

**STUDY PLAN FOR METEOROLOGICAL DATA COLLECTION
AT THE YUCCA MOUNTAIN SITE**

Study 8.3.1.12.2.1

Revision 2

June 1996

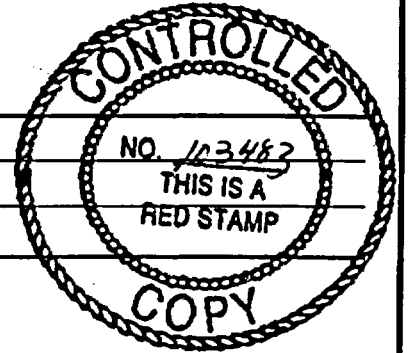
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YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
STUDY PLAN APPROVAL FORM

Study Plan Number 8.3.1.12.2.1

Study Plan Title Study Plan for Meteorological Data Collection at the Yucca Mountain Site

Revision Number 2



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ABSTRACT

Meteorological data collection and reporting that will provide the atmospheric dispersion information needed to support radiological dose calculations for pre-closure safety and design issues are described in this Study Plan. The meteorological data collection is based on a network of nine stations in the Yucca Mountain vicinity. Five stations have been operating since December 1985; four more were added during 1992. Data reporting suitable for the dispersion calculations is planned to meet data input requirements of a radiological dose model, when chosen. Other portions of the Meteorology Program include plans to utilize the data for other performance assessment and design issues, including technical support to the Environmental Impact Statement (EIS) for a Potential Repository at Yucca Mountain, Nevada.

1.0 PURPOSES AND OBJECTIVES

The purpose of the Meteorology Program presented in Section 8.3.1.12 of the Yucca Mountain Site Characterization Plan (SCP) is to provide regional and site-specific meteorological information that is needed to satisfy certain performance assessment and design issues. The issues are related to radiological dose calculations, the design of surface facilities, and hydrometeorological and climatic studies.

The Meteorology Program includes four related Investigations intended to provide information on the following meteorological topics: regional meteorology, conditions near potential locations of surface facilities, wind patterns relative to population centers, and extreme weather phenomena. These generally organize the information needs by purpose and spatial scale.

Separate SCP Programs (Geohydrology and Climate) include the collection of certain meteorological data for geohydrology and climatology studies. The first Investigation in the Meteorology Program includes a Study to perform a "synthesis" of the available data from the various Programs to use in characterizing regional meteorology. Work for three of the four investigations in the Meteorology Program, those not covered by this Study Plan, is described in the Scientific Investigation Implementation Package for Regional Meteorology (EFPD, 1995). The Regional Meteorology program is described in the Scientific Investigation Implementation Package for Regional Meteorology (EFPD, 1995).

1.1 Purposes of the Study

Investigation 8.3.1.12.2 contains this one Study, "Meteorological Data Collection at the Yucca Mountain Site." The primary purpose of this Study is to obtain information on atmospheric dispersion to support the calculations of radiological doses due to possible releases of airborne radioactive material during pre-closure repository operations. The atmospheric dispersion information is needed to predict possible transport pathways, and the dilution factor χ/Q ("chi over Q"), to use in radiological dose calculations. Optimum estimates of atmospheric dispersion require site-specific meteorological data taken near potential sources of airborne material, and at points along the transport pathway, due to the complex topography of the Yucca Mountain area.

The relationships between Investigations in the overall Meteorology Program, and the other Programs mentioned above, create secondary purposes for the meteorological data collection beyond that strictly needed for atmospheric dispersion. The primary additional measurements in the data collection activity are precipitation and atmospheric humidity, which are made for the hydrometeorology purposes.

Two Activities were identified in the SCP under this Study:

- the Site Meteorological Monitoring Program (8.3.1.12.2.1.1), and
- the Data Summary for Input to Dose Assessments (8.3.1.12.2.1.2).

The Site Meteorological Monitoring Program data collection activity was initiated early in the site characterization planning process, because the information developed in this Study is also needed for environmental permits that are required to proceed with many site characterization activities. This additional requirement necessitates following additional regulations and guidelines.

The second Activity, Data Summary, follows the data collection in the Monitoring Program. This activity includes processing the data collected into a format and content needed to characterize atmospheric dispersion for radiological dose calculation purposes.

1.2 Objectives of the Study

The primary objective of this Study is to provide the meteorological information needed for pre-closure radiological safety purposes to calculate radiological doses to workers and the general public. This primary objective is expressed in two parts, the two-step process of data collection and dispersion calculation identified in the two Activities in this Study. The secondary purposes related to other applications of the data are expressed in the third objective. The three objectives are:

- collect site-specific meteorological data needed to characterize atmospheric dispersion;
- calculate atmospheric dispersion parameters, and
- collect additional site-specific meteorological data needed to support Regional Meteorology investigations.

1.3 Regulatory Rationale and Justification

The regulatory requirements for site-specific meteorological data related to atmospheric dispersion are expressed following the issue resolution strategy developed in the SCP. The specific issues and information needs related to this Study are discussed in this section. General information on issues and information needs is found in Chapter 8 of the SCP. Specific information needs related to site-specific meteorological data is in the beginning of Section 8.3.1.12 in the SCP.

The issues related to radiological dose calculations, which in turn require site-specific meteorological data, are discussed below.

- Issue 2.1 (SCP 8.3.5.3) concerns possible radiological doses to the public resulting from routine releases during repository operation, that is, the "pre-closure" period.
- Issue 2.2 (SCP 8.3.5.4) is similar to Issue 2.1; this issue concerns repository site workers, rather than the general public.
- Issue 2.3 (SCP 8.3.5.5) is concerned with radiological doses that may occur due to accidental releases. This issue does not distinguish between workers and the general public.
- Issue 2.5 (SCP 8.3.5.6) addresses a higher-level finding related to pre-closure radiological safety; this is another approach to the same material addressed in Issues 2.1 through 2.3.
- Issue 2.7 (SCP 8.3.2.3) addresses certain repository facility design criteria related to radiological safety.

The other SCP Programs that are expected to utilize portions of the site-specific meteorological data collected in this Study are given below, with a brief description of the data requirement:

- Program 8.3.1.2, Geohydrology: hydrometeorological data for the Investigations on the regional hydrologic system and the description of the unsaturated zone hydrologic system.
- Program 8.3.1.5, Climate: current climatic data needed to establish present climatic conditions, which in turn will be used to characterize paleoclimate and predict future climate.
- Program 8.3.1.13, Off-site Installations: data related to transportation.

- **Program 8.3.1.14, Surface Characteristics:** data related to the locating of surface facilities.
- **Program 8.3.1.16, Pre-closure Hydrology:** requires site-specific precipitation and wind data.

2.0 RATIONALE FOR THE STUDY

The primary purpose of this study is to obtain atmospheric dispersion information needed to resolve the pre-closure radiological safety issues in site characterization. The dispersion information will be based on site-specific meteorological data, and will be used to calculate radiological doses to repository site workers and the general public for possible routine and accidental releases of airborne radioactive material. The dose calculations are to be performed separately from this Study.

Secondary purposes of the Study are to obtain similar meteorological data that are intended for other applications, which include support of:

- air quality permits related to site characterization activities;
- local wind pattern studies associated with nearby population centers; and
- characterizing regional climate.

The basic rationale for the design of this Study is to provide atmospheric dispersion information based on meteorological data that would be acceptable to regulatory agencies for the intended purposes. In order for the data to be acceptable, the appropriate measurements must be taken, in suitable locations, using methods given in regulatory guidelines. The monitoring activity was designed to comply with Nuclear Regulatory Commission (NRC) Regulatory Guide 1.23 (NRC, 1972 and 1981), and various Environmental Protection Agency (EPA) guidelines.

2.1 Technical Rationale and Justification

The basic approach for this Study is to collect certain meteorological data at stations representative of the areas for which information is needed, and to report the data in a format suitable for atmospheric dispersion calculations. The approach includes the following primary steps: siting the stations, selecting the parameters to be monitored, performing the monitoring, and reporting the results. The regulatory guidance in these areas ranges from very general (extent of monitoring program, and site locations) to quite specific (methods for performing measurements, and quality assurance).

Characterizing meteorological dispersion conditions in mountainous areas is a complex process. The presence of elevated terrain has significant influence on the local climate and meteorological conditions relevant to atmospheric dispersion (Haugen, 1975; Blumen, 1990). Thus, while a reasonably long period of record for some parameters exists from stations involved in the Nevada Test Site operations, the need was identified to collect site-specific data to properly address the information needs involved with site characterization. Section 5.1 of the SCP was a presentation of pertinent recent climate and meteorology information based on information available at the time; information needs were discussed in Section 5.3.3.

The first five stations in the meteorological monitoring network were established for environmental monitoring purposes. The network was accepted during the site characterization planning phase as adequate for initial purposes to support site characterization, and was described in Sections 5.1.3 and 8.3.1.12.2.1.1 of the SCP. Four stations were added during 1992 to better define airflow through Midway Valley and the primary site characterization area, and at Gate 510 of the Nevada Test Site, which is on the southern border near the community of Amargosa Valley. Additional airflow and precipitation stations may be added to provide additional data for atmospheric dispersion and hydrometeorology studies.

2.1.1 Technical Background

Characterization of atmospheric dispersion in the complex topography in the Yucca Mountain area, for the purposes stated in this Study, requires a network of stations operating for many years to determine the transport pathways and dilution by atmospheric mixing. Dispersion is a complex product of regional scale weather patterns and local scale atmospheric dynamics generated by the topography. Significant variations in dispersion conditions occur temporally on diurnal and seasonal cycles, and spatially for the scales of interest considering locations of possible sources of airborne radioactive material and populated areas. Thus, a comprehensive characterization of dispersion is necessary to ensure pre-closure radiological safety due to routine and accidental releases.

One portion of pre-closure radiological safety studies is focused on the dispersion conditions most likely to contribute to the maximum possible dose. It is possible that the highest ground-level concentrations of airborne material emitted near the proposed repository facilities could occur during periods of low wind speed and low atmospheric mixing conditions, which may exist frequently in nocturnal down-valley (drainage) winds.

Local topography, combined with typical clear skies and frequent weak large-scale weather patterns, contributes to regular occurrences of nocturnal down-valley winds, that is, air flowing from higher elevations toward lower valleys during nighttime hours. The ground tends to cool rapidly on clear nights, creating a stable air layer near the ground. Temperature inversions, that is, warmer temperatures aloft than near the ground, are very stable conditions. Stable air does not mix as well as unstable air that is typical of daytime conditions with strong sunlight warming the ground. Conversely, the same weather patterns that can produce the nocturnal drainage winds can also produce very good atmospheric mixing conditions in the daytime hours, and up-valley winds.

The program was established to characterize all relevant meteorological conditions. The greater potential for higher ground-level concentrations of airborne material occurring during the nocturnal down-valley winds was justification to focus the site and parameter selections on these conditions.

2.1.2 Site Selection

Locations for meteorological monitoring stations used to collect data as input to atmospheric dispersion models are chosen to represent conditions in three principal areas: the source of the airborne emissions; the receptor, or impact area; and transport pathways. Of these, the region near the source is typically the most important one. Since neither the radiological dose calculation nor the dispersion models have yet been chosen, the work to obtain meteorological data is proceeding based on reasonable data requirement expectations. Current examples of modeling guidance are the EPA Prevention of Significant Deterioration (PSD) monitoring guidelines (EPA, 1987a, and 1987b), the air quality modeling guideline (EPA, 1986), and NRC guidance (NRC, 1977 and 1983).

Descriptions of, and rationale for, the station locations in the monitoring network were presented in SCP Section 8.3.1.12.2.1.1. A summary of the station exposures for the original five stations, and the rationale for selecting those locations, is presented below. The NTS-60 site has a 60-meter tower that includes wind sensors at the 10-meter and 60-meter levels. All other sites have 10-meter towers with wind measurements at the top. These and the other meteorological measurements are described in Section 3 of this Plan. Figure 2-1 is a map showing the current monitoring locations. Geographic information on the station locations is shown in Table 2-1. Locations and rationale for the original five sites follows.

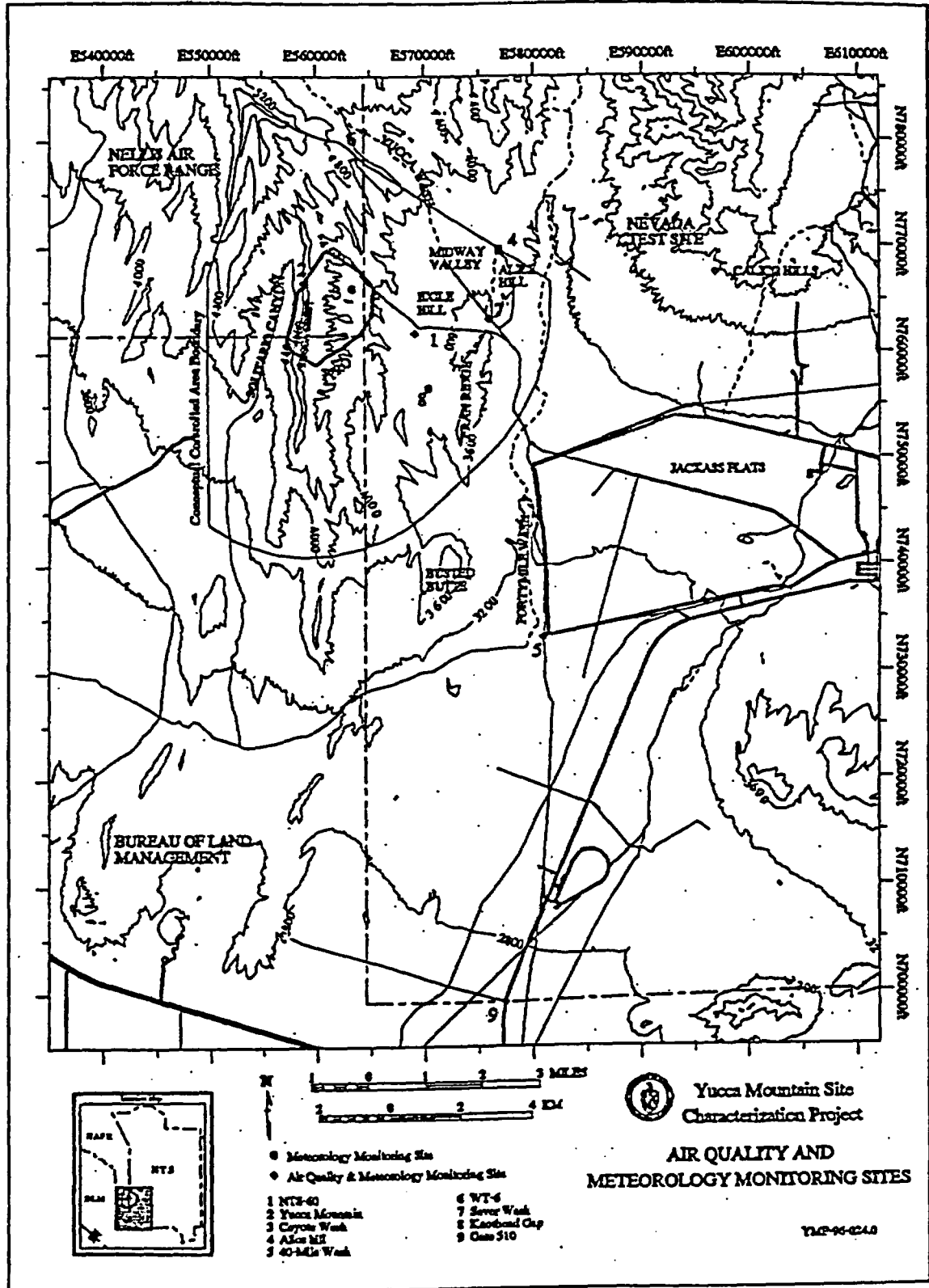


Figure 2-1. Meteorological Monitoring Network.

- **Site 1: NTS-60 (Main Site, previously called NTS-60 Repository)** is generally representative of the source region of possible airborne releases from the proposed repository surface facilities. Site exposure is a reasonably open area in Midway Valley, which is approximately 4 kilometers (km) north/south by 3 km east/west. The station is east of the central portion of the primary ridge of Yucca Mountain. The location is about 1.2 kilometers (km) east of the rapidly rising terrain with the Yucca Mountain ridge, and about 2 km west of Fran Ridge, which parallels the Yucca Mountain Ridge and is the western boundary of the Forty-Mile Wash in this area.
- **Site 2: Yucca Mountain** is located on the Yucca Mountain ridge crest, about 4 km west-northwest of the NTS-60 station. This location is out of immediate dominating airflow influences in Midway Valley, but could still be influenced by larger topographic features, particularly toward the north and east.
- **Site 3: Coyote Wash** is located in a narrow valley along the east side of the Yucca Mountain ridge, about 1.6 km east of the Yucca Mountain station. Coyote Wash is near one previous possible location for a portal for the Exploratory Study Facility (ESF). While the proposed portal has been relocated, this site is still important because it is representative of many small valleys along the east side of the Yucca Mountain ridge.
- **Site 4: Alice Hill** is located on top of a sloping hill about 3.4 km northeast of the NTS-60 station; the hill is near the fork between Forty-Mile Canyon and Yucca Wash, and is just north of Fran Ridge. The elevated location of Alice Hill is advantageous for observing meteorological conditions out of the immediate influence of the floor of Midway Valley.
- **Site 5: Forty-Mile Wash** is located along the floor of Forty-Mile Canyon southeast of Busted Butte, about 9.4 km southeast of the NTS-60 station. The site is just east of the drainage cut in Forty-Mile Wash. This location is a good indicator of airflow along an airborne transport pathway between the proposed repository surface facility and the Amargosa Valley populated area.

Plans for the location of the Exploratory Study Facility changed since original design of the meteorological monitoring network. These changes, coupled with advances in data input requirements for newer regulatory atmospheric dispersion models, created the need for finer resolution to the characterization of the airflow near the possible sources of radioactive material. Four new sites were installed and began operations by the end of 1992.

The new sites were added to obtain better definition of both nocturnal drainage winds and daytime up-valley winds that prevail in terrain like that in the Yucca Mountain area. One site is north of the main ridge crest, and one is at the southern boundary of the Nevada Test Site near Amargosa Valley. The other two are along probable paths of nocturnal drainage winds out of the Midway Valley area. Locations and rationale for the four new sites follows.

- **Site 6: WT-6** is at the WT-6 well pad, in the upper end of Yucca Wash, near the boundary line between the Nevada Test Site and the Nellis Air Force Range land. It is 6.1 km north-northwest of the NTS-60 site. Data from this location will help to characterize daytime up-valley airflow from the south and southeast through Midway Valley, and will also provide an up-canyon measurement during nocturnal down-valley airflow relevant to Midway Valley.
- **Site 7: Sever Wash** is in the topographic gap between Alice Hill and Fran Ridge, 2.1 km east-northeast of the NTS-60 site. This location will provide data to more completely characterize the surface nocturnal drainage flow out of Midway Valley through this gap, which is downhill from the ESF north portal.

- **Site 8: Knothead Gap** is in a saddle east of the gap at the northern end of Bow Ridge, in the southern end of Midway Valley, and is about 1.7 km south-southwest of the NTS-60 site. This location will be useful to determine the preferred nocturnal drainage for the area east of the proposed ESF South Portal. Possible pathways include directly flow to the southeast through the saddle between Bow Ridge and Fran Ridge, or circling northeastward toward the Sever Wash area.
- **Site 9: Gate 510** is along the southern border of the Nevada Test Site along the Lathrop Wells Road, at Gate 510, south of the Forty-Mile Wash site. It is about 19 km south-southeast of the NTS-60 site. Data from the Gate 510 site will assist in further characterization of airflow along a trajectory between the proposed repository area and the populated portions of Amargosa Valley.

Additional sites may be added to the network, as needed, to expand regional meteorological coverage.

Table 2-1. Meteorological Monitoring Site Location Descriptions.

Site	UTM Coordinates Zone 11 (meters)	Nevada System (feet)	Latitude-Longitude (deg° min' sec")	Elevation (msl)
Site 1 (NTS-60)	550,784E 4,077,374N	569,126E 761,795N	116°25'50"W 36°50'34"N	3750 ft 1143 m
Site 2 (Yucca Mountain)	547,646E 4,078,753N	558,844E 766,356N	116°27'56"W 36°51'19"N	4850 ft 1478 m
Site 3 (Coyote Wash)	548,874E 4,078,701N	562,874E 766,171N	116°27'06"W 36°51'17"N	4195 ft 1279 m
Site 4 (Alice Hill)	553,117E 4,079,779N	576,810E 769,661N	116°24'15"W 36°51'51"N	4050 ft 1234 m
Site 5 (40-Mile Wash)	554,385E 4,068,727N	580,843E 733,378N	116°23'26"W 36°45'52"N	3125 ft 953 m
Site 6 (WT-6)	549,388E 4,083,097N	564,612E 780,592N	116°26'45"W 36°53'40"N	4315 ft 1315 m
Site 7 (Sever Wash)	552,800E 4,077,847N	575,747E 763,324N	116°24'28"W 36°50'49"N	3545 ft 1081 m
Site 8 (Knothead Gap)	551,161E 4,075,773N	570,344E 756,538N	116°25'35"W 36°49'42"N	3710 ft 1131 m
Site 9 (G-510)	553,418E 4,058,398N	577,554E 699,491N	116°24'08"W 36°40'17"N	2750 ft 838 m

msl: elevation above mean sea level

Coordinates based on survey results given in Nevada State Plane, Central Zone, transformed to Universal Transverse Mercator (UTM), Zone 4626, and Geographic systems based on 1927 North American Datum projection.

2.1.3 Parameters Monitored

The technical rationale for the choice of parameters is based on regulatory guidance for atmospheric dispersion models, and typical climatic and boundary layer study requirements. The rationale is discussed in this section; the program is described in Section 3.

The primary dispersion model input requirements are wind speed and direction, and atmospheric stability. Wind speed and direction are measured at 10 meters above ground level (m-agl) at all stations, and at 60 m-agl at the NTS-60 station. Ten m-agl is a standard height for wind measurements for many meteorological purposes, including dispersion and environmental characterization studies. The 60 m-agl measurement at the NTS-60 site is desirable to study the depth of surface-based meteorological phenomena, such as drainage winds. The specific height 60 m-agl is typical in studies related to NRC purposes.

The additional parameters measured at all sites are temperature, atmospheric moisture (as dew-point temperature at the NTS-60 site, and relative humidity at the remainder of the sites), barometric pressure, and precipitation. Exposure of the sensors at the stations complies with monitoring guidance (EPA, 1987a), except where stations were purposely located in confined terrain. For example, the rising terrain near the Coyote Wash site is not "open terrain", but that location was chosen as representative of conditions in that type of terrain at that site.

EPA and NRC guidance on atmospheric stability measurements differ, and have changed in recent years. It is important to make comprehensive stability measurements, since a given model selected in the future could require certain stability input. Five separate atmospheric stability indicator measurements have been made at various times in the program, which are listed below. All nine sites are to be equipped with the first four stability indicator measurements. Total incoming solar radiation and the temperature difference between 10-m to 2-m have been added in response to EPA modeling input guidance (EPA, 1990).

The atmospheric stability indicator measurements used in the monitoring network are:

1. Standard deviation of the horizontal wind direction, also known as sigma-theta or sigma-A, it is computed for all horizontal wind direction measurements;
2. Temperature difference (60-m to 10-m at the NTS-60 site, 10-m to 2-m at the new "remote" sites and upgraded original sites);
3. Standard deviation of the vertical wind speed (measured at 10 m-agl, also known as sigma-w), is used with horizontal speed to estimate sigma-phi, the standard deviation of the vertical wind angle;
4. Total incoming solar radiation;
5. Net radiation; this was discontinued in 1991 because it was no longer recommended as a stability indicator.

2.1.4 Monitoring and Data Processing Operations

The operating procedures used in the meteorological monitoring network are a product of internal project operational and quality assurance requirements, and requirements and guidance promulgated by EPA and NRC, such as were cited in the previous two sections. The primary project document is the "Quality Assurance Requirements and Description" (DOE, 1995). These requirements are implemented by M&O Nevada Line Procedures (NLP). The NLP set forth requirements for activities such as creating and maintaining the procedure documents, utilizing nonconformance reporting, the control of measuring and test equipment, and the maintenance and control of operating equipment. The procedures that directly control the field and data processing operations are Nevada Work Instructions (NWI).

The EPA Prevention of Significant Deterioration (PSD) guidance is the primary regulatory guidance for meteorological monitoring, since it contained the most stringent requirements likely to be applicable to the monitoring program, and the most comprehensive operating and quality assurance guidance. Current EPA guidance is provided in the PSD Ambient Monitoring Guidelines (EPA, 1987a) and the meteorological monitoring guidance for regulatory modeling applications (EPA, 1987b).

NRC monitoring guidance is less specific than the EPA guidelines, and has not been changed as recently. The primary guidance is Regulatory Guide 1.23, (NRC, 1972), is in a draft form for revision (NRC, 1981). A more recent guideline related to data processing for monitoring at uranium recovery facilities provides additional monitoring guidance similar to that performed in this program (NRC, 1981).

2.2 Constraints on the Study

Meteorological monitoring is a passive testing procedure. Except for possible conflicts over surface land use, the monitoring does not interfere with other site characterization activities. Establishing monitoring stations requires adherence to project procedures that minimizes both environmental impact of the stations themselves, and resolves possible conflicts over use of specific land plots for testing purposes. Some monitoring stations are intentionally located near possible sources of airborne radioactive material which may result from the Exploratory Studies Facility portion of site characterization.

The work in this Plan relates to current local meteorological conditions. Pre-closure radiological safety determinations are to be based on recent meteorological conditions. Work on the future climate that could affect repository performance is addressed in the SCP Climate Program, which is described in the SCP Section 8.3.1.5.

Accuracy specifications applicable to the parameters monitored are given in EPA and NRC regulatory documents (EPA, 1987a, 1987b; NRC, 1981). Precision assessment is not included in the requirements nor guidelines. The specifications have been adopted for the monitoring work covered by this Plan. Monitoring procedures in the NWT's require corrective actions and possible data invalidation when instrument accuracy does not meet the project requirements. Regulatory requirements for accuracy, sensor characteristics, and data reporting resolution guidelines which are applicable to this project are shown in Table 2-2.

The limits and capabilities of the analytical methods that will use the information resulting from the monitoring work are not specified in this Study Plan. The "analytical method" in this case is the atmospheric dispersion model, which has not been selected yet. The monitoring work is being performed according to reasonable state-of-the-art methods for regulatory purposes, so the input requirements of the dispersion model chosen will, in all likelihood, be satisfied by the data obtained in this monitoring program.

Regulatory monitoring guidelines (EPA, 1987a) recommend one to five years of recent data for many purposes. The prudent period of monitoring depends on the likelihood of changing conditions during the lifetime of the projected facility, and the desirable strength of the certainty that the worst case conditions have occurred. The relatively long projected operating period, compared to typical industrial facilities, and the evolving EPA guidance on input meteorological data for dispersion modeling purposes (40 CFR 51, Appendix W) warrant continuation of the data collection program for the foreseeable future.

Table 2-2. Regulatory Specifications for Meteorological Equipment (page 1 of 2).

SPECIFICATION ¹	CHARACTERISTICS ²	ACCURACY ³	RESOLUTION
Horizontal Wind			
	Speed (meters per second)		
PSD:	SS: < 0.5	@ ≤ 5: ±0.25;	none
		@ > 5: ±5%	
OnS:	SS: ≤ 0.5, DC < 5 m	≤(0.2 + 5%)	0.1
NRC:	SS: < 0.4	@ < 2: ± 0.2	0.1
	DC: < 2 m	@ 2-22: ±10%	
Vertical Wind Speed (meters per second)			
PSD:	SS: < 0.25 see horiz. wind speed	none	
OnS:	SS: ≤ 0.25; DC: ≤ 5 m see horiz. wind speed	0.1	
Wind Direction (degrees)			
PSD:	SS: < 0.5 @ 10° deflection	± 5	none
	DR: 0.4 to 0.65; DC3: ≤ 5 m		
OnS:	SS: ≤ 0.5 @ 10° deflection	± 5	1
	DR: 0.4 to 0.7; DC: ≤ 5 m		
NRC:	SS: < 0.4	± 5	1
	DR: > 0.4; DD: < 2 m		

¹ Specifications

- PSD: EPA PSD Ambient Monitoring Guidelines (EPA, 1987a)
- OnS: EPA On-Site Meteorological Program Guidance for Regulatory Modeling Applications (EPA, 1987b)
- NRC: NRC Reg Guide 1.23; draft rev. 1, (NRC, 1981)

² Characteristics

- SS: Starting Speed (minimum speed at which sensor operates within specifications, meters/second)
- DC: Distance Constant (distance air flows past sensor while it responds to 63.2% of step change in speed)
- DR: Damping Ratio (ratio of actual to critical dampings)
- TC: Time Constant (time for sensor to respond to 63.2% of step change)
- DD: Delay Distance (distance air flows past vane while it responds to 50% of step change in direction)

³ Accuracy

Accuracy (tolerance limit): Acceptable difference between an observed result and the corresponding known input condition; percent (%) differences are a percent of the observed value.

Table 2-2. Regulatory Specifications for Meteorological Equipment (page 2 of 2).

SPECIFICATION	CHARACTERISTICS	ACCURACY	RESOLUTION
Temperature (degrees C)			
PSD:	none $\leq \pm 1.0$, or 0.5 (if vapor problem) none		
OnS:	TC ≤ 1 min	± 0.5	0.1
NRC:	none	± 0.5	0.1
Temperature Difference (Celsius degrees)			
PSD:	none	$\leq \pm 0.003^\circ\text{C/m}$	none
OnS:	TC ≤ 1 min	± 0.1	0.02
NRC:	none	$\leq \pm 0.003^\circ\text{C/m}$	0.1
Dew - Point Temperature (degrees Celsius; range -30 to +30)			
PSD:	none	$\leq \pm 1.5$, or	none
		$\leq \pm 0.5$ (if water vapor problem)	
OnS:	TC ≤ 30 min	± 1.5	0.1
NRC:	Op. range: RH > 60%	± 1.5	0.1
Precipitation (millimeters, converted from 0.01-inch increments)			
PSD:	Heated, Windscreen	$\pm 10\%$ @ < 7.6 cm/hr 0.254 mm	
OnS:	see PSD	$\pm 10\%$	0.3 mm
NRC:	none	$\pm 10\%$	0.254 mm
Barometric Pressure (millibars)			
PSD:	none	none	none
OnS:	none	± 3	0.5
Solar Radiation (Watts per square meter)			
PSD:	none	$\pm 5\%$	none
OnS:	TC: Solar ~ 5 s, net ≤ 30 s	$\pm 5\%$	10
	@ operating temperature: -20° to $+40^\circ$		

See Legend on previous page of this table.

3.0 DESCRIPTIONS OF THE TESTS AND ANALYSES

The tests and analyses in this Study are covered by the two SCP Activities. The "test" portion is the field monitoring work, Activity 8.3.1.12.2.1.1; the "analysis" is the reporting data in a format usable for dose calculation work, Activity 8.3.1.12.2.1.2. The descriptions of these two Activities follow.

3.1 Meteorological Monitoring Program

The meteorological monitoring program includes field measurements at five stations that have operated since late 1985, and four stations that began operating in 1992. Locations of the nine sites are given in a network area map in Figure 2-1, and in Table 2-1. Locations of the additional possible stations are discussed in Section 3.1.1. Elements of the program are described in this Section organized by approach and parameters, monitoring methods, data processing, expected results and their relationship to information needs.

3.1.1 Approach and Parameters

The technical rationale for the meteorological monitoring program was presented in Section 2.1 of this Plan. The purpose and reasons behind the design of the Study were presented in that Section. Basically, Environmental Protection Agency and Nuclear Regulatory Commission monitoring guidance is being followed to establish a comprehensive data base that could be used as meteorological input for atmospheric dispersion models likely to be used for the purposes stated.

The approach to implementing monitoring guidance from regulatory agencies and M&O project requirements is to follow the most stringent recommendations wherever possible. The operating characteristics of the equipment in use comply with the regulatory specification criteria shown in Table 2-2. Operating procedures and quality assurance tasks are established following the same monitoring guidance to ensure data acceptability.

The parameters monitored were identified in Section 2.1.3 of this Plan. Table 3-1 is a listing of the parameters being monitored. The table shows the sites in three categories by measurements being performed, including equipment upgrades in progress, and the height above ground level of the measurements. Further information on monitoring equipment is provided in the next Section of this Plan.

Table 3-1. Parameters Monitored in the Meteorological Monitoring Network.

Parameter	Site 1	Site 2-5	Site 6-9	Accuracy
Horizontal Wind Speed	60 and 10	10	10	(1)
Wind Direction	60 and 10	10	10	± 5°
Air Temperature	10 m (2)	10m (2)	2	± 0.5 C°
Temperature Difference	60 to 10 (3)	(3)	10 to 2	± 0.1 C°
Dew-Point Temperature	10 m (2)	n/a	n/a	± 1.5 C°(4)
Relative Humidity	n/a	10 (2)	2	(5)
Barometric Pressure	1	1	1	± 3 mb
Precipitation	1	1	1	± 10 %
Solar Radiation	2 (6)	2 (6)	2	± 5 %
Vertical Wind Speed	10	10 (6)	10	(1)

Heights of measurements are shown in meters above ground level

NOTES:

Accuracy (tolerance limit): Acceptable difference between an observed result and the corresponding known input condition; percent (%) differences are a percent of the observed value.

C° is Celsius degrees, used as a temperature range in accuracy statements

n/a Not applicable

- (1) For speeds < 5 m/s: ± 0.25 m/s; speeds > 5 m/s: ± 5% of speed
- (2) Being changed to 2 m with station upgrades
- (3) 10 to 2 m delta-temperature being added with station upgrades
- (4) Only applies at temperatures -30°C to +30°C
- (5) RH < 40%: RH ± 4%; for RH ≥ 40%, use RH equivalent to dew point ± 1.5 C°
- (6) To be added with station upgrades

3.1.2 Measurement Methods and Equipment

Information on the types of monitoring equipment and field operation procedures is provided in this Section. The measurement methods comply with regulatory guidance documents cited previously in the rationale portions of this Plan. The specifications of the equipment used meet or exceed the regulatory guidance provided in Table 2-2. The accuracy tolerance limits are also shown.

A brief description of the measurement methods currently used follows. The sensors provide an output electrical signal that is a function of the sensor condition (for example, sensor temperature) in a relationship established by the manufacturer.

- **Horizontal wind speed** sensors are 3-cup anemometers equipped with an optical disk and light chopper. The rotation rate of the cup shaft is measured by the frequency of the chopped direct-current (DC) signal. The shaft rotation rate is directly proportional to wind speed. Onsite data systems record scalar hourly averages of wind speed.

- **Horizontal wind direction** sensors have a single-axis vane connected to either a potentiometer or a resolver. Both sensor types provide an electronic signal proportional to the position of the vane. The sensor is aligned to true north using landmarks or marker stakes identified by magnetic compass and/or the time of solar noon. Onsite data systems record scalar hourly averages of wind direction using unit vector techniques.
- **Vertical wind speed** sensors are vertically mounted propeller anemometers. The propeller shaft is connected to a small electric generator, for which the output voltage is proportional to the shaft rotation rate. The rate is directly proportional to wind speed, depending in part on propeller characteristics. The vertical speed measurements are used only to calculate hourly standard deviation (σ_w) values.
- **Air temperature** sensors are thermistors or platinum wires mounted in aspirated shields. The sensors are part of an electrical bridge circuit, for which the output voltage is a function of sensor temperature. The temperature sensors at the original "remote" sites (Sites 2-5) were originally mounted in naturally aspirated shields, and are being upgraded to mechanical aspiration in 1993. Temperature measurements at Sites 1, and 6 through 9, are made using mechanically aspirated solar radiation shields.
- **Temperature difference** is measured using individual air temperature sensors in mechanically aspirated solar radiation shields, and electronic signal processing to compute the temperature difference.
- **Dew-point temperature** sensors were originally lithium chloride dew-cells, which were replaced by a chilled mirror system in 1993. The dew-cell element is treated with lithium chloride; it can sense the saturation point of the element, which is the dew-point temperature. The chilled mirror system cools a mirror to the dew point, which is sensed optically by condensation on the mirror. The sensors are mounted in a shield at Site 1.
- **Relative humidity** sensors are capacitive element solid-state devices that provide an output signal proportional to relative humidity. These sensors are mounted in aspirated shields similarly to the temperature sensors.
- **Barometric pressure sensors** are aneroid cells with mechanical or electronic detectors that sense the cell position, which in turn is related to barometric pressure.
- **Precipitation gauges** are tipping-bucket mechanisms that tip with a volume of water equivalent to 0.01-inch of rainfall; nominal funnel diameter is 8 inches. Gauges at sites with elevations over about 3,500 feet above mean sea level are heated during periods of frozen precipitation. Gauges likely to be exposed to strong winds during precipitation are being equipped with hanging-slat (Alter) wind shields. The choice of using heat and wind shields is based on operational experience at the given sites. Hourly precipitation totals are recorded by onsite processing.
- **Solar radiation** sensors are black and white pyranometers sensitive to solar radiation in the 0.3 to 3 micrometer wavelength range. The sensors are mounted horizontally to measure direct and diffuse sunlight.

Atmospheric mechanical turbulence measurements are used as indicators of atmospheric stability. The measurements are calculations based on fluctuations of either horizontal wind direction or vertical wind speed. The turbulence measurements are:

- standard deviation of the horizontal wind direction, also known as sigma-theta (σ_θ) or sigma-A (σ_A);
- standard deviation of the vertical wind speed, also known as sigma-w (σ_w).

Atmospheric stability can be calculated from various turbulence indicators, depending on dispersion model input requirements. Since the dispersion model to be used in the dose calculations has not been chosen yet, the specific stability data requirement is not known at this time. The methods currently anticipated as probable for use are described below.

- The lateral turbulence (σ_A) and wind speed method (EPA, 1987a, and 1986) is used to estimate Pasquill stability categories using the standard deviation of the horizontal wind direction, σ_A , scalar mean wind speed, and a day/night distinction. The basic steps in the method are:
 1. The standard deviation, σ_A , is calculated during on-site data processing from the once-per-second data system input for 15-minute periods.
 2. The root-mean-square of the 15-minute period values is then calculated to obtain an hourly σ_A , which is recorded during on-site data recording.
 3. During data processing, the hourly σ_A is used to determine an initial stability category, a designation from "A" (extremely unstable) through "F" (moderately stable).
 4. The initial category is adjusted to have hours with higher wind speed hours be closer to neutral stability, and nighttime hours with low wind speeds causing wind direction meander to be classified more stable.
- The lateral turbulence method by the NRC (NRC, 1981) is almost the same as the initial classification using σ_A described above, except that a seventh category, "G" for yet another more stable distinction, is added. No adjustments are made for wind speed or day/night.
- The vertical temperature difference method (NRC, 1981) reflects long-standing NRC guidance that assigns one of seven Pasquill categories based on the temperature lapse rate, typically from 10 to 60 m-agl.
- The radiation-based key to Pasquill-Gifford stability categories (draft revision to Supplement B to modeling guidance, EPA, 1990) assigns the "A" through "F" stability categories based partly on wind speed, with higher speeds being more neutrally stable. The category is also based on either solar radiation intensity in the daytime, greater radiation intensity is less stable, or temperature lapse rate from 2 to 10 m-agl, in three classes.

The methods used to operate and check the field monitoring equipment are described in M&O Nevada Work Instructions (NWI). The field procedure documents cover work in these general areas: calibrations, routine operations, quality control checks and nonconformance reporting, preventive and corrective maintenance, and quality assurance assessments. Summaries of the work in these areas follows:

- Calibrations: Operating equipment (that is, sensors and on-site monitoring equipment) are calibrated traceable to recognized standards, by outside vendors or by site technicians

following specific procedures in the applicable NWI. The calibrations assure that the equipment is operating within the acceptable accuracy tolerance limits given in Table 3-1. Calibrations of the measuring and test equipment (M&TE) is also either performed by outside vendors, or by site technicians following the applicable NWI.

- **Routine operations:** Trained site technicians visit each monitoring site at least once every nine days; typically, the visits are at least once or twice per work week. Site visits include checks of: the physical condition of the site area and sensors, proper time keeping and correct on-site data recording, and reasonableness of the current results. Conditions are documented on checklists, which are used during data processing as an important resource during data validation.
- **Quality control:** Site technicians do formal performance checks on the station system operations at least twice each year, or more often when results are suspect. The checks are used to either verify conformance with acceptable accuracy tolerance limits, or to initiate corrective actions when results are unacceptable. Check techniques are based on EPA guidance (EPA, 1989).
- **Maintenance:** Preventive and corrective maintenance actions are controlled by NWI, which in turn implement higher level procedures. Some maintenance is performed by site technicians, while other is done by vendors.
- **Quality assurance:** The two basic quality assurance activities in the monitoring work are M&O Quality Assurance (QA) monitoring, and independent performance audits. M&O QA performs audit and surveillance activities routinely to ensure continued compliance with M&O procedures. M&O contracts performance audits by independent personnel and equipment twice each calendar year to comply with EPA guidance (EPA, 1987a). Audit techniques are based on EPA guidance (EPA, 1989).

3.1.3 Data Processing

Data processing consists of four basic steps: onsite signal processing and recording, transferring data from the recording media used in the field to M&O computer files, validating data, and producing a final data base. Procedures controlling processing are contained in applicable NWI.

Onsite data processing was mentioned in the previous section by specific parameters when the processing is something other than routine hourly averages. Wind data are scalar, rather than vector, quantities. The standard deviation of horizontal wind direction calculations were described in detail. Data are recorded in solid-state electronic media (such as modules or cartridges). The recorded data is occasionally viewed in the field during site checks to ensure proper recording.

Data transfer from the on-site electronic recording media is accomplished by site and/or data technicians using commercial-grade data processing programs. Computer data files are created to concatenate (combine time periods) data for given stations. Copies of the raw data files are stored unchanged.

Data validation is a process of analyzing, reviewing, editing the data, and making changes based on site checklists and technical review. Data can be invalid when: equipment is operated in an out of tolerance mode; during periods of known equipment down-time, when equipment was not recording data; and during quality control checks or audits that interfere with data collection. Some quality control checks are passive, such as side by side measurements made in situ (without disturbing the normal operating mode).

Data processing is completed with preparation of a final data base. Information from this data base can be re-formatted for reports to the project office, regulatory agencies, or other M&O teammates.

3.1.4 Results

The topics addressed in this section are: the range of expected results, the representativeness of the test related to future conditions, and the relationship of the test to the set performance goals and confidence levels.

The range of expected results for the meteorological parameters being monitored is similar to the information reported in Chapter 5 of the SCP. As indicated in Section 2.1.1 of this Plan, meteorological conditions can differ between nearby stations due to topographic influences; these differences can be significant enough to alter the path and degree of dilution in the atmospheric transport of airborne emissions. These differences can be subtle combinations of wind direction, speed and atmospheric stability; the range of the results is not likely to vary significantly between stations.

The information collected during site characterization is used to investigate the "future conditions" relevant to the performance goals being addressed by this program. Some portions of hydrometeorology and climatology relate to climatic conditions up to 10,000 years in the future, but the results of this study are applicable to modern (present day) climatic and meteorological conditions.

The relationship between the meteorological monitoring program and the set performance goals and confidence levels is one of the Study supplying input data that are to be used to estimate atmospheric dispersion, which is one step in estimating radiological doses to the general public and site workers. The performance and design parameters identified in the performance allocation process in Table 8.3.1.12-1 of the SCP are: χ/Q ("chi over Q"), the primary measure of atmospheric dispersion; radon emanation from tuff, which is related to barometric pressure, and accident initiating events, extreme weather conditions.

The testing basis showed SCP Chapter 5 material as representative of current estimates. Confidence in these estimates ranged from "Low" for site-specific parameters to "Medium" for those related to extreme weather, which will be based largely on long-term data bases from regional stations. The needed confidence was identified as "High" for all parameters. Continued site-specific monitoring will increase the confidence level to "High".

3.2 Reporting for Dose Calculations

The purpose of the second Activity in this Study is to report the atmospheric dispersion data in a format suitable to be input data for the meteorological portion of the radiological dose calculation model intended for use in the dose assessment work. Typical model input requirements were presented in the SCP section 8.3.1.12.2.1.2. Work is planned on this portion of the study when the model to be used has been selected.

4.0 APPLICATION OF RESULTS

The meteorological data collected in this Study is intended for use in at least three primary areas; further applications are feasible due to the generalized scope of the monitoring activity. The three primary applications are: atmospheric dispersion for radiological dose calculations, design of surface facilities, and hydrometeorological and climatological studies.

4.1 Resolution of Design and Performance Issues

Work to resolve the design and performance issues related to the data collection in the meteorological monitoring program is accomplished through related Studies. The applications support higher level characterization activities, rather than directly resolve issues. The linkage between this Study and the performance and design issues is presented in the SCP Section 8.3.1.12, and is discussed in the next Section of this Plan.

4.2 Interfaces with Other Site Characterization Studies

The interfaces between this Study and other site characterization studies are summarized in this section. Further detail was presented in SCP Section 8.3.1.12. Study 8.3.1.12.2.1 is planned to collect on-site meteorological monitoring data. These data are to be provided to the following Studies or Investigations:

- Study 8.3.1.12.1.2 is the plan for a "synthesis" of on-site meteorological data collected in this Study (8.3.1.12.2.1) and other Yucca Mountain Site Characterization Studies that collect on-site meteorological data. This Study is intended to ensure maximum value is obtained from data collected. The Programs that include meteorological monitoring are 8.3.1.2 (Geohydrology), 8.3.1.5 (Climate), and 8.3.1.16 (pre-closure hydrology).
- Study 8.3.1.12.4.1 is the plan to characterize extreme weather events that could be significant to design of surface facilities.
- Investigation 8.3.1.12.3 will evaluate the possibility of preferential transport of airborne radioactive material toward population centers.

The primary purpose of this Study is related to characterizing atmospheric dispersion to support which is used with an appropriate emission factor (Q) to produce a concentration or exposure (χ) estimate. Various models calculate χ/Q values with different methods. Optimizing the χ/Q calculation requires consideration of dispersion factors such as topography and land-surface characteristics along the transport path, typical and/or worst-case meteorological conditions, and type of airborne material (particles or gases).

The Issues associated with radiological dose calculations are:

- Issue 2.1 - Radiological exposures to the public.
- Issue 2.2 - Radiological exposures to workers due to routine releases.
- Issue 2.3 - Radiological exposure to workers due to accidental releases.
- Issue 2.5 - Higher level finding related to pre-closure radiological safety.
- Issue 2.7 - Radiological design criteria.

The information provided to the other project Programs, such as Geohydrology and Climate, are applied to higher level performance issues. The primary related performance issue is ground-water travel, which in turn is connected to on-site meteorological data collection through topics such as climatological studies and characterizing infiltration of precipitation.

5.0 SCHEDULES AND MILESTONES

The following information is based on the schedule information originally appearing in SCP Section 8.3.1.12.5. The Major Events listed in SCP Table 8.3.1.12-3 and Figure 8.3.1.12-3 are the items shown below. The schedule has changed since the December 1988 SCP. Information on current status is provided for the major events, which are the only events being formally tracked.

5.1 Event A: Study plan approved.

The initial Study Plan 8.3.1.12.2.1 was approved as Revision 0 in April 1991. This version was accepted by the Nuclear Regulatory Commission. The Yucca Mountain Site Characterization Project Office (YMPO) identified a need for a document revision to conform to format and content guidelines shown in the "DOE Content Guidance for Description of Studies in Study Plans", which is Attachment 2 in YMPO Administrative Procedure (AP)-1.10Q (Y-AD-001, 8/90). Revision 1 to the Study Plan is a response to that need.

5.2 Event B: Annual meteorological monitoring data reports available to DOE.

Quarterly meteorological monitoring reports were prepared covering periods from the beginning of the program in December 1985, through the quarter ending February 1989. No annual reports were completed. At this point, data processing and reporting was suspended while computer software quality assurance issues were being addressed.

Processing resumed in 1992, with approval of the data processing and reporting programs. The data collected through 1991 is to be reported in a single report, which is described in Section 5.4 of this Plan. Annual reports were done for 1992, 1993, and 1994, and will continue to be prepared for subsequent yearly monitoring periods.

5.3 Event C: Summary reports available to DOE on average and unfavorable χ/Q values at each designated receptor.

Work on the choice of radiological dose calculation models has not proceeded as yet. Hence, work on the Activity to calculate χ/Q values has not been accomplished yet.

5.4 Event D: Draft of five-year summary report on meteorological conditions available to DOE.

The schedule in the SCP called for the five-year report being due to DOE in June 1993. The initial report for data collected from 1985 through 1991 was completed, see Section 5.2. The plans for future summary reports are being evaluated.

6.0 REFERENCES

- Blumen, W. (ed.), 1990. Atmospheric Processes Over Complex Terrain. Meteorological Monographs, Volume 23, Number 45. American Meteorological Society, Boston, MA.
- Haugen, D. A. (Coordinator), 1975. Lectures on Air Pollution and Environmental Impact Analyses. American Meteorological Society, Boston, MA.
- DOE, 1992: Quality Assurance Requirements and Description. U.S. Department of Energy, Office of Civilian Radioactive Waste Management. DOE/RW/0333P, December 1992.
- EFPD, 1995. Scientific Investigation Implementation Package for Air Quality Monitoring. Civilian Radioactive Waste Management System Management and Operating/Science Applications International Corporation. EFPD-91/002.
- EFPD, 1995. Scientific Investigation Implementation Package for Regional Meteorology. Civilian Radioactive Waste Management System Management and Operating/Science Applications International Corporation. EFPD-95/001.
- EPA, 1986: Guideline on Air Quality Models (Revised). EPA/OAR/OAQPS, EPA-450/2-78-027R, July 1986.
- EPA, 1987a: Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD). EPA/OAQPS, EPA-450/4-87-007, May 1987.
- EPA, 1987b: On-Site Meteorological Program Guidance for Regulatory Modeling Applications. EPA/OAQPS, EPA-450/4-87-013, June 1987.
- EPA, 1989: Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV. Meteorological Measurements. EPA/EMSL, EPA-600/4-90/003, August 1989.
- EPA, 1990: Guideline on Air Quality Models (Revised). EPA/OAR/OAQPS, EPA-450/2-78-027R, July 1986. Supplement B (draft) 1990.
- NRC, 1988: On-site Meteorological Measurement Program for Uranium Recovery Facilities - Data Acquisition and Reporting. NRC/ONRR, Regulatory Guide 3.63, Mar. 1988.
- NRC, 1977: Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors. NRC/OSD, Regulatory Guide 1.111, Rev.1, July 1977.
- NRC, 1972 and 1981: Onsite Meteorological Programs (Safety Guide 23). Regulatory Guide 1.23. 1972, with later draft revisions, including September 1981.
- NRC, 1983: Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants. NRC/ONRR, Regulatory Guide 1.145, Rev. 1, February 1983.