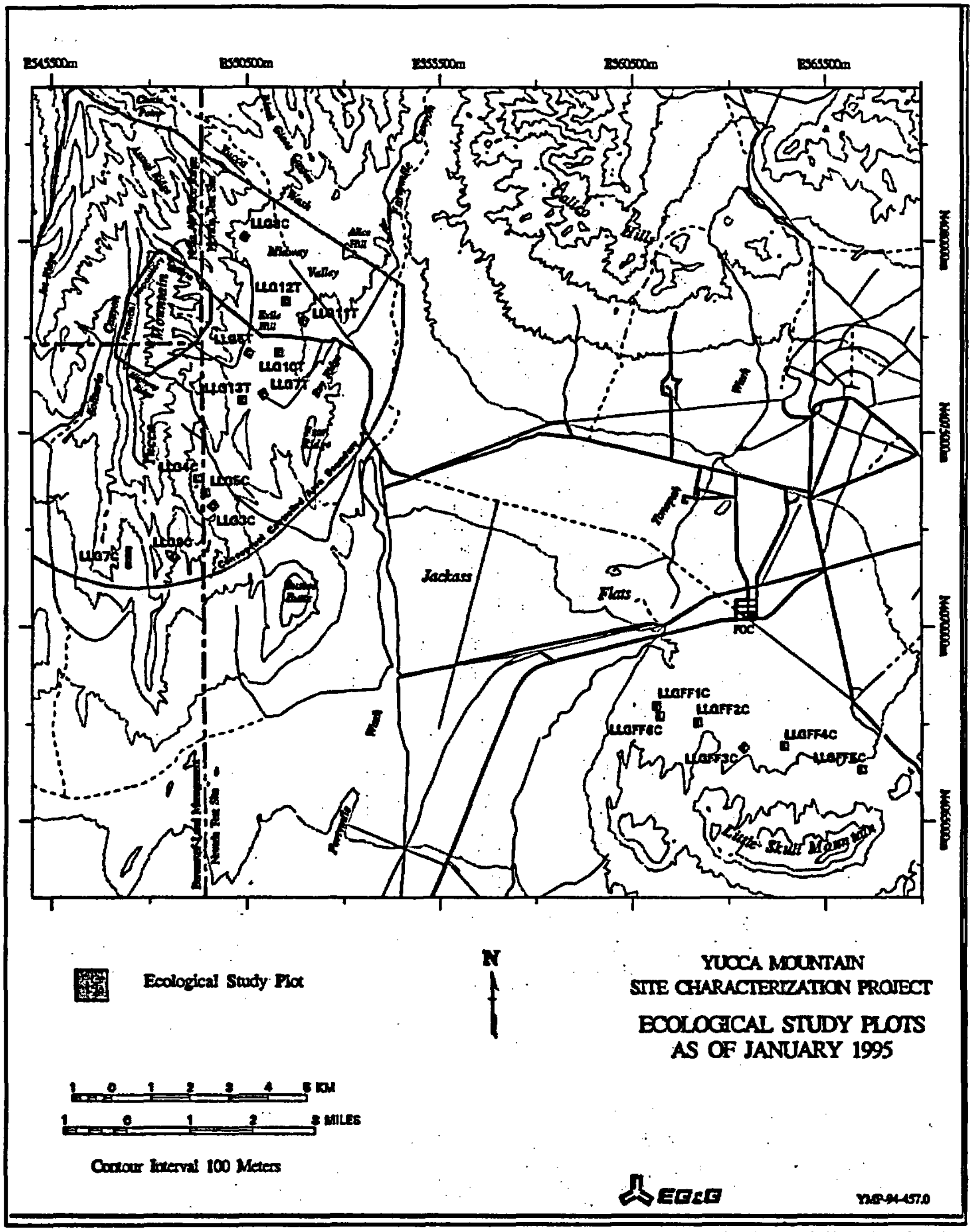

Figure 4-3. M&O Environmental Sciences Department Redesigned Ecological Study Plots at Yucca Mountain.

4.1.4 U.S. Geological Survey at the Yucca Mountain Site

The USGS is conducting hydrologic and geologic studies at Yucca Mountain to evaluate the suitability of Yucca Mountain as a high-level nuclear waste repository. Meteorological data derived from this investigation support these Site Characterization Plan (SCP) (DOE, 1988) studies: Site unsaturated zone hydrology (Investigation 8.3.1.2.2) and Site saturated zone hydrology (Investigation 8.3.1.2.3). These studies require meteorological information with particular emphasis on precipitation measurement. To support these needs, Study 8.3.1.2.1, Characterization of the Meteorology for Regional Hydrology, was instituted. Under this study, the USGS installed three separate networks at Yucca Mountain to meet the needs for meteorological data: 1) a network of five weather stations; 2) a network of 17 automated tipping-bucket precipitation gauges; and 3) a network of 108 nonrecording rain gauges.

4.1.4.1 Weather Station Network

The five weather stations were deployed in 1986 to obtain a wide spatial coverage of the Yucca Mountain Site, not only horizontally, but vertically due to the nature of the Site's complex terrain. It is well known that precipitation amount is generally affected by elevation differences. Quiring (1983) found this to be true for the Nevada Test Site. Other factors also affect precipitation catch, among those is site exposure to prevailing wind. The goal was to sample the environment at varying elevations and site exposures.

Each weather station consists of a 3-meter tripod and uses a CSI datalogger to record wind speed and direction (3-meter level), temperature and relative humidity in a naturally aspirated shelter (2-meter level), solar radiation (2-meter level), and barometric pressure (2-meter level at Station 3 only). All five stations feature 1.0 millimeter resolution tipping-bucket gauges, meaning that the bucket will tip when 1.0 millimeter of precipitation has fallen. In addition, three stations have a second gauge which is a 0.1 millimeter resolution tipping-bucket snow gauge, heated with a propane-fueled catalytic heater. Table 4-6 summarizes the geographic coordinates, the elevation, and the meteorological variables measured. The site map in Figure 4-4 shows the deployment of the USGS meteorological stations.

At each station the CSI datalogger samples each meteorological variable every second and averages and records data every 15 minutes. The datalogger detects a pulse produced by each tip of the bucket mechanism in the precipitation gauge and records the date and time of the tip.

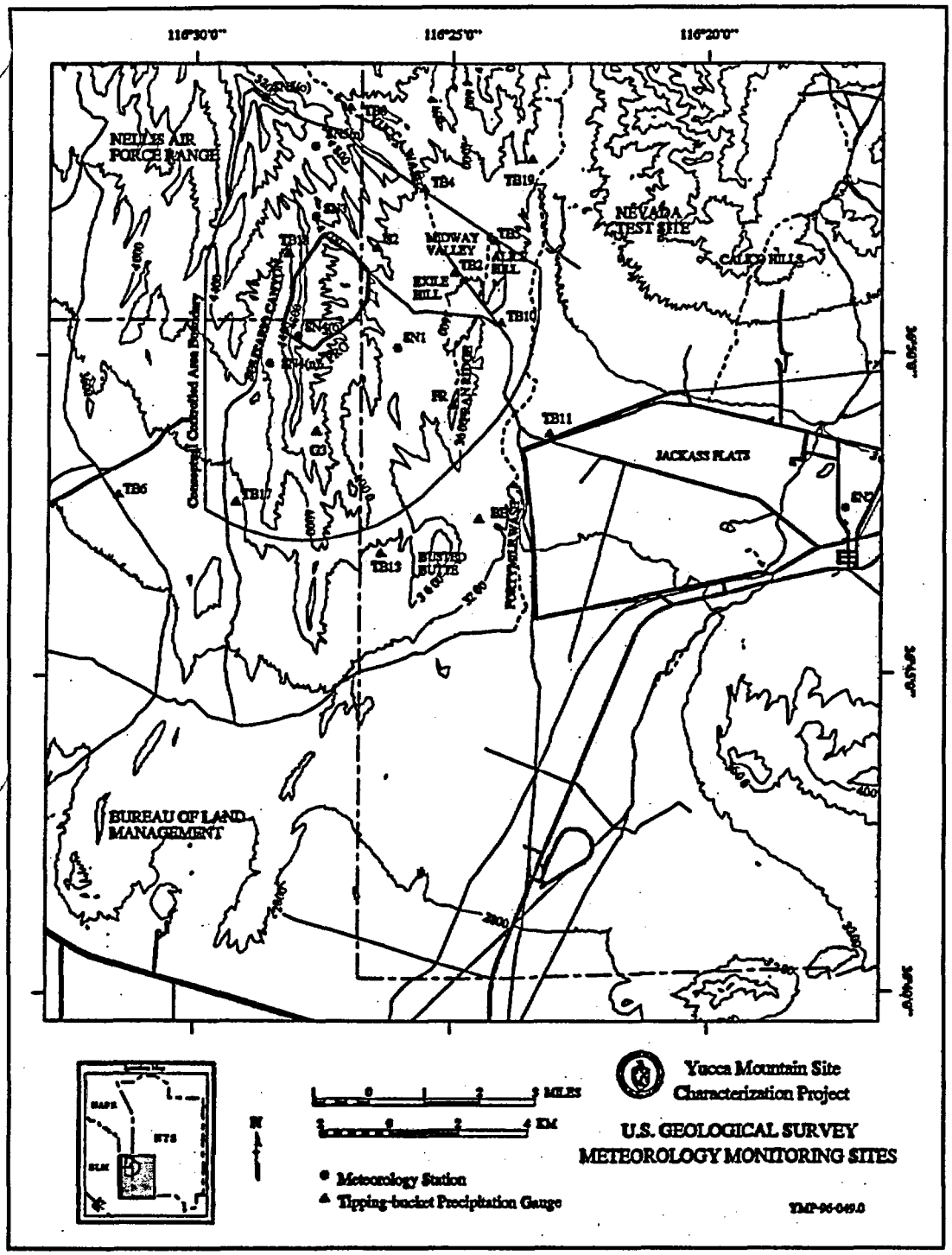

Figure 4-4. USGS Station and Tipping-Bucket Precipitation Gauge Networks at Yucca Mountain.

Table 4-6. USGS Meteorological Stations at the Yucca Mountain Site.

Station	Map ID	Wnd Dir	Wnd Spd	Tmp	DP/ RH	Solar Rad	PCP (2)	BP	Lat (1)	Long (1)	Elev (feet)	POR
Station 1	GS1	X	X	X	X	X	TB		365006	1162604	3815	1988-1995
Station 2	GS2	X	X	X	X	X	TB		364944	1161641	3482	1987-1995
Station 3	GS3	X	X	X	X	X	TB	X	365201	1162740	4432	1987-1995
Station 4 (old)	GS4(o)	X	X	X	X	X	TB		365018	1162800	4915	1987-1990
Station 4 (new)	GS4(n)	X	X	X	X	X	TB		364952	1162834	4900	1990-1995
Station 5 (old)	GS5 (o)	X	X	X	X	X	TB		365402	1162840	5128	1988-1993
Station 5 (new)	GS5 (n)	X	X	X	X	X	TB		365316	1162741	5128	1993-1995

Map ID = Map Identification, Wnd Dir = Wind Direction, Wnd Spd = Wind Speed, Tmp = Temperature, DP = Dew Point, RH = Relative Humidity, Solar Rad = Solar Radiation, Pcp = Precipitation, BP = Barometric Pressure, Lat = Latitude, Long = Longitude, Elev = Elevation, POR = Period of Record

NOTE: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).

This network is operated and maintained according to QARD requirements and approved Hydrologic Procedures. The sensors (except precipitation gauges) are removed and calibrated annually. Tipping-bucket gauges are laboratory-calibrated at least every five years. Data are downloaded weekly via radio telemetry and are checked to determine the operating efficiency of the sensors. Scheduled field checks ensure the instruments are operating within specified tolerance.

The database is created for each annual dataset. Data from 1986 through 1994 have been submitted to the Project TDB according to the data tracking information in Appendix A. A data report, summarizing data collected during the period 1988-1994, is in process and will be published as a USGS Open File Report (Flint et al, in process).

4.1.4.2 Tipping-Bucket Precipitation Gauge Network

The site infiltration model being developed by the USGS requires rainfall intensity information as an input. The tipping-bucket network was deployed to increase the number and density of precipitation observations at the Yucca Mountain Site. Tipping-bucket gauges were already in place as part of each weather station. These gauges are designed and calibrated to accurately measure rainfall rate or intensity as well as the total amount from individual storm events. Because of the complex terrain, precipitation amounts and intensities can vary significantly over a very short distance.

The network consists of 17 tipping-bucket gauges, four of which were first deployed in 1989 followed by the installation of the remaining 13 in October 1994. Four have been in operation since at least 1990. Table 4-7 provides the geographic information about this network and the site map in Figure 4-4 shows its deployment in relation to the weather station network. This network uses CSI dataloggers at each location to record the date and time of bucket tips. Each datalogger is powered by a 12-volt battery which is recharged by a solar panel. Each gauge is installed on the ground. Four gauges (G-3, Fran Ridge, Busted Butte, and N2) are propane-heated snow gauges. All have a resolution of 0.1 mm (except N2 which as a resolution of 2.0 millimeters).

The dataloggers record each tip by date and time-stamping the pulse. Data are downloaded periodically using a CSI memory module then transferred to a PC-based database. The gauge-specific calibration correction factor is applied and the derived data set is converted to maximum and average intensities and a total amount for each event. Each gauge is uniquely calibrated using an approved laboratory procedure and is operated and maintained according to approved Hydrologic Procedures. These data have not been submitted to the Project TDB as of this writing.

Table 4-7. USGS Tipping Bucket Precipitation Gauge Network at the Yucca Mountain Site.

Station	Map ID	Lat (1)	Long (1)	Elev (feet)	POR
TB2	TB2	365117	1162457	3645	1994-1995
TB4	TB4	365236	1162533	3960	1994-1995
TB5	TB5	365147	1162410	4020	1994-1995
TB6	TB6	364751	1163129	3370	1994-1995
TB8	TB8	365353	1162700	4360	1994-1995
TB10	TB10	365030	1162403	3480	1994-1995
TB11	TB11	364846	1162306	3340	1994-1995
TB13	TB13	364655	1162623	3525	1994-1995
TB17	TB17	364744	1162913	3560	1994-1995
TB18	TB18	365136	1162812	4380	1994-1995
TB19	TB19	365303	1162327	3770	1994-1995
G-3	G-3	364849	1162739	4765	1989-1995
Busted Butte	BB	364727	1162428	3310	1989-1995
Fran Ridge	FR	364913	1162459	4062	1989-1995
N2	N2	365141	1162628	3947	1989-1995

Map ID = Map Identification, Lat = Latitude, Long = Longitude, Elev = Elevation, POR = Period of Record

NOTE: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).

4.1.4.3 Nonrecording Rain Gauge Network

The network consisting of 108 nonrecording rain gauges was installed beginning in January 1990 to acquire precipitation records at a large number of sites. The gauges are of three types: 1) plastic wedge-shaped, 2) plastic 4-inch diameter circular with internal measurement tube, and 3) 8-inch diameter metal National Weather Service standard rain gauge, read with a dip stick. The geographical coordinates and elevations are given for each gauge in Appendix B. Figure 4-5 shows the relative locations of the USGS nonrecording gauges. This network was shut down in October 1995. Details on the network follow:

- Many of these were installed at hydrologic study boreholes used to measure soil moisture changes with depth as part of Investigation 8.3.1.2.2. Others were used to back up tipping-bucket totals at the weather stations. Mineral oil was used to minimize evaporation.

- These gauges provided total precipitation depth only. The gauges were read as soon as possible after a precipitation event in order to isolate one event from another.

- This network was operated according to QARD requirements as implemented in approved Hydrologic Procedures.

- A USGS Open File Report (OFR), contains the data set for water years 1992-93 and details on the network (Ambos, 1995). These data were also submitted to the Project TDB as shown in Appendix A.

- M&O/EFPD has acquired this data set and can provide a copy of the OFR.

- For more detailed information on this activity or the activities ducussed earlier, contact the USGS (see Appendix D).

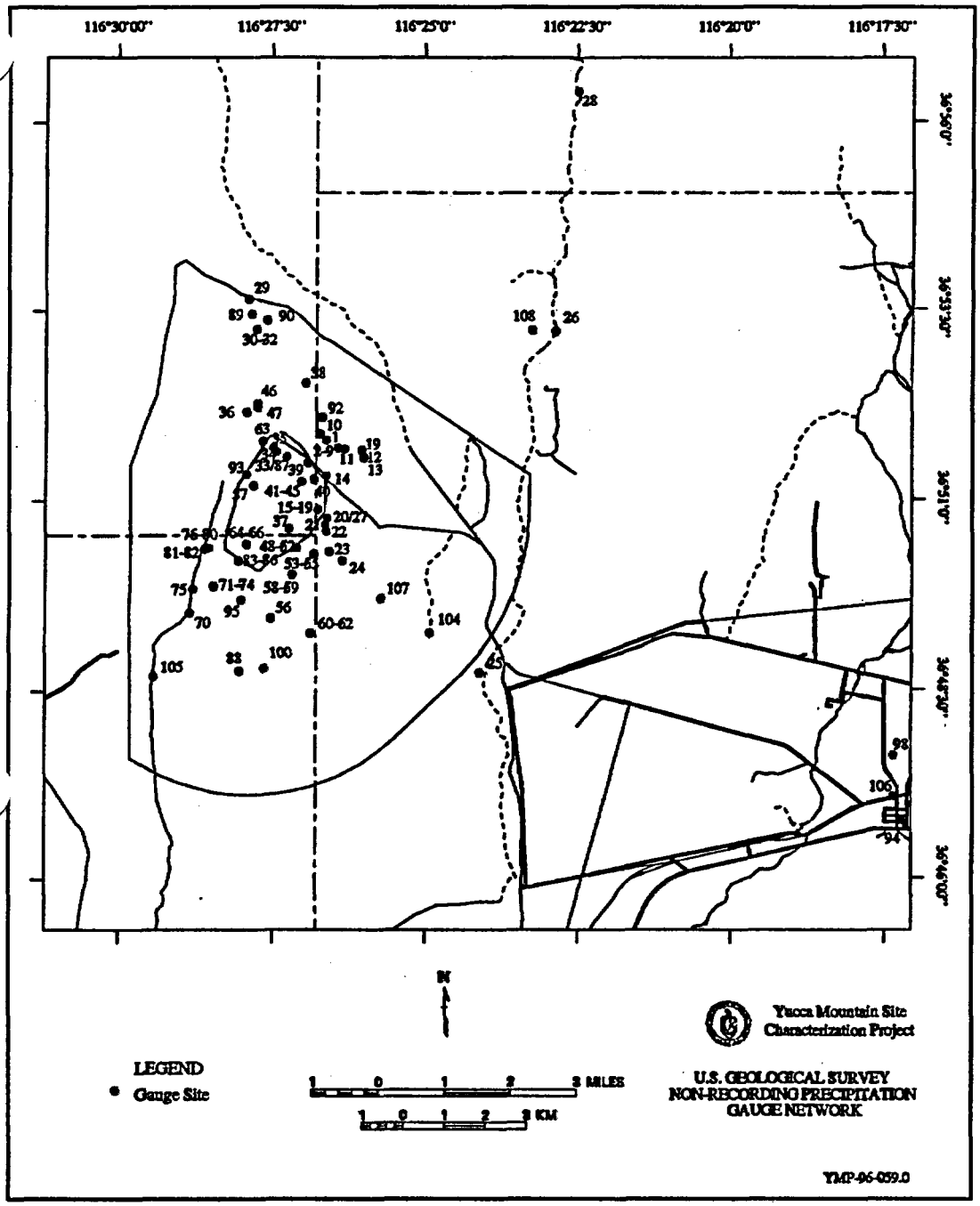

Figure 4-5. USGS Nonrecording Rain Gauge Network at Yucca Mountain.

4.2 Nevada Test Site Studies

4.2.1 Early Studies at the Nevada Test Site

With the advent of nuclear testing at the NTS, a large amount of effort went into the establishment of meteorological stations to support this national priority. Therefore, many stations were installed on the NTS in the mid 1950s to meet this new need for meteorological monitoring. Among the first was the manned weather station at Yucca Lake from which surface and upper air observations were taken, beginning in 1956. For a period of time there were over 100 sites on the NTS instrumented for meteorological observations. Other, specific data collection methods were developed to support special studies conducted to learn more about wind flow at the NTS (Buck, 1963; Kennedy, 1982, and Quiring, 1974 and 1979) and off-site (Allen (undated), Angell, 1969 and 1971, Randerson, 1973, and Quinn, 1985). Studies of other variables were also documented. Precipitation climatologies were developed by Quiring (1983) as well as studies of convective activity (Quiring, 1975). Quiring (1973) also reported on the characteristics of the inversion layer and atmospheric stability, which is of particular interest to M&O/EFPD in terms of the current data collection efforts supporting atmospheric stability calculations.

During the Nuclear Rocket Development Program of the 1960s, attention was shifted to supporting this activity with a number of meteorological stations in Jackass Flats (Area 25 of the NTS). Climatological summaries were developed showing the salient features of the seasonal and diurnal variations of wind and temperature near ground level and aloft (Quiring, 1968). Because of the complex topography and the rugged terrain in Jackass Flats, it was determined that meteorological variables could vary considerably between stations a short distance apart. Therefore, a dense network was needed to measure widely varying values over short distances. Large amounts of data were collected during these early years at the NTS. Most of these data are maintained in computer databases by NOAA/ARL/SORD in Las Vegas. These data may be obtained by contacting ARL/SORD. Many special studies were done resulting in a number of reports which provide valuable insight into the climatology of the NTS. ARL/SORD continues to collect meteorological data at the NTS and vicinity. This effort will be discussed below.

4.2.2 NOAA/ARL/SORD Network

4.2.2.1 Nevada Test Site Meteorological Data Acquisition Network

The Meteorological Data Acquisition (MEDA) network, installed in 1983 as an upgrade of an earlier network, is designed to provide real-time meteorological information during NTS operations. Tables 4-8 and 4-9 list the geographic coordinates, elevation, and meteorological variables measured specifically at

each site. Figure 4-6 shows the locations of the MEDA stations on the NTS. Several MEDA stations are located off the NTS and are scattered north, east, and southeast of the NTS. Figure 4-7 is a regional-scale map which shows the locations of the off-NTS MEDA stations, among regional stations.

Table 4-8. Meteorological Data Acquisition (MEDA) Stations and Reported Variables - Part 1.

Station	Map ID	Wnd Dir	Wnd Spd	Temp	DP/ RH	Pcp	BP	Lat (1)	Long (1)	Elev (feet)
MEDA1	M1	X	X	X	X	X		370139	1160530	4150
MEDA2	M2	X	X	X	X	X	X	370820	1160621	4400
MEDA3	M3	X	X	X	X	X		370015	1160154	3960
MEDA5	M5	X	X	X	X	X	X	364807	1155800	3090
MEDA6	M6	X	X	X	X	X	X	365727	1160248	3920
MEDA7	M7	X	X	X	X	X		371015	1162554	5600
MEDA8	M8	X	X	X	X	X		371112	1160754	4910
MEDA9	M9	X	X	X	X	X		370808	1160224	4230
MEDA10	M10	X	X	X		X		365624	1160445	5150
MEDA11	M11	X	X	X	X	X		365711	1155733	4120
MEDA12	M12	X	X	X	X		X	371129	1161254	7500
MEDA13	M13	X	X	X	X			365106	1155739	3170
MEDA14	M14	X	X	X	X	X		365803	1161027	4710
MEDA15	M15	X	X	X	X	X		371124	1160110	4470
MEDA16	M16	X	X	X	X	X	X	370346	1160310	4080
MEDA18	M18	X	X	X	X	X		370609	1161833	5040
MEDA19	M19	X	X	X	X	X		371611	1161915	7030
MEDA20	M20	X	X	X	X	X	X	371521	1162606	6570
MEDA22	M22	X	X	X				365606	1160251	4030
MEDA23	M23	X	X	X	X	X		363930	1155945	3740
MEDA24	M24	X	X	X	X	X	X	365015	1162809	4865
MEDA25	M25	X	X	X	X	X	X	364030	1162436	2750
MEDA26	M26	X	X	X	X	X	X	364839	1161500	3740
MEDA27	M27	X	X	X	X	X		364612	1160615	4530

NOTE: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).

Table 4-9. Meteorological Data Acquisition (MEDA) Stations and Reported Variables - Part 2.

Station	Map ID	Wnd Dir	Wnd Spd	Top	DP/ RH	PCP	BP	Law (1)	Long (1)	Elev (feet)
MEDA28	M28	X	X	X	X	X		365333	1160215	3630
MEDA29	M29	X	X	X	X			365400	1161642	4720
MEDA30	M30	X	X	X	X			370027	1162232	5240
MEDA31	M31	X	X	X	X			373945	1154651	4775
MEDA32	M32	X	X	X	X			372730	1142730	7480
MEDA33	M33	X	X	X	X	X		374251	1160918	5780
MEDA34	M34	X	X	X				380621	1171051	7130
MEDA35	M35	X	X	X	X	X	X	374733	1164530	5480
MEDA36	M36	X	X	X	X	X	X	363230	1153200	3100
MEDA43	M43	X	X	X				363945	1151115	9910

NOTE: (1) d = degrees, m = minutes, and s = seconds of latitude and longitude.

Variables measured are wind speed and direction, ambient air temperature, barometric pressure, relative humidity, and precipitation. At most sites wind speed and direction are measured at 10-meters above ground level (AGL), except at MEDA Stations 12 and 16 which measure winds and temperature at 30-meters AGL. Temperature at all other stations is measured at 2-meters. Pressure and relative humidity are measured at 2-meters AGL at all stations. Each station uses a CSI datalogger to record observations. The sampling frequency for wind data is one second and the averaging frequency is fifteen minutes. The peak speed is also recorded over each fifteen-minute period. Other variables are averaged over a five-minute period and recorded every fifteen minutes. Each station is fitted with a radio telemetry system that transmits data to a minicomputer at ARL/SORD every fifteen minutes.

Three of the MEDA stations are in Area 25, and one of these is located on Yucca Mountain (MEDA 24). The remaining stations on the NTS provide a reasonably dense source of surface-based meteorological data to the east and north of Yucca Mountain. These data will be useful in expanding the site-scale wind flow analysis into a regional-scale analysis as planned in the M&O/EFPD Regional Meteorology SIIP. ARL/SORD has validated these data and archived them in a database. M&O/EFPD has obtained this data set covering the period, 1983-1995. Data are available from ARL/SORD (see Appendix D).

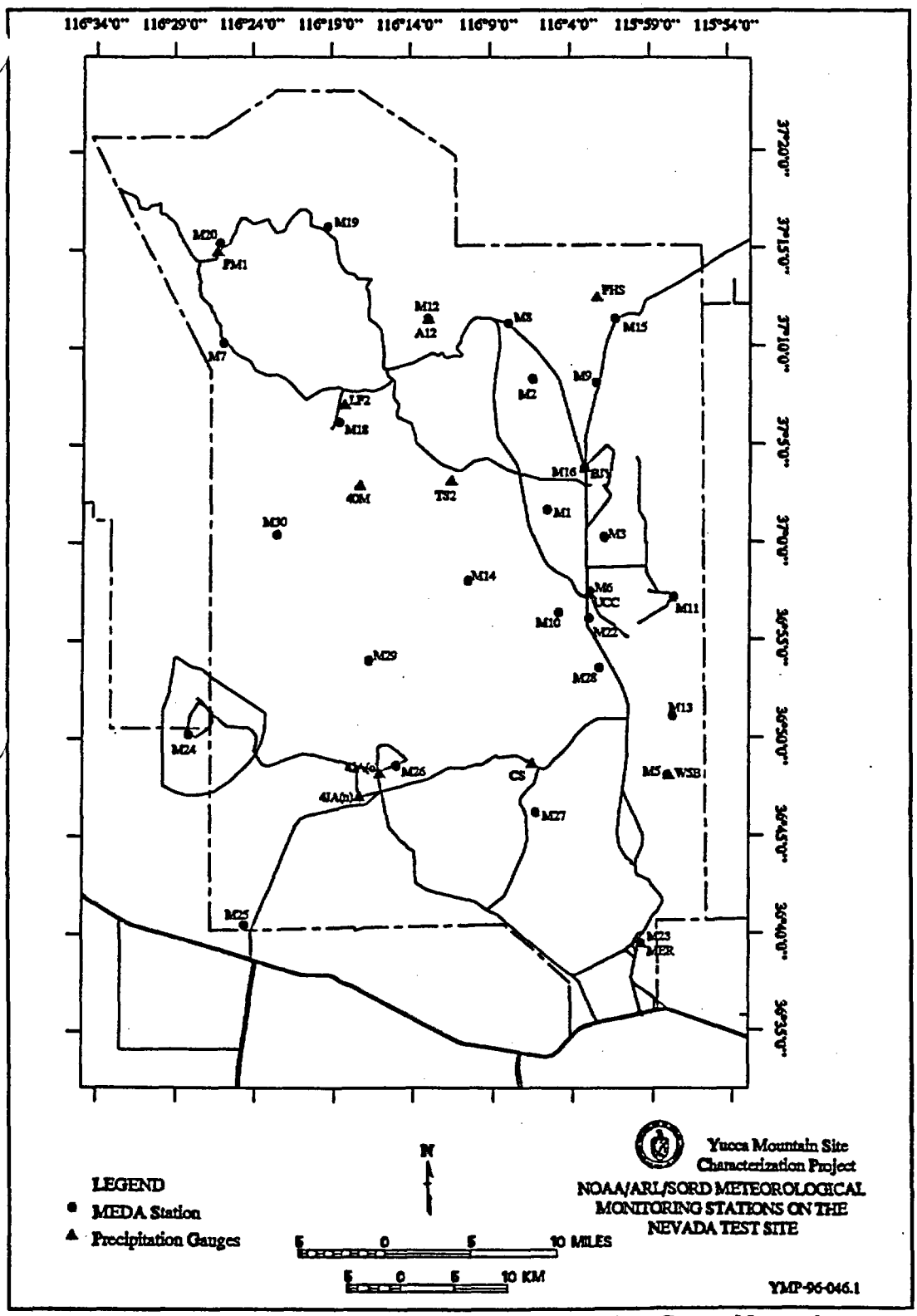

Figure 4-6. ARL/SORD MEDA Station and Precipitation Gauge Networks.

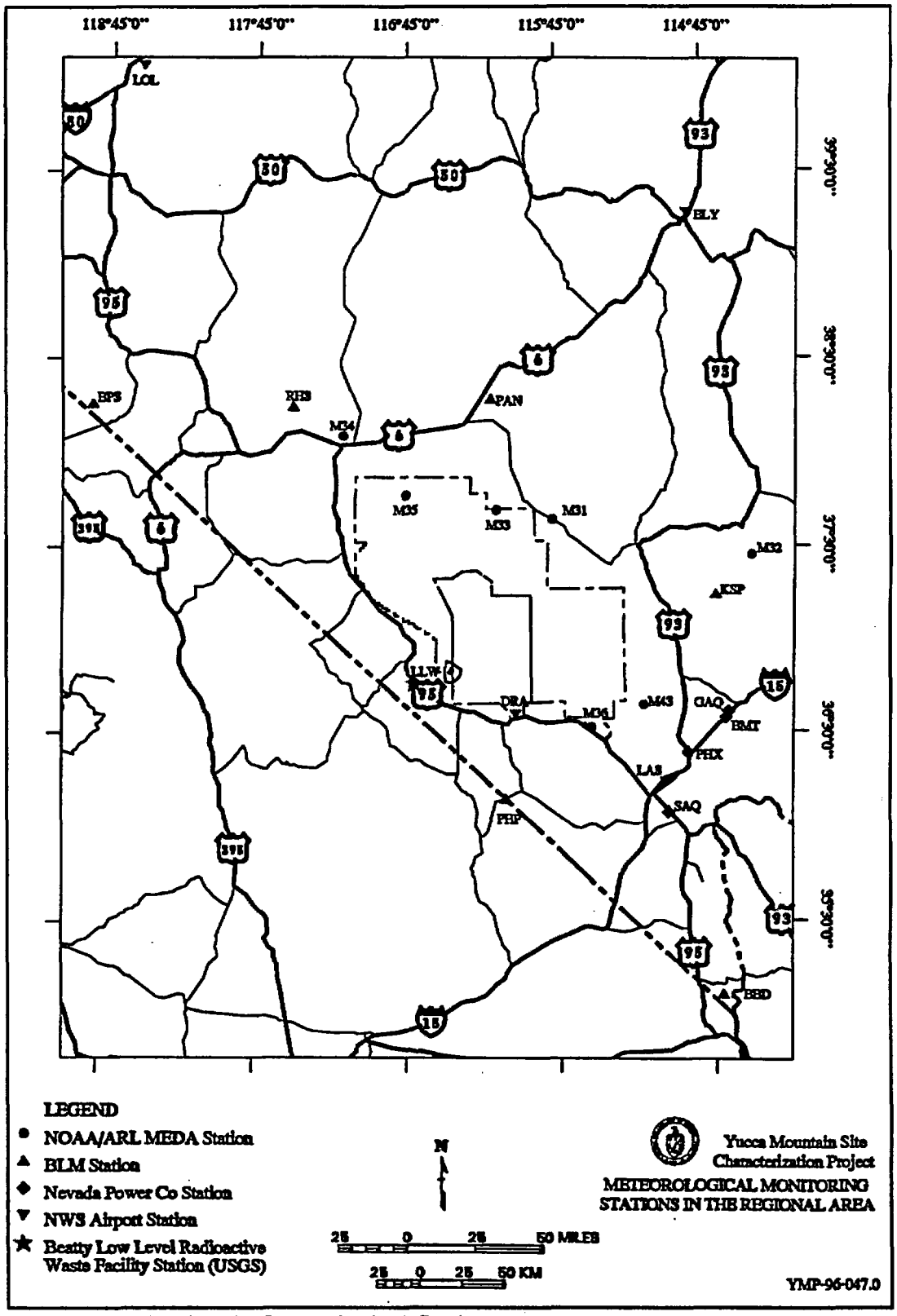

Figure 4-7. Regional Meteorological Stations.

4.2.2.2 Rain Gauge Network

One of the early meteorological data collection efforts at the NTS was the installation of a precipitation gauge network. In December 1957 the National Weather Service (Weather Bureau at the time) began routine collection of precipitation data. The first gauges (weighing buckets) were installed in Jackass Flats. By 1964 the number of stations had increased to 20 and were scattered throughout the NTS. Tipping-bucket gauges were installed at some sites but were found to present problems in addition to not recording snow properly. These sites received the addition of nonrecording storage gauges to serve as back devices in case of failure of the primary tipping-bucket gauge. The storage gauges provided a measure of total precipitation between service dates and provided a means of estimating amounts for individual precipitation events, or series of events. ARL/SORD continues to operate this network although some gauges have been removed or relocated over the life of the network. Table 4-10 lists the currently active stations according to their location and elevation and period of record. The map in Figure 4-6 shows the deployment of the network on the NTS in relation to the MEDA network.

This network was designed to develop a precipitation climatology for the complex terrain of the NTS. Subsequent precipitation analyses have been completed for the NTS (Quiring, 1983; French, 1983, 1986, and 1987). Precipitation data are recorded on strip charts at each gauge site. ARL/SORD retrieves the charts each month and records precipitation events as 24-hour and monthly totals. The data are not collected under the control of the QARD. However, the USGS has made extensive use of this data set in Yucca Mountain site and regional hydrologic studies (Kane et al, 1994; Hevesi and Flint, in process; and Hevesi, Ambos, and Flint, in process). Requests for these data should be directed to ARL/SORD (see Appendix D).

Table 4-10. NOAA/ARL Nevada Test Site Precipitation Gauge Network.

Station	Map ID	Lat (1)	Long (1)	Elev (feet)	POR
Buster Jangle Y	BJY	370346	1160309	4070	1960-1995
Well 5 B	W5B	364807	1155755	3080	1963-1995
Yucca Dry Lake	UCC	365723	1160251	3924	1958-1995
Rainier Mesa	A12	371128	1161255	7490	1959-1995
PHS Farm	PHS	371232	1160219	4565	1964-1995
Tippipah Springs 2	TS2	370311	1161129	4980	1964-1995
Little Feller 2	LF2	370705	1161814	5120	1976-1995
Pahute Mesa 1	PM1	371456	1162615	6550	1964-1995
Mercury	MER	36 39 29	115 59 45	3,770	1968-1995
Jackass Flats (new)	4JA(n)	36 47 05	116 17 20	3,422	1967-1995
Jackass Flats (old)	4JA(o)	36 48 16	116 16 02	3,610	1959-1995
Cane Springs	CS	36 48 44	116 06 29	4,000	1964-1995
40 Mile Canyon	40M	37 02 57	116 17 15	4,820	1960-1995

Map ID = Map Identification, Lat = latitude, Long = Longitude, Elev = Elevation, POR = Period of Record

NOTE: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).

4.2.2.3 Desert Rock Weather Station

The National Weather Service (NWS) moved operations from Yucca Flat to Desert Rock in 1979. Surface and upper air observations were taken at Yucca Flat beginning in the mid 1950s. Until recently, hourly surface observations were taken 24-hours per day with twice-daily radiosonde launches. Beginning in November 1995 surface observations were reduced to 18 hours per day. However, upper air soundings continue to be taken twice per day.

Surface observations are taken according to standard NWS procedures. The sensors are calibrated annually. Wind sensors are installed at the 10 meter level, all other sensors are installed at 2 meters. The nonrecording precipitation gauge is mounted on the ground. Table 4-11 lists the location of the station and the variables measured. Other reported hourly data include an estimation of cloud cover and any weather phenomena occurring at the time of the observation (e.g. blowing dust, thunder, etc.). A monthly climatological summary is prepared that includes: daily and monthly temperature maximum, minimum, and average; heating and cooling degree days; daily and monthly total rainfall and snowfall, daily average wind speed and direction; and daily peak wind and associated direction.

Observers take surface observations once each hour in the window beginning 15 minutes before the hour. Temperature and dew point are instantaneous, wind data are recorded as a 5-minute average, barometric pressure is recorded as an instantaneous value, and precipitation is measured using a calibrated depth measuring stick. Sky cover is reported as an instantaneous observation.

Upper air soundings are taken twice daily. Variables measured include: temperature, dew point, pressure, and wind speed and direction and reported at mandatory and significant levels up to as high as 100,000 feet. As a supplement to the soundings, a daily pilot ballon (PIBAL) launch occurs at mid-day, providing wind data up to 10,000 feet. These operations are also governed by NWS procedures.

M&O/EFPD has acquired the historical data sets of both surface and upper air observations through 1994. Such data will be valuable as an important source of surface data representative of the Mercury area, 29 miles southeast of Yucca Mountain. Upper air data will be important in relating surface wind flow to the upper air steering currents. This is key to developing probabilities of wind flow toward populated areas from Yucca Mountain and to determining mixing height for atmospheric dispersion modeling. M&O/EFPD has obtained the entire Desert Rock data set (surface and upper air) up through 1994.

4.3 Miscellaneous Regional Meteorological Data Sources

Other agencies are collecting meteorological data for various reasons within the Yucca Mountain region. These include the National Weather Service, the Bureau of Land Management, Nevada Power Company, and environmental monitoring at the Beatty Low-level radioactive waste burial facility. Regional data are valuable to environmental studies at Yucca Mountain because of their generally longer record and they can be summarized to describe the regional climate. Data collected by these agencies were not collected under the control of the QARD. The following sections describe the major sources of regional data.

4.3.1 National Weather Service

Other Nevada NWS stations at Tonopah, Ely, Las Vegas, Elko, Reno, Winnemucca, and Lovelock provide meteorological surface observations within the Yucca Mountain region. These observations are taken according to standard NWS procedures as described for Desert Rock. These stations offer a longer period of record on the periphery of the Yucca Mountain regional area of interest. They can be used to assess the general climatology of the southern Nevada region. Table 4-11 lists the stations closest to Yucca Mountain and the types of data taken. The map in Figure 4-7 includes these NWS stations as part of the regional coverage.

Table 4-11. National Weather Service Stations in Nevada.

Station	Map ID	Wnd Dir	Wnd Spd	Temp	DP/ RH	Solar Rad	Pcp	BP	Lat (1)	Long (1)	Elev (feet)	POR
Desert Rock	DRA	X	X	X	X		X	X	363700	1160200	3301	1962-1995
Ely	ELY	X	X	X	X	X	X	X	391700	1145100	6253	1953-1995
Las Vegas	LAS	X	X	X	X	X	X	X	361500	1150300	1880	1937-1995
Lovelock	LOL	X	X	X	X		X	X	400400	1183300	3900	1948-1995
Tonopah	TPH	X	X	X	X		X	X	380400	1170500	5376	1954-1995

NOTE: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).

The NWS collects upper air data from a nationwide network of stations, including Desert Rock, Elko, and Reno in Nevada, which are used to initialize prognostic atmospheric models. Elko and Reno are recently activated upper air stations. These stations replaced Ely and Winnemucca which have long periods of record. The upper air data are interpolated to a grid format for model initialization. This is done twice daily. M&O/EPFD has obtained a set of historical upper air gridded data for the U.S. through 1989. These gridded data sets may be part of the regional wind flow analysis in terms of relating regional airflow to synoptic-scale weather patterns.

4.3.2 Cooperative Network

The cooperative network, composed of volunteer observers, was established nationwide to gather climatological data. This network of volunteer observers is supervised by NOAA. They record precipitation and maximum and minimum temperature each day. Appendix C contains an extensive list of regional cooperative stations and there periods of record. This list includes sites in both California and Nevada. The map in Figure 4-8 depicts these sites.

The instruments used meet NWS standards for accuracy but are not recalibrated once installed. The volunteer observers record the data at a specified hour each day. The records are sent monthly to the National Climatic Data Center (NCDC), Asheville, NC, for quality control and archiving. Some of these records are quite long, a few over 100 years in Nevada. These data are collected apart from the Yucca Mountain program. However, these records have become a very significant resource in studying the present climate of Yucca Mountain. This is especially true in the extensive use of these records as part of the USGS hydrological investigations. NCDC summarizes these records and publishes the data in monthly climatological periodicals segregated by state. These and other climatological records for the western U.S. may be obtained from the Desert Research Institute (see Appendix D).

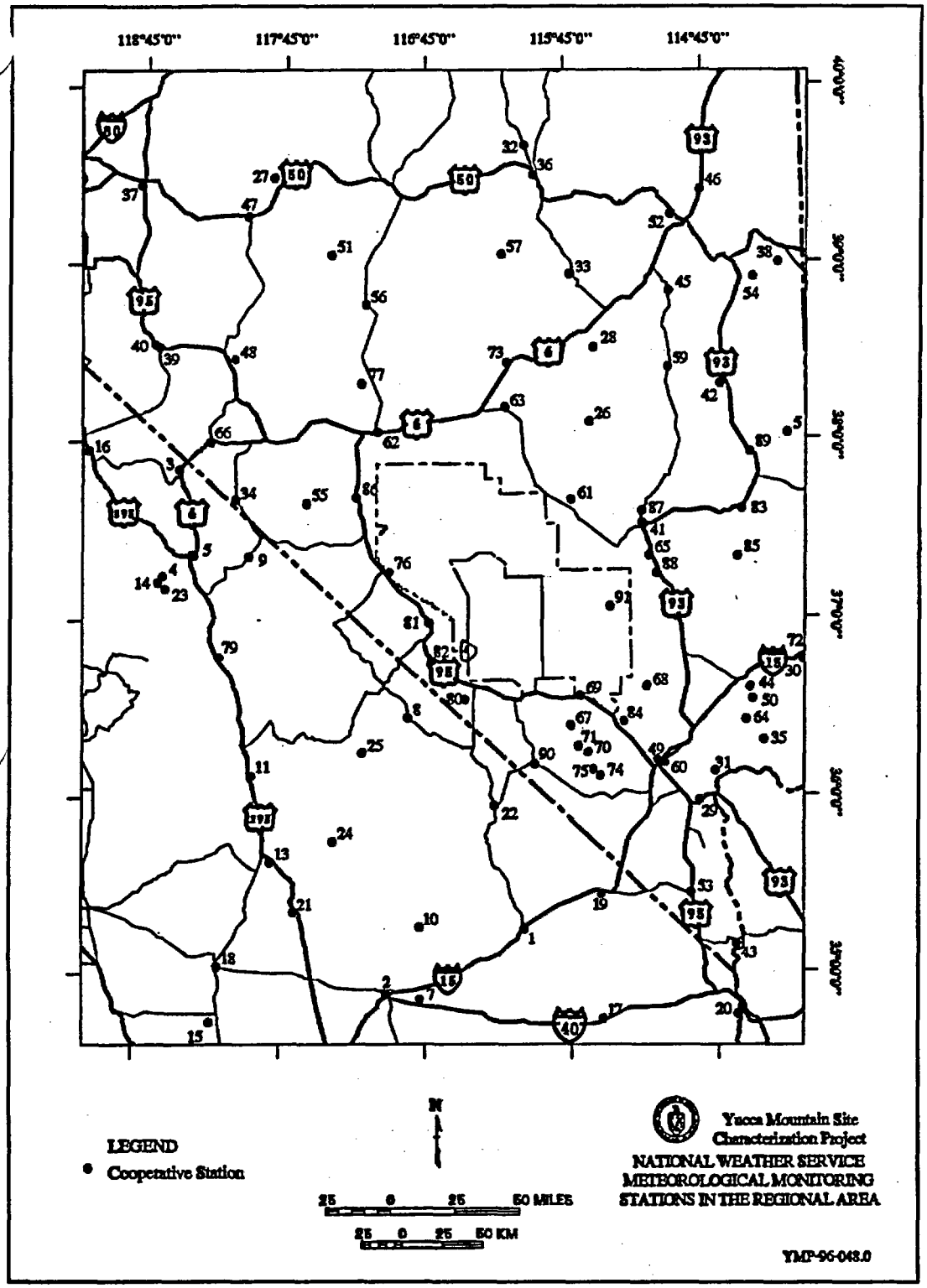

Figure 4-8. Cooperative Network Stations.

Historic data from the cooperative network have been valuable to the USGS who is studying regional precipitation. These studies include developing a regional climatology of annual average precipitation (Hevesi and Flint, in process) and developing a stochastic rainfall model for predicting precipitation frequency and moisture infiltration at Yucca Mountain (Hevesi and Flint, in process). Generally, a thirty year record is considered the minimum needed to establish an average climate for a given area. Many cooperatives in the region surrounding Yucca Mountain have such a record.

4.3.3 Bureau of Land Management

The BLM operates remote automated weather stations (RAWS) throughout the western U.S. The data are used primarily to assess fire danger in a particular region. Table 4-12 lists BLM stations in southern Nevada that provide additional regional surface data. The sites are included on the map in Figure 4-7.

Table 4-12. Bureau of Land Management Stations in Southern Nevada.

Station	Map ID	Wnd Dir	Wnd Spd	Tmp	DP/ RH	Pcp	BP	Lat (1)	Long (1)	Elev (feet)	POR
Kane Springs	KSP	X	X	X	X	X	X	371500	1144200	4590	1986-1995
Pahrump	PHP	X	X	X	X	X	X	361000	1160600	2600	1986-1995
Pancake	PAN	X	X	X	X	X	X	381813	1161133	5200	1986-1995
Royston Hills	RHS	X	X	X	X	X	X	381547	1173058	5100	1986-1995
Brawley Peaks	BPS	X	X	X	X	X	X	381555	1185123	8080	1986-1995
Big Bend	BBD	X	X	X	X	X	X	350700	1144200	1000	1986-1995

Map ID = Map Identification, Wnd Dir = Wind Direction, Wnd Spd = Wind Speed, Tmp = Temperature, DP = Dew Point, RH = Relative Humidity, Pcp = Precipitation, BP = Barometric Pressure, Lat = Latitude, Long = Longitude, Elev = Elevation, POR = Period of Record

NOTE: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).

Meteorological sensors are mounted on 6-meter towers. Wind speed and direction sensors are mounted at the 6-meter level. Temperature and relative humidity instruments are installed in naturally-aspirated shelters at 1.8-meters. The tipping-bucket rain gauge is mounted to the tower at the 1.8-meter level. The barometric pressure sensor is mounted inside the datalogger shelter at the 1.2-meter level.

Each station reports hourly observations. The variables are sampled and recorded as follows. Temperature and barometric pressure are sampled as one-second values just before the datalogger stores the hourly observation. Wind speed, wind direction, and relative humidity are sampled every second and averaged over the 10-minute period just before the hour. The peak wind and associated direction are for the greatest one-second value measured over the previous hour. Precipitation is reported as a cumulative amount which is reset during recalibration.

The sensors are calibrated on a biennial basis except the relative humidity sensor which receives an annual calibration. The tipping-bucket rain gauge is calibrated on site, the other sensors are removed and replaced with freshly calibrated ones.

The period of record for each station is 1986 to 1995. M&O/EFPD has acquired this data set and may include one or more of these sites in the regional wind flow analysis. BLM data may be obtained from Desert Research Institute (see Appendix D).

4.3.4 Beatty Low-Level Radioactive Waste Burial Facility

The USGS operates a meteorological station adjacent to the low-level radioactive waste burial facility along U.S. Highway 95, 10.5 miles southeast of Beatty, Nevada and approximately 12 miles due west of Yucca Mountain, since 1986. Data were collected as part of a study to estimate the potential for downward movement of radioactive nuclides into the unsaturated sediments below the waste burial trenches. This study was not a part of the Yucca Mountain Site Characterization activities and, therefore, not subject to QARD requirements.

Instruments are mounted on a tripod and data are recorded using a CSI datalogger. All sensors are recalibrated on an annual basis. The mounting heights of the instruments are adjusted to comply with guidelines of the American Association of State Climatologists, which attempts to standardize automated weather station installations. Wind sensors are installed at the 3.4 meter level, while the temperature/relative humidity probes are located at the 1.7-meters in a naturally aspirated shelter. The pyranometer, which measues incoming solar radiation, was installed at the 3.7-meter level. The sensor measurements are recorded every 10 seconds and averaged hourly. Table 4-13 lists information about the site location and the data variables measured. The location of this site is plotted on the regional map in Figure 4-7.

A number of annual reports, containing details of the operation and data summaries of calendar years 1986-1991 (by month for each year) were published as USGS Open File Reports (Wood et al, 1991a, 1991b, 1992a, 1992b and 1995). A subsequent report, summarizing recent data collection activity, is in preparation.

Table 4-13. Beatty Low-Level Radioactive Waste Burial Facility Meteorological Station.

Map ID	Wnd Dir	Wnd Spd	Tmp	RH	Solar Rad	Pcp	BP	Lat (1)	Long (1)	Elev (feet)	POR
LRW	X	X	X	X	X	X	X	364700	1164200	2753	1986-1992

Map ID = Map Identification, Wnd Dir = Wind Direction, Wnd Spd = Wind Speed, Tmp = Temperature, RH = Relative Humidity, Solar Rad = Solar Radiation, Pcp = Precipitation, BP = Barometric Pressure, Lat = Latitude, Long = Longitude, Elev = Elevation, POR = Period of Record

NOTE: (1) d = degrees, m = minutes, and s = seconds of north latitude (ddmmss) and west longitude (dddmmss).

Although these data were not collected as part of the Project, the data could be of significant value by contributing to understanding regional wind flow patterns west of Yucca Mountain. Therefore, M&O/EFPD is in the process of acquiring this data set and will include it as an additional data point in a regional wind flow analysis. These data, coupled with data taken as part of an intensive investigation of winds above Crater Flat and at the Yucca Mountain crest, will be helpful in determining the westward extent of frequently-observed easterly winds at the crest. When acquired, the data will be technically evaluated for applicability to the regional meteorological analyses and may be qualified according to the QARD.

4.3.5 Nevada Power Company

Nevada Power has operated at least four meteorological towers to meet Environmental Protection Agency (EPA) air quality standards. One of these is a 100-meter tower near the power plant at Moapa (BMT). Others are 10-meter towers. These data may also be used in the regional wind flow analysis and may fill in gaps in the eastern part of the region. Table 4-14 lists the locations and the data collected at each station as well as the period of record. The map in Figure 4-7 includes these sites.

Table 4-14 Meteorological Stations Operated for the Nevada Power Company in Southern Nevada.

Station	Map ID	Wnd Dir	Wnd Spd	Tmp	DP/ RH	Solar Rad	Pcp	BP	Lat (1)	Long (1)	Elev (feet)	POR
100M Tower	BMT	X	X	X	X	X	X	X	363505	1143900	1701	1978-1995
Glendale	GAQ	X	X	X					363700	1143800	1805	1978-1995
Stadium	SAQ	X	X	X					360505	1150200	1640	1982-1989
Pump House	PHX	X	X	X					362400	1145400	2100	1982-1995

Map ID = Map Identification, Wnd Dir = Wind Direction, Wnd Spd = Wind Speed, Tmp = Temperature, DP = Dew Point, RH = Relative Humidity, Solar Rad = Solar Radiation, Pcp = Precipitation, BP = Barometric Pressure, Lat = Latitude, Long = Longitude, Elev = Elevation, POR = Period of Record

NOTE: (1) d = degrees, m = minutes, and ss = seconds of north latitude (ddmmss) and west longitude (dddmmss).

On the 100-meter tower, wind speed and direction and temperature sensors are installed at the 10-meter, 55-meter, and 100 meter levels. Solar radiation and barometric pressure instruments are installed at the 2 meter level. The other stations are 10-meter towers. Wind and temperature sensors are at the 10-meter level. Variables are sampled once per minute and averaged hourly. M&O/EFPD has acquired these data up through 1989. If used in the regional analyses, the data may be qualified using the QARD.

4.3.6 U.S. Air Force and Sandia National Laboratories.

Sandia National Laboratories (SNL) collected meteorological data at the Tonopah Test Range (TTR) since at least 1961 in support of Department of Defense testing activities. The U.S. Air Force assumed the surface observing tasks in the early

1980s. Sandia also operated a 100-meter meteorological tower near the TTR. M&O/EFPD plans to acquire these significant data sets and may use them as part of the regional climate and wind flow studies.

5.0 CONCLUSIONS

Meteorological data acquisition within the YMP is an on-going process. Current Project participants are collecting data that are specific to their investigations and, therefore, use different measurement methods and site locations. The methods used and the monitoring locations were selected based on study requirements specific to each participant. Also, locations were chosen to provide the best description of the Site meteorology because significant spatial variations can occur over small areas (a few kilometers or less). These spatial variations are due primarily to the influences of the complex topography of the Site. Some of the meteorological variables measured at Yucca Mountain can be used by all participants in a general sense (e.g., solar radiation, precipitation, wind speed and direction, temperature, relative humidity, and pressure). Other measurements and calculated parameters dealing with atmospheric stability are useful only to M&O/EFPD studies. Therefore, the data collections efforts are complementary rather than overlapping.

Most of the Project meteorological stations are located from the Yucca Mountain ridge crest toward the east and south. Airflow towards the west through Crater Flat is being studied by M&O/EFPD as part of the Regional Meteorology Study. This study will concentrate on collecting data at various levels above the surface to determine the westward extent of air flow from the Yucca Mountain crest.

The Regional Meteorology Study will also investigate wind flow patterns within the region surrounding Yucca Mountain. The meteorology of the region varies spatially because of the inclusion of different climatic zones created by terrain physiography and seasonal changes in synoptic-scale wind flow regimes. Thus, data collected by agencies operating within the surrounding region are important in this study. M&O/EFPD has acquired much of the available regional data. Other YMP investigators could use some of the regional data in their various analyses.

All meteorological data taken at the Yucca Mountain site and much of the non-participant data used in the Project has been, or will be submitted to the Project TDB. Meteorological data used by Project investigators for some purposes, such as input to atmospheric dispersion models for radiological dose calculations, will need to be either taken under the provisions of the QARD, or qualified according to QARD requirements. Data for many other purposes not associated with safety calculations do not require the qualification step. Questions on the data sources should be directed to the group responsible for collecting the data.

M&O/EFPD scientists have developed a broad knowledge of the types, volume, and sources of meteorological data taken by Project participants and by other governmental and private agencies within the Yucca Mountain region. The objective of this report is to share this knowledge with other Project participants who may need current or historical meteorological data as part of their studies. As the M&O/EFPD regional studies progress, additional meteorological data will be sought to supplement data-sparse areas, if possible.

APPENDIX A

Meteorological Data and Reports Tracking Matrices

M&O/EFPD Meteorological Data.

DataTracking Number (DTN)	Item	Start Date (Month/Year)	End Date (Month/Year)
TM0000000000001.063	1993 Data Report	NA	NA
TM0000000000001.050	Validated Data	1/93	6/93
TM0000000000001.051	Validated Data	7/93	9/93
TM0000000000001.052	Validated Data	10/93	12/93
TM0000000000001.054	Validated Data	1/94	3/94
TM0000000000001.056	Validated Data	4/94	6/94
TM0000000000001.058	Validated Data	7/94	9/94
TM0000000000001.060	Validated Data	10/94	12/94
TM0000000000001.081	1994 Date Report	NA	NA

USGS Meteorological Station Data.

Data Tracking Number (DTN)	Stations	Variable	Start Date (Month/Day/Year)	End Date (Month/Day/Year)
GS950208312111.001	All	Precipitation Barometric Pressure Solar Radiation	4/18/87	5/2/89
		Wind Speed Wind Direction Temperature Relative Humidity	4/18/87	8/13/89
GS950208312111.002	All	Precipitation Barometric Pressure Solar Radiation	5/3/89	9/30/89
		Wind Speed Wind Direction Temperature Relative Humidity	8/14/89	9/30/89
GS920708312111.006	All	All	10/1/89	9/30/91
GS930108312111.002	All	All	10/1/91	9/30/92
GS940108312111.003	All	All	10/1/92	9/30/93
GS941208312111.006	All	All	10/1/93	9/30/94

Appendix A:Meteorological Data and Reports Tracking Matrices

Table A-3. USGS Nonrecording Precipitation Gauge Data.

Data Tracking Number (DTN)	Gauges	Variable	Start Date (Month/Day/Year)	End Date (Month/Day/Year)
GS920708312111.005	All	Precipitation	1/1/90	9/30/91
GS930108312111.003	All	Precipitation	10/1/91	9/30/92
GS940108312111.001	All	Precipitation	10/1/92	9/30/93
GS950708312111.003	All	Precipitation	10/1/93	9/30/94

APPENDIX B

USGS Nonrecording Rain Gauge Network at Yucca Mountain

Location	Map Identifier	Latitude (ddmmss N) (1)	Longitude (dddmmss W) (1)	Elevation (Feet)	Period of Record
UE-25 UZN #1	1	365148	1162637	3995	1990-1995
UE-25 UZN #2	2	365141	1162626	3947	1990-1995
UE-25 UZN #3	3	365141	1162626	3941	1990-1995
UE-25 UZN #4	4	365142	1162626	3942	1990-1995
UE-25 UZN #5	5	365142	1162626	3943	1990-1995
UE-25 UZN #6	6	365142	1162626	3938	1990-1995
UE-25 UZN #7	7	365142	1162626	3939	1990-1995
UE-25 UZN #8	8	365143	1162626	3939	1990-1995
UE-25 UZN #9	9	365143	1162626	3941	1990-1995
UE-25 UZN #10	10	365154	1162643	4038	1990-1995
UE-25 UZN #12	11	365142	1162619	3907	1990-1995
UE-25 UZN #13	12	365135	1162600	3821	1990-1995
UE-25 UZN #14	13	365135	1162600	3824	1990-1995
UE-25 UZN #18	14	365120	1162637	4019	1990-1995
UE-25 UZN #19	15	365053	1162646	4025	1990-1995
UE-25 UZN #20	16	365053	1162645	4027	1990-1995
UE-25 UZN #21	17	365054	1162645	4028	1990-1995
UE-25 UZN #22	18	365055	1162645	4029	1990-1995
UE-25 UZN #23	19	365055	1162646	4043	1990-1995
UE-25 UZN #28	20	365047	1162636	3958	1990-1995
UE-25 UZN #29	21	365042	1162638	3973	1990-1995
UE-25 UZN #30	22	365036	1162637	3959	1990-1995
UE-25 UZN #56	23	365020	1162634	3960	1990-1995
UE-25 UZN #60	24	365014	1162621	3892	1990-1995
UE-25 UZN #85	25	364844	1162406	3337	1990-1995
UE-25 UZN #92	26	365314	1162251	3669	1990-1995
UE-25 UZN #97	27	365047	1162636	3958	1990-1995

NOTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

APPENDIX B: USGS Nonrecording Rain Gauge Network at Yucca Mountain

Location	Map Identifier	Latitude (ddmmss N) (1)	Longitude (dddmmss W) (1)	Elevation (Feet)	Location
UE-29 UZN #91	28	365624	1162229	3647	1990-1995
USW UZ-N11	29	365340	1162753	5224	1992-1995
USW UZ-N15	30	365315	1162743	5109	1992-1995
USW UZ-N16	31	365316	1162746	5117	1992-1995
USW UZ-N17	32	365316	1162741	5128	1992-1995
USW UZ-N24	33	365135	1162716	4227	1990-1995
USW UZ-N25	34	365140	1162727	4335	1990-1995
USW UZ-N26	35	365143	1162729	4384	1990-1995
USW UZ-N27	36	365211	1162755	4859	1990-1995
USW UZ-N37	37	365039	1162713	4247	1992-1995
USW UZ-N36	38	365234	1162657	4642	1992-1995
USW UZ-N37	39	365130	1162656	4124	1991-1995
USW UZ-N40	40	365117	1162650	4079	1990-1995
USW UZ-N41	41	365114	1162658	4118	1990-1995
USW UZ-N42	42	365113	1162707	4179	1990-1995
USW UZ-N43	43	365115	1162702	4149	1990-1995
USW UZ-N44	44	365117	1162703	4162	1990-1995
USW UZ-N45	45	365115	1162660	4130	1990-1995
USW UZ-N46	46	365218	1162745	4501	1990-1995
USW UZ-N47	47	365215	1162744	4480	1990-1995
USW UZ-N48	48	365024	1162712	4211	1990-1995
USW UZ-N49	49	365025	1162713	4229	1990-1995
USW UZ-N50	50	365024	1162706	4173	1990-1995
USW UZ-N51	51	365025	1162706	4169	1990-1995
USW UZ-N52	52	365025	1162706	4172	1990-1995
USW UZ-N53	53	365017	1162650	4056	1991-1995
USW UZ-N54	54	365019	1162649	4046	1991-1995

NOTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

APPENDIX B: USGS Nonrecording Rain Gauge Network at Yucca Mountain

Location	Map Identifier	Latitude (ddmmss N) (1)	Longitude (dddmmss W)	Elevation (Feet)	Period of Record
USW UZ-N55	55	365021	1162650	4073	1991-1995
USW UZ-N57	56	364928	1162732	4186	1990-1995
USW UZ-N64	57	365113	1162749	4791	1992-1995
USW UZ-N65	58	365003	1162711	4372	1990-1995
USW UZ-N66	59	365001	1162719	4356	1990-1995
USW UZ-N67	60	364913	1162655	3920	1990-1995
USW UZ-N68	61	364916	1162653	3925	1990-1995
USW UZ-N69	62	364921	1162648	3918	1990-1995
USW UZ-N70	63	365148	1162740	4542	1990-1995
USW UZ-N71	64	365026	1162801	4925	1990-1995
USW UZ-N72	65	365027	1162759	4889	1990-1995
USW UZ-N73	66	365027	1162755	4867	1990-1995
USW UZ-N74	67	365030	1162760	4904	1990-1995
USW UZ-N75	68	365031	1162753	4799	1990-1995
USW UZ-N76	69	365030	1162754	4958	1990-1995
USW UZ-N77	70	364932	1162851	3901	1990-1995
USW UZ-N78	71	364952	1162828	4182	1990-1995
USW UZ-N79	72	364954	1162827	4155	1990-1995
USW UZ-N80	73	364953	1162816	4332	1990-1995
USW UZ-N81	74	364955	1162836	4065	1990-1995
USW UZ-N82	75	364952	1162847	3975	1990-1995
USW UZ-N83	76	365023	1162827	4157	1990-1995
USW UZ-N84	77	365023	1162832	4112	1990-1995
USW UZ-N86	78	365022	1162825	4172	1990-1995
USW UZ-N87	79	365023	1162832	4112	1990-1995
USW UZ-N88	80	365024	1162824	4202	1990-1995
USW UZ-N89	81	365022	1162836	4090	1990-1995
USW UZ-N90	82	365022	1162836	4090	1990-1995

NOTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

APPENDIX B: USGS Nonrecording Rain Gauge Network at Yucca Mountain

Location	Map Identifier	Latitude (ddmmss N) (1)	Longitude (dddmmss W)	Elevation (Feet)	Period of Record
USW UZ-N93	83	365012	1162803	4924	1990-1995
USW UZ-N94	84	365014	1162804	4926	1990-1995
USW UZ-N95	85	365015	1162804	4929	1990-1995
USW UZ-N96	86	365011	1162802	4893	1990-1995
USW UZ-N98	87	365135	1162716	4223	1990-1995
USW UZ 13	88	364847	1162802	4820	1990-1995
USW GA-1	89	365328	1162751	5187	1990-1995
USW G-2	90	365322	1162735	5098	1990-1995
UE25 WT-4	91	365140	1162603	3835	1990-1995
UE25 WT-18	92	365207	1162642	4383	1990-1995
USW H-5	93	365122	1162755	4851	1990-1995
HRF	94	364646	1161713	3410	1990-1995
USW H-3	95	364942	1162801	4866	1990-1995
Wea Station 4 (old)	96	365018	1162802	4915	1990-1995
Wea Station 5 (Prow)	97	365402	1162843	5870	1990-1995
Evaporation pan	98	364737	1161721	3460	1990-1995
Wea Station 4 (new)	99	364952	1162834	4900	1990-1995
G-3	100	364849	1162739	4765	1990-1995
Weather station 1	101	365006	1162604	3815	1990-1995
Weather station 2	102	364736	1161721	3492	1992-1995
Weather station 3	103	365210	1162740	4432	1990-1995
Fran Ridge	104	364917	1162455	4062	1990-1995
Plug Hill	105	364843	1162926	3710	1990-1995
4JA	106	364705	1161720	3422	1992-1995
Knothead Gap	107	364943	1162543	3720	1992-1995
Upper fortymile	108	365314	1162314	3765	1992-1995

NOTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

APPENDIX C

Selected Cooperative Observer Network Stations

Station	Map Identifier	Latitude (ddmmss N) (1)	Longitude (ddmmss W) (1)	Elevation (feet)	Period of Record
Adaven	26	380700	1153500	6250	1928-1982
Alamo	65	372200	1151000	3438	1948-1962
Amargosa Farms	80	363400	1162800	2475	1965-1993
Austin	27	393000	1175000	6604	1921-1993
Baker	1	351600	1160400	938	1971-1990
Barstow	2	345400	1170100	2320	1980-1993
Basalt	66	380000	1181600	6348	1948-1957
Beatty 8N	81	370000	1164300	4300	1972-1993
Benton	3	375100	1182900	5459	1964-1993
Bishop Creek	4	371500	1183500	8153	1959-1993
Bishop	5	372200	1182200	4108	1948-1993
Blue Eagle	28	383200	1153300	4780	1978-1993
Blythe	6	333700	1143600	269	1931-1993
Boulder City	29	355900	1145100	2526	1931-1993
Bunkerville	30	364600	1140700	1549	1979-1992
Caliente	82	373700	1143100	5000	1928-1992
Callville Bay	31	360900	1144400	1270	1989-1993
Cold Creek	67	362500	1154400	6001	NA
Daggett Airport	7	345200	1164700	1923	1948-1993
Death Valley	8	362800	1165200	-194	1961-1993
Deep Springs	9	372200	1175900	5226	1948-1993
Desert National WL Range	83	362600	1152200	2920	1948-1992
Diamond Valley	32	394100	1160200	5971	1979-1993
Duckwater	33	385700	1154300	5610	1966-1993

NA = Not Available
NOTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

Appendix C: Selected Cooperative Observer Network Stations

Station	Map Identifier	Latitude (ddmmss N) (1)	Longitude (ddmmss W) (1)	Elevation (feet)	Period of Record
Dyer	34	374100	1180500	4898	1948-1993
Echo Bay	35	361900	1142400	1250	1989-1993
Elgin	84	372100	1143300	4000	1951-1993
Eureka	36	393100	1155800	6539	1952-1993
Fallon	37	392700	1184700	3963	1928-1993
Goldfield	85	374200	1171400	5700	1948-1993
Goldstone Echo No. 2	10	351700	1164700	2949	1973-1993
Great Basin National Park	38	390000	1141300	6831	1987-1993
Haiwee	11	360800	1175700	3825	1948-1993
Hawthorn No. 2	39	383200	1183800	4331	1954-1993
Hawthorn No. 1	40	383300	1184000	4216	1948-1991
Hidden Forest	68	363800	1151200	7549	NA
Hiko	41	373300	1151300	3940	1989-1993
Independence	79	364800	1181100	3923	1927-1993
Indian Springs	69	363500	1154000	3136	NA
Indio Firestation	12	334400	1161600	-20	1927-1993
Inyokern	13	353900	1174900	2441	1948-1993
Key Pittman	86	373700	1151300	4300	1964-1989
Kyle Canyon	70	361600	1153700	7165	1948-1964
Lake Valley	42	381900	1143900	6352	1971-1993
Lake Sabrina	14	371300	1183700	9065	1975-1993
Lancaster	15	344400	1181300	2339	1974-1993
Laughlin	43	351000	1143700	679	1988-1993
Lee Vining	16	375700	1190700	6798	1988-1993
Lee Canyon	71	361800	1154100	9199	NA

NA = Not Available
NOTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

Appendix C: Selected Cooperative Observer Network Stations

Station	Map Identifier	Latitude (ddmmss N) (1)	Longitude (ddmmss W) (1)	Elevation (feet)	Period of Record
Logandale	44	363700	1142900	1411	1968-1992
Lund	45	385100	1150000	5571	1957-1993
McGill	46	392500	1144600	6299	1928-1993
Mesquite	72	364800	1140500	1601	1956-1965
Middlegate Lowery	47	391700	1180100	4600	1988-1993
Mina	48	382800	1180600	4547	1928-1993
Mitchell Caverns	17	344500	1153200	4350	1958-1993
Mojave	18	350300	1181000	2736	1948-1993
Mountain Pass	19	352800	1153200	4731	1955-1993
Needles Airport	20	344600	1143700	915	1948-1993
North Las Vegas	49	361300	1150800	1880	1951-1993
Overton	50	363300	1142800	1250	1948-1993
Pahranagat	87	371600	1150700	3360	1964-1993
Pahrump	89	361200	1155900	2671	1948-1993
Pioche	88	375600	1142700	6100	1948-1993
Randsburg	21	352200	1173900	3570	1948-1993
Rattlesnake	73	382700	1161000	5912	1948-1966
Red Rock Summit	74	360800	1153200	6499	NA
Red Rock	90	370500	1152700	3780	1977-1993
Reese River O'Toole	51	390400	1172500	6549	1972-1993
Roberts Ranch	75	361000	1153500	6099	NA
Ruth	52	391700	1145900	6841	1958-1993
Sacrobatus	76	371700	1170000	4019	1948-1961
Searchlight	53	352800	1145500	3540	1948-1992

NA = Not Available
NOTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

Appendix C: Selected Cooperative Observer Network Stations

Station	Map Identifier	Latitude (ddmmss N) (1)	Longitude (ddmmss W) (1)	Elevation (feet)	Period of Record
Shoshone	22	355800	1161600	1572	1972-1993
Shoshone 5N	54	385500	1142400	5928	1988-1993
Silverpeak	55	374000	1173500	4259	1967-1992
Smokey Valley	56	384700	1171000	5623	1949-1993
Snowball Ranch	57	390400	1161200	7159	1966-1993
South Lake	23	371100	1183400	9580	1975-1993
Spring Valley State Park	58	380200	1141100	5948	1974-1993
Sunnyside	59	382500	1150100	5299	1948-1993
Sunrise Manor	60	361200	1150500	1821	1961-1989
Tempiute	61	374100	1154300	4800	1972-1985
Tonopah	62	380400	1170500	5427	1954-1992
Trona	24	354600	1172300	1696	1948-1993
Twin Springs Fallini	63	381200	1161100	5299	1985-1993
Valley of Fire State Park	64	362600	1143100	2001	1972-1993

OTE (1): d=degrees, m=minutes, s=seconds of latitude and longitude.

APPENDIX D

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